

Table of Contents

<i>Contributing Sponsors</i> _____	2
<i>Poster Session #2 Sponsor</i> _____	2
<i>Ocean Optics XX Planning Committee</i> _____	3
<i>Ocean Optics XX Exhibitors</i> _____	4
<i>Welcome</i> _____	5
<i>2010 Jerlov Award</i> _____	5
2010 Recipient _____	6
<i>2010 Awards Banquet</i> _____	9
Invited Speaker _____	9
<i>Monday, September 27, 2010</i> _____	11
Organismal Response to Light Field _____	11
Radiative Transfer/Atmospheric Correction _____	11
Near Surface Processes _____	11
Invited Lectures _____	12
Poster Session #1 _____	12
<i>Tuesday, September 28, 2010</i> _____	17
Bio-optics North _____	17
Bio-optics South _____	18
Invited Lectures _____	18
Poster Session #2 _____	18
<i>Wednesday, September 29, 2010</i> _____	24
Chairman's Choice _____	24
New Instruments _____	24
Invited Lectures _____	25
Poster Session #3 _____	25
<i>Thursday, September 30, 2010</i> _____	30
Remote Sensing Systems and Shallow Water _____	30
Remote Sensing of Phytoplankton Characteristics _____	31
Remote Sensing of Bio-optical Properties _____	31
Invited Lectures _____	32
Awards Banquet Dinner / Dance _____	32
<i>Friday, October 1, 2010</i> _____	32
Optics in Spill Response _____	32
Invited Lectures _____	32
Closing Remarks _____	32
<i>Abstract Listing Alphabetical by Presenting Author</i> _____	33
<i>Alphabetical Index of Authors</i> _____	141

CONFERENCE SPONSOR



THE OCEANOGRAPHY SOCIETY

Contributing Sponsors



Poster Session #2 Sponsor



Ocean Optics XX Planning Committee

Heidi Dierssen *Chair* University of Connecticut *U.S.A.*

Scott Pegau *Co-chair* Prince William Sound Science Center *U.S.A.*

Bob Bidigare University of Hawaii at Manoa *U.S.A.*

Paula Bontempi NASA Headquarters *U.S.A.*

Grace Chang Sea Engineering Inc *U.S.A.*

Paula Coble University of South Florida *U.S.A.*

Alex Cunningham University of Strathclyde *U.K.*

Carlos Del Castillo John Hopkins University *U.S.A.* / *Puerto Rico*

Helga Gomes Bigelow Labs *U.S.A.* / *India*

Rick Gould US Naval Research Laboratory *U.S.A.*

Victor Kuwahara Soka University *Japan*

Zhongping Lee Mississippi State University *U.S.A.* / *China*

Marlon Lewis Dalhousie University *Canada*

Trudy Lewis Lewis Conference Services International Inc. *Canada*

Hubert Loisel Université du Littoral *France*

Merv Lynch Curtin University of Technology *Australia*

Jennifer Ramarui The Oceanography Society *U.S.A.*

Knut Stamnes Stevens Inst of Technology *U.S.A.* / *Scandinavia*

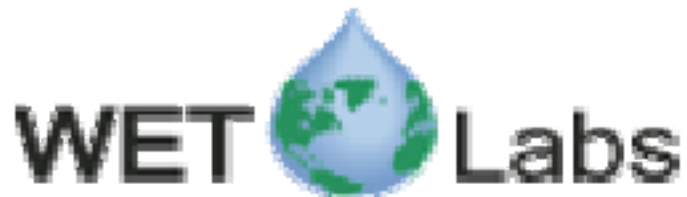
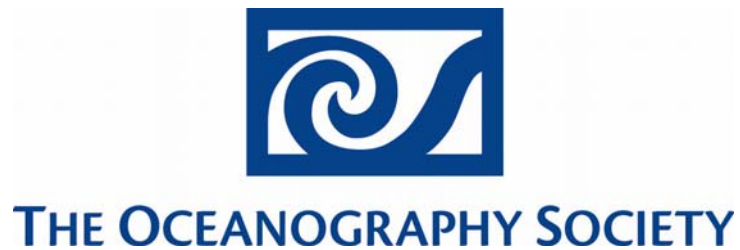
Ken Voss University of Miami *U.S.A.*

Conference Coordinator

Trudy D. Lewis
Lewis Conference Services International Inc.



Ocean Optics XX Exhibitors



Welcome

Welcome to the 20th installment of the Ocean Optics Conference. From its inception, the Ocean Optics Conference series has attracted a diverse audience of professionals and students addressing virtually every facet of optical oceanography including basic research, technological development, environmental management, and policy. Over the course of the 41 year history of the series, the conference has increased in scope and attendance and has become spiced with topics of local interest as the venues have become more varied and representative of the international oceanographic community. This year's conference promises to be as exciting as ever.

If there is a centerpiece of the conference, it is the banquet where attendees will experience fine local cuisine, wines and entertainment at the Hotel Captain Cook. We look forward to an exciting talk by our Banquet Guest Speaker, John Weller, entitled "The Last Ocean" and presentation of the Jerlov and Best Student Paper awards.

On behalf of the planning committee, I welcome you to Ocean Optics XX and Alaska!

Sincerely,

Heidi Dierssen

Chairperson, Ocean Optics XX Planning Committee

2010 Jerlov Award



Awarded in Recognition of Contribution Made to the Advancement of Our Knowledge of the Nature and Consequences of Light in the Ocean

Nils Gunnar Jerlov was an early leader in the area of ocean optics research. His name is recognized widely within the entire international oceanographic research community. Jerlov's theoretical and experimental work on ocean optical and related processes helped form the foundation of modern ocean optical research. He proposed the concept of an optical ocean water mass classification and the Jerlov water types are familiar to many outside of the ocean optics community. His book, *Marine Optics*, published in 1976, remains widely referenced and is considered required reading for all students of ocean optics and ocean color remote sensing.

The Oceanography Society (TOS) commemorates Dr. Jerlov and his many contributions to the study of light in the ocean with an international award, established in his name, to recognize outstanding achievements in ocean optics and ocean color remote sensing research.

TOS is responsible for setting award policy, garnering nominations from the international research community, and selecting a recipient from those nominated. To be eligible for nomination, the recipient's work must deal directly with the processes governing the interaction of light with the ocean and/or the

consequences of such interactions. The award may be issued in recognition of research (theoretical or applied, field-based or laboratory-based, a landmark paper or lifetime achievement), a pattern of excellence in education, a history of service to the international ocean optics research community, or contributions to all of the above. In the end, the nominated individual must have significantly advanced our knowledge of how light interacts with the ocean.

The award consists of a bronze medallion designed by Judith Munk, a lapel pin, travel support to attend the Ocean Optics Conference, and a cash award.

2010 Recipient

Plankton Research & Instruments and Bigelow Laboratory for Ocean Sciences

The Oceanography Society is pleased to announce that Charles S. Yentsch has been named the 2010 recipient of the Jerlov Award for his enduring, pioneering work on phytoplankton, their optical properties and productivity, which ultimately gave rise to the field of Ocean Color Remote Sensing. He is also recognized for his founding of new oceanographic institutions, nurturing of future leaders in the field, and providing a vibrant research environment for the study of Bio-Optics.



Charlie Yentsch

Trying to be an Optical Oceanographer – Short Bio

My childhood, into young adult years, was spent intrigued by the marine fossils captured in the ancient sea limestone of the Kentucky hillside and diving for abalone off the California coast near Redondo Beach. Then came WWII; I served and received the GI Bill for Education.

Looking back, I first became interested in biological optics when I was in graduate school in marine biology at Florida State University in Tallahassee and later at the Department of Oceanography at the University of Washington in Seattle and Friday Harbor. Looking for a more formal training in oceanography, I applied and was accepted as a doctoral candidate in the UW Department of Oceanography.

My Florida State University experience was under the direction of phycologist and naturalist Harold Humm. Fellow students were George Grice and Sylvia Earle who both helped me gain knowledge of the

marine ecology of Florida. When I entered the UW program I began to realize how underprepared I was in the physics, chemistry and the mathematics required for understanding classical oceanography. Fortunately I had a gentle entrance under Dick Fleming who had asked me to be responsible for the plankton-productivity effort for a salmon migration study. This involved light/dark bottle measurements of oxygen change, chlorophyll, and light scatter among other parameters. The stations were located throughout the Gulf of Alaska thus rough seas most of the time. Bottles of preserved specimens began to accumulate. I began to question my career choice. Back on campus my class work and my attitude improved, largely due to a course given by Wayne Burt. In short, he explained radiative transfer using a blackboard and a Beckman DU spectrophotometer, the instrument that would become my workhorse for the measurement of chlorophyll.

Shortly thereafter Francis Richards who was visiting UW from Woods Hole Oceanographic Institution, offered me a job at WHOI. I thoughtfully gazed up at the jars of withered plankton and said "yes!"

At the time WHOI was nothing like a university. It functioned more like a club with specific duties of membership. Once I moved to WHOI Bill Richardson stepped into my lab while I was working on an old flying spot galvanometer hooked up with a photovoltaic cell. Bill, having skills in optics, helped me build a fluorometer for measuring small amounts of chlorophyll --which was eventually replaced by the Turner series. Fluorometric chlorophyll is somewhat a standard in oceanographic labs, research vessels and ocean sensors. At the dock was the backbone: the research vessels *Atlantis*, *Chain*, and the *Crawford*. Most of the members spent considerable time at sea. I was too shy to ask who was financially supporting all of this, yet I did wonder who was paying my salary?

My first insight was in a harborside hangout with Fritz Fuglister, Val Worthington and Columbus Iselin, then director. Our getting together was an after-work ritual. In an informal discussion, Columbus informed me that I should stop seeking NSF support as this created an imbalance to the institution's budget. I was perplexed. After Columbus left on the ferry to go to his home on the Vineyard, I asked Fritz what he had meant by that comment. He did not know, but after a bit he related that Columbus was an ONR Code #2196 man and that the institution was run almost entirely by monies from the US Navy.

Things began to change. Grants and contracts gained an important role in the support of research at WHOI. The emphasis tended to erode the old communal interdisciplinary framework that characterized the early institution. I don't mean to single out WHOI – this restructure occurred to all the major oceanographic centers. Strangely only a few featured Ocean Optics. It took the launching of the ocean color satellite sensor to change this. Why? The broad answer was that the academic power in the ocean sciences was traditionally held by physical oceanographers. Hence the role of ocean color in ocean science was never clear. The best optical techniques were developed by the Danish scientists led by N. Jerlov, G. Kullenberg and N. Hoerslev.

In my opinion the closest US Laboratory to the Danish group was the Scripps Institution of Oceanography with Gif Ewing and the Visibility Laboratory led by S. Duntley with colleagues R. Austin, K. Baker, T. Petzold, R. Smith, J. Tyler and K. Voss. It was a sad day when upon the closing of this laboratory at Point Loma the university reported that the lab had to be closed because it did not fit into the university strategy.

When I left Woods Hole I vowed to set up a laboratory environment where people had the freedom to pursue the research questions as they wished. This eventually gave rise to the Bigelow Laboratory for Ocean Sciences in Maine. I'm proud to claim that at Bigelow I have had day-to-day colleagues such as S. Ackleson, W. Balch, J. W. Campbell, J. Cullen, J. Goes, R. Guillard, P. Holligan, P. Matrai, C. Mazel, D. Phinney, M. Sieracki, R. Spinrad and C. M. Yentsch.

With the advent of the satellite, the big question was and remains today, how do we resolve the time and space dilemma of sampling properties of the world's ocean including optical processes? Yet how different things are today. Everyone is running on all cylinders in the proposal/grant/reporting cycle just to keep funded. Students enter graduate school as co-authors on peer-reviewed publications and in some cases they have written proposals to grant and contract agencies for their graduate school funding; others undertake student loans. Hopefully the joys of doing good science will somehow persevere.

Previous Jerlov Award Recipients

- 2008: **Talbot Waterman**, Yale University
- 2006: **J. Ronald V. Zaneveld**, Oregon State University
- 2004: **Howard R. Gordon**, University of Miami
- 2002: **Raymond C. Smith**, University of California, Santa Barbara
- 2000: **André Morel**, Université Pierre et Marie Curie



<http://www.argans.co.uk/>
Email: enquiries@argans.co.uk

ARGANS Ltd.
Tamar Science Park
Plymouth
Devon
PL6 8BY

Activities, including funding from the European Space Agency (ESA), include:

Sentinel-3: To be launched in 2013, Sentinel-3 will be devoted to operational oceanography and monitoring the earth. ARGANS leads a consortium developing the products and prototype processing software for the OLCI and SLSTR instruments.

Water Radiance: Ocean colour algorithm development and optical modelling; making use of the new Sentinel-3 spectral bands.

Radiative Transfer Modelling:
Coupled atmosphere-ocean, polarisation, fast inversion with uncertainty propagation, spatial and three-dimensional radiative transfer, aquatic and terrestrial photosynthetic canopies, particle scattering.



ESA—P. Carril



MERIS Coastal: Leading a project to develop the MERIS Bright Pixel Atmosphere Correction, including conducting laboratory analyses and fieldwork to quantify the near infra-red optical signal.

MERIS Calibration and Validation: Close collaboration with European expert scientists for tools development (e.g. MERIS Match-up database), assessment and quality control of scientific products.

SPPA (Sensor Performance Product Assessment): Investigation of failures and anomalies found in Landsat, MERIS, MODIS and SeaWiFS products processed by ESA, and provision of advice on their technical status.



ARGANS Ltd welcomes CV's from potential employees.
We also collaborate strongly with external consultants and wish to make contact.



2010 Awards Banquet

The Awards Banquet dinner will be held on Thursday evening, between the hours of 1900h and 2200h. The location is the ballroom at the Captain Cook Hotel. All Ocean Optics Registrants are entitled to attend the Awards Banquet. Additional Guest tickets may be purchased in advance prior to the close of the conference day on Tuesday.

There will be an after dinner dance for all participants. Music will be provided by "Chill Factor"!

Invited Speaker

The Awards Banquet Invited Talk will be presented by John Weller, entitled "The Extreme Ice Survey"



John Weller started working on The Last Ocean with David Ainley in 2004. Since then he has worked full time on the project, wearing many different hats – strategist, grant writer, fundraiser, organizer, graphic designer, and finally, photographer. Weller was recently awarded a 2009 Pew Fellowship in Marine Conservation, which will support further development of the project.

John is a nature photographer and writer based in Boulder, Colorado. He was trained in economics and philosophy at Stanford University, and has been photographing professionally since 1999. His work has been shown in prestigious museums and galleries, and is part of private and corporate collections across the world. He has had more than 20 one-man photography shows since 1999, and his work has been published in magazines including Outdoor Photographer, American Photo, Rangefinder Magazine, and National Geographic.

Weller’s highly acclaimed first book of photography and essays, Great Sand Dunes National Park: Between Light and Shadow, was published in 2004. Reviewers said, “With this moving, haunting, informative and beautiful book, John Weller has become not just the Ansel Adams, but also the Edward Abbey, of the Great Sand Dunes.” –Clay Evans, Boulder Daily Camera Book Review

Major Breakthroughs Demand Complete Solutions



SATLANTIC

YOUR PARTNER IN RESEARCH

Satlantic develops precision optical and chemical sensors and systems for the investigation of aquatic environments. Our instruments are designed by scientists for scientists, and have been proven in the world's harshest climates. Our custom design capabilities enable us to provide our clients with the ideal solution package, backed by a highly responsive customer support team.

**RADIOMETRIC
SENSORS
AND SYSTEMS**

**CUSTOMER
SERVICE**

**OBSERVING
SYSTEMS**

**CHLOROPHYLL
FLUORESCENCE**

**CHEMICAL FREE
NITRATE SYSTEMS**



SATLANTIC INCORPORATED | +1.902.492.4780 | info@satlantic.com | satlantic.com

Monday, September 27, 2010

0800 – 1710 Registration Open

1000 Exhibits Open

0830 – 0900 OPENING REMARKS & Transfer of Speaking Bell - ESA Representative, Paula Bontempi,
TOS Representative

Organismal Response to Light Field

Chairperson: Sumit Chakraborty

0900 – 0920 Cummings, Molly Elizabeth; Maginnis, Tara; Gilerson, Alexander; Tonizzo, Alberto; Ahmed, Samir; Holt, Joan; Kline, Rick; Brady, Parrish - POLARIZED CAMOUFLAGE IN MARINE FISH — WHO DOES IT?

0920 – 0940 Gao, Meng; You, Yu; Dagach, Sergio; Kattawar, George W. - UNDERSTANDING CEPHALOPOD CAMOUFLAGE BY THE USE OF A NOVEL 3D VECTOR RADIATIVE TRANSFER CODE

0940 – 1000 Talapatra, Siddharth; Nayak, Aditya Ramakrishna; Zhang, Cao; Hong, Jiarong; Katz, Joseph; Twardowski, Michael; Sullivan, James; Donaghay, Percy - CHARACTERIZATION OF ORGANISMS, PARTICLES, AND BUBBLES IN THE WATER COLUMN USING A FREE-DRIFTING, SUBMERSIBLE, DIGITAL HOLOGRAPHY SYSTEM

10:00-1020 Break

Radiative Transfer/Atmospheric Correction

Chairperson: Malik Chami

1020 – 1040 Chowdhary, Jacek; Cairns, Brian; Ottaviani, Matteo; Mishchenko, Michael - NATURAL VARIATION OF POLARIZED WATER-LEAVING RADIANCE WITH CDOM: SIMULATIONS AND OBSERVATIONS FOR THE OPEN OCEAN

1040 – 1100 Wang, Menghua; Shi, Wei - THE SWIR-BASED ON-ORBIT VICARIOUS CALIBRATION APPROACH FOR MODIS OCEAN COLOR DATA PROCESSING

1100 – 1120 Kay, Susan; Hedley, John; Lavender, Samantha - MODELLING THE BEHAVIOUR OF LIGHT AT THE ATMOSPHERE-OCEAN BOUNDARY – AN APPROACH USING HIGH-RESOLUTION SEA SURFACE REALIZATIONS

1120 – 1140 Jamet, Cédric; Loisel, Hubert; Ruddick, Kevin; Zibordi, Giuseppe; Feng, Hui; Kuchinke, Christopher - COMPARISON OF THREE SEAWIFS ATMOSPHERIC CORRECTION ALGORITHMS IN TURBID WATERS FROM AERONET-OC MEASUREMENTS

1140 – 1200 Zege, Eleonora; Katsev, Iosif; Prikhach, Alexander; Mullen, Linda; Cochenour, Brandon - MODULATING RETRO-REFLECTOR LINKS IN SEAWATERS

1200 – 1330 Lunch Break

Near Surface Processes

Chairperson: Helen Czerski

1330 – 1350 Lewis, Marlon R.; Van Dommelen, Ronnie; Wei, Jianwei; Voss, Kenneth - THE UNDERWATER RADIANCE DISTRIBUTION

1350 – 1410 Randolph, Kaylan; Dierssen, Heidi; Twardowski, Michael; Zappa, Christopher; Cifuentes-Lorenzen, Alejandro; Freeman, Scott - OPTICAL MEASUREMENTS OF BUBBLE POPULATIONS DURING LARGE SCALE WAVE BREAKING IN THE SOUTHERN OCEAN AND THEIR SIGNIFICANCE TO REMOTE SENSING REFLECTANCE

1410 – 1430 Gernez, Pierre; Stramski, Dariusz; Darecki, Mirosław - VERTICAL CHANGES IN THE PROBABILITY DISTRIBUTION OF DOWNWELLING IRRADIANCE WITHIN THE NEAR-SURFACE OCEAN LAYER UNDER CLEAR SKY CONDITIONS

1430 – 1450 Twardowski, Michael; Zhang, Xiaodong; Freeman, Scott; Slivkoff, Matthew; Sullivan, James; Czerski, Helen; Vagle, Svein; You, Yu; Kattawar, George - INVERTING THE VOLUME SCATTERING FUNCTION TO INFER PARTICLE COMPOSITION AND DYNAMICS AT THE NEAR-SURFACE IN THE SURF ZONE AND OPEN OCEAN

1450 – 1510 You, Yu; Kattawar, George W. - MODELING DYNAMIC UNDERWATER POLARIZED RADIANCE FIELDS USING WAVE SLOPES AND IOPS FROM RADYU FIELD EXPERIMENTS

1510 – 1530 Voss, Kenneth; Kattawar, George; You, Yu; Gordon, Howard; Gleason, Arthur - DISCOVERY OF NON-PRINCIPAL-PLANE NEUTRAL POINTS IN THE IN-WATER UPWELLING POLARIZED LIGHT FIELD

15:30 – 16:00 Break

Invited Lectures

Chairperson: Grace Chang

1600 – 1640 Fournier, Georges - POLARIZATION IN SCATTERING

1640 – 1720 Hanlon, Roger T. - OPTICAL MAGIC: HOW CEPHALOPODS SENSE AND MANIPULATE LIGHT TO PRODUCE RAPID ADAPTIVE CAMOUFLAGE AND COMMUNICATION

Poster Session #1

17:30 - 19:00

Atmosphere/Radiative Transfer

1. Wang, Menghua; Shi, Wei - THE SWIR-BASED ON-ORBIT VICARIOUS CALIBRATION APPROACH FOR MODIS OCEAN COLOR DATA PROCESSING
4. Stamnes, Snorre; Stamnes, Knut; Hamre, Børge; Stamnes, Jakob - RADIATIVE TRANSFER IN THE COUPLED ATMOSPHERE-OCEAN SYSTEM: A VERSATILE MODEL BASED ON THE DISCRETE-ORDINATE METHOD
7. Babin, Marcel; Mazeran, Constant - A NEW NIR-VISIBLE ALGORITHM FOR ATMOSPHERIC CORRECTIONS OVER TURBID WATERS
10. Kay, Susan; Hedley, John; Lavender, Samantha - MODELLING THE BEHAVIOUR OF LIGHT AT THE ATMOSPHERE-OCEAN BOUNDARY – AN APPROACH USING HIGH-RESOLUTION SEA SURFACE REALIZATIONS
13. Zdun, Agnieszka; Rozwadowska, Anna - IMPACT OF AIR MASS ON AEROSOL OPTICAL PROPERTIES OVER THE BALTIC SEA
16. He, Xianqiang - ASSESSMENT OF THE AEROSOL MODELS FOR SEAWIFS AND MODIS BY AERONET DATA

19. Mobley, Curtis; Sundman, Lydia; Bissett, Paul; Cahill, Bronwyn - FAST AND ACCURATE LIGHT CALCULATIONS FOR COUPLED PHYSICAL-BIOLOGICAL-OPTICAL ECOSYSTEM MODELS

Bio-optics and Biogeochemistry

22. Wojtasiewicz, Bozena; Stramski, Dariusz - CHLOROPHYLL-SPECIFIC ABSORPTION AND SCATTERING COEFFICIENTS OF SELECTED CYANOBACTERIA
25. Kuwahara, Victor; Nakajima, Ryota; Othman, B. H. R.; Kushairi, M. R. M.; Toda, Tatsuki - GEOGRAPHICAL VARIABILITY OF UVR AND ITS RELATIONSHIP TO CORAL REEF COMMUNITIES AROUND THE MALAYSIAN PENINSULA
28. Shen, Fang; Zhou, Yunxuan; Hong, Guanlin - ABSORPTION CHARACTERISTICS OF NON-ALGAL PARTICLES IN HIGHLY TURBID WATERS OF THE YANGTZE RIVER ESTUARY AND ADJACENT COAST, CHINA
31. Gilerson, Alexander; Gitelson, Anatoly; Zhou, Jing; Gurlin, Daniela; Moses, Wesley; Ioannou, Ioannis; Ahmed, Samir - REMOTE SENSING ALGORITHMS FOR THE ESTIMATION OF CHLOROPHYLL-A IN COASTAL WATERS USING RED AND NEAR INFRARED BANDS
34. Shanmugam, Palanisamy; Sundarabalan, Balasubramanian; Ahn, Yu-Hwan; Ryu, Joo-Hyung - RETRIEVAL OF PARTICULATE BACKSCATTERING IN COASTAL/OCEANIC WATERS
40. Slade, Jr., Wayne Homer; Boss, Emmanuel - SPECTRAL ATTENUATION AND BACKSCATTERING AS INDICATORS OF PARTICLE SIZE DISTRIBUTION
43. Woźniak, Sławomir B.; Meler, Justyna; Lednicka, Barbara; Zdun, Agnieszka; Stoń-Egiert, Joanna - OPTICAL AND BIOGEOCHEMICAL PROPERTIES OF SUSPENDED PARTICULATE MATTER IN THE SOUTHERN BALTIC SEA
46. Theis, Anja; Schmitt, Bettina; Bracher, Astrid - BIO-OPTICAL MEASUREMENTS IN ATLANTIC OPEN OCEAN WATERS FOR SATELLITE VALIDATION
49. Trees, Charles; McLean, S. D.; Lewis, M. R.; Zibordi, Giuseppe. - MULTI-CAST MEASUREMENT PROTOCOLS FOR IMPROVING NEAR SURFACE RADIOMETRIC DATA
52. Naik, Puneeta; D'Sa, Eurico J; Goes, Joaquim I; Gomes, Helga do R.- MODELING PARTICULATE ABSORPTION PROPERTIES IN THE SOUTHEASTERN BERING SEA
55. Motokawa, Shozo; Toda, Tatsuki; Kikuchi, Tomohiko; Taguchi, Satoru - VARIABILITY IN THE SIZE-FRACTIONATED ABSORPTION COEFFICIENTS OF WATER COLUMN IN COASTAL WATER
58. Cunningham, Alex - OPTICAL SIGNIFICANCE OF BIOGENIC MINERALS IN SHELF SEAS
61. Dogliotti, Ana I.; Segura, Valeria; Lutz, Vivian A.- PRIMARY PRODUCTION IN THE PATAGONIAN CONTINENTAL SHELF AND SHELF-BREAK REGION: IMPROVED ESTIMATION USING SATELLITE-BASED MODELS
64. Conmy, Robyn; Schaeffer, Blake A; Lehrter, John C; Aukamp, Jessica; Daniels, Kathleen; Craven, George - CHARACTERIZING INHERENT OPTICAL PROPERTIES WITHIN NORTHWESTERN FLORIDA ESTUARIES: A LOOK AT THE FORGOTTEN AND EMERALD COASTS
67. Röttgers, Rüdiger; McKee, David - EVALUATION OF *IN SITU* ABSORPTION MEASUREMENTS IN COASTAL WATERS

70. Powers, Leanne; Fichot, Cedric; Miller, William - DEPTH RESOLVED RATES OF PHOTOCHEMICAL CARBON MONOXIDE PRODUCTION IN THE GULF OF MEXICO, A RIVER-DOMINATED COASTAL MARGIN
73. Hilting, Anna K.; Currin, Carolyn A.; Gallegos, Charles L.- LIGHT AVAILABILITY ALONG A WATER QUALITY GRADIENT IN A SHALLOW ESTUARY: PATTERNS, RELATIONSHIPS, AND POTENTIAL IMPLICATIONS
76. Balch, William - INSIGHTS FROM THE GULF OF MAINE NORTH ATLANTIC TIME SERIES (GNATS)- AN OPTICAL WINDOW INTO THE CHANGING BIOGEOCHEMISTRY OF THE COASTAL OCEAN
79. Slivkoff, Matthew; Klonowski, Wojciech; Twardowski, Michael; Freeman, Scott - DETERMINING THE NEAR FORWARD VOLUME SCATTERING FUNCTION FROM THE LISST-100X PARTICLE SIZE ANALYZER
82. Schwarz, Jill N; Pinkerton, Matt H; Gall, Mark; Maas, Els; Safi, Karl; Chang, Hoe; van Kooten, Marieke; Thompson, Karen; Wood, Simon; Cunningham, Chris - SEEKING CONNECTIONS BETWEEN HIGHER SPECTRAL RESOLUTION SHIP-BORNE RADIOMETRY AND SURFACE BIOGEOCHEMISTRY
85. Perry, Mary Jane; Briggs, Nathan; Cetinic, Ivona; D'Asaro, Eric; Lee, Craig M.; Sieracki, Michael E - THE CARBON TO CHLOROPHYLL RATIO IN THE OCEAN: DO CHANGES IN THE RATIO REFLECT CHANGING PHYSIOLOGY, COMMUNITY STRUCTURE, OR BOTH?
88. Oubelkheir, Kadija; Steven, Andrew D.L.; Ford, Phillip W.; Clementson, Lesley A. - BIO-OPTICAL AND BIOGEOCHEMICAL DYNAMICS OF A SUB-TROPICAL ESTUARY IN SOUTH-EAST QUEENSLAND, AUSTRALIA
91. Courtemanche, Bruno; Huot, Yannick - EXAMINING SVERDRUP'S HYPOTHESIS USING SATELLITE OCEAN COLOR AND THE ARGO PROFILING FLOATS
- Remote Sensing**
94. Ryu, Joo-Hyung; Moon, Jeong Eon; Son, Young Baek; Ahn, Yu-Hwan - PRELAUNCH STUDY OF CAL/VAL FOR GEOSTATIONARY OCEAN COLOR IMAGER
97. Zhang, Xiangguang; Asanuma, Ichio; Cao, Nan; Zhao, Chaofang; Huang, Bangqin - A NEW BIO-OPTICAL ALGORITHM FOR ESTIMATING COLORED DISSOLVED ORGANIC MATTER ABSORPTION IN COASTAL WATERS FROM MODIS DATA
100. Hlaing, Soe; Ahmed, Samir; Gladkova, Irina; Gilerson, Alexander; Grossberg, Michael; Shahriar, Faizul - COMPARISON OF A BIO-OPTICAL ALGORITHM AND A STATISTICALLY BASED APPROACH FOR SATELLITE DETECTIONS OF HARMFUL ALGAL BLOOMS
103. McKinna, Lachlan Ian William; Furnas, Miles; Ridd, Peter; Everingham, Yvette; Slivkoff, Matthew - INVERSION OF HYPERSPECTRAL REMOTE SENSING REFLECTANCE FOR QUANTITATIVE DETECTION OF TRICHODESMIUM SPP. WITHIN THE GREAT BARRIER REEF
106. Raymaekers, Dries; Knaeps, Els; Sterckx, Sindy; Tote, Carolien; Odermatt, Daniel - IMPROVING ACCURACY OF WATER QUALITY MONITORING IN CASE-II WATERS BY WAVELET TRANSFORMATION
109. Hill, Victoria; Zimmerman, Richard; Bissett, Paul - QUANTIFYING THE ABUNDANCE OF SUBMERGED AQUATIC VEGETATION IN NEARSHORE COASTAL ENVIRONMENTS WITH THE BROADBAND MULTISPECTRAL SENSOR, WORLDVIEW 2
112. Hochberg, Eric J - IMPACT OF GLINT ON HYSPIRI AQUATIC SCIENCE OBJECTIVES

115. Bai, Yan - REMOTE SENSING OF SALINITY IN CHANGJIANG PLUME BY MODIS DATA
118. Maritorena, Stéphane; Siegel, David A.; Nelson, Norm B.; Frew, James; Behrenfeld, Michael J.; Kostadinov, Tihomir; Bonhommeau, Sylvain; NASA, OBPB - THE OCEAN COLOR MEASURES PROJECT: CURRENT AND FUTURE PRODUCTS
121. Tuffillaro, Nicholas; Davis, Curtiss O; Jones, Katherine B.- DERIVATIVE SIGNATURES OF PLUMES FROM MERIS AND HICO
124. Aurin, Dirk; Dierssen, Heidi - APPLICATIONS OF NEW REGIONAL OCEAN COLOR REMOTE SENSING ALGORITHMS IN AN URBANIZED ESTUARY; TSM TRANSPORT DURING RECORD 2010 NEW ENGLAND FLOODS AND LINKS TO LAND USE
127. Hirata, Takafumi; Brewin, Bob; Hardman-Mountford, Nick; Smyth, Tim; Hirawake, Toru; Saitoh, Sei-Ichi; Ishizaka, Joji; Toratani, Mitsuhiro; Murakami, Hiroshi - NEW CHALLENGES IN SATELLITE RETRIEVALS OF MARINE PRODUCTS UNDER GLOBAL CLIMATE OBSERVATION MISSION
130. Vellucci, Vincenzo; Gentili, Bernard; Diamond, Emilie; Adams, Darrell; Dempsey, Cyril; Antoine, David - EVALUATION OF HYPERSPECTRAL RADIOMETRY FROM THE BOUSSOLE BUOY
133. Mao, Zhihua - RELATIONSHIP BETWEEN SUSPENDED SEDIMENT CONCENTRATION AND REMOTELY SENSED REFLECTANCE
136. Fanton d'Andon, Odile; Garnesson, Philippe; Gilles, Nicolas; Demaria, Julien; Sardou, Olivier; Mazeran, Constant; Lerebourg, Christophe; Barrot, Gilbert; Bourg, Ludovic; Goryl, Philippe; Laur, Henri ODESA: THE OPTICAL DATA PROCESSOR OF ESA
139. Frouin, Robert; Deschamps, Pierre-Yves; Dubuisson, Philippe - ESTIMATING CHLOROPHYLL FLUORESCENCE BY DIFFERENTIAL ABSORPTION IN THE OXYGEN B-BAND
142. Wang, Lin; Zhao, Dongzhi; Yang, Jianhong; Chen, Yanlong - RETRIEVAL OF TOTAL SUSPENDED MATTER FROM MODIS TERRA 250 M IMAGERY IN THE BOHAI SEA OF CHINA
145. Kanitz, Thomas; Althausen, Dietrich; Engelmann, Ronny; Baars, Holger; Macke, Andreas - MULTIWAVELENGTH RAMAN AEROSOL OBSERVATIONS OF SAHARAN AND PATAGONIAN DUST ABOARD THE RESEARCH VESSEL POLARSTERN DURING ITS MERIDIONAL CRUISE ANT-26/1
148. Dekker, Arnold Graham; Phinn, Stuart R.; Anstee, Janet M.; Bissett, Paul; Brando, Vittorio E.; Casey, B.; Fearn, Peter; Hedley, John; Klonowski, Wojciech; Lee, ZhongPing; Lynch, Mervyn; Lyons, Mitchell; Mobley, Curtis; Roelfsema, Chris - MULTIPLE OPTICAL SHALLOW WATER INVERSION METHODS FOR BATHYMETRY, IN-WATER OPTICS, AND BENTHOS MAPPING: HOW DO THEY COMPARE?
151. Craig, Susanne Elizabeth; Jones, Chris T.; Cullen, John J.; Li, William K.W.; Lazin, Gordana; Horne, Edward; Caverhill, Carla - DERIVING OPTICAL METRICS OF ECOLOGICAL VARIABILITY FROM A COASTAL OCEAN OBSERVATION PROGRAM
154. Bracher, Astrid; Sadeghi, Alireza; Dinter, Tilman; Schmitt, Bettina; Vountas, Marco; Röttgers, Rüdiger; Peeken, Ilka; Ye, Ying - PHYTOPLANKTON GROUPS FROM SPACE USING PHYTODOAS: IMPROVEMENTS BY MULTI-TARGET FITTING, YEARLY DATA SET, VALIDATION AND FIRST APPLICATION

157. Nechad, Bouchra; Ruddick, Kevin; Neukermans, Griet - REMOTE SENSING OF THE DIFFUSE ATTENUATION COEFFICIENT AND RELATED PARAMETERS IN TURBID WATERS: STATE OF THE ART AND FUTURE PERSPECTIVES

160. Marrable, Daniel Stephen; Fearn, Peter; Lynch, Mervyn; Klonowski, Wojciech - SPECTRAL ANALYSIS OF ESTUARINE WATER FOR CHARACTERISATION OF INHERENT OPTICAL PROPERTIES AND PHYTOPLANKTON CLASSIFICATION

Optics of Oil in Coastal Waters

163. Yao, Haibo - OIL SPECTRAL CHARACTERISTICS WITH HIGH RESOLUTION IMAGING SPECTROMETER - A CASE STUDY OF OIL FROM DEEP WATER HORIZON

166. Coble, Paula; Hu, Chuanmin; Ivey, James; Kovach, Charles; Cannizzaro, Jennifer; English, David; Arellano, Ana; Barnes, Brian; Peebles, Ernst - OPTICAL PROPERTIES OF DISPERSED AND NON-DISPERSED OIL IN THE GULF OF MEXICO IN THE AFTERMATH OF THE DEEPWATER HORIZON BLOWOUT

Near Surface Optics

169. Voss, Kenneth; Kattawar, George; You, Yu; Gordon, Howard; Gleason, Arthur - DISCOVERY OF NON-PRINCIPAL-PLANE NEUTRAL POINTS IN THE IN-WATER UPWELLING POLARIZED LIGHT FIELD

172. Lewis, Marlon R.; Van Dommelen, Ronnie; Wei, Jianwei; Voss, Kenneth - THE UNDERWATER RADIANCE DISTRIBUTION

175. Gould, Richard W.; Lewis, M. David; Smith, Regina D.; Ko, Dong S.- MAPPING COASTAL HYPOXIA IN THE NORTHERN GULF OF MEXICO WITH OCEAN COLOR IMAGERY

178. Bélanger, Simon; Ehn, Jens; Raimbault, Patrick; Leymarie, Edouard; Doxaran, David; Hooker, Stan; Babin, Marcel - ON THE ROLE OF SEA ICE MELTING ON NEAR-SURFACE VERTICAL VARIABILITY OF PARTICULATE ABSORPTION COEFFICIENT IN THE ARCTIC OCEAN

181. Hieronimi, Martin; Macke, Andreas - MONTE CARLO RADIATIVE TRANSFER SIMULATIONS ON THE INFLUENCE OF SURFACE WAVES ON UNDERWATER LIGHT FIELDS

184. Randolph, Kaylan; Dierssen, Heidi; Twardowski, Michael; Zappa, Christopher; Cifuentes-Lorenzen, Alejandro; Freeman, Scott - OPTICAL MEASUREMENTS OF BUBBLE POPULATIONS DURING LARGE SCALE WAVE BREAKING IN THE SOUTHERN OCEAN AND THEIR SIGNIFICANCE TO REMOTE SENSING REFLECTANCE

187. van Dijk, Mark Albert; Hoogveld, Hans L; Simis, Stefan G. H.; Kromkamp, Jacco C.; Gons, Herman J - SPECIFIC ABSORPTION SIGNATURES OF TAXONOMIC SUBPOPULATIONS IN PHYTOPLANKTON COMMUNITIES

Use of Historical Optical Observations Instrumentation and Platforms

190. Kim, Hyun-cheol; Ahn, Yu-Hwan.; Moon, Jeong Eon; Park, B.K.. - LATE SPRING BIO-OPTICAL FEATURES AROUND SVALBARD, ARCTIC SEA

193. Chekalyuk, Alexander - ADVANCED LASER FLUOROMETRY (ALF): NEW INSTRUMENTS, PLATFORMS AND FIELD OBSERVATIONS

196. Roughan, Moninya; Morris, Bradley D.; Doblin, Martina; Baird, Mark; Suthers, Iain - OCEAN OPTICS WITHIN NSW-IMOS: AN INTEGRATED MARINE OBSERVING SYSTEM FOR THE COAST OF SOUTHEASTERN AUSTRALIA.

199. Cone, Michael Thomas; Lu, Zheng; Fry, Edward - EASURING THE ABSORPTION COEFFICIENT OF PURE WATER IN THE UV USING AN INTEGRATING CAVITY ABSORPTION METER

202. Leymarie, Edouard; Antoine, David; Morel, André; Buis, Jean-Pierre; Buis, Nicolas; Victori, Stephane; Meunier, Sylvain; Canini, Marius; Houyou, Amel; Fougne, Bertrand; Henry, Patrice - MEASUREMENT OF THE UNDERWATER RADIANCE DISTRIBUTION: FIRST RESULTS FROM A NEW RADIANCE CAMERA
205. Crawford, Jim - A NEW LOW COST, MULTISPECTRAL IN-SITU ABSORBANCE INSTRUMENT
208. McKee, David; Piskozub, Jacek; Röttgers, Rüdiger; Reynolds, Rick - EVALUATION OF AN ITERATIVE SCATTERING CORRECTION SCHEME FOR *IN SITU* ABSORPTION AND ATTENUATION MEASUREMENTS BASED ON MONTE CARLO MODELLING
211. Gainusa-Bogdan, Alina; Boss, Emmanuel - A NOVEL CONCEPT FOR MEASURING SEAWATER INHERENT OPTICAL PROPERTIES IN AND OUT OF THE WATER
214. Alley, Derek Michael; Mullen, Linda; Laux, Alan; McBride, Walton - EXTENDED RANGE, NON-LINE-OF-SIGHT (NLOS) UNDERWATER IMAGING USING A TIME VARYING INTENSITY (TVI) APPROACH

Organismal Response and Adaptation to the Light Field

217. Chakraborty, Sumit; Lohrenz, Steven - PHYTOPLANKTON TYPES AND ABSORPTION PROPERTIES IN THE VICINITY OF MISSISSIPPI RIVER DURING AUTUMN AND SPRING OF 2005-06.
220. Gao, Meng; You, Yu; Dagach, Sergio; Kattawar, George W. - UNDERSTANDING CEPHALOPOD CAMOUFLAGE BY THE USE OF A NOVEL 3D VECTOR RADIATIVE TRANSFER CODE
223. Cummings, Molly Elizabeth; Maginnis, Tara; Gilerson, Alexander; Tonizzo, Alberto; Ahmed, Samir; Holt, Joan; Kline, Rick; Brady, Parrish - POLARIZED CAMOUFLAGE IN MARINE FISH — WHO DOES IT?
226. Obata, Mitsuko; Taguchi, Satoru - PHOTOACCLIMATION STRATEGY OF PHOTOSYSTEM II REACTION CENTER IN PRIMNESIOPHYCEAE ISOCHRYSIS GALBANA AS EVALUATED BY VARIABLE CHLOROPHYLL FLUORESCENCE

Invited Speakers

229. Alvain, Severine - LATEST NEWS ON REMOTE SENSING OF PHYTOPLANKTON FUNCTIONAL GROUPS: WHAT WE CAN DO NOW AND WHAT CAN WE EXPECT IN THE FUTURE?

Tuesday, September 28, 2010

Bio-optics North

Chairperson: Xiaodong Zhang

- 0800 – 0820 Cullen, John; Fennel, Katja - MODELING THE DYNAMICS OF OPTICAL PROPERTIES IN THE OCEAN, DIRECTLY AND MECHANISTICALLY
- 0820 – 0840 Estapa, Margaret L - MASS-SPECIFIC ABSORPTION BY SUSPENDED SEDIMENTS IN COASTAL LOUISIANA: CONNECTIONS TO PARTICLE COMPOSITION AND OCEAN COLOR
- 0840 – 0900 Perry, Mary Jane; Briggs, Nathan; Cetinic, Ivona; D'Asaro, Eric; Lee, Craig M.; Sieracki, Michael E. - THE CARBON TO CHLOROPHYLL RATIO IN THE OCEAN: DO CHANGES IN

THE RATIO REFLECT CHANGING PHYSIOLOGY, COMMUNITY STRUCTURE, OR BOTH?

0900 – 1920 Briggs, Nathan; Cetinic, Ivona; Gray, Amanda; Rehm, Eric; D'Asaro, Eric; Lee, Craig; Perry, Mary Jane - USING SPIKES IN OPTICAL MEASUREMENTS TO TRACK AN AGGREGATE FLUX EVENT FROM AUTONOMOUS PLATFORMS.

0920 – 0940 Matsuoka, Atsushi; Bricaud, Annick; Babin, Marcel - TRACKING THE TRANSPORTATION OF COLORED DISSOLVED ORGANIC MATTERS IN WESTERN ARCTIC WATERS: IMPLICATIONS FOR HYDROGRAPH OF THE ARCTIC OCEAN

0940 – 1000 Fichot, Cedric G; Lohrenz, Steven; Miller, William L.; Benner, Ron - DYNAMICS OF DOM OPTICAL PROPERTIES AND CHEMICAL COMPOSITION IN A RIVER-DOMINATED OCEAN MARGIN (NORTHERN GULF OF MEXICO)

1000 – 1020 Break

Bio-optics South

Chairperson: Eric Hochberg

1020 – 1040 Goes, Joaquim Ignacio; Gomes, Helga do Rosario; Matondkar, Prabhu G. Shivaprasad; Thoppil, Prasad G.; Fasullo, John T.; Roesler, Collin M.; Basu, Subhajit; Parab, Sushma G. - EXTENSIVE PHYTOPLANKTON BLOOMS IN THE NORTHERN ARABIAN SEA AND POTENTIAL FEEDBACK EFFECTS

1040 – 1100 Oubelkheir, Kadija; Steven, Andrew D.L.; Ford, Phillip W.; Clementson, Lesley A. - BIO-OPTICAL AND BIOGEOCHEMICAL DYNAMICS OF A SUB-TROPICAL ESTUARY IN SOUTH-EAST QUEENSLAND, AUSTRALIA

1100 – 1120 Segura, Valeria; Lutz, Vivian Alicia; Dogliotti, Ana Ines; Benavides, Hugo Rodolfo; Silva, Ricardo Ismael; Negri, Ruben Mario; Akselman, Rut., - PHYTOPLANKTON FUNCTIONAL TYPES IN THE PATAGONIAN SEA: ACCORDING TO PHOTOSYNTHETICAL AND BIO-OPTICAL CHARACTERISTICS

1120 – 1140 Courtemanche, Bruno; Huot, Yannick - EXAMINING SVERDRUP'S HYPOTHESIS USING SATELLITE OCEAN COLOR AND THE ARGO PROFILING FLOATS

1140 – 1200 Behrenfeld, Michael J. - THE 'CRITICAL DEPTH HYPOTHESIS' VERSUS THE 'DILUTION-RECOUPLING HYPOTHESIS' OF PHYTOPLANKTON BLOOMS

1200h – 1330 LUNCH

13:30-16:00 FREE PERIOD # 1

Invited Lectures

Chairperson: Victor Kuwahara

1600 – 1630 Dickey, Tommy - TOWARD THE UNDERSTANDING AND PREDICTION OF OPTICS NEAR THE OCEAN SURFACE

1700 - 1730 Churnside, James - LIDAR Measurements Along The Food Chain

Poster Session #2

Sponsored by Satlantic Inc.

17:30 - 19:00

Atmosphere/Radiative Transfer

2. Mélin, Frédéric; Clerici, Marco - THE COLORS AND SHADOWS CONTAINED IN DAILY PAR
5. Sanjuan Calzado, Violeta; Chiggiato, Jacopo; Trees, Charles - IMPROVED HEAT FLUXES IN OCEAN CIRCULATION MODELS BY OPTICS
8. Chowdhary, Jacek; Cairns, Brian; Ottaviani, Matteo; Mishchenko, Michael - NATURAL VARIATION OF POLARIZED WATER-LEAVING RADIANCE WITH CDOM: SIMULATIONS AND OBSERVATIONS FOR THE OPEN OCEAN
11. Budak, Vladimir P.; Efremenko, Dmitriy S.; Gilerson, Alexander; Klyuykov, Dmitriy A.; Korkin, Sergey V.; Oshchepkov, Sergey L.; Tonizzo, Alberto; Ahmed, Samir - CIAO: MODEL OF POLARIZATION RADIATION TRANSFER IN ATMOSPHERE – OCEAN SYSTEM
14. Knaeps, Els; Sterckx, Sindy; Ruddick, Kevin - SIMEC, AN ENVIRONMENT CORRECTION FOR MERIS BASED ON THE NIR SIMILARITY SPECTRUM
17. Chami, Malik; Ebert, Kerstin - INFLUENCE OF MULTIPLE SCATTERING ON THE DOWNWELLING IRRADIANCE AND ON THE DIFFUSE ATTENUATION COEFFICIENT IN COASTAL WATERS
20. Sokoletsky, Leonid; Gallegos, Sonia - TOWARDS DEVELOPMENT OF AN IMPROVED TECHNIQUE FOR REMOTELY-SENSED RETRIEVAL OF WATER QUALITY COMPONENTS: AN APPROACH BASED ON THE GORDON'S PARAMETER SPECTRAL RATIO

Bio-optics and Biogeochemistry

23. Doxaran, David; Babin, Marcel; Chami, Malik; Lorthiois, Thomas; Ruddick, Kevin G; McKee, David - VISIBLE AND NEAR-INFRARED SPECTRAL VARIATIONS OF LIGHT BACKSCATTERING BY PARTICLES IN COASTAL WATERS
26. Majchrowski, Roman; Stoń-Egiert, Joanna - VERTICAL ALGAL ACCESSORY PIGMENT DISTRIBUTIONS IN THE BALTIC SEA - PRELIMINARY MATHEMATICAL DESCRIPTION
29. Hargreaves, Bruce R.; Vaidya, Ashma - RIGOROUS CALIBRATION OF AN IMPROVED FILTER PAD METHOD FOR PHYTOPLANKTON SPECTRAL ABSORPTION & APPLICATION TO SOGASEX
32. Shanmugam, Palanisamy - MODIFIED-SEADAS ATMOSPHERIC CORRECTION ALGORITHM TO IMPROVE RETRIEVAL OF SURFACE REFLECTANCE IN CASE 2 WATERS
35. Nubi, Olubunmi Ayoola - MERIDIONAL DISTRIBUTION OF NUTRIENTS IN THE EASTERN EQUATORIAL ATLANTIC – PRELIMINARY STUDIES
38. Frolov, Sergey; Shulman, Igor; Anderson, Stephanie - MULTIVARIATE DATA ASSIMILATION WITH THE MONTEREY BAY COUPLED BIO-OPTICAL, PHYSICAL MODEL
41. Van der Woerd, Hendrik Jan; Eleveld, Marieke A.; Hommersom, Annelies; Peters, Steef W.M. - ERROR ESTIMATES IN CHL, SPM AND CDOM CONCENTRATION RETRIEVAL IN TURBID COASTAL WATER: PERFORMANCE OF A HYDROLIGHT BASED INVERSION SCHEME

44. Kheireddine, Malika; Loisel, Hubert; Mériaux, Xavier; Breton, Elsa; Courcot, Lucie; Houliez, Emilie; Lizon, Fabrice - PHYTOPLANKTON INHERENT OPTICAL PROPERTIES DURING EXPONENTIAL AND STATIONARY GROWTH PHASES
47. Ssebiyonga, Nicolausi; Erga, Svein; Frette, Øyvind; Stamnes, Jakob - MEASUREMENT OF INSTANTANEOUS PHYTOPLANKTON PHOTOSYNTHETIC PARAMETERS IN LAKE VICTORIAN (UGANDA) USING A FLUORESCENCE TECHNIQUE
50. Cao, Fang; Reader, Heather; Miller, William - RETRAINING THE SEAUUV/SEAUVC MODEL FOR IMPROVED ALGORITHM OF DARK, INSHORE WATERS FROM THE GEORGIA COAST, USA
53. Miller, William L. - QUANTIFYING PHOTOCHEMICAL REACTIONS IN THE SURFACE OCEAN WITH OPTICAL MODELS: POTENTIAL PROBLEMS TO PONDER
56. Lee, Sang; Zhao, Jinping; Son, SeungHyun - OPTICAL PROPERTIES AND BIO-OPTICAL ALGORITHMS IN THE NORTHEASTERN BERING SEA IN EARLY SUMMER, 2007
59. Kostadinov, Tihomir Sabinov; Siegel, David A.; Maritorena, Stéphane MULTIPLE-INDEX OPTICAL CHARACTERIZATION OF THE PARTICLE ASSEMBLAGE IN THE SANTA BARBARA CHANNEL, CALIFORNIA
62. Takao, Shintaro; Hirawake, Toru; Suzuki, Koji; Wright, Simon W.; Saitoh, Sei-Ichi - VARIATIONS OF NET PRIMARY PRODUCTIVITY AND PHYTOPLANKTON COMMUNITY COMPOSITION IN THE SOUTHERN OCEAN DURING AUSTRAL SUMMER AS ESTIMATED FROM OCEAN-COLOR REMOTE SENSING DATA
65. Arellano, Ana Rosa; Coble, Paula; Conmy, Robyn - AN INVESTIGATION OF INPUTS OF CARBON, NUTRIENTS, AND GROUNDWATER IN COASTAL FLORIDA USING COLORED DISSOLVED ORGANIC MATTER
68. Berthon, Jean-Francois; Zibordi, Giuseppe; Canuti, Elisabetta; Jankowski, Lukasz - BACK-SCATTERING PROPERTIES OF THE EUROPEAN COASTAL WATERS
71. Toro-Farmer, Gerardo; Boss, Emmanuel; Lee, Craig; Cetinic, Ivona; Jones, Burton - USE OF HYPERSPECTRAL IOP MEASUREMENTS ON A TOWED VEHICLE TO RESOLVE PHYTOPLANKTON AND PARTICLE VARIABILITY IN A TIDALLY DRIVEN ARCHIPELAGO STRAIT
74. Peperzak, Louis; Timmermans, Klaas; Wernand, Marcel; Van der Woerd, Hendrik - *IN SITU* PHYTOPLANKTON DYNAMICS COUPLED WITH APPARENT OPTICAL PROPERTIES IN A NOVEL MESOCOSM FACILITY
77. Wang, Guifen; Cao, Wenxi; Zhou, Wen; Yang, Yuezhong - BIO-OPTICAL PROPERTIES OF SEAWATER IN THE NORTHERN SOUTH CHINA SEA
80. Ehn, Jens; Reynolds, Rick; Bélanger, Simon; Doxaran, David; Matsuoka, Atsushi; Stramski, Dariusz; Babin, Marcel - PARTICLE DISTRIBUTIONS ACROSS THE CANADIAN BEAUFORT SEA CONTINENTAL MARGIN INFERRED FROM *IN SITU* OPTICAL MEASUREMENTS
83. Cullen, John; Fennel, Katja MODELING THE DYNAMICS OF OPTICAL PROPERTIES IN THE OCEAN, DIRECTLY AND MECHANISTICALLY
86. Matsuoka, Atsushi; Bricaud, Annick; Babin, Marcel - TRACKING THE TRANSPORTATION OF COLORED DISSOLVED ORGANIC MATTERS IN WESTERN ARCTIC WATERS: IMPLICATIONS FOR HYDROGRAPH OF THE ARCTIC OCEAN

89. Behrenfeld, Michael J; Boss, Emmanuel - THE 'CRITICAL DEPTH HYPOTHESIS' VERSUS THE 'DILUTION-RECOUPLING HYPOTHESIS' OF PHYTOPLANKTON BLOOMS

92. Klonowski, Wojciech; Lynch, Mervyn; Fearn, Peter; Slivkoff, Matthew - A LOOK-UP-TABLE APPROACH FOR SELECTING SEMI-ANALYTIC MODEL COEFFICIENTS USED IN SHALLOW WATER INVERSION

Remote Sensing

95. Lavender, Samantha Jane; Barker, Kathryn; Kay, Susan; Fanton d'Andon, Odile Hembise; Bourg, Ludovic; McCulloch, Mike; Kent, Chris; Goryl, Philippe - UNCERTAINTY ANALYSES OF OCEAN COLOUR SATELLITE DATA

98. Schaeffer, Blake A.; Hagy, James D.; Lehrter, John C.; Stumpf, Richard; Conmy, Robyn N. - USE OF SEAWIFS AND MODIS TO SUPPORT DEVELOPMENT OF NUMERIC NUTRIENT CRITERIA FOR FLORIDA COASTAL WATERS

101. Moore, Gerald; Lavender, Samantha; Kratzer, Suzanne; Icely, John; Huot, Jean-Paul - THE MERIS BRIGHT PIXEL ATMOSPHERIC CORRECTION: EVOLUTION, PERFORMANCE ASSESSMENT AND VALIDATION FOR THE MERIS 3RD REPROCESSING

104. Hirawake, Toru; Matsumoto, Keitaro; Shinmyo, Katsuhito; Fujiwara, Amane; Saitoh, Sei-Ichi - SIZE STRUCTURE OF PHYTOPLANKTON AND OPTICAL PROPERTIES IN THE ARCTIC OCEAN IN AUTUMN

107. Fearn, Peter Rhoderick - REMOTE SENSING OF MASSIVE FLOATING MACRO-ALGAL BLOOMS

110. Devred, Emmanuel; Sathyendranath, Shubha; Platt, Trevor; Stuart, Venetia - A SIMPLE ALGORITHM TO DERIVE PHYTOPLANKTON SIZE DISTRIBUTION FROM ABSORPTION PROPERTIES: APPLICATION TO SEAWIFS DATA

113. Bricaud, Annick; Ciotti, Aurea M.; Gentili, Bernard - SEASONAL AND INTERANNUAL VARIATIONS IN PHYTOPLANKTON SIZE AND COLORED DETRITAL MATTER ABSORPTION AT GLOBAL AND REGIONAL SCALES, AS DERIVED FROM THE SEAWIFS TIME SERIES

116. Baxter, Becky - POLARIMETRIC REMOTE SENSING OF OCEAN WAVES

119. Corson, Michael - THE HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN: LITTORAL ENVIRONMENTAL CHARACTERIZATION FROM THE INTERNATIONAL SPACE STATION

122. Torrecilla, Elena; Piera, Jaume; Stramski, Dariusz; Reynolds, Rick A.; Millán-Núñez, Eduardo - CLUSTER ANALYSIS OF HYPERSPECTRAL OPTICAL DATA FOR DISCRIMINATING PHYTOPLANKTON PIGMENT ASSEMBLAGES IN THE OPEN OCEAN

125. Montes-Hugo, Martin; Weidemann, Alan; Gould, Richard; Jolliff, Jason; Arnone, Robert; Churnside, James - OCEAN COLOR PATTERNS HELP TO PREDICT DEPTH OF OPTICAL LAYERS IN COASTAL MARINE WATERS

128. Lynch, Mervyn; Fearn, Peter; Klonowski, Wojciech; Majewski, Leon; Gray, Mark; Hacker, Jorg; Blake, Steve - HYPERSPECTRAL SENSING OF COASTAL SYSTEMS IN THE REMOTE REGIONS OF NW AUSTRALIA

131. Lerebourg, Christophe; Mazeran, Constant; Huot, Jean-Paul; Antoine, David; Bourg, Ludovic; Delwart, Steven; Ondrusek, Michael; Lavender, Samantha; Goryl, Philippe - MERIS VICARIOUS ADJUSTMENT IN THE NEAR INFRA RED AND VISIBLE

134. Gentili, Bernard; Mallet, Marc; Chami, Malik - TEMPORAL VARIATION OF THE IMPACT OF DUST SEA SURFACE FORCING ON THE REGIONAL OCEANIC PRIMARY PRODUCTION USING SEAWIFS OBSERVATIONS AND A MODELLING APPROACH
137. Dong, Qiang; Shang, Shaoling; Lee, ZhongPing; Hong, Huasheng - A MODIFIED QAA TO DERIVE IOPS FROM OCEAN COLOR REMOTE SENSING
140. Darecki, Mirosław - EUPHOTIC ZONE DEPTH IN STRATIFIED ARCTIC WATERS AND ITS REMOTE SENSING
143. Kishino, Motoaki; Furuya, Ken - COLORS OF RED TIDES: EXPERIMENTAL STUDIES ON COLOR OF PHYTOPLANKTON
146. Hedley, John; Roelfsema, Chris; Phinn, Stuart - PROPAGATING UNCERTAINTY THROUGH A SHALLOW WATER MAPPING ALGORITHM BASED ON RADIATIVE TRANSFER MODEL INVERSION
149. Brockmann, Carsten; Sathyendranath, Shubha; Doerffer, Roland - TOWARDS OPERATIONAL COASTAL OCEAN COLOUR PRODUCTS – THE COASTCOLOUR APPROACH
152. Blondeau-Patissier, David; Brando, Vittorio E.; Dekker, Arnold G.; Phinn, Stuart R.; Weeks, Scarla J.; Schroeder, Thomas; Park, Young Je - PHYTOPLANKTON RESPONSE TO EPISODIC EVENTS AND LONG-TERM TRENDS IN THE GREAT BARRIER REEF LAGOONAL WATERS: TOWARDS A REGIONAL CHARACTERISATION
155. Creanor, Danielle; Cunningham, Alex - ASSESSING THE SPATIAL VARIABILITY OF OPTICALLY SIGNIFICANT MATERIAL CONCENTRATIONS IN UK SHELF SEAS USING A SPECTRAL MATCHING APPROACH
158. Pratt, Patty, Ip, Justin; McCarthy, Jim, Chou, Mau-Song; Donovan, John; and Hauss, Bruce - STATUS OF VIIRS SYSTEMS ENGINEERING FOR OCEAN COLOR SCIENCE QUALITY DATA: CONFIDENTLY RETRIEVING WATER-LEAVING RADIANCE AND CHLOROPHYLL CONCENTRATION FROM ACO & OCC ON NPP BASED ON RIGOROUS SENSOR TESTING PROGRAM
161. Stamnes, Knut; Li, Wei; Tanikawa, Tomonori; Hamre, Børge; Stamnes, Jakob A FAST YET ACCURATE ALGORITHM FOR RETRIEVAL OF AEROSOL AND MARINE PARAMETERS IN COASTAL WATERS

Optics of Oil in Coastal Waters

164. Pegau, William Scott; Wijesekera, Hemantha; Boyd, Tim; Moline, Mark - SPATIAL SCALES OF IRRADIANCE VARIABILITY
167. Hu, Chuanmin; Lee, ZhongPing; English, David; Ivey, James; Cannizzaro, Jennifer; Coble, Paula; Kovach, Charles - REMOTE DETECTION OF OIL SLICKS IN THE OCEAN: IS THERE AN OPTICAL SIGNATURE?

Near Surface Optics

170. Chang, Grace; Twardowski, Michael - POINT SPREAD FUNCTIONS AND VISIBILITY: GAINING CLARITY ON IMAGE PROCESSING IN NATURAL WATERS
173. Orrico, Cristina M; Zaneveld, J. Ron V; Barnard, Andrew H; Moline, Mark A; Robbins, Ian; Moore, Casey - USING A+BB TO DETERMINE THE DEPTH OF VISIBILITY OF A BIOLUMINESCENT POINT SOURCE
176. Hudson, Stephen; Hamre, Børge; Granskog, Mats; Stamnes, Jakob J. - FACTORS CONTROLLING LIGHT TRANSMISSION THROUGH THIN FIRST-YEAR ARCTIC SEA ICE - OBSERVATIONS AND MODELLING

179. Czerski, Helen; Twardowski, Michael; Vagle, Svein; Slivkoff, Matthew - RESOLVING BUBBLE SIZE DISTRIBUTIONS AND DYNAMICS IN NEAR-SURFACE WATERS WITH OPTICS AND ACOUSTICS
182. Gleason, Arthur C. R.; Voss, Kenneth J; Gordon, Howard R - MEASURING AND MODELING THE POLARIZED UPWELLING RADIANCE DISTRIBUTION IN CLEAR AND COASTAL WATERS
185. Hancke, Kasper; Hovland, Erlend Kjeldsberg; Volent, Zsolt; Sakshaug, Egil - CDOM IN THE BARENTS SEA: ABUNDANCE AND ORIGIN ACROSS THE POLAR FRONT
188. Wernand, Marcel Robert; Van der Woerd, Hendrik J. - OCEAN COLOR CHANGES IN THE NORTH PACIFIC SINCE 1930

**Use of Historical Optical Observations
Instrumentation and Platforms**

191. Ebert, Kerstin; Chami, Malik; Allais, Anne Gaele; Galland, Frédéric; Bouhier, Marie Edith; Edmond, Toussaint; Boffety, Matthieu; Maciol, Nicolas; Nicolas, Stéphane - ANALYSIS OF UNDERWATER IMAGE DEGRADATION USING RADIATIVE TRANSFER MODELING. APPLICATION TO SUBMARINE IMAGE VISIBILITY
194. Van Dommelen, Ronnie; Lewis, Marlon; Wei, Jianwei - INSTRUMENTATION, CALIBRATION AND VALIDATION OF A HIGH-DYNAMIC-RANGE RADIANCE CAMERA
197. Mullen, Linda; Laux, Alan; Zege, Eleonora P; Katsev, Iosif L; Prikhach, Alexander S - MODULATED PULSE SYSTEM FOR EXTENDED RANGE UNDERWATER IMAGING
200. Tonizzo, Alberto; Ibrahim, Amir; Chowdhary, Jacek; Gilerson, Alexander; Ahmed, Samir - ESTIMATING PARTICLE COMPOSITION FROM THE POLARIZED WATER LEAVING RADIANCE
203. Zielinski, Oliver; Dittmar, Thorsten; Rohde, Peter; Ungermann, René; Voss, Daniela - CDOM AND PAH'S IN THE MARINE ENVIRONMENT - *IN SITU* SENSING WITH TIME RESOLVED FLUORESCENCE AND LIQUID CORE WAVEGUIDES
206. Erickson, Jeffrey Stephen - BUILDING AN AUTOMATED MICROFLOW FLOW CYTOMETER FOR UNDERSEA OPERATION
209. Woods, Sarah; Piskozub, Jacek; Włodzimierz, Freda; Jonasz, Mirosław; Bogucki, Darek - LIGHT BEAM DEPOLARIZATION ON TURBULENT CONVECTIVE FLOW: LABORATORY MEASUREMENTS
212. Piera, Jaume; Torrecilla, Elena; Pons, Sergi; Aymerich, Ismael Fernandez; Ross, Oliver Nicolas; Dañobeitia, Juan José; Artigas, Mireia Lara; Berdalet, Elisa; Simó, Rafel; Afinkiev, Teodor; Fernández, Roemi; Armada, Manuel - ANERIS. AN AUTONOMOUS PROFILER FOR CONCURRENT CHARACTERISATION OF PHYSICAL AND BIO-OPTICAL PROCESSES AT SMALL SCALES
215. Haubrich, David; Fry, Edward S.; Kattawar, George W.; Musser, Joseph A. - INSTRUMENTATION TO MEASURE THE BACKSCATTERING COEFFICIENT FOR ARBITRARY PHASE FUNCTIONS

Organismal Response and Adaptation to the Light Field

218. Jolliff, Jason; Gould, Richard; deRada, Sergio - ESTABLISHING BASELINE SUBSURFACE LIGHT FIELDS FOR THE FLOWER GARDEN BANKS NATIONAL MARINE SANCTUARY
221. Dierssen, Heidi M; Johnsen, Geir; Cummings, Molly; Maginnis, Tara; Holt, Joan - SPECTRAL POLARIZED REFLECTANCE FROM SKIN PREPARATIONS FROM FOUR DIFFERENT SUBTROPICAL FISH SPECIES

224. Wojtasiewicz, Bozena; Stramski, Dariusz - CHLOROPHYLL-SPECIFIC ABSORPTION AND SCATTERING COEFFICIENTS OF SELECTED

227. Datskos, Panos; Rajic, Slobodan; Lavrik, Nickolay - NANO/MICRO-ELECTRO-MECHANICAL SYSTEMS (NEMS/MEMS): CANTILEVERS

Invited Speakers

230. Hu, Chuanmin - ONE INDEX, MANY APPLICATIONS

Wednesday, September 29, 2010

Chairman's Choice

Chairperson: Heidi Dierssen

0800 – 0820 Gould, Richard W.; Lewis, M. David; Smith, Regina D.; Ko, Dong S.- MAPPING COASTAL HYPOXIA IN THE NORTHERN GULF OF MEXICO WITH OCEAN COLOR IMAGERY

0820 – 0840 Bélanger, Simon; Ehn, Jens; Raimbault, Patrick; Leymarie, Edouard; Doxaran, David; Hooker, Stan; Babin, Marcel - ON THE ROLE OF SEA ICE MELTING ON NEAR-SURFACE VERTICAL VARIABILITY OF PARTICULATE ABSORPTION COEFFICIENT IN THE ARCTIC OCEAN

0840 – 0900 Ebert, Kerstin; Chami, Malik; Allais, Anne Gaelle; Galland, Frédéric; Bouhier, Marie Edith; Edmond, Toussaint; Boffety, Matthieu; Maciol, Nicolas; Nicolas, Stéphane - ANALYSIS OF UNDERWATER IMAGE DEGRADATION USING RADIATIVE TRANSFER MODELING. APPLICATION TO SUBMARINE IMAGE VISIBILITY.

0900 – 0920 van Dijk, Mark Albert; Hoogveld, Hans L.; Simis, Stefan G. H.; Kromkamp, Jacco C.; Gons, Herman J. - SPECIFIC ABSORPTION SIGNATURES OF TAXONOMIC SUBPOPULATIONS IN PHYTOPLANKTON COMMUNITIES

0920 – 0940 Bhandari, Purushottam; Logan, Luke; Voss, Kenneth J - POLARIZED DOWNWELLING RADIANCE DISTRIBUTION NEAR THE OCEAN SURFACE

0940 – 1020 Break

New Instruments

Chairperson: Sarah Woods

1020 – 1040 Mullen, Linda; Laux, Alan; Zege, Eleonora P; Katsev, Iosif L; Prikhach, Alexander S - MODULATED PULSE SYSTEM FOR EXTENDED RANGE UNDERWATER IMAGING

1040 – 1100 Alley, Derek Michael; Mullen, Linda; Laux, Alan; McBride, Walton - EXTENDED RANGE, NON-LINE-OF-SIGHT (NLOS) UNDERWATER IMAGING USING A TIME VARYING INTENSITY (TVI) APPROACH.

1100 – 1120 Erickson, Jeffrey Stephen - BUILDING AN AUTOMATED MICROFLOW FLOW CYTOMETER FOR UNDERSEA OPERATION

1120 – 1140 Haubrich, David; Fry, Edward S.; Kattawar, George W.; Musser, Joseph A.- INSTRUMENTATION TO MEASURE THE BACKSCATTERING COEFFICIENT FOR ARBITRARY PHASE FUNCTIONS

1140 – 1200 Cetinic, Ivona; Weatherbee, Ryan; Thomas, Andrew C.; Perry, Mary Jane - REDUCING UNCERTAINTY IN THE PRIMARY PRODUCTIVITY ASSESMENT BY COUPLING SATELLITE AND IN-WATER ROBOTIC MEASUREMENTS

1200h – 1330h LUNCH

13:30-16:00 FREE PERIOD #2

Invited Lectures

Chairperson: Helga Gomes

1600 – 1630 Boss, Emmanuel - OPTICS AND SEDIMENT DYNAMICS

1700 - 1730 Mikkelsen, Ole; Agrawal, Yogi - LIGHT SCATTERING MEASUREMENTS OF ALL KINDS OF PARTICLES AT ALL KINDS OF ANGLES

Poster Session #3

17:30 - 19:00

Atmosphere/Radiative Transfer

3. Blum, Mirjam; Rozanov, Vladimir; Dinter, Tilman; Bracher, Astrid - EVALUATION OF THE COUPLED ATMOSPHERIC-OCEANIC RADIATIVE TRANSFER MODEL SCIATRAN EMPLOYING IN-SITU AND SATELLITE REMOTE SENSING MEASUREMENTS
6. Amin, Ruhul; Gould, Richard; Hou, Weilin; Martinolich, Paul; Montes, Marcos - INTERCOMPARISON OF ATMOSPHERIC CORRECTION ALGORITHMS APPLIED TO HICO IMAGERY
9. Duforêt-Gaurier, Lucille; Frouin, Robert; Dessailly, David; Labonnote, Laurent; Brogniez, Gerard; Dubuisson, Philippe - REMOTE-SENSING OF OCEAN-COLOR ABOVE THIN CIRRUS CLOUDS
12. Jamet, Cédric; Loisel, Hubert; Ruddick, Kevin; Zibordi, Giuseppe; Feng, Hui; Kuchinke, Christopher - COMPARISON OF THREE SEAWIFS ATMOSPHERIC CORRECTION ALGORITHMS IN TURBID WATERS FROM AERONET-OC MEASUREMENTS
15. Zhao, Dongzhi; Ma, Yujuan; Yang, Jianhong - THE CHARACTERS OF AEROSOL DISTRIBUTION IN THE YELLOW SEA AND THE VALIDATION OF AOT OBSERVED BY MODIS
18. Zege, Eleonora; Katsev, Iosif ; Prikhach, Alexander; Mullen, Linda; Cochenour, Brandon - MODULATING RETRO-REFLECTOR LINKS IN SEAWATERS
21. Ostrowska, Mirosława - DEPENDENCE OF QUANTUM YIELD OF CHLOROPHYLL A FLUORESCENCE IN THE SEA ON ENVIRONMENTAL FACTORS – THE PRELIMINARY RESULTS

Bio-optics and Biogeochemistry

24. Lorthiois, Thomas; Doxaran, David; Chami, Malik; McKee, David; Jourdin, Frederic - IMPORTANCE OF PARTICULATE BACKSCATTERING MEASUREMENTS IN THE NEAR INFRARED BANDS FOR IMPROVING REMOTE SENSING ALGORITHMS IN COASTAL WATERS
27. Svensen, Øyvind; Frette, Øyvind; Kildemo, Morten; Aas, Lars Martin Sandvik; Erga, Svein Rune; Stamnes, Jakob - INVESTIGATIONS OF THE POLARIZATION PROPERTIES OF ALGAE SCATTERING

30. Goela, Priscila Costa; Cristina, Sónia; Icely, John; Newton, Alice - LIGHT ABSORPTION BY PARTICULATE AND DISSOLVED ORGANIC MATTER IN COASTAL AND OCEANIC SITES OF THE SOUTHWEST COAST OF EUROPE: A CONTRIBUTION TO MERIS SENSOR VALIDATION
33. Gonzalez-Silvera, Adriana; Millan-Nunez, Roberto; Santamaria-del-Angel, Eduardo; Santander-Cruz, Jonatan; Callejas-Jimenez, Mariana; Gracia-Escobar, Maria Fernanda - TIME AND SPACE VARIABILITY OF SOME BIO-OPTICAL PROPERTIES AT ANTARES BAJA CALIFORNIA STATION, MEXICO (2007-2009)
36. Dupouy, Cécile; Röttgers, Rüdiger - ABSORPTION BY DIFFERENT COMPONENTS DURING A HIGH FRESHWATER EVENT OF THE 2008 LA NINA EPISODE IN A TROPICAL LAGOON
39. Sullivan, James Michael; Twardowski, Michael; Katz, Joseph; Hong, Jiarong; Talapatra, Siddharth; Donaghay, Percy - UNDERSTANDING PARTICLE DYNAMICS USING IN-SITU HOLOGRAPHIC MICROSCOPY
42. Jaegler, Thomas; Bélanger, Simon - A NOVEL APPROACH TO CHARACTERIZE COLORED DISSOLVED ORGANIC MATTER (CDOM) USING *IN SITU* MULTISPECTRAL FLUORESCENCE AND ABSORPTION METERS
45. Xing, Xiaogang; Claustre, Hervé; Morel, André; Gentili, Bernard; Poteau, Antoine; d'Ortenzio, Fabrizio - A COMBINED DATA TREATMENT TO IMPROVE THE RETRIEVAL OF CHLA CONCENTRATION AND NOISE-FREE RADIOMETRIC PROFILE IN OCEANIC WATERS: APPLICATION TO PROFILING FLOATS MEASUREMENTS
48. Du, Keping; Lee, ZhongPing - A NEW DATA PROCESSING METHOD FOR HYDROSCAT-6 BASED ON HYDROLIGHT
51. Franz, Bryan; Werdell, Jeremy - A GENERALIZED FRAMEWORK FOR MODELING OF INHERENT OPTICAL PROPERTIES WITHIN OCEAN REMOTE SENSING APPLICATIONS
54. Estapa, Margaret L - MASS-SPECIFIC ABSORPTION BY SUSPENDED SEDIMENTS IN COASTAL LOUISIANA: CONNECTIONS TO PARTICLE COMPOSITION AND OCEAN COLOR
57. Chase, Alison P; Roesler, Collin S; Hankinson, Sam; Teegarden, Greg; Laine, Edward - THE USE OF SPECTRAL REFLECTANCE TO IDENTIFY PHYTOPLANKTON SPECIES SUCCESSION IN COASTAL MAINE
60. Stavn, Robert Hans - OPTICAL PROPERTIES OF SUSPENDED SEDIMENTS AND AGGREGATES: PRIMARY AND SECONDARY PARTICLES
63. Antoine, David; Siegel, David A; Kostadinov, Tihomir; Maritorena, Stéphane; Nelson, Norm B; Gentili, Bernard; Vellucci, Vincenzo; Guillocheau, Nathalie - OPTICAL PARTICLE BACKSCATTERING IN CONTRASTED BIO-OPTICAL OCEANIC REGIMES OF THE MEDITERRANEAN SEA (BOUSSOLE SITE), THE SANTA BARBARA CHANNEL, CALIFORNIA (PLUMES AND BLOOMS STATIONS) AND THE SARGASSO SEA (BERMUDA BIO-OPTICS PROJECT)
66. Stoń-Egiert, Joanna; Majchrowski, Roman; Darecki, Mirosław; Ostrowska, Mirosława - INFLUENCE OF UNDERWATER LIGHT FIELDS ON PIGMENT CHARACTERISTICS IN THE BALTIC SEA – RESULTS OF STATISTICAL ANALYSIS
69. Voelker, Christoph David; Losch, Martin; Losa, Svetlana; Hohn, Soenke; Wolf-Gladrow, Dieter - PHOTOACCLIMATION AND THE CHL:C RATIO IN A GLOBAL MODEL OF MARINE PHYTOPLANKTON

72. Ficek, Dariusz Antoni; Zapadka, Tomasz; Meler, Justyna - SPECTRAL ABSORPTION PROPERTIES OF OPTICALLY ACTIVE CONSTITUENTS IN POMERANIAN LAKES (POLAND)
75. Gomes, Helga Do Rosario; Goes, Joaquim Ignacio; Matondkar, Prabhu; Basu, Subhajt; Parab, Sushma; Roesler, Collin; Werdell, Jeremy - OPTICAL PROPERTIES OF WINTER BLOOMS OF NOCTILUCA MILIARIS IN THE ARABIAN SEA
78. Spada, Frank Wayne; Chang, Grace; Twardowski, Michael; Freeman, Scott - COST EFFECTIVE PLATFORMS FOR THE DEPLOYMENT OF OPTICAL SENSORS IN DYNAMIC ENVIRONMENTS
81. Neukermans, Griet; Loisel, Hubert; Mériaux, Xavier; McKee, David; Astoreca, Rosa; Doxaran, David; Ruddick, Kevin - VARIABILITY OF TOTAL, BACK AND SIDE SCATTERING TO MASS CONCENTRATION RATIO OF MARINE PARTICLES
84. Fichot, Cedric G; Lohrenz, Steven; Miller, William L.; Benner, Ron - DYNAMICS OF DOM OPTICAL PROPERTIES AND CHEMICAL COMPOSITION IN A RIVER-DOMINATED OCEAN MARGIN (NORTHERN GULF OF MEXICO)
87. Briggs, Nathan; Cetinic, Ivona; Gray, Amanda; Rehm, Eric; D'Asaro, Eric; Lee, Craig; Perry, Mary Jane - USING SPIKES IN OPTICAL MEASUREMENTS TO TRACK AN AGGREGATE FLUX EVENT FROM AUTONOMOUS PLATFORMS
90. Goes, Joaquim Ignacio; Gomes, Helga do Rosario; Matondkar, Prabhu G. Shivaprasad; Thoppil, Prasad G.; Fasullo, John T; Roesler, Collin M.; Basu, Subhajt; Parab, Sushma G. - EXTENSIVE PHYTOPLANKTON BLOOMS IN THE NORTHERN ARABIAN SEA AND POTENTIAL FEEDBACK EFFECTS
93. Włodzimierz, Freda - BACKSCATTERING COEFFICIENT RETRIEVAL FROM MEASUREMENTS OF SINGLE ANGLE LIGHT SCATTERING IN SOUTHERN BALTIC

Remote Sensing

96. Ferreira, Amábile; Garcia, Carlos Alberto Eiras; Garcia, Virgínia Maria Tavano; Dogliotti, Ana Ines - VARIABILITY IN THE HYPERSPECTRAL REMOTE SENSING REFLECTANCE AND PERFORMANCE OF OC4V4 ALGORITHM IN THE PATAGONIAN SHELF -BREAK
99. Hooper, Brett A.; Baxter, Becky; Scott, Nicholas; Vierra, Kenneth; Piotrowski, Cindy - REMOTE CHARACTERIZATION OF THE UPPER OCEAN USING AIRBORNE MULTISPECTRAL POLARIMETRIC IMAGING
102. Tanikawa, Tomonori; Wei, Li; Stamnes, Knut - A NEW OCEAN COLOR ALGORITHM FOR THE GCOM-C1/SGLI SENSOR
105. Mériaux, Xavier; Loisel, Hubert; Neukermans, Griet; Ruddick, Kevin - COMPARISON BETWEEN REMOTE SENSING REFLECTANCE ESTIMATED FROM ABOVE OR IN WATER UPWELLING RADIANCES
108. Epps, Sarah; Lohrenz, Steven; Tuell, Grady; Martin, Kevin - OPTICAL PROPERTIES IN RELATION TO SUSPENDED PARTICULATE MATTER (SPM) IN THE NORTHERN GULF OF MEXICO
111. Cristina, Sónia; Goela, Priscila; Icely, John; Moore, Gerald; Newton, Alice - EVALUATION OF THE MERIS MARINE PRODUCTS IN COASTAL AND OCEANIC WATERS OFF CAPE SAGRÉS ON THE SOUTH-WEST COAST OF PORTUGAL
114. Wozniak, Monika; Krezel, Adam; Darecki, Mirosław; Wojtasiewicz, Bożena - OPTICAL PROPERTIES OF BALTIC SEA PHYTOPLANKTON

117. Salama, Mhd. Suhyb - UNCERTAINTY OF APPARENT AND INHERENT OPTICAL PROPERTIES AS DERIVED FROM GLOBAL OCEAN COLOR PRODUCTS
120. Romero, Silvia Inés; Ferrari, Ramiro - OPTICAL CHARACTERIZATION OF WATER MASSES IN THE PLATA PLUME
123. Arnone, Robert; Fargion, G.; Scadino, T.; Lawson, A.; Ladner, S.; Ahmed, S.; Weidemann, Alan.; Gibson, W.; Zibordi, Giuseppe; Feng, Hui.; Holben, B. ; Davis, Curtiss.- SPATIAL AND TEMPORAL UNCERTAINTY OF SATELLITE OCEAN COLOR PRODUCTS USING AERONET OCEAN COLOR
129. Sagan, Slawomir; Darecki, Mirosław; Kowalczyk, Piotr - SMALL SCALE OPTICAL VARIABILITY OVER THE A LONG DISTANCES - APPLICATION OF VERSATILE ON-BOARD FLOW-THROUGH SYSTEM FOR UNDERWAY OBSERVING SPATIAL DISTRIBUTION OF SURFACE WATER OPTICAL PROPERTIES
132. Loisel, Hubert; Lubac, Bertrand; Dessailly, David; Duforêt-Gaurier, Lucille; Vantrepotte, Vincent - EFFECT OF INHERENT OPTICAL PROPERTIES VARIABILITY ON THE CHLOROPHYLL RETRIEVAL FROM OCEAN COLOR REMOTE SENSING: AN *IN SITU* APPROACH
135. Ahmed, Samir; Arnone, Robert; Gilerson, Alexander; Harmel, Tristan; Hlaing, Soe; Weidemann, Alan - MULTI- AND HYPERSPECTRAL OCEAN COLOR MEASUREMENTS FROM LONG ISLAND SOUND OBSERVATION PLATFORM (LISCO): COMPARISON WITH SATELLITE MEASUREMENTS & ASSESSMENTS OF UNCERTAINTIES
138. Son, SeungHyun; Wang, Menghua - ASSESSMENT OF MODIS-AQUA CHLOROPHYLL-A DATA IN THE CHESAPEAKE BAY
141. Barker, Kathryn; Huot, Jean-Paul; Moore, Gerald; Mazeran, Constant; Lerebourg, Christophe; Lavender, Samantha - *IN-SITU* RADIOMETRIC MEASUREMENT PROTOCOL AND DATA ANALYSIS, INCLUDING THE EFFECTS OF TILT ON DOWNWELLING SOLAR IRRADIANCE
144. Zimmerman, Richard; Sukenik, Charles I; Hill, Victoria; Hu, Yongxiang - EXPLOITING LIDAR TO RETRIEVE PARTICLE DISTRIBUTIONS OF THE UPPER OCEAN
147. Pennucci, Giuliana - GLIDER DATA PROCESSING AND DATA COMPARISON IN OPTICAL PARAMETER ESTIMATION FOR ENVIRONMENTAL CHARACTERIZATION
150. Davis, Curtiss; Arnone, Robert; Gould, Richard; Corson, Michael; Lee, ZhongPing - THE HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN (HICO) PROVIDES A NEW VIEW OF THE COASTAL OCEAN
153. Omachi, Claudia Yuki; Ferreira, Amábile; Garcia, Virginia Maria Tavano; Garcia, Carlos Alberto Eiras; Campos, Edmo José Dias - BIO-OPTICAL SIGNALS AND THE PHYTOPLANKTON FUNCTIONAL TYPES IN THE SOUTHWESTERN ATLANTIC OCEAN
156. Lee, ZhongPing; Huang, Changchun; Lubac, Bertrand; Guo, Laodong; Ko, Dong-Shan; Lohrenz, Steven; Gould, Richard - CHARACTERIZATION OF SUSPENDED PARTICULATES IN THE NORTHERN GULF OF MEXICO FROM OCEAN COLOR REMOTE SENSING
159. Martinez, Elodie Claire; Antoine, David; d'Ortenzio, Fabrizio; De Boyer Montegut, Clement - CHANGING CHARACTERISTICS OF PHYTOPLANKTON SPRING AND FALL BLOOMS IN THE NORTH ATLANTIC FROM THE 1980S' TO 2000S'
162. Neil, Claire; Cunningham, Alex; McKee, David; Polton, Jeff - IS THERE A LINK BETWEEN HYDROLOGICAL PROCESSES AND REMOTE SENSING REFLECTANCE IN COASTAL SEAS?

Optics of Oil in Coastal Waters

165. Epps, Sarah; Lohrenz, Steven; Joung, DongJoo; Asper, Vernon - SHIP-BASED REMOTE SENSING REFLECTANCE OBSERVATIONS RELATED TO THE DEEPWATER HORIZON PETROLEUM CONTAMINATION EVENT, GULF OF MEXICO
168. Lewis, Mark David; Gould, Richard W; Ladner, Sherwin; Gallegos, Sonia; Jolliff, Jason; Bennert, Ellen; Li, Rong-Rong - SPECTRAL AND SPATIAL ANALYSIS OF THE GULF OF MEXICO OIL SPILL USING SATELLITE AND *IN SITU* DATA

Near Surface Optics

171. Wei, Jianwei; Lewis, Marlon; Van Dommelen, Ronnie - RADIANCE DISTRIBUTION AS A FUNCTION OF DEPTH IN TYPICAL SEA WATERS
174. Bhandari, Purushottam; Logan, Luke; Voss, Kenneth J - POLARIZED DOWNWELLING RADIANCE DISTRIBUTION NEAR THE OCEAN SURFACE
177. Zhang, Xiaodong - SCATTERING BY PURE WATER AND PURE SEAWATER
180. Twardowski, Michael; Zhang, Xiaodong; Freeman, Scott; Slivkoff, Matthew; Sullivan, James; Czerski, Helen; Vagle, Svein; You, Yu; Kattawar, George - INVERTING THE VOLUME SCATTERING FUNCTION TO INFER PARTICLE COMPOSITION AND DYNAMICS AT THE NEAR-SURFACE IN THE SURF ZONE AND OPEN OCEAN
183. Zappa, Christopher J; Banner, Michael; Gemmrich, Johannes; Schultz, Howard; Morison, Russel; Wei, Jianwei; Lewis, Marlon - THE INFLUENCE OF OCEAN SURFACE ROUGHNESS AND BREAKING WAVES ON SUBSURFACE RADIANCE
186. You, Yu; Kattawar, George W. - MODELING DYNAMIC UNDERWATER POLARIZED RADIANCE FIELDS USING WAVE SLOPES AND IOPS FROM RADYO FIELD EXPERIMENTS
189. Vantrepotte, Vincent; Loisel, Hubert; Dessailly, David; Duforêt-Gaurier, Lucille; Mélin, Frédéric - GLOBAL PARTICULATE MATTER POOL TEMPORAL VARIABILITY OVER THE SEAWIFS PERIOD (1997-2007)

Use of Historical Optical Observations Instrumentation and Platforms

192. Vuorenkoski, Anni; Dalglish, Fraser; Shirron, Joseph; Giddings, Thomas - MULTI-PATH EFFECTS ON OPTICAL COMMUNICATION LINKS
195. Oishi, Tomohiko; Ebata, Hiroki; Takakusaki, Mitsuhiro; Nemoto, Moyu; Suzuki, Ryou; Takahashi, Hirokazu; Furuta, Masaji - DEVELOPMENT OF TWO CHANNEL EMISSION FLUOROMETER WITH MULTI-WAVELENGTH EXCITATION BASE ON SIMULTANEOUS ILLUMINATION METHOD
198. Dalglish, Fraser R; Ramos, Brian; Britton, Walter B; and Caimi, Frank M. - MULTISTATIC DISTRIBUTED LASER LINE SCAN IMAGING ARCHITECTURE
201. Kobayashi, Hiroshi; Ishizaka, Joji; Jintasaeranee, Pachoenchoke; Gunbua, Vichaya; Fukasawa, Tatsuya - WATER-LEAVING RADIANCE MEASURED USING WITH COVERED RADIOMETERS IN TURBID WATERS
204. Ouyang, Bing; Dalglish, Fraser - UNDERWATER LASER SERIAL IMAGING USING COMPRESSIVE SENSING
207. Cetinic, Ivona; Weatherbee, Ryan; Thomas, Andrew C.; Perry, Mary Jane - REDUCING UNCERTAINTY IN THE PRIMARY PRODUCTIVITY ASSESMENT BY COUPLING SATELLITE AND IN-WATER ROBOTIC MEASUREMENTS

210. Zielinski, Oliver; Wernand, Marcel R. - THE ECOLOR-SECCHI-DISC: AN ELECTRONIC REINVENTION OF PROVEN OCEAN COLOR TOOLS
213. Sosik, Heidi M.; Olson, Robert J. - RECENT ADVANCES IN AUTOMATED UNDERWATER PLANKTON OBSERVATIONS WITH IMAGING FLOWCYTOBOT
216. Giddings, Thomas; Shirron, Joseph - THE SHOWER CURTAIN EFFECT AND ELECTRO-OPTICAL IMAGING SENSORS

Organismal Response and Adaptation to the Light Field

219. Talapatra, Siddharth; Nayak, Aditya Ramakrishna; Zhang, Cao; Hong, Jiarong; Katz, Joseph; Twardowski, Michael; Sullivan, James; Donaghay, Percy - CHARACTERIZATION OF ORGANISMS, PARTICLES, AND BUBBLES IN THE WATER COLUMN USING A FREE-DRIFTING, SUBMERSIBLE, DIGITAL HOLOGRAPHY SYSTEM
222. Laney, Samuel - THE DYNAMICS OF SUN-STIMULATED PHYTOPLANKTON FLUORESCENCE
225. Russell, Brandon; Dierssen, Heidi; Zimmerman, Richard - DYNAMIC VARIABILITY IN THE SPECTRAL-POLARIZED LIGHT FIELD MEASURED OVER SEAGRASS AND SAND HABITATS
228. Fournier, Georges - POLARIZATION IN SCATTERING

Thursday, September 30, 2010

Remote Sensing Systems and Shallow Water

Chairperson: Peter Fearn

- 0800 – 0820 Dekker, Arnold Graham; Phinn, Stuart R.; Anstee, Janet M.; Bissett, Paul; Brando, Vittorio E.; Casey, B.; Fearn, Peter; Hedley, John; Klonowski, Wojciech; Lee, ZhongPing; Lynch, Mervyn; Lyons, Mitchell; Mobley, Curtis; Roelfsema, Chris- MULTIPLE OPTICAL SHALLOW WATER INVERSION METHODS FOR BATHYMETRY, IN-WATER OPTICS, AND BENTHOS MAPPING : HOW DO THEY COMPARE?
- 0820 – 0840 Hedley, John; Roelfsema, Chris; Phinn, Stuart - PROPAGATING UNCERTAINTY THROUGH A SHALLOW WATER MAPPING ALGORITHM BASED ON RADIATIVE TRANSFER MODEL INVERSION
- 0840 – 0900 Kanitz, Thomas; Althausen, Dietrich; Engelmann, Ronny; Baars, Holger; Macke, Andreas - MULTIWAVELENGTH RAMAN AEROSOL OBSERVATIONS OF SAHARAN AND PATAGONIAN DUST ABOARD THE RESEARCH VESSEL POLARSTERN DURING ITS MERIDIONAL CRUISE ANT-26/1
- 0900 – 1920 Brockmann, Carsten; Sathyendranath, Shubha; Doerffer, Roland - TOWARDS OPERATIONAL COASTAL OCEAN COLOUR PRODUCTS – THE COASTCOLOUR APPROACH
- 0920 – 0940 Davis, Curtiss; Arnone, Robert; Gould, Richard; Corson, Michael; Lee, ZhongPing - THE HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN (HICO) PROVIDES A NEW VIEW OF THE COASTAL OCEAN
- 0940 – 1000 Pennucci, Giuliana - GLIDER DATA PROCESSING AND DATA COMPARISON IN OPTICAL PARAMETER ESTIMATION FOR ENVIRONMENTAL CHARACTERIZATION.

1000 – 1020 Break

Remote Sensing of Phytoplankton Characteristics

Chairperson: Blake Schaeffer

- 1020 – 1040 Bracher, Astrid; Sadeghi, Alireza; Dinter, Tilman; Schmitt, Bettina; Vountas, Marco; Röttgers, Rüdiger; Peeken, Ilka; Ye, Ying - PHYTOPLANKTON GROUPS FROM SPACE USING PHYTODOAS: IMPROVEMENTS BY MULTI-TARGET FITTING, YEARLY DATA SET, VALIDATION AND FIRST APPLICATION
- 1040 – 1100 Craig, Susanne Elizabeth; Jones, Chris T.; Cullen, John J.; Li, William K.W.; Lazin, Gordana; Horne, Edward; Caverhill, Carla - DERIVING OPTICAL METRICS OF ECOLOGICAL VARIABILITY FROM A COASTAL OCEAN OBSERVATION PROGRAM
- 1100 – 1120 Creanor, Danielle; Cunningham, Alex - ASSESSING THE SPATIAL VARIABILITY OF OPTICALLY SIGNIFICANT MATERIAL CONCENTRATIONS IN UK SHELF SEAS USING A SPECTRAL MATCHING APPROACH
- 1120 – 1140 Omachi, Claudia Yuki; Ferreira, AmáBILE; Garcia, Virginia Maria Tavano; Garcia, Carlos Alberto Eiras; Campos, Edmo José Dias - BIO-OPTICAL SIGNALS AND THE PHYTOPLANKTON FUNCTIONAL TYPES IN THE SOUTHWESTERN ATLANTIC OCEAN
- 1140 – 1200 Blondeau-Patissier, David; Brando, Vittorio E.; Dekker, Arnold G.; Phinn, Stuart R.; Weeks, Scarla J.; Schroeder, Thomas; Park, Young Je - PHYTOPLANKTON RESPONSE TO EPISODIC EVENTS AND LONG-TERM TRENDS IN THE GREAT BARRIER REEF LAGOONAL WATERS: TOWARDS A REGIONAL CHARACTERISATION.
- 1200 – 1330 LUNCH

Remote Sensing of Bio-optical Properties

Chairperson: Dirk Aurin

- 1330 – 1350 Lee, ZhongPing; Huang, Changchun; Lubac, Bertrand; Guo, Laodong; Ko, Dong-Shan; Lohrenz, Steven; Gould, Richard - CHARACTERIZATION OF SUSPENDED PARTICULATES IN THE NORTHERN GULF OF MEXICO FROM OCEAN COLOR REMOTE SENSING
- 1350 – 1410 Marrable, Daniel Stephen; Fearn, Peter; Lynch, Mervyn; Klonowski, Wojciech - SPECTRAL ANALYSIS OF ESTUARINE WATER FOR CHARACTERISATION OF INHERENT OPTICAL PROPERTIES AND PHYTOPLANKTON CLASSIFICATION
- 1410 – 1430 Martinez, Elodie Claire; Antoine, David; d'Ortenzio, Fabrizio; De Boyer Montegut, Clement - CHANGING CHARACTERISTICS OF PHYTOPLANKTON SPRING AND FALL BLOOMS IN THE NORTH ATLANTIC FROM THE 1980S' TO 2000S'
- 1430 – 1450 Nechad, Bouchra; Ruddick, Kevin; Neukermans, Griet - REMOTE SENSING OF THE DIFFUSE ATTENUATION COEFFICIENT AND RELATED PARAMETERS IN TURBID WATERS: STATE OF THE ART AND FUTURE PERSPECTIVES
- 1450 – 1510 Stamnes, Knut; Li, Wei; Tanikawa, Tomonori; Hamre, Børge; Stamnes, Jakob - A FAST YET ACCURATE ALGORITHM FOR RETRIEVAL OF AEROSOL AND MARINE PARAMETERS IN COASTAL WATERS
- 1510 – 1530 Neil, Claire; Cunningham, Alex; McKee, David; Polton, Jeff - IS THERE A LINK BETWEEN HYDROLOGICAL PROCESSES AND REMOTE SENSING REFLECTANCE IN COASTAL SEAS?

Invited Lectures

Chairperson: Hubert Loisel

1600 – 1630 Alvain, Severine - LATEST NEWS ON REMOTE SENSING OF PHYTOPLANKTON FUNCTIONAL GROUPS: WHAT WE CAN DO NOW AND WHAT CAN WE EXPECT IN THE FUTURE?

1700 - 1730 Hu, Chuanmin - ONE INDEX, MANY APPLICATIONS

Awards Banquet Dinner / Dance

1900 – 2300

Friday, October 1, 2010

Optics in Spill Response

Chairperson: Robyn Conmy

0900 – 0920 Pegau, William Scott; Wijesekera, Hemantha; Boyd, Tim; Moline, Mark - SPATIAL SCALES OF IRRADIANCE VARIABILITY

0920 – 0940 Coble, Paula; Hu, Chuanmin; Ivey, James; Kovach, Charles; Cannizzaro, Jennifer; English, David; Arellano, Ana; Barnes, Brian; Peebles, Ernst - OPTICAL PROPERTIES OF DISPERSED AND NON-DISPERSED OIL IN THE GULF OF MEXICO IN THE AFTERMATH OF THE DEEPWATER HORIZON BLOWOUT

0940 – 1000 Lewis, Mark David; Gould, Richard W; Ladner, Sherwin; Gallegos, Sonia; Jolliff, Jason; Bennert, Ellen; Li, Rong-Rong - SPECTRAL AND SPATIAL ANALYSIS OF THE GULF OF MEXICO OIL SPILL USING SATELLITE AND *IN SITU* DATA

1000 – 1020 Break

Invited Lectures

Chairperson: Carlos Del Castillo

1020 – 1050 Datskos, Panos; Rajic, Slobodan; Lavrik, Nickolay - NANO/MICRO-ELECTRO-MECHANICAL SYSTEMS (NEMS/MEMS): CANTILEVERS

1050 – 1120 Kattawar, George W. - OCEAN OPTICS IN THE NEAR FUTURE 5-10 YEARS OUT, WHERE WE'RE HEADED AND CURRENT CHALLENGES

Closing Remarks

11:20 – 12:00

Abstract Listing Alphabetical by Presenting Author

MULTI- AND HYPERSPECTRAL OCEAN COLOR MEASUREMENTS FROM LONG ISLAND SOUND OBSERVATION PLATFORM (LISCO): COMPARISON WITH SATELLITE MEASUREMENTS & ASSESSMENTS OF UNCERTAINTIES

Ahmed, Samir¹; Arnone, Robert²; Gilerson, Alexander³; Harmel, Tristan³; Hlaing, Soe³; Weidemann, Alan²

¹City College of New York 160 Convent Avenue, New York, NY, 10031, United States; ²Naval Research Laboratory, Stennis Space Center, Mississippi, 39529 - 5004, United States; ³160 Convent Avenue, New York, NY, 10031, United States

The recently established Long Island Sound Coastal Observational platform (LISCO) near Northport, NY, combines co-located Multispectral SeaPRISM and hyperspectral HyperSAS radiometers for ocean color measurements. LISCO substantially expands observational capabilities for the continuous monitoring and assessment of the quality of ocean color remote sensing data, and improves potential for cal/val of current and future Ocean Color satellite observations, as well as for inter-satellite validation and better characterization of measured spectra in coastal waters. Results of measurements by both instruments, in operation since October 2009 are presented, evaluated and compared with the data of ocean color satellite sensors. Uncertainties related to the bi-directional reflectance distribution function (BRDF) corrections in coastal waters, adjacency effects and different methods of measurements of diffuse atmospheric transmittance are assessed based on the matchups obtained with ocean color satellite data in the area of the platform. Preliminary results clearly show the advantages of instrument co-location and the potential for the validation of the current (MODIS and MERIS) and future (NPOESS, Sentinel) ocean color satellites.

EXTENDED RANGE, NON-LINE-OF-SIGHT (NLOS) UNDERWATER IMAGING USING A TIME VARYING INTENSITY (TVI) APPROACH.

Alley, Derek Michael¹; Mullen, Linda¹; Laux, Alan¹; McBride, Walton²

¹NAVAIR 22347 Cedar Point Road, Patuxent River, MD, 20670-1161, United States; ²Planning Systems Incorporated/QinetiQ North America, Stennis Space Center, MS, 39529, United States

Degraded Visual Environments (DVEs) such as fog, sand, and turbid ocean water severely affect the performance of conventional imaging systems that are based on considering only unscattered line-of-sight photons as the useable signal. The primary challenge in DVEs is to overcome the large amounts of light scattering that limit both image resolution and contrast in today's imaging systems. Researchers at the Naval Air Systems Command have developed a non-line-of-sight (NLOS) imaging system by modernizing the time-varying intensity (TVI) approach that originated in the early 1970's at the Scripps Visibility Laboratory. Besides using scattered light as a useable signal as in the TVI approach, our engineers have developed an innovative wireless communication paradigm that allows a substantial physical separation between laser source and receiver components. This method sends coded information about the laser source scanning sequence via photons scattered from the target and the medium between target and receiver. The receiver component is then able to collect the information-laden scattered light and to reconstruct the scanning sequence, resulting in amazingly clear imagery. This crucial wireless capability allows the NLOS imaging system to operate in dangerous environments without the need of a tether between the laser source and receiver components. The NLOS approach also enables the capability to "see around corners", a subject that has attracted considerable attention lately. Laboratory water tank experiments were conducted with the wireless bistatic NLOS imager to evaluate the effect of system and environmental variables on its performance. An interactive computer simulation was developed as an engineering tool to help evaluate the effect of the many variables that may affect NLOS system performance. Results from experiments and simulations will be discussed and compared. They show that the NLOS concept can be applied to less scattering environments as well, expanding its list of promising applications.

LATEST NEWS ON REMOTE SENSING OF PHYTOPLANKTON FUNCTIONAL GROUPS: WHAT WE CAN DO NOW AND WHAT CAN WE EXPECT IN THE FUTURE?

Alvain, Severine¹

¹LOG / ULCO / CNRS 32 avenue Foch, Wimereux, 62930, France

Biogeochemistry of the ocean is strongly linked with the ecosystem composition and more particularly with the vegetation part of it. Proper knowledge and prediction of many essential biogeochemical cycles strongly depends on the nature of the phytoplankton ecosystem. It is thus of great importance to improve our knowledge about phytoplanktonic ecosystem composition at large scale: spatial and temporal distribution, responses to climate variability? New remote sensing observations now give us the opportunity to acquire original information for these essential questions. Thus, some algorithms have been developed recently to detect phytoplankton groups (PFTs) from marine signal anomalies acquired by classic ocean color satellites. In this talk I will focus on latest remote sensing of phytoplankton methods: What is available today? What can we expect in the future: limitations and improvements?

INTERCOMPARISON OF ATMOSPHERIC CORRECTION ALGORITHMS APPLIED TO HICO IMAGERY

Amin, Ruhul¹; Gould, Richard¹; Hou, Weilin¹; Martinolich, Paul¹; Montes, Marcos²

¹Naval Research Lab., Stennis Space Center, Bldg 1009, Code 7330, Stennis Space Center, MS, 39529, United States; ²Naval Research Lab., Code 7212, Washington, DC, 20375, United States

The Hyperspectral Imager for the Coastal Ocean (HICO) has been operating aboard the International Space Station since installation on 24 September 2009. HICO provides 100 m resolution hyperspectral imagery optimized for the coastal ocean. Accurate retrieval of bio-optical properties from ocean color imagery relies on accurate atmospheric correction; a small inaccuracy in atmospheric correction can lead to significant errors in the retrieved products. We examine results from three atmospheric correction approaches applied to HICO data, and compare the results to those from the standard multispectral atmospheric correction.

One approach was to “hyperspectralize” the standard multispectral atmospheric correction algorithms applied to SeaWiFS and MODIS imagery. This involved adapting the standard multispectral Gordon/Wang NIR atmospheric correction by spline interpolation of the aerosol and Rayleigh radiances using the MERIS input aerosol and Rayleigh tables as “control points”. A second approach is to automate the Cloud and Shadow atmospheric correction methods. This is a scene-dependent method that requires accurate detection of cloud and shadow, but no additional ancillary information (such as aerosol optical depth, ozone, etc.). Although clouds are relatively easy to detect (we use NIR radiance threshold for cloud detection), detecting their shadows over water is quite challenging. We developed an approach that works reasonably well over homogeneous water bodies. It is based on the fact that the sensor radiance measured over water pixels is composed of three components: the direct and diffuse radiance, and the path radiance, while the radiance of corresponding shadow pixels consists of just the reflection of the diffuse sky light and the path radiance. Since HICO is hyperspectral, we found that integrating the blue channels and applying a sliding box (normalizing the integrated value by the mean) enables us to automatically detect cloud shadows in the imagery. The third approach we examine is TAFKAA, a hyperspectral atmospheric correction algorithm developed specifically to address the confounding variables associated with aquatic remote sensing application. The algorithm uses lookup tables generated with a vector radiative transfer code to estimate remote sensing reflectance based on the spectral characteristics of the at-sensor radiance data. We present some preliminary results comparing the three atmospheric correction approaches.

OPTICAL PARTICLE BACKSCATTERING IN CONTRASTED BIO-OPTICAL OCEANIC REGIMES OF THE MEDITERRANEAN SEA (BOUSSOLE SITE), THE SANTA BARBARA CHANNEL, CALIFORNIA (PLUMES AND BLOOMS STATIONS) AND THE SARGASSO SEA (BERMUDA BIO-OPTICS PROJECT)

Antoine, David¹; Siegel, David A²; Kostadinov, Tihomir²; Maritorena, Stéphane²; Nelson, Norm B²;

Gentili, Bernard¹; Vellucci, Vincenzo¹; Guillocheau, Nathalie²

¹CNRS-LOV LOV, Caserne Nicolas, Quai de la Darse, Villefranche sur mer, 06230, France; ²UC Santa Barbara, Santa Barbara, CA, 93106-3060, United States

Variability in the optical particle backscattering coefficient, *bbp*, is investigated in oceanic waters from two sites, namely the *BOUée pour l'acquiSition d'une Série Optique à Long termE* site (BOUSSOLE) in the northwestern Mediterranean Sea and the *Plumes & Blooms* (PnB) stations in the Santa Barbara Channel, off southern California. Putting together data from these two sites allows covering the two orders of magnitude in *bbp* possibly encountered in the open ocean. A conspicuous relationship is found between *bbp* at wavelengths of 442 and 555 nm and the chlorophyll concentration, Chl. Data are largely spread around this relationship, however, which makes Chl a poor predictor of *bbp*. A tighter relationship is found between *bbp* and the beam attenuation coefficient for particles at 660 nm, *cp*(660). The backscattering ratio, *bp*, i.e., the ratio of *bbp* to particle total scattering, *bp*, ranges from about 0.2% to 1%, similarly to values previously reported in oceanic waters. No relationship is found between *bp* and Chl, whereas a significant spectral dependence is found between 442 and 555 nm. Optical closure is obtained between field determinations of *bbp* and their values derived from inversion of measurements of the irradiance reflectance, *R*, and of the diffuse attenuation coefficient for downward irradiance, *K_d*. The same inversion applied to *R* and *K_d*'s at a third oceanic site, namely the *Bermuda Bio-optics Project* (BBOP) in the oligotrophic Sargasso Sea, provides coherent results in terms of the *bbp*-Chl relationship. Extension of this inversion to satellite-derived marine reflectances shows degraded performances.

AN INVESTIGATION OF INPUTS OF CARBON, NUTRIENTS, AND GROUNDWATER IN COASTAL FLORIDA USING COLORED DISSOLVED ORGANIC MATTER

Arellano, Ana Rosa¹; Coble, Paula¹; Conmy, Robyn²

¹USF 140 7th Ave S., St Petersburg, FL, 33701, United States; ²EPA 1 Sabine Island Dr., Gulf Breeze, FL, 32561, United States

Very few studies of the exchange of water between aquifers and the ocean have been conducted along Florida coast. King's Bay is a manatee sanctuary located on the West Florida Shelf. Over the past 25 years, springs supplying groundwater to King's Bay have shown a three-fold increase in nitrate concentration. It has been challenging to track sources of both nutrients and other water quality parameters because there are multiple water supplies to King's Bay. This project seeks to establish relationships between fluorescent dissolved organic matter and groundwater source for this spring-fed watershed in western Florida. High resolution fluorescence spectroscopy will allow discrimination of source water type in the King's Bay watershed, including discrimination between deep and shallow aquifers and among groundwater, wells, springs, and surface water sources. Statistical relationships between optical properties and other water quality parameters will be determined. The goal of this project is to improve the estimate of water, nutrients, and carbon from groundwater discharge into the coastal zone. The project will improve understanding of carbon cycling in coastal areas where groundwater sources are significant, as well as assist in management and mitigation of freshwater resources. Even though the project is in its initial stages, preliminary data will be presented.

SPATIAL AND TEMPORAL UNCERTAINTY OF SATELLITE OCEAN COLOR PRODUCTS USING AERONET OCEAN COLOR

Arnone, Robert¹; Fargion, G.²; Scadino, T.¹; Lawson, A.¹; Ladner, S.¹; Ahmed, S.³; Weidemann, Alan.¹; Gibson, W.⁴; Zibordi, Giuseppe.⁵; Feng, Hui.⁶; Holben, B.⁷; Davis, Curtiss.⁸

¹NRI code 7330, ssc, MS, 39529, United States; ²CHORES, San Diego, CA, 39154, United States; ³CUNY, New York, New York, 10016, United States; ⁴LSU, Baton Rouge, LA, 70808, United States; ⁵JRC, ISPRA, Italy, 00, Italy; ⁶UNH, Durham, NH, 03824, United States; ⁷NASA Goddard, Greenbelt, Maryland, 20771, United States; ⁸Oregon State University, Corvallis, Oregon, 97331-4501, United States

A real time match-up of satellite products from different satellite sensors was evaluated using multiple Aeronet OC insitu data for coastal product validation. A time-series of MERIS, MODIS, SeaWiFS products (remote sensing reflectance (RRS), Inherent Optical Properties, and aerosol optical depths AOD)) were validated with 4 aeronet sites in different coastal water sites. The spatial variability of satellite products at different resolutions (250m, 300m and 1000m) is a significant contributor to the uncertainty of satellite product. Additionally, the variability of the daily changes in AOD and RRS as measured by a 'point' Aeronet OC site is another uncertainty in product validation. We evaluated these uncertainties at different coastal locations for the time period and contrasted the uncertainty at different satellites and different satellite resolutions. We demonstrated, higher spatial sensor resolution reduced the uncertainty in coastal areas. A web site has been developed to provide real-time match – up and product uncertainty at multiple areas and satellites. This monitoring capability is designed to help determine; 1) product drift, 2) instability of coastal algorithms, 3) inter-satellite uncertainty.

APPLICATIONS OF NEW REGIONAL OCEAN COLOR REMOTE SENSING ALGORITHMS IN AN URBANIZED ESTUARY; TSM TRANSPORT DURING RECORD 2010 NEW ENGLAND FLOODS AND LINKS TO LAND USE

Aurin, Dirk¹; Dierssen, Heidi¹

¹University of Connecticut 1080 Shennecossett Road, Groton, CT, 06340, United States

Until recently, remote sensing of optical and biogeochemical properties of the Long Island Sound estuary (LIS) in northeastern United States was confounded by the optical complexity of its waters. Strong, episodic delivery of suspended sediments and dissolved materials from two major river sources generates turbid, brown plumes stretching into the estuary and beyond. High nutrient abundance in the urbanized upper estuary (near New York City) leads to highly concentrated and diverse phytoplankton populations. Vigorous tidal and sub-tidal forces mix sediment-dominated and phytoplankton-dominated waters with North Atlantic shelf waters leading to extremely high variability in optical properties. A new regionally tuned semi-analytical ocean color algorithm (QAALIS) has been developed which can accommodate this variability in optical properties across the region and retrieves absorption and backscattering coefficients, as well as total suspended materials (TSM) and – to some extent – chlorophyll concentration (Chl). Applying the QAALIS, we are able to gain insights into how the system is impacted by natural forcing, such as the record New England flooding events during spring 2010. TSM (derived from MODIS retrievals of the backscattering coefficient at 660 nm) is mapped across the region for the periods before and after the flooding, and shows that transports at the mouth of the Hudson River are roughly three-fold higher than at the mouth of the Connecticut River, even though flow rates were comparable. A likely explanation for the disparity in the export of TSM between these two river systems is the relative development of their lower watersheds, wherein the banks of the lower Connecticut River are principally rural and characterized by marsh and woodlands, while the Hudson River is highly urbanized and characterized by extensive coverage of impervious surface.

A NEW NIR-VISIBLE ALGORITHM FOR ATMOSPHERIC CORRECTIONS OVER TURBID WATERS

Babin, Marcel¹; Mazeran, Constant²

¹Université Laval & LOV-CNRS 1045, avenue de la Médecine, local 2078, Université Laval, Québec, QC, G1V 0A6, Canada; ²ACRI-ST, 260, route du Pin Montard, BP 234, Sophia Antipolis, Cedex, 06904, France

We present a new algorithm for atmospheric correction of ocean color remote sensing data collected over turbid waters. The algorithm uses 5 MERIS bands (560, 620, 709, 775 and 865 nm) and is based on the inversion of forward ocean and atmosphere optical models. The visible wavebands were chosen to limit of complexity the ocean model. The inversion method accounts for the uncertainties of this ocean model, which was parameterized using a large data set of coastal-water optical properties. The algorithm is thoroughly assessed using a blend of artificial, *in situ* and satellite data, and compared with the current

operational algorithms of the MERIS and MODIS sensors. The latter algorithms use red and NIR wavebands. The virtue of atmospheric correction algorithms that use visible bands in addition to NIR ones, is to avoid extrapolation of aerosol reflectance over a large spectral range toward smaller wavelengths, and to obtain a large ocean signal that facilitates the deconvolution of ocean and atmosphere. They are expected to prevent typical underestimation of ocean reflectance. They require, however, the use of a universal optical model for the ocean that unavoidably involves significant uncertainties. The assessment of our algorithm nevertheless confirms that using few visible wavebands in atmospheric corrections provide more robust atmospheric corrections in moderately to highly turbid waters. Results are shown for the plumes of the Mackenzie, Amazon and Rio del Plata Rivers.

REMOTE SENSING OF SALINITY IN CHANGJIANG PLUME BY MODIS DATA

Bai, Yan¹

¹Second Institute of Oceanography, State Oceanic Administration 36 Baochubei Road, Hangzhou, 310012, China

The Changjiang River is the third largest river with large fresh water flux in the world, which has a great impact on the ecosystem of East China Sea (ECS), the 11th largest marginal sea. A good relationship was found between salinity and the absorption coefficient of color dissolve organic matter (CDOM) at 400nm, based on the *in situ* data of a large field survey in ECS in the summer of 2006, with $R=0.95$ and $SD=3.38$. Such conservation relationship showed that the absorption coefficient of CDOM (A_{cdom}) can be a good proxy to monitoring the variation of river plume and the scale of its influenced area. However, the atmospheric correction for turbid water and the separation of absorption coefficient between non-algae particles and CDOM are two major problems in the plume monitoring. In this paper, we used the SWIR atmospheric correction algorithm for turbid water instead of near-infrared bands to get the spectral water-leaving radiances product. Then, a quasi-analytic remote sensing algorithm of CDOM has been developed, which can separate the absorption coefficient between CDOM and organic detritus. And then, the A_{cdom}(400) was transformed to the salinity. Based on these algorithms, the salinity images were produced with the MODIS data during the cruise time in ECS in the summer of 2009; the MODIS-derived salinity data validated with the independent salinity data showed a good consistent result. Finally, variations of the Changjiang River plume were analyzed with the MODIS data, which showing the influenced scales and shapes of low-salinity plume varied with the Changjiang river flux and prevailing wind direction.

INSIGHTS FROM THE GULF OF MAINE NORTH ATLANTIC TIME SERIES (GNATS)- AN OPTICAL WINDOW INTO THE CHANGING BIOGEOCHEMISTRY OF THE COASTAL OCEAN

Balch, William¹

¹Bigelow Laboratory for Ocean Sciences POB 475, 180 McKown Point Road, W. Boothbay Harbor, ME, 04575, United States

The Gulf of Maine North Atlantic Time Series (GNATS) is a transect time series extending between Portland, ME and Yarmouth, NS. It has been in operation for 12 years. A host of apparent and inherent optical properties are measured from ferries, ships of opportunity, gliders and satellite sensors. The power of GNATS is the parallel set of biogeochemically-relevant variables primarily related to the carbon cycle. Trends in optical properties over the time series are directly relevant to climate change as well as changes in the carbon cycle in this Case II shelf sea. Analysis of particle size distribution functions (PSDFs) and independent biogeochemical data reveals some highly significant covariation over time and space but with only low to moderate correlation. Indeed, the particle size distribution is important to the optical properties in these waters. Moreover, the PSDF reveals several important aspects of the ecology and carbon cycling of the region but there are some significant limitations. In toto, the GNATS data set allows verification of the important (as well as not-so-important) links between optics and biogeochemistry of coastal waters.

IN-SITU RADIOMETRIC MEASUREMENT PROTOCOL AND DATA ANALYSIS, INCLUDING THE EFFECTS OF TILT ON DOWNWELLING SOLAR IRRADIANCE

Barker, Kathryn¹; Huot, Jean-Paul²; Moore, Gerald³; Mazeran, Constant⁴; Lerebourg, Christophe⁴; Lavender, Samantha¹

¹ARGANS Limited Unit 3, Drake Building, Tamar Science Park, Plymouth, PL6 8BY, United Kingdom; ²Electromagnetics and Space Environment/TEC-EES, ESTEC, Noordwijk, Holland, 299 2200 AG, Netherlands; ³Bio-Optika, Crofters, Plymouth, Cornwall, PL18 9NQ, United Kingdom; ⁴ACRI-ST 260, Route du Pin Montard, Sophia Antipolis, Cote d'Azur, B.P 234, 06904, France

In support of MERIS calibration and validation activities, product evaluation and the third MERIS reprocessing, the MERIS Data Quality Working Group (QWG) and the MERIS Validation Team (MVT) work closely together to provide quality-controlled in-situ radiometric matchup datasets. The MERIS Matchup In-situ Database (MERMAID) provides a valuable, centralised tool for these activities, making available concurrent in-situ and MERIS datasets of fully normalised water reflectances, $\rho_{wn}(\lambda)$, from a wide range of water types, atmospheric parameters (aerosol optical, $\tau(\lambda)$, and angstrom exponent ($\alpha(\lambda)$), and in-situ data flagging. MERMAID comprises in-situ ρ_w from several measurement approaches and instruments, from fixed buoys and towers to floating instrumentation rigs, and necessary to the validation is an understanding of the measurement protocols followed by Principle Investigators. As such, MERMAID is now accompanied by a document of carefully screened protocols.

In collaboration with PIs, parallel analysis of protocols and matchup data identified areas of methodologies which are particularly sensitive to measurement errors. We will present the results of an investigation deriving from this, showing how tilt on irradiance sensors can seriously affect measurements of surface total downwelling irradiance ($E_s(\lambda)$), and have consequent impacts on the accuracy of ρ_w and matchup results, with the potential for subsequent error propagation to studies using this data. The investigation utilised the MERMAID atmospheric parameters and intermediate MERIS products from the atmospheric correction to compute theoretical surface E_s , and also the in-situ parameters provided by PIs. Comparisons were made between computed theoretical E_s using MERIS lookup tables and in-situ E_s , and also between in-situ ρ_w computed using 'MERIS-like' E_s (termed ' ρ_{w_ISME} ') and MERIS ρ_w . Results indicated the need to include in MERMAID 'homogenised' versions of datasets (i.e. ' ρ_{w_ISME} ') alongside the in-situ ρ_w , both of which contributed to the MERIS vicarious adjustment and BPAC developments, also to be presented at Ocean Optics XX.

POLARIMETRIC REMOTE SENSING OF OCEAN WAVES

Baxter, Becky¹

¹Georgetown University 37th and O Streets, NW, Washington, DC, 20057, United States

The polarization state of light contains valuable information about the surface orientation, surface roughness, and index of refraction of imaged scenes. This characteristic of reflected light can be exploited to expand and improve upon traditional non-polarimetric passive ocean remote sensing capabilities. Polarimetric remote sensing of the ocean surface has the potential to improve wave observations since its response is a function of the two-dimensional wave slope field and significant wave height. Thus, these observations can provide sea state measurements over broad regions and in areas devoid of wave buoys. The ability to remotely capture the surface slope field and its evolution over time and space will lead to better physical understandings of wave dynamics and wave interaction with currents and bathymetry.

According to Fresnel reflection, light reflected at the ocean surface will become partially linearly-polarized with the polarization axis determined by the normal to the plane of reflection. By measuring the polarization of reflected light at two or more orientation angles, we can uniquely define the RMS local surface attitude for each pixel, and thus the slope field. Once the two-dimensional slope field is calculated, the significant wave height can be obtained through integration. By collecting polarimetric, time-series imagery, full 3D frequency-wavenumber spectra of the wave height field may be obtained. This is an improvement over previous remote-sensing, time-series techniques which produce 3D slope spectra with a transfer function containing an unknown gain between slope and wave height.

In this paper, we present preliminary analysis of airborne multi-spectral polarimetric imagery collected over a deep-water buoy using Areté Associates' Airborne Remote Optical Spotlight System-MultiSpectral Polarimeter (AROSS-MSP). AROSS-MSP is a research-grade imaging system capable of measuring four color bands (blue, green, red, and near-infrared) and three polarization states for the full linear polarization response of the imaged scene. At typical flight altitude (10,000 ft), the camera resolution is nominally 1 meter, covering a 2.4 square kilometer area with a frame rate of 2 Hz. At 1 meter resolution, the system captures the large wind waves (>2m wavelength) and swell which combined define the significant wave height of the sea. We present data collected over the mid-Atlantic Bight and coastal Oregon in 2008 and 2009. Comparisons between our multispectral polarimetric data, *in situ* buoy observations, and modeled results of the expected polarimetric signature show good agreement. The model incorporates two sources of radiance/polarization reaching the sensor: surface reflected sky radiance and scattered path radiance. The latter accounts for a significant portion of the total radiance and strongly affects the polarization state. These preliminary results are encouraging and a step towards the ultimate goal of remotely collecting wave height observations from airborne polarimetric imagery. Approved for Public Release, Distribution Unlimited

THE 'CRITICAL DEPTH HYPOTHESIS' VERSUS THE 'DILUTION-RECOUPLING HYPOTHESIS' OF PHYTOPLANKTON BLOOMS

Behrenfeld, Michael J¹; Boss, Emmanuel²

¹Oregon State University Cordley Hall 2082, Corvallis, OR, 97331, United States

²University of Maine 5706 Aubert Hall, Orono, ME, 04469-5706, United States

The Critical Depth Hypothesis formalized by Sverdrup attempts to explain the occurrence vernal phytoplankton blooms and has served as a cornerstone in plankton ecology for over 50 years. The central tenet of the hypothesis is that blooms are caused by enhanced growth rates in response to improved light, temperature, and stratification conditions. The annual cycle of phytoplankton biomass was revisited using satellite data for the subarctic Atlantic. Results showed that (1) phytoplankton biomass begins to accumulate in the winter when mixed layer depths are at a maximum, not in the spring, (2) coupling between phytoplankton growth and losses increases during spring stratification, rather than decreases, and (3) maxima in net population growth rates are as likely to occur in midwinter as in spring. These satellite-based findings were then re-evaluated and confirmed using continuous, multi-year optics measurements from a profiling float. Together, these data challenge the Critical Depth Hypothesis and a 'Dilution-Recoupling Hypothesis' hypothesis is proposed to account for the new observations.

ON THE ROLE OF SEA ICE MELTING ON NEAR-SURFACE VERTICAL VARIABILITY OF PARTICULATE ABSORPTION COEFFICIENT IN THE ARCTIC OCEAN

Bélanger, Simon¹; Ehn, Jens²; Raimbault, Patrick³; Leymarie, Edouard⁴; Doxaran, David⁴; Hooker, Stan⁵; Babin, Marcel⁴

¹Université du Québec à Rimouski 300 allée des ursulines, Rimouski, QC, G5L 3A1, Canada; ²Marine Physical Laboratory, San Diego, CA, 92093-0238, United States; ³LMGEM, Marseille, Marseille, 13288, France; ⁴Laboratoire d'Océanologie de Villefranche, Villefranche-sur-mer, Alpes Maritimes, 06238, France; ⁵NASA/GSFC, Greenbelt, MD, 20771, United States

Remotely sensed ocean color data can be used to derive the absorption coefficient for marine particles within a surface layer that corresponds to slightly more than the first attenuation depth (1/K_d). During the Malina expedition to the Canadian Beaufort Sea, vertical profiles of the spectral particulate absorption coefficient (a_p) were measured from samples taken at discrete depths using a spectrophotometer. An improved quantitative filter-pad technique approach, in which the filter absorbance was determined by placing the filter inside a large integrating sphere, was used. The method is compared to a_p measurements performed using a Point-Source Integrating Cavity Absorption Meter (PSICAM), which is theoretically free of scattering errors. Phytoplankton and non-algal particles absorption coefficients (a_{phys} , a_{nap}) were

distinguished after pigment extraction with methanol. The results show inhomogeneous vertical distribution of a_p within the first attenuation depth. Most of this surface stratification in a_p can be explained by higher a_{nap} within the first meter from the sea surface. Bio-optical and chemical analyses provide insights on the origin of this particulate-rich layer, which seems related to melt water from sea ice. The implications for ocean color remote sensing data interpretation will be discussed.

BACK-SCATTERING PROPERTIES OF THE EUROPEAN COASTAL WATERS

Berthon, Jean-Francois¹; Zibordi, Giuseppe¹; Canuti, Elisabetta¹; Jankowski, Lukasz¹

¹E.C. Joint Research Centre Via Fermi, Ispra, 21020, Italy

The particulate back-scattering coefficient bbp , together with the absorption coefficient a , determines the light signal emerging from the sea surface. The spectral dependence of bbp and the intensity of the back-scattering ratio bbp/bp provide information on the composition of particles and their properties.

The present study is based on a unique and consistent bio-optical data set (JRC “BioMaP” comprising more than 1500 stations) including apparent and inherent optical properties as well as optically significant constituents collected during the last 10 years in different European coastal seas. The sampled basins include the Adriatic Sea, the Ligurian Sea, the Eastern Mediterranean Sea, the western Black Sea, the English Channel and North Sea, the northern and southern Baltic Sea.

Focus is brought here into the variability of the magnitude and spectral dependency of bbp and bbp/bp for these highly diverse optically complex environments (e.g., the beam attenuation coefficient at 412 nm varies from less than 0.1 to 15 m^{-1} while the Chlorophyll a concentration ranges between 0.03 and 60 $mg\ m^{-3}$).

At 442 nm, bbp varies between 0.0003 and 0.2 m^{-1} (with bbp/bp between 0.002 and 0.04) and the average exponent describing its power decrease in the visible goes from 0.4 (English channel) to 1.9 (Eastern Mediterranean Sea), in rough agreement with the assumption that it should vary from 0 in turbid coastal waters to 2 in oligotrophic waters. Globally, bbp/bp decreases from the blue to the green according to a power function with an average exponent equal to 0.80 (+/- 0.62). As expected, bbp at 442 nm is globally well correlated with the total suspended matter ($r^2=0.73$) and not with Chla ($r^2=0.27$) whereas bbp/bp is non-linearly correlated with the Chla/TSM ratio.

Empirical models describing these variations and implications on the variability of the “remote-sensing ratio” $bb/[a+bb]$ in coastal waters are presented and discussed.

POLARIZED DOWNWELLING RADIANCE DISTRIBUTION NEAR THE OCEAN SURFACE

Bhandari, Purushottam¹; Logan, Luke²; Voss, Kenneth J²

¹University of Miami 1320 Campo Sano Dr., Coral Gables, FL, 33146, United States; ²1320 Campo Sano Dr., Coral Gables, FL, 33146, United States

It is difficult to study the downwelling polarized radiance distribution near the surface of the ocean because of its very dynamic nature and because the four images that are required to study all the four Stokes Parameters should be taken simultaneously. We have built the “Polarized Downwelling Radiance Distribution Camera System (DPOL)” which collects four separate fisheye images, each with different polarization information. We have used this instrument in the Santa Barbara Channel and off Hawaii to obtain the four Stokes parameters I, Q, U and V, degree of polarization and the angle of plane of polarization. We find that near the surface, for clear sky, the dominant source of polarization is the refracted sky light. As one progresses deeper in the water column the polarization due to light scattering by water increases and polarization due to the water becomes dominant.

PHYTOPLANKTON RESPONSE TO EPISODIC EVENTS AND LONG-TERM TRENDS IN THE GREAT BARRIER REEF LAGOONAL WATERS: TOWARDS A REGIONAL CHARACTERISATION.

Blondeau-Patissier, David¹; Brando, Vittorio E.²; Dekker, Arnold G.²; Phinn, Stuart R.³; Weeks, Scarla J.⁴; Schroeder, Thomas⁵; Park, Young Je²

¹Centre for Spatial Environmental Research, The University of Queensland AND Environmental Remote Sensing Group, CSIRO Land and Water C.S. Christian Laboratory, Clunies Ross Street, Canberra, 2601, Australia; ²Environmental Remote Sensing Group, CSIRO Land & Water, Canberra, ACT, 2601, Australia; ³Centre for Spatial Environmental Research, School of Geography, Planning and Environmental Management, The University of Queensland, Brisbane, QLD, 4072, Australia; ⁴Global Change Institute, and Centre for Spatial Environmental Research, The University of Queensland, Brisbane, QLD, 4072, Australia; ⁵Environmental Remote Sensing Group, CSIRO Land & Water, Brisbane, QLD, 4068, Australia

Central to the structure and functionality of marine and freshwater ecosystems, understanding phytoplankton dynamics is essential for coastal managers and decision makers. Yet little is known about the temporal frequency and spatial distribution of algal blooms within the Great Barrier Reef (GBR). Often depicted as a pristine ecosystem with clear blue and warm lagoonal and reef waters, the GBR is in fact much more complex with bio-geochemical concentrations and bio-optical properties ranging from oligotrophic to mesotrophic, and even eutrophic in some of its subregions. Primarily limited by nutrients availability, phytoplankton growth in the GBR can show sudden pulses as a response to (1) nutrient-rich upwelling events and (2) large quantities of sediments and organic matter brought into the nearshore waters via episodic river runoffs. Using eight years of MERIS ocean color and MODIS SST data, we will show how this increase in productivity dynamically propagates through the lagoon. Temporal and spatial differences in phytoplankton dynamics in the various subregions of the GBR will be discussed using climatology-based and trend analyses as a first approach for a better understanding of bloom cycles in the GBR. We believe this information can contribute to the mapping of the GBR productivity at a regional scale.

EVALUATION OF THE COUPLED ATMOSPHERIC-OCEANIC RADIATIVE TRANSFER MODEL SCIATRAN EMPLOYING IN-SITU AND SATELLITE REMOTE SENSING MEASUREMENTS

Blum, Mirjam¹; Rozanov, Vladimir¹; Dinter, Tilman¹; Bracher, Astrid¹

¹University of Bremen P.O. Box 330440, Bremen, D-28334, Germany

The atmospheric radiative transfer model SCIATRAN [V. V. Rozanov *et al.*, 2002; A. Rozanov *et al.*, 2005, 2008] was extended to include the radiative transfer within the ocean. This was done by including the inherent optical properties of water, and additionally extending the data bases by in-situ measurements of the optical important properties. To evaluate the quality of the coupled version, the model has been compared to MERIS TOA reflectances and reflectances at the top of the surface water by using known input parameters (chl-a concentration, salinity, temperature and depth) from the BOUSSOLE time series measurements [Antoine *et al.*, 2008], and informations about aerosols from AERONET at the corresponding station in Villefranche (optical thickness, phase functions, single scattering albedo and extinction coefficients; PI: Davind Antoine). The results of different sites and seasonal settings (phytoplankton blooms and non-blooms, varying particulate matter concentrations etc.) look very promising for the SCIATRAN model to capture the RT back to the top of the atmosphere. This will improve both the retrieval of different PFTs from high spectrally resolved satellite data as the retrieval of various atmospheric trace gases, such as BrO, NO₂, and glyoxal over ocean water.

OPTICS AND SEDIMENT DYNAMICS

Boss, Emmanuel¹

¹University of Maine 5706 Aubert Hall, Orono, ME, 04469-5706, United States

Optical properties in the coastal ocean can be strongly affected by sediment dynamics (resuspension, settling and aggregation). Optical properties are the most common mean to study particle dynamics. Hence

it is crucial for both the ocean optics and sedimentology communities that the link between optical properties and particles properties be well understood. Unfortunately, sediments exhibit characteristics that preclude Mie theory from being applicable to them; they are not spheres and often form complex aggregates. In this talk I will focus on these problems and suggest some fixes and show field, lab and theory linking sediments and optics.

Thanks to my partners in OASIS, Paul Hill, Tim Milligan and John Trowbridge as well as Wayne Slade for many ideas/comments that made it to this presentation and to ONR for generous and continuous support.

LIGHT ABSORPTION BY PHYTOPLANKTON IN ARCTIC AND SUBARCTIC SEAS: A GLOBAL VIEW

PHYTOPLANKTON GROUPS FROM SPACE USING PHYTODOAS: IMPROVEMENTS BY MULTI-TARGET FITTING, YEARLY DATA SET, VALIDATION AND FIRST APPLICATION

Bracher, Astrid¹; Sadeghi, Alireza²; Dinter, Tilman¹; Schmitt, Bettina¹; Vountas, Marco³; Röttgers, Rüdiger⁴; Peeken, Ilka¹; Ye, Ying¹

¹Alfred-Wegener-Institute for Polar and Marine Research Bussestr. 24, Bremerhaven, 28219, Germany; ²Phytooptics, Institute of Environmental Physics, Bremen, Bremen, 28359, Germany; ³Institute of Environmental Physics, Bremen, Bremen, 28359, Germany; ⁴GKSS, Institute of Coastal Research, Geesthacht, Schleswig-Holstein, 21502, Germany

Simultaneously derived global information on the quantitative distribution of major functional phytoplankton types (PFTs) of the world ocean improves the understanding of the role of marine phytoplankton's role in the global marine ecosystem and biogeochemical cycles. Global biomass distributions from 2008 of different dominant PFTs (Diatoms, cyanobacteria, coccolithophores, Phaeocystis-type-haptophytes) are derived with PhytoDOAS, a method of Differential Optical Absorption Spectroscopy (DOAS) currently specialized for deriving chl-a conc. of PFTs by Bracher et al. (2009) from satellite data of SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric Cartography) on ENVISAT. The method has been improved by simultaneous fitting of the various PFTs. Results of validating the global maps of PFT distribution are validated with collocated pigment water samples analyzed via HPLC from various trans-Atlantic cruises. Phytoplankton groups are calculated from pigments by applying the CHEMTAX program (Mackey et al. 1996) and compared with satellite retrievals. These global PFT data sets can be used as input data for global ecosystem models and first applications of this approach will be presented.

SEASONAL AND INTERANNUAL VARIATIONS IN PHYTOPLANKTON SIZE AND COLORED DETRITAL MATTER ABSORPTION AT GLOBAL AND REGIONAL SCALES, AS DERIVED FROM THE SEAWIFS TIME SERIES

Bricaud, Annick¹; Ciotti, Aurea M.²; Gentili, Bernard¹

¹Laboratoire d'Océanographie de Villefranche, CNRS and Université Pierre et Marie Curie-Paris 6, BP 08, Villefranche-sur-Mer, 06238, France; ²UNESP-CLP/SV, Campus do Litoral Paulista, Praça Infante Dom Henrique s/n°, São Vicente, SP, CEP 11330-900, Brazil

A method has been previously proposed (Ciotti and Bricaud, 2006) to retrieve a size factor for phytoplankton (Sf), absorption coefficients of Colored Detrital Matter (acdm), and associated spectral slope (Scdm), from ocean color measurements. Application of this method to the SeaWiFS data set (1998-2009) allowed us to compare the time and spatial variations of surface chlorophyll concentration (Chl), Sf, acdm(443), and Scdm. As expected, at the global scale, the correlations between these parameters showed large scatter. We focused our discussion on the compared variations over the twelve-year period, for three oceanic areas of biogeochemical importance: the Eastern Equatorial Pacific, the North Atlantic and the Mediterranean Sea. In the three areas, both Sf and acdm(443) present large seasonal and interannual variations, generally correlated to Chl. CDM maxima over time, however, appear in some occasions to last

longer than those of Chl. Very large seasonal cycles are observed for Scdm, which appear to be consistent with photobleaching, challenging the assumption of a constant value commonly used in bio-optical models. In the Equatorial Pacific, the seasonal cycles of Chl, Sf, acdm(443) and Scdm, as well as the relationships between these parameters, are strongly affected by the 1997-98 El Niño/La Niña event, and Sf vs. Chl trends resemble field observations. In the Mediterranean Sea, Sf vs. Chl relationships reveal discontinuities in the expected decrease in cell size with decreasing Chl. Also, Scdm is steeper than in the Equatorial Pacific, which may be associated to photobleaching or indicate newly produced CDOM.

USING SPIKES IN OPTICAL MEASUREMENTS TO TRACK AN AGGREGATE FLUX EVENT FROM AUTONOMOUS PLATFORMS.

Briggs, Nathan¹; Cetinic, Ivona²; Gray, Amanda³; Rehm, Eric³; D'Asaro, Eric³; Lee, Craig³; Perry, Mary Jane²

¹University of Maine 193 Clark's Cove Rd, Walpole, ME, 04573, United States; ²193 Clark's Cove Rd, Walpole, ME, 04573, United States; ³University of Washington APL, Seattle, Washington, 98105, United States

Phytoplankton aggregate sinking events play an important role in the carbon cycle, but these events can be difficult to capture reliably and on a large scale. Low-power optical instruments on autonomous platforms offer one way to address this issue. When a phytoplankton aggregate passes through the sample volume of an optical instrument, it creates an ephemeral spike in measurements of backscattering, fluorescence, or attenuation. We analyzed such spikes from several optical instruments aboard both ships and autonomous gliders south of Iceland and as part of the North Atlantic Bloom 2008 project.

Spikes appeared in the surface measurements of all instruments on all platforms during the height of the spring diatom bloom, increased in depth to 600m within ~10 days, and then decreased in abundance again following the end of the bloom. The spike levels of all instruments were well correlated, but the magnitude of the response depended on the instrument's configuration and internal averaging and the platform's configuration and hydrodynamics. Our findings suggest that the 2008 North Atlantic spring diatom bloom was followed by a mesoscale-wide aggregate flux event and that low-power optical instruments aboard autonomous gliders can reliably capture such events. However, in order to relate these spike measurements to other estimates of aggregate concentration or flux, each instrument-platform configuration should ideally be calibrated *in situ*.

TOWARDS OPERATIONAL COASTAL OCEAN COLOUR PRODUCTS – THE COASTCOLOUR APPROACH

Brockmann, Carsten¹; Sathyendranath, Shubha²; Doerffer, Roland³

¹Brockmann Consult Max-Planck-Str.2, Geesthacht, 21502, Germany; ²Plymouth Marine Laboratory, Plymouth, United Kingdom, 12345, United Kingdom; ³GKSS Research Centre, Geesthacht, Schleswig-Holstein, 21502, Germany

After more than 8 years in space the ESA MERIS instrument has delivered a unique dataset of ocean colour measurements of the coastal zone, at 300m resolution and with a unique spectral band set. This dataset shall be processed with best fitting algorithms for different coastal zones globally distributed. Of most critical importance is the atmospheric correction. A regional approach will be applied in order to account for the reflection, scattering and absorption characteristics of the regionally water surfaces and aerosols. Two types of algorithms – the inversion of radiative transfer model calculations using an artificial neural network (Doerffer) and the Quasi Analytical Algorithm (Lee) – will be combined with the fuzzy logic approach to optically classify the water body. The algorithms will be regionally tuned with specific IOPs, where available, and/or conversion factors from IOPs to concentrations. Investigations will be made to apply higher level algorithms for retrieval of Phytoplankton parameters using the Sathyendranath and Platt model. This work will be undertaken in a large, internationally coordinated effort, where scientists from the regional waters addressed provide requirements, in-situ data for algorithm calibration and validation. This

work is undertaken in the framework of the ESA DUE project Coastcolour. The results will include a coherent processed large data set covering the whole MERIS mission, internationally discussed protocols, and a near real time service for coastal MERIS Full Resolution products.

CIAO: MODEL OF POLARIZATION RADIATION TRANSFER IN ATMOSPHERE – OCEAN SYSTEM

Budak, Vladimir P.¹; Efremenko, Dmitriy S.¹; Gilerson, Alexander²; Klyuykov, Dmitriy A.¹; Korkin, Sergey V.³; Oshchepkov, Sergey L.⁴; Tonizzo, Alberto²; Ahmed, Samir²

¹Moscow Power Engineering Institute (Technical University) Krasnokazarmennaya, 14, Moscow, 111250, Russian Federation; ²Optical Remote Sensing Laboratory, Department of Electrical Engineering, The City College of the City University of New York, New York, NY, 10031, United States; ³NASA Goddard Earth Sciences and Technology Center, University of Maryland, Greenbelt, MD, 20771, United States; ⁴National Institute for Environmental Studies, Tsukuba, Ibaraki, 305-8506, Japan

The Coupled Interface Atmosphere – Ocean (CIAO) code gives the radiation field reflected from atmosphere-ocean system for the purposes of remote sensing as well as the radiation field inside the ocean at an arbitrary depth. We include the atmospheric absorption due to trace gases by means of HITRAN, and aerosol and hydrosol optical properties are included according to definition of Mc Clatchey et al. and O.V. Kopelevich, respectively. The cloud layer is also supposed to be in the model. We consider the sea surface roughness to be non-correlated. The polarization state of the incident collimated beam is assumed to be arbitrary. The algorithm is built upon the matrix solution of the sampled vector radiative transfer equation (VRTE). The sampling of the VRTE is produced with discrete ordinates. We represent light field inside the scattering media as a superposition of the anisotropic and regular (smooth) parts. The anisotropic part is evaluated analytically upon the approximate VRTE solution. This approximate solution is referred as to the Modification of the Spherical Harmonics Method (MSH). The MSH describes forward scattered radiation provided the dispersion of the scattered rays' paths is neglected. It is formulated upon the analysis of the VRTE solution's spatial spectrum – the moments of the VRTE solution. The smoothness of the spatial spectrum caused by significant anisotropy of the light field is used. Such approach reduces the size of vectors and matrices used to compute the regular part and the computation time as well if compared with traditional approach. The computational time does not depend on the thickness of the slab. The impact of the scattering anisotropy was demonstrated not to be significant. Matrix-Operator Method (MOM) describes vertical inhomogeneity of the media. It also yields the effect of ordinates' refraction at the boundary of the slabs with different optical density. The computed code has been developing and applying to the simulation of polarization signals for the GOSAT like space born sensor for the global observations of green house gases. The results of numerical simulations are compared with the measurements over ocean in various water conditions using CCNY hyperspectral multi-angular polarization probe.

RETRAINING THE SEAUV/SEAUVc MODEL FOR IMPROVED ALGORITHM OF DARK, INSHORE WATERS FROM THE GEORGIA COAST, USA

Cao, Fang¹; Reader, Heather¹; Miller, William¹

¹UGA 220 Marine Science BLD, University of Georgia , Athens, GA, 30602, United States

Accurate description of the ultraviolet irradiation (UVR) penetration in the ocean is crucial for the study of the key role of light in the aquatic systems. We have obtained new spatial-temporal scale data including in-situ ocean color (water leaving radiance, $L_w(\lambda)$) and attenuation coefficients ($K_d(\lambda)$), dissolved organic carbon (DOC), and colored dissolved organic matter (CDOM) absorption coefficient ($a_g(\lambda)$) data collected in 2009 and 2010 around Sapelo Island, GA. We then have retrained and validated the Fichot et al. (2008) algorithms (SeaUV and SeaUVc) for improved retrieval of $K_d(\lambda)$ ($\lambda = 325, 340, 380, 412, 443, 490$ nm) and CDOM absorption coefficients ($a_g(320)$) from ocean color data for these darker, inshore waters. Extrapolation of these results to other coastal systems is examined. Preliminary use of a reasonably robust linear relationship between the [DOC] and CDOM absorption coefficients ($r^2 > 0.95$), shows promise for

application with the retrained algorithms to retrieve improved DOC concentrations in nearshore Georgia coastal waters from the remote-sensing ocean color.

REDUCING UNCERTAINTY IN THE PRIMARY PRODUCTIVITY ASSESMENT BY COUPLING SATELLITE AND IN-WATER ROBOTIC MEASUREMENTS

Cetinic, Ivona¹; Weatherbee, Ryan ²; Thomas, Andrew C.²; Perry, Mary Jane¹

¹University of Maine 193 Clark's Cove Road, Walpole, ME, 04573-3307, United States; ²University of Maine/ 5741 Libby Hall, Orono, ME , 04469-5741, United States

Satellite-based measurements of biogeochemical parameters allow us to assess primary productivity all around the globe. However, this cosmopolitan approach is highly depended on cloud coverage, temporal and spatial averaging, as well as the assumptions about the distribution of key parameters in the euphotic zone. The key in defining the uncertainties associated with remote sensing measurements is coupling them with corresponding *in situ* dataset. Biogeochemical measurements collected by an underwater glider enables us to properly address the inaccuracies due to interpixel variability, water-column structure and regionally specific [or regionally varying?] bio-optical regimes. Here we present the dataset from Gulf of Maine, a highly productive complex coastal ecosystem, and that shows how regional tuning of the primary productivity models, by way of *in situ* robots, can improve the inaccuracies associated with remote sensing primary productivity assessment.

PHYTOPLANKTON TYPES AND ABSORPTION PROPERTIES IN THE VICINITY OF MISSISSIPPI RIVER DURING AUTUMN AND SPRING OF 2005-06.

Chakraborty, Sumit¹; Lohrenz, Steven ²

¹The University of Southern Mississippi 1020 Balch Blvd, Stennis Space Center, MS, 39529, United States; ²1020 Balch Blvd, Stennis Space Center, MS, 39529, United States

Data collected in the northeastern Gulf of Mexico near the Mississippi River delta were used to investigate the relation between the phytoplankton pigments, functional types and absorption properties. Two cruises were conducted during periods of low (October-2005) and high (April-2006) river discharge. The October 2005 cruise followed the two major hurricanes, Hurricane Katrina in August and Hurricane Rita in September of 2005. Microphytoplankton dominated in October 2005 while the phytoplankton assemblage was mixed in April 2006, and showed a clear transition from nearshore to offshore stations. The nearshore (low salinity) stations were dominated by microphytoplankton while nano and picophytoplankton dominated the shelf stations. Absorption coefficients were strongly correlated with variations in total chlorophyll a (TChla) and pigment-specific absorption coefficients were lower for microphytoplankton compared to nano and picophytoplankton. However, the average specific absorption coefficients were higher in October 2005 ($a_{ph}(440) = 0.059 \pm 0.03 \text{ m}^2 \text{ mg}^{-1} [\text{Chla}]^{-1}$) in comparison to April 2006 ($a_{ph}(440) = 0.043 \pm 0.017 \text{ m}^2 \text{ mg}^{-1} [\text{Chla}]^{-1}$). Light absorption was dominated by non-pigment components in waters strongly influenced by river discharge during the April 2006 cruise. Overall, chlorophyll-specific absorption coefficients provided useful information about the degree of pigment packaging and its variability within phytoplankton size classes.

INFLUENCE OF MULTIPLE SCATTERING ON THE DOWNWELLING IRRADIANCE AND ON THE DIFFUSE ATTENUATION COEFFICIENT IN COASTAL WATERS.

Chami, Malik¹; Ebert, Kerstin¹

¹Laboratoire Océanographie Villefranche (LOV) La Darse, BP 8, Villefranche sur Mer, 06230, France

The Beer-Lambert law describes light attenuation in the water as exponentially degrading with depth. Many applications in marine optics apply this law to approximate the oceanic radiation field by an exponential decrease. Most notably, the definition of the diffuse downwelling attenuation coefficient K_d and the

definition of euphotic zone depth assume that downwelling irradiance is decreasing as an exponential function.

We investigated here the limitations of the Beer-Lambert law in moderately turbid coastal waters using radiative transfer calculations. A synthetic data set of 160 cases covering realistic inherent optical properties of coastal waters was generated using the ocean-atmosphere radiative transfer model OSOA. The variations of the irradiance with respect to the scattering optical properties of particulate suspended matter (e.g., the single-scattering albedo) and the optical depth are examined. We also investigate how the downward irradiance vertical profile could depart from the exponential approximation.

Our results show that the differences observed between the exact radiative transfer calculations and the Beer-Lambert law increase with high particulate loading and high values of optical depth. These differences are ascribed to the increased influence of multiple scattering processes on the downwelling radiation field. This study highlights that the Beer-Lambert law does not rigorously apply in moderately turbid waters which could lead to important implications for the derivation of the diffuse attenuation coefficient K_d in coastal waters. As an example, we will examine the sensitivity of the accuracy in K_d estimates on the depth interval used for K_d derivation.

POINT SPREAD FUNCTIONS AND VISIBILITY: GAINING CLARITY ON IMAGE PROCESSING IN NATURAL WATERS

Chang, Grace¹; Twardowski, Michael²

¹Sea Engineering, Inc. 200 Washington St., Suite 210, Santa Cruz, CA, 95060, United States; ²WET Labs, Inc., Narragansett, RI, 02882, United States

The point spread function (PSF) is essentially the blurring of an image of a point source taken underwater and is due primarily to scattering by particulates within the water body. Knowledge of the PSF is important for the interpretation of images from underwater electro-optical systems as it can be used to restore or enhance original images that have been modulated or blurred.

The data sets presented here were collected from Scripps Institution of Oceanography (SIO) Pier and in the Santa Barbara Channel as part of the ONR-sponsored Radiance in a Dynamic Ocean (RaDyO) program. The measured optical properties of interest include hyper- and multi-spectral scattering and attenuation coefficients and the volume scattering function. Ancillary physical measurements were collected in conjunction with the optical properties. We compute the PSF and modulation transfer function (MTF), which is the magnitude of the Fourier transform of the PSF, for two different water bodies using empirical and analytical formulations. Additionally, we estimate horizontal and vertical visibility of a target based on the MTF and an empirical relationship. Advanced statistical analysis using continuous wavelet transforms, cross wavelet transforms, and wavelet coherence is employed to investigate the sources of variability of the imaging and visibility parameters and the frequencies at which they occur. Physical forcing (wind stress, shear, etc.) and particle characteristics such as relative density and size distribution are explored as potential causes of image modulation. Results from the two different water bodies: (1) a dynamic shallow-water environment and (2) a relatively clear and deeper water environment are compared.

THE USE OF SPECTRAL REFLECTANCE TO IDENTIFY PHYTOPLANKTON SPECIES SUCCESSION IN COASTAL MAINE

Chase, Alison P¹; Roesler, Collin S²; Hankinson, Sam²; Teegarden, Greg³; Laine, Edward²

¹Bowdoin College 6800 College Station, Brunswick, ME, 04011, United States; ²6800 College Station, Brunswick, ME, 04011, United States; ³Saint Josephs College Maine, Standish, Main, 04084, United States

The annual spring transition from diatoms to dinoflagellates in the Gulf of Maine is an indicator of increased levels of the toxic phytoplankton *Alexandrium fundyense*. Monitoring this species succession using spectral reflectance and ultimately remote sensing is a potentially valuable tool in efforts to detect

harmful algal blooms. To explore the use of ocean color for identifying the diatom to dinoflagellate transition we used a step-wise forward model which incorporates: microscopically determined phytoplankton composition, phytoplankton accessory pigments, phytoplankton absorption, and *in situ* spectral reflectance data. Of importance to the model is the differential absorption of light by the different phytoplankton groups, particularly in the blue-green region of the spectrum. Since the two groups absorb light differently, spectral reflectance values and ratios will vary based on the presence of different species groups, given that in general reflectance varies inversely with absorption. We found that even with high values of CDOM, which absorbs blue-green light similarly to phytoplankton, we could identify the transition from diatoms to dinoflagellates using both simulated and observed reflectance ratios. This finding demonstrates the use of spectral reflectance to identify the onset of an increased dinoflagellate population in the optically complex waters of coastal Maine.

ADVANCED LASER FLUOROMETRY (ALF): NEW INSTRUMENTS, PLATFORMS AND FIELD OBSERVATIONS

Chekalyuk, Alexander¹

¹LDEO of Columbia University 61 Rt 9W, Palisades, NY, 10964, United States

The development of the ALF technology has been recently sponsored by NOAA, NASA, NSF, and NOPP to improve our capacity for characterization of natural aquatic environments. The ALF analytical methods and instruments can be flexibly configured to use in the field/shipboard laboratories and on various platforms (ships, aircrafts, autonomous unmanned vehicles, buoys, and moorings). They uniquely combine spectrally and temporally resolved measurements of laser-stimulated emission. The spectral deconvolution improves assessments of chlorophyll, phycobiliprotein (PBP) pigments, and chromophoric dissolved organic matter. Three spectral types of phycoerythrin are discriminated for characterization of PBP-containing phytoplankton and cyanobacteria. The spectrally-corrected measurements of variable fluorescence yield improved assessments of phytoplankton photophysiological status and biomass, and can be used for more accurate pigment concentration retrievals via accounting for non-photochemical quenching.

The ALF technique has been implemented in a portable benchtop fluorometer for underway flow-through measurements and discrete sample analysis in various shipboard and stationary settings. Feasibility of using the ALF methods and analytical algorithms in the airborne LIDAR settings has been explored under the NASA sponsorship. The new NOPP project is focused on developing the next generation, commercial ALF instruments, including the Aquatic Laser Fluorescence Analyzer (ALFA) and ALF *In Situ* (ALFIS) for oceanographic research, validation of satellite ocean color data, and environmental monitoring.

An extensive series of ALF field measurements in diverse water types, including offshore and coastal zones of Atlantic and Pacific Oceans, Bering, Mediterranean and Arabian Seas, Chesapeake, Delaware and Monterey Bays, and a number of estuaries and rivers, have revealed significant spectral complexity of natural waters. The ALF has been used for studies of mixed phototrophic populations, new ecological or biogeochemical measurements supporting ocean color remote sensing, detection of spectrally variable pigment fluorescence, dysfunctional photosynthetic apparatus and products of pigment degradation, PBP-containing cyanobacteria and cryptophytes. The ALF operational integration into the major oceanographic programs is in progress, including the California Current Ecosystem Long Term Ecological Research (CCE LTER, NSF) and California Cooperative Oceanic Fisheries Investigations (CalCOFI, NOAA).

NATURAL VARIATION OF POLARIZED WATER-LEAVING RADIANCE WITH CDOM: SIMULATIONS AND OBSERVATIONS FOR THE OPEN OCEAN

Chowdhary, Jacek¹; Cairns, Brian²; Ottaviani, Matteo²; Mishchenko, Michael²

¹Columbia University & NASA/GISS 2880 Broadway, New York, NY, 10025, United States;

²NASA/Goddard Institute for Space Studies, 2880 Broadway, New York, NY, 10025, United States

Light scattered in oceanic waters exhibit features as a function of wavelength and scattering angle that vary with the scattering and absorption properties of marine suspended and dissolved matter. However, the features and their angular variations are different for the total and polarized radiance of this light. This suggests that for remote sensing observations over oceans, one can use polarized radiance features to either verify or improve the retrieval of ocean color from total radiance features.

A number of theoretical and experimental studies have been conducted in recent years to explore such applications in spaceborne polarimetry of open oceans. While the emerging results are promising, the studies commonly rely on empirical relationships for the variation of scattering and absorption properties of bulk oceanic waters. The natural variability of these properties can be as large, but the effects of such variability on polarized water-leaving radiance are seldom considered. Addressing the latter variability is particularly important for absorption by colored dissolved organic matter (CDOM). Not only does CDOM absorption strongly affect the underwater light in the blue part of the visible spectrum, it is also highly variable in ways that are difficult to prescribe.

The focus of this talk is on quantifying the variability of CDOM absorption in open oceans, on applying the results to radiative transfer (RT) studies of polarized water-leaving radiance, and on validating the conclusions with data obtained by an airborne polarimeter. We first review the hydrosol model developed for multiangle, multispectral RT studies of polarized water-leaving radiance. Secondly, we use field observations of the diffuse downward irradiance attenuation coefficient to quantify the natural variability of CDOM absorption in open oceans. We then conduct RT computations to assess the natural variability of polarized water-leaving radiance with CDOM. And finally, we validate our results with data obtained by an airborne version of the polarimeter onboard the 2010 NASA/Glory mission.

LIDAR MEASUREMENTS ALONG THE FOOD CHAIN

Churnside, James¹

¹NOAA Earth System Research Laboratory, Boulder, Colorado, U.S.A.

Blue-green light is the best probe available to measure the distribution of marine organisms over a wide range of space/time scales. We are particularly interested in scales that are important for understanding trophic interactions, but too large to be covered quickly by a surface vessel. The utility of aircraft for covering large areas quickly is not a new discovery. By 1920, the menhaden fishery in Chesapeake Bay was using visual observations from aircraft to find fish; a practice that is still used. The invention of the laser suggested the possibility of probing deeper into the ocean and detecting vertical structure with airborne lidar. The application of airborne lidar to commercial fishing has been limited, at least in part because of difficulties in signal interpretation. The potential for ecosystem research is greater, although interpretation remains an issue. Identification of plankton and fish can generally be done by selecting the right combination of polarization, spatial characteristics, and signal strength. Coincident imaging can improve the accuracy of the identification in many cases. These measurements can be combined with selected in-situ sampling to provide even more accurate results. Despite the successes, interpretation of lidar data would benefit from a better understanding of ocean optics in a number of areas. One notable example is scattering by large, non-spherical particles.

OPTICAL PROPERTIES OF DISPERSED AND NON-DISPERSED OIL IN THE GULF OF MEXICO IN THE AFTERMATH OF THE DEEPWATER HORIZON BLOWOUT

Coble, Paula¹; Hu, Chuanmin²; Ivey, James³; Kovach, Charles⁴; Cannizzaro, Jennifer²; English, David²; Arellano, Ana²; Barnes, Brian²; Peebles, Ernst²

¹Univ. South Florida 140 Seventh Ave. S., St. Petersburg, FL, 33701, United States; ²140 Seventh Ave. S., St. Petersburg, FL, 33701, United States; ³Fish and Wildlife Research Institute, St. Petersburg, FL, 33701, United States; ⁴Florida Dept. Environmental Protection, SW District 13051 N. Telecom Pkwy., Tampa, FL, 33637-0926, United States

In response to the sudden and catastrophic blowout of the Deepwater Horizon oil rig in the Gulf of Mexico on April 20, 2010, a team of scientists began to study the optical properties of the oil with the purpose of determining best methodologies for *in situ* tracking of the spill and for detection with satellite remote sensing technologies. Initial efforts using off the shelf oil detection fluorometers provided unsatisfactory results, leading to the clear conclusion that full optical characterization of the spill was needed. Crude petroleum from different wells have been shown to have distinguishing chemical and hence optical properties, chiefly arising from aromatic hydrocarbon content. Polyaromatic hydrocarbons (PAHs) have very high fluorescence efficiencies with distinct spectra, and hence have been used to fingerprint crude oils for decades. Several complicating factors exist in the real world tracking of a spill in seawater. Natural weathering of the oil can include loss of lighter molecular weight components by dissolution or evaporation at the sea surface, photochemical alteration and degradation, and microbial decomposition. Spill control procedures using chemical agents both at the surface to control slicks and at the well head (1500m? depth) further complicate the optical properties of the oil by changing droplet size, altering fluorescence and absorption properties, and changing the density of the plume, thereby causing uncertainty in the probability and location of subsurface plumes.

While this research is currently in the very early stages, initial results indicate that optical backscatter and multichannel fluorescence are sensitive and specific enough to distinguish between oil at different stages of the weathering process. Further studies of this type will be critical in successful mapping and mitigation of oil spill effects, which are projected to significantly impact Gulf of Mexico ecosystems for decades. We will present our preliminary results as well as results of ongoing studies on algorithm development, *in situ* instrument optimization, and efforts to develop an optical methodology for discrimination between oil contamination at trace levels and natural organic components in seawater.

MEASURING THE ABSORPTION COEFFICIENT OF PURE WATER IN THE UV USING AN INTEGRATING CAVITY ABSORPTION METER

Cone, Michael Thomas¹; Lu, Zheng²; Fry, Edward²

¹Texas A&M University 4242 TAMU, College Station, TX, 77843-4242, United States; ²4242 TAMU, College Station, TX, 77843-4242, United States

The Integrating Cavity Absorption Meter (ICAM) provides an excellent means to measure the optical absorption coefficient of pure water. This is due to the long effective path length provided by the high reflectivity walls of the ICAM, as well as its inherent elimination of the effects of scattering.

Pope and Fry (1997) were able to demonstrate the ICAM's effectiveness for 380-700 nm. However, the region from 250-380 nm was still problematic due to a limitation in the reflectivity of the cavity wall materials used in the original ICAM design.

We have developed a new diffuse reflecting material with the highest known reflectivity. The material is a fumed silica powder and has reflectivities of 0.998 at 532 nm, and more importantly 0.996 at 266 nm. This is significantly better than Spectralon, the current industry standard for diffuse reflecting materials, which has reflectivities of 0.991 at 532 nm, and 0.96 at 266 nm. The new material has been further improved by baking the powder under vacuum and backfilling with an inert gas. This was then used to design a new UV-ICAM that can measure the absorption coefficient of pure water from 250-600 nm.

CHARACTERIZING INHERENT OPTICAL PROPERTIES WITHIN NORTHWESTERN FLORIDA ESTUARIES: A LOOK AT THE FORGOTTEN AND EMERALD COASTS

Conmy, Robyn¹; Schaeffer, Blake A¹; Lehrter, John C¹; Aukamp, Jessica¹; Daniels, Kathleen¹; Craven, George¹

¹US EPA / ORD / GED 1 Sabine island Drive, Gulf Breeze, FL, 32561, United States

Assessing water clarity as a component of water quality allows for a comparative ecological assessment across estuarine resources. Presently, for estuaries and coastal waters in the Gulf of Mexico (GOM), there are no quantitative criteria to protect designated uses within these valued ecosystems. Protective water quality standards may include water clarity, which varies with phytoplankton concentration (chlorophyll a), total suspended matter (TSM), and colored dissolved organic matter (CDOM). A better understanding of the variability of inherent optical properties (IOPs) and their cumulative effect on light attenuation is needed at regional scales to develop criteria for these ecosystems. This is particularly true for northern GOM estuaries in Florida; which are undergoing some of the largest population growth rates in the state; yet are highly under sampled for optical characteristics. These systems are currently rated good to fair condition with respect to water quality indices using traditional methods. Application of optical methods can aid in making more robust assessments of regional water quality.

Presented here are discrete and *in-situ* IOP results (spatial and temporal) from four Northern GOM estuaries: Pensacola, Choctawhatchee, St. Andrew and St. Joe bays. These bays represent a transitional gradient from river-dominated to seawater-dominated systems. Monthly sampling surveys occurred between September 2009 and August 2010. Relative contributions of absorption due to CDOM, phytoplankton, and non-algal particles to light attenuation are examined during an El-Nino year during which the winter of 2009-2010 was the second wettest year on record for the region. Fluorescent DOM optical properties were also used to characterize sources of these optically-relevant constituents. This work will contribute to decision-making activities (water quality standards) using remotely sensed water quality data from MODIS and Landsat.

THE HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN: LITTORAL ENVIRONMENTAL CHARACTERIZATION FROM THE INTERNATIONAL SPACE STATION

Corson, Michael¹

¹Naval Research Laboratory 4555 Overlook Avenue, SW, Washington, DC, 20375, United States

The Hyperspectral Imager for the Coastal Ocean (HICO), now operating on the International Space Station, is the first spaceborne hyperspectral imager optimized for environmental characterization of the coastal ocean. With performance requirements based on two decades of airborne imaging experience at the Naval Research Laboratory and other laboratories, HICO provides high signal-to-noise ratio for low-albedo coastal scenes, 95 meter ground sample distance, and a large 45 x 190 km scene size to capture the scale of coastal dynamics. Sponsored by the Office of Naval Research as an Innovative Naval Prototype, HICO used a heritage design and commercial off-the-shelf components to save cost and schedule, and was delivered only 16 months after program start. This talk will discuss the HICO imager's development and performance, and initial coastal environmental products.

EXAMINING SVERDRUP'S HYPOTHESIS USING SATELLITE OCEAN COLOR AND THE ARGO PROFILING FLOATS

Courtemanche, Bruno¹; Huot, Yannick¹

¹Sherbrooke University, member of Canada Research Chair in Earth Observation and Phytoplankton Ecophysiology 946 lisieux, Sherbrooke, QC, J1K 2A4, Canada

In 1953, H. U. Sverdrup proposed his now well-known hypothesis to explain the initiation of the vernal bloom of phytoplankton : the bloom should start when the surface mixed layer becomes shallower than the critical depth (depth to which the depth-integrated respiration and photosynthesis are equal). Here, we investigate Sverdrup's hypothesis using 19745 match-ups between the SeaWiFS satellite and the Argo fleet of autonomous profilers between 1998 and 2008 over the North Atlantic Ocean. The phytoplankton concentration was followed using the chlorophyll-a concentration from SeaWiFS to identify the start of the bloom. The critical depth was derived using the daily-integrated photosynthetically available radiation and the downwelling diffuse attenuation coefficient at 490 nm from SeaWiFS. The mixed layer depth (MLD) was obtained from the Argo salinity and temperature profiles. We compared pre-bloom (498 points) and

bloom initiation conditions (948 points). Based on this analysis, we found that Sverdrup's hypothesis could not be rejected statistically.

DERIVING OPTICAL METRICS OF ECOLOGICAL VARIABILITY FROM A COASTAL OCEAN OBSERVATION PROGRAM

Craig, Susanne Elizabeth¹; Jones, Chris T.¹; Cullen, John J.¹; Li, William K.W.²; Lazin, Gordana²; Horne, Edward²; Caverhill, Carla²

¹Dalhousie University 1355 Oxford Street, Halifax, NS, B3H 4J1, Canada; ²Bedford Institute of Oceanography, Department of Fisheries and Oceans, Dartmouth, Nova Scotia, B2Y 4A2, Canada

In recent years, ocean colour remote sensing has evolved beyond simple estimates of biomass, with advances made that permit insight into ecological phenomena that directly affect the water leaving radiance field. These new approaches potentially allow us fundamental insights into the impacts of climate change on important ecosystems, the effects of physical forcing on phytoplankton community structure, and provide us with powerful new tools for monitoring and managing marine resources. Key to the understanding of ecosystem function is the ability to characterize phytoplankton functional types, which have been related to cell size, which, in turn, directly affects the inherent optical properties (IOPs) of phytoplankton absorption, *aph*, and particulate backscattering, *bbp*. The fundamental relationships among ecosystem characteristics and optical properties were examined through a multi-step analysis of an extensive data set gathered as part of a multidisciplinary integrated program of research based in the optically complex waters of Bedford Basin near Halifax, Canada. First, an examination of the relationships between *in situ* measurements of IOPs and various metrics of phytoplankton community structure (e.g., HPLC pigments, flow cytometry) was performed. Second, the potential of remote sensing to reveal IOP-phytoplankton community structure relationships in these waters was explored by testing the ability of, amongst others, the quasi-analytical algorithm of Lee et al. (Applied Optics, 2002) to successfully retrieve phytoplankton IOPs from *in situ* reflectance. Ultimately, it is hoped that these approaches can be extended to satellite measurements of ocean colour in coastal areas, as illustrated by preliminary results of *in situ* matchups with full resolution (300 m) MERIS imagery of Bedford Basin.

A NEW LOW COST, MULTISPECTRAL IN-SITU ABSORBANCE INSTRUMENT

Crawford, Jim¹

¹Turner Designs 845 W. Maude Ave, Sunnyvale, CA, 94085, United States

The design of a new in-situ absorbance instrument called the ICAM under development based on the technology developed by Dr. Fry of Texas A&M through an NSF grant will be shared. The ICAM uses a double integrating cavity design yet still has a straight flowthrough sample tube. The results from initial prototypes will be shared showing improved sensitivity, a larger dynamic range, and dramatically improved turbidity rejection compared to currently available instruments. The integrating cavity also allows for measurements in the UV. In addition, the ICAM uses all solid-state technology for lower cost, reduced power, decreased weight and improved reliability.

ASSESSING THE SPATIAL VARIABILITY OF OPTICALLY SIGNIFICANT MATERIAL CONCENTRATIONS IN UK SHELF SEAS USING A SPECTRAL MATCHING APPROACH

Creanor, Danielle¹; Cunningham, Alex¹

¹University of Strathclyde 107 Rottenrow, Glasgow, G40NG, United Kingdom

Remotely mapping the spatial variability of optically significant materials (OSMs) in shelf seas requires the inversion of remote sensing reflectance (Rrs) signals. One technique which is increasingly employed for solving the inversion problem is to match the observed Rrs spectrum with entries corresponding to known OSM values in a spectral library. Previous studies have indicated that multiple solutions may occur when

this matching technique is employed in Case 2 waters. The purpose of the work reported here is to investigate the origin of this potential ambiguity and to quantify its severity in optically complex coastal seas. As a first step, radiative transfer modelling incorporating specific inherent optical properties representative of UK shelf seas was used to derive linear relationships between Rrs and bb/a. These relationships were used to generate a predictive model connecting OSM concentrations and bb/a spectra. This removed the high computational burden associated with radiative transfer modelling and enabled the construction of a high resolution look-up table (LUT) relating bb/a spectra to their corresponding OSM values. The matching process then consisted of converting an Rrs signal to a corresponding bb/a spectrum and interrogating the LUT using a least squares fitting method. The number of matches in the LUT was determined as a function of the degree of noise present in the observation and the strictness of the matching criterion. Perfect matching for the six visible wavebands of the SeaWiFs satellite radiometer was achieved only when the observed bb/a spectrum was represented exactly in the library. The introduction of noise representing observational errors rapidly led to multiple matches, as did relaxation of the matching criterion. As an example of the sensitivity of OSM recovery to errors of observation, it was found that an average error of 0.1%, statistically distributed across all wavebands, led to an average recovery error of 6.4% in chlorophyll concentration for 3000 randomly selected observations. The operational significance of the sensitivity of the spectral matching technique to observational errors and variability in the specific inherent optical properties used for LUT generation is currently being investigated using Rrs spectra measured *in situ* and from space over the shelf waters off the western coast of the United Kingdom. Preliminary results indicate that the main spatial patterns of particulate material distributions can be effectively recovered in spite of the ambiguity problem.

EVALUATION OF THE MERIS MARINE PRODUCTS IN COASTAL AND OCEANIC WATERS OFF CAPE SAGRES ON THE SOUTH-WEST COAST OF PORTUGAL.

Cristina, Sónia¹; Goela, Priscila¹; Icely, John²; Moore, Gerald³; Newton, Alice⁴

¹IMAR Faculdade de Ciências e Tecnologia Universidade de Coimbra, Coimbra, 3004-517, Portugal; ²Sagremarisco Lda., Apartado 21, Vila do Bispo, Algarve, 8650-999, Portugal; ³Bio-Optika, Crofters, Gunnislake, Coanwall, PL18 9NQ, United Kingdom; ⁴LOICZ, NILU-CEE, Box 100, Kjeller, Oslo, 2027, Norway

In-water constituents such as chlorophyll *a*, suspended particulate matter and yellow substances, as well as radiometric data sets from field measurements with a Satlantic hyperspectral radiometer were used to evaluate the performance of Medium Resolution Imaging Spectrometer (MERIS) sensor on the ENVISAT satellite, from inshore to offshore sites on the south west coast of Portugal. Regular measurements of these parameters were taken from this region between September 2008 and July 2009 covering both Case 1 and Case 2 waters. Six images were obtained under cloud free conditions, without flags for high glint, and low sun during this sampling period.

Water-leaving reflectances (ρ_w) were estimated from downwelling $E_s(\lambda)$ and upwelling $L_u(\lambda)$ spectral irradiances, and compared with MERIS ρ_w . The values of ρ_w were processed according to the MERIS *in situ* measurement protocols, before they could be compared with the MERIS data. A previous study in this area (Cristina et al., 2009) shows that are still problems with the calibrating the algorithm that links remote sensing data with *in situ* measurements, particularly at the coastal site where there are adjacency effects from land on the reflectance data observed by the satellite sensor. However, there have been recent developments towards improving the processing protocols for MERIS data including: the ICOL (Improved Contrast between Ocean and Land) processor; the new vicarious adjustment in the near infrared; and, most recently, the implementation of the MEGS 8 processor. The influence of these recent developments on the quality of the MERIS marine products will be evaluated using the best *in situ* data from the Portuguese field work.

MODELING THE DYNAMICS OF OPTICAL PROPERTIES IN THE OCEAN, DIRECTLY AND MECHANISTICALLY

Cullen, John¹; Fennel, Katja¹

¹Dalhousie University Department of Oceanography, Halifax, NS, B3H 4J1, Canada

Over the last decade, significant progress has been made toward modeling the dynamics of optically active constituents of seawater to generate predictions of biologically driven optical variability in the ocean. Models are generally grounded in established approaches for describing the dynamics of nutrients, phytoplankton, zooplankton and detritus, with embedded procedures to convert the simulated biological quantities to optical properties. Results can then be compared with optical measurements, but it is inherently difficult to ascribe the sources of errors in the two-step process, i.e., to the ecosystem model vs. the optical coupling. Following suggestions that have been made repeatedly for well over a decade but not yet implemented in a comprehensive framework, we have begun to develop a system that simulates the dynamics of optical properties directly, for example, by using the absorption coefficient for photosynthetic pigments as a state variable and modeling photosynthesis by constraining photosynthetic quantum yield vs. photosynthetically utilizable radiation as a function of nutrient supply and light history. In turn, both nutrition and irradiance regime influence the chemical composition of photosynthetic cells, which is modeled dynamically as the ratio of scattering to absorption. Direct simulation of the dynamics of optical properties is highly relevant to optical forecasting, for example, for the specification of solar spectral irradiance, the quantification of biological-optical-physical interactions such as local heating, and application of data assimilation procedures that will use optical measurements to drive both hindcast and forecast models. Further, the new formulations are designed to implement developing knowledge of the mechanistic links between the physiology and ecology of microbes and their optical properties, guiding new research in the process.

POLARIZED CAMOUFLAGE IN MARINE FISH — WHO DOES IT?

Cummings, Molly Elizabeth¹; Maginnis, Tara²; Gilson, Alexander³; Tonizzo, Alberto³; Ahmed, Samir³; Holt, Joan⁴; Kline, Rick⁴; Brady, Parrish²

¹University of Texas 2400 Speedway (Patterson Bldg) C0930, Austin, TX, 78712, United States; ²2400 Speedway (Patterson Bldg) C0930, Austin, TX, 78712, United States; ³Dept. of Electrical Engineering, City College of New York, New York, TX, 10031, United States; ⁴Marine Science Institute, University of Texas, Port Aransas, TX, 78373, United States

While much is known about the polarized reflectance response in marine cephalopods, relatively little is known about this response in marine vertebrates. Here we report on investigations into the polarized skin reflectance response of multiple fish species occupying a variety of marine habitats from seagrass beds, sand flats, to open water. Each of these habitats represents unique optical challenges for camouflage in the polarized realm, and the various species examined exhibit very different responses. Live restrained southern flounder (*Paralichthys lethostigma*), rockhinds (*Epinephelus adscensionis*), pinfish (*Lagodon rhomboides*) and lookdowns (*Selene vomer*) were examined in a controlled environment that altered individual components (e-vector orientation, degree of incident polarization) of the polarized light field while measuring the Stokes parameters of skin reflection. Response was measured both with and without visual input to determine the degree of active or passive polarization response. Fish exhibited biologically relevant polarization response (e.g. biased e-vector reflectance for the dominant e-vector orientation in the ocean), some degree of active control of polarized reflectance, and exhibited species-level differences associated with differences in habitats.

OPTICAL SIGNIFICANCE OF BIOGENIC MINERALS IN SHELF SEAS.

Cunningham, Alex¹

¹University of Strathclyde 107 Rottenrow, Glasgow, G40NG, United Kingdom

Most studies of the influence of suspended mineral particles on the optical properties of shelf seas concentrate on particles of terrigenous origin, which play a dominant role in estuaries and shallow coastal waters. However phytoplankton blooms can produce significant quantities of biogenic minerals, the main

examples being calcite plates from coccolithophores and silica frustules from diatom cells. Both are found in great quantities in fossil deposits as well as in the modern ocean. These two classes of particle differ in their shape, range of sizes and refractive index, and consequently have significantly different optical properties. The scattering of light by coccoliths has been well studied, mainly because they have such an obvious remote sensing signature, but diatom frustules have received much less attention. In both cases, the quantitative effects of high concentrations of these particles on the underwater light field are relatively unexplored. Moreover, since standard gravimetric procedures for determining mineral suspended solids (MSS) do not discriminate between the biogenic and terrigenous fractions, the presence of biogenic particles in mixed particle suspensions may contribute to the wide range of variability reported for the specific scattering and backscattering coefficients of suspended minerals. The work presented here is based on observations of high MSS values at two locations in shelf seas where terrigenous mineral concentrations were naturally low. The first was in the Scotia Sea during the senescent phase of the spring diatom bloom (consisting mainly of *Eucampia* and *Fragilariopsis* species) and the second in the Celtic Sea during a bloom of the coccolithophore *Emeliana huxleyi*. Specific inherent optical properties (SIOPs) were estimated from *in situ* observations for the two classes of particles at these locations, and radiative transfer calculations carried out which incorporated these SIOPs and covered a realistic range of biogenic mineral concentrations. These calculations allowed the potential contribution of biogenic minerals to shelf sea optics to be predicted *in situ* where they were not the dominant component in mixed particle populations. They also made it possible to assess the effect of high concentrations of biogenic minerals on the operation of algorithms for inverting remote sensing reflectance signals in Case 2 waters, and for light harvesting by other phytoplankton species present in the water column.

RESOLVING BUBBLE SIZE DISTRIBUTIONS AND DYNAMICS IN NEAR-SURFACE WATERS WITH OPTICS AND ACOUSTICS

Czerski, Helen¹; Twardowski, Michael²; Vagle, Svein³; Slivkoff, Matthew²

¹University of Southampton, UK 12 Massey House, 181 Brooklands Road, Sale, M33 3PJ, United Kingdom; ²WET Labs, Narragansett, Rhode Island, 02882, United States; ³Institute of Ocean Sciences, Sidney, BC, V8L 4B2, Canada

Simultaneous collocated measurements of acoustical attenuation and optical scattering were used to investigate oceanic bubble populations. Optical data were collected using a MASCOT device which measured the VSF at angles from 10 to 170 degrees at 10 degree increments, and a LISST device measure measured the VSF from 0.1 to 13 degrees in logarithmically spaced increments. The optical inversions provide information about the major features of the bubble size distribution from sub-micron bubbles to a few hundred microns in radius. An acoustical resonator measured attenuation between 25 kHz and 1 MHz and yielded size distributions for bubbles with radii between 5 and 100 microns. These two sets of measurements are compared to elucidate the bubble population present. The time-dependence of the measured population and its implications for bubble cloud dynamics are also examined.

MULTISTATIC DISTRIBUTED LASER LINE SCAN IMAGING ARCHITECTURE

Dagleish, Fraser R.¹; Ramos, Brian¹; Britton, Walter B. ¹; and Caimi, Frank M. ¹

¹Harbor Branch Oceanographic at Florida Atlantic University 5600 US 1 North, Fort Pierce, FL, 34946,

Distributed Laser Line Scan (DLLS) concepts are currently being investigated due to the potential to acquire imagery over large stand-off distances with more immunity to highly variable optical conditions as compared with the LLS imagers used primarily aboard solitary underwater vehicles. Further advantages relate to relatively low laser power, low cost, and simplicity of operational hardware. However, in very turbid conditions, operational distances between illuminator and target need to be no more than a couple of meters to stay within the optimal operating envelope. Therefore, the target region from which imagery is obtainable from single imagers is quite small, and long operational times are necessary to cover typical

survey areas. For multiple-contact optical identification missions, it is therefore preferred to obtain simultaneous images from multiple small patches of seabed using multiple platforms.

A multiple access communications approach is therefore proposed to simultaneously acquire image data from more than one site. Due to the relatively narrow optical transmission spectrum and a desire to realize low cost and complexity image acquisition systems, the possibility of using intensity modulation or coded pulse multiplexing schemes to implement multiple access imaging is attractive using single-wavelength illumination.

This paper describes a Frequency Division Multiple Access (FDMA) approach and proof of concept demonstration of a multistatic version of the distributed LLS imaging architecture. Initial results demonstrate that at least two separate images can be transmitted simultaneously through more than 30 optical thicknesses with same wavelength, low power intensity modulated lasers.

EUPHOTIC ZONE DEPTH IN STRATIFIED ARCTIC WATERS AND ITS REMOTE SENSING.

Darecki, Mirosław¹

¹Institute of Oceanology PAS Powstancow Warszawy 55, Sopot, 81-712, Poland

Euphotic zone depth, Z_e , defined as the depth where light intensity falls to one percent of that at the sea surface is one of the primary parameters that control aquatic life and is often used to assess the condition of marine environment. Very common, Z_e is estimated from the subsurface concentration of chlorophyll-a, which can be retrieved with remote sensing techniques. In coastal and stratified waters such estimation can be questionable.

During two extensive field campaigns in the Svalbard coastal waters in 2009 and 2010, the profiles of the downwelling irradiance have been measured and Z_e was calculated. The strong spatial variability of the Z_e in the area is presented and discussed.

Relationships between Z_e and measured simultaneously remote sensing reflectance have been used to develop empirical algorithm for remote estimation of Z_e . Performance of this algorithm and as well the other methods for indirect retrieval of Z_e , have been evaluated and retrieved values are compared with *in situ* measurements made in Spitsbergen fiords and shelf waters. The strong stratification in the fiords waters has been identified as a major factor contributing to the higher estimation error.

NANO/MICRO-ELECTRO-MECHANICAL SYSTEMS (NEMS/MEMS): CANTILEVERS

Datskos, Panos¹; Rajic, Slobodan¹; Lavrik, Nickolay¹

¹Oak Ridge National Laboratory 1 Bethel Valley Rd., Bldg. 5800, MS 6054, Oak Ridge, TN, 37831-6054, United States

The recent developments in micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS) have enabled the use of new transduction modes that are based primarily on mechanical phenomena and involve mechanical energy conversion. This presentation will focus on: (i) early history of MEMS/NEMS; (ii) principles and models; (iii) microfabrication; (iv) noise mechanisms and figures of merit; and (v) applications of cantilevers. While MEMS/NEMS can encompass a diverse family of designs, devices with simple cantilever configurations are especially attractive as transducers for physical, chemical and biological sensing. A cantilever device converts physical or chemical changes into a mechanical response. More specifically a chemical interaction with a MEMS surface will result in changes in the Gibbs surface free energy, which, in turn, will produce a mechanical response. The functionality of MEMS/NEMS depends on both the shape (geometry) of the device as well as on the material. For example, when quantum well microcantilevers are fabricated the energy states can be manipulated in real-time using external stress thereby providing photon wavelength tunability. As the scale of these devices shrinks further

to the nanoscale higher mechanical frequencies can be achieved. All these phenomena provide us with the tools to investigate a variety of interactions at the nanoscale, provide us with new insights, and make possible devices with more desirable functionalities.

THE HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN (HICO) PROVIDES A NEW VIEW OF THE COASTAL OCEAN

Davis, Curtiss¹; Arnone, Robert²; Gould, Richard²; Corson, Michael³; Lee, ZhongPing⁴

¹Oregon State University 104 COAS Admin. Bldg., Corvallis, OR, 97331, United States; ²Naval Research Laboratory, Stennis Space Center, MS, 39529, United States; ³Naval Research Laboratory, Washington, DC, 20375, United States; ⁴Mississippi State University, Stennis Space Center, MS, 39529, United States

The Hyperspectral Imager for the Coastal Ocean (HICO) was installed on the International Space Station on September 24, 2009. HICO is the first spaceborne hyperspectral imager optimized for environmental characterization of the coastal zone. With a high signal-to-noise ratio for ocean imaging, 90 m GSD and full spectral coverage from 400 to 900 nm and a 45 by 190 km scene size HICO provides a unique view of the coastal ocean from space. HICO data are collected and processed to produce maps of coastal bathymetry, bottom characteristics, and water column optical properties. To illustrate this versatility we present examples of HICO products for a diversity of coastal environments.

MULTIPLE OPTICAL SHALLOW WATER INVERSION METHODS FOR BATHYMETRY, IN-WATER OPTICS, AND BENTHOS MAPPING : HOW DO THEY COMPARE?

Dekker, Arnold Graham¹; Phinn, Stuart R.²; Anstee, Janet M.¹; Bissett, Paul³; Brando, Vittorio E.¹; Casey, B.⁴; Fearn, Peter⁵; Hedley, John⁶; Klonowski, Wojciech⁵; Lee, ZhongPing⁷; Lynch, Mervyn⁵; Lyons, Mitchell²; Mobley, Curtis⁸; Roelfsema, Chris²

¹CSIRO POBOX 1666, Canberra, 2620, Australia; ²Centre for Spatial Environmental Research, School of Geography, Planning and Environmental Management, The University of Queensland, Brisbane, Queensland, 4072, Australia; ³Florida Environmental Research Institute 10500 University Center Dr. Suite 140, Tampa, Florida, 33612, United States; ⁴Planning Systems Inc., Stennis Space Centre, Mississippi, 39529, United States; ⁵Department of Imaging and Applied Physics, Curtin University, Perth, West Australia, 6845, Australia; ⁶School of Biosciences, University of Exeter, Exeter, Devon, EX4 4PS, United Kingdom; ⁷Geosystems Research Institute, Mississippi State University, Stennis Space Centre, Mississippi, 39529, United States; ⁸Sequoia Scientific, Inc., 2700 Richards Road, Suite 107, Bellevue, Washington, 98005, United States

There is a need in science, resource management and defense activities for image processing algorithms capable of sufficiently accurate mapping of bathymetry, water quality/optical properties, and benthos/substrate composition in optically shallow waters from airborne and satellite image data. This paper presents results of a comparison of the performance of published optically shallow water mapping algorithms at Lee Stocking Island in the Bahamas, and Moreton Bay in eastern Australia. These are sites with published airborne hyper-spectral data and field bathymetry, inherent optical properties and benthos/substrate composition data. One empirical approach and five physics-based inversion methods for mapping were compared. Accuracies were assessed for each method including computation times. The assessment showed that: (1) physics-based methods were more accurate than the empirical approach, and the accuracy and processing times of these were inversely related to the complexity of the models used; (2) all inversion methods provided moderately accurate retrievals of bathymetry, water column IOP and benthic/substrate reflectance within optically shallow areas of less than 10m depth, with relatively homogenous benthic/substrate cover types; (3) more accurate retrievals were obtained from the more complex and locally parameterized methods; and (4) no single method or data set can be considered optimal for mapping optically shallow waters. Some uncertainties remain on the absolute accuracy and performance of the inversion methods and on their ability to be applied in operational, large area airborne or satellite hyper-spectral image data. Future work should consider additional sites with fully matched field and image data sets, but variable depth, water composition and benthic composition.

A SIMPLE ALGORITHM TO DERIVE PHYTOPLANKTON SIZE DISTRIBUTION FROM ABSORPTION PROPERTIES: APPLICATION TO SEAWIFS DATA

Devred, Emmanuel¹; Sathyendranath, Shubha²; Platt, Trevor²; Stuart, Venetia¹

¹Bedford Institute of Oceanography 1 Challenger Drive, Dartmouth, NS, B3K3T8, Canada; ²Plymouth Marine Laboratory, Prospect Place, The Hoe, Plymouth, Devon, PL1 3DH, United Kingdom

Information on phytoplankton size distribution is of interest in studies of ocean biogeochemical cycles, the state of the marine ecosystems and in fisheries management. Several methods have been proposed to derive the three main size classes, namely, pico-, nano- and microphytoplankton, but these methods generally rely on an analysis of HPLC accessory pigment concentrations to derive phytoplankton size classes. One of the limitations of the use of pigment composition to derive phytoplankton size class is in the use of accessory pigments that occur in more than one class, which may introduce some bias. For example, fucoxanthin is the main pigment marker for diatoms (microphytoplankton), however, it can also be found in some nanophytoplankton (e.g., prymnesiophytes and cryptophytes). The work presented here uses only the phytoplankton absorption and biomass (as indexed by chlorophyll-a), to derive the proportion of the three size classes in a sample. An iterative application of the Sathyendranath et al. (2001) and the Devred et al. (2006) two-population absorption model allows one to derive first the specific absorption of microphytoplankton and combined nano- and picophytoplankton, and then the individual specific absorption of pico- and nanophytoplankton. The fraction of each size class is then obtained by solving a system of equations that describes the total phytoplankton absorption as a linear combination of the specific absorption spectra of the three size classes. Results from our algorithm compared well with phytoplankton size classes obtained from HPLC pigment analysis. Some discrepancies could be explained by the differences in the methods used.

Our method is applied to a one year eight-day composite time series of phytoplankton absorption derived from satellite ocean-colour data from the SeaWiFS sensor for 2007, at three selected sites representative of different biological regimes (i.e., oligotrophic, coastal and polar) to give a detailed view of the seasonal succession of the three size classes at those locations.

TOWARD THE UNDERSTANDING AND PREDICTION OF OPTICS NEAR THE OCEAN SURFACE

Dickey, Tommy¹

¹University of California Santa Barbara Ocean Physics Laboratory/Dept. of Geography, Santa Barbara, CA, 93106, United States

A longstanding oceanographic problem concerns the propagation of light near the ocean surface, particularly at the air-sea interface and within the surface boundary layer. This fundamental problem requires the characterization and quantification of a broad suite of physical, chemical, and bio-optical processes. Some of the applications for this general problem include: imaging, surface gravity waves, phytoplankton physiology and productivity, near surface thermodynamics, natural and man-made surfactants, bubbles, and gas exchange across the air-sea interface. In this talk, I will review research directed toward increasing the understanding and prediction of the optics of the near surface of the ocean. This research encompasses the development of new technologies, laboratory experiments, field observations, and modeling. In particular, I will introduce some of the recent Radiance in a Dynamic Ocean (RaDyO) activities that have taken place in the coastal ocean off California and in the open ocean of the North Pacific off Hawaii. RaDyO is dedicated to the understanding and prediction of variations in radiance distributions as they are affected by the atmospheric forcing and physical, chemical, biological, and optical conditions of the surface boundary layer and the upper ocean. Several RaDyO and other investigators will present pertinent results during Ocean Optics XX.

SPECTRAL POLARIZED REFLECTANCE FROM SKIN PREPARATIONS FROM FOUR DIFFERENT SUBTROPICAL FISH SPECIES

Dierssen, Heidi M¹; Johnsen, Geir²; Cummings, Molly³; Maginnis, Tara³; Holt, Joan³

¹University of Connecticut 1080 Shennecossett Rd., Groton, CT, 06340, United States; ²Norwegian University of Science and Technology (NTNU), Trondheim Biological Station, Trondheim, N-7491, Norway; ³University of Texas, Austin, TX, 78712, United States

Some of the most sophisticated examples of biological camouflage have evolved in the oceans in order for species to evade detection by visually oriented predators. As a first step towards understanding how fish species regulate their spectral and polarized reflectivity, we imaged thin skin preparations of four different species of fish found in coastal waters of Texas. A portable imaging spectrometer was mounted on a Leitz Leica MS5 stereomicroscope with a moving slide table to provide high resolution images of the skin preparations under different polarization conditions. To account for the spectral dependency of the light source, the images were normalized to reflectance of a spectralon plaque visible in each image composite. Images across the width of each sample were reconstructed from vertical image slices to provide a spatial resolution of approximately 0.004 mm² per pixel or 240 pixels per mm², a resolution high enough to isolate different pigment cells on the skin. The spectra range from 420-680 nm at <1 nm resolution. The polarized spectral characteristics of pinfish, Southern flounder, sand trout, and killifish with and without scales are compared under no polarization, horizontal, vertical, left circular and right circular polarization. Differences in the reflected color, as well as polarized conditions are presented.

PRIMARY PRODUCTION IN THE PATAGONIAN CONTINENTAL SHELF AND SHELF-BREAK REGION: IMPROVED ESTIMATION USING SATELLITE-BASED MODELS

Dogliotti, Ana I.¹; Segura, Valeria²; Lutz, Vivian A.²

¹Instituto de Astronomía y Física del Espacio (IAFE) Pabellón IAFE-Ciudad Universitaria, C.C. 67- Suc. 28, Ciudad Autónoma de Buenos Aires, C1428ZAA, Argentina; ²Instituto Nacional de Investigación y Desarrollo Pesquero, Mar del Plata, Buenos Aires, B7602HSA, Argentina

The Patagonian Continental Shelf (PCS) and shelf-break regions comprise a large and rich biological area of the ocean; therefore, the interest in improving the estimation of primary production using a satellite approach. Field studies performed during spring 2005 showed a high spatial variability in the (chlorophyll) biomass-normalised photosynthetic parameters (PmB and alphaB). The overall variability in both parameters was similar (coefficient of variation, CV~70%); however, the variability in chlorophyll concentration (chl a) was higher (CV=148%), evidencing the patchy characteristic of the spring blooms in PCS. Using field measurements, different and relatively simple (non-spectral and vertically homogeneous biomass) models were tested. The Platt and Sathyendranath (J. Geophys. Res., 98, 14561-14576, 1993) model showed the best results, and was selected as the 'local algorithm'. To estimate the photosynthetic parameters required by the local algorithm to compute primary production on a larger (regional) scale, correlations between the measured parameters and remotely-sensed properties, such as temperature and chlorophyll, were tested, but no significant relationships were found. Therefore, a partition of the PCS into biogeochemical regions approach was performed based on remotely-sensed sea-surface temperature, chl a, normalized water-leaving radiance at 551 nm, photosynthetically active radiation (PAR) and bathymetry. The estimation of primary production using averaged field parameters within each biogeochemical region was improved with respect to that estimated using fixed parameters for the whole PCS (relative and absolute percent difference, RPD ~ -1.3% and APD ~ 35%).

A MODIFIED QAA TO DERIVE IOPS FROM OCEAN COLOR REMOTE SENSING

Dong, Qiang¹; Shang, Shaoling¹; Lee, ZhongPing²; Hong, Huasheng¹

¹Xiamen University 422 Siming South Rd, Xiamen, Fujiang, 361005, China; ²Mississippi State University, Stennis Space Center, Mississippi, 39529, United States

Based on the Quasi-Analytical Algorithm architecture, we proposed a QAA refinement for the derivation of inherent optical properties (IOPs) and tested its performance with measurements made in the Taiwan Strait.

Specifically, we proposed schemes 1) to correct questionable remote-sensing reflectance at 412 nm, which is important for the separation of absorption coefficients between phytoplankton (a-ph) and detritus-gelbstoff (a-dg). And 2) to include a third wavelength (490 nm) for the separation of absorption coefficients of gelbstoff (a-g) and detritus (a-d). When applying this refined QAA to MODIS-Aqua measurements in the Taiwan Strait, a shallow channel with highly variable (both spatially and temporally) water properties, it not only produced more pixels with valid retrievals, but also reduced the differences between satellite retrievals and *in situ* measurements. The application of this refinement to obtain global IOPs from MODIS-Aqua is also discussed.

VISIBLE AND NEAR-INFRARED SPECTRAL VARIATIONS OF LIGHT BACKSCATTERING BY PARTICLES IN COASTAL WATERS

Doxaran, David¹; Babin, Marcel¹; Chami, Malik¹; Lorthiois, Thomas¹; Ruddick, Kevin G²; McKee, David³

¹LOV (CNRS) Quai de la Darse, Villefranche sur Mer, 06230, France; ²RBINS-MUMM, Brussels, BE, 1100, Belgium; ³Department of Physics, University of Strathclyde, Glasgow, UK, 1100, United Kingdom

Light backscattering by suspended particles in natural waters is a key parameter in marine optics providing information on the concentration, composition and size of hydrosols. It also makes hydrosols detectable from space by ocean colour satellite sensors, notably during phytoplankton blooms and in coastal waters directly affected by river inputs of non-algal particles and resuspension of bottom sediments.

The remote sensing of hydrosols from space involves the discrimination between hydrosols and aerosols which both scatter light. This discrimination remains difficult as the size distributions and near-infrared optical properties of hydrosols are still poorly documented, especially in coastal waters where complex mixing of biogenic and mineral suspended particles can be found.

We present field measurements of the particulate backscattering coefficient (bbp, in m⁻¹) carried out in various coastal waters (European estuaries and river plumes, southern North Sea, Baltic Sea, Beaufort and Laptev Seas in the Arctic Ocean) and covering the visible and near-infrared spectral regions.

Results show the significant impact of particulate absorption effects on bbp at short visible wavelengths. A flattening of the bbp spectrum is also observed in the near-infrared as compared to the visible region. Taking into consideration the uncertainties associated to field measurements of bbp, we show that bbp(λ) significantly departs from the widely used power-law function in λ -s, where λ and s are respectively the wavelength and bbp spectral slope. Computations using Mie theory are used to better understand how field-measured particulate absorption and size distribution respectively impact on bbp(λ).

A NEW DATA PROCESSING METHOD FOR HYDROSCAT-6 BASED ON HYDROLIGHT

Du, Keping¹; Lee, ZhongPing²

¹Beijing Normal University 19 Xijiekouwai Street, Beijing, 100875, China; ²Geosystems Research Institute, Mississippi State University, Stennis Space Center, MS, 39529, United States

Inherent optical properties (IOPs), e.g., absorption and backscattering coefficients, and volume scattering function are critical information for radiance transfer simulation. To obtain IOPs of natural waters, HydroScat-6 (HS6, HOBILabs) is used widely to measure the backscattering coefficient (bb) of waters. Basically, HS6 measures the volume scattering function (VSF) at 140 degree scattering angle, and then bb is computed based on the “sigma corrected” measurement. However, this standard data processing method embedded in HydroSoft for “sigma correction” is based on the Case-I model, which is not suitable for highly turbid coastal waters or inland waters, e.g., Taihu lake, China. To improve bb measurements of non-Case-I waters, a new data processing method for HS6 is proposed. This method is based on the Hydrolight radiative transfer model, and the Fournier-Forand phase functions are used to determine iteratively the best backscattering probability (ratio of backscattering and scattering) for different wavelengths. Results show that the new method can get much better backscattering data for highly turbid waters.

REMOTE-SENSING OF OCEAN-COLOR ABOVE THIN CIRRUS CLOUDS

Duforêt-Gaurier, Lucille¹; Frouin, Robert²; Dessailly, David¹; Labonnote, Laurent³; Brogniez, Gerard³; Dubuisson, Philippe³

¹LOG / UCLO / CNRS 32 avenue Foch, Wimereux, 62930, France; ²SIO/UCSD Climate Research Division, La Jolla, California, 9500, United States; ³USTL, LOA, Université Lille Nord de France, Villeneuve d'Ascq, France, 59650, France

Ocean color remote sensing from space is currently limited to cloud-free areas. Consequently, the daily ocean coverage is 15-20%, and weekly products show no information in many areas. This limits considerably the utility of satellite ocean color observations for operational oceanography. Global coverage is required every three to five days in the open ocean and at least every day in the coastal zone. In view of the requirements of spatial coverage, an algorithm is proposed to estimate the marine signal in the presence of thin cirrus clouds from SeaWiFS data. This algorithm assumed that the atmospheric signal can be modeled with an acceptable accuracy according to a polynomial function with three terms. Thus, the atmospheric reflectance can be estimated using the three spectral bands: 510, 765 and 865 nm. In the near-infrared wavelengths, the marine reflectance is assumed to be negligible in open waters. Consequently, satellite measurements can be directly related to the atmospheric signal. At 510 nm, the marine reflectance is estimated using the Hinge point property. Once the polynomial function calculated, atmospheric reflectance can be derived at shorter wavelengths. The algorithm is tested on a SeaWiFS image. The oceanic features retrieved below the clouds exhibit continuity with the adjacent features of the ocean.

ABSORPTION BY DIFFERENT COMPONENTS DURING A HIGH FRESHWATER EVENT OF THE 2008 LA NINA EPISODE IN A TROPICAL LAGOON

Dupouy, Cécile¹; Röttgers, Rüdiger²

¹IRD Centre IRD de Noumea, Noumea, 98848, New Caledonia; ²GKSS Research Center, Geesthacht, Geesthacht, 21502, Germany

Coral reef systems are very sensitive to anthropogenic perturbations (nutrients, mining) and long-term climatic changes which are particularly amplified in lagoons. The New Caledonian lagoon (22 177 km², 25 m as a mean depth) lies in the South Western Tropical Pacific from 20°S to 22°S, and 166° to 167°E. It has a heterogeneous bathymetry due to a complex geomorphology. It is largely connected to the open ocean in the south part of the lagoon, but only by narrow passes in the south west part of the lagoon. The Valhybio cruise was performed to characterize *in situ* inherent bio-optical properties of waters driving the remote sensing reflectance in the New Caledonian lagoon. During La Nina episode in 2008, the intense discharge of freshwater from land and the associated salinity reductions were critical for all optical properties, pigment concentrations and biodiversity of phytoplankton. Here we present results about inherent optical properties, i.e. total, particle and CDOM, detritus and phytoplankton absorption (ac9, Ultrathin, PSICAM, spectrophotometers) in addition to scattering and backscattering coefficients. The relative contribution of particles and CDOM absorption largely varied from offshore to the river mouths, showing different geographical distributions, and exhibiting distinct relationships with POC and pigment concentrations. Spectral features of phycoerythrin absorption from Trichodesmium, as detected with the PSICAM, are clearly shown. The influence of CDOM on reflectance modeling is calculated in the UV-Vis channels. Colored Dissolved Organic Matter which is a fraction of dissolved organic carbon in the upper part of the ocean and has a relatively small contribution in case of Case 1 waters has been largely underestimated in this particular case of high river discharge in a tropical environment.

ANALYSIS OF UNDERWATER IMAGE DEGRADATION USING RADIATIVE TRANSFER MODELING. APPLICATION TO SUBMARINE IMAGE VISIBILITY.

Ebert, Kerstin¹; Chami, Malik¹; Allais, Anne Gaelle²; Galland, Frédéric³; Bouhier, Marie Edith²; Edmond, Toussaint²; Boffety, Matthieu³; Maciol, Nicolas⁴; Nicolas, Stéphane⁴

¹Laboratoire Océanographie Villefranche (LOV) La Darse, BP 8, Villefranche sur Mer, 06230, France; ²Ifremer, Centre de Méditerranée, BP 330, La Seyne sur Mer, France, 83507, France; ³Institut Fresnel, CNRS, Aix-Marseille Université, Ecole Centrale Marseille, Campus de St Jérôme, Marseille, France, 13013, France; ⁴Prolexia, 865 Avenue de Bruxelles, La Seyne sur Mer, France, 83500, France

Underwater images suffer strong degradation effects as limited visibility, low contrast, strong blur, non uniform illumination, and diminished colors with dominating blue/green hue. All these phenomena are related to light propagation in the water and can be explained by radiative transfer theory.

To understand these effects, the exact underwater light field was simulated for clear and moderately turbid waters illuminated by an artificial light source. An object of varying reflectivity is placed at changing distance from a camera-lamp ensemble. Hyperspectral radiances and irradiances were calculated in the visible spectral range using the OSOA radiative transfer model.

One originality of this work is to examine separately the contribution of the source, the object, the camera, and the water turbidity on the signal received by a camera and thus, on image degradation.

Our results show that the downwelling irradiance E_d reaching the object could locally increase due to the object reflectivity. Also, despite the optical attenuation of light along the object-camera pathway, the signal received by a camera could increase with turbidity by 70%, strongly depending on the object-camera distance. Both findings can be interpreted in terms of multiple scattering mechanisms. The increase of E_d with object reflectivity is explained by the redirection of upwelling photons reflected by the object. The increased signal measured by the camera for higher turbidity is caused by the significant number of forward scattering events near the camera. This study also aims at revisiting the parameterization of optical degradation effects to improve algorithms for underwater image processing.

PARTICLE DISTRIBUTIONS ACROSS THE CANADIAN BEAUFORT SEA CONTINENTAL MARGIN INFERRED FROM *IN SITU* OPTICAL MEASUREMENTS

Ehn, Jens¹; Reynolds, Rick¹; Bélanger, Simon²; Doxaran, David³; Matsuoka, Atsushi³; Stramski, Dariusz¹; Babin, Marcel³

¹Scripps Institution of Oceanography University of California at San Diego, La Jolla, CA, 92093-0238, United States; ²Université du Québec à Rimouski, Rimouski, Québec, G5L 3A1, Canada; ³Laboratoire d'Océanographie de Villefranche, Villefranche-sur-Mer, Provence-Alpes-Côte d'Azur, 06238, France

The Canadian Beaufort Sea is an optically complex environment owing to multiple sources and sinks of colored dissolved organic matter, sea ice dynamics, and terrestrial influences from rivers such as the Mackenzie River. During the MALINA campaign in August 2009, we measured vertical profiles of multi-spectral inherent optical properties (IOPs) in conjunction with properties of the suspended particle assemblage (e.g. mass concentration, organic carbon content) in this region. Significant variability was observed in the vertical and horizontal distributions of both IOPs and particulate matter. Using mass-specific optical properties derived empirically from discrete data, we utilize *in situ* optical measurements to examine particle distributions in this region.

Our measurements indicate that large concentrations of particulate matter are transported past the Mackenzie shelf break to the Canadian Basin in both a surface river plume as well as in intermediate nepheloid layers. The scattering properties of these layers (e.g. high backscattering to scattering or scattering to absorption ratio) suggest a composition of inorganic particles and/or refractory organic debris of terrestrial origin, originating either from river input or bottom resuspension. In contrast to these layers, the ubiquitous subsurface chlorophyll maximum in offshore waters exhibited pigment absorption features and scattering properties more typical for particles of marine origin. Our results demonstrate the utility of using optical measurements for studying biogeochemical interactions between the shelf and offshore regions within the Arctic Ocean.

OPTICAL PROPERTIES IN RELATION TO SUSPENDED PARTICULATE MATTER (SPM) IN THE NORTHERN GULF OF MEXICO

Epps, Sarah¹; Lohrenz, Steven²; Tuell, Grady³; Martin, Kevin²

¹University of Southern Mississippi 1020 Balch Blvd., Stennis Space Center, MS, 39529, United States;

²1020 Balch Blvd., Stennis Space Center, MS, 39529, United States; ³Optech International, Kiln, Mississippi, 39556, United States

Suspended particulate matter (SPM) can consist of a variety of components including small mineral particles, both living and dead organic matter and associated heterogeneous aggregates. By modifying light availability it affects marine organisms' access to solar radiation. In some environments SPM acts as a vehicle for transporting nutrients and pollutants. Anthropogenic activities may be affected by SPM through in-filling of harbors and shipping channels and by the fouling of marine equipment. Sources of SPM include fluvial inputs, re-suspension of bottom materials and *in situ* generation by marine organisms. Determination of SPM is generally defined as particles in the water column retained on a filtration membrane of a specific pore size, e.g., that captured on a 0.4 μm filtration membrane. However, discrete sampling of SPM is labor intensive and can only provide limited spatial and temporal coverage. Hence, there has been a growing effort to develop and refine remote sensing algorithms for assessment of SPM distributions.

One of the objectives of this research is to develop a suspended particulate matter (SPM) algorithm for the Coastal Zone Mapping and Imaging Lidar system (CZMIL). This next generation coastal mapping system adopts a data fusion paradigm to produce estimates of absorption, backscattering, particulate backscattering, attenuation, and remote sensing reflectance through the combination of lidar and hyperspectral data. To investigate the relationships between these parameters and SPM, contemporaneous *in situ* measurements of these properties were taken in the northern Gulf of Mexico over the course of fifteen months (2009 - 2010) during five research cruises. The project area included oligotrophic marine waters as well as near shore and coastal environments. The Mississippi and Atchafalaya river outlets were also observed during each excursion. The relationships between SPM and the measured optical properties are currently being evaluated for algorithm development.

BUILDING AN AUTOMATED MICROFLOW FLOW CYTOMETER FOR UNDERSEA OPERATION

Erickson, Jeffrey Stephen¹

¹Naval Research Laboratory 4555 Overlook Avenue SW, Washington, DC, 20375, United States

Optical biosensors have begun to move from the laboratory to the point of use. In addition to incorporating robust approaches for bioanalysis, fluidic and optical components have to be miniaturized and integrated into an automated and portable platform. The choices of biochemistry, optics, fluidics and electronics must be made with all the other components and user requirements in mind. We are building and testing a microflow cytometer for incorporation into the payload of an unmanned, underwater glider to identify marine algae in real time. The system must operate at high pressures, resist clogging and fouling, incorporate standards to assure fidelity of analysis, fit in a compartment less than 8" across, accommodate limited power availability, and transmit data remotely when the glider rises to the surface. Tradeoffs in selection of optical and fluidic components include reliability, size, power, and long-term functional stability under variable temperature and pressure. The design of the microflow cytometer itself must accommodate tradeoffs. For example, the larger the inlet diameter, the more easily large algae can be accommodated but the higher the variance in the data. Faster sheath flow rates can decrease this variance, but faster flows increase the demands for the pumps and sheath fluid recycling or purification. Flowing both the sheath and sample fluids faster increases the number of particles interrogated per minute, but also requires more expensive detectors and more powerful electronics. Several different designs will be presented and evaluated in terms of advantages and disadvantages for point-of-use sensing, and considerations relevant to use outside the lab will be emphasized.

MASS-SPECIFIC ABSORPTION BY SUSPENDED SEDIMENTS IN COASTAL LOUISIANA: CONNECTIONS TO PARTICLE COMPOSITION AND OCEAN COLOR

Estapa, Margaret L¹

¹University of Maine Aubert Hall, University of Maine, Orono, ME, 04469, United States

Mass-specific spectral absorption coefficients ($a_{\text{SPM}}^*(\lambda)$) of suspended particulate matter (SPM) are necessary for modeling particle-hosted photochemical reactions, useful for tuning ocean-color algorithms for SPM concentration, and may contain information on particle composition. $a_{\text{SPM}}^*(\lambda)$ of surficial sediments and SPM isolated from coastal Louisiana were determined in a center-cuvette integrating sphere, and compared to IOPs of SPM measured with *in situ* optical equipment in the field. Absorption coefficients and spectral slopes measured in the field and the lab agreed with each other, and were comparable to values published elsewhere for similar particles. A positive linear correlation exists between weight-fraction organic carbon content and $a_{\text{SPM}}^*(412)$ in marine SPM, but not in riverine SPM. Features observed in derivative $a_{\text{SPM}}^*(\lambda)$ spectra correspond to absorption bands of iron oxide minerals. Relative variations in $a_{\text{SPM}}^*(\lambda)$ among samples collected during different seasons and from 2003-2008 in the Atchafalaya Bay appear to be smaller than variations in field SPM concentrations. The mean $a_{\text{SPM}}^*(645)$ of Louisiana coastal SPM measured directly in the lab is in rough agreement with $a_{\text{SPM}}^*(645)$ derived from the coefficients of empirically-calibrated, regional 645nm satellite reflectance algorithms for SPM.

REMOTE SENSING OF MASSIVE FLOATING MACRO-ALGAL BLOOMS

Fearns, Peter Rhoderick¹

¹Curtin University GPO Box U1987, Perth, 6845, Australia

Massive floating macro-algal blooms, green tides, have occurred in the Yellow Sea in recent years. The most notable event was the impact of the green tides on the 2008 Olympic Games sailing course with millions of tonnes of algae washing ashore along the Qindao coastline (China News, 2009; Liu et al. 2009). A recurrence of the massive green tide was observed in 2009 (Liu et al., in press), with many expecting a similar event to occur in 2010. Recent studies based on morphological and phylogenetic analysis have confirmed the source of the green tides to be *Porphyra yezoensis* aquaculture rafts along the Jiangsu coastline (Keesing et al. submitted). The development and magnitude of the green tide events has been observed using remote sensing techniques (Hu, 2009, Shi & Wang, 2009, Liu et al., in-press). The two 250 m resolution MODIS bands are sensitive to the spectral differences between floating algae and the surrounding water. Of interest is the ability to provide reliable estimates of the spatial extent and biomass of floating algae, however the highly variable spectral reflectance of the Yellow Sea, due to high turbidity, compounded with often hazy atmosphere, makes the delivery of reliable results difficult. Our aim is to provide reliable estimates of floating algae origin, extent, and estimates of total biomass. To this end, we present a Scaled Algae Index (SAI) algorithm which is based on the terrestrial NDVI product, combined with the local area processing approach (Normalised Difference Algae Index-NDAI) of Shi and Wang (2009). We also report on analysis of the sensitivity of the derived algal spatial coverage to choices in various processing parameters. An update on the expected 2010 event will also be presented.

VARIABILITY IN THE HYPERSPECTRAL REMOTE SENSING REFLECTANCE AND PERFORMANCE OF OC4V4 ALGORITHM IN THE PATAGONIAN SHELF -BREAK

Ferreira, Amabile¹; Garcia, Carlos Alberto Eiras¹; Garcia, Virginia Maria Tavano¹; Dogliotti, Ana Ines²

¹Federal University of Rio Grande Av. Rio Grande 609, Rio Grande, 96205001, Brazil; ²Institute of Astronomy and Space Physics (IAFE-CONICET) Pabellón IAFE-Ciudad Universitaria, C.C. 67- Suc. 28, Buenos Aires, Buenos Aires, C1428ZAA, Brazil

Ocean color images from the Southwestern Atlantic Ocean usually show a band with high phytoplankton biomass during spring and summer periods along the Patagonian Shelf Break. Six cruises were conducted

in October 2006, March and October 2007, January and October 2008 and January 2009, when more than 120 oceanographic stations were occupied in the region. Here we present the Remote Sensing Reflectance (Rrs) variability and an evaluation of the SeaWiFS's empirical algorithm OC4v4 used to estimate chlorophyll a concentration ([chl]) based on Rrs ratios. Surface chlorophyll a concentration varied from 0.10 to 18.87 mg m⁻³ (mean of 2.82 3.35 mg m⁻³). Spectral Rrs (measured using a hyperspectral radiometer profiler) presented a great variability in both magnitude and spectral shape. A hierarchical cluster analysis was applied to Rrs spectra in order to classify the whole set of Rrs spectra into coherent groups. Three spectrally distinct classes were defined, differing significantly from one another by their [chl] range. Evaluation of the OC4v4 algorithm showed a relatively good relationship between measured [chl] and algorithm-derived concentrations, combining all cruises ($r^2=0.72$, slope of 0.83 and intercept of 0.06), with a positive bias (Mean Relative Percentage Difference, RPD=24.45%). The model was also applied to each class determined by the cluster analysis. Large errors were found for the classes related to the highest (RPD=82.07%; Mean Absolute Percentage Difference, APD=112.18%) and intermediate (RPD=27.66%; APD=56.09%) [chl] values, but results for the class associated to the lowest [chl] are in good agreement with the analyzed algorithm (RPD=2.03%; APD=32.61%). Moreover, positive and negative errors were related to higher and lower phytoplankton specific absorption coefficients (i.e. normalized by [chl]), respectively, reflecting the impact of variability in the absorption efficiency on the performance of empirical approaches in the region.

SPECTRAL ABSORPTION PROPERTIES OF OPTICALLY ACTIVE CONSTITUENTS IN POMERANIAN LAKES (POLAND)

Ficek, Dariusz Antoni¹; Zapadka, Tomasz¹; Meler, Justyna²

¹Institute of Physics Pomeranian University Arciszewskiego 22, Slupsk, 76-200, Poland; ²Institute of Oceanology, Polish Academy of Sciences, Sopot, -, 81-712, Poland

In 2004-08 the absorption properties and concentrations of optically active constituents (OAC) were investigated empirically in 15 northern Polish lakes of different trophicity. The research revealed a high concentration and variability of OAC i.e. chlorophyll-a concentration CChla=1.3-336mgm⁻³, concentration of suspended particulate matter CSPM=0.8-265gm⁻³, absorption of coloured dissolved organic matter aCDOM(440)=0.35-17.8m⁻¹.

The research enabled to analyse the values and range of variability of spectral absorption coefficient of phytoplankton, nonalgal particles (NAP), coloured dissolved organic matter (CDOM) and their exponential slopes. The results have been compared with data obtained in different parts of the world. The comparisons have revealed certain disparities among the main constituents of absorption occurring in lakes, naturally rich in these substances, and those observed in seas and oceans. For the same concentrations - CChla and CSPM - both the coefficients of light absorption by phytoplankton and by NAP in lakes have been observed to reach noticeably higher values when compared with those of seas and oceans. However, the comparison of data from Polish and other lakes (located in various parts of the world) shows a considerable similarity of their optical properties. It has also been shown that extrapolating of commonly used parametrizations onto rich in OAC lake waters may lead to lowering the light absorption coefficient values.

DYNAMICS OF DOM OPTICAL PROPERTIES AND CHEMICAL COMPOSITION IN A RIVER-DOMINATED OCEAN MARGIN (NORTHERN GULF OF MEXICO)

Fichot, Cedric G¹; Lohrenz, Steven²; Miller, William L.³; Benner, Ron¹

¹University of South Carolina EWS 603, 712 Main Street, Columbia, SC, 29208, United States;

²Department of Marine Science, University of Southern Mississippi, Stennis Space Center, MS, 39529, United States; ³Department of Marine Science, University of Georgia, Athens, GA, 30602, United States

Surface waters of the northern Gulf of Mexico receive large and variable inputs of terrigenous and marine dissolved organic matter (DOM) of contrasting optical properties, chemical composition and photochemical reactivities. Here, we investigate the seasonal dynamics of DOM properties using a

combination of optical and chemical measurements, photodegradation experiments and modeling with an emphasis on quantifying the role of photochemistry as a regulating process. Field measurements and samples were collected during five research cruises to the northern Gulf of Mexico in January, April, July, and October-November of 2009 and March of 2010. These data are used in the development of optical algorithms, the determination of quantum efficiencies (DOC removal and DOM absorption loss), and the optical (fluorescence and absorption) and chemical (lignin, amino acids and neutral sugars) characterization of DOM.

POLARIZATION IN SCATTERING

Fournier, Georges¹

¹DRDC Valcartier 2459 Pie XI Blvd North, Quebec, QC, G3J 1X5, Canada

Aerosols are generally composed of water aggregated on or by a small nucleation center and due to surface tension have smooth almost spherical shapes. For hydrosols, the buoyancy and absence of this surface tension effect leads to a great variability in shape and in very irregular or bumpy surfaces. Hydrosols can have the general shape of spheres, spheroids, plates or cylinders, however almost all are far from smooth and this smaller scale shape irregularity completely modifies the effect of scattering on the polarization. This effect is particularly significant in the backscattering direction, which is all-important for imaging applications. This variability in shape and the significant surface irregularities of hydrosols seriously mitigate the usefulness of exact codes. On the other hand, the relative index of refraction is generally less than 1.1. This allows one to use approximate relationships based on the fundamental physics and build a relatively simple framework to evaluate and predict the effect of scattering on polarization in water. We will present and develop this simple polarization model and explore its practical consequences to both remote sensing and imaging in natural waters.

A GENERALIZED FRAMEWORK FOR MODELING OF INHERENT OPTICAL PROPERTIES WITHIN OCEAN REMOTE SENSING APPLICATIONS

Franz, Bryan¹; Werdell, Jeremy²

¹NASA/GSFC NASA/GSFC, 614.2, B28, W123, Greenbelt, MD, 20771, United States; ²NASA/GSFC, 614.2, B28, W123, Greenbelt, MD, 20771, United States

Marine inherent optical properties (IOPs) refer to the absorption and scattering characteristics of ocean water and its dissolved and particulate constituents, both of which govern the transmission of light through the water column. Marine remote sensing reflectance, $R_{rs}(l)$, the spectral distribution of light reflected upward from beneath the water surface, is a remotely measurable quantity that is directly related to the total absorption and total backscattering coefficients. A multitude of models exist in the published literature that attempt to retrieve IOPs from $R_{rs}(l)$ and to further separate the total absorption and backscattering into components, such as backscattering due to particles and absorption due to phytoplankton pigments and colored dissolved and non-algal matter. These models rely on assumptions or empirical relationships to define spectral shapes (eigenvectors) for each absorption and scattering component, and operate to retrieve the magnitudes (eigenvalues) of each component required to match the spectral distribution of R_{rs} . Thus, models often differ only in the assumptions employed to define the eigenvectors. To facilitate a controlled evaluation of the various approaches, the Ocean Biology Processing Group developed the Generalized IOP model (GIOP). This software, which is implemented in the standard NASA ocean color processing code and distributed to the research community through SeaDAS, allows for the construction of different IOP models at run time by selection from a wide assortment of published eigenvectors for the component absorption and scattering properties. Using GIOP, specific assumptions can be isolated and evaluated, new models can be constructed, and regionally-tuned models can be developed. The theoretical basis for the GIOP framework will be described in this paper, and the range of existing options will be detailed.

BACKSCATTERING COEFFICIENT RETRIEVAL FROM MEASUREMENTS OF SINGLE ANGLE LIGHT SCATTERING IN SOUTHERN BALTIC.

Włodzimierz, Freda¹

¹Institute of Oceanology PAS Powstańców Warszawy 55, Sopot, 81-712, Poland

Direct measurements of backscattering (or scattering) coefficient in seawater are difficult to prepare. That is why the light scattering coefficient is most frequently determined as a difference between an attenuation and absorption coefficients. The backscattering coefficient is frequently approximated by mean of single angle scattering meters. We have revisited the problem on a basis of measured volume scattering functions (VSFs) in Southern Baltic waters. The measurements were prepared with a multispectral volume scattering meter for angles between 0.5 and 179 deg (with 0.25 deg step). The data set consist of various water types: turbid surface water taken near river mouth, coastal water, open sea water. Some samples were collected from various depths. It gave the opportunity to show an average function x , which connects the volume scattering function with the backscattering coefficient and its stability versus scattering angle. Discussion has been concerned both on light scattered into 117 deg and 140 deg for backscattering coefficient. Similar investigation had been prepared for scattering coefficient and the VSF measured for angle 4 deg. Spectral response for the ratio of backscattering coefficient to VSF has been shown.

ESTIMATING CHLOROPHYLL FLUORESCENCE BY DIFFERENTIAL ABSORPTION IN THE OXYGEN B-BAND

Frouin, Robert¹; Deschamps, Pierre-Yves¹; Dubuisson, Philippe²

¹Scripps Institution of Oceanography 8810 Shelback Way, La Jolla , CA, 92037, United States; ²Université des Sciences et Technologies de Lille, Villeneuve d'Ascq, Nord, 59655, France

A methodology is investigated to remotely sense the solar-induced chlorophyll fluorescence of natural waters. The methodology exploits absorption in the oxygen B-band around 687 nm, located near the peak of fluorescence emission at 685 nm. Inside the oxygen absorption lines, the fluorescence signal enhances the reflected solar radiance. By using a pair of spectral bands inside and outside the absorption region, or more generally spectral bands for which oxygen absorption is sufficiently different, the emitted contribution to the measured radiance can be extracted. Feasibility is demonstrated and retrieval accuracy quantified through simulations of the above-surface and top-of-atmosphere reflectance that fully account for interactions between scattering and absorption and include radiometric noise. The differential absorption technique works well from just above the surface. Pairs of spectral bands centered on the same wavelength provide the best results. Performance is degraded from space, due to the influence of aerosol vertical structure on the oxygen transmittance, but improved compared with that of the standard baseline technique, especially in coastal waters.

A NOVEL CONCEPT FOR MEASURING SEAWATER INHERENT OPTICAL PROPERTIES IN AND OUT OF THE WATER

Gainusa-Bogdan, Alina¹; Boss, Emmanuel¹

¹University of Maine 5706 Aubert Hall, Orono, ME, 04469-5706, United States

Seawater inherent optical properties (IOPs) are key parameters in a wide range of applications in environmental studies and oceanographic research. The volume scattering function and the absorption coefficient (a) fully determine the way light propagates through water. We predict that the geometry of the image formed on a CCD array by light scattered back from water illuminated with a laser source (the rate at which the light intensity decreases from the center of illumination outward) will mainly depend on the backscattering coefficient (bb), while the total amount of light detected will depend on a combination of a and bb . If so, an *in situ* instrument emitting a laser beam into the water and retrieving the backscattered light intensity as a function of distance from the center of illumination should provide information on both the water absorption and the backscattering coefficients. In this feasibility study we use Monte Carlo modeling of light propagation to create an inversion algorithm that would translate the signal from such an instrument into values of a and bb . Our results, based on simulations spanning the entire natural range of

seawater IOP combinations, indicate that an 8 cm - diameter instrument would be able to predict *bb* within less than 13% relative difference, and a within less than 54% (for 90% of the inverted *a* values, the relative errors fall below 29%). Such a compact and relatively simple device could have multiple applications for *in situ* optical measurements, including *a* and *bb* retrievals from instrumentation mounted on autonomous underwater vehicles. Furthermore, the same methodology could be used to develop an out-of-water sensor for much needed long-term *in situ* measurements of backscattering and absorption.

UNDERSTANDING CEPHALOPOD CAMOUFLAGE BY THE USE OF A NOVEL 3D VECTOR RADIATIVE TRANSFER CODE

Gao, Meng¹; You, Yu²; Dagach, Sergio²; Kattawar, George W.²

¹Texas A&M University Department of Physics and Astronomy, College Station, TX, 77843-4242, United States; ²Department of Physics and Astronomy, College Station, TX, 77843-4242, United States

One of the great enigmas of cephalopods is their remarkable ability to camouflage themselves with astonishing speed and precision. They are capable of matching the color, patterns and even the texture of their surroundings and are also responsive to the polarization of the light field as well. We will present a 3-dimensional fully polarized Monte Carlo radiative transfer code for use in modeling light transfer within cephalopod skin. We will consider the fundamental processes involved in camouflage such as chromatophore dynamics, iridiphore, and leucophore light-matter interaction behaviors. These will then be used to calculate and predict the polarized reflectance distribution of light from cephalopod skin. We will present results of such reflectance distributions for various underwater light conditions as well as skin reflectance distributions for dorsal and lateral samples of skin. To our knowledge this is the first fully polarized 3-dimensional radiative transfer code to be reported specifically for this purpose. We will present results of such reflectance distributions for various underwater light conditions as well as skin reflectance distributions.

TEMPORAL VARIATION OF THE IMPACT OF DUST SEA SURFACE FORCING ON THE REGIONAL OCEANIC PRIMARY PRODUCTION USING SEAWIFS OBSERVATIONS AND A MODELLING APPROACH.

Gentili, Bernard¹; Mallet, Marc²; Chami, Malik¹

¹Laboratoire d'Océanographie Villefranche (LOV) La Darse, BP 8, Villefranche sur Mer, 06 230, France; ²Laboratoire Aérologie, 14 avenue Edouard Belin, Toulouse, France, 31400, France

Mineral dusts are able to influence the biological productivity of the ocean through the addition of iron which stimulates photosynthesis by phytoplankton. In parallel to the iron hypothesis, dust aerosols that are not deposited over oceans are able to significantly reduce the solar energy available at the sea surface through scattering and absorption processes of incoming radiation. In this study, the impact of atmospheric dusts on the Photosynthetically Available Radiation just above the sea surface and on the resulting oceanic primary production is investigated. SeaWiFS observations acquired in West Africa coast over the period 1998-2007 are used together with a 1D modelling approach coupling an atmospheric radiative transfer model and a primary production model. The seasonal and annual variability of the dust sea surface forcing is studied. Results reveal that the occurrence of dusts could lead to a significant decrease of the oceanic regional primary production by 15% to 20% during spring period. The decadal loss of the primary production due to dusts impact over all the study area is analyzed. This study suggests that dust sea surface forcing cannot be ignored in coupled atmosphere-ocean models for calculating primary production at regional scale in highly productive waters.

VERTICAL CHANGES IN THE PROBABILITY DISTRIBUTION OF DOWNWELLING IRRADIANCE WITHIN THE NEAR-SURFACE OCEAN LAYER UNDER CLEAR SKY CONDITIONS

Gernez, Pierre¹; Stramski, Dariusz¹; Darecki, Mirosław²

¹Scripps Institution Oceanography University California San Diego, La Jolla, CA, 92093-0238, United States; ²Institute of Oceanology, Polish Academy of Sciences, Sopot, ., 81-712, Poland

Ocean surface waves produce fluctuations in the underwater light field over temporal scales from a fraction of a second to tens of seconds. Under clear sky conditions, very intense fluctuations in downwelling irradiance occur at near-surface depths as a result of sunlight focusing after refraction by waves on the water surface. Regardless of sky conditions, the underwater light field at sufficiently large depths is mostly diffuse where relatively weak wave-induced light fluctuations are produced by fluctuations in surface wave elevation. Under overcast skies the relatively weak fluctuations in diffuse light are also associated with variable light attenuation over varying water column height above the depth of measurement.

The main objective of this work is to examine changes in the probability distribution of downward irradiance, $P(E_d)$, with depth under sunny conditions when strong wave focusing of sunlight is a prevalent feature of the near-surface light field. We are particularly interested in the top ~10 m of the water column, where the intensity of wave-induced light fluctuations drops dramatically with increasing depth. Measurements of the downwelling irradiance fluctuations were performed using the Underwater Porcupine Radiometer System with a sampling frequency of 1 kHz, which is required for resolving wave-induced fluctuations. These measurements were made from the Floating Instrument Platform (FLIP) in the Santa Barbara Channel as part of the ONR Radiance in a Dynamic Ocean (RaDyO) program. Additional measurements were made from the “Acqua Alta” tower in the Adriatic Sea (Gulf of Venice).

Our results show that $P(E_d)$ at shallow depths down to a few meters below the surface is highly skewed towards large instantaneous values of E_d , which are associated with wave focusing. The coefficient of skewness can exceed the value of 2. This obviously indicates that the light fluctuations due to wave focusing depart significantly from the Gaussian process. At these depths, the Pareto or Gumbel distributions can provide useful parameterization of the experimental $P(E_d)$. A log-normal distribution also provided an adequate approximation for most near-surface measurements. With increasing depth below 5 m, the $P(E_d)$ distribution approaches the Gaussian distribution. This is indicated by both the skewness and kurtosis coefficients, which assume the values close to 0 and 3, respectively. We also use a graphical method of a Q-Q (quantile-quantile) plot to compare the experimental $P(E_d)$ and the normal distribution. The Q-Q plot follows a strongly nonlinear pattern at shallow near-surface depths and tends to linear pattern with a 1:1 slope as the depths increases below 5 m. This result supports the rapid vertical transformation of irradiance fluctuations from non-Gaussian towards Gaussian process within the uppermost oceanic layer.

THE SHOWER CURTAIN EFFECT AND ELECTRO-OPTICAL IMAGING SENSORS

Giddings, Thomas¹; Shirron, Joseph¹

¹Metron, Inc. 1818 Library St., Ste. 600, Reston, VA, 20190, United States

Electro-optical imaging sensors in ocean environments must often contend with thin, highly turbid layers in the water column (e.g., nepheloid layers). The shower curtain effect refers to the influence of scattering layer location on image quality. If an optically thick but physically thin scattering layer is positioned between an imaging sensor and the object plane, the image quality is generally observed to improve as the layer moves toward the object plane, and dramatically so as the layer reaches the object plane. An analysis of the problem quantifies the effects on image quality in terms of the contrast loss, edge blurring, and signal-to-noise ratio. Results from high-fidelity simulations show that not all measures of image quality are degraded as the scattering layer moves toward the sensor and away from the object plane. These observations are explained using analytical models for the image transfer process.

REMOTE SENSING ALGORITHMS FOR THE ESTIMATION OF CHLOROPHYLL-A IN COASTAL WATERS USING RED AND NEAR INFRARED BANDS

Gilerson, Alexander¹; Gitelson, Anatoly²; Zhou, Jing¹; Gurlin, Daniela²; Moses, Wesley²; Ioannou, Ioannis¹; Ahmed, Samir¹

¹City College of New York 140 St @ Convent Ave, New York, NY, 10031, United States; ²Center for Advanced Land Management Information Technologies, University of Nebraska-Lincoln, Lincoln, Nebraska, 68583, United States

Remote sensing algorithms which employ the red and NIR bands for the retrieval of chlorophyll concentrations [Chl] in coastal waters are less sensitive than traditional blue-green ratio algorithms to the absorption of the colored dissolved organic matter (CDOM) and scattering of mineral particles. We tested such algorithms using comprehensive synthetic datasets of reflectance spectra and inherent optical properties (IOP), related to various water parameters and compared with MERIS and MODIS satellite imagery and field measurements. Over 2000 reflectance spectra were simulated using HYDROLIGHT radiative transfer program with 1 nm resolution for conditions typical of coastal waters: [Chl] = 1 – 100 mg/m³, CDOM absorption at 400 nm 0 – 5 m⁻¹, and various shape of specific chlorophyll absorption spectra: some of them were typical for known phytoplanktonic groups and others were parameterized as a sum of specific absorptions of picoplankton and microplankton with several weighting factors. Concentrations of nonalgal particles in the datasets were in the range of 0 – 1 g/m³ and 1 – 10 g/m³. This separation by non-algal particulate concentrations was done because of the significant impact of non-algal particles on the chlorophyll fluorescence contribution and on the other reflectance spectral features. Simulations were based on the findings of many authors for IOP characteristics, and were similar to the assumptions used in the construction of the IOCCG datasets. Field measurements were conducted in the Chesapeake Bay (2005), Long Island Sound, New York City vicinity (2006-2009), and Nebraska lakes (2008-2009) with water sampling for [Chl] and mineral concentrations as well as measurements of water optical characteristics (absorption and attenuation) and reflectance spectra. 2-band algorithms were tested with MODIS bands Rrs(748)/Rrs(667) and MERIS bands Rrs(708)/Rrs(665). 3-band algorithm was tested only with MERIS bands in the form $[Rrs^{-1}(665) - Rrs^{-1}(708)] \times Rrs(753)$. The 2-band algorithm with MERIS spectral bands, Rrs(708)/Rrs(665), was found to be very robust proxy of [Chl] in a wide range of water conditions with a minimal sensitivity to CDOM concentrations and fluorescence quantum yield. Significant sensitivity of the ratio to mineral concentrations can be efficiently pared by an additional term in the numerator. Algorithms which include NIR bands near 750 nm are significantly less accurate. It is shown that the magnitude of the specific chlorophyll absorption near 675 nm plays a major role in the reliability of the algorithms especially at the low [Chl]. Uncertainties of blue-green ratio algorithms applied to coastal waters are also estimated for a variety of water compositions. It was found that errors of 100-300% can be expected.

MEASURING AND MODELING THE POLARIZED UPWELLING RADIANCE DISTRIBUTION IN CLEAR AND COASTAL WATERS

Gleason, Arthur C. R.¹; Voss, Kenneth J¹; Gordon, Howard R¹

¹University of Miami 1320 Campo Sano Dr., Coral Gables, FL, 33146, United States

Knowledge of the polarized, upwelling, bidirectional radiance distribution function (BRDF) is important for generating consistent, long-term data records for ocean color because the satellite sensors from which the data are derived are sensitive to polarization. A model for the unpolarized BRDF (Morel et al. 2002) has been validated in Case I waters (Voss et al. 2007), but variations in the polarization of upwelling radiance due to sun angle, viewing geometry, dissolved material and suspended particles have not been systematically documented. In this work we simulated the upwelling radiance distribution using a Monte Carlo-based radiative transfer code and measured it using set of fish-eye cameras with linear polarizing filters. The results of mode-data comparisons from experiments off Hawaii in clear Case I water and off Monterey, CA, in more turbid, coastal conditions will be presented.

LIGHT ABSORPTION BY PARTICULATE AND DISSOLVED ORGANIC MATTER IN COASTAL AND OCEANIC SITES OF THE SOUTHWEST COAST OF EUROPE: A CONTRIBUTION TO MERIS SENSOR VALIDATION

Goela, Priscila Costa¹; Cristina, Sónia¹; Icely, John²; Newton, Alice³

¹IMAR - Institute of Marine Research a/c Departamento de Zoologia, Faculdade de Ciências e Tecnologia, Universidade de Coimbra, Coimbra, 3004-517, Portugal; ²Sagremarisco Lda., Apartado 21, Vila do Bispo, Algarve, 8650-999, Portugal; ³NILU-CEE, Box 100, Kjeller, Oslo, 2027, Norway

The inherent optical properties of light absorption in coastal and oceanic sites should be well understood at a global level for the development of ocean colour algorithms. Two variable components of light absorption, which are important contributors to accurate adjustments to ocean colour algorithms, are considered and discussed based on data from a study conducted on the south west coast of Portugal. These are particulate absorption, comprising of phytoplankton and non-algal particles absorption; and coloured dissolved organic matter (CDOM) absorption, expressed in terms of the coefficients $a_p(\lambda)$, $a_{ph}(\lambda)$, $a_{nap}(\lambda)$ and $a_{CDOM}(\lambda)$. This study is part of a global effort to collect data to validate marine products of MERIS, the ENVISAT ocean colour sensor, as contracted by European Space Agency (ESA). Particulate absorptions were determined with Transmittance-Reflectance approach, using NaClO bleaching to remove the phytoplankton contribution to the total particulate matter absorption spectra; CDOM was assessed according to REVAMP protocols (2002). Phytoplankton absorption coefficients were transformed into specific coefficients $-a^*_{ph}(\lambda)$, normalizing it with respect to chlorophyll *a* concentrations determined both by HPLC and spectrophotometric methods. Results show that the absorption of light by particulate matter is almost totally dependent on the phytoplankton, with no significant contribution from non-algal particles (mean contribution of 10% to total particulate absorption), both in the coastal and oceanic waters off the south west of Portugal, emphasising the dominance of case 1-type waters. Specific phytoplankton coefficients show significant fluctuations between seasons and stations, ranging from 0.007 to 0.059 at 678 nm; nonetheless, a good correlation is observed between $a_p(443)$ and a_p at other MERIS equivalent wavelengths. Particulate matter has generally more weight than dissolved matter absorption in the total absorption budget. These results should contribute to improvements to the regional ocean colour algorithms.

EXTENSIVE PHYTOPLANKTON BLOOMS IN THE NORTHERN ARABIAN SEA AND POTENTIAL FEEDBACK EFFECTS

Goes, Joaquim Ignacio¹; Gomes, Helga do Rosario¹; Matondkar, Prabhu G. Shivaprasad²; Thoppil, Prasad G.³; Fasullo, John T.⁴; Roesler, Collin M.⁵; Basu, Subhajt²; Parab, Sushma G.²

¹Bigelow Laboratory for Ocean Sciences 180 McKown Point Road, Boothbay Harbor, ME, 04575, United States; ²Biological Oceanography Division, National Institute of Oceanography, Dona Paula, Goa, 403004, India; ³Planning Systems Inc., Stennis Space Centre, Mississippi, 39529, United States; ⁴Program in Atmospheric and Oceanic Sciences, University of Colorado, Boulder, Colorado, 80309, United States; ⁵Bowdoin College, Brunswick, Maine, 04011, United States

Over the past 10 years the Arabian Sea ecosystem has witnessed rapid changes linked to the general warming trend over Eurasia. In particular, large parts of southwest Asia (SWA) and the Himalayan-Tibetan Plateau (HTP) region have been experiencing significant decreases in spring snow persistence that have hastened and strengthened southwest monsoon (SWM) winds. Since 1998, as a result of intensification of wind-driven upwelling along the coasts of Somalia, Oman and Yemen, the western Arabian Sea has witnessed record increases in phytoplankton blooms. The impacts of the warming trend and the reduction in snow cover have not been limited to the SWM. Since 1998, winter convective mixing during the northeast monsoon (NEM) has been weakening, but despite this trend, chlorophyll (Chl *a*) concentrations in the Arabian Sea have been on the rise. Our collaborative studies with our Indian colleagues initiated in 2003, have allowed us to ascribe this increase in Chl *a* during the NEM to unprecedented blooms of a heterotrophic dinoflagellate, *Noctiluca miliaris*. Thick, surface dwelling blooms of *Noctiluca* have become a regular feature of the Arabian Sea during the NEM, replacing diatoms as the dominant winter-bloom forming phytoplankton. The extraordinary intensity of these blooms, and their persistence into the spring inter-monsoon when sea surface conditions in the Arabian Sea are most able to influence rainfall over the Indian subcontinent, demands that begin to question the feedback effects of *Noctiluca* blooms on heat and moisture fields over the Arabian Sea and as a consequence on the erratic monsoonal rainfall patterns being witnessed in recent years. This presentation will provide data from recent cruises on the extraordinary bio-

optical and ecophysiological characteristics of these blooms and also examine whether: 1) *Noctiluca* blooms prior to the onset of the SWM significantly increase the attenuation of light in the water column causing faster than normal heating of sea surface waters, and 2) perturbations in SST and moisture by *Noctiluca* blooms are large enough to induce changes in evaporation and atmospheric moisture content and stability over the Arabian Sea and rainfall over the Indian subcontinent.

OPTICAL PROPERTIES OF WINTER BLOOMS OF NOCTILUCA MILIARIS IN THE ARABIAN SEA

Gomes, Helga Do Rosario¹; Goes, Joaquim Ignacio¹; Matondkar, Prabhu²; Basu, Subhajit²; Parab, Sushma²; Roesler, Collin³; Werdell, Jeremy⁴

¹Bigelow Laboratory For Ocean Sciences 180 McKown Pt Road, West Boothbay Harbor, ME, 04575, United States; ²National Institute Of Oceanography, Dona Paula, Goa, 403004, India; ³Bowdoin College, Brunswick, Maine, 04011, United States; ⁴NASA Goddard Space Flight Center, Greenbelt, Maryland, 20771, United States

Winter blooms of *Noctiluca miliaris*, a conspicuously large heterotrophic dinoflagellate containing green symbionts of the prasinophyte *Pedimonas noctilucae*, have only been observed in the northern Arabian Sea within the last decade. A field program conducted since February 2003 has produced a large database of taxonomic data that shows that these blooms are replacing the traditional diatom dominated blooms documented in previous large-scale studies such as the (JGOFS in the early 1990s and the International Indian Ocean Expeditions (IIOEs) of 1959–1965. We have recently established a more detailed study that encompasses the ecophysiology, biogeochemistry and optical properties of this unusual and possibly climate change related blooms. These include phytoplankton pigments, spectral specific absorption coefficient for phytoplankton, and photosynthesis versus irradiance (P versus E) curve parameters that will allow us to examine phytoplankton community structure and photophysiological characteristics of the bloom, and provide the potential for use with long term ocean color records to establish the precise time when *N. miliaris* first made its appearance in the northern Arabian Sea, as well as quantify its spatial patterns and trends since its discovery in the last decade

TIME AND SPACE VARIABILITY OF SOME BIO-OPTICAL PROPERTIES AT ANTARES BAJA CALIFORNIA STATION, MEXICO (2007-2009)

Gonzalez-Silvera, Adriana¹; Millan-Nunez, Roberto²; Santamaria-del-Angel, Eduardo²; Santander-Cruz, Jonatan²; Callejas-Jimenez, Mariana²; Gracia-Escobar, Maria Fernanda²

¹University of Baja California Carr. Tijuana-Ensenada Km 103, Ensenada - Baja California, 22800, Mexico; ²Carr. Tijuana-Ensenada Km 103, Ensenada - Baja California, 22800, Mexico

This study is dedicated to the understanding of time and space variability of bio-optical variables at a coastal station off Baja California Peninsula (ANTARES Baja California station, 31.75°N/116.96°W). The sampling procedure begun in May 2007 and in this presentation we will report changes observed in the absorption properties by three components of seawater (phytoplankton, detritus and chromophoric-dissolved-organic-matter or CDOM) from surface to the end of the photic zone in relation to changes in environmental conditions (inorganic nutrients and irradiance) and phytoplankton community structure. Chlorophyll-a concentration (Chla) ranged from 0.06 to 1.5 mg m⁻³ with a strong vertical variability related to advective processes and the depth of the nutricline. At low Chla phytoplankton community structure was dominated by small cells which were evaluated by HPLC pigment concentration (Zeaxanthin and DVChla). At high Chla diatoms or dinoflagellates were the dominant fraction. The phytoplankton absorption coefficient at 440 nm (aph(440)) varied between 0.03 and 0.5 m⁻¹ while aph(675) from 0.025 to 0.034 m⁻¹. They also presented a strong temporal variability with higher values at depth. CDOM absorption coefficient at 350 nm was strongly variable with higher values at surface and at higher depths. It was calculated the contribution of each component for total absorption at 440 nm (a(440)) and results indicate that phytoplankton was the dominant component at the first optical depth. The shape of the absorption spectrum of phytoplankton was explained by mechanisms such as that at surface there were

higher proportions of photoprotective pigments while photosynthetic pigments dominate at higher depths. Finally, we discuss the implications of these results for the remote sensing of these properties.

MAPPING COASTAL HYPOXIA IN THE NORTHERN GULF OF MEXICO WITH OCEAN COLOR IMAGERY

Gould, Richard W.¹; Lewis, M. David¹; Smith, Regina D.²; Ko, Dong S.³

¹Naval Research Laboratory NRL Code 7331, Stennis Space Center, MS, 39529, United States; ²Jacobs Advanced Systems Group, c/o NRL Code 7331, Stennis Space Center, MS, 39529, United States; ³NRL Code 7322, Stennis Space Center, MS, 39529, United States

The “dead zone” off the coast of Louisiana in the northern Gulf of Mexico forms every year from mid-April through September and is the second largest hypoxic zone in the world. Ship-based surveys have been conducted each summer since 1985 by the Louisiana Universities Marine Consortium (LUMCON) to map the spatial extent of the bottom hypoxic waters. However, ship sampling is expensive and is not spatially or temporally synoptic. Can we supplement the cruise information by combining surface satellite imagery and 3D hydrodynamic modeling to map the spatial extent of bottom-water hypoxia? First, we created a 10-year satellite ocean color climatology (monthly composites of relative and absolute partitioned absorption coefficients) for the northern Gulf of Mexico. Next, for each year, we extracted optical properties at hypoxic locations (delineated by the mid-summer ship surveys), to define expected optical conditions of hypoxic waters. Then, for a new image, the observed satellite-derived optical properties are compared to the expected conditions and coupled with a model-derived stratification index (surface-to-bottom density difference) in a four-tiered testing approach, to provide a real-time spatial estimate of possible hypoxic areas. The premise is that correspondence to optical properties observed in past hypoxic events can be used to “predict” where hypoxia is most likely to occur in a new image. We compare hypoxic predictions from this approach with cruise-mapped hypoxic regions. Satellite ocean color imagery can be used to augment ship surveys and delineate areas of expected hypoxic conditions in near-real time, providing coastal managers with a new monitoring tool.

FACTORS CONTROLLING LIGHT TRANSMISSION THROUGH THIN FIRST-YEAR ARCTIC SEA ICE - OBSERVATIONS AND MODELLING

Hudson, Stephen ¹; Hamre, Børge²; Granskog, Mats¹; Stamnes, Jakob J.²

¹Norwegian Polar Institute, Tromsø, 9296, Norway; ²Department of Physics and Technology, University of Bergen, Bergen, 5020, Norway

Optical properties of the Arctic sea ice and snow cover control to a large degree the light available for primary production in Arctic waters. Rapid decreases in ice extent and thickness, resulting in an ice cover dominated by thin, first-year sea ice, are changing the light conditions in the Arctic Ocean and its marginal seas. Because knowledge of factors controlling light transmission through thin, first-year sea ice is limited, we performed a field campaign to collect data on spectral transmission through thin sea ice.

The spectral transmittance was determined from three simultaneous measurements with three radiometers, one measuring the irradiance incident upon the surface, the other measuring the irradiance reflected from the surface, and the third measuring the irradiance transmitted through the ice and snow at a platform floating at the bottom of the ice. Ice thicknesses ranged from 4 to 45 cm, and the snow cover ranged from 0 to 10 cm. The transmission of photosynthetically active radiation (PAR) through these different sea ice environments varied from 2% to 92%.

Ice samples were collected to determine the contribution to light attenuation by chromophoric dissolved organic matter (CDOM) and particulate matter (algal and non-algal material). This information was used together with a coupled atmosphere-ocean discrete ordinate radiative transfer (CAO-DISORT) model to retrieve a complete set of physical parameters that characterise the optical properties of sea ice at each

measurement site. Finally, we made an overall assessment of the most important factors controlling light transmission through snow-covered, first-year Arctic sea ice.

OPTICAL MAGIC: HOW CEPHALOPODS SENSE AND MANIPULATE LIGHT TO PRODUCE RAPID ADAPTIVE CAMOUFLAGE AND COMMUNICATION

Hanlon, Roger T.¹

¹Marine Biological Laboratory 7 MBL Street, Woods Hole, MA, 02543, United States

No marine animal can sense and manipulate light for fast and diverse patterning better than the cephalopods (octopus, cuttlefish, squid). The cephalopod eye extracts visual information from the adjacent light field and immediately (i.e. 700 mseconds) produces effective camouflage or communication in which pattern, brightness, color, posture and even 3D skin texture are tuned to the visual background or to other animals. These visual sensorimotor mechanisms will be described and illustrated with experimental data and underwater video. Cephalopod vision includes nighttime as well as polarization sensitivity but curiously the eye is colorblind (thus how do they achieve color blind camouflage?). A new discovery indicates that the skin may provide distributed sensing of light as well. The skin manipulates the existing light for exceptional diversity of patterning, and the pigmented chromatophores and various light reflectors and diffusers will be described, including recent efforts to quantify and model the light interactions in the skin. There is indirect behavioral evidence that cephalopods communicate via polarization signals, which are produced and controlled by iridescent cells in the skin; recent spectrometry measurements of the skin show how this may work. These multidisciplinary approaches will be summarized and incorporated into some wider principles of camouflage and communication in the marine environment.

RIGOROUS CALIBRATION OF AN IMPROVED FILTER PAD METHOD FOR PHYTOPLANKTON SPECTRAL ABSORPTION & APPLICATION TO SOGASEX

Hargreaves, Bruce R.¹; Vaidya, Ashma¹

¹Lehigh University EES Dept, 31 Williams Drive, Bethlehem, PA, 18015, United States

Accurate spectral absorption measurements of phytoplankton from natural water samples are essential for many field campaigns and can increase accuracy of satellite measurements of phytoplankton (biomass, rates of photosynthesis, physiological status of phytoplankton) and inherent optical properties of water. For the SOGASEX cruise (Feb-Apr 2008 sequential Lagrangian gas exchange tracer experiments in the Southern Ocean, Atlantic sector near 51 deg. N, 38 deg. W) accurate spectral phytoplankton absorption data contribute to estimates of rates of photosynthesis and the role of photosynthesis in the Southern Ocean biological carbon sink. A new portable Quantitative Filterpad Technique based on Transmittance & Reflectance measurements (pQFT-TR) with a diode array spectrometer has been rigorously calibrated to account for cuvette scattering (via center mount integrating sphere) and fluorescence artifacts (via optical blocking filters and comparison with scanning spectrophotometry). Sensitivity to mineral particle scattering was tested by addition of kaolin to algal cultures. With this new calibration and the demonstration of pQFT-TR indifference to variations in particle scattering, phytoplankton spectra from the Southern Ocean Gas Exchange Experiment (SOGASEX) are reanalyzed to calculate mean cell size and relation of size and [chl-a] to chlorophyll-specific absorption. Results showed a characteristic spectral shape when coccolithophore phytoplankton were the dominant taxon. Comparisons of SOGASEX mixed layer filterpad 'ap' spectra from discrete samples with matching ac9 'ap' data from paired profiles (with and without 0.2um filtration to remove particles) showed significant differences (compared to pQFT-TR data, ac9 raw 'ap' values were ca. 30% high, while scatter-corrected ac9 'ap' values were ca.30% low). Supported by NASA grant NNX07AV23G.

INSTRUMENTATION TO MEASURE THE BACKSCATTERING COEFFICIENT FOR ARBITRARY PHASE FUNCTIONS

Haubrich, David¹; Fry, Edward S.¹; Kattawar, George W.¹; Musser, Joseph A.²

¹Texas A&M University Texas A&M University, Dept. of Physics, TAMU 4242, College Station, TX, 77843-4242, United States; ²Stephen F. Austin State University, Dept. of Physics & Astronomy, PO 13044, SFA Station, Nacogdoches, Texas, 75962-3044, United States

The backscattering coefficient b_b , which is the integral of the volume scattering function in the backwards direction, is one of the inherent optical properties used in the characterization of natural waters. Current instruments measure the backscattering at the so called "Magic Angle". This is based on work done by Oishi (1990). This theory assumes that the backscattering coefficient is, to a good approximation, proportional to the signal at the magic angle. Of course, such an assumption guarantees that if there is anything interesting in the water, it will probably be missed.

We have developed an instrument to directly measure the backscattering coefficient for arbitrary phase functions; the instrument is suitable for *in situ* applications.

We present our design in both theory and experiment. We explain the theory behind our instrument and based on measurements made in the laboratory we demonstrate that our prototype shows the predicted behavior. We present data for various extinctions up to 8 m^{-1} . With a knowledge of the extinction, the instrument accuracy was better than 6.5 % throughout this range, a simple design modification will significantly improve this accuracy. We present calibration data from different particle sizes representing differently shaped volume scattering functions. Based on these measurements we demonstrate that our prototype has the necessary resolution to measure backscattering coefficients that range from those found in the cleanest sea waters to those typically found in biologically-rich coastal-type waters.

Our instrument is approximately 30 cm long and has a diameter of 15 cm. The laser is housed inside the instrument, while an umbilical cord connects it to the power supply and the detectors outside. Excluding these, the weight of the instrument is below 1 kg.

We discuss potential improvements that should be made for a commercial version of the instrument.

ASSESSMENT OF THE AEROSOL MODELS FOR SEAWIFS AND MODIS BY AERONET DATA

He, Xianqiang¹

¹Second Institute of Oceanography, SOA, China Baochubei Road 36, Hangzhou, 310012, China

The operational atmospheric correction algorithm for the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and the Moderator Resolution Imaging Spectroradiometer (MODIS) uses twelve predefined aerosol models to extrapolate the aerosol scattering radiance at the near infrared to visible spectral regime. The accuracy of the extrapolation depends on how well these twelve aerosol models close to the reality. In this paper, we use the AERONET data to evaluate the ability of the current aerosol models for SeaWiFS and MODIS over the global open ocean. The results show that current aerosol models for SeaWiFS and MODIS approximate the reality well for most of the global open ocean, but underestimate the spectral shape of the aerosol optical thickness and overestimate the water-leaving reflectance at 440nm as a whole. The water-leaving reflectance at 440nm in the east-central part of the Northern Atlantic, the Southern Atlantic, the Pacific Ocean, and the Southern Indian Ocean, is slightly overestimated with the mean bias less than 0.001, which meets the accuracy requirement of the atmospheric correction algorithm (absolute error less than 0.001 for water-leaving reflectance at 443nm). However, the water-leaving reflectance at 440nm in western part of the Northern Atlantic and the Northern Indian Ocean is significantly overestimated, with the mean bias larger than 0.001. Also, in the region affected by the Sahara desert, the water-leaving reflectance at 440nm is significantly underestimated for the strong absorption properties of the dust aerosol, which is not included in the current aerosol models for SeaWiFS and MODIS. Although this systematic overestimation can be partially remedied by the vicious calibration, it may limit the accuracy of the current atmospheric correction.

PROPAGATING UNCERTAINTY THROUGH A SHALLOW WATER MAPPING ALGORITHM BASED ON RADIATIVE TRANSFER MODEL INVERSION

Hedley, John¹; Roelfsema, Chris²; Phinn, Stuart²

¹Exeter University School of Biosciences, Prince of Wales Road, Exeter, EX4 4PS, United Kingdom;

²Center for Spatial Environmental Research, School of Geography Planning and Environmental Management, University of Queensland, Brisbane, Queensland, 4072, Australia

A recent area of development in remote sensing of optically shallow water regions is in the simultaneous retrieval of multiple parameters such as depth, benthic type, and water optical properties by radiative transfer model inversion. However, the benthic heterogeneity of environments such as coral reefs places a high information-content demand on imagery from which an inversion algorithm must also deduce depth and water optical properties. Current inversion methods based on look-up tables or successive approximation return a single per-pixel best fit solution, ignoring the possibility other solutions within the bounds of sensor or environmental noise.

This paper describes an image analysis methodology that propagates model uncertainty to the outputs for each pixel, giving both a mean value and confidence intervals on all the retrieved parameter values of depth, benthic type proportions and water optical properties. The method works by performing multiple inversions on the pixel reflectance spectrum, perturbed each time by a model of sensor and environmental noise derived from the image itself. The outputs make explicit the uncertainties of the inversion algorithm in relation to image spectral resolution and noise, and allow the evaluation of different imagery sources for specific applications.

In the work to be presented, the algorithm was applied to a 1 m resolution 17-band airborne CASI image and a 2.4 m resolution 4-band Quickbird image of Heron Island reef, Australia. The limitations of the imagery produced uncertainty effects which traded-off across the retrieved parameters. Bathymetry estimation was quite robust. For regions shallower than 10 m estimations from the Quickbird imagery were subject only to a small increase of uncertainty over CASI. Benthic type estimations and optical properties were challenging for either sensor. In addition to the variation of uncertainty across parameters, uncertainty is also dependent on image content. Depth zonation of benthic types means that uncertainty was often less than indicated by a-priori estimations. Overall the method seems capable of providing a meaningful image-based quantitative estimate of retrieval uncertainty, and hence has the potential to increase the value of remotely sensed data from these challenging environments.

MONTE CARLO RADIATIVE TRANSFER SIMULATIONS ON THE INFLUENCE OF SURFACE WAVES ON UNDERWATER LIGHT FIELDS

Hieronymi, Martin¹; Macke, Andreas²

¹Leibniz Institute of Marine Sciences at Kiel University (IFM-GEOMAR) Duesternbrooker Weg 20, Kiel, D-24105, Germany; ²Leibniz Institute for Tropospheric Research (IfT), Leipzig, D, 04318, Germany

A Monte Carlo model has been developed for calculating the penetration of light into the ocean. For monochromatic light (490 nm) the spatial exact allocation of the scattered parts of underwater light is described in terms of the variation of particle content and the angle of light incidence. Based on this model, it is possible to generate complex spatiotemporal fluctuating light fields according to every possible shape of the water surface. This method is applied to show the focusing effect of regular waves (from capillary to swell waves) and to illustrate characteristic light regimes due to irregular wave systems at high seas.

QUANTIFYING THE ABUNDANCE OF SUBMERGED AQUATIC VEGETATION IN NEARSHORE COASTAL ENVIRONMENTS WITH THE BROADBAND MULTISPECTRAL SENSOR, WORLDVIEW 2.

Hill, Victoria¹; Zimmerman, Richard¹; Bissett, Paul²

¹Old Dominion University 4600 Elkhorn Av, Norfolk, VA, 23529, United States; ²Florida Environmental Research Institute, Portland, Oregon, 97201, United States

The desire to quantify submerged aquatic vegetation (SAV) across the submarine landscape has grown tremendously in the last decade, especially in relatively turbid coastal environments characterized by high concentrations of colored dissolved organic matter (CDOM), phytoplankton and suspended sediments. Airborne imaging technology, providing high spatial and spectral resolution has been used successfully to map SAV abundance, but the logistics of airborne campaigns often prevent the use of this technology for time series observations needed to monitor ecosystem health and detect change in a timely manner. Here we explored the utility of Worldview2 (WV2), a commercial sensor providing 50nm spectral resolution and 3 meter spatial resolution, for mapping and quantifying SAV distributions in the Big Bend region of Florida, in the northern Gulf of Mexico. The shallow benthos (to 4 m depth) in this region was dominated by dense meadows of seagrasses (up to 4 spp) and associated macroalgae. Water column optical properties were strongly influenced by colored dissolved organic material, so much so that areas close to river mouths were red in color. Satellite imagery was atmospherically calibrated using co-incident ground based measurements of Rrs. A simple physics based approach was used to retrieve bottom reflectance signatures from the WV2 imagery, from which bottom type was identified and seagrass abundance was quantified using relationships developed from *in situ* observations. This method involves the use of measured water column optical properties and bathymetry to remove the filtering effect of the water column from Rrs revealing the underlying benthic reflectance signature. Remotely sensed properties (habitat type, seagrass density and bathymetry) were validated against *in situ* observations with a high degree of fidelity, indicating that WV2 may become an extremely valuable tool for managing valuable coastal ecosystems and observing their dynamics.

LIGHT AVAILABILITY ALONG A WATER QUALITY GRADIENT IN A SHALLOW ESTUARY: PATTERNS, RELATIONSHIPS, AND POTENTIAL IMPLICATIONS

Hilting, Anna K.¹; Currin, Carolyn A.²; Gallegos, Charles L.³

¹NOAA 101 Pivers Island Road, Beaufort, NC, 28516, United States; ²101 Pivers Island Road, Beaufort, NC, 28516, United States; ³Smithsonian Environmental Research Center, Edgewater, Maryland, 21037-0028, United States

What controls light availability in a shallow estuary, where benthic primary production may strongly influence water quality and nutrient cycling? This question is crucial for predicting the impacts of expanded military operations to New River estuarine resources aboard Marine Corps Base Camp Lejeune, North Carolina. We collected over 100 measurements of water quality parameters; light attenuation coefficients (KdPAR); and the spectral patterns of light absorption, attenuation, and scattering on a seasonal basis at six shallow water sites in the New River Estuary from October 2007 to March 2009. We used a Wetlabs ECO VSF-3 and AC-S to determine the backscattering-to-scattering ratio at 22 sites along the water quality gradient from the mouth to the head of the estuary. We found a wide range of water quality conditions: 0.96 to 198.17 mg_{l-1} chlorophyll a, 0.26 to 17.45 m₋₁ CDOM absorption, and 2.44 to 53.97 ntu associated with Kd(PAR) values ranging 0.62 to 7.30 m⁻¹. The backscattering-to-scattering ratio ranged from 0.12 to 0.23. We used radiative transfer modeling to link the estuary's optically active constituents (OACs) and their inherent optical properties (IOPs) to light attenuation. The results will be used to fine-tune a regional bio-optical model to predict K_d(PAR) under variable water quality conditions. We explore the importance of the role of OACs on light availability at specific wavelengths and the potential effects on benthic taxonomic composition and examine the role of a changing backscattering-to-scattering ratio along a water quality gradient.

NEW CHALLENGES IN SATELLITE RETRIEVALS OF MARINE PRODUCTS UNDER GLOBAL CLIMATE OBSERVATION MISSION

Hirata, Takafumi¹; Brewin, Bob²; Hardman-Mountford, Nick³; Smyth, Tim³; Hirawake, Toru⁴; Saitoh, Sei-ichi⁴; Ishizaka, Joji⁵; Toratani, Mitsuhiro⁶; Murakami, Hiroshi⁷

¹Hokkaido Univ N10W5, Sapporo, 060-0810, Japan; ²University of Plymouth, Plymouth, Devon, PL4 8AA, United Kingdom; ³Plymouth Marine Laboratory, Plymouth, Devon, PL1 3DH, United Kingdom; ⁴Hokkaido University, Hakodate, Hokkaido, 041-8611, Japan; ⁵Nagoya University, Nagoya, Aichi, 464-8601, Japan; ⁶Tokai University, Numazu, Shizuoka, 410-0395, Japan; ⁷Japan Aerospace Exploration

Agency (JAXA), Tsukuba, Ibaraki, 305-8505, Japan

Japan Aerospace eXploration Agency (JAXA) has started Global Change Observation Mission (GCOM) for a long-term monitoring (10-15 years) of global water cycles and climate change from space. GCOM consists of two satellite series, the GCOM-W for global water cycles and GCOM-C for climate change. GCOM-C1 is the first satellite in the GCOM-C series (launched in 2014), carrying a multi-channel optical sensor SGLI (Second generation GLObal Imager) with polarimetry and forward / backward observation functions. The SGLI wavelengths extends from near-UV (380nm) to thermal infrared wavelengths (12 μ m), with spatial resolutions of 250m to 1km. SGLI will derive conventional marine variables (such as Chlorophyll-a, Colored Dissolved Organic Matter and Suspended Matter Indices and Sea Surface Temperature) as standard products. In addition, derivation of new products (such as Phytoplankton Functional Types, Inherent Optical Properties, Primary Production, Red Tide flag etc) will be challenged, using an improved atmospheric correction scheme. The current status of algorithm development for some new products will be presented.

SIZE STRUCTURE OF PHYTOPLANKTON AND OPTICAL PROPERTIES IN THE ARCTIC OCEAN IN AUTUMN

Hirawake, Toru¹; Matsumoto, Keitaro²; Shinmyo, Katsuhito²; Fujiwara, Amane²; Saitoh, Sei-Ichi²

¹Hokkaido University 3-1-1 Minato-cho, Hakodate, 041-8611, Japan; ²3-1-1 Minato-cho, Hakodate, 041-8611, Japan

Normal 0 false false false MicrosoftInternetExplorer4 Size structure of phytoplankton community determines a structure of food web in the ocean. Recently, abrupt decline of sea ice extent occurred in the Arctic Ocean and its effect on the phytoplankton community structure is anticipated. We had developed a bio-optical model to determine spatio-temporal distribution phytoplankton dominant size in the Arctic and sub-Arctic waters during summer. Here we investigated the performance of the model against optical properties in the Arctic Ocean during autumn. Impact and contribution of colored dissolved organic matter (CDOM) on the optical properties were also assessed. Measurements of spectral radiation, backscattering coefficient, and water sampling to determine chlorophyll *a* (*chl-a*) concentration and absorption coefficients of particles and CDOM were carried out at 15 stations during the cruise of R/V Mirai in September and October 2009. Although the *chl-a* concentration in autumn was extremely low (<0.5 mg m⁻³) and small phytoplankton less than 2 μ m was dominant over the most of studied area in contrast to the summer, the model using the bio-optical data in summer is possible to detect the phytoplankton size in autumn correctly. However, light absorption coefficient of CDOM at 440 nm, a CDOM (440), was very high and varied from 0.06 to 0.15 m⁻¹. Relationship among the a CDOM (440), salinity and chl-a suggested that CDOM in the studied area was originated from phytoplankton in melt-water or extremely low saline riverine water. Contribution of a CDOM to total light absorption in the riverine water at short wavelengths was irregularly high and exceeded 50%. Identification of origin of CDOM is key issue for accurate estimation of ocean color products in the Arctic Ocean.

COMPARISON OF A BIO-OPTICAL ALGORITHM AND A STATISTICALLY BASED APPROACH FOR SATELLITE DETECTIONS OF HARMFUL ALGAL BLOOMS

Hlaing, Soe¹; Ahmed, Samir¹; Gladkova, Irina¹; Gilerson, Alexander¹; Grossberg, Michael¹; Shahriar, Faizul¹

¹City College of New York 160 Convent Avenue, New York, NY, 10031, United States

Effective satellite detection and identification of Harmful Algal Blooms (HABS) is well recognized as a cost effective and very desirable goal. Towards this end, we have used Florida's very extensive historical database, from the Fish and Wildlife Research Institute of thousands of observations and in-situ corroborations of HABs in the West Florida Shelf (WFF) to examine the range of applications and limitations of the Red Band Difference (RBD) algorithm technique and a related selective *K. brevis* bloom

classification index (KBBI) recently reported by us for bloom detection and classification of *K. brevis* blooms from satellite Ocean Color Sensor measurements. These results are then compared with those obtained using a second, statistically based approach, in which the historical WSF data base, in conjunction with contemporaneous satellite observations at the same scene, of three ocean color wavelengths and sea surface temperature, was used by us to train a classifier to identify *K. brevis* blooms. Both the RBD and statistical classifier techniques are tested using satellite (primarily MODIS AQUA) data, and compared for *K. brevis* detection in WFS locations, and evaluated against the historical data base. The results of these procedures are analyzed, and factors affecting retrieval accuracies (including fraction of false positives) are assessed. Both techniques are found to be effective for WFS bloom retrievals and warrant further examination and development.

IMPACT OF GLINT ON HYSPIRI AQUATIC SCIENCE OBJECTIVES

Hochberg, Eric J¹

¹Nova Southeastern University 8000 N. Ocean Dr., Dania Beach, FL, 33004, United States

Normal.dotm 0 0 1 201 1151 NSU Oceanographic Center 9 2 1413 12.0 0 false 18 pt 18 pt 0 0 false false false Among the science objectives of the Hyperspectral Infrared Imager (HyspIRI) mission, there are several questions that address aquatic ecosystems. Overall, HyspIRI has a bias toward the coastal ocean, where visible to shortwave infrared (VSWIR) image data can provide excellent information about the composition, distribution and functional status of optically shallow ecosystems, such as coral reefs and seagrass beds, where the problem of determining benthic community structure and processes is confounded by unknown water depths and unknown water column optical properties. As with any VSWIR remote sensing of aquatic systems, glint has the potential to confound HyspIRI science retrievals. The HyspIRI SunGlint Subgroup has conducted a preliminary assessment of the impact of glint on HyspIRI aquatic science objectives. Through computer-based modeling of water-leaving reflectances, the general conclusion of the Subgroup is that, for retrievals in optically shallow water, glint impacts are secondary to impacts of water quality (or lack thereof). Compensation for glint reflectance is straightforward, with the main issue being discrimination of the glint signal from the atmospheric aerosol signal. While further characterization and validation are required, the current overall consensus of the Subgroup is that glint will not adversely impact HyspIRI aquatic science objectives.

REMOTE CHARACTERIZATION OF THE UPPER OCEAN USING AIRBORNE MULTISPECTRAL POLARIMETRIC IMAGING

Hooper, Brett A.¹; Baxter, Becky¹; Scott, Nicholas¹; Vierra, Kenneth¹; Piotrowski, Cindy¹

¹Areté Associates 1550 Crystal Drive, Arlington, VA, 22202, United States

Remote sensing of the near-shore ocean environment is increasingly important to gain a better understanding of the hydrodynamics of waves, tides, turbulence, and currents in this environment on regional scales of approximately 100 km². Many of the typical *in situ* observations, such as buoys, are point measurements making it difficult, if not impossible, to cover these regional scales. Airborne remote sensing offers a viable, low-cost alternative for covering large areas on the order of 10-200 km². Furthermore, time-series optical remote sensing is an emerging technology, which is enabling users to study important hydrodynamic parameters in the marine environment, such as those mentioned above. Arété Associates has constructed, tested and flown an airborne multispectral polarimetric time-series imaging system to provide unique information for retrieving some of these dynamic environmental parameters. Arété's Airborne Remote Optical Spotlight System-Multispectral Polarimeter (AROSS-MSP) is a 12-channel sensor system that measures 4 color bands (RGB-NIR) and 3 polarization states for the full linear polarization response of the imaged scene. Typical image footprints provide area coverage on the water surface on the order of 2 square kilometers with 2 m ground sample distance. These images are combined in a mosaic that can cover a tidal basin on the order of 200 km², such as Skagit Bay in Washington State, in about an hour. Polarimetric remote sensing provides information about imaged scenes which cannot be obtained from luminance and spectral measurements alone, such as surface orientation,

surface roughness, and index of refraction. This new multispectral polarimetric system (AROSS-MSP) enables the minimization of surface reflections to image the sub-surface water column at greater depth than randomly polarized light to track sedimentation fronts. Exploiting the polarization state of light reflected from the ocean surface will also enable measurement of the two-dimensional slope field of the surface. From this measurement, the significant wave height of the surface wavefield can be calculated. AROSS-MSP also has the ability to image through marine haze and maximizes wave contrast to improve hydrographic parameter retrievals, such as: waterline contours and topography, directional wave spectra, water depth and currents. Color and polarization imagery on this scale and resolution is also capable of distinguishing fronts at salt water and fresh water interfaces, sea grass and other sub-aquatic vegetation distribution, in addition to bottom structure on exposed tidal flats. "Approved for Public Release, Distribution Unlimited"

CDOM IN THE BARENTS SEA: ABUNDANCE AND ORIGIN ACROSS THE POLAR FRONT

Hancke, Kasper¹; Hovland, Erlend Kjeldsberg¹; Volent, Zsolt²; Sakshaug, Egil¹

¹Bynesvegen 46, Trondheim, 7491, Norway; ²Norwegian University of Science and Technology
Bynesvegen 46, Trondheim, 7465, Norway

Coloured dissolved organic matter (cDOM) is an important optical constituent in seawater, with the potential to attenuate light significantly, especially in the blue to violet part of the visible spectrum. Thus, cDOM influences the underwater light spectrum, reducing energy available to phytoplankton and affecting the remote sensing signal. In addition, trapping of heat by cDOM in the upper layers of the ocean can potentially lead to stronger stratification and sea ice melting in the Arctic. We present data from two cruises transecting the Polar Front from Atlantic to Arctic waters in the Barents Sea, in 2007 and 2008. The former took place during post-bloom conditions (max *in situ* Chl a

ONE INDEX, MANY APPLICATIONS

Hu, Chuanmin¹

¹University of South Florida 140 Seventh Avenue, South, St. Petersburg, FL, 33701, United States

Most ocean color inversion algorithms are designed to estimate concentrations of the various optically active constituents (OACs) suspended or dissolved in water. Floating algae drifting on the ocean's surface due to current-driven aggregation or buoyancy-driven vertical migration, on the other hand, are difficult to detect or quantify using these traditional algorithms. Yet these small-scale blooms play important roles in affecting the local biogeochemistry and ecology. A floating algae index (FAI) is proposed here to characterize the small-scale algae blooms. The MODIS FAI is based on the MODIS medium-resolution data in the red, near-IR, and shortwave-IR bands using the same design as the MODIS fluorescence line height (FLH). Model simulations and data comparison suggest that FAI is relatively a stable index under various atmospheric and observing conditions. Several applications are presented to demonstrate how FAI may be used to quantify the various surface drifting macroalgae and cyanobacteria under complex optical conditions. In the absence of blooms, FAI may serve as a simple yet reliable proxy for water's turbidity.

REMOTE DETECTION OF OIL SLICKS IN THE OCEAN: IS THERE AN OPTICAL SIGNATURE?

Hu, Chuanmin¹; Lee, ZhongPing²; English, David³; Ivey, James⁴; Cannizzaro, Jennifer³; Coble, Paula³; Kovach, Charles⁵

¹University of South Florida 140 Seventh Avenue, South, St. Petersburg, FL, 33701, United States;
²Mississippi State University, Northern Gulf Institute, Stennis Space Center, MS, 39529, United States;
³140 Seventh Avenue, South, St. Petersburg, FL, 33701, United States; ⁴Florida Fish and Wildlife Research Institute, 100 Eighth Avenue SE, St. Petersburg, FL, 33701, United States; ⁵Florida Department of Environmental Protection, 13051 N. Telecom Parkway, Temple Terrace, FL, 33637, United States

Remote sensing technology to detect surface oil slicks and monitor oil spills in the ocean includes both active and passive means using visible, infrared, microwave, radar, and LIDAR sensors, each with several advantages and disadvantages. While Synthetic Aperture Radar (SAR) data have been used extensively for oil spill monitoring, differentiating oil slicks from other similar features (e.g., freshwater slicks, upwelling, low-wind induced surface patches) using the dampened backscattering signal often relies on *a priori* knowledge of the environment and on texture analysis. Multi-band or hyperspectral data from passive sensors, although suffering from cloud cover, might be able to show spectral optical signatures that are unique to oil slicks. The Deepwater Horizon oil spill tragedy since late April 2010 provides an opportunity to examine the optical properties of the oil slicks under various observing conditions using satellite instruments such as MODIS and MERIS. Because of their modulation on surface capillary waves, the slicks can be detected under sun glint using the same principles of SAR. When sun glint is negligible, their surface reflectance can be examined in reference against the nearby oil-free water. The different refraction index and absorption/scattering properties of oil in contrast to the surrounding water may lead to distinguishable reflectance properties. Here we report our preliminary findings from MODIS/MERIS and other remote sensing data. In particular, we analyze the spectral shapes and magnitudes of the oil slicks at various concentrations, and compare them with other known features such as *Sargassum* and *Trichodesmium* blooms. The results may be used to help design spectral bands in future coastal-oriented satellite missions, for example GEO-CAPE and HypSIIRI.

A NOVEL APPROACH TO CHARACTERIZE COLORED DISSOLVED ORGANIC MATTER (CDOM) USING *IN SITU* MULTISPECTRAL FLUORESCENCE AND ABSORPTION METERS

Jaegler, Thomas¹; B elanger, Simon¹

¹Universit e du Qu ebec   Rimouski 300, all e des Ursulines, Rimouski, QC, G5L 3A1, Canada

Colored dissolved organic matter (CDOM) has significant effect on biological activity and photochemical reactions in aquatic ecosystems. Simultaneous utilization of multispectral fluorescence and absorption meters can potentially be used to derive new parameters *in situ*, such as fluorescence quantum yield (FQY) and fluorescence indices (FI), providing new sights on the sources and sinks processes regulating CDOM concentration in natural waters. We conducted fieldwork and a series of controlled experiments to test the potential of two recently commercialized *in situ* instruments: a customized ECOTriplet (WetLabs) with one excitation at 370 nm and three emission wavelengths at 420, 465 and 500 nm; a high-resolution spectrophotometer (a-sphere, Hobilabs), which is an integrating sphere allowing absorption measurements free of scattering error. Preliminary results indicate that the spectral response of fluorescence varies significantly among the different river systems sampled along the Estuary and Gulf of St Lawrence. The potential of these new technologies to characterize CDOM *in situ* will be further discussed.

COMPARISON OF THREE SEAWIFS ATMOSPHERIC CORRECTION ALGORITHMS IN TURBID WATERS FROM AERONET-OC MEASUREMENTS

Jamet, C edric¹; Loisel, Hubert¹; Ruddick, Kevin²; Zibordi, Giuseppe³; Feng, Hui⁴; Kuchinke, Christopher⁵

¹LOG/ULCO/CNRS LOG/MREN, 32 avenue Foch, Wimereux, 59000, France; ²Unit of the North Sea Mathematical Models (MUMM), Royal Belgian Institute for Natural Sciences (RBINS), 100 Gulledele, Brussels, Brussels, B-1200, Belgium; ³EC-JRC Centre for Environment and Sustainability, Global Environment Monitoring Unit, TP272, Ispra, Ispra, 21020, Italy; ⁴Ocean Process Analysis Laboratory, Institute for the Study of Earth, Oceans and Space, University of New Hampshire, Durham, New Hampshire, 03824, United States; ⁵Environment Protection Authority, GPO Box 1751, Hobart, Tasmania, 7001, Australia

This paper presents preliminary results of an inter-comparison study of three coastal waters atmospheric correction algorithms for the SeaWiFS sensor: the standard SeaWiFS/MODIS algorithm (reprocessing version R2007: Stumpf, 2003; version R2009: Bailey, 2010) named S03R2007 and S02R2009 respectively, the algorithm developed by Ruddick et al. (2000) named R00 (R00R2007 and R00R2009 for reprocessing

version R2007 and R2009, respectively) and the algorithm of Kuchinke, named K09 (2009). The algorithms are compared using ground-based measurements from the three AERONET-Ocean Color sites in the Adriatic Sea and in the East Coast of United States (2 sites).

Based on a matchup exercise, the best overall estimates of the marine and aerosol parameters are obtained with the SeaWiFS standard algorithm, S03R2009 with relative error varying from 14.97% for $\lambda=490$ nm to 35.27% for $\lambda=670$ nm. The less accurate estimates are given by R00R2007, the relative error being between 16.62% for $\lambda=555$ nm and 51.07% for $\lambda=412$ nm. An improvement of the retrieval values of $nL_w(\lambda)$ is observed when using the new SeaWiFS reprocessing with errors decreasing at 412 and 443 nm. The improvement is slightly better for higher wavelengths. K09 is the most accurate algorithm at 412 nm which is a critical wavelength in turbid waters and also at 510 nm. But its retrievals are wavelength-dependent which is not the case for S03R2009. This latter is very stable as the RMS does not vary a lot with the wavelength.

The same conclusions can be done for the aerosol optical properties (aerosol optical thickness $\tau(865)$ and the Ångström coefficient, $\alpha(510,865)$). $\tau(865)$ was highly over-estimated and $\alpha(510,865)$ was under-estimated with S03R2007 and R00R2007. With R2009, those parameters are retrieved more accurately, even if $\alpha(510,865)$ is still moderately under-estimated. K09 is not so accurate retrieving the aerosol parameters; this is due to the aerosol models taken into account in this algorithm.

The recommendation of this work is to use the new SeaWiFS atmospheric correction algorithm to study the marine and aerosol parameters in turbid waters.

ESTABLISHING BASELINE SUBSURFACE LIGHT FIELDS FOR THE FLOWER GARDEN BANKS NATIONAL MARINE SANCTUARY

Jolliff, Jason¹; Gould, Richard¹; deRada, Sergio¹

¹Naval Research Laboratory 1009 Balch Boulevard, Stennis Space Center, MS, 39529, United States

The Flower Garden Banks National Marine Sanctuary (FGBNMS) consists of three separate areas in the northwestern Gulf of Mexico where salt dome crests rise to within ~18-meters of the surface from an outer-continental shelf relief of 100-150-meters, and these geologic features provide a platform for unique coral reef ecosystems. It is known that such ecosystems are sensitive to photon flux variability, and this is particularly the case for Mesophotic coral ecosystems (MCE's) that consist of light-dependent corals growing beyond the depth limit of traditional SCUBA surveys. Thus we are combining MODIS and SeaWiFS ocean color data with atmospheric and in-water radiative transfer models, as well as high-resolution ocean circulation models, in order to establish baseline environmental conditions for FGBNMS coral reef communities – with specific emphasis on near-bottom Photosynthetically Available Radiation (PAR). Since the original FGBNMS boundary designation in January 1992, high-resolution multibeam bathymetry surveys have revealed numerous other topographic features in the surrounding region capable of supporting biological communities designated by the FGBNMS managers as critical habitats. It is an additional aim of this research to identify likely locations for specific biological communities where no detailed surveys have been performed.

MULTIWAVELENGTH RAMAN AEROSOL OBSERVATIONS OF SAHARAN AND PATAGONIAN DUST ABOARD THE RESEARCH VESSEL POLARSTERN DURING ITS MERIDIONAL CRUISE ANT-26/1

Kanitz, Thomas¹; Althausen, Dietrich¹; Engelmann, Ronny¹; Baars, Holger¹; Macke, Andreas¹

¹Institute for Tropospheric Research Permoser Str. 15, Leipzig, 04318, Germany

In the framework of the Oceanet experiment the mass and energy fluxes between ocean and atmosphere are investigated. For the first time the shipborne atmospheric radiation measurement platform Oceanet took part in the meridional cruise ANT-26/1 of the research vessel Polarstern.

Vertical profiles of backscatter coefficient, extinction coefficient and particle depolarization are determined at different wavelengths by the Raman lidar Polly^{XT}. In this way the height resolved radiative effects of single lofted layers are estimated by the use of the Library Radiative Transfer model.

The cruise of the RV Polarstern across the Atlantic started at Bremerhaven, Germany on 16 October 2009 and ended at Punta Arenas, Chile on 25 November 2009. Two measurements are presented. On 31 October 2009 a Saharan dust plume was observed close to the Cape Verde islands. The lofted aerosol layers extended from 0.8km to 2.5km height. Meteorological charts of the GFS and NAAPS confirm the continental, African origin of the observed air masses. The Saharan dust plume is characterized by an AOT of 0.26, a lidar ratio of 55 sr at a wavelength of 532nm and an Angstrom exponent of 0.2 for extinction at 355 and 532 nm. Radiative transfer calculations were made in using an ocean albedo of 0.05 and a solar zenith angle of 30°. At the bottom of the atmosphere the radiative forcing is about -59.2W/m².

The measurement of the 20 November 2009, about 700km southeast from Montevideo shows a Patagonian dust plume. The Patagonian desert is known for continuous dust emissions, due to dry soil with sparse vegetation and surface winds of about 70 km/h. In comparison to the Saharan dust plume, observed Patagonian dust plumes were optical thinner. They are characterized by AOTs of about 0.02 and comparable vertical extents.

The Polly^{XT} will take part in the following meridional cruises of the research vessel Polarstern.

This offers the opportunity to establish a unique database above the barely investigated Atlantic. Furthermore, it is planned to expand the cruises of the Oceanet-Atmosphere platform to other oceans.

OCEAN OPTICS IN THE NEAR FUTURE 5-10 YEARS OUT, WHERE WE'RE HEADED AND CURRENT CHALLENGES

Kattawar, George W¹

¹Texas A&M University TAMU-4242, College Station, TX, 77843-4242, United States

As many of you are aware, the future of Ocean Optics is in a very precarious situation and as a community; we must unite and present a very strong case for the importance of our research to the future of the Navy, our nation, and the world. I will try to present some new, as well as old ideas which have yet to be implemented, to show how they may lead to outstanding advancements in remotely measuring such things as sound speed, temperature, salinity, backscattering coefficients, Mueller matrices, just to mention a few. We will also explore the fascinating world of ultrashort laser pulses and show how they might be used to open up new areas of hyperspectral sensing and acoustic communication. The possibility of using adaptive optics for underwater imaging will also be discussed. We will also address some of the most pressing problems facing us in ocean biology which is so crucial to our ecosystem.

MODELLING THE BEHAVIOUR OF LIGHT AT THE ATMOSPHERE-OCEAN BOUNDARY – AN APPROACH USING HIGH-RESOLUTION SEA SURFACE REALIZATIONS

Kay, Susan¹; Hedley, John²; Lavender, Samantha³; Nimmo-Smith, W.A.M.⁴

¹University of Exeter Hatherly Laboratories, Prince of Wales Road, Exeter, EX4 4PS, United Kingdom; ²Hatherly Laboratories, Prince of Wales Road, Exeter, EX4 4PS, United Kingdom; ³ARGANS Ltd, Unit 3, Drake Building, Tamar Science Park, Derriford, Plymouth, Devon, PL6 8BY, United Kingdom; ⁴Marine Institute, University of Plymouth, Plymouth, PL4 8AA, United Kingdom

This study investigates the effect of surface shape on the directional reflectance and transmittance of light at the air-water interface. In many marine applications biophysical parameters such as chlorophyll concentration and water depth are retrieved from optical measurements made above the water surface, for example by airborne or satellite remote sensing. These retrievals rely on accurate modelling of the behaviour of light at the water surface. Often, optical models of the air-water interface correctly describe slope statistics but do not reproduce the spatial pattern of water surface elevation. This means that

phenomena such as multiple reflections between wave sides, the shadowing effect of large waves and spatial variation in reflectance cannot be accurately captured. In the work presented here Monte Carlo ray tracing was used to investigate the behaviour of light, using models of the wind-blown sea surface that incorporate both slope and elevation features on scales from 3 millimetres to 200 metres. The surfaces were created by a Fourier inversion method, using the broadband elevation variance spectrum of Elfouhaily *et al.* (1997) and the two-dimensional spreading function of Heron *et al.* (2006). The numerically realized surfaces have mean square slopes that fall within the range given by the model of Cox and Munk, and an elevation standard deviation within 25% of the empirical approximation $0.005U_{10}^2$, for wind speeds U_{10} below 15 ms^{-1} . Initial results show that, for many viewing angles, the modelled radiance is within 10% of that predicted using a standard Cox and Munk slope statistics approach. However, the new model predicts greater back- and sideways-scattering; this effect is greater when the sun is aligned with the wind and for larger solar zenith angles, where wave shadowing and multiple scattering are more likely to occur. The model can include polarization with little computational overhead, and work to include whitecaps is underway. The model has the potential to improve radiative transfer modelling for ocean colour imaging and other aquatic remote sensing, and for applications where the subsurface light field is significant.

PHYTOPLANKTON INHERENT OPTICAL PROPERTIES DURING EXPONENTIAL AND STATIONARY GROWTH PHASES

Kheireddine, Malika¹; Loisel, Hubert¹; Mériaux, Xavier¹; Breton, Elsa¹; Courcot, Lucie¹; Houliez, Emilie¹; Lizon, Fabrice¹

¹LOG 32 avenue Foch, Wimereux, 62930, France

Numerous studies were performed on the inherent optical properties (IOPs) of phytoplankton cells since the 70s. These researches essentially focussed on the exponential growth phase comparable to bloom conditions encountered in the natural environment. Consequently, very few experiments were dedicated to the study of the phytoplankton IOPs during the stationary growth phase, and even none for the particulate backscattering coefficient, b_{bp} . This is mostly due to the potential contamination of the culture by detrital particles generated during degradation processes occurring during this phase. In the present study, the particulate backscattering (b_{bp}) and phytoplankton absorption (a_{ph}) coefficients were measured during both exponential and stationary growth phases. Effect of the age of cells on a_{ph} and b_{bp} were examined for 4 species of diatoms commonly found in coastal waters of the eastern English Channel. Particle size distribution, chlorophyll *a* (Chl *a*), particulate organic carbon (POC), detrital absorption, and relative electron transport rate (rETR) were also measured. We found that for each species, a_{ph} is significantly higher during the exponential growth phase when normalized to Chl *a*, than during the stationary growth phase (by a factor of 2 ± 1). This is due to the influence of pigment composition and package effect, which are the two main sources of variability in algal absorption for a given Chl *a*. The same tendency was observed between the two phases for b_{bp} when normalized to Chl *a* (by a factor of 2.3 ± 1) and POC (by a factor of 2.5 ± 1). It's surprising given that more detritus are present during the stationary growth phase than during the exponential ones (as confirmed from detrital absorption measurements). Consequently, our results indicate that the observed increased backscattering can not be explained by the presence of detritus, but rather by a modification of the scattering properties of the cells between the two phases (and especially by the higher carbon content in the exponential than in the stationary growth phase). Comparison with standard b_{bp} vs. Chl relationships developed from *in situ* measurements strongly suggests that part of the scatter observed around these mean relationships is explained by the cells physiological state.

LATE SPRING BIO-OPTICAL FEATURES AROUND SVALBARD, ARCTIC SEA

Kim, Hyun-cheol¹; Ahn, Yu-Hwan²; Moon, Jeong Eon²; Park, B.K.¹

¹Korea Polar Research Institute, KORDI Songdo Techno Park, 7-50, Songdo, Yeosu, Incheon, 406-840, Korea, Republic of; ²Korea Ocean Research and Development Institute, Ansan, ., ., Korea, Republic of

Polar regions are issued due to global warming, the warming related to climate change is currently observed by remote sensing which have gave us almost recent global information of the change. Change of

marine ecosystem can be inferred from ocean color remote sensing. However, optical properties in high latitude are different from that in mid latitude like temperate water region. Hence, to develop the accuracy of ocean color remote sensing in Arctic Sea, we have assessed ocean around Ny-Alesund, Svalbard sampling bio-optics and phytoplankton since 2006. Chlorophyll-a retrieved from MODIS/AQUA is compared with sampled chlorophyll-a around Ny-Alesund. There are bits of under- and over- estimating according to the mass of chlorophyll-a, such as 1 mg m^{-3} . And water-leaving radiances retrieved from MODIS/AQUA are underestimated by 35% according to in-situ water-leaving radiances. Hence using sampled data of up-to-now, a new experimental algorithm of chlorophyll-a is developed. However, our sampling area did not covered off shore of Svalbard, there is still uncertainty to retrieve chlorophyll-a concentration of off sea

COLORS OF RED TIDES: EXPERIMENTAL STUDIES ON COLOR OF PHYTOPLANKTON

Kishino, Motoaki¹; Furuya, Ken¹

¹The University of Tokyo 1-1-1 Yayoi, Bunkyo, Tokyo, 113-8657, Japan

Reflectance of phytoplankton was examined using unialgal cultures of *Micromonas pusilla* (prasinophyte), *Dunaliella tertiolecta* (green algae), *Chaetoceros sociale* (diatoms), *Heterosigma akashiwo* (raphidophyte), *Prorocentrum minimum* simulated reflectance was determined by spectral photoradiometer and small water tank in a dark room. Reflectance was then converted to the CIE chromaticity coordinates (x, y) and plotted on CIE chromaticity diagrams. Absorption coefficient of each phytoplankton was compared with spectral reflectance. Reflectance of each phytoplankton species was well correlated with the absorption coefficient, especially at high concentration. Influence of back scattering was obvious at a certain range of spectra where reflectance was disaccord with absorption. Spectral reflectance of each species showed its own characteristics in the optical properties, and they are different each other. (dinoflagellate), *Synechococcus* sp. (cyanobacteria), and *Rhodomonas salina* (cryptophyte). This difference was considered to represent class-specific optical properties of phytoplankton.

A LOOK-UP-TABLE APPROACH FOR SELECTING SEMI-ANALYTIC MODEL COEFFICIENTS USED IN SHALLOW WATER INVERSION

Klonowski, Wojciech¹; Lynch, Mervyn¹; Fearn, Peter¹; Slivkoff, Matthew¹

¹Curtin University of Technology PO Box U1987 , Perth, 6845, Australia

Semi-analytical equations are widely used in hyperspectral remote sensing to retrieve inherent optical properties (IOPs), bathymetry and benthic cover over shallow water coastal environments. The equations incorporate a set of model coefficients used to approximate the radiative transfer equation and a separate set of parameterisation coefficients that are to be retrieved in the inversion process. The accuracy of these equations largely depends on using appropriate fixed model coefficients and parameterisation. Generally, focus is given to the model parameterisation, such as IOP and bottom reflectance spectra, for improving retrieval accuracy in a specific region of interest. However, often, the model coefficients obtained from literature have been derived for specific solar-sensor geometry (such as nadir view), and by using an average particle phase function. We investigate the potential limitations of using these static model coefficients compared with approaches that use arbitrary solar-sensor viewing angles and particle phase functions. We derive a Look-Up-Table (LUT) of new model coefficients covering a wide range of environmental conditions including solar-sensor geometry, water depth and particle backscattering ratios, and demonstrate improvements in the retrieval accuracy of water column IOPs, bathymetry and benthic cover.

SIMEC, AN ENVIRONMENT CORRECTION FOR MERIS BASED ON THE NIR SIMILARITY SPECTRUM

Knaeps, Els¹; Sterckx, Sindy¹; Ruddick, Kevin²

¹VITO Boeretang 200, MOL, 2400, Belgium; ²Management Unit of the North Sea Mathematical Models (MUMM), Royal Belgian Institute for Natural Sciences (RBINS), 100 Gulledele, Brussels, 1200, Belgium

Recently a new environment correction has been proposed for hyperspectral airborne datasets based on the correspondence with the NIR similarity spectrum (Sterckx et al, accepted). The NIR similarity spectrum provided a base to both detect and correct adjacency effects. Detection of the magnitude of the environment effects is based on the deviations from the NIR similarity spectrum. The detection was tested on airborne hyperspectral datasets from two different sites and flown at different flight altitude. The adjacency correction algorithm estimates the contribution of the background radiance based on the correspondence with the NIR similarity spectrum. Again the correction was tested on the same test imagery and validated using in-situ water-leaving reflectance measurements. The main advantage of the method is that no assumptions have to be made on the NIR albedo, such that the correction can be applied over more turbid waters, i.e. until the similarity spectrum is valid.

Here the NIR similarity correction is applied to MERIS and is referred to as SIMEC. Details are provided on the adjusted method. The method is tested on a MERIS dataset of lake Trasimeno with coincident in-situ measurements. The results are compared with the ICOL adjacency correction, which is implemented in BEAM.

WATER-LEAVING RADIANCE MEASURED USING WITH COVERED RADIOMETERS IN TURBID WATERS

Kobayashi, Hiroshi¹; Ishizaka, Joji²; Jintasaeranee, Pachoenchoke³; Gunbua, Vichaya³; Fukasawa, Tatsuya⁴

¹University of Yamanashi 4-3-11, Takeda, Kofu, 400-8511, Japan; ²Nagoya University/Furo-cho, Nagoya, Aichi, 464-8601, Japan; ³Burapha University/169 Long-Hard Bangsaen Road, Tambon Saensook, Amphur Muang, Chonburi, 20131, Thailand; ⁴Hokkaido University/Kita 13, Nishi 8, Kita-ku, Sapporo, Hokkaido, 060-8628, Japan

Water-leaving radiance was measured using with two radiometers attached with different cover sizes. The used cover sizes respectively were 0.164 m, 0.104 m and 0.027 m. The observations were carried out in Ariake bay in Japan on November 2009 and around the estuary of Bangpakong River at northeastern of the upper Gulf in Thailand on December 2009. Corrected water-leaving radiance is written as (Gordon and Ding, 1992)

- $L_{wcorrected} = L_{wsize1} \exp(-karsize1)$
- $ka = \ln(L_{wsize1}/L_{wsize2}) / (rsize2 - rsize1)$

where L_w is the measured water-leaving radiance, r is the cover's shade size, upper suffixes mean cover sizes, a is the total absorption coefficient, $k = 2/\tan(z0w)$, and $z0w$ is solar zenith angle in water. Total absorption coefficient was calculated from radiometric data using these equations. In addition, total absorption coefficient was calculated from measurement of each absorption coefficient of phytoplankton, non-algal particle, and colored dissolved organic matter and that of water. These results agree each other except shorter wavelength region. The discrepancy in shorter wavelength was caused by water molecule scattering. If the quantitative influence of water molecule scattering on this method is evaluated, it is possible that the real water-leaving is determined using with only one radiometer attached with small size cover and with the measurement of total absorption coefficient in turbid waters.

MULTIPLE-INDEX OPTICAL CHARACTERIZATION OF THE PARTICLE ASSEMBLAGE IN THE SANTA BARBARA CHANNEL, CALIFORNIA

Kostadinov, Tihomir Sabinov¹; Siegel, David A.¹; Maritorena, Stéphane¹

¹ICISS, UC Santa Barbara 6832 Ellison Hall, ICESS, Santa Barbara, CA, 93106-3060, United States

An extensive in-situ bio-optical data set is used to construct and evaluate multiple optical indices characterizing the surface suspended particles in the Santa Barbara Channel (SBC), California. Knowledge of oceanic particle assemblages, especially their biogenic component, is of paramount importance for understanding ocean ecosystems structure and function and their role in the global carbon cycle. Suspended particulates are optically active and therefore knowledge of individual particle optical properties can be used to constrain the oceanic light field, and conversely, bulk optical properties measured in-situ or estimated from satellite observations can be used to retrieve information on the particle assemblage, such as the particle size distribution and the bulk index of refraction. The Plumes and Blooms project has been collecting extensive monthly in-situ bio-optical and hydrographic observations at seven stations in the optically complex coastal waters of the SBC. Observations include spectral absorption, beam attenuation and backscattering coefficients, recently added particle size distribution measurements with the LISST-100X instrument, as well as ancillary data. These concurrent observations allow the calculation of multiple optical indices of the particle assemblage and its variability, such as the spectral slopes of the particulate beam attenuation and backscattering coefficients, the slope of the particle size distribution, and the complex index of refraction. Consistency and relationships between the different indices and independent ancillary observations such as chlorophyll and biogenic and lithogenic silica concentrations is investigated and the SBC particle assemblage is characterized, attempting to assess its sources of variability.

GEOGRAPHICAL VARIABILITY OF UVR AND ITS RELATIONSHIP TO CORAL REEF COMMUNITIES AROUND THE MALAYSIAN PENINSULA

Kuwahara, Victor¹; Nakajima, Ryota²; Othman, B. H. R. ³; Kushairi, M. R. M. ⁴; Toda, Tatsuki²

¹Soka University 1-236 Tangi-cho, Hachioji-shi, Tokyo, 192-8577, Japan; ²1-236 Tangi-cho, Hachioji-shi, Tokyo, 192-8577, Japan; ³University of Kebangsaan Malaysia, Bangi, Selangor, 43600, Malaysia;

⁴Universiti Industri Selangor, Shah Alam, Selangor, 40000, Malaysia

The objectives of this study are to (1) characterize the geographical variability of ultraviolet radiation (UVR) attenuation, (2) determine the environmental factors, specifically CDOM, regulating UVR attenuation, and (3) investigate the relationship between UVR and coral reef spatial coverage and health in the surrounding waters of the Malaysian Peninsula. A total of 14 coral reef communities were bio-optically surveyed from August 11 – 26, 2007. The results show distinct geographical differences of UVR water column penetration and concentration of attenuating factors between the West and East coasts of the Malaysian Peninsula. The West coast survey stations displayed relatively shallow 10% UV-B penetration (1.68 ± 1.12 m), high chlorophyll a (3.00 ± 4.72 mg/L), high chromophoric dissolved organic matter (CDOM; 6.61 ± 3.31 ppb), high particulate organic carbon (POC; 190.7 ± 97.99 mg m⁻³) and low dissolved organic carbon (DOC; 1.34 ± 0.65 mg m⁻³). The East coast showed opposite results of relatively deeper 10% UV-B penetration (5.03 ± 2.19 m), low chlorophyll a (0.34 ± 0.22 mg/L), low CDOM (1.45 ± 0.44 ppb), low POC (103.2 ± 37.93 mg m⁻³), and high DOC (1.91 ± 1.03 mg m⁻³). The geographical difference suggests UVR-specific absorbing material from the West coast waters are comprised of terrestrial derived, chromophoric content, low molecular weight DOC with high photobleaching relative to the East coast survey stations. Further, percent spatial coverage of healthy coral reefs based on line-transect image analysis were 64.11 ± 1.34 and $33.77 \pm 13.61\%$ for West and East coast stations, respectively. The implications from these results suggest that source and sink of bio-optically significant CDOM and DOC factors are uncoupled in coral reef communities of Malaysia, and West coast coral reef communities are healthier.

THE DYNAMICS OF SUN-STIMULATED PHYTOPLANKTON FLUORESCENCE

Laney, Samuel¹

¹Woods Hole Oceanographic Institution WHOI MS 32, Woods Hole, MA, 02543, United States

The sun-stimulated fluorescence of marine phytoplankton contains information about the photosynthetic state of these important organisms, but despite decades of effort this easy-to-measure signal remains difficult to interpret in physiologically or ecologically meaningful terms. Critical insight into this problem can be gained by examining the relationship between sun-stimulation and fluorescence emission as a

dynamical process, where phytoplankton mediate the transfer of ambient irradiance into fluorescence. A new framework will be presented that describes sun-stimulated fluorescence in a dynamical sense, using an optical-physiological model that reproduces many of the dynamical behaviors that are apparent in actual field and laboratory observations of phytoplankton fluorescence. The dynamical insight that this new framework provides is valuable not only for *in situ* measurements of this important optical signal but also to satellite remote sensing of phytoplankton fluorescence, especially in the context of planning observational strategies for new generations of geosynchronous ocean color remote sensors.

UNCERTAINTY ANALYSES OF OCEAN COLOUR SATELLITE DATA.

Lavender, Samantha Jane¹; Barker, Kathryn¹; Kay, Susan²; Fanton d'Andon, Odile Hembise³; Bourg, Ludovic³; McCulloch, Mike¹; Kent, Chris¹; Goryl, Philippe⁴

¹ARGANS Ltd Unit 3, Drake Building, Plymouth, PL6 8BY, United Kingdom; ²University of Exeter, Exeter, Devon, EX4 4PS, United Kingdom; ³ACRI-ST, Sophia Antipolis, Alpes-Côte d'Azur, Cedex, France; ⁴European Space Agency, Frascati, Rome, I - 00044, Italy

Uncertainty analysis is essential for the quality control and validation of satellite data. The results from two linked studies are presented: an investigation into the dependence of Envisat's Medium Resolution Imaging Spectrometer (MERIS) variability on sub-pixel size; determining uncertainties for ocean colour products as part of the Sentinel-3 Level 2 Optical Prototype Processor development. Quantification of errors in MERIS data at the sub-pixel scale (of either reduced or full resolution) is especially emphasised in optically complex waters. The results of an initial study aimed at quantifying, using ratios of sub-pixel areas to megapixel areas of a number of randomly selected MERIS scenes, and empirically defining the relationship at the MERIS visible bands are presented. The Sentinel-3 satellite, scheduled to launch in 2013, is the third in a series of five space missions within the European Global Monitoring for Environment and Security (GMES) programme. The mission aims to produce consistent long-term datasets with both an improved accuracy and reliability; this abstract concentrates on the Ocean Land Color Instrument (OLCI) that is the MERIS follow-on. The requirement of the Quality Assurance framework for Earth Observation (QA4EO) applies to all products so a method to determine uncertainties must be investigated and applied. Research has focused on several techniques including error sensitivity analysis / propagation where Gaussian noise is added to the input parameters of an equation / processing step that is being evaluated. OLCI simulations will be presented. Together these two studies look at different aspects of uncertainty with both being important for the subsequent transfer of uncertainties to models that import satellite data.

CHARACTERIZATION OF SUSPENDED PARTICULATES IN THE NORTHERN GULF OF MEXICO FROM OCEAN COLOR REMOTE SENSING

Lee, ZhongPing¹; Huang, Changchun²; Lubac, Bertrand²; Guo, Laodong³; Ko, Dong-Shan⁴; Lohrenz, Steven³; Gould, Richard⁴

¹Mississippi State University 1103 Balch Blvd, Stennis Space Center, MS, 39529, United States; ²1103 Balch Blvd, Stennis Space Center, MS, 39529, United States; ³University of Southern Mississippi, Stennis Space Center, MS, 39529, United States; ⁴Naval Research Laboratory, Stennis Space Center, MS, 39529, United States

The ecosystem in the Northern Gulf of Mexico (NGOM) is composed of fresh waters from coastal run-offs and the Mississippi River as well as clear-salty waters from the gulf. As a result, the composition of water constituents, as well as their spatial and temporal distributions, is complex and non-uniform. Severe hypoxia events are constantly happening in the NGOM region. In this study, using properties derived from both *in situ* and satellite measurements, we try to characterize the nature of the suspended particulates. In particular, not only the concentrations (and their spatial distributions) of the total suspended particulates were derived from satellite images, but also the organic/inorganic nature of these particulates were characterized with the backscattering ratio; and the organic and inorganic portions (and their spatial distributions) of the particulates were evaluated. These results will help us to understand the dynamics of coastal suspended sediments and the dynamics of hypoxia

OPTICAL PROPERTIES AND BIO-OPTICAL ALGORITHMS IN THE NORTHEASTERN BERING SEA IN EARLY SUMMER, 2007

Lee, Sang¹; Zhao, Jinping²; Son, SeungHyun³

¹Korea Polar Research Institute Songdo Techno Park, 7-50, Songdo-dong, Incheon, 406-840, Korea, Republic of; ²Ocean University of China, Qindao, China, 406-840, China; ³I.M. System Group, Rockville, MD, 20746, United States

There have been very few studies on bio-optical properties in the Northern Bering Sea. In early summer of 2007 (mid-May to mid-June), optical measurements have been made using a high resolution Profiling Reflectance and Radiometer (PRR-800) by Biospherical Instruments Inc. during the Healy cruise in the northeastern Bering Sea. Total and size-fractioned Chlorophyll-a data were also measured in limited stations as well as a species composition of phytoplankton. In this study, the PRR measurements are first investigated to understand the optical properties within the water column. Then, we assessed the current NASA global standard chlorophyll-a algorithms and recently developed local chlorophyll-a algorithms for the high latitudes using the remote sensing reflectance data in the Northern Bering Sea. Similar to the results from other studies, the NASA global chlorophyll-a algorithms are overestimated at low concentration. In addition, chlorophyll-a using the local algorithm has more errors over the Northern Bering Sea. Thus we derived a locally tuned relationship and best two-band ratio relationship for more reliable chlorophyll retrievals. An existing algorithm for phytoplankton functional types is also examined using the *in situ* optical data and the model results are compared with *in situ* phytoplankton dominance data.

MERIS VICARIOUS ADJUSTMENT IN THE NEAR INFRA RED AND VISIBLE

Lerebourg, Christophe¹; Mazeran, Constant¹; Huot, Jean-Paul²; Antoine, David³; Bourg, Ludovic¹; Delwart, Steven²; Ondrusek, Michael⁴; Lavender, Samantha⁵; Goryl, Philippe⁶

¹ACRI-ST 260, route du Pin Montard - B.P. 234, Sophia Antipolis, 06904, France; ²ESA/ESTEC, Keplerlaan 1, Postbus 299, Noordwijk, Noordwijk, 2200, Netherlands; ³Laboratoire d'Océanographie de Villefranche (LOV), Quai de La Darse, BP 8, Villefranche sur Mer, cote d'azur, 06238, France; ⁴NOAA, 5200 Auth Rd, Camp Springs, Maryland, MD 20746-4304, United States; ⁵ARGANS ltd, Tamar Science Park, Plymouth, Devon, PL6 8BY, United Kingdom; ⁶ESA/ESRIN, Via Galileo Galilei, Casella Postale 64, Frascati, Roma, 00044, Italy

All recent validation efforts of MERIS Level2 ocean colour data have acknowledged that the water reflectances retrieved in the visible channels do not meet the desired 5% accuracy for clear waters. These errors may come from a number of reasons at instrument or algorithm level. First of all, inspection of the signal in the Near-infrared (NIR) over oligotrophic sites has shown a discrepancy in the expected theoretical spectral shape. It is in full accordance with other *in-situ* comparisons: offset in the aerosol optical thickness and Angström exponent, and systematic offset bigger than 10% in the marine signal. Knowing the strong sensitivity of the atmospheric correction step, an adjustment is justified in the NIR. In addition, because the marine reflectance provides only a small contribution of the total top-of-atmosphere signal (about 10% in the blue), the performance goal would require a hardly reachable 0.5% top-of-atmosphere calibration accuracy, in the absence of algorithmic sources of error. This justifies, in the visible, the development of a vicarious adjustment, i.e. a TOA signal correction with respect to ground truth measurements, as developed for other ocean colour missions (SeaWiFS, MODIS). This presentation describes the methods and results of such adjustments implemented in the MERIS 3rd reprocessing. First, in the NIR, an original signal reconstruction avoiding the selection of an aerosol model allows to derive a robust adjustment factor at 865 nm. This already improves the water-leaving reflectance retrieval. Then, a classical vicarious adjustment in the visible is applied. Quantitative results are shown using the MERMAID database. Because it is a Level2 correction, the impact is subordinated to all other changes of the 3rd reprocessing, prior to the adjustment (new Level 1 calibration), new smile correction within the water branch and new radiative transfer Look-up tables.

THE UNDERWATER RADIANCE DISTRIBUTION

Lewis, Marlon R.¹; Van Dommelen, Ronnie²; Wei, Jianwei³; Voss, Kenneth⁴

¹Dalhousie University Oxford Street, Halifax, NS, B3H 4J1, Canada; ²Satlantic Inc., Halifax, Nova Scotia, B3K 5X8, Canada; ³Oxford Street, Halifax, NS, B3H 4J1, Canada; ⁴University of Miami, Miami, Florida, 33146, United States

A significant source of uncertainty in the prediction of the apparent optical properties of the ocean is the geometrical distribution of the radiance field and its variation with respect to time and space; this uncertainty directly affects attempts to use measurements of reflectance and attenuation for the diagnosis of ocean constituents. Uncertainties in the time and depth dependent variations in the radiance distribution, and their sources of variation, propagate as well to the prediction of the performance of new imaging systems. The problem starts at the sea surface, where the generally unknown sky radiance distribution, coupled with a roughened air-sea interface, plays a major role in the transmission of sun and sky radiance to below the surface. In the ocean interior, the volume scattering function and the absorption coefficient alter the radiance distribution in both the forward and backward direction; in the perhaps usual situation of multiple scattering, the uncertainty in the radiance distribution becomes large. Within the Radiance in a Dynamic Ocean (RaDyO) program we have created and deployed a high-dynamic range (10^6) camera that can resolve and record the spatial radiance distribution at the ocean surface and at depth. We present here results from deployments of the camera in eutrophic, mesotrophic and oligotrophic environments. The instrument resolves both the downwelling and upwelling radiance distribution and its variation with depth, time and wavelength; from these measurements, the apparent optical properties E_D , EU , E_o , E_{ou} and E_{od} are computed by integration. The distribution functions (e.g. the average cosines) are computed directly, as are the various diffuse attenuation coefficients and reflectances. The fully-specified radiance field therefore provides all the pertinent information to derive not only the apparent optical properties, but the inherent optical properties: the absorption coefficient and, in principle by inversion, the volume scattering function.

SPECTRAL AND SPATIAL ANALYSIS OF THE GULF OF MEXICO OIL SPILL USING SATELLITE AND *IN SITU* DATA

Lewis, Mark David¹; Gould, Richard W¹; Ladner, Sherwin¹; Gallegos, Sonia¹; Jolliff, Jason¹; Bennert, Ellen²; Li, Rong-Rong²

¹Naval Research Laboratory Building 1009, Stennis Space Center, MS, 39529, United States; ²Naval Research Laboratory / Code 7232 4555 Overlook Ave, SW, Washington, DC, 20375, United States

The explosion of the Deepwater Horizon oil rig on April 20, 2010 resulted in what is now considered to be the largest oil spill in US history. Oil from the spill has reached the Louisiana marshes and will continue to impact the environment. Addressing the extent and impact of the oil spill will be a focus for several years.

The ability to detect, identify, and map oil in the Gulf of Mexico using *in situ* and remote sensing assets is presented. The Hyperspectral Imager for Coastal Ocean (HICO) is a hyperspectral sensor built by the Naval Research Laboratory (NRL) and currently operating on the International Space Station (ISS). NRL is also responsible for the mission planning, targeting, and data processing. In addition to HICO scenes of the oil spill, imagery from the MODerate Resolution Imaging Spectroradiometer (MODIS) and the Medium Resolution Imaging Spectrometer (MERIS) have been collected and processed. Spectra from oil contaminated water and from uncontaminated water were identified and the ability to separate these spectra was investigated. In addition, *in situ* data was collected and matched with the satellite data. Results from analyses of these data sets are presented.

MEASUREMENT OF THE UNDERWATER RADIANCE DISTRIBUTION: FIRST RESULTS FROM A NEW RADIANCE CAMERA

Leymarie, Edouard¹; Antoine, David¹; Morel, André¹; Buis, Jean-Pierre²; Buis, Nicolas²; Victori, Stephane²; Meunier, Sylvain²; Canini, Marius²; Houyou, Amel²; Fournie, Bertrand³; Henry, Patrice³

¹Laboratoire d'Océanographie de Villefranche LOV, Quai de la Darse, Villefranche sur Mer, 06238, France; ²CIMEL Electronique, Paris, Paris12, 750012, France; ³CNES, Toulouse, Haute Garonne, 31000, France

The Measurement of the underwater radiance distribution is of great interest in the field of marine optics. For remote sensing applications, the knowledge of the anisotropy of the radiance distribution (Bidirectional Reflectance Distribution Function or BRDF) is needed when interpreting ocean color data. Models exist for this BRDF in Case 1 waters into which the anisotropy is described by the "Q factor" (ratio of the upwelling radiance in a given direction to the upward plane irradiance), and is expressed as a function of the chlorophyll concentration and observation geometry. Comparison of this model with *in situ* data has been already performed but should still be extended with additional data. In contrast, there is no measurement, and, accordingly, no model, for optically-complex case 2 waters. In addition, the measurement of the radiance distribution over both hemispheres can be used to derive all Apparent Optical Properties (AOP), which is useful for optical closure.

We present results from a multi-spectral "radiance camera" deployed during several cruises in the Mediterranean (Optic-Med and LSCV08 cruises) and Arctic (Malina cruise). This camera is based on fish-eye optics and a high sensitivity CMOS detector. It allows radiance measurements over one hemisphere with a 1-degree resolution (Azimuth and zenith angles). Comparisons of absolute quantities measured by our camera and by others instruments are presented as well as comparisons between measured and modeled radiance distributions. Measurements of the full radiance distribution acquired through the simultaneous use of two cameras are also presented for depths down to 80m.

SHIP-BASED REMOTE SENSING REFLECTANCE OBSERVATIONS RELATED TO THE DEEPWATER HORIZON PETROLEUM CONTAMINATION EVENT, GULF OF MEXICO

Epps, Sarah¹; Lohrenz, Steven²; Joung, DongJoo¹; Asper, Vernon¹

¹1020 Balch Boulevard, Stennis Space Center, MS, 39529, United States; ²University of Southern Mississippi 1020 Balch Boulevard, Stennis Space Center, MS, 39529, United States

The oil plume event following the explosion of the Deepwater Horizon drilling rig, on April 20, 2010, has been described as one of the worst environmental disasters in the history of the United States. In addition to rescue, containment and clean-up efforts, extensive scientific inquiry was initiated to assess the distribution of oil and its impact on the environment. Platforms for observation have included satellites, airborne sensors, ship-based observations and autonomous underwater vehicles. Here, we describe results from two cruises during which remote sensing reflectance (Rrs) observations were acquired in the vicinity of the Deepwater Horizon wellhead site. Observations were made using an ASD, Inc. hand held spectroradiometer. Surface water environments observed by this method included sites with aggregated oil, clear waters and areas characterized by an oily sheen on the surface. Additionally, similar Rrs observations were made in the vicinity of the plume site in March 2010, a few weeks prior to the explosion. Therefore, the relationship between pre-event and post event observations could also be evaluated. Advantages of ship based Rrs observations include less atmospheric interference potential in the signal and the ability to perform complementary *in situ* measurements. These data may be used for sea-truth correlations for contemporaneous hyperspectral observations from airborne and satellite platforms.

EFFECT OF INHERENT OPTICAL PROPERTIES VARIABILITY ON THE CHLOROPHYLL RETRIEVAL FROM OCEAN COLOR REMOTE SENSING: AN *IN SITU* APPROACH

Loisel, Hubert¹; Lubac, Bertrand²; Dessailly, David¹; Duforêt-Gaurier, Lucille¹; Vantrepotte, Vincent¹

¹LOG/CNRS/ULCO 32 avenue Foch, Wimereux, 62930, France; ²Northern Gulf Institute, Mississippi State University, Stennis Space Center, Stennis, Mississippi, 39529, United States

The impact of the inherent optical properties (IOPs) variability on the chlorophyll, Chl, retrieval from ocean color remote sensing algorithms is analyzed from an *in situ* data set covering a large dynamic range. The effect of the variability of the specific phytoplankton absorption coefficient, a_{phy}/Chl , specific particulate backscattering coefficient, bbp/Chl , and colored detrital matter absorption to non-water absorption ratio, $acdm/anw$, on the performance of standard operational algorithms is examined. This study confirms that empirical algorithms are highly dependent on the specific IOPs values (especially bbp/Chl and $acdm/anw$): Chl is over-estimated in waters with specific IOPs values higher than averaged values, and vice versa. These results clearly indicate the necessity to account for the influence of the specific IOPs variability in Chl retrieval algorithms

IMPORTANCE OF PARTICULATE BACKSCATTERING MEASUREMENTS IN THE NEAR INFRARED BANDS FOR IMPROVING REMOTE SENSING ALGORITHMS IN COASTAL WATERS

Lorthiois, Thomas¹; Doxaran, David¹; Chami, Malik¹; McKee, David²; Jourdin, Frederic³

¹Laboratoire Océanographie Villefranche (LOV) La Darse, BP 08, Villefranche sur Mer, 06230, France; ²Department of Physics, University of Strathclyde, Glasgow, Scotland, G1 1XQ, United Kingdom; ³Service hydrographique et océanographique de la marine, Brest, France, 29228, France

Coastal waters affected by river discharges are optically complex due to the contributions of terrestrial matter of various origins. Therefore, the extraction of relevant information on biogeochemical parameters (such as the particle concentration, composition and size) from the particulate optical properties remains difficult.

The Rhone River (France) is the major source of terrestrial inputs into the Mediterranean Sea. Because the optical properties of its oceanic constituents are poorly documented, it is currently difficult to determine the fate of the terrestrial substances using remotely sensed data.

Intensive oceanographic campaigns were recently conducted in the Rhone river plume in order to relate the optical and biogeochemical properties of particles for various hydrological conditions. Optical measurements of light absorption, attenuation, particulate scattering and backscattering covering the visible and near-infrared spectral regions were carried out.

Results show that the spectral variations of light backscattering by particles, bbp , are significantly lower in the near-infrared relatively to the visible part of the spectrum. This study highlights that a power-law function fitted over the sole visible spectrum range might not be relevant. Indeed, the extrapolation of bbp from the visible to longer wavelengths ignoring near infrared measurements could lead to errors in bbp up to 10%. The implications of these errors for atmospheric corrections over coastal zones could be important and will be discussed. Finally, relationships are proposed between the measured particle size distributions and spectral slopes of the particulate attenuation, scattering and backscattering coefficients to improve the performance of remote sensing algorithms in coastal waters.

HYPERSPSPECTRAL SENSING OF COASTAL SYSTEMS IN THE REMOTE REGIONS OF NW AUSTRALIA

Lynch, Mervyn¹; Fearn, Peter¹; Klonowski, Wojciech¹; Majewski, Leon²; Gray, Mark¹; Hacker, Jorg³; Blake, Steve⁴

¹Curtin University of Technology, PO Box U1987, Perth, WA, 6845, Australia; ²Bureau of Meteorology, PO Box 1289K, Melbourne, VIC, 3001, Australia; ³Airborne Research Australia, Flinders University, PO Box 335, Salisbury South, SA, 5106, Australia; ⁴WA Marine Science Institution, University of WA, 35 Stirling Hwy, Crawley WA, 6009, Australia

The Kimberley region of Australia is the last remaining wilderness area of Australia with very low overall population, absence of significant coastal population centres and very limited coastal access from the land. It is characterized as a biodiversity "hot spot" and to date has an enviable record with respect to no recorded species extinction since white occupation of Australia. However, the region is characterized by

almost an absence of comprehensive and uniform coverage of baseline information to support the environmental monitoring and management of its conservation values. This is a particularly pressing issue as plans by industry put the region under pressure to yield its offshore oil and gas resources. In 2009, a marine subsurface pipeline fractured and was not repaired for some 8 weeks. It released a significant flow of oil into the surrounding ocean and coastal waters. In the absence of a suitable on-orbit high spatial resolution hyperspectral sensor, we have undertaken several airborne campaigns into the NW and Kimberley regions of Australia to determine the shallow water bathymetry, a coarse benthic cover classification and the ocean's diffuse attenuation coefficient. Additionally, we have captured high spatial resolution digital imagery that defines the key coastal habitats and ecosystems in the region. An important component of the research is an *in situ* validation campaign involving radiometric, bathymetric and water sampling. The Kimberley region is susceptible to major tidal forcing which leads to significant resuspension of coastal sediments. Additional campaigns are planned for 2010 and will include flying a CW LIDAR for mapping the coastal vegetation's spatial distribution in order to link the terrestrial and marine environments and their interactions. The paper will review some of the results achieved including data obtained from one of the recently acquired hyperspectral sensors.

THE CHARACTERS OF AEROSOL DISTRIBUTION IN THE YELLOW SEA AND THE VALIDATION OF AOT OBSERVED BY MODIS

Zhao, Dongzhi¹; Ma, Yujuan¹; Yang, Jianhong¹

¹No 42, Lingshui Street, Dalian, 116023, China

Aerosol optical thickness (AOT) data measured with a ship-based multiband sun photometer was taken in 2009 to study the aerosol properties over the Yellow Sea. Variations of AOT, Turbidity Coefficient of three fix-point sites indicated the values of AOT increased before 12 o'clock. what's more, the variation of AOT has the same character as the variation of Turbidity Coefficient. And, the maximum values and distribution scales of AOT, Turbidity Coefficient and Angstrom Exponent were different in different months. In addition, the AOT over the coastal zone in the same period was measured by an automatic sun photometer CE318. The data was used to analyze the temporal and spatial distribution and the influencing factors of aerosol. There are three types of the daily change, single peak type, gradually decreasing type and two peaks-single valley type. the maximum values and distribution scales of AOT, Turbidity Coefficient and Angstrom Exponent were different in different months over coastal zones. Variation of Turbidity Coefficient was the main reason of variation of AOT over Yellow Sea and the coastal zones, variation of Angstrom Exponent didn't have much effect. AOT observed by MODIS in 2009 were also received. Data measured *in situ* were used to verify the validation of AOT measure by MODIS. The precision of AOT observed by MODIS over offshore was not high, even it couldn't meet the demands of practical application. So the improvement of MODIS algorithm of AOT in local area was proposed. and Angstrom Exponent in one day couldn't be ignored. The measurements

VERTICAL ALGAL ACCESSORY PIGMENT DISTRIBUTIONS IN THE BALTIC SEA - PRELIMINARY MATHEMATICAL DESCRIPTION

Majchrowski, Roman¹; Stoń-Egiert, Joanna²

¹Institute of Physics, Pomeranian University in Słupsk Arciszewskiego 22b, Słupsk, 76 200, Poland;

²Institute of Oceanology, Polish Academy of Sciences, Powstańców Warszawy 55, Sopot, 81-712, Poland

Knowledge of the vertical distribution of algae accessory pigments in oceans and seas is important in environmental analysis and can be used both to model species composition of algae in the sea and in remote sensing algorithms. Vertical distributions of photosynthetic and photoprotecting pigments are the result of algae adaptation to different environmental conditions, especially light. Therefore, it is important to obtain simple mathematical expression for describing the vertical distributions of algal accessory pigments in seas. Formulae for determining the vertical distributions of selected algal accessory pigments in the ocean waters (case 1 waters) have already been found.

The aim of this work is to present the preliminary mathematical description of vertical distributions of algal accessory pigments in Baltic seawater (as example of case 2 waters). Analyses were based on ca 250 empirical datasets of accessory pigment depth profiles gathered during about 40 research courses in the last decade mainly in the southern Baltic region. The statistical relationships between the concentrations of accessory pigments and the trophic index of waters (as measured by the surface concentrations of chlorophyll a) and the optical depths in different seasons in the Baltic Sea were analysed. The analysis focused on the vertical distributions of pigments often treated as markers used to define groups of algal species: chlorophyll b, chlorophylls c, fucoxanthin, alloxanthin, diadinoxanthin, diatoxanthin, peridinin, zeaxanthin.

A mathematical expression was established and formulas based on it were found linking the relations between vertical distributions of the concentrations of different accessory pigments and the chlorophyll a concentration at the surface.

RELATIONSHIP BETWEEN SUSPENDED SEDIMENT CONCENTRATION AND REMOTELY SENSED REFLECTANCE

Mao, Zhihua¹

¹Second Institute of Oceanography, SOA, China 36 Baochubeilu Rd, Hangzhou, 310012, China

Suspended sediment is an important parameter of water quality and a main factor to affect the lifetime of port use, which needs to be monitored on the spatial distribution and temporal changes. High suspended sediment concentration is one of the main factors to lead the failure of the atmospheric correction procedure of ocean color satellite data in case 2 waters. It also dominates the optical properties in the coastal ocean and makes it difficult to retrieve chlorophyll concentration and other water constituents from satellite remote sensing data. The East China Sea, especially in the Yangtze estuary and Hangzhou Bay, is famous for large area distribution of high concentration of suspended sediment, as high as more than 5000 mg/l. Four cruises were carried out to measure the suspended sediment concentration and optical properties at 560 stations. The relationship between the water-leaving radiance at different wavelengths and SSC was analyzed and the results show that the radiance at green bands is sensible to suspended sediment at low concentration and almost saturated at high concentration, while the radiance at red bands has a good relationship with suspended sediment at high concentration, meanwhile the radiance at near-infrared bands has also a big value under high suspended sediment concentration. A new algorithm of remote-sensing suspended sediment concentration is developed and the results show that the algorithm has a nice performance both at low and high SSC. The algorithm is used to obtain SSC from SeaWiFS and MODIS data and the distribution of SSC show that the algorithm is suitable for retrieving SSC from satellite remote sensing data in the East China Sea.

THE OCEAN COLOR MEASURES PROJECT: CURRENT AND FUTURE PRODUCTS

Maritorena, Stéphane¹; Siegel, David A.²; Nelson, Norm B.²; Frew, James³; Behrenfeld, Michael J.⁴; Kostadinov, Tihomir²; Bonhommeau, Sylvain⁵; NASA, OBP⁶

¹University of California, Santa Barbara ICESS/UCSB, Santa Barbara, CA, 93106-3060, United States; ²ICESS/UCSB, Santa Barbara, CA, 93106-3060, United States; ³Donald Bren School of Environmental Science & Management, UCSB, Santa Barbara, CA, 93106-5131, United States; ⁴Dept. of Botany and Plant Pathology, Oregon State University, , Corvallis, OR, 97331-2902, United States; ⁵IFREMER Sète, Sète, Hérault, 34200, France; ⁶NASA Goddard Space Flight Center, Greenbelt, MD, 20771, United States

The goal of the Ocean Color MEASURES project is to create and distribute a wide variety of established and new ocean color products for evaluation by the research community. These products are candidates to become Earth Science Data Records (ESDR's) or Climate Data Records (CDR's). The proposed products to be evaluated include spectral apparent and inherent optical properties, Net Primary Production (NPP), Particle Size Distribution (PSD), Phytoplankton Functional Types (PFT's) or merged products from multiple sensors (SeaWiFS, MODIS, MERIS). Quality and validation indices for the products are also

developed and distributed. Products are initially developed and distributed by ICES/UCSB but ultimately the Ocean Biology Processing Group (OBPG) at the Goddard Space Flight Center (GSFC) undertakes these activities. Examples of current and future products from the ocean color MEaSURES project are presented along with information on how, where and when to obtain the data.

SPECTRAL ANALYSIS OF ESTUARINE WATER FOR CHARACTERISATION OF INHERENT OPTICAL PROPERTIES AND PHYTOPLANKTON CLASSIFICATION

Marrable, Daniel Stephen¹; Fearn, Peter¹; Lynch, Mervyn¹; Klonowski, Wojciech¹

¹Curtin University of Technology Kent St Bentley, Perth, 6112, Australia

The Swan River estuary in Perth Western Australia is used for transport, recreational fishing, water sports and is home to the world famous black swan. The health of the estuary suffers greatly in the presence of common and potentially harmful algal blooms. Weekly water column data have been collected by the Swan River Trust since the beginning of 1995. Data are collected by means of boat trips along the entire length of the estuary taking measurements at 15 different locations. Measurements have been made with the use of YSI 6600 multi-parameter sondes for our in-situ profiling. Measurements include; conductivity/salinity, temperature, pH, dissolved oxygen, chlorophyll fluorescence, turbidity, phytoplankton taxonomy and phytoplankton biomass. The purpose of this study is to evaluate the suitability of using a boat-mounted hyperspectral radiometer to estimate the biomass and class of naturally occurring phytoplankton in the Swan River estuary. The in-situ hyperspectral reflectance data are inverted by use of an advanced multi-component optical model (Klonowski, unpublished), to deliver estimates of the concentration of water column optical constituents, as well as classification of dominant algal classes. Analysis of the model has shown that it is very sensitive to variations in algal spectral properties. A selection of the most common algal species is being cultured in the laboratory for analysis of their optical properties. It is intended that a spectral library of the absorption spectra of different species will be used in the inversion algorithm in order to improve the quality of the fit between the optical model and the measured remote sensing reflectance. The parameters retrieved from the inversion will be validated with in-situ water measurements taken by the Swan River Trust. We will provide an overview of the optical model, details of the sampling field program and preliminary results of the inversion technique.

CHANGING CHARACTERISTICS OF PHYTOPLANKTON SPRING AND FALL BLOOMS IN THE NORTH ATLANTIC FROM THE 1980S' TO 2000S'

Martinez, Elodie Claire¹; Antoine, David¹; d'Ortenzio, Fabrizio¹; De Boyer Montegut, Clement²

¹CNRS, LOV Quai de la Darse, BP08, Villefranche sur Mer, 06238, France; ²Laboratoire d'Océanographie Spatiale / Ifremer, Pointe du Diable, Plouzané, Bretagne, 29280, France

Using two decades of satellite ocean color observations (including CZCS and SeaWiFS data) spatial and temporal covariability between ocean chlorophyll (Chl) and Sea Surface Temperature (SST) have been recently investigated to highlight the long-term variability. A Chl-SST inverse relationship was frequently observed, and decadal changes in Chl essentially result from basin-scale low-frequency natural oscillations of the physical environment.

The present study focuses on the northern Atlantic between 30°N and 50°N. The objective is to investigate changes in seasonal cycles that may have occurred besides the long-term changes. Mixed-layer depths (MLD) derived from *in situ* data are used to investigate the role of the oceanic stratification in the observed Chl changes. In the North Atlantic, a fall bloom showing similar amplitude with the widely documented spring bloom was used to develop in the 1980's. The spatial distribution and decadal time evolution of both Chl and MLD fields differ west of 40°W from the east.

East of 40°W, in the 2000's, the fall bloom has strongly decreased and high Chl values are confined at the northern boundary (50°N). MLD deepens one month later end of summer and may prevent the full development of the fall bloom. Conversely in spring, high Chl values extend farther south in the 2000's.

This pattern follows a MLD deepening between the two decades allowing the uplift of deeper nutrients in the mid-latitudes. West of 40°W, although a northward/southward move of the high Chl in fall/spring between the two decades can be noticed similarly than in the east, these changes are weak. The maximum amplitude of Chl during the fall bloom remains similar than during the spring bloom and MLD characteristics barely changed.

TRACKING THE TRANSPORTATION OF COLORED DISSOLVED ORGANIC MATTERS IN WESTERN ARCTIC WATERS: IMPLICATIONS FOR HYDROGRAPH OF THE ARCTIC OCEAN

Matsuoka, Atsushi¹; Bricaud, Annick¹; Babin, Marcel¹

¹Laboratoire d'Océanographie de Villefranche B.P. 8 Quai de la Darse, Villefranche-sur-mer, 06230, France

Light absorption coefficient of colored dissolved organic matter (CDOM) [$a_{\text{CDOM}}(\lambda)$] plays an important role in the heat budget of the Arctic Ocean, contributing to the recent decline in sea ice, as well as in biogeochemical processes. While the absorption properties of this material have been reported for Arctic waters, their variations related to physical processes are still not well documented. We investigated $a_{\text{CDOM}}(\lambda)$ along a transect from moderate latitudes in the Pacific Ocean to the southern Beaufort Sea waters. $a_{\text{CDOM}}(440)$ values tended to increase significantly from moderate to high latitudes, peaking at the Mackenzie River mouth. At the River mouth, $a_{\text{CDOM}}(440)$ showed a high and negative correlation with salinity at surface ($r^2=0.84$), indicating strong river influence and its conservative behavior in the river plume. Excluding the surface waters, a weak but positive relationship between $a_{\text{CDOM}}(440)$ and salinity was observed above the halocline, resulting from lateral advection of Pacific waters. In contrast, the correlation was negative below the halocline, suggesting the waters originated from the Barents Sea after sea ice formation. The spectral slope of $a_{\text{CDOM}}(\lambda)$ [S_{CDOM}] showed a negative correlation with $a_{\text{CDOM}}(440)$ throughout the water column, except at surface and at lower halocline where S_{CDOM} values were rather constant with increasing $a_{\text{CDOM}}(440)$. Slopes for S_{CDOM} versus $a_{\text{CDOM}}(440)$ relationships were significantly different above or below the halocline. Together, our results suggest that analyzing the relationships among CDOM absorption coefficients, their spectral slopes, and salinity are useful for tracking the transportation of CDOM in the Arctic Ocean using optical criteria.

ODESA: THE OPTICAL DATA PROCESSOR OF ESA

Fanton d'Andon, Odile¹; Garnesson, Philippe¹; Gilles, Nicolas¹; Demaria, Julien¹; Sardou, Olivier¹; Mazeran, Constant¹; Lerebourg, Christophe¹; Barrot, Gilbert¹; Bourg, Ludovic¹; Goryl, Philippe²; Laur, Henri²

¹260 route du Pin Montard, Sophia Antipolis, 06600, France; ²ESA/ESRIN Via Galileo Galilei CP 64, Frascati, Roma, 00044, Italy

The goal of this presentation is to introduce ODESA (Optical Data processor of ESA) to the Ocean Colour community. The ODESA system intends to provide a complete Level2 processing environment for the MERIS instrument as well as for the future ESA optical sensors on board Sentinel 3.

ODESA supplies the user community with the MERIS Ground Segment development platform MEGS®, including source code, embedded in an efficient framework for testing and for validation activities. These validation facilities include match-up processing & analysis, data set selection & analysis, level 3 products generation & analysis and the possibility to perform remote processing, e.g. for testing purpose and for validation activities requiring large amounts of data.

EVALUATION OF AN ITERATIVE SCATTERING CORRECTION SCHEME FOR *IN SITU* ABSORPTION AND ATTENUATION MEASUREMENTS BASED ON MONTE CARLO MODELLING

McKee, David¹; Piskozub, Jacek²; Röttgers, Rüdiger³; Reynolds, Rick⁴

¹University of Strathclyde 107 Rottenrow, Glasgow, G4 0NG, United Kingdom; ²Institute of Oceanology, Polish Academy of Science, Sopot, Trojmiasto, 81-712, Poland; ³GKSS, Geesthacht, Hamburg, 21502, Germany; ⁴Scripps Institution of Oceanography, La Jolla, San Diego, California, 92093, United States

In situ measurements of attenuation and absorption using collimated beam systems are generally limited by the extent to which scattered photons can be properly constrained. Standard scattering correction procedures for these measurements are based upon a set of assumptions that may not be reliable for natural samples, leading to potentially significant systematic errors. Monte Carlo simulation is a useful tool for characterising the performance of optical sensors, particularly for assessing scattering errors. An updated, iterative scattering correction method based on Monte Carlo simulations of WETLabs AC9/S optical geometry and coincident backscattering data will be presented. Its performance will be assessed by comparing *in situ* IOP measurements with lab-based PSICAM absorption and LISST attenuation measurements on water samples. Results demonstrate the urgent need for improved scattering corrections for both absorption and attenuation measurements, particularly in turbid coastal and shelf seas.

INVERSION OF HYPERSPECTRAL REMOTE SENSING REFLECTANCE FOR QUANTITATIVE DETECTION OF TRICHODESMIUM SPP. WITHIN THE GREAT BARRIER REEF

McKinna, Lachlan Ian William¹; Furnas, Miles²; Ridd, Peter¹; Everingham, Yvette¹; Slivkoff, Matthew³

¹James Cook University, Australia School of Engineering and Physical Sciences, James Cook University, Townsville, Queensland, 4811, Australia; ²Australian Institute of Marine Science, Townsville, Queensland, 4811, Australia; ³Department of Imaging and Applied Physics, Curtin University of Technology, Perth, Western Australia, 6102, Australia

Trichodesmium spp. are diazotrophic, marine cyanobacteria commonly found within tropical and subtropical waters. Much effort has been placed into quantifying Trichodesmium using ocean colour remote sensing methods. This study examined the use of the quasi-analytical algorithm (QAA) for inverting hyperspectral remote sensing reflectance (R_{rs}) measurements of Trichodesmium spp. within the Great Barrier Reef (GBR), Australia. Hyperspectral R_{rs} data was modelled using Hydrolight with known Trichodesmium chlorophyll-a (Chl_a) specific spectral absorption (a^*_{tri}) and backscattering (b^*_{btri}) coefficients. The QAA was used to invert simulated R_{rs} spectra to yield the spectral phytoplankton absorption coefficient (a_{phi}). To ascertain the presence of Trichodesmium, a similarity index (SI) was computed to compare the derived a_{phi} with a known reference Trichodesmium absorption coefficient (a_{tri}). The magnitude of a_{phi} was then used to estimate the Chl_a concentration. The relationship between Chl_a and the magnitude of a_{tri} was determined from field measurements made within the GBR. Values of a_{tri} were measured over a wide range of Chl_a concentrations (0.4 – 9000 mg m⁻³) deemed to be representative of naturally occurring Trichodesmium abundances within the GBR. The QAA method was applied to R_{rs} data collected along transects within the GBR to estimate Trichodesmium Chl_a specific abundance. The along-transect QAA derived Chl_a values were validated with measurements made using a Chl_a fluorometer within a ship-board, flow-through system.

THE COLORS AND SHADOWS CONTAINED IN DAILY PAR

Mélin, Frédéric¹; Clerici, Marco¹

¹E.C. - Joint Research Centre via Fermi, 2749, ISPRA, 21027, Italy

The irradiance in the ultraviolet and visible spectral domain that enters the sea is a fundamental variable for marine ecology and the radiative budget of the upper ocean, and the availability of satellite-derived global fields of daily photosynthetically available radiation (PAR) has become an important asset for marine biochemistry. This study aims at assessing the level of complexity in the representation of the atmospheric radiative processes needed for oceanographic applications. Three sets of radiative transfer simulations have been performed. One is derived with increasingly thick liquid clouds to construct a look-up table for cloudy conditions, while another is based on specific realistic cases of liquid and ice clouds (from cirrus to deep convective clouds). A third set is derived with different types of aerosols (marine, continental, desert

dust, biomass burning) with varying optical depths. The daily spectrally-integrated PAR distributions represented by these sets overlap: for given latitude and date, different types of clouds or aerosols can be associated with the same PAR, as can fairly thin liquid or cirriform clouds and sufficiently thick aerosol layers. On the other hand, for the same conditions and PAR, the geometry, expressed by the ratio of direct and diffuse components, and the spectral shape of the corresponding irradiance show large differences, particularly when comparing results for clouds and aerosols. For a given PAR, the irradiance is relatively bluer and more diffuse in cloudy conditions than for an atmosphere loaded with aerosols. Despite these differences, the consequences in terms of depth of light penetration in the ocean and marine biochemical rates are found to be well constrained. The implications of using satellite PAR products as inputs to wavelength- and depth-resolved primary production or photochemistry models are discussed.

COMPARISON BETWEEN REMOTE SENSING REFLECTANCE ESTIMATED FROM ABOVE OR IN WATER UPWELLING RADIANCES.

Mériaux, Xavier¹; Loisel, Hubert¹; Neukermans, Griet²; Ruddick, Kevin²

¹LOG / ULCO / CNRS 32 avenue Foch, Wimereux, 62930, France; ²MUMM / BMM, Brussels, Gulledele 100, 1200, Belgium

Bio-optical and radiometric measurements have been performed in the French Guyana coastal waters in October 2009. The sampling waters cover moderate to extremely turbid conditions. The data set gathered during this cruise encompasses Inherent Optical Properties (absorption, attenuation, and backscattering), above and in-water radiometric measurements (upwelling radiances, down-welling irradiances) as well as biogeochemical parameters (chlorophyll, suspended particulate matter), and particle size distribution measurements. Favorable field conditions (sea state, cloud free weather) encountered during the acquisition of the measurements have allowed a comparison exercise between the remote sensing reflectances (Rrs) estimated from upwelling radiances measured above or below the water surface. The latter reflectance measurements, both performed with Trios hyperspectral (every 3 nm from 400 to 900 nm) radiometers, have also been compared with radiative transfer simulations performed with Hydrolight using *in situ* IOPs measurements and above water light field conditions as input parameters. In this study we analyze and discuss the differences observed between the Rrs calculated from above and in water measurements considering the different protocols used for their estimations. Rrs comparisons with MODIS match-up are also provided.

LIGHT SCATTERING MEASUREMENTS OF ALL KINDS OF PARTICLES AT ALL KINDS OF ANGLES

Mikkelsen, Ole¹; Agrawal, Yogi¹

¹Sequoia Scientific, Inc 2700 Richards Road, Suite 107, Bellevue, WA, 98005, United States

This talk presents new instruments that offer field as well as laboratory capabilities to measure inherent optical properties of water, and of particles. The small-angle scattering phase functions have been studied with the LISST-100X. The small-angle forward scattering phase function of size-sorted, irregularly shaped particles have also been published, offering an alternate to Mie theory. With this data, small-angle forward scattering can now be inverted to construct size distribution of terrigenous particles, without resorting to Mie theory.

Equally important are measurements of the near- π scattering in-situ, of relevance to LIDAR. This capability is built into the LISST-Back. The backscattering phase functions of size-sorted irregular particles are also being studied. We have shown that using Mie theory is inappropriate to predict near- π VSF for particles whose size distribution is derived from near-forward scattering. Thus the new near-forward and near- π characterization permits synthesizing the near- π VSF from the simpler near-forward data. Recently, with extension to include polarization discrimination, the azimuthal structure of backscattering with the LISST-Back has been inverted to construct some of the elements of the near- π Mueller matrix.

Finally, data from a new in-situ holographic instrument will be presented, showing natural particles *in situ* in a marine environment. Together, these instruments add powerful new capabilities for marine optics.

QUANTIFYING PHOTOCHEMICAL REACTIONS IN THE SURFACE OCEAN WITH OPTICAL MODELS: POTENTIAL PROBLEMS TO PONDER.

Miller, William L.¹

¹University of Georgia Marine Sciences Bldg., Stanford Drive, Athens, GA, 30602, United States

A great deal of progress has been made over the last ten years toward development of quantitative models for marine photochemistry that can be driven with optical data retrieved from ocean color data. Increasing predictive accuracy and a better understanding of the variability in ocean optical signals relevant to photochemical reactions have created new possibilities to quantitatively address the spatial and temporal contribution of marine photochemistry to regional and global biogeochemical cycles. There remains, however, a significant uncertainty and confusion regarding how critical photochemical reaction mechanisms can be accurately integrated with the ocean optical data needed to model these reactions. Here, using examples of marine photo-reactive compounds (DMS, CO, CO₂, H₂O₂, CDOM, etc.) from new and previous work done in our group (ex. Fichot & Miller (2010) Remote Sensing Environment, 114:1363-1377), we quantitatively examine the potentially large modeling pitfalls that can occur from inexact extrapolation of UV spectra and misrepresentation and/or misunderstanding of and marine photochemistry.

FAST AND ACCURATE LIGHT CALCULATIONS FOR COUPLED PHYSICAL-BIOLOGICAL-OPTICAL ECOSYSTEM MODELS

Mobley, Curtis¹; Sundman, Lydia²; Bissett, Paul³; Cahill, Bronwyn⁴

¹Sequoia Scientific, Inc. 2700 Richards Road, Suite 107, Bellevue, WA, 98005, United States; ²Sundman Consulting / 1453 S. Haleyville Circle, Aurora, CO, 80018, United States; ³WeoGeo, Inc. / 2828 SW Corbett Avenue, Suite 135, Portland, OR, 97201, United States; ⁴IMCS, Rutgers Univ. / 71 Dudley Road, New Brunswick, NJ, 08901, United States

Coupled physical-biological-optical ecosystem models are playing an increasingly important role understanding the oceans at local to global spatial scales and daily to decadal temporal scales. Existing models often use very sophisticated treatments of the hydrodynamics and increasing sophisticated biology, but still grossly oversimplify the optics, to the possible detriment of the ecosystem predictions. To bring optical computations up to the standards of the physical and biological components without unacceptable computational costs, we developed an extremely fast radiative transfer numerical model, named EcoLight-S (ubroutine). EcoLight-S solves the azimuthally averaged radiative transfer equation (RTE) to obtain in-water spectral irradiances for use in calculations of photosynthesis, photo-oxidation, and radiant heating. EcoLight-S requires less than 1 s of computer time (on a 2 MHz PC) to solve the RTE from 400-700 nm to a depth below the euphotic zone, while still computing PAR to within a few percent of the exact value. Moreover, EcoLight-S is suitable for use in Case 2 and optically shallow waters with reflective bottoms, for which no analytical irradiance models exist. EcoLight-S also computes ancillary quantities such as the remote-sensing reflectance, which can be useful for validation of ecosystem model predictions. This talk will describe the features of EcoLight-S and illustrate its use in ecosystem predictions.

OCEAN COLOR PATTERNS HELP TO PREDICT DEPTH OF OPTICAL LAYERS IN COASTAL MARINE WATERS

Montes-Hugo, Martin¹; Weidemann, Alan²; Gould, Richard²; Jolliff, Jason²; Arnone, Robert²; Churnside, James³

¹Universite du Quebec a Rimouski Insitut des sciences de la mer; Universite du Quebec a Rimouski, Rimouski, QC, GL53A1, Canada; ²Naval Research Laboratory Ocean Sciences Branch, SSC, MS, 39529, United States; ³NOAA Earth System Research Laboratory, Boulder, CO, 80305, United States

Detection of single or multiple optical subsurface laminar features (e.g., thin layers) in marine waters and within the penetration range of airborne or spaceborne imaging instruments has many implications on ecological studies, management of fisheries, and military applications.

This study has two objectives: 1) to corroborate a previous index based on remote sensing reflectance ratio ($R1 = R_{rs}(443)/R_{rs}(490)$) for predicting depth of lidar-derived backscattering layers, 2) to evaluate at what extent these relationships hold in different marine regions. Measurements of inherent optical properties (absorption coefficient and scattering coefficient) were obtained from a towed underwater vehicle (Scanfish) in three geographic locations (Aegean Sea, AS, Monterey Bay, MB, and East Sound, ES). For each site, case studies were examined based on subsurface optical layers distributed at two different depths (7 and 20 m in ES, 15 and 27 m in AS, and 7 and 20 m in MB). R1 was theoretically derived from each Scanfish profile (25 m depth, ES, 50 m, MB and AS) and the R1 skewness (γ) was calculated for each case study. Despite of having different trophic status (0.082, 0.127, and 0.190 inverse meters) in AS, MB and ES, respectively, a common statistical pattern consisting of lower γ - deeper optical layer was found in all studied areas. This trend was mainly explained by differences on spectral attenuation with depth of the two wavelengths under study. The observed relationships between γ and the depth of the optical marine layer confirmed previous finding using airborne lidar and ocean color data. Also, our analysis supports the use of local specific γ ranges to identify the relative vertical position of optical submerged structures in different marine environments.

THE MERIS BRIGHT PIXEL ATMOSPHERIC CORRECTION: EVOLUTION, PERFORMANCE ASSESSMENT AND VALIDATION FOR THE MERIS 3RD REPROCESSING.

Moore, Gerald¹; Lavender, Samantha²; Kratzer, Suzanne³; Icely, John⁴; Huot, Jean-Paul⁵

¹Bio_Optika Crofters, Middle Dimson, Gunnislake, PL18 9NQ, United Kingdom; ²ARGANS Limited, Plymouth, Devon, PL8 8BY, United Kingdom; ³University of Stockholm, Stockholm, X, X, Sweden; ⁴Sagremarisco Lda, Vila do Bispo, Algarve, 8650-999, Portugal; ⁵ESA / Estec, Noordwijk, X, postbus 299, Netherlands

The bright pixel atmospheric correction (BPAC, Moore et al 1999) has been part of the operational processor for MERIS on ENVISAT, since the launch. The BPAC consists of a coupled atmosphere-hydrological model that is parameterised by the Ångström exponent, the properties of pure water and those of particulate matter in the near infra-red (NIR). The BPAC is used in the operational processor for the MERIS in order to correct for the Antoine and Morel (1999) atmospheric correction for excess NIR reflectance in case 2 waters. As part of the MERIS Coastal project the methodology and parameterisation has been substantially upgraded in preparation for the MERIS 3rd reprocessing. The hydrological model now accounts for the full BRDF of the ocean and is implemented as polynomials that are dependent only on the inherent optical properties (IOPS) of particulates and pure water in the near infra red (NIR). As such the polynomial formulation of the hydrological model allows rapid inversion of the MERIS reflectance spectra. The BPAC uses three NIR bands to invert the backscatter, aerosol optical thickness and the Ångström exponent. The band set is adjusted according to the magnitude of the backscatter signal with MERIS bands at 709nm, 778nm and 864nm used for mesotrophic to moderate sediment loads and MERIS bands 778nm, 864nm and 885nm used for high sediment loads. The algorithm is structured so that it can use the 1020nm band of the Sentinel OCLI sensor. The reflectance model accounts for the 'smile' effect seen in the MERIS, where the wavelength changes according to pixel position. Particulates are characterised in terms of backscatter and absorption; critically the NIR backscatter to absorption ratio has been found to significantly deviate from the conventional value of zero. This has implications for highly turbid estuaries, and has been found to be of the order of 1.5 (a:bb) at 709nm with a weak spectral dependence. The a:bb was determined by inversion models of very clear MERIS scenes over a number of geographically diverse regions, and showed only small regional variability. The effects of the NIR / visible vicarious calibration used for the 3rd reprocessing is examined on the BPAC retrievals of backscatter. Validation data is shown for the Baltic and for mesotrophic coastal Portuguese waters, the limits of applicability of for BPAC are demonstrated for a number of globally important highly turbid regions estuaries e.g. the Yellow Sea and Amazon plume. Internally the BPAC calculates particulate backscatter, chlorophyll absorption and fluorescence, from the red/NIR spectral region. These products can be made

available using the ODESA processor, and validation of these products is shown for the coastal Baltic. Moore, G. F et al. (1999). "The atmospheric correction of water colour and the quantitative retrieval of suspended particulate matter in Case II waters." *Int. J. Remote Sensing* 20: 1713-1733. Antoine, D. and A. Morel (1999). "A multiple scattering algorithm for atmospheric correction of remotely sensed ocean colour (MERIS instrument): principle and implementation for atmospheres carrying various aerosols including absorbing ones." *Int. J. Remote Sensing* 20(9): 1875-1916.

VARIABILITY IN THE SIZE-FRACTIONATED ABSORPTION COEFFICIENTS OF WATER COLUMN IN COASTAL WATER

Motokawa, Shozo¹; Toda, Tatsuki¹; Kikuchi, Tomohiko²; Taguchi, Satoru¹

¹Soka University 1-236 Tangi-Cho, Hachioji, 192-8577, Japan; ²Yokohama National University, Yokohama, Kanagawa, 240-8501, Japan

Phytoplankton absorption play a key role in ocean color measurement. Cell size of phytoplankton is the predominant factors influencing the characteristics of absorption in water column. Variability in the size-fractionated absorption coefficients were investigated during September 2009 - March 2010 in coastal water. Sea water was collected at surface and two optical depths (10% and 1% light levels of surface). Each samples were divided into three size fractions using mesh filters (183 μ m and 20 μ m mesh size), and membrane filter (2 μ m pore size). The absorption coefficient at nine wavelengths (412, 440, 488, 510, 555, 650, 676, and 715nm) were measured using an absorption and attenuation meter with a 25cm pathlength (ac-9). The ac-9 was set up as a bench-top instrument in a fixed tilt position (45°). Phytoplankton pigments were measured by HPLC. According to chlorophyll *a* concentration, seasonal blooms of phytoplankton occurred in October and March. Dominant size of phytoplankton were nanophytoplankton (2-20 μ m) and microphytoplankton (>20 μ m) throughout the water column in October and March, respectively. The chlorophyll *a* specific absorption coefficients at 440nm of picophytoplankton (<2 μ m) were highest in three size fractions. The absorption coefficients of picophytoplankton in coastal water were high as well as open waters.

MODULATED PULSE SYSTEM FOR EXTENDED RANGE UNDERWATER IMAGING

Mullen, Linda¹; Laux, Alan¹; Zege, Eleonora P²; Katsev, Iosif L²; Prikhach, Alexander S²

¹NAVAIR 22347 Cedar Point Road, Patuxent River, MD, 20670, United States; ²Institute of Physics, Belarus Academy of Sciences, Scaryna Ave. 68, Minsk, 220072, Belarus

Optical imaging in turbid ocean water is a challenge due to the high probability that light will scatter multiple times as it propagates to and from the object of interest. Techniques that have been developed to suppress the contribution from scattered light and increase the image contrast include those using a pulsed source with a range-gated receiver or a modulated continuous wave source with a coherent RF receiver. The main disadvantage of the continuous wave, amplitude modulated system is that it is impossible to 'gate out' the volumetric backscatter signal as can be done in the pulsed, range-gated system. The challenge of the conventional pulsed, range-gated approach is to suppress the multiple small-angle forward scatter that degrades image resolution. A new approach is currently being investigated that combines the advantages of the modulated continuous wave and pulsed range-gated approaches while significantly reducing the limitations of each technique when used independently. This modulated pulse system uses high frequency (>0.5GHz) modulation within a 10-20ns macro pulse to help discriminate against both backscatter and small angle forward scatter. The goal of recent laboratory tank experiments was to study the propagation of a modulated pulse source as a function of system (modulation frequency, receiver field of view), environment (water clarity), and target (reflectivity) parameters, and to compare the non-modulated and modulated pulse return signals. In parallel with the experimental work, software was developed to simulate the propagation of a modulated pulse in water. Model and experimental results showing how the high frequency modulation helps suppress multiply scattered light will be presented, and the implications of this modulated pulse approach for improving and extending the range of underwater optical imaging systems will be discussed.

MODELING PARTICULATE ABSORPTION PROPERTIES IN THE SOUTHEASTERN BERING SEA

Naik, Puneeta¹; D'Sa, Eurico J¹; Goes, Joaquim I²; Gomes, Helga do R.²

¹Louisiana State University Howe-Russell Geoscience complex, Coastal Studies Institute, Baton Rouge, LA, 70803, United States; ²Bigelow Laboratory for Ocean Sciences, West Boothbay Harbor, Maine, 04575-0475, United States

Particulate absorption properties were measured during a cruise in the southeastern Bering Sea Shelf. The particulate ($a_p(\lambda)$), phytoplankton ($a_{PHY}(\lambda)$) and non-algal particulate ($a_{NAP}(\lambda)$) absorption were measured using a shipboard hyperspectral waveguide system from 190-722 nm at 1 nm intervals. The dataset was divided into two parts, one part was used for modeling and the other was used for validation. The $a_{PHY}(\lambda)$ was related to $a_{PHY}(443)$ using a second order quadratic equation, $a_{NAP}(\lambda)$ was related to $a_{NAP}(443)$ using an exponential equation and $a_p(\lambda)$ was related to $a_p(443)$ using a linear equation at every 5 nm from 400-700 nm. The $a_{PHY}(\lambda)$, $a_{NAP}(\lambda)$ and $a_p(\lambda)$ could be well modeled using their respective equations with $r^2 > 0.90$ for all wavelengths with the lowest r^2 being in the red portion of the spectrum. The validation was done by comparing the modeled absorption coefficients with the in-situ measurements. The modeled absorption coefficients were linearly correlated to in-situ absorption at all wavelengths. For wavelengths in the blue region the slopes were closer to 1 and percentage RMSE was less than 20%.

REMOTE SENSING OF THE DIFFUSE ATTENUATION COEFFICIENT AND RELATED PARAMETERS IN TURBID WATERS: STATE OF THE ART AND FUTURE PERSPECTIVES

Nechad, Bouchra¹; Ruddick, Kevin¹; Neukermans, Griet¹

¹100 Gulledele, Brussels, 1200, Belgium

Underwater attenuation of light is of interest to a range of users including: ecosystem modellers, who require information on Photosynthetically Available Radiation for calculation of primary production, divers, who require information on horizontal visibility for underwater operations, water quality managers, for whom parameters such as euphotic depth can be important environmental indicators, and more generally marine biologists studying processes such as visual predation. Characterisation of these processes can be achieved by a range of parameters including diffuse attenuation coefficient of downwelling PAR, spectral diffuse attenuation coefficient for downwelling irradiance, horizontal visibility, euphotic depth, Secchi depth, etc. In this contribution algorithms for estimation of these parameters by remote sensing will be reviewed with a focus on applications and algorithms in turbid waters, including validation aspects and algorithm performance. Future perspectives will be discussed for both polar-orbiting and geostationary sensors.

IS THERE A LINK BETWEEN HYDROLOGICAL PROCESSES AND REMOTE SENSING REFLECTANCE IN COASTAL SEAS?

Neil, Claire¹; Cunningham, Alex¹; McKee, David¹; Polton, Jeff²

¹University of Strathclyde 107 Rottenrow, Glasgow, G40NG, United Kingdom; ²National Oceanography Centre, 6 Brownlow Street, Liverpool, England, L35DA, United Kingdom

Marked temporal and spatial variations in remote sensing reflectance measured at red wavelengths are frequently observed in tidally mixed shelf seas. The reflectance patterns often appear to be spatially correlated with identifiable physical processes such as the input of turbulent mixing energy, tidal current strength and the passage of weather systems. Two interesting questions arise from these observations. First, what are the underlying mechanisms which generate the reflectance variability? Second, can improved understanding of these mechanisms enable us to exploit satellite remote sensing to provide information on shelf sea dynamics?

Both questions are explored using the Irish Sea (a semi-enclosed basin situated between the islands of Great Britain and Ireland) as a test site. This area offers several advantages, including the existence of a well-tested numerical model of its hydrodynamics (POLCOMS) and a large database of observations of seawater composition and in-situ optical properties. As a first step, the correlation between remote sensing reflectance at 667 nm and the concentration of mineral particles in suspension (MSS) was investigated, and its sensitivity to the presence of other optically significant materials quantified by a combination of radiative transfer modelling and water sample analysis. Preliminary results indicate that this correlation is sufficiently robust in these waters to allow reflectance to be used as an indicator of MSS concentrations and, by implication, of spatial variability in the hydrological processes on which they depend.

In a first analysis of 30 reasonably cloud-free MODIS scenes for the Irish Sea, no simple relationships were found to hold across the whole study area between satellite-derived MSS values and physical variables such as bathymetry, sea surface temperature and thermal stratification of the water column. A more detailed study of contrasting winter and summer conditions revealed interesting links between hydrographic parameters such as bed shear stress, seasonal stratification patterns and turbulent kinetic energy density. Detailed clarification of these correlations is providing important information for the formulation of models and also for the choice of locally tuned algorithms for interpreting satellite images.

VARIABILITY OF TOTAL, BACK AND SIDE SCATTERING TO MASS CONCENTRATION RATIO OF MARINE PARTICLES

Neukermans, Griet¹; Loisel, Hubert²; Mériaux, Xavier²; McKee, David³; Astoreca, Rosa⁴; Doxaran, David⁵; Ruddick, Kevin¹

¹RBINS Gulledele 100, Brussels, 1200 , Belgium; ²ULCO, Wimereux, Wimereux, 62930 , France; ³University of Strathclyde, Glasgow, Glasgow, G1 1XQ, United Kingdom; ⁴ULB, Brussels, Brussels, 1050, Belgium; ⁵LOV, Villefranche-sur-Mer, Villefranche, 06234 , France

Total Suspended Matter (TSM), the dry mass concentration of marine particles in suspension, is an important parameter for water quality assessment and ecosystem and sediment transport modeling. TSM concentration is estimated from space, based on the assumption that the ratio of the back scattering coefficient to dry mass concentration of suspended particles is constant. *In situ* measurements of scattering might be used as a proxy for the labour intensive measurement of TSM concentration. Remote sensing of TSM and the estimation of TSM from a scattering measurement require a thorough understanding of the relationship between scattering properties and TSM concentration. We investigate the relationship between various scattering properties (total, back and side scattering) and TSM concentration for coastal and offshore waters in various regions (Coastal Atlantic, Southern North Sea, Mediterranean sea and French Guyana waters) and quantify the uncertainty on TSM concentration estimation from each scattering property. We further quantify the variability of the total, side and back scattering to mass concentration ratio and explain this variability in terms of the physical (size) and chemical (organic fraction, apparent density) properties of the particles. As an application, we quantify the effect of the uncertainty on the mass specific backscattering ratio on algorithms for retrieval of TSM from space.

MERIDIONAL DISTRIBUTION OF NUTRIENTS IN THE EASTERN EQUATORIAL ATLANTIC – PRELIMINARY STUDIES

Nubi, Olubunmi Ayoola¹

¹Centre for Mathematical Physics - University of Abomey Calavi, Rep. of Benin. NIOMR, 3, Wilmot Point Road, Off Ahmodu Bello Way, Bar Beach, Victoria Island, Lagos, PMB 12729, Nigeria

This research work was carried out as part of the mandate of the Regional Program for Physical Oceanography in West Africa (PROPAO) to enhance human capacity building in the field of oceanography in West Africa. Nutrient data from the eastern equatorial Atlantic collected during EGEE/AMMA cruises between 2005 and 2007 were analyzed to illustrate the potential impact of equatorial upwelling on the distribution pattern of nutrients (nitrite, nitrate, phosphate, and silicate). For the purpose of this report

compilation, nutrient data for EGEE 3, 4, 5, and 6 (2006 and 2007) were taken into consideration, and all the plots here reported show the potential influence of equatorial upwelling on the nutrient distribution pattern in the equatorial Atlantic. Further studies shall be dedicated to the analysis of the nutrient distribution and variability in the Gulf of Guinea, and to the processes responsible for this variability, i.e. upwelling, biological, and potential trend due to climate change.

PHOTOACCLIMATION STRATEGY OF PHOTOSYSTEM II REACTION CENTER IN PRIMNESIOPHYCEAE ISOCHRYSIS GALBANA AS EVALUATED BY VARIABLE CHLOROPHYLL FLUORESCENCE

Obata, Mitsuko¹; Taguchi, Satoru¹

¹Soka University 1-236 Tangi-cho, Hachioji, 192-8577, Japan

Effect of photon flux density (PFD) on photosystem II (PSII) reaction center in *Isochrysis galbana* (Prymnesiophyceae) was studied based on variable chlorophyll *a* fluorescence. *Isochrysis galbana* was preconditioned in continuous culture which was acclimated at four different PFD levels (growth PFD) ranging from limited and partially saturated light (LPSL) condition to completely saturated light (CSL) condition for cell growth. The quantum yields of PSII under dark and light conditions (F_v/F_m and F_v'/F_m'), and the quenching parameters (qP and 1-qP) were measured by the pulse amplitude modulation fluorometer (PAM). To examine response of F_v'/F_m' , qP and 1-qP, they were determined at step-wise increase in the PFD of actinic light (actinic PFD). Decrease of the qP and increase of the 1-qP with actinic PFD were observed regardless of growth PFD. The qP and the 1-qP crossed at transition point between LPSL and CSL condition. In contrast, the F_v/F_m and the F_v'/F_m' were relatively constant regardless of growth PFD. These results suggest that the photoacclimation of the reaction center can be characterized for the redox state of the reaction centers. The state of the reaction centers in *I. galbana* was suggested to change from oxidative to reductive state upon a shift LPSL and CSL condition. The acclimation of the reaction centers leads enhancement of electron transport when the energy supply is insufficient for algal energy demands, and enhancement of fluorescence emission when the energy supply is excess for algal energy demands.

DEVELOPMENT OF TWO CHANNEL EMISSION FLUOROMETER WITH MULTI-WAVELENGTH EXCITATION BASE ON SIMULTANEOUS ILLUMINATION METHOD

Oishi, Tomohiko¹; Ebata, Hiroki¹; Takakusaki, Mitsuhiro²; Nemoto, Moyu²; Suzuki, Ryou²; Takahashi, Hirokazu³; Furuta, Masaji³

¹Tokai Univ. Orido 3-20-1, Shimizu-Ku, Shizuoka, 424-8610, Japan; ²The Tsurumi-Seiki, Co., Ltd., Tsurumi-Cho 2-2-20, Tsurumi-Ku, , Yokohama, Kanagawa, 230-0051, Japan; ³Fukada Salvage and Marine WorksCo., Ltd., Tatsumi Building, Iidabashi 3-8-7, Chiyoda-Ku, Tokyo, 102-0072, Japan

We developed a new illumination method so we called “simultaneous illumination method”. This method has the advantage that it does not need to synchronize between light source and sensor signals, i.e., totally independent between them, so that it drastically simplify instrumentation. As a first trial of this method, we apply it to an oceanographic fluorometer since it can easily increase the number of measurement emission wavelength by just mounting optical sensors as many emission wavelength as we need in principle. The developed fluorometer has two channels emission wavelength with 15 wavelength of excitation. The aim of this prototype is to make feasibility studies for extending the number of emission wavelength, finally up to 16 wavelength. It was found that a new type of *in situ* fuorometer with multi-excitation and multi-emission (16 * 16), which has not been realized yet, can be achieved without any difficulties.

BIO-OPTICAL SIGNALS AND THE PHYTOPLANKTON FUNCTIONAL TIONES IN THE SOUTHWESTERN ATLANTIC OCEAN

Omachi, Claudia Yuki¹; Ferreira, Amábile²; Garcia, Virginia Maria Tavano²; Garcia, Carlos Alberto Eiras²; Campos, Edmo José Dias¹

¹Universidade de São Paulo Praça do Oceanográfico, 191, sala 200, São Paulo, 05508-120, Brazil;

²Fundação Universidade Federal do Rio Grande, Instituto de Oceanografia, Av. Itália, km 80, Rio Grande, RS, 96201-90, Brazil

Phytoplankton functional type (PFT) shifts between diatoms and coccolithophores from spring to the summer blooms in the Patagonian Atlantic Ocean. PFT was estimated from phytoplankton absorption coefficient: picoplankton ($a_{ph} \leq 0.023 \text{ m}^{-1}$), nanoplankton ($0.023 \text{ } 0.069 \text{ m}^{-1}$). We applied this PFT to analyse SeaWiFS chlorophyll, phytoplankton absorption coefficient, calcite (CLCT) and backscattering coefficient (b_{bp}) for 2004 to 2006. Distinct seasonal pattern was found for the northern and southern part of the inner and mid shelf. Southern part of the study area showed stronger seasonal pattern than the northern part. Inner shelf presented the highest CLCT of the region with maximum due to nanoplankton, Chl

USING A+BB TO DETERMINE THE DEPTH OF VISIBILITY OF A BIOLUMINESCENT POINT SOURCE

Orrico, Cristina M¹; Zaneveld, J. Ron V²; Barnard, Andrew H²; Moline, Mark A³; Robbins, Ian³; Moore, Casey²

¹WET Labs 620 Applegate Street, Philomath, OR, 97370, United States; ²620 Applegate Street, Philomath, OR, 97370, United States; ³California Polytechnic State University, Biological Sciences Department, San Luis Obispo, CA, 93407, United States

Bioluminescence naturally occurs in marine coastal regions and is induced by mechanical stimulation of an organism which produces light via a chemical reaction. Induced bioluminescence can be considered to be a collection of internal point sources and is attenuated as it propagates to the surface. As the induced bioluminescent light propagates to the surface, it is attenuated due to absorption or backward scattering. However, forward scattered light is not lost and can be detected. The diffuse attenuation coefficient, or the rate at which light is lost as it propagates to the surface, determines the intensity of forward scattered light that will reach the surface. In the case of a point source, light attenuation is approximated well by measuring $a+b_b$, where a is the absorption coefficient and b_b is the backscattering coefficient, and follows $1/r^2 \exp(- (a+b_b) r)$. A reflecting tube absorption meter with no scattering correction approximates $a+b_b$ well. An experiment was conducted at night to determine the depth of a simulated bioluminescent point source while varying the absorption and attenuation properties of a homogeneous water column. A WET Labs ac-s was used to measure $a+b_b$, and was input into the model for attenuation of a point source. Measurement results are compared with theory, and the predicted depth of visibility of the point source is compared with that obtained using human observers. The purpose of this experiment was to validate a simple model for attenuating a bioluminescent point source light at depth, in order to provide an estimate of the visibility of bioluminescence at the water surface in complex coastal environments. Understanding the behavior of stimulated bioluminescence in complex coastal environments is relevant to covert Navy operations.

DEPENDENCE OF QUANTUM YIELD OF CHLOROPHYLL A FLUORESCENCE IN THE SEA ON ENVIRONMENTAL FACTORS – THE PRELIMINARY RESULTS

Ostrowska, Mirosława¹

¹Institute of Oceanology Polish Academy of Sciences ul Powstancow Warszawy 55, Sopot, 81-712, Poland

Quantum yield of chlorophyll a fluorescence in the sea depends on different environmental factors, mainly on light conditions, trophicity and temperature of water body. Our goal is to find the statistical relationship between the fluorescence quantum yield and factors mentioned above using empirical data. To determine quantum yield of sun-induced chlorophyll a fluorescence we used measurements of underwater spectral radiance and irradiance fields in 685 nm region, collected in different seasons, different seas and at different depth. The chlorophyll a concentration (as an indicator of trophicity we assume the surface chlorophyll a concentration), Photosynthetically Available Radiation PAR, and temperature of water were

measured simultaneously. The statistical analyses of these data allow establishing preliminary mathematical expressions which describe fluorescence quantum yield as a function of PAR level, trophicity and temperature. In the future we are going to apply these relationships to analyse of the budget of light energy absorbed by phytoplankton pigments utilized in chemical and non chemical quenching. We can also use these dependences in the development of new fluorometric methods for investigation of marine phytoplankton.

BIO-OPTICAL AND BIOGEOCHEMICAL DYNAMICS OF A SUB-TROPICAL ESTUARY IN SOUTH-EAST QUEENSLAND, AUSTRALIA

Oubelkheir, Kadija¹; Steven, Andrew D.L.¹; Ford, Phillip W.²; Clementson, Lesley A.³

¹CSIRO Land and Water 120 Meiers Road, Indooroopilly, QLD, 4068, Australia; ²CSIRO Land and Water, Canberra, ACT, 2601, Australia; ³CSIRO Marine and Atmospheric Research, Hobart, TAS, 7001, Australia

Recent advances in bio-optical methods have revolutionized our ability to measure many of the short-time biogeochemical dynamics that characterize estuaries. In the Logan estuary, a highly turbid estuary in a peri-urban setting in south-east Queensland, Australia, biogeochemical dynamics were investigated during monthly or bimonthly sampling through concurrent determinations of inherent optical properties and biogeochemical quantities. The *in situ* high frequency bio-optical approach complements a standard ongoing long-term monitoring program and helps to better understand the major controls on biogeochemical processes in the estuary and their inter-play with primary and secondary production.

Inherent optical properties of the water column were determined using *in situ* profilers and included hyperspectral absorption and scattering coefficients, spectral backscattering coefficient, and colored dissolved organic matter (CDOM) fluorescence; in parallel with discrete determinations of particulate and CDOM absorption and CDOM fluorescence excitation-emission spectra. Nitrate concentration was also measured with an *in situ* profiler to access the fine scale variability. Discrete biogeochemical quantities included phytoplankton pigments, total suspended matter, dissolved organic carbon, and nutrient concentrations. Concurrent surface PCO₂ measurements were also made and provide an indication of the variability of the overall trophic status along the estuary. In addition to the regular spatial sampling along the estuary, the variability along the tidal cycle was examined at 3 representative sites.

This suite of simultaneous *in situ* measurements of biogeochemical and optical properties allows exploration of the bio-optical relationships, and contributes to the calibration/validation of ocean color remote sensing imagery. Similar bio-optical monitoring programs are currently being implemented in key areas of south-east Queensland in estuaries and coastal waters in order to examine long-term trends in ecosystems dynamics resulting from human developments and global climate change.

UNDERWATER LASER SERIAL IMAGING USING COMPRESSIVE SENSING

Ouyang, Bing¹; Dalglish, Fraser¹

¹Florida Atlantic University Ocean Visibility and Optics Lab, Harbor Branch, Florida Atlantic Univ., Fort Pierce, FL, 34946, United States

In this paper, the application of Compressive Sensing (CS) as an underwater laser serial imager is explored. CS theory [4] states that if a signal is sparse enough in a known transform domain, then the signal can be reconstructed using a small set (less than Nyquist sampling rate) of *random* linear measurements. CS based imaging (CI) is a natural extension of CS theory since images are in general sparse in Discrete Cosine transform and wavelet domain. In a CI system, the target is modulated either at the illuminator or at the receiver with a set of binary random measurement matrices in serial mode using a spatial modulation device such as Digital Mirror Device. A photomultiplier tube (PMT) is used to obtain the corresponding set of measurements, together the measurement matrices are applied to a nonlinear optimization algorithm to reconstruct the image. In underwater laser serial imaging applications, CI can provide some distinct advantages: it simplifies the optical design and sampling electronics and offers higher photon efficiency than the traditional imaging system. In addition, the illuminator based design is especially suitable for bi-

static laser imaging configuration. However in turbid coastal water, spreading due to scattering media is a serious obstacle, resulting in the existing binary measurement matrices become ineffective. To overcome this issue, a multi-resolution binary measurement matrix is developed. This highly sparse implementation enables the spatial modulated pattern to be retained after the light propagates from illuminator to the target. In addition, the concept of “model assisted imaging” is introduced. In this paradigm, the radiative transfer model will be incorporated into an operational system to predict the actual modulation pattern when the light propagates from the illuminator to the target. This predicted pattern will then be used in addition to the PMT measurements that are used to reconstruct the target image using total variation minimization with quadratic constraints. Simulations were conducted to verify the effectiveness of this technique. To improve the authenticity of the simulation, different scattering phase functions were used in modulation pattern prediction and in generating PMT measurements. Performance at a range of imager depths and attenuation coefficient were simulated. The simulation has shown some very promising results, with reconstructed images exhibiting good contrast and resolution at multiple attenuation lengths.

SPATIAL SCALES OF IRRADIANCE VARIABILITY

Pegau, William Scott¹; Wijesekera, Hemantha²; Boyd, Tim³; Moline, Mark⁴

¹Oil Spill Recovery Institute Box 705, Cordova, 99574, United States; ²Naval Research Laboratory, Stennis, Mississippi, 39529, United States; ³Scottish Association for Marine Science, Oban, Argyll, PA37 1QA, United Kingdom; ⁴Center for Coastal Marine Sciences, San Luis Obispo, California, 93407, United States

As part of the ONR sponsored Radiance in a Dynamic Ocean program we collected measurements of irradiance fluctuations from autonomous underwater vehicles and tethered packages. This allows us to examine factors influencing variability in the light field from centimeters to a kilometer. The tethered package allows us to examine fluctuations in the light field down to one hundredth of a second. We combine the irradiance measurements with the physical and inherent optical properties to try and sort out how the light field is influenced at various time and space scales. Measurement results will be presented showing how different factors affect the underwater light field.

GLIDER DATA PROCESSING AND DATA COMPARISON IN OPTICAL PARAMETER ESTIMATION FOR ENVIRONMENTAL CHARACTERIZATION.

Pennucci, Giuliana¹

¹ITT Visual Information Solution 2 Arlington Square , Bracknell, RG12 1WA, United Kingdom

Long-range and remotely sensed satellites systems are being utilized in the oceanic and coastal areas to quantify temperature, currents and water properties. Our goal is to integrate Autonomous Underwater Vehicle Gliders (AUVGs) in order to maximize the impact and ground truth capabilities of the more extensive satellite observations. AUVG is a uniquely mobile platform capable of moving to specific location and depths thus providing high resolution water parameters at varying spatial and temporal scales. We will present results from three cruises supported by NURC in the Ligurian Sea: two trials occurred in October 2008 (LSCV 08-Ligurian Sea Cal/Val 2008) and March 2009 (Battlespace Characterization 2009-BP09), while the third was held in August 2010. The common points of those sea trials were the generation of an extensive and accurate optical data set (in coastal and oceanic waters) and the deployment of Slocum gliders. In particular, prior to the BP10 cruise a fleet of six Slocum Gliders will be deployed to survey the Ligurian Sea, providing measurements to assist in the selection of station locations and along track surveys. These gliders have been recently purchased by NURC and outfitted with a variety of bio-optical instrumentation. The aim of this paper is to perform glider data analysis to maximize the optical information content of the collected data and to minimize uncertainties as well as to provide comparisons between *in situ* and remote sensing measurements. The objective is to contribute to the future development of a wide area littoral network, as an approach for integrating *in situ* autonomous platforms and remote sensing for near-real time data fusion. We will present glider sensor reliability in intermediate/shallow waters (from 0 to 100 meters) and retrieval uncertainties of optical properties from glider-sampling

transects. A quality assessment of the results will be performed comparing glider products with those available from *in situ* (HyperPRO) measurements and satellite observations (MODIS and MERIS).

IN SITU PHYTOPLANKTON DYNAMICS COUPLED WITH APPARENT OPTICAL PROPERTIES IN A NOVEL MESOCOSM FACILITY

Peperzak, Louis¹; Timmermans, Klaas²; Wernand, Marcel²; Van der Woerd, Hendrik¹

¹VU University Amsterdam De Boelelaan 1087, Amsterdam, NL-1081 HV, Netherlands; ²Royal Netherlands Institute for Sea Research / NIOZ, P.O. Box 59, Den Burg, Holland, NL-1790 AB, Netherlands

The accuracy of remote sensing algorithms for phytoplankton biomass and physiology is difficult to test under natural conditions due to rapid changes in physical and biological forcings and the practical inability to manipulate nutrient conditions in the sea. Therefore, indoor mesocosms equipped with hyperspectral radiometers and bottom irradiance meters were used to examine changes in optical properties during blooms of biogeochemically-relevant phytoplankton (*Emiliania huxleyi*, *Phaeocystis globosa*, *Skeletonema costatum*) under controlled conditions. In addition, *in situ* measurements were made of phytoplankton pigments, particulate organic carbon, photosystem II quantum efficiency, individual cell scatter characteristics, growth rate, and absorption using an integrating cavity absorption meter (ICAM). Water-leaving radiance algorithms for Absorbed Radiation by Phytoplankton (ARP), Fluorescence (F) and hence ϕ (F/ARP), a remote-sensing indicator of physiological status, were developed and correlated with *in situ* data of phytoplankton biomass and physiology. First results indicate that ARP and FLH are species- or taxon-specific and that ARP is strongly dependant on physiologically-induced changes in pigment composition.

THE CARBON TO CHLOROPHYLL RATIO IN THE OCEAN: DO CHANGES IN THE RATIO REFLECT CHANGING PHYSIOLOGY, COMMUNITY STRUCTURE, OR BOTH?

Perry, Mary Jane¹; Briggs, Nathan¹; Cetinic, Ivona¹; D'Asaro, Eric²; Lee, Craig M.²; Sieracki, Michael E³

¹University of Maine 193 Clark's Cove Road, Walpole, ME, 04573, United States; ²Applied Physics Laboratory, University of Washington, Seattle, WA, 98105, United States; ³Bigelow Laboratory for Ocean Sciences, West Boothbay Harbor, ME, 04575, United States

The 2008 North Atlantic spring bloom experiment used a combination of autonomous platforms – a Lagrangian mixed layer float and four Seagliders – to study the evolution of the spring bloom. Four visits by a ship provided multiple opportunities for calibration of autonomous sensors as well as for additional biological and chemical measurements including particulate organic carbon, chlorophyll and other pigments, phytoplankton absorption coefficients, and phytoplankton species. Diatoms dominated the early bloom until they depleted silicate, a nutrient that is in relatively low supply in the subpolar North Atlantic. Depletion of silicate likely triggered a diatom dump (aggregation followed by rapid sinking of aggregates out of the euphotic zone). After the dump, the phytoplankton community became dominated by picophytoplankton. Transitions in community structure were reflected in optical signatures (*in situ* chlorophyll fluorescence/optical backscatter ratio, filter pad values of $a^*_{\text{phyt}(676)}$), ratios of total extracted chlorophyll *a* to particulate organic carbon and phytoplankton species. We suggest that, in a region with strong seasonality, chlorophyll to backscatter ratios can be used to assess shifts in plankton community structure.

ANERIS. AN AUTONOMOUS PROFILER FOR CONCURRENT CHARACTERISATION OF PHYSICAL AND BIO-OPTICAL PROCESSES AT SMALL SCALES

Piera, Jaume¹; Torrecilla, Elena¹; Pons, Sergi¹; Aymerich, Ismael Fernandez¹; Ross, Oliver Nicolas¹; Dañobeitia, Juan José¹; Artigas, Mireia Lara²; Berdalet, Elisa²; Simó, Rafel²; Afinkiev, Teodor³; Fernández, Roemi³; Armada, Manuel³

¹CSIC Passeig Marítim Barceloneta 37-49, Barcelona, 08003, Spain; ²Instituto de Ciencias del Mar ICM-

CSIC. Passeig Marítim Barceloneta 37-49, Barcelona, Barcelona, 08003, Spain; ³Centro de Automática y Robótica CAR-CSIC. Carretera Campo del Real, La Poveda, Madrid, Madrid, 28500, Spain

Hydrodynamics plays a primary role in aquatic ecosystems, affecting processes across a wide range of temporal and spatial scales. The research on biological-physical interactions requires the multi-scale characterization of the environmental changes derived from the transport mechanisms and the response of organisms to these changes.

Traditional sampling methods, such as ship based observations only provide spot measurements within a highly dynamic and heterogeneous environment. Likewise, satellite-based remote sensing of ocean colour has its limitations as it can only probe the skin of the ocean lacking the necessary temporal and vertical resolution. Further progress thus depends on different sampling strategies that are able to resolve the relevant space and time scales at which ecological processes occur.

To improve our understanding of biological dynamics in the ocean, an interdisciplinary team coordinated by the Marine Technology Unit (UTM) in Barcelona, is developing an intelligent oceanographic probe with high resolution autonomous sampling and collecting capabilities within the framework of the multidisciplinary project ANERIS. The ANERIS profiling system is mainly being designed: (1) to gather fine-scale profiles of biological structure by using hyperspectral sensors during the free-fall descent, (2) to detect phytoplankton structures of interest by processing the whole set of hyperspectral distributions along depth and (3) to autonomously collect discrete water samples within significant depths in terms of phytoplankton composition during the ascent by incorporating a number of automatically-triggered bottles into its design. This multi-instrumented high resolution system will be able to measure high resolution physical parameters and hyperspectral optical properties in the upper meters of the water column, while simultaneously collect water samples for laboratory analysis to be used as reference for groundtruthing. This mode of operation is intended to be useful for studying coastal environments, covering a wide range of temporal and spatial scales where different events may happen and even validating remotely-sensed hyperspectral ocean data collected by airborne imagers.

DEPTH RESOLVED RATES OF PHOTOCHEMICAL CARBON MONOXIDE PRODUCTION IN THE GULF OF MEXICO, A RIVER-DOMINATED COASTAL MARGIN.

Powers, Leanne¹; Fichot, Cedric ²; Miller, William¹

¹UGA University of Georgia, 220 Marine Sciences Bldg, Athens, GA, 30602, United States; ²University of South Carolina, Columbia, South Carolina, 29208, United States

After carbon dioxide, carbon monoxide (CO) is the second largest identified product in the photooxidation of marine dissolved organic matter (DOM). Solar radiation in the ultraviolet and blue range is responsible for most of the DOM photodegradation so that the photoproduction of CO largely depends on surface water optical properties. Here we report depth-resolved and -integrated photochemical rates of CO production in the northern Gulf of Mexico from samples collected on four research cruises in 2009 and 2010 (April, July, Oct/Nov 2009 and March 2010) with repeat occupation of 10 of 20 stations. To obtain CO photochemical production rates, we determined photochemical efficiency for each sample as apparent quantum yield (AQY) spectra, defined as the ratio of moles CO produced to the moles photons absorbed at a given wavelength (λ). Calculations employ our laboratory determined AQY spectra and CDOM absorption ($ag(\lambda)$) spectra, together with *in situ* diffuse attenuation coefficients ($Kd(\lambda)$) measured during all cruises using a Satlantic MicroPRO profiler modified with four UV channels. Photochemical CO production rates in this coastal margin are examined for seasonal AQY and spatial production variability, and compared to CO production rates in other oceanic regimes.

STATUS OF VIIRS SYSTEMS ENGINEERING FOR OCEAN COLOR SCIENCE QUALITY DATA:
CONFIDENTLY RETRIEVING WATER-LEAVING RADIANCE AND CHLOROPHYLL
CONCENTRATION FROM ACO & OCC ON NPP BASED ON RIGOROUS SENSOR TESTING
PROGRAM

Pratt, Patty¹, Ip, Justin¹; McCarthy, Jim¹, Chou, Mau-Song¹; Donovan, John¹; and Hauss, Bruce²

¹Northrop Grumman Aerospace Systems (NGAS) and ²DKK One Space Park Drive Bldg R10, Redondo Beach California 90728 patty.pratt@ngc.com

VIIRS is nearing the end of the analysis phase of its formal testing program and a path forward has been set for several sensor and test artifacts that are of importance to those planning to utilize VIIRS sensor data from NPP for ocean color products. The highlights of the major tests and phenomena essential to the performance of ocean color are presented here informally to guide future users to understand aspects that affect their area of interest. The intention of this paper is to point to the major NPP VIIRS-specific features to provide insight into how various user applications may be affected by sensor or test artifacts, if at all. Some of these features include opportune improvements and advancements and others are the result of workarounds to engineering problems identified in testing. Finally, the purpose of this paper is to present a timeline of the facts and analyses that led to the conclusions driving the system engineering efforts for meeting the mission requirements of NPP which include science quality ocean color products. Here we highlight and summarize the pertinent testing and analysis, algorithm development and various validation tools being developed for on-orbit verification of ocean color from VIIRS.

OPTICAL MEASUREMENTS OF BUBBLE POPULATIONS DURING LARGE SCALE WAVE BREAKING IN THE SOUTHERN OCEAN AND THEIR SIGNIFICANCE TO REMOTE SENSING REFLECTANCE

Randolph, Kaylan¹; Dierssen, Heidi²; Twardowski, Michael³; Zappa, Christopher⁴; Cifuentes-Lorenzen, Alejandro²; Freeman, Scott³

¹University of Connecticut 1080 Shennecossett Rd, Groton, CT, 06378, United States; ²1080 Shennecossett Rd, Groton, CT, 06378, United States; ³WET Labs, Inc. (East Coast Branch), 165 Dean Knauss Dr., Narragansett, Rhode Island, 02882, United States; ⁴Ocean and Climate Physics, 206B Oceanography, 61 Route 9W, Palisades, NY, 10964, United States

Submerged bubble populations recurrently introduced into the surface ocean by breaking waves influence mixing processes, the transfer of gases and heat across the air-sea interface, the optical properties of the water column, and ocean color reflectance. Due to their size compared to wavelengths of light and refractive index relative to water, bubbles are effective at backscattering light. The magnitude of light reflected from the sea surface can be significantly enhanced due to bubble entrainment at temporal scales of minutes and the spectral nature of the light field can be shifted towards green wavelengths. Previous investigations have determined that bubbles have a unique optical signature, readily identifiable in the volume scattering function (VSF). Optical measurements of bubble plumes in the Atlantic Sector of the Southern Ocean collected under sustained high wind conditions (13-15 m s⁻¹, SWH 3-5 m) during the Southern Ocean Gas Exchange Experiment (SOGasEx, March 10-April 4, 2008) show a significant enhancement in particle populations in time periods on the order of seconds. The evolution of a bubble population is evident in the high temporal resolution (1-20 Hz) data collected from multiple instruments including the MASCOT volume scattering meter (WET Labs), the LISST particle size analyzer (Sequoia Scientific), an ac-9 absorption-attenuation meter, (WET Labs), and backscattering sensors (ECO sensors, WET Labs). Bubble plumes were traced through time using the shape of the VSF augmentation, specifically at the critical angle between 60° and 80°, which allows differentiation between the bubble and particle contributions to light scattering, and with changes in the particle size distribution. The frequency of bubble detection in the VSF and LISST was compared with concurrently measured wave breaking statistics for consistency. The significance of bubbles plumes and whitecaps to backscattered light and remote sensing reflectance is considered from measured inherent and apparent optical properties, collected above and below the air-sea interface, at stations with similar biogeochemistry experiencing markedly different wind conditions.

IMPROVING ACCURACY OF WATER QUALITY MONITORING IN CASE-II WATERS BY WAVELET TRANSFORMATION

Raymaekers, Dries¹; Knaeps, Els²; Sterckx, Sindy²; Tote, Carolien²; Odermatt, Daniel³

¹VITO Boeretang 200, Mol, 2400, Belgium; ²Boeretang 200, Mol, 2400, Belgium; ³University of Zurich - RSL - , Winterthurerstr. 190, Zurich, 8057, Switzerland

Inland and coastal waters, the so-called case-II waters, are optically complex because of the independent variation of Algae, Total Suspended Matter (TSM) and Coloured Dissolved Organic Matter (CDOM) in the water and their combined influence on the water-leaving reflectance spectra. This implicates that standard algorithms in use for water quality retrieval from the open ocean are not suited for these waters. With the introduction of new sensors with better spectral, spatial and radiometric resolution, new improved algorithms and approaches have been developed to retrieve water quality parameters in these complex waters. Under the ESA funding scheme, a Swiss/Belgian initiative resulted in a project to build a new generation airborne imaging spectrometer, namely APEX (Airborne Prism Experiment). First test flights were held in June 2009, including a campaign over two diverse water bodies: the eutrophic, perialpine, Lake Constance (Switzerland) and the river Scheldt (Belgium). In this study a new curve fitting approach is presented to derive TSM, CHL and CDOM concentrations in inland and coastal waters from APEX imagery. The approach is based on the wavelet transformation of subsurface irradiance reflectance spectra and is introduced in a curve fitting algorithm. This allows to focus on specific features that occur on different scales of the spectra. By weighing the specific features, different aspects of the spectral variation in shape and magnitude can be taken into account. For the development of the algorithm, realistic APEX water leaving reflectance spectra are simulated, including atmospheric and sensor noise, for a wide range of measured Specific Inherent Optical Properties (SIOPs) and water constituent concentrations. The results show that by including a set of robust wavelet features in the minimization criteria of the curve fitting, the retrieval of TSM, CHL and CDOM is less influenced by errors in the atmospheric correction and specific sensor noise. Finally, the algorithm is validated on the acquired APEX imagery.

CDOM AND PAH'S IN THE MARINE ENVIRONMENT - *IN SITU* SENSING WITH TIME RESOLVED FLUORESCENCE AND LIQUID CORE WAVEGUIDES

Zielinski, Oliver¹; Dittmar, Thorsten²; Rohde, Peter¹; Ungermann, René¹; Voss, Daniela¹

¹An der Karlstadt 8, Bremerhaven, 27568, Germany; ²Max Planck Research Group for Marine Geochemistry, University of Oldenburg, Oldenburg, -, 26129, Germany

Marine environments are influenced by a wide diversity of anthropogenic and natural substances and organisms that may have adverse effects on human health and ecosystems. Among these, polycyclic aromatic hydrocarbons (PAH's) are of high relevance and real-time measurements are required to adequately monitor these pollutants. Optical *in situ* methods are suitable for long term observations and application in remotely or autonomous operated platforms. Detecting and quantifying PAH concentrations in marine natural waters is challenging due to low substance concentrations and cross sensitivity in its absorption and fluorescence characteristics especially with chromophoric dissolved organic matter (CDOM). Two approaches to increase sensitivity and specificity are followed within this work, both intended for an *in situ* sensor application. Liquid core waveguides offer exceptionally high sensitivity for absorption characteristics whereas time-resolved fluorescence provides information on the fluorescence lifetime of sea water constituents, the later utilizing a novel ellipsoidal measurement cell for signal increase. Set-up and recent results of both approaches are demonstrated and perspectives for operational applications are discussed.

OPTICAL CHARACTERIZATION OF WATER MASSES IN THE PLATA PLUME

Romero, Silvia Inés¹; Ferrari, Ramiro²

¹University of Buenos Aires Intendente Güiraldes 2160, Buenos Aires, C1428EGA, Argentina; ²Intendente Güiraldes 2160, Buenos Aires, C1428EGA, Argentina

The Plata River is one out of five discharging large volumes of fresh water into the subtropical Atlantic. Low salinity plume waters associated with the Plata discharge show strong seasonal variability as seen from in-situ hydrographic and satellite ocean color data. In the present work we test the performance of NASA's bio-optical evaluation products (total absorption coefficient (a), absorption due to gelbstoff and detrital material (adg), absorption due to phytoplankton (aph) and particulate backscatter (bp)) as indicators of surface salinity. Preliminary tests were carried out on a SeaWiFS 1 Km resolution image obtained on 27 August 2003 between 15:21 and 15:32 UTC, concomitant with in-situ salinity data from the NICOP La Plata winter cruise. The atmospheric correction applied was based on MUM's algorithm for turbid waters calibrated for the Plata estuary. All bio-optical products were estimated by semi and quasi analytical algorithms (Carder, GSM and QAA). The best performance was obtained using GSM. Within the low salinity plume extending from the coast to 60 km offshore, our results show absorptions due to phytoplankton and due to gelbstoff and detrital material, greater than 0.2 and 0.12, respectively. The salinity front lies in a region of strong decline (above one order of magnitude) in aph and adg in a distance of about 30 km (between 60 and 90 km from the coast). All bio-optical variables show modal distributions associated with three distinctive water masses: Subtropical (~ 36), sub-Antarctic shelf (32.5 <S <34) and Plata plume (<32.5) waters. Although the results do not vary significantly from those obtained through satellite chlorophyll-a, inherent optical properties are essentially not dependent on the radiation distribution and are useful in the detection and monitoring of smaller scale patterns important in the understanding of the Plata Plume dynamics.

OCEAN OPTICS WITHIN NSW-IMOS: AN INTEGRATED MARINE OBSERVING SYSTEM FOR THE COAST OF SOUTHEASTERN AUSTRALIA.

Roughan, Moninya^{1,3,4}; Morris, Bradley D.^{1,3}; Doblin, Martina^{2,3}; Baird, Mark^{2,3}; Suthers, Iain^{1,3}

¹University of New South Wales, Sydney NSW 2052, Australia; ²University of Technology Sydney, NSW, 2007, Australia; ³Sydney Institute of Marine Science Mosman NSW 2088 Australia; ⁴mroughan@unsw.edu.au

Here we introduce the Ocean Optics program within the NSW component of Australia's integrated marine observing system (NSW-IMOS). For the first time we have concurrent time series measurements of physical and bio-geochemical properties in the continental shelf waters of the East Australian Current (EAC). We present preliminary results from both the mooring program and glider deployments. We also identify calibration issues with the bio-optical measurements. Some of the primary goals are to understand the bio-physical response to EAC forcing, as well as validating contemporary ocean colour derived estimates of chlorophyll, CDOM and TSS against direct IMOS observations, developing NSW specific optical inversion algorithms for near shore, optically complex coastal waters and finally, parameterization of future linked ecosystem models and the evaluation of forecasting abilities through the collection of biological and geochemical data streams.

DYNAMIC VARIABILITY IN THE SPECTRAL-POLARIZED LIGHT FIELD MEASURED OVER SEAGRASS AND SAND HABITATS

Russell, Brandon¹; Dierssen, Heidi²; Zimmerman, Richard³

¹University of Connecticut 1080 Shennecossett Rd, Groton, CT, 06340, United States; ²1080 Shennecossett Rd, Groton, CT, 06340, United States; ³Department of Ocean, Earth & Atmospheric Sciences, Old Dominion University, Norfolk, VA, 23529, United States

Biological camouflage has evolved in multiple phyla as an adaptation to visually-orienting predators. Organisms may change their polar spectral reflectivity to minimize their contrast to their environment and thereby avoid detection. Here, we present measurements of the dynamic and complex light field in the nearshore, coastal environment as a foundation for exploring the underlying camouflage mechanisms of select species of fish found in these habitats. Spectral polarized light and reflectance measurements were made in waters near Port Aransas, Texas in June 2010. Two habitats were explored: 1) Seagrass meadows,

habitat for the dynamically camouflaging pinfish; and 2) Sandy sediment, habitat of the Southern flounder. Polarized benthic reflectance spectra will be presented from the Divespec (NightSea) and the DOBBS from these two environments. In addition, temporal variability in spectral polarized side-looking radiance will also be presented from a moored HTSRB. Spectral-polarized qualities of the light field will be correlated to physical/chemical characteristics of the water, including depth, tidal cycle, turbidity, chl-a, for the different habitats. These field measurements will serve as parameters for light-field modeling and laboratory organismal studies, as well as facilitate interpretation of the dynamic camouflage mechanisms specific to organisms dwelling in these different habitats.

PRELAUNCH STUDY OF CAL/VAL FOR GEOSTATIONARY OCEAN COLOR IMAGER

Ryu, Joo-Hyung¹; Moon, Jeong Eon¹; Son, Young Baek¹; Ahn, Yu-Hwan¹

¹Kordi 1270 Sadong, Ansan , 426-744, Korea, Republic of

In order to provide quantitative control of the standard products of Geostationary Ocean Color Imager (GOCI), on-board radiometric correction, atmospheric correction, and bio-optical processing are obtained continuously by comprehensive and consistent calibration and validation procedures. For calibration and validation of GOCI, we installed the spectroradiometers at the Jeodo and Gagecho ocean research stations and ocean environmental sensors at the Dokdo and Eochungdo buoys. HyperSAS data acquired at Jeodo station were slightly different in *in-situ* radiance and irradiance, but did not have spectral shift in absorption bands. Although all radiance bands measured between HyperSAS and SeaWiFS had an average 25% error, the 11% absolute error was relatively lower when atmospheric correction bands were omitted. We have to consider and improve this error rate for calibration and validation of GOCI. A reference target site around Dokdo was used for studying calibration and validation of GOCI. In-situ ocean- and bio-optical data were collected during August and October 2009. Absorption spectra of chlorophyll, suspended matter, and dissolved organic matter also showed their spectral characteristic. As we strive to solve the problems of radiometric, atmospheric, and bio-optical correction, it is important to be able to progress and improve the future quality of calibration and validation of GOCI.

EVALUATION OF *IN SITU* ABSORPTION MEASUREMENTS IN COASTAL WATERS

Röttgers, Rüdiger¹; McKee, David²

¹Institute for Coastal Research , GKSS Max Planck Str. 1, Geesthacht, D-23883, Germany; ²University of Strathclyde, Glasgow, Scotland, G4 0NG, United Kingdom

Measurements of light absorption *in situ* are commonly made using collimated beam systems (Wetlabs AC9/ACS). The determination is adversely affected by scattering of photons. The correction for these photon losses relies on different assumptions but the validity of these assumption in turbid coastal water had never been shown. In addition an instrument with an integrating sphere design (Hobilabs, A-sphere) is now available, that theoretically has none or only minor scatter errors. Both types of instrument were tested (*in situ* and in the lab) and its absorption determination evaluated in turbid coastal waters (Baltic Sea, North Sea, River Elbe) by comparison to lab-based measurements using a point-source integrating-cavity absorption meter (PSICAM), an instrument that had been proofed to have negligible scatter errors. Differences in the obtained absorption between these three types of instruments are shown. Significant difference are observed for scatter corrected AC9/ACS measurements as well as for A-sphere measurements. These errors are discussed regarding the validity of the set of assumptions made for the scattering correction procedures. Empirical relationships between these absorption results and those obtained by the PSICAM are used to improve scatter correction in turbid and shelf sea waters for both types of instruments.

SMALL SCALE OPTICAL VARIABILITY OVER THE A LONG DISTANCES - APPLICATION OF VERSATILE ON-BOARD FLOW-THROUGH SYSTEM FOR UNDERWAY OBSERVING SPATIAL DISTRIBUTION OF SURFACE WATER OPTICAL PROPERTIES.

Sagan, Slawomir¹; Darecki, Mirosław¹; Kowalczyk, Piotr¹

¹Institute of Oceanology Polish Academy of Sciences Powstancow Warszawy 55, Sopot, 81-712, Poland

To resolve spatial scales of optical variability in highly variable environments (as coastal or semi-enclosed basins) there is a need for near-synoptic mapping of parameters. This can be achieved with the use of AUVs or with fixed FerryBox-like systems. Another possible solution is the flow-through system which employs profiling optical package for continuous underway measurements. A versatile on-board flow-through system developed at IOPAS consist of ac9 (WetLabs), CDOM fluorescence (TRiOS), and CTD (SeaBird). Others sensors, in our case LISST (Sequoia) and bbe FluoroProbe (Moldaenke), might be easily added to the flow. System offers the capability of continuous measurements in subsurface water of 2 m depth. The spatial sampling resolution, several to hundred meters, is a product of sampling frequency and the cruising speed, modified by time lag and a damping effect of the tank. Possibility of quick assembling and disassembling of the system allows for easy switch between underway measurements and vertical profiling with the same package while arriving on the station. We present examples of changes in the relations between measured optical parameters while crossing different water masses. We also present the comparison of the data with concurrent continuous measurements of remote sensing reflectance measured from the ship bow. Apart for providing the valuable stream of data, the system ads for efficiency factor for ship time use. System was tested in the open and coastal Baltic waters, as well as in Arctic fjords of Svalbard.

UNCERTAINTY OF APPARENT AND INHERENT OPTICAL PROPERTIES AS DERIVED FROM GLOBAL OCEAN COLOR PRODUCTS

Salama, Mhd. Suhyb¹

¹ Department of Water Resources, ITC, University of Twente, Hengelosestraat 99, 7500 AA Enschede, The Netherlands

Deriving inherent optical properties (IOPs) from ocean color data requires accurate atmospheric correction, reliable retrieval algorithms and consistent method for uncertainty estimation.

In this paper I propose an operational method to estimate the average-uncertainty of all derived IOPs. The method avoids estimating the radiometric uncertainty but rather evaluates their propagation to satellite-derived IOPs and quantifies the average-uncertainty of all IOPs per unit change of the radiometric quantity.

The method is validated against the NOMAD *in-situ* data and applied to global IOPs products as merged from SeaWiFS and MODIS. The performance of the proposed method is accurate ($R^2 \sim 0.99$) and simple, it provides vital information for accuracy assessment, assimilation and to de-trend time series of IOPs.

IMPROVED HEAT FLUXES IN OCEAN CIRCULATION MODELS BY OPTICS

Sanjuan Calzado, Violeta¹; Chiggiato, Jacopo ¹; Trees, Charles ¹

¹NATO Undersea Research Centre Viale San Bartolomeo 400, La Spezia, 19126, Italy

The present work proposes the use of optical data and models for a better characterization in ocean circulation models of the incoming heat flux from solar radiation. An accurate definition of this parameter is crucial since as it not only affects heat content and hence model dynamics, but also biogeochemical processes occurring within the water column.

In oceanic circulation models, incoming heat flux from solar radiation is provided as a forcing parameter from meteorological models and is parameterized as radiant flux incident on the sea surface. Then, the propagation in the water column of this incident radiant flux is calculated following Paulson and Simpson (1977) formulation for a predefined Jerlov optical water type and vertical attenuation for the entire basin. Heat fluxes from solar radiation are calculated as the decrement of shortwave irradiance in between ocean layers in the model.

Optical oceanography has significantly evolved in the past 30 years with advanced optical instrumentation and computational models. The use of such radiance formulations in the physical model can now be considered obsolete. This work presents new forcing schemes for incoming solar radiation based on in-situ observations, a review of propagation patterns within the water column and heat estimates from solar irradiance based on optical modeling.

USE OF SEAWIFS AND MODIS TO SUPPORT DEVELOPMENT OF NUMERIC NUTRIENT CRITERIA FOR FLORIDA COASTAL WATERS.

Schaeffer, Blake A.¹; Hagy, James D.¹; Lehrter, John C.¹; Stumpf, Richard²; Conmy, Robyn N.¹

¹US EPA 1 Sabine Island Drive, Gulf Breeze, FL, 32561, United States; ²NOAA, National Ocean Service, Center for Coastal Monitoring and Assessment, 1305 East-West Highway, n/SCI1, Silver Spring, MD, 20910, United States

Human activities on land increase nutrient loads to coastal waters, which can increase phytoplankton production and biomass and associated ecological impacts. EPA has determined that numeric nutrient criteria are needed for Florida's coastal waters to prevent impairment of water quality due to nutrient enrichment. Coastal waters are defined here as marine waters up to 3 nautical miles from shore, but excluding waters defined to be estuaries (generally semi-enclosed waters). The objective of this study is to provide baseline chlorophyll distributions for each of Florida's coastal water bodies. This project includes 98 coastal water bodies in Florida, 23 along the Panhandle from the Alabama border to Apalachee Bay, 36 along the west shelf from Cedar Key to Florida Bay, and 39 along the east coast from the Georgia border to Biscayne Bay. Water quality monitoring provides important information for developing and implementing nutrient criteria, which must be based on a defensible scientific rationale. However, Florida's coastal waters have not been monitored comprehensively, and regular monitoring of coastal areas is challenging. Thus, there is insufficient data based on field-sampling to support numeric nutrient criteria development for all of the State's coastal waters. Application of remote sensing data to quantify coastal water quality has the potential to greatly improve protection for these waters. Remote sensing provides statewide coverage at a regular and frequent temporal interval, enabling application of existing quantitative approaches for criteria development. Remote sensing also provides historical temporal coverage that allows for retrospective examination of water quality changes in relation to landscape changes. Spatial and temporal measures of relative chlorophyll are resolved across Florida's coastal waters using SeaWiFS and MODIS. Relative chlorophyll is characterized with SeaWiFS OC4 and MODIS OC3 algorithms between 1997 and 2010 and compared with in-situ measurements and harmful algal bloom cell abundance observations. Statistical distributions for selected coastal water bodies are presented and evaluated as possible numeric criteria.

SEEKING CONNECTIONS BETWEEN HIGHER SPECTRAL RESOLUTION SHIP-BORNE RADIOMETRY AND SURFACE BIOGEOCHEMISTRY

Schwarz, Jill N.¹; Pinkerton, Matt H.¹; Gall, Mark¹; Maas, Els¹; Safi, Karl¹; Chang, Hoe¹; van Kooten, Marieke¹; Thompson, Karen¹; Wood, Simon¹; Cunningham, Chris¹

¹National Institute of Water & Atmosphere Research Private Bag 14 901, Kilbirnie, Wellington, 6022, New Zealand

The error on the OC3 and OC4 chlorophyll algorithms, which includes radiometric and atmospheric correction uncertainties as well as natural bio-optical variability, is now well established on a global scale at around 30%. Many approaches are being developed to derive more than 'just' chlorophyll concentrations from ocean reflectances, to transform the natural uncertainty portion of the error into useful information. Some of these focus on specific taxa or variables of interest (e.g diatom, coccolithophore and diazotroph algorithms, primary production algorithms, POC algorithms) while others aim for a more general derivation of water quality (suites of characteristic pigments, inherent optical properties, bio-optical blending algorithms). Yet another study has begun the long task of classifying waters by suites of bio-optical plus sea surface temperature data, while the even longer task of building a comprehensive database of the specific optical properties of algae and sediments appears to have proceeded only slowly over the past 5-10

years. In this period of development and searching, it seems timely to review an accumulated dataset of high spectral resolution reflectances from diverse waters including the Arctic, Antarctic, North Atlantic, West Pacific sub-tropical to sub-Antarctic, Baltic and coastal areas in Europe and New Zealand. Two radiometers are compared, with spectral resolutions of 0.4 nm (SUMOSS) and ~3 nm (TriOS). These data can be used to examine pigment signatures (after Morrow, Bidigare, Aguirre-Gomez) using fourth-derivative and curve-fitting algorithms, and fluorescent line heights with an adjustable central fluorescence wavelength. They can also be used to compare algorithms for satellites with different spectral bands. These analyses are all summarized in this presentation. In addition, a first comparison between high resolution radiometry and a broad suite of biogeochemical descriptors, including nutrient uptake rates, bacterial growth rates, phytoplankton growth rates and the interactions between the bacterial and phytoplankton communities, is presented.

PHYTOPLANKTON FUNCTIONAL TYPES IN THE PATAGONIAN SEA: ACCORDING TO PHOTOSYNTHETICAL AND BIO-OPTICAL CHARACTERISTICS

Segura, Valeria¹; Lutz, Vivian Alicia²; Dogliotti, Ana Ines³; Benavides, Hugo Rodolfo¹; Silva, Ricardo Ismael¹; Negri, Ruben Mario¹; Akselman, Rut¹

¹INIDEP Paseo Victoria Ocampo n° 1, Mar del Plata, 7600, Argentina; ²CONICET-INIDEP Paseo Victoria Ocampo N°1, Mar del Plata, Buenos Aires, 7600, Argentina; ³IAFE-CONICET, Pabellón IAFE-Ciudad Universitaria, C.C. 67- Suc. 28 , Buenos Aires, 1428, Argentina

Phytoplankton Functional Types (PFTs) can be defined on the base of the photosynthetic parameters (α^B and P_m^B) and bio-optical characteristics such as the specific absorption coefficient ($a_{ph}^B(\lambda)$). It is well known that these characteristics change according to the taxonomic composition, the size structure of the phytoplankton and the environmental conditions (light, temperature, and nutrients) where they live. The Patagonian Sea is a productive area of the world ocean. In spite of the biological importance, primary production has not been thoroughly studied in the region. Previous works in this area showed a wide variation in production values during spring, and that these changes could be due to variations in the phytoplankton communities present. Here we centre our study in distinguishing different PFTs, according to photosynthetic and bio-optical characteristics, in different locations in the Patagonian Sea, during different seasons (2005- 2006). A wide variability in the characteristics analyzed was observed, for example P_m^B varied from ~0.12 to 9.90 $\text{mgC}[\text{mgChla}]^{-1}\text{h}^{-1}$ and $a_{ph}^B(440)$ from ~0.006 to 0.051 $\text{m}^2(\text{mgChla})^{-1}$ resulting in several PFTs for the different periods of the year. Some PFTs share the same range of phytoplankton size, but they differ in their physiological or bio-optical characteristics. As an example of the complexity found, some groups composed of large size cells (determined by microscopic analysis) have values of their photosynthetic and bio-optical characteristics expected for small size classes. Therefore, in some areas of the ocean, as shown here for the Patagonian Sea, PFTs are not only a function of cell size, rather in some cases can be mainly determined by their response to the environment affecting a combination of their photosynthetic and bio-optical characteristics.

MODIFIED-SEADAS ATMOSPHERIC CORRECTION ALGORITHM TO IMPROVE RETRIEVAL OF SURFACE REFLECTANCE IN CASE 2 WATERS

Shanmugam, Palanisamy¹

¹Indian Institute of Technology Madras Chennai, Chennai, --, 600036, India

The surface reflectance is of the key products from ocean colour satellite data and is used in various bio-optical algorithms to derive several higher-order products. Atmospheric correction by the removal of atmospheric path radiance provides this surface reflectance. Currently, SeaDAS atmospheric correction algorithm is considered an operational and widely used algorithm to retrieve surface reflectance in global waters. However, several of previous studies frequently noted improbable negative reflectance values with this algorithm in optically-complex Case 2 waters that contain significant amount of suspended sediments and phytoplankton concentrations. This limits the ocean colour data applications mostly to the open ocean

waters. Here we introduced simple steps to resolve the atmospheric correction problem in such waters. These steps were tested under various atmospheric conditions over the Arabian Sea which represented intense algal blooms in offshore and highly turbid waters along its coastal areas. Whilst the SeaDAS atmospheric correction algorithm yielded negative values in most bloom pixels, the new steps introduced in that algorithm provided effective in reducing the errors of both the surface reflectance and the chlorophyll concentration estimates. The retrieved surface reflectances were also compared with *in situ* data and significant improvements were observed in these products when chlorophyll values exceeded 2 mg m⁻³.

ABSORPTION CHARACTERISTICS OF NON-ALGAL PARTICLES IN HIGHLY TURBID WATERS OF THE YANGTZE RIVER ESTUARY AND ADJACENT COAST, CHINA

Shen, Fang¹; Zhou, Yunxuan¹; Hong, Guanlin¹

¹East China Normal University, State Key Lab of Estuarine and Coastal Research. Zhongshan Bei Road 3663, Coastal Building, Shanghai, 200062, China

The investigation on inherent optical properties (IOPs) of coastal water-colour components at regional scale, is very crucial in developing coastal bio-optical algorithms. In contrast to chromophoric dissolved organic matters (CDOM) and phytoplankton, variability of absorption characteristic of non-algal particles (NAP) is less well described in highly turbid estuarine and coastal waters. Three cruise campaigns were conducted off the Yangtze River Estuary seawards during May, August and November 2009, for the investigations of bio-optical properties in the coastal waters. Water samplings were taken monthly in 2009 within the Yangtze River Estuary, for the analysis of IOPs of the estuarine waters. It is found that the absorption coefficient of NAP at 440 nm is high and surpasses that of CDOM 3-5 folds in the Xuliujing (the starting point of the Estuary), 5-10 folds in the Wusongkou (in the middle of the Estuary) and 10-20 folds in the Turbidity Maximum Zone (in the exit of the Estuary). It is indicated that the contribution of NAP absorption to total absorption can be predominant in the estuarine waters. Overestimation of CDOM or chlorophyll will be resulted in if neglecting it. The observation shows that the NAP absorption can change with variations in river discharges and seasonal scales, which is also relevant to suspended sediment concentrations and salinity. The NAP absorption has a wavelength-dependency and is subject to the degradation of exponent law with wavelengths increase, similar to the regularity of CDOM absorption.

MULTIVARIATE DATA ASSIMILATION WITH THE MONTEREY BAY COUPLED BIO-OPTICAL, PHYSICAL MODEL

Frolov, Sergey¹; Shulman, Igor²; Anderson, Stephanie³

¹Monterey Bay Aquarium Research Institute, Moss Landing, California, 95039, United States; ²Naval Research Laboratory Bldg 1009, Stennis Space Center, Bay St. Louis, MS, 39529, United States; ³Bldg 1009, Stennis Space Center, Bay St. Louis, MS, 39529, United States

Bio-optical physical models have become a major tool to forecast the evolution of coupled properties over predictable time scales. It is critical to combine such interdisciplinary models with available observations in order to improve the model's initialization, calibration of parameters, uncertainty estimation, etc. We present preliminary results from data assimilation experiments with the coupled bio-optical physical model of the Monterey Bay. The approach is based on using multivariate EOFs to reduce the complexity of the data assimilation problem and to provide an instantaneous update of coupled properties. The research is being conducted in the framework of the NRL project on "Bio-Optical Studies of Predictability and Assimilation for the Coastal Environment (BIOSPACE)" with the objective to study the variability and predictability of underwater light and coupled bio-optical and physical properties of the water column. The primary interest is on time scales of 1 to 5 days--time scales when atmospheric model forecast is available.

SPECTRAL ATTENUATION AND BACKSCATTERING AS INDICATORS OF PARTICLE SIZE DISTRIBUTION

Slade, Jr., Wayne Homer¹; Boss, Emmanuel¹

¹University of Maine 360 Aubert Hall, Orono, ME, 04469, United States

The particulate beam attenuation is a fundamental measure of water turbidity, and a useful proxy for total particulate mass and organic carbon concentration. Measurements of the spectral particulate beam attenuation coefficient, $c_p(\lambda)$ [m^{-1}], in the ocean typically exhibit an inverse power-law dependence on wavelength (λ), and the slope of the power-law has been theoretically related to the slope of the particle size distribution (PSD), also assumed to be an inverse power-law as a function of particle size. To our knowledge, no direct comparison of *in situ* PSD and $c_p(\lambda)$ has been previously performed. The first part of this work focuses on a direct comparison between PSD and $c_p(\lambda)$ for several datasets, both in the water column and within the bottom boundary layer. The results of this comparison support the use of beam attenuation slope as an indicator of changes in PSD, as suggested by theory. However, the spectral particulate beam attenuation cannot currently be measured from autonomous vehicles or over long periods on moored observing systems due to size limitations, bio-fouling, and power demand. Recently, sensors measuring spectral particulate backscattering, $b_{bp}(\lambda)$ [m^{-1}], have been deployed at moored observatories and on autonomous underwater vehicles, and some have suggested this measurement may also be used to obtain information about the shape of the PSD. The second part of this work focuses on comparison of coincident measurements of $b_{bp}(\lambda)$ and PSD. The results of this analysis are less clear, suggesting that the relationship between $b_{bp}(\lambda)$ and PSD may not be as clear as with $c_p(\lambda)$ and PSD.

DETERMINING THE NEAR FORWARD VOLUME SCATTERING FUNCTION FROM THE LISST-100X PARTICLE SIZE ANALYZER

Slivkoff, Matthew¹; Klonowski, Wojciech¹; Twardowski, Michael²; Freeman, Scott²

¹WETLabs (now at In-situ Marine Optics P/L, Western Australia) 1/3 Park Ave, Crawley, 6009, Australia;
²Department of Research, WET Labs Inc, 70 Dean-Knauss Drive, Narragansett, Rhode Island, 02812, United States

Equations were derived to estimate the near-forward in-water VSF from the LISST-100X laser diffraction instrument, avoiding the use of small-angle approximations. The LISST-100X detector ring radii and surface area was measured in order to verify the angular calibration of the instrument and the solid angles of its detectors. In order to determine the detector solid angle without using a small angle approximation, a ray tracing model was developed which estimated the angle of incidence of light reaching each detector. Basic instrument dark current, stray light and scintillation characterization measurements were made in the field and the laboratory, which suggest that subtle variations to published methods for determining the signals measured from in-water scattering may extend the useful operating range of the instrument into clearer waters. Based on theory and estimates of the logarithmically-varying detector acceptance angles, we propose an initial attempt at dealing with the attenuation correction of LISST data using an iterative technique which uses the shape of the VSF as measured by the LISST-100X. We provide an appendix which outlines our procedure to calculate VSF's from the LISST-100X instrument's measured data for community evaluation.

ASSESSMENT OF MODIS-AQUA CHLOROPHYLL-A DATA IN THE CHESAPEAKE BAY

Son, SeungHyun¹; Wang, Menghua¹

¹NOAA/NESDIS/STAR 5200 Auth Road, Camp Springs, MD, 20746, United States

There are several empirical and semi-analytical models for the satellite chlorophyll-a data. We have examined various existing chlorophyll-a (Chl-a) models for the Chesapeake Bay waters using the NOMAD *in situ* optical and bio-optical measurements. The Chl-a models may not be appropriate for the upper Chesapeake Bay waters, where waters are usually very turbid (sediment-dominated). However, Chl-a data from the OC-based (OC3 and OC4) models provided better correlations with *in situ* Chl-a data in the lower Bay of the Chesapeake Bay, where optical properties are more similar to those in open ocean waters.

In this study, we evaluate the performance of the MODIS-Aqua standard Chl-a (OC3) products derived from the NASA standard NIR and the new NIR-SWIR combined methods in the Chesapeake Bay waters using *in situ* measurements from the Chesapeake Bay Water Quality Database. Both previous (version 5.2) and the reprocessed (R2009) MODIS-Aqua standard ocean color products, in addition to the NIR-SWIR results, are used for the evaluation. Results show that both MODIS NIR Chl-a data (version 5.2 and R2009) are overestimated over most of the Chesapeake Bay although there are some considerable improvements in the recent reprocessed MODIS-Aqua Chl-a data. The MODIS-derived Chl-a data using the NIR-SWIR combined method are overall generally lower compared with those from both standard MODIS NIR Chl-a data in the Chesapeake Bay. While both MODIS NIR Chl-a data are still overestimated in the lower Bay, the MODIS NIR-SWIR Chl-a data are relatively well correlated with the *in situ* Chl-a measurements. This suggests that the existing Chl-a model works well at least in the lower Bay of the Chesapeake Bay region.

RECENT ADVANCES IN AUTOMATED UNDERWATER PLANKTON OBSERVATIONS WITH IMAGING FLOWCYTOBOT

Sosik, Heidi M.¹; Olson, Robert J.¹

¹Woods Hole Oceanographic Institution MS 32, Woods Hole, MA, 02543-1049, United States

Underwater imaging with microscopic resolution provides unprecedented capability to observe natural plankton communities. Imaging FlowCytobot is a submersible imaging-in-flow cytometer that combines individual particle measurements of light scattering and chlorophyll fluorescence with high resolution (~1 micron) video imaging. It is especially effective for sampling nano- and microphytoplankton, with cell identification possible to at least genus for most microplankton, and can operate unattended for periods of 6 months or longer. Repeated long term deployments of the research prototype Imaging FlowCytobot at the Martha's Vineyard Coastal Observatory off Massachusetts and a pier near Port Aransas, Texas have provided new insights into dynamics of coastal communities, including seasonal variations in diatom diversity and monitoring of harmful algal blooms. New developments towards a pre-commercial design of Imaging FlowCytobot are leading to reduced size and power demand, along with modifications for increased reliability and ease of manufacture.

COST EFFECTIVE PLATFORMS FOR THE DEPLOYMENT OF OPTICAL SENSORS IN DYNAMIC ENVIRONMENTS

Spada, Frank Wayne¹; Chang, Grace²; Twardowski, Michael³; Freeman, Scott³

¹Sea Engineering, Inc. 200 Washington St. Ste. 210, Santa Cruz, CA, 95060, United States; ²200 Washington St. Ste. 210, Santa Cruz, CA, 95060, United States; ³WET Labs, Inc., 70 Dean Knauss Dr., Narragansett, RI, 02882, United States

There is an increasing demand for simple and efficient deployment of optical sensors in dynamic environments such as the surf zone, rivers, tidal estuaries, etc. Recently, a study was conducted to predict optical variability in the surf zone as the result of dynamic processes such as sediment resuspension and bubble injection from breaking waves. Optical sensors were initially deployed on two 2-m tripods weighing ~100 kg each, and on ONR SBIR sponsored WET Labs man-portable optical drifters (Surf zone Water Attenuation Nodes; SWANs). The tripods were cabled to shore, allowing for real-time data transmission and shore power; the SWANs communicated via radio frequency transmission. For safety and logistical reasons, the tripods were deployed ~30 m outside the impacting surf zone, well outside of the desired research area. The SWANs drifted in and out of the surf zone depending on tidal and wave and current variability. The challenge constituted dynamic, reliable methods of deploying optical sensors in the impacting surf zone. After several iterations, small floats were developed using PVC pipe and pour-in-place foam for buoyancy. Larger sensors were deployed on sheets of Polyethylene foam. The floats, as well as the SWANs were held in place with compact anchors. A grid of optical sensor floats was deployed via swimmers in the surf zone for a fraction of the cost of larger platforms while also enabling optical measurements directly in the dynamic surf impact zone. Future developments for these types of platforms include remote deployments and data telemetry.

MEASUREMENT OF INSTANTANEOUS PHYTOPLANKTON PHOTOSYNTHETIC PARAMETERS IN LAKE VICTORIAN (UGANDA) USING A FLUORESCENCE TECHNIQUE

Ssebiyonga, Nicolausi¹; Erga, Svein²; Frette, Øyvind¹; Stamnes, Jakob¹

¹University of Bergen, Norway University of Bergen, Department of Physics and Technology, p.o box 7803, Bergen, N-5020, Norway; ²Department of Physics and Technology, University of Bergen, p.o box 7803, Bergen, N-5020, Norway

We measured instantaneous photosynthetic parameters in Murchison bay using the Fast Repetition rate Fluorometer. Murchison bay is a shallow bay located in Lake Victoria and is the source of water to more than 1 million people in Uganda. The physicochemical environment of the water in the bay is highly influenced by the excessive nutrient loading and the urban effluents from Kampala (capital city of Uganda). Sampling took place between December 2009 and March 2010 at six stations; with some stations in the inner semi-enclosed part of the bay and others towards the open outer part of the bay. The bay is eutrophic with total phosphorus > 0.02 mg/L. The photosynthetic parameters; the quantum yield of photochemistry Fv:Fm was in the range 0.2-0.45 and the functional absorption cross section was in the range 100-600 Å² per quanta. The chlorophyll concentration was >100µg/L. This is the first study to measure the instantaneous photosynthetic rates in Lake Victoria. The FRRF photosynthetic rates are to be compared with the photosynthetic rates obtained from oxygen concentration measurements.

A FAST YET ACCURATE ALGORITHM FOR RETRIEVAL OF AEROSOL AND MARINE PARAMETERS IN COASTAL WATERS

Stamnes, Knut¹; Li, Wei²; Tanikawa, Tomonori²; Hamre, Børge³; Stamnes, Jakob³

¹Stevens Institute of Technology 1 Castle Point on Hudson, Hoboken, NJ, 07030, United States; ²1 Castle Point on Hudson, Hoboken, NJ, 07030, United States; ³University of Bergen, Bergen, Hordaland, N-5000, Norway

A new algorithm for the inversion of ocean color data will be presented. This algorithm gives simultaneous retrieval of aerosol and marine parameters in coastal waters. The Levenberg-Marquardt (LM) optimal estimation method was used here instead of the traditional look-up table method to improve the retrieval accuracy. The forward radiative transfer model for the coupled atmosphere-water system was replaced by a neural network (NN) function in order to speed up the retrieval process. We used both forward and inverse NN training for the radiative transfer calculations. The inverse training provides good initial values for the retrieval, while the forward training provides simulated radiances and Jacobians required for the LM optimal estimation. The retrieval speed improved about 100 times as a result of the NN training. We applied this new algorithm to analyze a SeaWiFS image obtained over the Santa Barbara Channel. Five parameters were obtained from the retrieval: aerosol optical depth, the aerosol model fraction, the chlorophyll concentration, the CDOM absorption at 443 nm, and the backscattering coefficient at 443 nm. The water leaving radiance is provided as a by-product. The results were compared with both the standard SeaDAS v4.8 algorithm and our earlier optical estimation algorithm without the use of forward/inverse NN training. The comparison shows that our new results are consistent with our earlier optimal estimation results, but the retrieval speed has increased by a factor larger than 100 due to the NN training.

RADIATIVE TRANSFER IN THE COUPLED ATMOSPHERE-OCEAN SYSTEM: A VERSATILE MODEL BASED ON THE DISCRETE-ORDINATE METHOD

Stamnes, Snorre¹; Stamnes, Knut²; Hamre, Børge³; Stamnes, Jakob³

¹Stevens Institute of Technology 1 Castle Point on Hudson, Hoboken, NJ, 07030, United States; ²1 Castle Point on Hudson, Hoboken, NJ, 07030, United States; ³University of Bergen, Bergen, Hordaland, N-5000, Norway

A versatile code for radiative transfer in the coupled atmosphere-ocean system is described. The code has the following features: (i) it allows for a user-specified number of layers in the atmosphere as well as the water to adequately resolve the vertical variation in inherent optical properties; (ii) it computes upward and downward irradiances, scalar irradiance and diffuse attenuation coefficients at user-specified optical depths in the atmosphere and water; (iii) it computes radiances in user-specified directions at user-specified optical depths in the atmosphere and water. The user specifies the layer-by-layer input parameters consisting of optical depth, absorption and scattering coefficients as well as expansion coefficients of the scattering phase function. The inherent optical properties can be either user-specified or adopted from a companion code that provides inherent optical properties based on published models and data. Models for open ocean (Case 1) and turbid coastal waters (Case 2) waters will be available. The optical properties of the atmosphere are based on band models to include gaseous absorption. Standard models for aerosol scattering and absorption will be available. This coupled code is designed to be a versatile tool for researchers in the ocean optics community. It is expected to address the needs of researchers interested in analyzing irradiance and radiance measurements in the field and laboratory as well as those interested in making simulations of the top-of-the-atmosphere radiance in support of remote sensing algorithm development.

OPTICAL PROPERTIES OF SUSPENDED SEDIMENTS AND AGGREGATES: PRIMARY AND SECONDARY PARTICLES

Stavn, Robert Hans¹

¹University of North Carolina at Greensboro PO Box 26174, Greensboro, NC, 27402, United States

True optical parameters, such as the properly determined mass-specific scattering cross section for mineral matter, give us the ability to invert the mass concentration of the suspended mineral matter, the modal size of the suspended mineral particles, and/or the state of aggregation of the suspended mineral particles. The use of true optical parameters allows the full power of optical theory to be applied to practical problems. The above outlines major goals in the program of Biogeo-optics.

The generating of true mass-specific scattering cross sections requires the determination of the mass concentration of Particulate Inorganic Matter (PIM) and Particulate Organic Matter (POM) for the region under investigation. Then Model II multiple linear regression of the particle scattering coefficient against PIM and POM gives the partial regression slopes, the statistical estimates of the mineral and organic mass-specific scattering cross sections. These field measured true optical parameters are then readily analyzed theoretically.

I will present results utilizing Mie calculations of a coated sphere (recommended by Latimer and Boss), the fractal model of mineral aggregates proposed by Hill and his associates, and the major particle size distribution (PSD) models proposed in the last two decades. The correct combination of PSD, specialized Mie calculations, and models of the relation of primary and secondary particles of aggregates allow the prediction and analysis of the mass-specific mineral scattering cross sections measured in Mobile Bay, Alabama, USA and in the Irish Sea. I will further investigate the optical consequences of various combinations of primary and secondary particles in the formation of aggregates. These results from the program in Biogeo-optics unite the endeavors of those in the ocean optics community and those in the sedimentology community.

INFLUENCE OF UNDERWATER LIGHT FIELDS ON PIGMENT CHARACTERISTICS IN THE BALTIC SEA – RESULTS OF STATISTICAL ANALYSIS

Stoń-Egiert, Joanna¹; Majchrowski, Roman²; Darecki, Mirosław¹; Ostrowska, Mirosława¹

¹Institute of Oceanology Polish Academy of Sciences ul Powstancow Warszawy 55, Sopot, 81-712, Poland; ²Institute of Physics, Pomeranian University in Słupsk, Arciszewskiego 22b, 76-200 Słupsk, Poland, Słupsk, Słupsk, 76-200, Poland

Light intensity and its spectral distribution in the water body is considered to be a main abiotic factor directly modifying qualitative and quantitative composition of phytoplankton pigments, and thus – absorption properties of marine algae. The nature of underwater light fields affects the intercellular content of the photosynthetic and photoprotectant pigments by the phenomenon of intensity and chromatic photoadaptation. These processes may occur as a result of high intensity of the blue light in the surface layer of water or the presence of narrow spectral lights at different depths – determining the vertical distributions of the relative content of photosynthetic and photoprotectant groups of pigments in the water body.

The aim of this study was to determine the relationships between the concentrations of individual pigments groups, called ‘accessory’, and the various optical characteristics of the light fields in the waters of the Southern Baltic Sea. The analysis were based on database of empirical measurements including the results of chromatographic separation of pigments by HPLC techniques and distributions of underwater light fields measured by a spectrophotometer MER 2049 during 27 research cruises on r/v ‘Oceania’ in 1999-2004. As a result of statistical analysis the following relationships were obtained:

- (to chlorophyll a concentrations), i.e. chlorophylls b, chlorophylls c and the group of photosynthetic carotenoids depending on spectral fitting function (so-called ‘chromatic acclimation factor’),

- and between the total relative concentrations of photoprotectant carotenoids occurring in between the total relative concentrations of major groups of photosynthetic pigments the Baltic waters in function of potentially destructive radiation (PDR), defined as the absolute amount of energy absorbed by chlorophyll a in a unit mass in the blue part of the spectrum (400 , 480 nm).

Additionally, the comparative analysis between the relative concentrations of main groups of pigments and suitable irradiance characteristics in ocean (case 1 waters) and the Baltic waters (case 2 waters) were also carried out.

UNDERSTANDING PARTICLE DYNAMICS USING IN-SITU HOLOGRAPHIC MICROSCOPY

Sullivan, James Michael¹; Twardowski, Michael¹; Katz, Joseph²; Hong, Jiarong²; Talapatra, Siddharth²; Donaghay, Percy³

¹WET Labs 70 Dean Knauss Rd., Narragansett, RI, 02882, United States; ²The Johns Hopkins University, Baltimore, MD, 21218, United States; ³University of Rhode Island, Narragansett, RI, 02882, United States

Optical scattering in all but the clearest natural waters is dominated by the local particle dynamics. The link between the suspended particle field and the bulk scattering properties of natural waters is poorly known because adequate technology is lacking to fully characterize all the parameters of the particle field required to compute the bulk optical properties (especially for ephemeral bubbles and aggregates). Holography provides non-intrusive, non-destructive, high-resolution 3-D imaging of particles (including bubbles) in their natural environment at a resolution and sample volume size that no other instrument can currently achieve. Because of the ability to optical section the hologram (image planes) during reconstruction, it allows the extraction of all individual particle characteristics (at the same lateral resolution), their 3-D spatial distribution, and motion (in short pulsed serial holograms). As part of a NOPP project to commercialize an in-situ Digital Holographic Microscope (DHM), field data with a prototype in-situ DHM and several bench-top DHMs were collected in East Sound, WA; an environment that had both zooplankton and phytoplankton thin layers and notable particle dynamics. Preliminary results from this study and a project overview will be presented.

RETRIEVAL OF PARTICULATE BACKSCATTERING IN COASTAL/OCEANIC WATERS

Shanmugam, Palanisamy¹; Sundarabalan, Balasubramanian¹; Ahn, Yu-Hwan²; Ryu, Joo-Hyung³

¹Chennai, Chennai, 600036, India; ²Indian Institute of Technology Madras Chennai, Ansan, Seoul, 425-600, Korea, Republic of; ³Korea Ocean Research and Development Institute, Ansan, Seoul, Seoul, Korea, Republic of

Accurate retrieval of particulate backscattering coefficients has been a great challenge in optically complex Case 2 waters. Although several models exist for retrieval of the Inherent Optical Properties (IOP's) such as particulate backscattering (b_{bp}) from the remote sensing reflectance, these models produce b_{bp} with high errors mainly because of improper parameterization or inappropriate definition of the slope and reference parameters. After analyzing the performance of several models for open and coastal waters, we found that GSM model retrieves b_{bp} with accuracy better than the other models. However, its retrieved b_{bp} values are still uncertain in coastal waters mainly because of the above problems. In this study, we introduced new steps in the GSM model to improve the retrieval of b_{bp} in a wide range of waters. One important step involved in the improved model is an appropriate definition of the slope parameter that varies depending on the characteristics and concentration of the sea water constituents. When applied to simulated dataset from Boss-Roesler simulation data sets and NOMAD *in situ* data set, the improved model outperforms the GSM model. The RMSE for the simulated data sets was found low ($0.1266 \text{ m}^{-1} b_{bp}(443)$) with the improved model when compared to that with the GSM ($0.1937 \text{ m}^{-1} b_{bp}(443)$). For NOMAD *in situ* data set the RMSE value was reduced from 0.1526 m^{-1} for the GSM to 0.1256 m^{-1} for the improved model. Results of the sensitivity analysis showed that the improved model is more robust than the GSM model and can be used to accurately retrieve b_{bp} values from a wide range of waters commonly found in the coastal and offshore domains.

TOWARDS DEVELOPMENT OF AN IMPROVED TECHNIQUE FOR REMOTELY-SENSED RETRIEVAL OF WATER QUALITY COMPONENTS: AN APPROACH BASED ON THE GORDON'S PARAMETER SPECTRAL RATIO

Sokoletsky, Leonid¹; Gallegos, Sonia²

¹Elizabeth City State University 1704 Weeksville Road, Elizabeth City, NC, 27909, United States; ²Naval Research Laboratory Building 1009, Stennis Space Center, MS, 39529, United States

Numerical measures of water quality components (WQCs) such as chlorophyll-*a* or suspended solids concentrations or dissolved organic matter absorption are often based on using spectral reflectance ratios. However, these ratios are not free from error caused primarily by uncertainties in observation-lighting geometry, the particulate scattering phase function and the contribution (d_E) of the diffuse component to the total (direct+diffuse) downwelling irradiance. To overcome these uncertainties, the remote-sensing Gordon's parameter (G) spectral ratio is used instead of the spectral reflectance ratios. Uncertainties introduced by different factors into the spectral reflectance ratios for two types of reflectances - irradiance reflectance R and remote-sensing reflectance r_{rs} - are examined. The factors, representing an extremely wide set of natural waters, geometrical and atmospheric conditions, include: 5 different scattering phase functions with the particulate backscattering probability B_p (from 0.009 to 0.156), 14 values of solar zenith angle in the water q_i (from 0 to 46 degrees) and 7 values of d_E (from 0.125 to 0.5). The variability of R and r_{rs} spectral ratios is shown to be minimal under high values of d_E , i.e. when diffuse light is significant. At spectral ratios close to unity, uncertainties tend to be zero. Modeling shows that uncertainties lie in the range of [0%; 4.1%] and [0%; 11.3%] for R and r_{rs} spectral ratios, respectively, if the Gordon's parameter spectral ratio is in the range from 0.1 to 10 for any selected values of d_E . However, within the range of [0.5; 2] (that generally corresponds to the moderate values of WQCs), the same uncertainties are significantly smaller: [0%; 1.3%] and [0%; 3.1%], respectively. Thus, the suggested Gordon's spectral ratio approach applied to remote-sensing WQCs retrieval may give some improvement in accuracy, especially for extremely clear or turbid natural waters.

INVESTIGATIONS OF THE POLARIZATION PROPERTIES OF ALGAE SCATTERING

Svensen, Øyvind¹; Frette, Øyvind¹; Kildemo, Morten²; Aas, Lars Martin Sandvik²; Erga, Svein³; Stamnes, Jakob¹

¹University of Bergen University of Bergen, PO Box 7803, Bergen, N-5020, Norway; ²Department of Physics, NTNU, Trondheim, Trondheim, 7491, Norway; ³Department of Biology, University of Bergen, PO Box 7803, Bergen, Bergen, N-5020, Norway

We have used a Mueller matrix ellipsometer to measure the full Mueller matrix of variety of algae with different shapes, sizes, and refractive indices. The Mueller matrix gives the polarization state of the scattered light. Our experimental setup for measuring the Mueller matrix is a multiple laser Mueller matrix ellipsometer developed at NTNU in Trondheim. The measurements are done for every 2nd degree from 20° to 164° at 473 nm and 532 nm. The polarization of light scattered from microalgae has earlier been investigated only for a few species, for which it was found that the Mueller matrix showed little variation between the species. In our study we investigated nine algae species, and the selection of species was based upon a high variability in shape, size, and refractive index. As in the earlier investigations, we found only small variations in the Mueller matrix between the species. The most significant variations were seen in elements M11, M12 and M33.

VARIATIONS OF NET PRIMARY PRODUCTIVITY AND PHYTOPLANKTON COMMUNITY COMPOSITION IN THE SOUTHERN OCEAN DURING AUSTRAL SUMMER AS ESTIMATED FROM OCEAN-COLOR REMOTE SENSING DATA

Takao, Shintaro¹; Hirawake, Toru²; Suzuki, Koji¹; Wright, Simon W.³; Saitoh, Sei-Ichi²

¹Graduate School of Environmental Science, Hokkaido University, North 10 West 5, Kita-ku, Sapporo, Hokkaido, 060-0810, Japan; ²Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minatocho, Hakodate, Hokkaido, 041-8611, Japan; ³Australian Antarctic Division and Antarctic Climate and Ecosystems Cooperative Research Centre, 203 Channel Highway, Kingston, Tasmania, 7050, Australia

Phytoplankton population dynamics play an important role in biogeochemical cycles in the Southern Ocean during austral summer. Recent environmental changes such as a rise in sea surface temperature (SST) are likely to impact on net primary productivity (NPP) and phytoplankton community composition. However, their spatiotemporal relationships remain to be unclear in the Southern Ocean. Here we assessed the relationships among NPP, dominant phytoplankton groups, and SST in the Indian sector of the Southern Ocean for the past decade (1997/1998 - 2006/2007) during austral summer using satellite remote sensing data. A phytoplankton absorption based model for estimating NPP was also developed using SeaWiFS data, and the estimates were verified with *in situ* NPP data. As a result, we found a statistically significant reduction in NPP in the polar frontal zone for the past decade. Moreover, the decrease in NPP positively correlated with the dominance of diatoms ($r=0.92$) estimated by the algorithm PHYSAT (Alvain et al., 2005), but not correlated with SST. In the seasonal ice zone, NPP correlated with not only the dominance of diatoms positively ($r=0.79$), but also the prevalence of haptophytes ($r=-0.75$) and SST ($r=-0.63$) negatively. Our results suggested that summer NPP was strongly affected by the phytoplankton community composition in the Southern Ocean.

CHARACTERIZATION OF ORGANISMS, PARTICLES, AND BUBBLES IN THE WATER COLUMN USING A FREE-DRIFTING, SUBMERSIBLE, DIGITAL HOLOGRAPHY SYSTEM

Talapatra, Siddharth¹; Nayak, Aditya Ramakrishna¹; Zhang, Cao¹; Hong, Jiarong¹; Katz, Joseph¹; Twardowski, Michael²; Sullivan, James²; Donaghay, Percy³

¹Johns Hopkins University 223 Latrobe, Johns Hopkins University, Baltimore, MD, 21218, United States; ²WET Labs, Inc. Department of Research 165 Dean Knauss Dr., RI 02882, Narragansett, RI, 02882, United States; ³University of Rhode Island, GSO, Narragansett, RI, 02882, United States

A submersible holographic imaging system, "HOLOSUB" developed at The Johns Hopkins University was deployed recently at Eastsound, WA, as part of a collaborative effort with other groups to characterize the biology and structure of thin layers. Holograms were also recorded within the wake of a boat and under breaking waves in order to characterize the spatial and temporal variations of bubble size distributions. The HOLOSUB is a free-drifting platform, which has been designed to minimize the relative motion with the free-stream current, enabling us to capture multiple exposures of the same object. This platform is also equipped with a ballast system for depth control, which facilitates recording of data while slowly profiling the water column. The on-board optical setup consists of two in-line holography systems. Its light source is a pulsed 660nm wavelength, Nd-YLF laser, and holograms are recorded by two digital cameras at two

different magnifications within the same sampling volume. In recent deployments the system characteristics have been: sample depth - 100 mm, resolution - 5.68 and 3.9 $\mu\text{m}/\text{pixel}$, and field of view - 11.5X11.5 mm and 8X8 mm, respectively. During the deployments, the depth of thin layers in the water column in the vicinity of the HOLOSUB was detected by the spatial variability of the Volume Scattering Function (VSF), which was measured by the WET Labs custom prototype device "MASCOT". The HOLOSUB was then deployed to obtain datasets that spanned the entire water column, while acquiring data both within and outside the thin layers. Slow drifting of the HOLOSUB captured time series of holograms of the same organism allowing us to calculate its velocity, trajectory, orientation, and interactions with other organisms. Ongoing data analysis will provide statistics of species concentration and spatial arrangement, including variation with elevation, as well as nearest neighbor statistics among organisms of the same or different species.

A NEW OCEAN COLOR ALGORITHM FOR THE GCOM-C1/SGLI SENSOR

Tanikawa, Tomonori¹; Wei, Li²; Stamnes, Knut²

¹Stevens Institute of Technology Castle Point on Hudson, Hoboken, NJ, 07030-5991, United States; ²Castle Point on Hudson, Hoboken, NJ, 07030-5991, United States

The Global Change Observation Mission-Climate/Second-generation Global Imager (GCOM-C1/SGLI) is scheduled to be launched in 2014. The SGLI instrument has two major new features: 250 m spatial resolution and polarization/multidirectional observation capabilities. The 250 m resolution provides enhanced observation capability over coastal areas where the environment is most sensitive to human activities. The polarization and multidirectional observations will enable more accurate aerosol retrievals over land and ocean areas, which will help improve climate prediction models.

The algorithm has been constructed for the GCOM-C1/SGLI. It is designed for simultaneous retrievals of marine and atmospheric parameters including aerosol optical depth, aerosol model fraction, chlorophyll concentration, CDOM absorption and backscattering coefficient in coastal waters. The SGLI sensor has seven channels at wavelengths 412, 443, 490, 530, 565, 670 and 865 nm that can be used for ocean color remote sensing. A fully-vectorized radiative transfer model (RT) for the coupled atmospheric-ocean system is used to simulate radiances and calculate Jacobians (weighting functions). This RT model simulates the measured spectral radiant quantities for the full Stokes vector. We will explore the potential for retrieving information about marine parameters as well as aerosol type and loading from the polarized radiance measurements provided by the SGLI sensor.

BIO-OPTICAL MEASUREMENTS IN ATLANTIC OPEN OCEAN WATERS FOR SATELLITE VALIDATION

Theis, Anja¹; Schmitt, Bettina¹; Bracher, Astrid¹

¹Alfred Wegener Institute Bussestraße 24, Bremerhaven, 27570, Germany

In order to validate satellite data with ground-truth data and to give an impression on the uncertainty of satellite derived biogeochemical properties like chl-a concentration bio-optical measurements were performed on several transatlantic ship cruises.

Within this presentation a comparison between remote sensing reflectances determined from hyperspectral above and below water radiometric measurements is shown. The radiometric data were collected with TriOS-RAMSES radiometers in open ocean waters. The remote sensing reflectances are used to validate MERIS, MODIS and SeaWiFS remote sensing reflectance data.

Additionally, apparent and inherent optical properties will be determined from below water measurements and used to validate existing definitions of biogeochemical provinces in the Atlantic Ocean and draw empirical relationships.

ESTIMATING PARTICLE COMPOSITION FROM THE POLARIZED WATER LEAVING RADIANCE

Tonizzo, Alberto¹; Ibrahim, Amir¹; Chowdhary, Jacek²; Gilerson, Alexander¹; Ahmed, Samir¹

¹ORS Lab CCNY - CUNY 140th St and Convent Ave, New York, NY, 10031, United States; ²Dept of Applied Physics and Applied Mathematics Columbia University, New York, NY, 10031, United States

Polarization characteristics of light from the water body measured below or above the water surface can improve the retrieval of in – water particulate components. In this study we investigate the geometrical and spectral properties of the underwater polarized light field for various water compositions mostly in coastal regions using our newly developed hyperspectral multiangular polarization probe and correlate polarized radiance to the properties of the water components: inherent optical properties (IOPs), concentration, size distribution and refractive index. Experimental results are compared with the results of a coupled atmosphere – ocean polarized radiative transfer model [Chowdhary et al. 2006]. The simulations are based on a four – component water model: water itself, CDOM, phytoplankton – like particles and nonalgal – like particles. In – water IOPs were measured with an AC – s (WETLabs) and concentrations of Chlorophyll a and nonalgal particles were obtained by fitting *in situ* measurements. Particles size distributions were obtained with the LISST 100X particle size analyzer. The bulk particulate refractive index was varied until the modeled DOP matched the measured one. This refractive index was, indeed the only unknown in the radiative transfer model and depended very much on the specific location. Estimated values of the refractive index were compared with results given by the model developed by Twardowski et al. [2001] for which the required *in situ* measurements are the particulate backscattering coefficient, the total particulate scattering coefficient, and the particulate attenuation coefficient. The methodology was applied to data collected in the Atlantic Ocean approximately 20 – 25 miles away from the shore of Norfolk, VA and in the New York Harbor, NY and yielded results that agreed with expectations, i.e., estimated bulk refractive index was 1.04 in Case I waters and 1.13 – 1.17 in turbid Case II waters.

USE OF HYPERSPECTRAL IOP MEASUREMENTS ON A TOWED VEHICLE TO RESOLVE PHYTOPLANKTON AND PARTICLE VARIABILITY IN A TIDALLY DRIVEN ARCHIPELAGO STRAIT

Toro-Farmer, Gerardo¹; Boss, Emmanuel²; Lee, Craig³; Cetinic, Ivona⁴; Jones, Burton⁵

¹University of Southern California 3616 Trousdale Pkway AHF 107, Los Angeles, CA, 90089-0371, United States; ²University of Maine / 5706 Aubert Hall, Orono, ME, 04469-5706, United States; ³University of Washington / 1013 NE 40th St, Seattle, WA, 98105-6698, United States; ⁴University of Maine / 193 Clark's Cove Road, Walpole, ME, 04573-3307, United States; ⁵3616 Trousdale Pkway AHF 107, Los Angeles, CA, 90089-0371, United States

In-situ and satellite retrieved optical spectra depend on the amount and composition of dissolved and suspended materials in the water, as well as on the optical characteristics of the water itself. Natural or anthropogenic processes in coastal areas can drastically change the amount and composition of materials suspended or dissolved in the water column, as well as the inhabiting phytoplankton species, consequently affecting the optical properties measured with optical sensors. To study spatial-temporal variations of the absorption and attenuation spectra in a highly dynamic tidally driven strait of the Philippines archipelago, an underwater hyperspectral spectrophotometer was deployed on an undulating towed vehicle along with other physical and optical sensors. Repeated 3-dimensional surveys of the strait were obtained during an entire diurnal tidal period. The surveys included shallow transects parallel to the coastal line (<=50 m depth), and deeper cross-channel transects (<160m). The sampling strategy facilitated retrieving quasi-synoptic sections of the absorption and attenuation spectra throughout the tidal cycle. We will present comparisons between multispectral subsets of the data and the full hyperspectral dataset, highlighting how additional information can be retrieved when a more extensive wavelength range is covered. Multispectral signatures from satellite images are compared against in-situ hyperspectral and physical data, emphasizing the importance to remote sensing of accurate *in situ* hyperspectral measurements for validation/calibration

efforts. The variation of spectral signatures with respect to other environmental variables can help evaluate the response of phytoplankton functional groups to the physical dynamics, and their effects on local and global biogeochemical processes.

CLUSTER ANALYSIS OF HYPERSPECTRAL OPTICAL DATA FOR DISCRIMINATING PHYTOPLANKTON PIGMENT ASSEMBLAGES IN THE OPEN OCEAN

Torrecilla, Elena¹; Piera, Jaume¹; Stramski, Dariusz²; Reynolds, Rick A.²; Millán-Núñez, Eduardo³

¹Marine Technology Unit, CSIC Passeig Marítim de la Barceloneta, 37-49, Barcelona, 08003, Spain; ²Marine Physical Laboratory, Scripps Institution of Oceanography, University of California San Diego, La Jolla, San Diego, California, 92093-0238, United States; ³CICESE, Ecología Marina, Carretera Ensenada-Tijuana No. 3918 Fraccionamiento Zona Playitas, Ensenada, Baja California, 22860, Mexico

Optical remote sensing provides a potential tool for the identification of dominant phytoplankton groups and monitoring spatial and temporal changes in biodiversity in the upper ocean. We examine an approach in which an unsupervised hierarchical cluster analysis is applied to phytoplankton pigment data and spectra of the absorption coefficient and remote-sensing reflectance with the aim of identifying different phytoplankton assemblages in open ocean environments. We apply this technique to optical and phytoplankton pigment data sets collected at several stations within the eastern Atlantic Ocean, where the surface total chlorophyll-a concentration (TChl-a) ranged from 0.11 to 0.62 mg/m³. We selected stations which show significant differences in the ratios of the two most dominant accessory pigments relative to TChl-a, as derived from the HPLC (High Performance Liquid Chromatography) analysis. The performance of cluster analysis of absorption and remote-sensing spectra is evaluated by comparisons with the cluster partitioning for the corresponding HPLC pigment data. The pigment-based clusters serve as a reference for identifying different phytoplankton assemblages in terms of pigment composition. Two validation indices, cophenetic and Rand, are examined in these comparisons to quantify the degree of similarity between the pigment-based clusters and optical-based clusters. The results indicate that the second derivative calculated from hyperspectral (1 nm resolution) data of phytoplankton absorption coefficient, $a_{ph}(\lambda)$, and remote-sensing reflectance, $R_{rs}(\lambda)$, provide better discrimination of phytoplankton pigment assemblages than traditional multispectral band-ratios or ordinary hyperspectral data of absorption and remote-sensing reflectance. Sensitivity tests were also performed to determine the influence of parameter choice (e.g., spectral range, smoothing filter size, band separation) on the performance of the analysis.

MULTI-CAST MEASUREMENT PROTOCOLS FOR IMPROVING NEAR SURFACE RADIOMETRIC DATA

Trees, Charles¹, McLean, S.D.², Lewis, Marlon³ and Zibordi, Giuseppe⁴

¹NATO Undersea Research Centre (NURC), La Spezia, ITA; ²Ocean Networks Canada Centre for Enterprise and Engagement, University of Victoria, CAN; ³WETSAT Inc, Philomath, OR, USA; ⁴Joint Research Centre, Ispra, ITA

As part of NASA's Spectral Ocean Radiance Transfer Investigation and Experiment (SORTIE) project and NURC's Scientific Program of Work (2008-2010), three ocean color calibration and validation cruises occurred in the Ligurian Sea in which the proposed 'multicast' measurement protocol was tested. During these cruises, which sampled both eutrophic and oligotrophic conditions, anywhere up to three hyperspectral radiometers (HyperPRO II) were deployed simultaneously from the stern of the research vessel. Generally, a deep, single cast (100 m) was performed first and then 5 to 8 shallow casts were collected, sampling from the near surface to 10 meters depth. The time to synchronously collect these 'multicast' profiles varied from 5 to 9 minutes. Near the surface, waves contribute to enhanced localized backscattering due to focusing and defocusing of the waves, thus reducing the accuracy of extrapolating subsurface radiance and irradiance to the surface intercept. These perturbations, collected by profiling radiometers, depend upon the deployment speed and acquisition rate of the instrument. For free-falling profilers like the HyperPRO II, it is important to increase the number of near surface measurements using

the ‘multicast’ approach, thus improving K_{Lu} , K_{Ed} , $Ed(0-)$ and $Lu(0-)$ retrievals. Results will be presented to document measurement uncertainties of ‘multicasts’ (single HyperPRO II), uncertainties between simultaneous ‘multicasts’ (2 to 3 HyperPRO II’s in tandem) and methods to merge the ‘multicast’ near surface values with the single deep profile.

DERIVATIVE SIGNATURES OF PLUMES FROM MERIS AND HICO

Tuffiaro, Nicholas¹; Davis, Curtiss O¹; Jones, Katherine B.²

¹Oregon State University P. O. BOX 1028, CORVALLIS, OR, 97339-1028, United States; ²University of Otago, Dunedin, Otago, 9016, New Zealand

Littoral river plumes are complex optical environments. To resolve this complexity we use derivative analysis to create signatures for sediments and chlorophyll based on high resolution spectral data from HICO --- the Hyperspectral Imager for the Coastal Ocean developed by NRL and currently flying on the International Space Station. HICO has 90 channels between 400-900 nm and a ground sampling distance of 90m. We compare the results of derivative analysis from HICO to standard products from MERIS, as well as in-situ data, at two sites: the Columbia River in the Northwest of the United States, and the Otago Shelf fed by the Clutha River on the South Island of New Zealand, during periods of high sediment flows (winter). We present early results showing how space borne hyperspectral imaging can enhance our view of river plumes along the littoral coast.

INVERTING THE VOLUME SCATTERING FUNCTION TO INFER PARTICLE COMPOSITION AND DYNAMICS AT THE NEAR-SURFACE IN THE SURF ZONE AND OPEN OCEAN

Twardowski, Michael¹; Zhang, Xiaodong²; Freeman, Scott¹; Slivkoff, Matthew¹; Sullivan, James¹; Czerski, Helen³; Vagle, Svein⁴; You, Yu⁵; Kattawar, George⁵

¹WET Labs 70 Dean Knauss Dr, Narragansett, RI, 02882, United States; ²University of North Dakota, Grand Forks, ND, 58202, United States; ³University of Rhode Island, Narragansett, RI, 02882, United States; ⁴Institute of Ocean Sciences, Sidney, BC, V8L 4B2, Canada; ⁵Texas A&M University, College Station, TX, 77843, United States

As part of the ONR RaDyO program, collaborative optical and physical measurements were made in the surf zone off Scripps pier and in the open ocean south of Hawaii to investigate the propagation of light through surface waters and the air-sea interface. For these efforts, the volume scattering function (VSF) was measured at 20 Hz at angles spanning 10 to 170 degrees in 10 degree increments with a prototype MASCOT device, while the near-forward portion of the VSF from 0.1 to 20 degrees in 32 logarithmically spaced intervals was measured at 1 Hz with a LISST device. Together these measurements nominally provide full resolution of the VSF. Data were collected just below the air-sea interface. In the surf zone, unique modification of the phase function was observed in passing suspended sediment plumes, in wave-injected bubble plumes, and combinations of these particle populations relative to the background. Sediment plumes exhibited higher relative backscattering levels than the background, while a clear phase function enhancement in the 60 to 80 degree range was observed in association with bubble plumes. Both features are consistent with theoretical predictions. Off Hawaii, periods of bubble injection from breaking waves provided bubble scattering signatures over a relatively clear background. VSFs from both locations have been inverted to infer particle composition, including bubbles, using a basis vector, least-squares minimization fitting procedure applied to a library of phase functions, each representing a lognormally distributed subpopulation with specific refractive index and coating, where applicable. Phase functions for mineral particle subpopulations were estimated using FDTD computations for randomly oriented, asymmetric polyhedrons. Phase functions for coated bubbles were computed with Mie theory. Inversion results exhibit stable solutions that agree with concurrent acoustical measurements of bubbles, aggregate particle size distribution expectations, and anecdotal evidence from the field. In some cases results show

evidence for bubble populations persisting over periods of minutes, presumably stabilized by surfactant coatings.

ERROR ESTIMATES IN CHL, SPM AND CDOM CONCENTRATION RETRIEVAL IN TURBID COASTAL WATER: PERFORMANCE OF A HYDROLIGHT BASED INVERSION SCHEME.

Van der Woerd, Hendrik Jan¹; Eleveld, Marieke A.¹; Hommersom, Annelies¹; Peters, Steef W.M.¹

¹Vrije Universiteit De Boelelaan 1087, Amsterdam, NL-1181 HV, Netherlands

After the conception of the HYDROPT (*) inversion scheme by Reinold Pasterkamp in 2004, this algorithm has been tested extensively in many applications, ranging from inland lakes to intertidal areas and oceanic waters. The strength of the algorithm is the instant retrieval of three basic constituents, CHL-a, SPM and CDOM. The HYDROPT algorithm is based on the exact solutions of the HYDROLIGHT numerical radiation transfer model and can deal with varying Solar Zenith Angle, Viewing geometry and even cloud fraction. Despite the complexity, the model is fast and is used at IVM for operational near-real time processing of large sets of satellite imagery. The real innovation, however, has been the production of three formal standard errors in the fitted concentrations, based on the Goodness-of-Fit between measured and modeled spectra and the Jacobian matrix in the solution space near the best-fit solution. Also, the flexible adaptation to inherent absorbance and scattering of CHL, SPM and CDOM proves to be very useful for a rapid assessment of the changes in concentrations and errors, in case the waters have a different biochemical environment. This turns out to be essential in coastal areas with rapid mixing of multiple water masses. The performance of the algorithm is explained in detail. Next to the concentration retrieval, the presentation will demonstrate the essential use of the estimated error in the following cases: Validation of CHL and SPM in the Dutch Coastal zone, combining SPM modeling observations, SPM, CHL and CDOM retrieval in estuaries and intertidal areas.

(*) Van der Woerd, H.J., Pasterkamp, R., 2008. HYDROPT: A fast and flexible method to retrieve chlorophyll-a from multispectral satellite observations of optically complex coastal waters. *Remote Sensing of Environment* 112, 1795–1807.

SPECIFIC ABSORPTION SIGNATURES OF TAXONOMIC SUBPOPULATIONS IN PHYTOPLANKTON COMMUNITIES

van Dijk, Mark Albert¹; Hoogveld, Hans L¹; Simis, Stefan G. H. ²; Kromkamp, Jacco C.³; Gons, Herman J¹

¹NIOO-KNAW Rijksstraatweg 6, Nieuwersluis, 3631 AC, Netherlands; ²Finnish Environment Institute SYKE, Helsinki, -, FI-00251, Finland; ³NIOO-KNAW Centre for Marine Ecology, Yerseke, Zeeland, 4401 NT, Netherlands

Remote sensing of plankton biomass and carbon fixation in oceanic and inland waters requires accurate knowledge of biomass-specific absorption. This Chl_a-specific absorption coefficient is highly variable in nature and depends on the organisms' size, shape and physiological status. Up to date, this variability has not been directly assessed for eutrophic inland and coastal waters. At the red Chl_a absorption peak (675 nm) which is used for remote sensing in these waters, this coefficient ($a_{chl_a}(675\text{ nm})$) can vary by a factor of 4, mainly by pigment packaging.

We aim to assess the impact of this biological variability on satellite mapping of algal and cyanobacterial biomass and productivity in eutrophic inland and coastal waters and try to reduce it by resolving part of variability that is caused by the taxonomic composition of the phytoplankton community. For this purpose we have developed a method that enables us to determine the absorption coefficients of selected subpopulations from natural waters by means of flow cytometric sorting. Selected clusters can be sorted at high purity and then be analyzed by spectrophotometry and HPLC without affecting their optical properties.

In an additional case study, we sampled a large eutrophic lake compare the accuracy of using a chlorophyll specific absorption coefficient that has been reconstructed from spectra of sorted subpopulations and flow cytometric counts of cluster abundance with that of using a constant, mean value of this coefficient. The combination of taxonomically resolved specific absorption coefficients and autonomous *in situ* flow cytometry is expected to allow improvement of remote sensing of biomass and productivity.

INSTRUMENTATION, CALIBRATION AND VALIDATION OF A HIGH-DYNAMIC-RANGE RADIANCE CAMERA

Van Dommelen, Ronnie¹; Lewis, Marlon¹; Wei, Jianwei²

¹Satlantic Inc. 3481 North Marginal Road, Halifax, NS, B3K 5X8, Canada; ²Dalhousie University, Halifax, Nova Scotia, B3J 4J1, Canada

Measurement of radiance in ocean water is fundamental in that all other radiometric quantities can be derived from it. However, until recently it has been extremely difficult to measure it with the required high-dynamic range and high spatial/temporal resolution. We recently developed a new high-dynamic range radiance camera (RadCam) for the Office of Naval Research's Radiance in a Dynamic Ocean (RaDyO) program. Each camera has a hemispheric field-of-view with a spatial resolution of half a degree, and a scene-dynamic range of nearly one million. This allows the camera to image and measure the solar radiance. A sky camera measures the downwelling radiance distribution at the ocean surface and a profiling system simultaneously measures downwelling and upwelling radiance distributions in the water. In this presentation, we focus on three aspects of the radiance camera system. We introduce the instrumentation of the camera system and its capability to measure the sky and in-water radiance distributions. The calibration methods are explained and camera characterization results are presented. Finally we validate the camera using field measurements and comparisons to standard radiance and irradiance sensors.

GLOBAL PARTICULATE MATTER POOL TEMPORAL VARIABILITY OVER THE SEAWIFS PERIOD (1997-2007)

Vantrepotte, Vincent¹; Loisel, Hubert¹; Dessailly, David¹; Duforêt-Gaurier, Lucille¹; Mélin, Frédéric²

¹CNRS LOG UMR8187 32, avenue Foch, Wimereux, 62930, France; ²European Commission - Joint Research Centre, Institute for Environment and Sustainability, Ispra, VA, 21027, Italy

The suspended particulate matter pool in the open ocean is diversely composed of phytoplankton, heterotrophic organisms, viruses and organic detritus which relative proportion and size distribution are susceptible to vary widely in space and time according to biogeochemical conditions and physical forcing. This work illustrates the major patterns of temporal variability detected from 10-year SeaWiFS time series of marine particles backscattering coefficient at 490 nm (bbp(490)), an indicator of the particulate organic carbon concentration and particles backscattering spectral dependency (γ), a proxy for the relative proportion between smaller-sized and larger particles. Specifically, the relative importance of seasonality in the bbp(490) and γ signals has been assessed using the outputs of the Census X-11 time series decomposition method. In addition, the presence of significant monotonic changes in the data has been estimated using non-parametric Kendall statistics. Observed temporal patterns in bbp(490) and γ in terms seasonality and long term changes are compared and related to those reported for the phytoplankton chlorophyll (Chl) over the same time period in order to discuss on the spatial heterogeneity of particulate matter pool origin and controlling factors. Strong discrepancies are found between bbp(490) and Chl seasonal and year-to-year variations while γ temporal dynamics is more likely associated with the phytoplankton biomass growth cycle and long term evolution. In specific areas such as the tropical Pacific Ocean, the parallel changes in the particulate matter size structure and phytoplankton biomass trends in Chl and γ might reflect the influence of climate forcing (i.e. ENSO events) on marine ecosystem structure and functioning.

EVALUATION OF HYPERSPECTRAL RADIOMETRY FROM THE BOUSSOLE BUOY

Vellucci, Vincenzo¹; Gentili, Bernard¹; Diamond, Emilie¹; Adams, Darrell²; Dempsey, Cyril²; Antoine,

David¹

¹LOV-CNRS Laboratoire d'Océanographie de Villefranche Quai de la Darse BP 8, Villefranche sur mer, 06238, France; ²Satlantic Inc. Richmond Terminal, Pier 9, 3481 North Marginal Road, Halifax, Nova Scotia, B3K 5X8, Canada

The BOUSSOLE mooring has been quasi-continuously deployed in the deep and clear northwestern Mediterranean Sea since September 2003. One major goal of the project is to establish a long-term bio-optical time series in support to calibration of top-of-atmosphere observations by ocean colour remote sensing satellites and validation of the geophysical products derived from these observations (so-called “cal/val” activities). Conceived in the “multispectral era”, the mooring was equipped with Satlantic OCI-200 and OCR-200 series radiometers for deriving radiometric quantities at 7 visible wavelengths, from 412 to 680 nm. These radiometers are out of production and recovering hardware for their maintenance is more and more difficult. Moreover, they undercover the cal/val demands of the new and next generation satellite sensors, whose bandsets have an increasing number of bands. A radiometer change-over of the BOUSSOLE mooring was necessary to ensure continuity and evolution of the radiometry time series.

As a first step, starting from September 2007, the mooring has been equipped with additional Satlantic HyperOCI and HyperOCR series for measurement of above-surface downward irradiance and upwelling nadir radiance at 137 wavelengths in the near ultraviolet to near infrared domains (350-800 nm every 3.3 nm).

Here we show an analysis of the data collected with the two radiometer families during the 7th BOUSSOLE deployment, which took place from June 2008 to April 2009. Basic radiometric quantities and their derived products are compared in order to investigate the consistency of the measurements and quantifying the relative accuracy of the instruments.

PHOTOACCLIMATION AND THE CHL:C RATIO IN A GLOBAL MODEL OF MARINE PHYTOPLANKTON

Voelker, Christoph David¹; Losch, Martin ¹; Losa, Svetlana ¹; Hohn, Soenke¹; Wolf-Gladrow, Dieter¹

¹Alfred Wegener Institute for Polar and Marine Research Am Handelshafen 12, Bremerhaven, 27515, Germany

Satellite-estimated chlorophyll concentrations are the largest available data set for validation of global marine ecosystem models. In doing so, a conversion from concentrations of chlorophyll to particulate organic carbon, nitrogen or phosphorus is needed. However, marine phytoplankton species have a strong ability to acclimate their photosynthetic apparatus to light and nutrient conditions, leading to variations in the Chl:C ratio by an order of magnitude. There are now several models of algal physiology that describe photoacclimation and its dependence on irradiance and nutrients. Here we present a comparison of observed versus modeled Chl:C ratios from an implementation of the model by (Geider, R.J. and MacIntyre, H.L. and Kana, T.M., A dynamic regulatory model of phytoplankton acclimation to light, nutrients and temperature, *Limnology & Oceanography* 43, 1998, 679-694) into a global ecosystem model. We show that the resulting distribution of the C:Chl ratio reflects the observed large-scale patterns. The Geider model has been criticised of failing to reproduce observed variation of Chl:C under conditions of nutrient/light-colimitation (Armstrong, R.A., *Optimality-based modeling of nitrogen allocation and photoacclimation in photosynthesis*, *Deep-Sea Research Part II* 53, 2006, 513-531). We have not found any indication from our global model that this leads to a bias. Our implementation of the Geider model takes into account limitations by other nutrients such as iron and silicon. We discuss the implications these imitations have on the Chl:C ratio in high-nutrient-low-chlorophyll regions, such as the Southern Ocean. Finally, we discuss the impact of the variability of the Chl:C ratio on modeled vertical carbon fluxes.

DISCOVERY OF NON-PRINCIPAL-PLANE NEUTRAL POINTS IN THE IN-WATER UPWELLING POLARIZED LIGHT FIELD

Voss, Kenneth¹; Kattawar, George²; You, Yu²; Gordon, Howard²; Gleason, Arthur³

¹Univ of Miami 1320 Campo Sano Dr., Coral Gables, FL, 33143, United States; ²Texas A&M University, College Station, TX, TX, 77843-4242, United States; ³1320 Campo Sano Dr., Coral Gables, FL, 33143, United States

Neutral points are specific directions in the light field where the three Stokes parameters Q, U, V, and thus the degree of polarization simultaneously go to zero. With single scattering in a Rayleigh atmosphere, the only neutral points in the sky are in the solar direction and the anti-solar direction, opposite the sun. Early measurements of the polarization in transmitted skylight found neutral points in other locations, named the Brewster, Babinet, and Arago points. The positions of these neutral points were explained by Chandrasekhar by including the effects of multiple scattering in the light field. Neutral points in and slightly out of the principal plane (the plane containing the direction of the solar beam and the zenith) have been measured in the atmosphere; however, to our knowledge, they have not been measured off of the principal plane in the ocean. We have made the first measurement of non-principal-plane neutral points in the upwelling light field in the water. These neutral points are located at approximately 50⁰-60⁰ nadir angle and at approximately 135⁰ azimuth to the sun which is well off of the principal plane. They are very sensitive to the balance between the upwelling radiance from polarized skylight and the upwelling radiance due to the direct solar beam. Normal 0 false false false MicrosoftInternetExplorer4

MULTI-PATH EFFECTS ON OPTICAL COMMUNICATION LINKS

Vuorenkoski, Anni¹; Dagleish, Fraser¹; Shirron, Joseph²; Giddings, Thomas²

¹Harbor Branch Oceanographic at Florida Atlantic University 5600 N US 1, Fort Pierce, FL, 34946, United States; ²Metron, Inc, 1818 Library Street, Suite 600, Reston, VA, 20190, United States

The bandwidth of optical free-space underwater communication channels is typically reduced in turbid environments by temporal and spatial dispersion of modulated signal. This work involves studying the effect of higher order scattering on the channel characteristics. A Monte-Carlo solution to the time dependant radiative transfer equation is employed to simulate an underwater optical channel impulse response with varying Inherent Optical Properties (IOPs), path lengths, and location of multiple optical receivers. Additional diagnostics were added to the code to generate time resolved sub-pulses reaching the receiver, aggregated according to the number of scatter events experienced during the path length. The model predicts that the short input pulse experiences significant temporal and spatial dispersion during propagation, and it is also evident that as the scattering coefficient increases, higher order scattering starts to dominate with highest order scattering components primarily determining the overall magnitude of pulse dispersion.

Of particular interest to this research is the effect of multiple scattering on the ellipticity and orientation of the field components of the received signal. To better understand this phenomenon the full 16 element Mueller Matrix impulse response of the propagation medium is measured using several different scattering agents and turbidities. The types of scattering particles differ in their size distribution, real part of the refractive index and include both spherical and non-spherical particles. By studying the temporal, as well as spatial structure of the depolarization of short pulses, the feasibility of more advanced polarization discrimination or diversity schemes is being examined. The longer term objectives of this work are in developing a Mueller Matrix measurement test-bed for evaluating validity of vector radiative transfer models as well as development of scattering meters to measure such phenomenon in natural waters.

BIO-OPTICAL PROPERTIES OF SEAWATER IN THE NORTHERN SOUTH CHINA SEA

Wang, Guifen¹; Cao, Wenxi¹; Zhou, Wen¹; Yang, Yuezhong¹

¹South China Sea Institute of Oceanology, Chinese Academy of Sciences No 164 West Xingang Road, Guangzhou, 510301, China

Bio-optical properties were examined in the Northern South China Sea based on the in-situ data collected during cruises in autumn from 2004 to 2009. Optical and biogeochemical properties of suspended particles were investigated. Particulate absorption coefficients were found to vary nonlinearly with *Chl*, with the relative contribution of phytoplankton being averaged about 70%. Variations in the chlorophyll a-specific absorption of phytoplankton were discussed by considering the variability of phytoplankton community structure, which implied the effect of size structure and pigment composition. The size parameter was derived from the normalized phytoplankton spectra which showed consistent variability with the algal size structure. Relationships between surface particulate organic carbon and the chlorophyll a concentration were observed, the POC:Chl ratio tended to be higher for open ocean waters than that of coastal waters which was likely due to the different particle structures and phytoplankton community structures. Empirical algorithms for retrieving the particulate organic carbon and chlorophyll a concentration from ocean color were developed and compared with these existing algorithms.

THE SWIR-BASED ON-ORBIT VICARIOUS CALIBRATION APPROACH FOR MODIS OCEAN COLOR DATA PROCESSING

Wang, Menghua¹; Shi, Wei¹

¹NOAA/NESDIS E/RA3, RM102, 5200 Auth Road, Camp Springs, MD, 20746, United States

Satellite ocean color remote sensing places very stringent requirements on the sensor's radiometric calibration. This is simply due to the fact that the desired ocean signals (i.e., water-leaving radiance) comprise such a small part of the total radiance measured by the satellite instrument. For example, in the blue, the water-leaving radiance usually <10% of the sensor-measured radiance, and scattering from the atmosphere and the sea surface comprises the rest. Even if the effects of the atmosphere and the sea surface are perfectly removed, the relative error in the water-leaving radiance will be at least 10 times the relative error in the sensor calibration. Therefore, the key to a successful ocean color mission is sensor on-orbit vicarious calibration, which has been used for both SeaWiFS and MODIS for producing high quality ocean color products in the open ocean.

Recently, an atmospheric correction algorithm using the shortwave infrared (SWIR) bands has been developed and shown for producing significantly improved water optical and biological properties over turbid waters. To produce accurate water-leaving radiance spectra data using the SWIR algorithm, a vicarious calibration procedure for deriving sensor spectral gains with the SWIR algorithm is necessary. In this presentation, we describe an approach in deriving vicarious gains from blue to near-infrared (NIR) (i.e., 412-869 nm) for the SWIR atmospheric correction algorithm for MODIS-Aqua ocean color products. In particular, with the SWIR approach the spectral gains for the MODIS NIR bands can now be derived. Both MODIS-Aqua data and *in situ* MOBY measurements have been used independently for the vicarious calibrations. The SWIR-derived spectral gains and the NIR-derived gains (two independent approaches) are compared and shown to be consistent, i.e., both the NIR and SWIR-based atmospheric correction algorithms can be used for producing consistent ocean color products in the open ocean and coastal turbid waters.

RADIANCE DISTRIBUTION AS A FUNCTION OF DEPTH IN TYPICAL SEA WATERS

Wei, Jianwei¹; Lewis, Marlon¹; Van Dommelen, Ronnie²

¹Dalhousie University 1355 Oxford Street, Halifax, NS, B3H 4J1, Canada; ²Satlantic Inc, 3481 North Marginal Road, Halifax, NS, B3K 5X8, Canada

The underwater radiance angular distribution (RAD) is of great value in radiative transfer calculations, biological physiology and ecology, underwater image engineering and many other applications. A full understanding of the RAD requires knowledge of the boundary conditions and the optical properties of the participating media. Simulating the RAD is subject to uncertainties associated with assumptions and simplifications of the underlying physical processes. Measuring the RAD *in situ* provides a direct means to

validate such models. Attempts of this kind are surprisingly scarce and hence our knowledge of the RAD underwater is tenuous.

A unique sampling strategy for the RAD has been successfully developed and tested (see abstract by Van Dommellen, Lewis and Wei, et al., 2010, Ocean Optics XX). A large number of data sets have been collected using a new generation of high dynamic range radiance camera. In this talk, we present the findings about the RAD from three typical sea waters: 1) the oceanic clear waters in North Pacific gyre off Hawaii which is oligotrophic, 2) the coastal moderate waters in the Santa Barbara Channel which is mesotrophic, and 3) the turbid waters in Bedford Basin, Nova Scotia which is eutrophic. The structure of the RAD is examined as a function of water depth. The downwelling average cosine is also derived for each case. Fluctuating patterns in the radiance field associated with the ruffled sea surface are also evaluated.

OCEAN COLOR CHANGES IN THE NORTH PACIFIC SINCE 1930

Wernand, Marcel Robert¹; Van der Woerd, Hendrik J.¹

¹Royal Netherlands Institute for Sea Research Landsdiep 4, Den Hoorn, Texel, 1797 SZ, Netherlands

An analysis of historical ocean color data from the North Pacific Ocean is presented. Ocean color has been measured by the Forel-Ule color index; a sea color comparator scale composed of 21 tube colors. The main objective of this research is to characterize color changes of the North Pacific Ocean at a timescale of lustrums. Next to the seasonal color changes, due to the yearly cycle of biological activity, this North Pacific time series collected between 1930 and 1999 might contain information on global changes in climate conditions. From seasonal independent analyses of the long-term variations it was found that the greenest values, with mean Forel-Ule scale, FU, of 4.1 were reached during the period of 1950–1954, with a second high (FU = 3) in the period 1980–1984. The bluest ocean was encountered during the years 1990–1994. The data indicate that after 1955 a remarkable long bluing took place till 1980.

CHLOROPHYLL-SPECIFIC ABSORPTION AND SCATTERING COEFFICIENTS OF SELECTED CYANOBACTERIA

Wojtasiewicz, Bozena¹; Stramski, Dariusz²

¹Institute of Oceanography, University of Gdansk, Marszalka Pilsudskiego 46, Gdynia, 81-378, Poland;

²Marine Physical Laboratory, Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California, 92093-0238, United States

Blooms caused by the mass occurrence of cyanobacteria are a common phenomenon in the Baltic Sea and Polish lakes. Potential toxicity of cyanobacteria together with the frequency and extent of cyanobacterial blooms cause a major concern because of their influence on water quality, water purification treatment, and hazards to humans and other organisms. The optical properties (the spectral absorption and beam attenuation coefficients) of four different genera of cyanobacteria isolated from natural waters, *Synechocystis* sp., *Nodularia spumigena*, *Anabaena* sp. and *Microcystis* sp., were measured in the laboratory using a Perkin Elmer Lambda 18 spectrophotometer equipped with an integrating sphere and special geometry for measuring absorption and attenuation coefficients. The measurements were taken in the spectral region from 290 nm to 860 nm with a step of 1 nm. The chlorophyll-a concentration of cultures was determined spectrophotometrically on methanol extracts. The genera were chosen to match the dominating cyanobacteria groups of Polish lakes and the Baltic Sea. The spectra of chlorophyll-a specific absorption and scattering coefficients differ in terms of both the magnitude and spectral shape among the selected cultures. The culture of *Synechocystis* sp. showed the largest magnitude of chlorophyll-specific absorption whereas in the case of *Nodularia spumigena* the magnitude was almost twice lower. The absorption spectrum of the *Nodularia spumigena* species revealed a peak in the UV region, which suggests the presence of MAAs. The magnitude of the absorption peak of phycocyanin was higher than the chlorophyll red-peak absorption maximum in the case of *Synechocystis* sp. and *Anabaena* sp. The spectral

shapes of scattering had the steepest slope with scattering increasing toward the blue wavelengths for *Microcystis* sp., whereas the spectral scattering of the *Nodularia spumigena* species was relatively flat.

LIGHT BEAM DEPOLARIZATION ON TURBULENT CONVECTIVE FLOW: LABORATORY MEASUREMENTS

Woods, Sarah¹; Piskozub, Jacek²; Włodzimierz, Freda³; Jonasz, Mirosław⁴; Bogucki, Darek⁵

¹Naval Research Laboratory 1009 Balch Blvd, Stennis Space Center, MS, 39529, United States; ²Institute of Oceanology PAS, ul. Powstancow Warszawy 55, Sopot, 81-712, Poland; ³Gdynia Maritime University, Morska 81-87, Gdynia, 81-225, Poland; ⁴MJC Optical Technology, Beaconsfield, QC, H9W 2W7, Canada; ⁵Texas A&M University - Corpus Christi, Corpus Christi, TX, 78412, United States

In an effort to investigate the role of turbulence in near-forward scattering, laboratory measurements of scattering on turbulent flow were carried out in a Rayleigh-Bénard convective tank. Particle Image Velocimetry and profiling thermistor temperature measurements are used to characterize the turbulent flow through determination of the large scale flow features, turbulent kinetic energy dissipation rates, and thermal dissipation rates. Polarized diffractometer measurements allow for determination of the turbulence-induced depolarization rate, which is comparable to that observed with polarimetric lidar. Measurements were made over a range of turbulent strengths, with Rayleigh number between 10^8 and $3 \cdot 10^9$, and with turbulent parameters corresponding to those characteristic of the oceanic mixed layer. Results show that the turbulence-induced depolarization rate is indirectly proportional to the strength of the turbulent flow, suggesting that light beam depolarization from turbulent flow may contain useful information regarding the smallest length scales of turbulent flow.

OPTICAL PROPERTIES OF BALTIC SEA PHYTOPLANKTON

Wozniak, Monika¹; Krezel, Adam¹; Darecki, Mirosław²; Wojtasiewicz, Bożena¹

¹University of Gdansk Al Marszałka Piłsudskiego 46, Gdynia, 81 - 378 , Poland; ²Institute of Oceanology of Polish Academy of Sciences, Powstancow Warszawy 55, Sopot, Pomerania, 81-712, Poland

Optical properties of chosen groups of phytoplankton were investigated under laboratory conditions. An experiment has been carried out in a black circular tank (1.2 m in diameter, 1.4 m height). The tank was filled with water with salinity of 7 PSU (equal to salinity of the Baltic Sea surface waters). Remote sensing measurements were carried out for different concentrations of chlorophyll in the water (from 4 up to 115 $\mu\text{g/l}$). Upwelling and downwelling radiances at the surface and downwelling irradiance at different water depths were measured within the wavelength range from 320 to 950 nm at 3.3 nm intervals by means of TriOS Ramses hyperspectral radiance sensors. All measurements were performed indoors under light conditions similar to natural. Phytoplankton cultures were taken from Culture Collection of Baltic Algae. Phytoplankton species such as *Synechocistic sp Nodularia spumigena*, *Anabaena sp*, *Synechococcus sp*, *Skeletonema costatum*, *Cyclotella meneghiniana*, which can cause algal blooms in the Baltic Sea, were investigated. The cultures were bred under special conditions of temperature of 18°C and 16/8 H light/dark cycle. The goal of the experiment is to find some particular optical properties of the cultures. The changes in the spectrum of the reflectance R_{rs} depends on the species and chlorophyll concentration. The experiment will enhance identification of the species causing algal blooms from the satellite level. It is crucial because some algal blooms which occur in the Baltic Sea are potentially toxic, which causes economical, sociological, sanitary and touristic problems.

OPTICAL AND BIOGEOCHEMICAL PROPERTIES OF SUSPENDED PARTICULATE MATTER IN THE SOUTHERN BALTIC SEA

Woźniak, Sławomir B.¹; Meler, Justyna¹; Lednicka, Barbara¹; Zdun, Agnieszka¹; Stoń-Egiert, Joanna¹

¹Institute of Oceanology, Polish Academy of Sciences Powstańców Warszawy 55, Sopot, 81-712, Poland

Optical and biogeochemical properties of particulate matter suspended in surface waters of the southern Baltic Sea have been examined. The empirical data were gathered at over 350 stations during 15 short cruises on board r/v Oceania conducted between August 2006 and September 2009. The studied area included open waters of southern Baltic Sea as well as coastal regions of Gdańsk Bay. Among various optical quantities determined, the spectral values of light absorption coefficient of all particles, absorption coefficient of phytoplankton, and scattering and backscattering coefficients of particles were included. Biogeochemical properties of particles were characterized in terms of concentrations of suspended particulate matter (SPM), particulate organic matter (POM), particulate organic carbon (POC), chlorophyll a (Chl a) and other phytoplankton pigments. Our data show large variability in the studied area of both metrics of particle concentration (e.g. 30-fold to 50-fold ranges in SPM, POM, and POC, and 190-fold range in Chl a) and inherent optical properties (IOPs) (e.g. 45-fold range in the absorption coefficient of particles at 440nm, 55-fold range in the scattering coefficient at 555nm, and 70-fold range in the backscattering coefficient at 420nm). Although generally most of the encountered particle populations were primarily composed of organic matter, however different analyzed particle concentration ratios suggest that particle composition varied to a certain degree. For example the average value of POM/SPM ratio was 0.8 but the corresponding coefficient of variation (CV), calculated as a ratio of the standard deviation to the mean value and expressed in percent, was 22%. In case of two other exemplary composition ratios, POC/SPM (with average value of 0.25) and Chl a/SPM (with average value of $3.4 \cdot 10^{-3}$), corresponding CV values were even greater, being of 42% and 73%, respectively. The relationships between IOPs and different metrics of suspended particle concentration were preliminary examined using our data and it was found the IOPs cannot easily be quantified in terms of concentration of only one of the following: SPM, POM, POC or Chl a. Even if we consider the optical coefficients which show the highest possible correlation with concentration of a certain constituent, we still find a large variability in such empirically established relationships. For example, the mass-specific (SPM-specific) absorption coefficient at 440nm varies significantly - the corresponding CV value is 73%. In case of chlorophyll-specific absorption coefficient of phytoplankton at 440 nm the CV value is 60%. In another example, the mass-specific scattering coefficient at 555 nm and mass-specific backscattering coefficient at 420 nm show corresponding values of CV of 44% and 63%, respectively.

A COMBINED DATA TREATMENT TO IMPROVE THE RETRIEVAL OF CHLA CONCENTRATION AND NOISE-FREE RADIOMETRIC PROFILE IN OCEANIC WATERS: APPLICATION TO PROFILING FLOATS MEASUREMENTS

Xing, Xiaogang¹; Claustre, Hervé²; Morel, André²; Gentili, Bernard²; Poteau, Antoine²; d'Ortenzio, Fabrizio²

¹LOV-CNRS Laboratoire d'oceanographie, quartier la darse, Villefranche sur Mer, 06230, France;

²Laboratoire d'oceanographie, quartier la darse, Villefranche sur Mer, 06230, France

Eight profiling floats (PROVBIO) have been equipped with a suite of optical sensors [Chla fluorescence, CDOM fluorescence, $b_b(555)$, $c(660)$, $E_d(412)$, $E_d(490)$, $E_d(555)$]. They were deployed in 2008 in various open-ocean areas, and have collected bio-optical data over time periods extending up to two years. The specificities of such measurements (e.g. floats are not recovered preventing post-calibration of sensors, radiometric measurements are not accompanied with simultaneous above-surface reference measurements) require specific data treatment to be developed.

Here we propose a combined data treatment involving both the Chla fluorescence and the radiometric profile as provided by the floats (1) to refine the calibration of the fluorescence into Chla concentration (which includes the re-calibration of fluorometer and correction of fluorescence quenching) and (2) to retrieve a noise-free (in particular with respect to clouds) radiometric profile. The connection between both datasets lies in the relationship that links K_{bio} , the partial attenuation coefficient relevant to biogenic material, as derived from the radiometric profile, to the Chla concentration as derived from the fluorescence profile.

The method progressively integrates the fluorescence profile with respect to increasing depth and compares it with the calculated K_{bio} in the same layer. The convergence of both calculations allows, in particular, the slope of the linear regression relating Chla and fluorescence to be retrieved. The present method is tested

for contrasted situations like those in CDOM-poor (South Pacific Gyre) or CDOM-rich (Mediterranean Sea) oligotrophic waters, as well as the North Atlantic waters with high biomass.

OIL SPECTRAL CHARACTERISTICS WITH HIGH RESOLUTION IMAGING SPECTROMETER - A CASE STUDY OF OIL FROM DEEP WATER HORIZON

Yao, Haibo¹

¹Mississippi State University Building 1103, Suite 118, Stennis Space Center, MS, 39529, United States

Crude oil spill in coastal waters is a severe threat to the environment and can cause catastrophic consequence to the coastal ecological systems. Such oil spill could be caused by accidents happened to oil tankers or oil drilling platforms, such as the recent explosion of Deep Water Horizon (DWH) off the coast of Louisiana in the Gulf of Mexico. In the event of such an accident, remote sensing imagery from both airborne and space-borne platforms are normally used to track and mapping the spread of oil slick. The oil spectral reflectance features could be an important source for oil spill detection and mapping. Since hyperspectral imagery can provide detailed spectral information for the above purposes, hyperspectral remote sensing data have been collected since the DWH accident. Examples of the hyperspectral data include AVIRIS (airborne) and Hyperion (space-borne). The spectral resolution for AVIRIS and Hyperion is 10 nm. Designed for more general purposes, such spectral resolution might not be optimal for oil detection in coastal waters in the current crisis. This paper will use a portable pushbroom prism-grating-prism imaging spectrometer to measure oil and coastal water samples obtained from the DWH accident. The array size of the imaging spectrometer's detector is 1600 x 1200. If a vertical binning of 1 is used in data acquisition, it can provide a spectral resolution of 0.7 nm. The high spectral resolution data can also be re-sampled to 10 nm for a comparison study with AVIRIS or Hyperion data. It is expected this study will provide detailed information to describe spectral characteristics of oil in coastal water and might lead to new sensor design for oil leaking detection and mapping in coastal waters.

MODELING DYNAMIC UNDERWATER POLARIZED RADIANCE FIELDS USING WAVE SLOPES AND IOPS FROM RADYO FIELD EXPERIMENTS

You, Yu¹; Kattawar, George W.¹

¹Texas A&M University 4242 TAMU, College Station, TX, 77840, United States

As part of the RaDyO program, we have developed a hybrid vector radiative transfer model which we have applied to simulations of highly dynamic underwater polarized radiance fields using water optical properties and ocean surface wave slopes obtained from field measurements. Using a combination of a three-dimensional Monte-Carlo method and the matrix operator method, this hybrid model has been proven computationally effective for simulations involving a dynamic air-sea interface. Given field measurements as inputs, model-simulated radiance and polarization fields under a dynamic surface can be compared to their counterparts from field measurements with appropriate collocation and synchronization. This hybrid model serves as a bridge to connect field measurements of water optical properties, wave slopes and polarized light fields. It can also be used as a powerful yet convenient tool to predict the temporal underwater polarized radiance in a real-world situation.

THE INFLUENCE OF OCEAN SURFACE ROUGHNESS AND BREAKING WAVES ON SUBSURFACE RADIANCE

Zappa, Christopher¹; Banner, Michael²; Gemmrich, Johannes³; Schultz, Howard⁴; Morison, Russel²; Wei, Jianwei⁵; Lewis, Marlon⁵

¹Lamont-Doherty Earth Observatory, Columbia University 61 Route 9W, Palisades, NY, 10964, United States; ²School of Mathematics, University of New South Wales, Sydney, NSW, 2052, Australia; ³Physics and Astronomy Dept, University of Victoria, Victoria, BC, V8W 3P6, Canada; ⁴Department of Computer Science, University of Massachusetts, Amherst, MA, 01003, United States; ⁵Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1, Canada

Recent experiments were conducted in Santa Barbara Channel in September of 2008 and in the open ocean off Hawaii in September of 2009 as part of the Office of Naval Research Departmental Research Initiative titled Radiance in a Dynamic Ocean (RaDyO). RaDyO aims to refine present understanding of light propagation and imaging across the air-sea interface and within the ocean surface boundary layer.

Breaking waves are a conspicuous transient feature of the wind driven sea surface manifested most clearly by whitecapping or the entrainment of air. Breaking also includes microbreaking, or waves that break without air entrainment, and are therefore less visible. The passage of open ocean whitecaps at different scales shades the subsurface light field transiently. Microbreaking and small-scale surface roughness including capillary waves will modulate the refraction of light at the air-sea interface and will contribute minimally to the shading. In this study we examine the relevant time-dependent geometrical properties of the breaking wave front and trailing foam patches including their spatial and temporal scales. We investigate the effect of these wave breaking events as well as the modulated ocean surface roughness and microbreaking on the radiation distribution detected by a subsurface camera (RadCam) at varying depths directly beneath the surface imagery.

IMPACT OF AIR MASS ON AEROSOL OPTICAL PROPERTIES OVER THE BALTIC SEA

Zdun, Agnieszka¹; Rozwadowska, Anna¹

¹Institute of Oceanology Polish Academy of Sciences ul Powstancow Warszawy 55, Sopot, 81-712, Poland

The atmospheric aerosols are an important component of the atmosphere. Through their direct (extinction) and indirect (the modification of clouds microstructure) interaction with solar radiation and the Earth's thermal radiation they affect radiative balance of the atmosphere and stimulate the climate variability. The aerosols are also the crucial problem in atmospheric correction of remote sensing measurements.

The local meteorological situation in Baltic Sea region and advection of air masses different origin influence the spectrum of the aerosol optical thickness (aerosol optical thickness for $\lambda=500$ nm and Angström exponent). Therefore, the aim of this paper is to relate history of air masses advected above Gotland Island to changes of the aerosol optical properties.

The database of aerosol optical properties for Gotland station (57°55'N, 18°57'E) is treated as a representative for the Baltic Sea conditions. The Gotland station is a part of the global ground-based radiometric network AERONET (<http://aeronet.gsfc.nasa.gov>). The measurements cover the time period 1999-2003. Six-day backward trajectories of air advected to the Gotland station at the heights $h=300$ m, $h=500$ m and $h=3000$ m above the sea level were used to trace air mass history. They were calculated by HYSPLIT model (version 4, (<http://www.arl.noaa.gov/ready.html>)).

MODULATING RETRO-REFLECTOR LINKS IN SEAWATERS

Zege, Eleonora¹; Katsev, Iosif¹; Prikhach, Alexander¹; Mullen, Linda²; Cochenour, Brandon²

¹B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Pr. Nezavisimosti 68, Minsk, 220072, Belarus; ²Naval Air Systems Command, NAVAIR, Electro-Optics and Special Mission Sensors Division, 22347 Cedar Point Road,, Patuxent River, MD, 20670, United States

A special type of optical communication system uses a Modulating Retro-Reflector (MRR). Modulating retro-reflectors, in which the reflectance is changed as a function on time, are now the subject of extensive research and development for underwater and above water optical communication networks. The basic concept of such systems is that a low-power remote system can receive an optical signal from a base station and reflect the modulated signal (information-bearing signal) back to the base station. Since the base station supplies the optical power, this allows the remote system to communicate without excessive power consumption. Recently a new modification of such a system using polarization to improve performance was suggested, but the theory did not exist to evaluate the effectiveness of this approach. Nevertheless the first experiments showed the potential of this polarization approach to extend the range of a MRR link in

turbid water. The difficulties in the developing the theory describing the MRR link even without this feature are well-known.

In this paper we present:

1. Analytical theory of the MRR link that provides all system parameters needed for the link characterization (the maximal and minimal power of the signal registered by the receiver while the retro reflector is on or off respectively, signal-to-noise ratio, etc).
2. Generalization of this theory to the MRR link with the use of a linearly polarized beam and polarization rotation over 90 deg at the MRR. This approach is based on the theory on the polarized beam propagation previously developed by authors.
3. Computer simulation of the MRR link performance in seawaters (conventional systems and the MRR with polarization rotation).
4. Estimation of the MRR link parameters in various environments.

SCATTERING BY PURE WATER AND PURE SEAWATER

Zhang, Xiaodong¹

¹University of North Dakota 4149 University Ave Stop 9011, Grand Forks, ND, 58202, United States

Recent development in theoretical and experimental thermodynamics greatly improved the estimate of scattering by pure water and pure seawater. For pure water, the improvement was due to analytical calculation of the term $dn/d\rho$ directly, bypassing the estimate of term dn/dP , which is difficult to measure. For pure seawater, a new theoretical model was developed for the first time relating the scattering to the salinity directly. The theory agrees with Morel's measurements within the experimental error of 2% for both water and seawater. The model predicts a non-linear increase of scattering with salinity. Also, because of nonlinearity of scattering with sea salts, the use of NaCl as a proxy for seawater will incur up to 7% errors in scattering for either equivalent mass or refractive index.

A NEW BIO-OPTICAL ALGORITHM FOR ESTIMATING COLORED DISSOLVED ORGANIC MATTER ABSORPTION IN COASTAL WATERS FROM MODIS DATA

Zhang, Xiangguang¹; Asanuma, Ichio¹; Cao, Nan¹; Zhao, Chaofang²; Huang, Bangqin³

¹Tokyo University of Information Science 4-1 Onaridai, Wakaba-ku, Chiba, 265-8501, Japan; ²College of Information Science and Engineering, Ocean University of China, Qingdao, Shandong, 266100, China; ³College of Oceanography and Environmental Science, Xiamen University, Xiamen, Fujian, 361005, China

The China east coastal region contains some of the most consistently highly turbid coastal waters to be found anywhere. Atmospheric correction for the ocean color products derived from the MODIS uses two NIR bands centered at 748 and 869nm. For turbid water, standard MODIS data processing often produces significant errors in the derived ocean color products due to significant ocean water-leaving radiance contributions at the two NIR bands. The ocean color remote sensing has been conducting a technical challenge to estimate chlorophyll-a concentration as well as CDOM over the coastal waters with experiencing the difficulties of gaining accuracies because of negative radiance in the short visible bands. It is our objectives to propose a new bio-optical algorithm to estimate CDOM in coastal waters from the remote sensing data.

The terrestrial originated Colored Dissolved Organic Matter (CDOM) is observed and distributed in the river runoff and along the coast of the China main land. Since 2007, the short expeditions using fishing boats have been conducted in the Qingdao Bay and the Xiamen Bay in China. Through these expeditions, waters are sampled to determine chlorophyll-a concentrations, nutrients, CDOM, as well as the CTD profiling of temperature, salinity, and photo-synthetically available irradiance.

The MODIS data from the AQUA were received and processed at the Tokyo University of Information Sciences. CDOM was retrieved as a reference with the traditional bio-optical algorithm using the remote sensing visible reflectance. The correlation, single regression and multiple regression analysis were applied to build a new bio-optical algorithm to estimate CDOM from the traditional CDOM, the in-situ CDOM, the remote sensing visible reflectance, and the Rayleigh-corrected radiance at the top of the atmosphere.

RETRIEVAL OF TOTAL SUSPENDED MATTER FROM MODIS TERRA 250 M IMAGERY IN THE BOHAI SEA OF CHINA

Wang, Lin¹; Zhao, Dongzhi¹; Yang, Jianhong¹; Chen, Yanlong¹

¹No.42, Linghe Street, Dalian, 116023, China

MODIS 250 m data for analyzing the Bohai Sea of China have unique advantages due to the high spatial resolution, short revisit period, or free of cost. The statistical retrieval model for concentration of total suspended matter (TSM) is developed based on the *in situ* measurements of TSM and remote sensing reflectance spectra in the Bohai Sea of China. A robust linear relationship was established between equivalent remote sensing reflectance (converting ASD remote sensing reflectance by spectral response function) based on band 1 (620–670 nm) MODIS Terra 250 m data and *in situ* measurements of TSM ($R^2=0.95$; $n=27$; $RMS=0.51$) acquired in August and September 2008. The model was validated by *in situ* measurements ($MRE=12.9\%$) in September 2009. And the remote sensing products of monthly average concentration of TSM have been produced based on MODIS 250 m data from January to December, 2009. The distribution characteristics of TSM in the Bohai Sea of China are closely related with the spatial pattern and seasonal variability. This study demonstrates that the moderately high resolution of MODIS 250 m data can provide useful help for examining the transport and fate of materials in relative smaller bodies of water.

THE ECOLOR-SECCHI-DISC: AN ELECTRONIC REINVENTION OF PROVEN OCEAN COLOR TOOLS

Zielinski, Oliver¹; Wernand, Marcel R.²

¹Bremerhaven University of Applied Sciences An der Karlstadt 8, Bremerhaven, 27568, Germany; ²Royal Netherlands Institute for Sea Research, Den Burg, Texel, 1790AB, Netherlands

Water transparency and color measurements come up with a long history in limnology and oceanography. A standardized method to determine the water clarity was adopted at the end of the 19th century. This method (lowering a white painted disc into the water until it disappeared out of sight) was described by Pietro Angelo Secchi in *Il Nuovo Cimento* and was published in 1865. In the last decade of the 19th century François Alphonse Forel (1890) and Willi Ule (1892) composed a color comparator scale, with tints varying from indigo-blue to cola brown, to quantify the color of natural waters, like seas, lakes and rivers. For each measurement, the observer compares the color of the water above a submersed Secchi disc with the hand-held Forel-Ule scale. The Forel-Ule scale has been applied globally and intensively by oceanographers and limnologists from the beginning of its existence. Taking advantage of modern hyperspectral sensors, the authors present a new technology aided approach in transparency and color classification of the sea leading towards an improved instrumentation for a proven quantity. Furthermore, we recommend a reintroduction of the Forel-Ule scale in global observation and modeling efforts to expand the historical ocean color database and to facilitate a tie-in with climate change research.

EXPLOITING LIDAR TO RETRIEVE PARTICLE DISTRIBUTIONS OF THE UPPER OCEAN

Zimmerman, Richard¹; Sukenik, Charles I²; Hill, Victoria³; Hu, Yongxiang⁴

¹Old Dominion University 4600 Elkhorn Av, Norfolk, VA, 23529, United States; ²Old Dominion University, Department of Physics, Norfolk, Virginia, 23529, United States; ³4600 Elkhorn Av, Norfolk, VA, 23529, United States; ⁴NASA Langley Research Center, Hampton, Virginia, 23681, United States

Passive ocean color remote sensing has revolutionized our ability to quantify horizontal patterns of algal distributions across the ocean surface. LIDAR technology, which has already proven its ability to produce high resolution models of bathymetry/topography, offers to provide critical insights into the vertical distribution of these particles, significantly improving our ability to model biogeochemical processes in the upper ocean. LIDAR signals modeled at 1 m vertical resolution generated distinct simulated LIDAR return signatures for three stations located near the mouth of Chesapeake Bay ranging from stratified waters with very high scattering coefficients near the coast to clear, vertically homogeneous waters offshore. Integrating the depth resolved LIDAR signal over the entire water column at each station provided simulated CALIPSO return signals from each depth that were positively correlated to the mean beam attenuation coefficient for each station, with the brightest signals emanating near the coast. We then constructed a laboratory system to measure LIDAR signals for defined water samples. Total laser backscattering from water samples collected on several cruises was measured over a single depth bin 37 cm deep, and compared to beam attenuation of the same water samples measured using a laboratory spectrophotometer and 10 cm pathlength cuvette. The relative LIDAR power increased to a maximum as c approached 1 m^{-1} , then declined asymptotically to 0.5 as beam attenuation increased. Integration of the radiative transfer model over the same distance (37 cm) faithfully reproduced this pattern, which results from the progressive diffusion and attenuation of the laser beam with turbidity. The ability of the model to predict the field observations and laboratory experiments supports its validity as a general description of radiative propagation of the LIDAR beam through an optically active medium, and suggests a path forward for determining particle distributions in the upper ocean from full waveform LIDAR data.

Alphabetical Index of Authors

A

Aas, Lars, 31, 134
 Adams, Darrell, 16, 141
 Afinkiev, Teodor, 28, 118
 Agrawal, Yogi, 30, 108
 Ahmed, Samir, 11, 13, 15, 19, 22, 27, 33, 34, 41, 44,
 52, 62, 78, 87, 136
 Ahn, Yu-Hwan, 14, 15, 19, 93, 123, 133
 Akselman, Rut, 21, 126
 Allais, Anne, 27, 29, 69
Alley, Derek, 19, 29, 41
 Althausen, Dietrich, 17, 37, 91
Alvain, Severine, 20, 39, 42
Amin, Ruhul, 30, 42
 Anderson, Stephanie, 127
 Anstee, Janet, 17, 37, 65
 Antoine, David, 16, 19, 25, 32, 35, 38, 43, 98, 99, 104,
 141
 Arellano, Ana, 18, 23, 39, 43, 57
 Armada, Manuel, 28, 118
 Arnone, Robert, 25, 33, 34, 37, 41, 43, 64, 109
 Artigas, Mireia, 28, 118
 Asanuma, Ichio, 15, 150
 Asper, Vernon, 35, 100
 Astoreca, Rosa, 32, 112
 Aukamp, Jessica, 14, 58
Aurin, Dirk, 16, 44
 Aymerich, Ismael, 28, 118

B

Baars, Holger, 17, 37, 91
 Babin, Marcel, 13, 18, 20, 22, 24, 29, 44, 47, 67, 70,
 105
Bai, Yan, 16, 45
 Baird, Mark, 19, 122
Balch, William, 15, 45
 Banner, Michael, 35, 148
 Barker, Kathryn, 24, 34, 46, 96
 Barnard, Andrew, 27, 114
 Barnes, Brian, 18, 39, 57
 Barrot, Gilbert, 17, 105
 Basu, Subhajit, 21, 32, 33, 79, 80
 Baxter, Becky, 25, 33, 46, 88
Behrenfeld, Michael, 16, 21, 24, 47, 103
Bélanger, Simon, 18, 24, 29, 31, 47, 70, 89
 Benavides, Hugo, 21, 126
 Benner, Ron, 20, 32, 73
 Bennert, Ellen, 35, 39, 99
 Berdalet, Elisa, 28, 118
Berthon, Jean-Francois, 23, 48
Bhandari, Purushottam, 29, 35, 48
 Bissett, Paul, 13, 16, 17, 37, 65, 85, 108
 Blake, Steve, 25, 101
Blondeau-Patissier, David, 26, 38, 49
Blum, Mirjam, 30, 49
 Boffety, Matthieu, 27, 29, 69

Bogucki, Darek, 28, 145
 Bonhommeau, Sylvain, 16, 103
 Boss, Emmanuel, 14, 19, 23, 24, 30, 47, 50, 75, 128,
 136
 Bouhier, Marie, 27, 29, 69
 Bourg, Ludovic, 17, 24, 25, 97, 98, 105
 Boyd, Tim, 26, 39, 116
 Bracher, Astrid, 14, 17, 30, 38, 49, 50, 136
 Brady, Parrish, 11, 20, 62
 Brando, Vittorio, 17, 26, 37, 38, 49, 65
 Breton, Elsa, 23, 92
 Brewin, Bob, 16, 86
 Bricaud, Annick, 20, 24, 25, 51, 105
 Briggs, Nathan, 15, 20, 32, 51, 118
 Britton, Walter, 36, 63
Brockmann, Carsten, 26, 37, 52
 Brogniez, Gerard, 30, 68
Budak, Vladimir, 22, 52
 Buis, Jean-Pierre, 19, 99
 Buis, Nicolas, 19, 99

C

Cahill, Bronwyn, 13, 108
 Caimi, Frank, 36, 63
 Cairns, Brian, 11, 22, 56
 Callejas-Jimenez, Mariana, 31, 80
 Campos, Edmo, 34, 38, 114
 Canini, Marius, 19, 99
 Cannizzaro, Jennifer, 18, 26, 39, 57, 89
 Canuti, Elisabetta, 23, 48
Cao, Fang, 23, 53
 Cao, Nan, 15, 150
 Cao, Wenxi, 24, 143
 Casey, B, 17, 37, 65
 Caverhill, Carla, 17, 38, 59
 Cetinic, Ivona, 15, 20, 23, 29, 32, 36, 51, 53, 118, 136
Chakraborty, Sumit, 19, 53
 Chami, Malik, 22, 25, 27, 29, 30, 54, 67, 69, 76, 101
Chang, Grace, 26, 32, 54, 129
 Chang, Hoe, 15, 125
Chase, Alison, 31, 55
Chekalyuk, Alexander, 19, 55
 Chen, Yanlong, 17, 151
 Chiggiato, Jacopo, 22, 124
 Chou, Mau-Song, 26, 119
Chowdhary, Jacek, 11, 22, 27, 56, 136
Churnside, James, 21, 25, 56, 109
 Cifuentes-Lorenzen, Alejandro, 12, 18, 120
 Ciotti, Aurea, 25, 51
 Claustre, Hervé, 31, 147
 Clementson, Lesley, 15, 21, 115
 Clerici, Marco, 21, 107
Coble, Paula, 18, 23, 26, 39, 43, 57, 89
 Cochenour, Brandon, 12, 30, 149
Cone, Michael, 19, 57
 Conmy, Robyn, 14, 23, 24, 43, 58, 125
Corson, Michael, 25, 34, 37, 58, 64
 Courcot, Lucie, 23, 92

Courtemanche, Bruno, 15, 21, 59
Craig, Susanne, 17, 38, 59
Craven, George, 14, 58
Crawford, Jim, 19, 60
Creanor, Danielle, 26, 38, 60
Cristina, Sônia, 31, 33, 60, 79
Cullen, John, 17, 20, 24, 38, 59, 61
Cummings, Molly, 11, 19, 28, 61, 66
Cunningham, Alex, 14, 26, 35, 38, 39, 60, 62, 112
Cunningham, Chris, 15, 125
Currin, Carolyn, 15, 85
Czerski, Helen, 12, 27, 35, 63, 138

D

d'Ortenzio, Fabrizio, 31, 35, 38, 104, 147
Dagach, Sergio, 11, 19, 76
Dalgleish, Fraser, 36, 63, 116, 143
Daniels, Kathleen, 14, 58
Dañobeitia, Juan, 28, 118
Darecki, Mirosław, 12, 26, 32, 33, 34, 63, 77, 123, 132, 146
D'Asaro, Eric, 15, 20, 32, 51, 118
Datskos, Panos, 28, 40, 64
Davis, Curtiss, 16, 33, 34, 37, 44, 64, 138
De Boyer Montegut, Clement, 35, 38, 104
Dekker, Arnold, 17, 26, 37, 38, 49, 65
Delwart, Steven, 25, 98
Demaria, Julien, 17, 105
Dempsey, Cyril, 16, 141
deRada, Sergio, 28, 90
Deschamps, Pierre-Yves, 17, 75
Dessailly, David, 30, 34, 36, 68, 100, 141
Devred, Emmanuel, 25, 65
Diamond, Emilie, 16, 141
Dickey, Tommy, 21, 66
Dierssen, Heidi, 12, 16, 18, 28, 37, 44, 66, 120, 122
Dinter, Tilman, 17, 30, 38, 49, 50
Dittmar, Thorsten, 27, 121
Doblin, Martina, 19, 122
Doerffer, Roland, 26, 37, 52
Dogliotti, Ana, 14, 21, 33, 67, 72, 126
Donaghay, Percy, 11, 31, 36, 132, 135
Dong, Qiang, 25, 67
Donovan, John, 26, 119
Doxaran, David, 18, 22, 24, 29, 30, 32, 47, 67, 70, 101, 112
D'Sa, Eurico, 14, 111
Du, Keping, 31, 68
Dubuisson, Philippe, 17, 30, 68, 75
Duforêt-Gaurier, Lucille, 30, 34, 36, 68, 100, 141
Dupouy, Cécile, 31, 69

E

Ebata, Hiroki, 36, 114
Ebert, Kerstin, 22, 27, 29, 54, 69
Edmond, Toussaint, 27, 29, 69
Efremenko, Dmitriy, 22, 52
Ehn, Jens, 18, 24, 29, 47, 70
Eleveld, Marieke, 23, 139
Engelmann, Ronny, 17, 37, 91

English, David, 18, 26, 39, 57, 89
Epps, Sarah, 33, 35, 70, 100
Erga, Svein, 23, 31, 130, 134
Erickson, Jeffrey, 28, 29, 71
Estapa, Margaret, 20, 31, 71
Everingham, Yvette, 16, 106

F

Fanton d'Andon, Odile, 17, 24, 96, 105
Fargion, G, 33, 43
Fasullo, John, 21, 33, 79
Fearn, Peter, 17, 18, 24, 25, 37, 38, 65, 72, 94, 101, 104
Feng, Hui, 11, 30, 33, 44, 90
Fennel, Katja, 20, 24, 61
Fernández, Roemi, 28, 118
Ferrari, Ramiro, 33, 121
Ferreira, Amábile, 33, 34, 38, 72, 114
Ficek, Dariusz, 32, 73
Fichot, Cedric, 15, 20, 32, 73, 119
Ford, Phillip, 15, 21, 115
Fougnie, Bertrand, 19, 99
Fournier, Georges, 12, 37, 74
Franz, Bryan, 31, 74
Freeman, Scott, 12, 15, 18, 32, 35, 120, 128, 129, 138
Frette, Øyvind, 23, 31, 130, 134
Frew, James, 16, 103
Frolov, Sergey, 127
Frouin, Robert, 17, 30, 68, 75
Fry, Edward, 19, 28, 29, 57, 83
Fujiwara, Amane, 24, 86
Fukasawa, Tatsuya, 36, 95
Furnas, Miles, 16, 106
Furuta, Masaji, 36, 114
Furuya, Ken, 26, 93

G

Gainusa-Bogdan, Alina, 19, 75
Gall, Mark, 15, 125
Galland, Frédéric, 27, 29, 69
Gallegos, Charles, 15, 85
Gallegos, Sonia, 22, 35, 39, 99, 133
Gao, Meng, 11, 19, 76
Garcia, Carlos, 33, 34, 38, 72, 114
Garcia, Virginia, 33, 34, 38, 72, 114
Garnesson, Philippe, 17, 105
Gemmrich, Johannes, 35, 148
Gentili, Bernard, 16, 25, 31, 32, 43, 51, 76, 141, 147
Gernez, Pierre, 12, 77
Gibson, W, 33, 44
Giddings, Thomas, 36, 77, 143
Gilerson, Alexander, 11, 13, 15, 19, 22, 27, 34, 41, 52, 61, 78, 87, 136
Gilles, Nicolas, 17, 105
Gitelson, Anatoly, 13, 78
Gladkova, Irina, 15, 87
Gleason, Arthur, 12, 18, 27, 78, 142
Goela, Priscila, 31, 33, 60, 79
Goes, Joaquim, 14, 21, 32, 79, 80, 111
Gomes, Helga, 14, 21, 32, 79, 80, 111

Gons, Herman, 18, 29, 140
Gonzalez-Silvera, Adriana, 31, 80
 Gordon, Howard, 12, 18, 27, 78, 142
 Goryl, Philippe, 17, 24, 25, 97, 98, 105
 Gould, Richard, 18, 25, 28, 30, 34, 35, 37, 38, 39, 42,
 64, 81, 90, 97, 99, 109
 Gracia-Escobar, Maria, 31, 80
Granskog, Mats, 27, 81
 Gray, Amanda, 20, 32, 51
 Gray, Mark, 25, 101
 Grossberg, Michael, 15, 87
 Guillocheau, Nathalie, 32, 43
 Gunbua, Vichaya, 36, 95
 Guo, Laodong, 34, 38, 97
 Gurlin, Daniela, 13, 78

H

Hacker, Jorg, 25, 101
 Hagy, James, 24, 125
 Hamre, Børge, 13, 26, 27, 39, 81, 130, 131
 Hancke, Kasper, 27, 88
 Hankinson, Sam, 31, 55
Hanlon, Roger, 13, 82
 Hardman-Mountford, Nick, 16, 86
Hargreaves, Bruce, 22, 82
 Harmel, Tristan, 34, 41
Haubrich, David, 28, 29, 83
 Hauss, Bruce, 26, 119
He, Xianqiang, 13, 83
 Hedley, John, 11, 13, 17, 26, 37, 65, 84, 92
 Henry, Patrice, 19, 100
Hieronymi, Martin, 18, 84
Hill, Victoria, 16, 34, 85, 151
Hilting, Anna, 15, 85
Hirata, Takafumi, 16, 86
Hirawake, Toru, 16, 23, 24, 86, 134
Hlaing, Soe, 15, 34, 41, 87
 Hochberg, Eric, 16, 87
 Hohn, Soenke, 32, 142
 Holben, B, 33, 44
 Holt, Joan, 11, 19, 28, 62, 66
 Hommersom, Annelies, 23, 139
 Hong, Guanlin, 13, 127
 Hong, Huasheng, 25, 67
 Hong, Jiarong, 11, 31, 36, 132, 135
 Hoogveld, Hans, 18, 29, 140
 Hooker, Stan, 18, 29, 47
Hooper, Brett, 33, 88
 Horne, Edward, 17, 38, 59
 Hou, Weilin, 30, 42
 Houliez, Emilie, 23, 92
 Houyou, Amel, 19, 99
Hovland, Erlend, 27, 88
 Hu, Chuanmin, 18, 26, 28, 39, 57, 88, 89
 Hu, Yongxiang, 34, 151
 Huang, Bangqin, 15, 150
 Huang, Changchun, 34, 38, 97
 Hudson, Stephen, 27, 81
 Huot, Jean-Paul, 24, 25, 34, 46, 98, 109
 Huot, Yannick, 15, 21, 59

I

Ibrahim, Amir, 27, 136
 Icely, John, 24, 31, 33, 60, 79, 109
 Ioannou, Ioannis, 13, 78
 Ip, Justin, 26, 119
 Ishizaka, Joji, 16, 36, 86, 95
 Ivey, James, 18, 26, 39, 57, 89

J

Jaegler, Thomas, 31, 89
Jamet, Cédric, 11, 30, 90
 Jankowski, Lukasz, 23, 48
 Jintasaeranee, Pachoenchoke, 36, 95
 Johnsen, Geir, 28, 66
 Jolliff, Jason, 25, 28, 35, 39, 90, 99, 109
 Jonasz, Miroslaw, 28, 145
 Jones, Burton, 23, 136
 Jones, Chris, 17, 38, 59
 Jones, Katherine, 16, 138
 Joung, DongJoo, 35, 100
 Jourdin, Frederic, 30, 101

K

Kanitz, Thomas, 17, 37, 91
 Katsev, Iosif, 12, 27, 29, 30, 111, 149
 Kattawar, George, 11, 12, 18, 19, 28, 29, 35, 40, 76,
 83, 92, 138, 142, 148
 Katz, Joseph, 11, 31, 36, 132, 135
Kay, Susan, 11, 13, 24, 92, 96
 Kent, Chris, 24, 97
Kheireddine, Malika, 23, 92
 Kikuchi, Tomohiko, 14, 110
 Kildemo, Morten, 31, 134
Kim, Hyun-cheol, 19, 93
Kishino, Motoaki, 26, 93
 Kline, Rick, 11, 19, 62
Klonowski, Wojciech, 15, 17, 18, 24, 25, 37, 38, 65,
 94, 101, 104, 128
 Klyuykov, Dmitriy, 22, 52
 Knaeps, Els, 16, 22, 94, 120
 Ko, Dong, 18, 28, 34, 38, 81, 97
Kobayashi, Hiroshi, 36, 95
 Korkin, Sergey, 22, 52
 Kostadinov, Tihomir, 16, 23, 32, 43, 95, 103
 Kovach, Charles, 18, 26, 39, 57, 89
 Kowalczuk, Piotr, 34, 123
 Kratzer, Suzanne, 24, 109
 Krezel, Adam, 33, 146
 Kromkamp, Jacco, 18, 29, 140
 Kuchinke, Christopher, 11, 30, 90
 Kushairi, M. R. M., 13, 96
Kuwahara, Victor, 13, 96

L

Labonnote, Laurent, 30, 68
 Ladner, Sherwin, 35, 39, 99
 Laine, Edward, 31, 55
Laney, Samuel, 36, 96

Laur, Henri, 17, 105
 Laux, Alan, 19, 27, 29, 41, *See*
 Lavender, Samantha, 11, 13, 24, 25, 34, 46, 92, 96, 98, 109
 Lavrik, Nickolay, 28, 40, 64
 Lawson, A, 33, 44
 Lazin, Gordana, 17, 38, 59
 Lednicka, Barbara, 14, 146
 Lee, Craig, 15, 20, 23, 32, 51, 118, 136
Lee, Sang, 23, 97
 Lee, ZhongPing, 17, 25, 26, 31, 34, 37, 38, 64, 65, 67, 68, 89, 97
 Lehrter, John, 14, 24, 58, 125
Lerebourg, Christophe, 17, 25, 34, 98, 105
Lewis, Mark, 35, 39, 99
Lewis, Marlon, 12, 14, 18, 27, 28, 35, 81, 98, 138, 140, 144, 148
Leymarie, Edouard, 18, 19, 29, 47, 99
 Li, Rong-Rong, 35, 39, 99
 Li, Wei, 26, 39, 130
 Li, William, 17, 38, 59
 Lizon, Fabrice, 23, 92
 Logan, Luke, 29, 35, 48
 Lohrenz, Steven, 19, 20, 32, 33, 34, 35, 38, 53, 70, 73, 97, 100
 Loisel, Hubert, 11, 23, 30, 32, 33, 34, 36, 90, 92, 100, 107, 112, 141
 Lorthiois, Thomas, 22, 30, 68, 101
 Losa, Svetlana, 32, 142
 Losch, Martin, 32, 142
 Lu, Zheng, 19, 57
 Lubac, Bertrand, 34, 38, 97, 100
 Lutz, Vivian, 14, 21, 67, 126
 Lynch, Mervyn, 17, 18, 24, 25, 37, 38, 65, 94, 101, 104
 Lyons, Mitchell, 17, 37, 65

M

Ma, Yujuan, 30, 102
 Maas, Els, 15, 125
 Maciol, Nicolas, 27, 29, 69
 Macke, Andreas, 17, 18, 37, 84, 91
 Maginnis, Tara, 11, 19, 28, 61, 66
Majchrowski, Roman, 22, 32, 102, 132
 Majewski, Leon, 25, 101
 Mallet, Marc, 25, 76
Mao, Zhihua, 17, 103
Maritorena, Stéphane, 16, 23, 32, 43, 95, 103
Marrable, Daniel, 18, 38, 104
 Martin, Kevin, 33, 70
Martinez, Elodie, 35, 38, 104
 Martinolich, Paul, 30, 42
 Matondkar, Prabhu, 21, 32, 79, 80
 Matsumoto, Keitaro, 24, 86
Matsuoka, Atsushi, 20, 24, 70, 105
 Mazeran, Constant, 13, 17, 25, 34, 44, 98, 105
 McBride, Walton, 19, 29, 41
 McCarthy, Jim, 26, 119
 McCulloch, Mike, 24, 97
 McKee, David, 14, 19, 22, 30, 32, 35, 39, 68, 101, 106, 112, 123

McKinna, Lachlan, 16, 106
 McLean, S, 14, 138
 Meler, Justyna, 14, 32, 73, 146
Mélin, Frédéric, 21, 36, 107, 141
 Mériaux, Xavier, 23, 32, 33, 92, 107, 112
 Meunier, Sylvain, 19, 99
Mikkelsen, Ole, 30, 108
 Millán-Núñez, Eduardo, 25, 137
 Millan-Nunez, Roberto, 31, 80
 Miller, William, 15, 20, 23, 32, 53, 73, 108, 119
 Mishchenko, Michael, 11, 22, 56
Mobley, Curtis, 13, 17, 37, 65, 108
 Moline, Mark, 26, 27, 39, 114, 116
 Montes, Marcos, 30, 42
Montes-Hugo, Martin, 25, 109
 Moon, Jeong Eon, 15, 19, 93, 123
 Moore, Casey, 27, 114
Moore, Gerald, 24, 33, 34, 46, 60, 109
 Morel, André, 19, 31, 99, 147
 Morison, Russel, 35, 148
 Morris, Bradley, 19, 122
 Moses, Wesley, 13, 78
Motokawa, Shozo, 14, 110
 Mullen, Linda, 12, 19, 27, 29, 30, 41, 111, 149
 Murakami, Hiroshi, 16, 86
 Musser, Joseph, 28, 29, 83

N

Naik, Puneeta, 14, 111
 Nakajima, Ryota, 13, 96
 Nayak, Aditya, 11, 36, 134
Nechad, Bouchra, 17, 39, 111
 Negri, Ruben, 21, 126
Neil, Claire, 35, 39, 112
 Nelson, Norm, 16, 32, 43, 103
 Nemoto, Moyu, 36, 114
 Neukermans, Griet, 17, 32, 33, 39, 107, 111, 112
 Newton, Alice, 31, 33, 60, 79
 Nicolas, Stéphane, 27, 29, 69
 Nimmo-Smith, W., 92
Nubi, Olubunmi, 22, 113

O

Obata, Mitsuko, 20, 113
 Odermatt, Daniel, 16, 120
Oishi, Tomohiko, 36, 114
 Olson, Robert, 36, 129
Omachi, Claudia, 34, 38, 114
 Ondrusek, Michael, 25, 98
Orrico, Cristina, 27, 114
 Oshchepkov, Sergey, 22, 52
Ostrowska, Mirosława, 30, 32, 115, 132
 Othman, B. H. R., 13, 96
 Ottaviani, Matteo, 11, 22, 56
Oubelkheir, Kadija, 15, 21, 115
Ouyang, Bing, 36, 116

P

Parab, Sushma, 21, 32, 33, 79, 80

Park, B.K., 19, 93
 Park, Young, 26, 38, 49
 Peebles, Ernst, 18, 39, 57
 Peeken, Ilka, 17, 38, 50
Pegau, William, 26, 39, 116
Pennucci, Giuliana, 34, 37, 117
Peperzak, Louis, 24, 117
Perry, Mary, 15, 20, 29, 32, 36, 51, 53, 118
 Peters, Steef, 23, 139
 Phinn, Stuart, 17, 26, 37, 38, 49, 65, 84
 Piera, Jaume, 25, 28, 118, 137
 Pinkerton, Matt, 15, 125
 Piotrowski, Cindy, 33, 88
 Piskozub, Jacek, 19, 28, 106, 145
 Platt, Trevor, 25, 65
 Polton, Jeff, 35, 39, 112
 Pons, Sergi, 28, 118
 Poteau, Antoine, 31, 147
Powers, Leanne, 15, 119
Pratt, Patty, 26, 119
 Prikhach, Alexander, 12, 27, 29, 30, 111, 149

R

Raimbault, Patrick, 18, 29, 47
 Rajic, Slobodan, 28, 40, 64
 Ramos, Brian, 36, 63
Randolph, Kaylan, 12, 18, 120
Raymaekers, Dries, 16, 120
 Reader, Heather, 23, 53
 Rehm, Eric, 20, 32, 51
 Reynolds, Rick, 19, 24, 25, 70, 106, 137
 Ridd, Peter, 16, 106
 Robbins, Ian, 27, 114
 Roelfsema, Chris, 17, 26, 37, 65, 84
 Roesler, Collin, 21, 31, 32, 33, 55, 79, 80
Rohde, Peter, 27, 121
Romero, Silvia, 33, 121
 Ross, Oliver, 28, 118
 Röttgers, Rüdiger, 14, 17, 19, 31, 38, 50, 69, 106, 123
Roughan, Moninya, 19, 122
 Rozanov, Vladimir, 30, 49
 Rozwadowska, Anna, 13, 149
 Ruddick, Kevin, 11, 17, 22, 30, 32, 33, 39, 68, 90, 94, 107, 111, 112
 Russell, Brandon, 37, 122
 Ryu, Joo-Hyung, 14, 15, 123, 133

S

Sadeghi, Alireza, 17, 38, 50
 Safi, Karl, 15, 125
Sagan, Slawomir, 34, 123
 Saitoh, Sei-Ichi, 16, 23, 24, 86, 134
 Sakshaug, Egil, 27, 88
Salama, Mhd. Suhyb, 33, 124
Sanjuan Calzado, Violeta, 22, 124
 Santamaria-del-Angel, Eduardo, 31, 80
 Santander-Cruz, Jonatan, 31, 80
 Sardou, Olivier, 17, 105
 Sathyendranath, Shubha, 25, 26, 37, 52, 65
 Scadino, T, 33, 43

Schaeffer, Blake, 14, 24, 58, 125
 Schmitt, Bettina, 14, 17, 38, 50, 136
 Schroeder, Thomas, 26, 38, 49
 Schultz, Howard, 35, 148
Schwarz, Jill, 15, 125
 Scott, Nicholas, 33, 88
Segura, Valeria, 14, 21, 67, 126
 Shahriar, Faizul, 15, 87
 Shang, Shaoling, 25, 67
Shanmugam, Palanisamy, 14, 22, 126, 133
Shen, Fang, 13, 127
 Shi, Wei, 11, 13, 143
 Shinmyo, Katsuhito, 24, 86
 Shirron, Joseph, 36, 77, 143
Shulman, Igor, 127
 Siegel, David, 16, 23, 32, 43, 95, 103
 Sieracki, Michael, 15, 20, 118
 Silva, Ricardo, 21, 126
 Simis, Stefan, 18, 29, 140
 Simó, Rafel, 28, 118
Slade, Jr., Wayne, 14, 128
 Slivkoff, Matthew, 12, 15, 16, 24, 27, 35, 63, 94, 106, 128, 138
 Smith, Regina, 18, 28, 81
 Smyth, Tim, 16, 86
Sokoletsky, Leonid, 22, 133
 Son, SeungHyun, 23, 34, 97, 128
 Son, Young Baek, 15, 123
Sosik, Heidi, 36, 129
Spada, Frank, 32, 129
Ssebiyonga, Nicolausi, 23, 130
 Stamnes, Jakob, 13, 23, 26, 27, 31, 39, 81, 130, 131, 134
 Stamnes, Knut, 13, 26, 33, 39, 130, 131, 135
Stamnes, Snorre, 13, 131
Stavn, Robert, 31, 131
 Sterckx, Sindy, 16, 22, 94, 120
 Steven, Andrew, 15, 21, 115
 Stoń-Egiert, Joanna, 14, 22, 32, 102, 132, 146
 Stramski, Dariusz, 12, 13, 24, 25, 28, 70, 77, 137, 145
 Stuart, Venetia, 25, 65
 Stumpf, Richard, 24, 125
 Sukenik, Charles, 34, 151
 Sullivan, James, 11, 12, 31, 35, 36, 132, 135, 138
Sundarabalan, Balasubramanian, 14, 133
 Sundman, Lydia, 13, 108
 Suthers, Iain, 19, 122
 Suzuki, Koji, 23, 134
 Suzuki, Ryou, 36, 114
Svensen, Øyvind, 31, 134

T

Taguchi, Satoru, 14, 20, 110, 113
 Takahashi, Hirokazu, 36, 114
 Takakusaki, Mitsuhiro, 36, 114
Takao, Shintaro, 23, 134
Talapatra, Siddharth, 11, 31, 36, 132, 134
Tanikawa, Tomonori, 26, 33, 39, 130, 135
 Teegarden, Greg, 31, 55
Theis, Anja, 14, 136
 Thomas, Andrew, 29, 36, 53

Thompson, Karen, 15, 125
 Thoppil, Prasad, 21, 32, 79
 Timmermans, Klaas, 24, 117
 Toda, Tatsuki, 13, 14, 96, 110
 Tonizzo, Alberto, 11, 19, 22, 27, 52, 61, 136
 Toratani, Mitsuhiro, 16, 86
Toro-Farmer, Gerardo, 23, 136
Torrecilla, Elena, 25, 28, 118, 137
 Tote, Carolien, 16, 120
Trees, Charles, 14, 22, 124, 138
 Tuell, Grady, 33, 70
Tufillaro, Nicholas, 16, 138
 Twardowski, Michael, 11, 12, 15, 18, 26, 27, 31, 32,
 35, 36, 54, 63, 120, 128, 129, 132, 135, 138

U

Ungermann, René, 27, 121

V

Vagle, Svein, 12, 27, 35, 63, 138
 Vaidya, Ashma, 22, 82
Van der Woerd, Hendrik, 23, 24, 27, 117, 139, 144
van Dijk, Mark, 18, 29, 140
 Van Dommelen, Ronnie, 12, 18, 27, 35, 98, 140, 144
 van Kooten, Marieke, 15, 125
Vantrepotte, Vincent, 34, 36, 100, 141
 Vellucci, Vincenzo, 16, 32, 43, 141
 Victori, Stephane, 19, 99
 Vierra, Kenneth, 33, 88
Voelker, Christoph, 32, 142
 Volent, Zsolt, 27, 88
 Voss, Daniela, 27, 121
 Voss, Kenneth, 12, 18, 27, 29, 35, 48, 78, 98, 142
 Vountas, Marco, 17, 38, 50
Vuorenkoski, Anni, 36, 143

W

Wang, Guifen, 24, 143
 Wang, Lin, 17, 151
Wang, Menghua, 11, 13, 34, 128, 143
 Weatherbee, Ryan, 29, 36, 53
 Weeks, Scarla, 26, 38, 49
 Wei, Jianwei, 12, 18, 27, 35, 98, 140, 144, 148

Wei, Li, 33, 135
 Weidemann, Alan, 25, 33, 34, 41, 44, 109
 Werdell, Jeremy, 31, 32, 74, 80
Wernand, Marcel, 24, 27, 36, 117, 144, 151
 Wijesekera, Hemantha, 26, 39, 116
 Włodzimierz, Freda, 28, 33, 75, 145
Wojtasiewicz, Bożena, 13, 28, 33, 145, 146
 Wolf-Gladrow, Dieter, 32, 142
 Wood, Simon, 15, 125
Woods, Sarah, 28, 145
Wozniak, Monika, 33, 146
Wozniak, Sławomir, 14, 146
 Wright, Simon, 23, 134

X

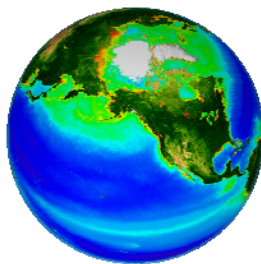
Xing, Xiaogang, 31, 147

Y

Yang, Jianhong, 17, 30, 102, 151
 Yang, Yuezhong, 24, 143
Yao, Haibo, 18, 147
 Ye, Ying, 17, 38, 50
 You, Yu, 11, 12, 18, 19, 35, 76, 138, 142, 148

Z

Zaneveld, J. Ron, 27, 114
 Zapadka, Tomasz, 32, 73
 Zappa, Christopher, 12, 18, 35, 120, 148
Zdun, Agnieszka, 13, 14, 146, 149
Zege, Eleonora, 12, 27, 29, 30, 111, 149
 Zhang, Cao, 11, 36, 135
Zhang, Xiangguang, 15, 150
 Zhang, Xiaodong, 12, 35, 138, 150
 Zhao, Chaofang, 15, 150
Zhao, Dongzhi, 17, 30, 102, 151
 Zhao, Jinping, 23, 97
 Zhou, Jing, 13, 78
 Zhou, Wen, 24, 143
 Zhou, Yunxuan, 13, 127
 Zibordi, Giuseppe, 11, 14, 23, 30, 33, 44, 48, 90, 138
 Zielinski, Oliver, 27, 36, 121, 151
 Zimmerman, Richard, 16, 34, 37, 85, 122, 151



SeaWiFS Project, NASA/GSFC and GeoEye, inc.