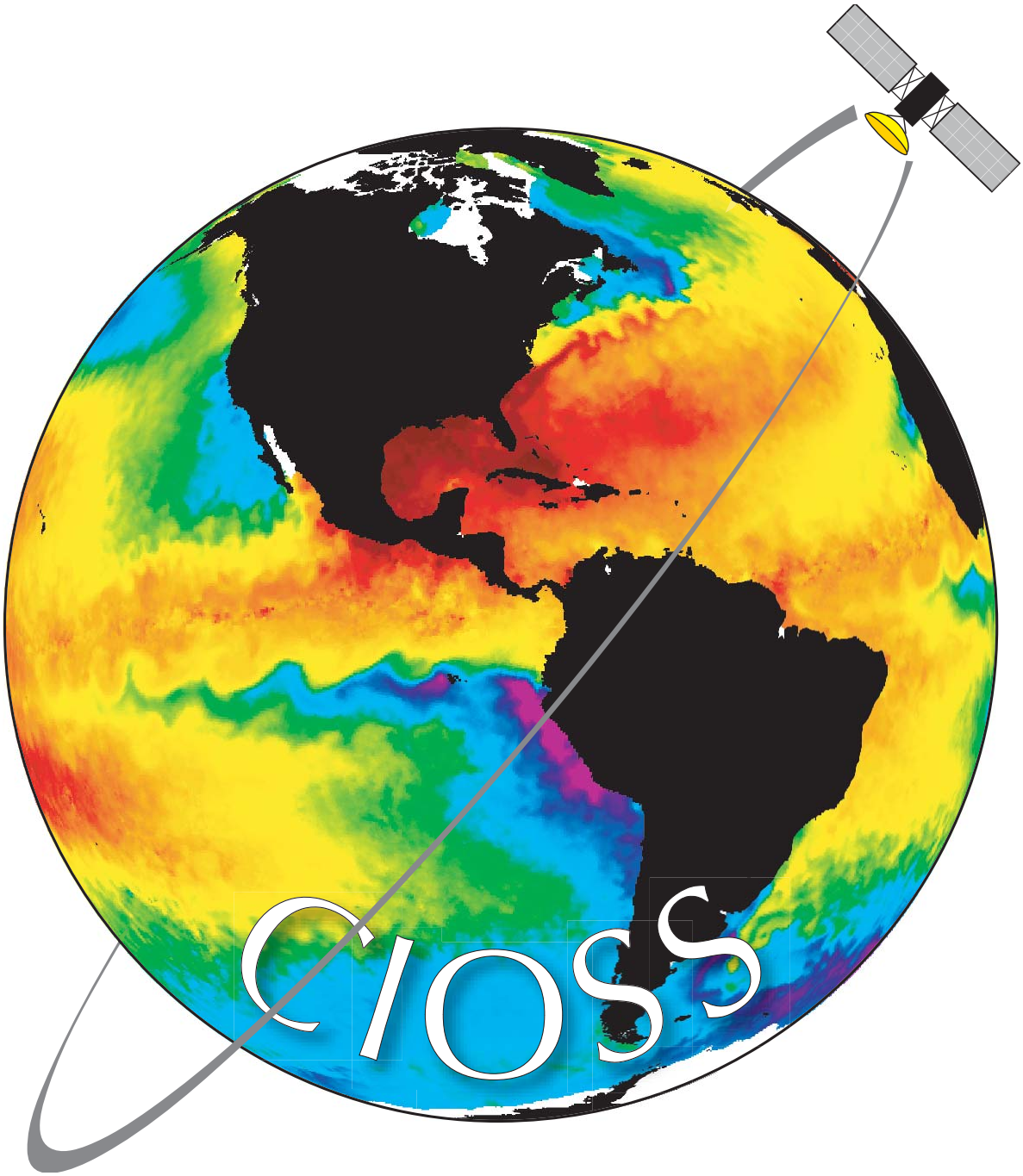
The Cooperative Institute for Oceanographic Satellite Studies (CIOSS) Year 2 Annual Progress Report

(April 1, 2004 - March 31, 2005)



List of CIOSS Fellows

Dr. Ted Strub: Professor; COAS; Director of CIOSS
Dr. Michael Freilich: Professor and Associate Dean; COAS; Deputy Director of CIOSS
Dr. Mark Abbott: Professor and Dean; COAS; Chair of CIOSS Executive Board
Dr. John Allen: Emeritus Professor; COAS
Dr. John Barth: Professor; COAS
Dr. Eric Bayler: Research Scientist and Program Manager; NOAA/NESDIS/ORA/ORAD
Dr. Andrew Bennett: Professor; COAS
Dr. Paul Chang: Research Scientist; NOAA/NESDIS/ORA/ORAD
Dr. Dudley Chelton: Professor; COAS; Chair of CIOSS Council of Fellows
Dr. Pablo Clemente-Colon: Research Scientist; NOAA/NESDIS/ORA/ORAD
Dr. James Coakley: Professor; COAS
Dr. Curt Davis: Senior Research Professor; COAS (as of June 2005)
Dr. Gary Egbert: Professor; COAS
Dr. Steven Esbensen: Emeritus Professor; COAS
Dr. Chris Goldfinger: Professor; COAS
Dr. James Good: Emeritus Professor; COAS
Dr. Alexander Ignatov: Research Scientist; NOAA/NESDIS/ORA/ORAD
Dr. Michael Kosro: Associate Professor; COAS
Dr. Ricardo Letelier: Professor; COAS
Dr. Jon Luke: HMSC Visitor Center Program Manager: Oregon Sea Grant
Dr. Eric Maloney: Assistant Professor; COAS
Dr. Laury Miller: Chief, Ocean Dynamics and Data Assimilation Branch; NOAA/NESDIS/ORA/ORAD
Dr. Robert Miller: Professor; COAS
Dr. Michael Ondrusek: Research Scientist; NOAA/NESDIS/ORA/ORAD
Dr. William Pichel: Research Scientist; NOAA/NESDIS/ORA/ORAD
Dr. James Richman: Associate Professor; COAS
Dr. Roger Samelson: Professor; COAS
Dr. Eric Skyllingstad: Associate Professor; COAS
Dr. Yvette Spitz: Associate Professor; COAS
Dr. Peter Strutton: Assistant Professor; COAS
Dr. Michelle Wood: Professor; University of Oregon
Dr. Dawn Wright: Professor; Geosciences, OSU

Front Cover: Three-day average sea-surface temperature (SST) for the time period 23-25 June 2003 constructed from measurements by the Advanced Microwave Scanning Radiometer (AMSR) on the NASA Earth Observing System (EOS) Aqua satellite. The near all-weather measurement capability of the AMSR has been providing unprecedented temporal sampling of global SST with a spatial resolution of approximately 50 km since 1 June 2002. Numerous interesting features are evident in this figure, including cusp-like patterns associated with tropical instability waves in both the Pacific and the Atlantic, a meandering ribbon of warm water associated with the Gulf Stream, and large areas of cold water associated with the eastern boundary currents off North and South America and northwest Africa.

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I. BACKGROUND

A. Introduction

The Cooperative Institute for Oceanographic Satellite Studies (CIOSS) was established between the National Oceanic and Atmospheric Administration (NOAA) and Oregon State University (OSU) by a Memorandum of Agreement (MOA), signed on October 2, 2003 by OSU President Edward J. Ray and signed on December 23, 2003 by Under Secretary for Oceans and Atmosphere, U.S. Department of Commerce, VADM Conrad C. Lautenbacher. CIOSS was selected competitively from proposals submitted in response to a Request for Proposals posted in the Federal Register Notice (FRN, May 3, 2002, Volume 67, Number 86). Initial research collaborations are between OSU's College of Oceanic and Atmospheric Sciences (COAS) and the Office of Research and Applications (ORA) within NOAA's National Environmental Satellite, Data, and Information Service (NESDIS). Information about COAS can be found on its web site (http://coas.oregonstate.edu/).

B. Purpose

The primary purpose of CIOSS is to establish a cooperative (federal-academic) center of excellence for research involving satellite remote sensing of the ocean and its air-sea interface. CIOSS provides a mechanism to bring together the resources of a research-oriented university (OSU), NESDIS and other NOAA line offices, with additional partners at other universities, and government and private agencies. CIOSS is designed to accomplish the following:

- Extend NOAA's research involving the ocean and its interaction with the overlying atmosphere by developing and using satellite remote sensing methods that better resolve the ocean and the air-sea interface.
- Serve as a focal point for interactions between NOAA and the oceanographic research community, for research activities related to NOAA's mission responsibilities and strategic objectives in the coastal and open ocean.
- Improve the effectiveness of graduate-level education and expand the scientific possibilities and experiences available to graduate students, including participation in joint research programs with NOAA and other government agencies.
- Provide expanded collaborative and training opportunities in satellite ocean-atmosphere remote sensing, modeling and calibration/validation activities for researchers from NOAA laboratories and facilities.

C. CIOSS Focus

The Cooperative Institute for Oceanographic Satellite Studies has been established within the College of Oceanic and Atmospheric Sciences at Oregon State University, making use of the extensive and broad-ranging expertise of COAS faculty in satellite remote sensing, data analysis, modeling and data assimilation. The Institute supports research that enhances the ability of NOAA/NESDIS to accomplish its goals, while also training scientists in the use of remotely sensed data. Making use of the strengths within COAS, the initial focus is on the large-scale continental margins of the U.S., with applications to other ocean margins of the world ocean. The initial "test bed" for satellite technique development, modeling and data analysis is the California Current, along the U.S. west coast. This focus is aligned with

the present national priority to create an integrated observing system for the "coastal" ocean, interpreting the word "coastal" in a broad sense. This is also a region where many of the COAS faculty are collaborating in national field programs, providing a wealth of field data with which to test remote sensing and model fields.

II. RESEARCH AND OUTREACH THEMES

The following five themes of mutual interest to NOAA and OSU are being pursued during the initial five years. The research under these themes addresses the highest priority and most relevant issues in oceanographic satellite remote sensing and modeling.

A. **Theme 1: Satellite Sensors and Techniques**: Development of satellite oceanography techniques and applications; evaluation of existing and proposed satellite sensors, algorithms, techniques and applications.

B. **Theme 2: Ocean-Atmosphere Fields and Fluxes**: Development, evaluation and analysis of improved fields of physical and biological variables in the upper ocean, and of surface variables and fluxes at the air-sea interface, using combinations of remote sensing, in situ data and modeling.

C. **Theme 3: Ocean-Atmosphere Models and Data Assimilation**: Use of satellite-derived fields to force and evaluate numerical models of the oceanic and atmospheric circulation, including the assimilation of those fields using methods of inverse modeling. For some applications, the ocean models will include components of marine ecosystems.

D. **Theme 4: Ocean-Atmosphere Analyses**: Dynamical and statistical analyses of data sets derived from satellites, models and in situ instruments, in order to increase our understanding of the physical, chemical, biological, geological and societal processes that affect and are affected by the ocean-atmosphere system.

E. **Theme 5: Outreach**: We include three broad Outreach areas, each to be related to CIOSS research and its results.

1. **Formal Education** of students (K-12, undergraduate and graduate students), other scientists, resource managers and the general public in aspects of oceanography, surface meteorology and the use of remotely sensed data sets and numerical models. Short courses and training workshops are included in this category, as are workshops designed to develop or evaluate present and planned sensors and techniques.

2. **Informal Education** of the same groups in the same subjects, but in contexts outside of the formal educational system, short courses and workshops. This may take the form of web-based material, presentations, forums, and exhibits at public science museums ("free-choice education").

3. **Data Access** includes activities that enhance the use of data sets derived from satellites and models by research scientists, students, educators, resource managers and the general public.

III. DESCRIPTION OF TASKS

For budgetary and administrative purposes, CIOSS uses a simple structure to partition activities into three "tasks." Task I involves NOAA/NESDIS's basic support for the administration and general operations of CIOSS, including outreach, using core funding. Task II consists of research and additional outreach projects that are funded by NOAA/NESDIS. Task III includes additional research and outreach projects that are funded by agencies other than NOAA/NESDIS.

A. Task I: CIOSS Core Office Administration and Outreach

Provides general administrative support for CIOSS research and core outreach activities (all Themes). Task I includes but is not limited to the following activities:

1. General operation of CIOSS, including providing salaries for the Administrative Program Specialist, Director, Deputy Director and other administrative staff members, as they are added to the CIOSS office;
2. Necessary funding for domestic and international travel for the Director and CIOSS staff;
3. Publication of the annual and other reports, newsletters, articles, brochures, etc.;
4. Outreach activities supported by the annual core funding from the Oceanographic Research Applications Division (ORAD), primarily the organization of workshops and short courses, sponsored by CIOSS. CIOSS may also help to organize workshops sponsored by other agencies, on topics included in the CIOSS Research Themes.

B. Task II: CIOSS Research and Additional Outreach, Funded by NOAA/NESDIS

Provides support for research projects in CIOSS' Research Themes; provides support for outreach beyond that covered in Task I (additional workshops and short courses, formal and informal education, improvement of data access). Task II includes all activities funded by NESDIS offices, except those included in Task I (core administration and outreach). These include projects funded by ORAD through the annual omnibus proposal, along with other projects funded by NESDIS, through proposals addressed to specific funding opportunities. Details of these projects will be developed in each proposal.

C. Task III: CIOSS Research and Outreach, Funded by Agencies other than NOAA/NESDIS

Provides support for research projects in CIOSS' Research Themes and outreach projects, similar to those in Task II, when funded by agencies outside of NOAA/NESDIS. Details of these projects will be developed in each proposal, as specific opportunities are identified.

IV. SUMMARIES OF ACCOMPLISHMENTS DURING THE SECOND YEAR

This report covers the period from April 1, 2004 through March 31, 2005.

A. Task I: Administration

Activities of the CIOSS office during the second year included: efforts to hire post-docs in research projects identified as the first priorities during the first two years; logistical support for workshops; design and improvements to the CIOSS web page; planning and support for meetings for the Council of Fellows and Executive Board; budgeting and preparation of required reports and communication with program managers and support staff within NESDIS. At the end of the second year, the Administrative Specialist, Janine Kobel, moved to another position within the University and a new Administrative Specialist was hired (Amy Vandehey). Ms. Vandehey started at the end of March, 2005. These activities are described in more detail below.

Six post-doc positions were identified during the first year for the top priority research projects. Two were hired and began work in year 1. Two were hired during year 2 and are now working on their projects. Two more have now been hired and will start this summer. These six projects are identified below under Task II Research.

The primary workshops held during the second year were two workshops that initiated the COAST (Coastal Ocean Applications and Science Team) activities and a workshop on Ocean Vector Winds. CIOSS will continue to coordinate workshops for both of these ongoing activities and initiate workshops on new topics. CIOSS also helped to coordinate logistics for Andrew Bennett's Integrated Ocean Modeling workshop. The scientific content of these workshops is described below.

The web page (http://cioss.coas.oregonstate.edu/) has been maintained and highlights recent events within CIOSS, including the results of workshops. Maintaining and updating the web page is part of the responsibilities of the Administrative Specialist.

During the second year, the membership of the Council of Fellows was expanded to include ORAD members Paul Chang and Mike Ondrusek. Eric Bayler is a non-voting member, as is Director Ted Strub. Dudley Chelton chairs the Council. The full Council met on April 14, 2004, with Eric, Paul and Ricardo Letelier joining via phone. Local members of the Council met several other times during the year to discuss progress and form plans for coming events. The Council also serves as the review panel for proposed CIOSS projects. The local panel reviewed proposals in March 2005 and sent their recommendations to Eric Bayler, who solicited comments and suggestions from his Branch Chiefs and the ORAD Council members and approved the proposed projects with minor changes.

An Executive Board provides general guidance to CIOSS regarding policies, research themes, and coordination with other institutes and agencies. There are presently five voting members of the Board, three from NOAA (the AA for NESDIS, the Director for ORA and the Director of PMEL) and two from OSU (the Dean of COAS [Chair] and the Director of Oregon Sea Grant). There are two non-voting, ex-officio members of the Board (the Director of CIOSS and the chair of the Council of Fellows). The first meeting of the Executive Board was scheduled for late May 2005, but was postponed until the end of August because of scheduling conflicts.

As requested, CIOSS contributed a report on its activities to Fran Holt (ORA), which is included as an appendix to the CoRP Report. CIOSS also contributed to COAST documents, including a white paper on the GOES-R Coastal Waters Imager, the GOES-R Risk Reduction Plan and a brochure on the Coastal Waters Imager. CIOSS coordinated publication of the brochure through the COAS Publications Office.

The last of the major "founding documents" is the Five-Year Plan. Work on this plan continued during the second year. CIOSS submitted a draft of this document to ORA's Eric Bayler and Marilyn Moll for review in December, 2004. After revising the document to accommodate their suggestions, the final Five-Year Plan was sent to ORA/ORAD in May, 2005.

CIOSS personnel (Ted Strub, Janine Kobel and Matt Wahl) attended the Directors and Administrators Meeting in Fort Collins during June 7-8, 2004. Subsequently, Carol Wallace replaced Matt Wahl as the COAS fiscal manager, responsible for CIOSS accounts. Carol and Janine participated in a number of conference calls with Marilyn Moll and other administrators from other CI's. Carol Wallace and Janine Kobel attended a NOAA Grants Administrators Workshop, focusing on the use of the electronic "Grants Online" and "Grants.Gov" systems. The Administrative Specialist, Amy Vandehey, as well as Carol Wallace, will attend this year's Administrators Meeting at CREST in New York City in October.

During the second year, discussions continued concerning the need for greater NOAA interactions at CIOSS and the possibility of extended visits by NOAA personnel to CIOSS. One visit is presently planned. Dick Reynolds (NESDIS NODC) will spend a month in Corvallis this summer, working with Dudley Chelton to improve the spatial and temporal resolution of the SST fields produced routinely by NODC. In addition, Laury Miller (NESDIS/ORAD) has plans for one or more short visits to CIOSS (several weeks) to help with plans to produce surface velocity fields that combine altimeter, scatterometer and coastal radar data. These fields would cover the broad coastal area, within several hundred kilometers of the coast. Laury Miller's appointment as NESDIS Branch Chief for Ocean Dynamics and Data Assimilation provides even more incentive for a visit to strengthen collaborations with CIOSS.

To further increase NOAA interactions, both Ted Strub and Dudley Chelton visited CIRA in Fort Collins (at different times) to discuss possible collaborative projects. Ted Strub visited after the directors meeting in June, 2004. In October 2004, CIOSS Fellow Dudley Chelton visited CIRA and presented a seminar entitled, "Global Evidence for Air-Sea Interaction from Satellite Observations and Operational Numerical Weather Prediction Models." At the end of March 2005, Dudley visited NESDIS in Camp Springs, MD to participate as a member of the Hiring Committee for the Branch Chief of the Ocean Dynamics and Data Assimilation Branch (formerly known as the Laboratory for Satellite Altimetry). While in Camp Springs, Dudley also gave a seminar in the Joint Center for Satellite Data Assimilation (JCSDA) seminar series. The title of the seminar was "The Impact of SST Specification on Surface Winds in Numerical Weather Prediction Models."

Another connection has been established between CIOSS and the CoastWatch (NESDIS) node in Monterey, CA, specifically between Ted Strub and David Foley (CoastWatch). Initial discussion began during a visit of Mike Laurs (PFEL) and David Foley to CIOSS, continued within the context of IOOS workshops on observing systems, and during a visit of Ted Strub to the CoastWatch node. Both CIOSS and CoastWatch provided supporting letters for a proposal to the NOAA "Environmental Literacy" Request for Proposals (RFP), and will continue collaborations on new products and technology to deliver those products to the public.

In order to develop specifications and documents describing the HES-CW sensor (Hyperspectral Environmental Suite-Coastal Waters), planned for GOES-R, a proposal for two COAST workshops was submitted and approved in October 2004. This is a three year proposal for ongoing support of the COAST team's preparations for HES-CW.

In February, CIOSS held a meeting of all Fellows that could attend in Corvallis, at which the Director presented a summary of activities of the previous year. A change in emphasis for research projects was described – concentrating on directed research projects that addressed CIOSS Themes and ORAD priorities, with funding for personnel other than post-docs. New proposals for research projects were solicited. In March, the CIOSS Council met as a review panel and selected the proposed project to forward to Eric Bayler. Eric solicited reviews from ORAD personnel and asked for a full proposal, with minor suggestions. The final "Annual Omnibus Proposal" included these projects, plus one project in the R2O (Research to Operations), funded by Stan Wilson (NESDIS) and four previously reviewed projects in the US GLOBEC program, funded by Beth Turner (NOS).

An additional proposal has been submitted to the R2O program (NESDIS, Stan Wilson). These are one year proposals involving ocean winds and ocean color. Two additional proposals are being submitted. The first is a one year proposal to the GOES-R Procurement program, administered by John Pereira (NESDIS). The second is a three year proposal to the GOES-R Risk Reduction (GOES-R3) program administered by Paul Menzel (NESDIS). This is a major proposal for a suite of GOES-R3 projects, both within CIOSS and at other institutions.

Publication of Reports:

Cooperative Institute for Oceanographic Satellite Studies: Initial Report February 11, 2004.

Cooperative Institute for Oceanographic Satellite Studies: Semi-Annual Report May 26, 2004.

Cooperative Institute for Oceanographic Satellite Studies: Year 2 Annual Progress Report (this report). Draft submitted, May, 2005.

Resubmission of CIOSS Five Year Cooperative Plan, May 11, 2005.

Other Publications:

COAST White Paper - The Coastal Ocean Applications and Science Team (COAST): Science Support for Using GOES-R/HES for Imaging Coastal Waters

COAST Brochure titled - Coastal Waters Imaging on GOES-R: A Key Component of the Integrated Ocean Observing System

B. Task I: Core Outreach

Core Outreach activity falls under Task I, above.

- Our major effort under the theme of **Formal Education** is a collaboration with **SMILE (Science and Mathematics Investigative Learning Experience)**. During its first year, CIOSS established a partnership with the SMILE program to develop curricular material for its high school program. This material is based on CIOSS Research

Themes, emphasizing oceanographic uses of remote sensing and mapping, with applications in the coastal ocean. During the second year, CIOSS proposed to NESDIS, and was granted, an additional amount of funding ($40K) to support SMILE in the first year of the use of the material in the public school districts where SMILE works (approximately 12 districts in Oregon). Within the context of the annual "High School Challenge," the SMILE coordinators worked with the NOS HazMat office in Seattle, since the theme of this year's Challenge was an oil spill. Teachers' workshops were held in August 2004 and January 2005 to hand out materials and train teachers for the High School Challenge that was held in April 2005. There was another teachers' workshop, held during May 19-21, 2005 in Newport. The major themes were: exploring the Marianas Trench; assessing student learning in enrichment environments; and behind-the-scenes tours and research at the Oregon Coast Aquarium and Hatfield Marine Science Center.

- A workshop (**Formal Education)** was held on the methods used to retrieve vector winds from satellite sensors (active and passive) on February 8-10. The workshop was hosted by CIOSS (Dudley Chelton and Mike Freilich), NESDIS (Paul Chang) and the National Hurricane Center at the Florida International University in Miami. It was titled; "Satellite Measurements of Ocean Vector Winds: Present Capabilities and Future Trends". The workshop brought together research and operational users to examine present and potential future missions and data sets related to near-surface ocean vector wind measurements. Participants established the measurement requirements for research and operational applications of satellite observations of ocean vector winds. Participants formulated and provided recommendations to NASA and NOAA regarding their development of future missions, new data products, and support for new scientific investigations. The participants expressed the desire to continue to hold similar workshops.

- The two COAST workshops were also held and are described (below) under Task II: Additional Outreach.

- Under the theme of **Informal Education**, discussions continue with HMSC (Jon Luke) and "Informal Education" (Shawn Rowe) about not only setting up public displays at HMSC, but involving those in the new Informal Education program in the design and evaluation of those displays. Molly Phipps (OSU), who is coordinating the SMILE activities, has begun a PhD program within the newly formed program at OSU in Informal Education. We are now discussing the possibility of Molly designing a display at HMSC, which would use CIOSS themes, as part of her PhD Thesis work. Shawn Rowe has submitted a proposal to the NOAA "Environmental Literacy" program (NOAA's Office of Education and Sustainable Development), as described under Task III: Additional Outreach.

C. Task II: Core Research Funded by NESDIS

During its first 2 years, the CIOSS strategy has been to use its core funding to hire post-docs to work on key CIOSS Research Themes. Initially, three post-docs were hired. Results from these activities are presented in more detail in the Research Appendix. This activity falls under Task II, above. Three new post-docs are now, or will soon be, joining CIOSS.

1. **Modeling- John Allen and Paul Choboter**

   Analysis of fields from coastal ocean models. Paul Choboter (CIOSS post-doc), working with CIOSS Fellows John Allen and Roger Samelson, has analyzed the fields from John Kindle's (NRL, one of the CIOSS partners) model of the California Current, looking at the dynamics of the poleward undercurrent. He has also pursued theoretical investigations of upwelling systems. These projects provide metrics against which data assimilation models can be evaluated. This contributes to the research theme of **Ocean-Atmosphere Models and Data Assimilation**.

2. **Ocean Optics- Ricardo Letelier and Iain MacCallum**

   Phytoplankton physiology as determined from satellite and ship-board optical measurements. Iain MacCallum (CIOSS post-doc) is working with CIOSS Fellow Ricardo Letelier and has assembled the data sets necessary to compare satellite and ship-board optical measurements. Analyses of the combined data sets will be carried out within the COAST project. CIOSS supports 50% of this effort, which contributes to the research themes of **Satellite Sensors and Techniques** and **Ocean-Atmosphere Fields and Fluxes**.

3. **Surface Radiation- Jim Coakley and Guang Guo**

   Estimates of surface radiation from satellite fields. Guang Guo (CIOSS post-doc) is working with CIOSS Fellow Jim Coakley, assembling a data set of radiation data from research cruises with satellite imagery from the same times and locations. These data sets will be used to evaluate and improve methods of estimating surface radiation from satellite data. This addresses the CIOSS research themes of **Satellite Sensors and Techniques** and **Ocean-Atmosphere Fields and Fluxes**.

4. **Surface Winds – Mike Freilich and Hai-Ying Jiao**

   Field-wide validation of WindSat. CIOSS Fellow Mike Freilich is currently working with CIOSS post-doc Hai-Ying Jiao who is performing "field-wide" validation of WindSat data, from coincident swaths of WindSat and QuikSCAT. Hai-Ying will also work on methods of increasing the resolution of surface wind fields, derived from satellite sensors. This contributes to the research themes of **Satellite Sensors and Techniques** and **Ocean-Atmosphere Fields and Fluxes.**

5. **Data Assimilation in Coastal Models - John Allen, Gary Egbert, Robert Miller and Byong-Ju Chois**

   Assimilation of altimeter and coastal radar data. Byong-Ju Chois will begin working as a CIOSS post-doc this summer, developing techniques to assimilate satellite altimeter and surface radar data into nested coastal circulation models. This will contribute to the research theme of **Ocean-Atmosphere Models and Data-Assimilation**.

6. **Mesoscale Circulation from Satellites and Radar – Ted Strub, Michael Kosro and Martin Saraceno.**

   Combination of altimeter, scatterometer and coastal radar. Martin Saraceno will begin working as a CIOSS post-doc this summer, with the goal of developing methods to combine coastal radar data with multiple satellite altimeter and scatterometer data sets, in order to quantify the mesoscale variability in surface circulation off Oregon. This contributes to research themes of **Satellite Sensors and Techniques, Ocean-Atmosphere Fields and Fluxes** and **Ocean-Atmosphere Analyses**.

Two additional projects were funded by NESDIS and completed in year 2, involving GIS.

7. **GIS- Dawn Wright**

   Marine GIS and Satellite Remote Sensing for Ocean and Coastal Resource Management
   Graduate Students: Peter Bower, Michele Punke
   Undergraduate Interns: Craig Graham, Lisa Reilly, John Robinson, Kidus Yared

   SUMMARY
   The goal of the work performed under this grant was the augmentation of existing mandates of CIOSS (expanding research in satellite remote sensing, satellite data management and use access technology; increasing recruitment and outreach, including undergrad, grad and post-grad education), with a particular emphasis on the integration of satellite remote sensing data with geographic information systems (GISs) for ocean and coastal resource management applications. We also sought to address problems of data access and usability of satellite remote sensing data for the community of coastal and ocean resource managers and policy makers in the Pacific Northwest and elsewhere, which is a continuing goal. This, along with the outreach and education activities performed in collaboration with our Science and Math Investigative Learning Experiences (SMILE; smile.oregonstate.edu) and Native Americans in Marine and Space Sciences (NAMMS; www.oce.orst.edu/native/), Programs at OSU, as well as with the NOAA Coastal Services Center (CSC), may help to establish the broader connectivity between NESDIS and the new Coasts, Estuaries, and Oceans (CEO) Program within NOS, particularly as it relates to the transition of research to operations.

8. **Ocean Bottom Mapping- Chris Goldfinger**

   Geologic and Geophysical Bottom Character Database for U.S. West Coast Groundfish, Oregon
   Habitat Team: Chris Romsos, Andrew Lanier, Daniel Wisdom, Natalie Reed

   SUMMARY
   As harvest levels for northeast Pacific groundfish fisheries continue to shrink, increasing attention is turning to conservation strategies and to the complex questions of the contribution of habitat to the productivity and long-term sustainability of fish stocks.

   The goal of this project is the creation and use of a comprehensive, helpful and easily accessible, multi-layer GIS database of the geologic and geophysical data for the Oregon

continental margin. The project expands on previous work that has been underway for several years, allowing us to use additional data and techniques to improve and assess the quality of habitat mapping on the continental margin of Oregon and Washington.

We are producing this database in both ERDAS and ArcGIS formats, and distribute it on a platform-independent CD-ROM and via the web to managers, fishermen, NGO's and interested parties. The datasets are being made available via the web on an existing web site. Formats and standards will be compatible with other ongoing and proposed fisheries databases.

D. Task II: Additional Outreach Funded by NESDIS

The Two COAST Workshops:

GOES-R Coastal Water Imager

NOAA has formed the Coastal Ocean Applications and Science Team (COAST) to evaluate HES-CW (Hyperspectral Environmental Suite with Coastal Waters imaging capability) threshold and goal requirements and recommend priorities for the goals, and involve the broader oceanographic community to help NOAA achieve their objectives for HES-CW. In summary, HES-CW: a) will allow a major advance in our ability to monitor and manage the coastal ocean; b) if built to the threshold requirements, will meet the basic needs for coastal imaging; c) if built to meet the goal requirements of hourly imaging and hyperspectral imaging, will provide significant additional benefits; and d) data will be key for the planned development of nowcast and forecast models for the coastal ocean.

NOAA HES-CW applications include:

- Water quality monitoring
- Coastal hazard assessment
- Navigation safety
- Human and ecosystem health awareness
- Natural resource management in coastal and estuarine areas
- Climate variability prediction (e.g., carbon cycle)
- Landscape changes
- Coral reef detection and health appraisal
- Development of Nowcast and Forecast models of the coastal ocean

E. Task III: Additional Research, funded by other agencies

Oceans and Human Health grant for Peter Strutton

This is a grant from OAR/OGP, not a CIOSS amendment, but it is closely related to the GOES-R work. Pete Strutton and Michelle Wood (U. of Oregon) are funded (by NOAA/OAR/OGP) to investigate the optics and other aspects of Harmful Algal Blooms (HABs) in the ocean off Oregon. The efforts include both in situ observations and satellite data analysis. This work will be coordinated with the COAST research and contribute to that effort. It represents the beginning of what CIOSS expects to be a growing effort in HAB research within CIOSS.

F. Task III: Additional Outreach, funded by other agencies

As mentioned under Task I: Core Outreach, Shawn Rowe has submitted a proposal to the NOAA "Environmental Literacy" program. If funded, this project will establish partnerships between CIOSS, the OSU/Sea Grant Informal Education program, CoastWatch, PMEL, GLOBEC, the Institute for Learning Innovation and others. The priority addressed is the innovative presentation of NOAA science and earth observing data through educational data visualizations and other educational tools. One aspect of the proposed work is the use of the HMSC public wing as a laboratory to study the effective design and evaluation of public display technology in delivering NOAA products to the public.

V. HIGHLIGHTS OF CIOSS ADMINISTRATION & OUTREACH ACTIVITIES

CIOSS Director Ted Strub and Eric Bayler established periodic calls to coordinate activities. Janine Kobel and, later, Amy Vandehey (CIOSS Administrative Specialists) took part in periodic conference calls with Marilyn Moll and other administrators.

2004

Apr 7-9: The National Research Council (NRC) Climate Research Committee (CRC) met April 7 and then held a two-day joint workshop with the Coordinating Committee on Global Change. At the CRC meeting, CIOSS Fellow Jim Coakley was assigned to serve as the CRC Liaison for the ongoing NRC study of NOAA Climate Data Records from Operational Satellites. The joint workshop focused on aspects of implementing the U.S. Climate Change Science Plan and the development of a future NRC study of Earth Observations from Space.

Apr 14: The CIOSS Council of Fellows met, with Ricardo Letelier, Eric Bayler, and Paul Chang joining by phone. Topics included: the Year 1 Progress Report; the Year 2 core Proposal; the 5-Year Plan; outreach (SMILE and OMSI/HMSC); the Vector Wind workshop; Bennett's ITR workshop; visits by personnel from CIRA and CoastWatch; GOES-R SWT for CWI (Letelier); CREST workshop on aerosols; and research by present post-docs.

Apr 14-16: CIOSS Fellow Ricardo Letelier attended the NASA Ocean Color Research Team (OCRT) Meeting at the Marriott Metro Center in Washington, DC. This was the first meeting since the OES re-competition for MODIS ocean science, and algorithm validation took place. The discussions and presentations were centered on: 1) the future of Ocean Color as an operational product; 2) new possible NASA multispectral, hyperspectral, and Lidar missions; 3) the funding status of SeaWiFS; and 4) the selection of core MODIS ocean products to be made available routinely to the community through what was known as the SeaWiFS/Simbios Project (http://oceancolor.gsfc.nasa.gov/). Ricardo Letelier will be involved with work groups to define the Ocean Color Products selection and with Calibration/Validation.

Apr 27-28: Research Scientist Dusanka Zupanski and Deputy Director Ken Eis from the Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University visited CIOSS to discuss possible collaborations on data assimilation and other topics of mutual interest with colleagues at CIOSS. Dr. Zupanski presented the seminar "Data Assimilation and Model Error Estimation," and Dr. Eis presented "Overview of CIRA's Research and Possible Collaborations with CIOSS." One topic of possible collaboration is the simulation of Top of the Atmosphere (TOA) radiation in bands proposed for future satellite sensors. The TOA radiances in the visible and IR bands on the GOES-R Coastal Waters Imager would be of strong interest.

Apr 27-28: CIOSS Fellow Jack Barth attended the first meeting of the National Science Foundation's (NSF) Ocean Research Interactive Observatory Network (ORION) Executive Steering Committee in Washington, DC. The committee will play the lead role in generating the Science Plan and the Project Execution Plan for NSF's Ocean Observatories

Initiative. He will help communicate opportunities for coordination between CIOSS activities and NSF's observatory science plans.

May 3-5: CIOSS Fellow Jim Coakley attended the CALIPSO Science Team meeting in Nice, France. CALIPSO is a joint U.S.-French satellite mission flying a LIDAR and imaging infrared radiometer for characterizing the properties of aerosols and clouds, particularly thin cirrus. CALIPSO is scheduled to be launched jointly with CloudSat April 15, 2005. The two satellites will fly on formation with Aqua, creating what is referred to as the A-train.

May 5-7: CIOSS Fellows Jack Barth and Mike Kosro attended the second organizational meeting of the Northwest Association of Networked Ocean Observing Systems (NANOOS) (http://www.nanoos.org) in Portland, Oregon. NANOOS is one of the regional efforts of the Integrated Ocean Observing System (IOOS) currently being organized by Ocean.US. NANOOS continues to evolve a governance structure that will be able to receive federal funds and spend them on Pacific Northwest Ocean observing system components. The group included "better access to satellite data and products, delivery and distribution" as one of its priorities for the national IOOS backbone.

May 10: Eric Bayler (NESDIS/ORA/ORAD) is contributing to CIOSS half the funds needed to allow Oregon State University's Science & Math Investigative Learning Experience (SMILE) Program to implement a high school curriculum during the 2004-05 school year. These funds will allow SMILE to hold a teacher training workshop in August to train teachers in the use of material used in their after-school SMILE clubs. CIOSS continues to seek funds to allow SMILE to hold the culminating "High School Challenge" event, during which teams of high school students solve an integrated environmental problem, using skills in mapping, oceanography, and remote sensing—skills developed throughout the year in the SMILE club activities.

May 10: Alan Strong and William Skirving (NESDIS/ORA/ORAD) visited CIOSS to discuss their Coral Reef Watch (CRW) project. They discussed the use of scatterometer winds and coastal radar surface currents in improved monitoring and prediction of coral bleaching. They presented the seminars: "Corals and Climate: Beyond Natural Variability?" and "The Interaction of Coral Bleaching and the Hydrodynamics of a Reef."

May 10-13: CIOSS Fellow Ricardo Letelier co-chaired (with John Pereira from NESDIS) a session on "Ecosystem-Based Management" at the GOES-R User Conference. Ricardo will also serve on the newly established Science Working Group for the Coastal Waters Imager on the GOES-R satellite.

May 27: CIOSS's second semi-annual Progress Report was sent to NOAA/NESDIS/ORA (Eric Bayler and Marilyn Moll).

June 3-4: CIOSS Fellow Andrew Bennett hosted a modular ocean data assimilation workshop (Information Technology Research or ITR) at COAS. Activity in this project is designed to rationalize software development in oceanography, specifically software that combines computer models of the ocean with observations of the ocean. Models that survive testing will have credibility for the analysis and forecasting of the state of the ocean, and for the design and assessment of observing systems. CIOSS helped coordinate logistics and workshop materials, communicated with participants, and set up participant lodging.

June 7-9: CIOSS Director Ted Strub attended the NESDIS Cooperative Institutes Directors' workshop in Fort Collins, Colorado. After the meeting, Ted met with the following research scientists at CIRA: Manajit Singupta, Stan Kidder, Mark DeMaria, Bill Cotton and his group, a group of CIRA/ATS scientists, Don Hillger, Tomi Vukicevic, Ken Eis and Dusanka Zupanski.

June 8-9: CIOSS Administrators Janine Kobel and Matt Wahl attended the NESDIS Cooperative Institutes Administrators' workshop in Fort Collins, Colorado. Marilyn Moll facilitated the meeting. Janine and Matt met all the administrators of the other four Cooperative Institutes (CICS, CIMSS, CIRA, CREST).

June 14: CIOSS Fellow Dawn Wright hosted two undergraduate students, affiliated with the Native Americans in Marine and Space Sciences (NAMSS) and Indian Education Office, in her lab on summer internships related to CIOSS activities. Interns Craig Graham and Lisa Reily integrated new additions to the Oregon Coastal Atlas, including Landsat, MODIS, and AVHRR satellite imagery. They also worked with graduate student Peter Bower on setting up an Open GIS Consortium (OGC)-standard Web Map Service (WMS) interface to metadata served from the Atlas in its capacity as a node of the National Spatial Data Infrastructure. In addition, two other undergraduates traveled to the NOAA Coastal Services Center (CSC) in Charleston, SC to work on various GIS and remote sensing projects as paid interns. The NOAA CSC interns are Geography undergraduate John Robinson, and Computer Science undergraduate Kidus Yared. They spent mid-June through August at CSC, with airfare and summer stipend paid for by the NOAA/NESDIS CIOSS Cooperative Agreement. Both are African-American. They received additional training at the center and worked on various projects, assisting staffers there in the GIS Integration & Development and the Coastal Remote Sensing program areas of the Center.

August 10: The first SMILE teacher training workshop was held, led by Melissa Feldberg and Peter Bower, both of OSU.

September 20-24: CIOSS Fellows Dudley Chelton and Roger Samelson attended and gave presentations at the IEEE/IGARSS meeting in Anchorage, Alaska: "The dispersion characteristics of westward propagating sea level variability" (Chelton and de Szoeke); and "Solitary Rossby waves in the ocean" (Samelson, de Szoeke and Chelton).

September 29-30: Coastal Applications and Science Team (COAST) meeting #1, Corvallis, Oregon, hosted by CIOSS.

Meeting Objectives:

- Review the GOES-R Project, HES studies, and threshold requirements and goals for imaging coastal waters.
- Review the potential applications to be addressed by imaging coastal waters.
- Start addressing relationships between applications and requirements; are the threshold requirements adequate? How do we prioritize the goal requirements?
- Prepare outline of brochure; start drafting text and collecting illustrations.

Week of October 4: The 3-year COAST proposal was submitted.

October 14: CIOSS Fellow Dudley Chelton visited the Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University Fort Collins and presented the

seminar "Global Evidence for Air-Sea Interaction from Satellite Observations and Operational Numerical Weather Prediction Models."

November 8-10: CIOSS Fellows Dudley Chelton and Andrew Bennett attended the CLIVAR Workshop on Ocean Reanalysis at NCAR in Boulder, CO. Andrew co-chaired a working group on "Uncertainties, biases, estimation errors and assimilation techniques". Dudley gave a presentation titled, "SST influence on surface winds."

December 8-9: CIOSS Representatives Janine Kobel and Carol Wallace traveled to Washington, DC for NOAA's Grants Administration workshop.

2005

January 19: CIOSS Council of Fellows meeting held.

January 20: All local CIOSS Council of Fellows members held a meeting in Corvallis where the Director, Ted Strub, presented a summary of activities of the previous year. The change in emphasis for research projects was described – concentrating on directed research projects that addressed CIOSS Themes, with funding for personnel other than post-docs. New proposals for research projects were solicited.

January 24-25: The second meeting of the Coastal Applications and Science Team (COAST) was held in Portland, Oregon, hosted by CIOSS.

Meeting Objectives:

- Review HES-CW requirements; prioritize the goal requirements.
- Review the white paper and finalize it. Review the brochure and give direction so that it can be finalized.
- Review proposed GOES-R Risk Reduction activities. Edit the list and suggest other activities.
- Plan advocacy activities for the next 6 months.

January 28-29: SMILE conducted the second teacher training workshop for use of the new oceanographic curricular material. Five new activities were introduced by Peter Bower, including an online GIS web site, where students could map oceanographic data in the Oregon coastal ocean.

February 8-10: Satellite Measurements of Ocean Vector Winds: Present Capabilities and Future Trends workshop, Florida International University, Miami, hosted by CIOSS and the National Hurricane Center. The workshop brought together research and operational users to examine present and potential future missions and data sets related to near-surface ocean vector wind measurements. Participants established the measurement requirements for research and operational applications of satellite observations of ocean vector winds. Participants formulated and provided recommendations to NASA and NOAA regarding their development of future missions, new data products, and support for new scientific investigations. PowerPoint presentations and the agenda of the workshop can be found on the CIOSS web page (http://cioss.coas.oregonstate.edu/) under "Workshops/Miami (FL) Workshop on Ocean Winds, Feb 2005".

February: The Five-Year Plan was sent to ORA/ORAD for final review and comments.

February: The 2 COAST workshops have resulted in recommendations for the sensor specifications, a white paper describing applications that will become possible due to data from this sensor, modifications to the GOES-R Risk Reduction Plan that address needs in the coastal ocean, and a brochure that can be used to educate members of the community about the benefits of a HES-CW sensor. The brochure is called Coastal Waters Imaging on GOES-R. It features Coastal Monitoring in the Next Generation of GOES, Satellite Imagery for Coastal Resource Management and efforts for the future. The plans for risk reduction for GOES-R ocean data products were presented by CIOSS Fellows Curt Davis and Mark Abbott at the Annual GOES-R Risk Reduction meeting in Silver Spring, MD on February 22-23. The brochure and a PowerPoint presentation summarizing the GOES-R HES-CW plans can be found on the CIOSS web page (http://cioss.coas.oregonstate.edu/) under "Workshops/Portland (OR) COAST GOES-R Workshop, Jan 2005".

March 22-24: CIOSS Fellows Mike Freilich and Dudley Chelton attended the NASA Ocean Vector Winds Science Team Meeting in Seattle. Dudley gave a presentation titled, "An assessment of the accuracy of SST influence on low-level winds in numerical weather prediction models."

March: The CIOSS Council met as a review panel and selected the proposed project to forward to NESDIS/ORA (Eric Bayler), which was approved with minor modifications. The CIOSS omnibus proposal for year 3 was then submitted on March 23.

April 14-15: CIOSS and The Science and Math Investigative Learning Experience (SMILE) Program are collaborating on an oceanographic curriculum for 12 high school after-school clubs that meet throughout the school year. SMILE has held two teacher-training workshops on the Oregon State University campus to introduce teachers from SMILE's rural and minority school districts to oceanography, remote sensing, and mapping. The culmination of these after-school club meetings was the SMILE High School Challenge, a one-and-a-half-day event, during which SMILE high school club members, teachers, and volunteers convened at Western Oregon University and Oregon State University to play out a disaster scenario. This year's challenge was called, "Reaction, Action and Remediation of an Oil Spill".

April-May: CIOSS efforts are expanding within two NOAA initiatives: (1) The Research-to-Observations (R2O) project led by Stan Wilson (NESDIS); and (2) the GOES-R Risk Reduction (GOES-R3) research led by Paul Menzel (NESDIS). Supplemental proposals have been submitted for four R2O projects concerning improved wind fields for operational use, specifications for ocean color Climate Data Records and evaluation of re-engineering plans for the next ocean color cal/val buoys. A supplemental proposal is being prepared by members of the COAST team for GOES-R3 projects, to be directed by Curt Davis in CIOSS and to include CIOSS Principal Investigators at OSU, NESDIS and other academic and federal institutes.

VI. APPENDIX 1: HIGHLIGHTS OF THE RESEARCH & OUTREACH ACCOMPLISHMENTS

A. Task I: Outreach

1. The "Ocean Vector Winds" Workshop, held February 8-10, 2005

Background and Objectives of the Workshop

Satellite measurements of ocean surface vector winds (both speed and direction) are increasingly used in operational as well as research activities. Over the open ocean, scatterometer observations are analyzed extensively by the oceanographic, meteorological, and climate research communities. For coastal studies, recent analyses suggest that very high-resolution winds may be obtained from special processing of the QuikSCAT data and from the Synthetic Aperture Radar (SAR). Operationally, global, near-real-time scatterometer data are routinely assimilated into national and international global numerical weather prediction/analysis systems. In the U.S., QuikSCAT measurements are provided in real time to NWS weather forecasters through the AWIPS and N-AWIPS systems, and high-resolution radar backscatter cross-section and vector wind data are analyzed and distributed operationally for ice edge and severe weather/cyclone forecasting.

A polarimetric radiometer (WindSat) was launched by the U.S. Navy in January 2003. Six months of ocean vector wind data (September 2003 through February 2004) based on the first version of the wind retrieval algorithm were released in July 2004. These interim data are available for analysis at http://podaac.jpl.nasa.gov/windsat.

Looking ahead to the near-term future, a dual-swath, C-band scatterometer instrument (ASCAT) will be launched by EUMETSAT on the METOP-1 satellite in late 2005.
The objective of the Satellite Vector Wind Measurement Workshop, sponsored jointly by the NOAA/OSU Cooperative Institute for Oceanographic Satellite Studies, and NASA, is to bring together operational users and researchers from a broad range of scientific disciplines to:

- Review and refine satellite vector wind measurement requirements;
- Identify new data products that can be generated from QuikSCAT, WindSat and ASCAT measurements;
- Identify new and different scientific studies and operational applications that require vector wind data with greater spatial resolution, temporal sampling, and/or accuracy than can be obtained from present and planned future missions.

The recommendations from this Workshop, to be distributed in the form of a report, will be used to inform NOAA and NASA in the development of future missions, new data products, and support for new scientific investigations.

B. Task II: Research Funded by NESDIS

1. Modeling – John Allen and Paul Choboter (post-doc)

Project Description – Models of the California Undercurrent

One of the primary research themes of CIOSS is the use of satellite-derived fields to force and evaluate numerical models of the oceanic and atmospheric circulation. Progress in understanding coastal circulation dynamics provides an opportunity to improve the utility of satellite-derived fields in both the evaluation and the forcing of numerical models. Postdoctoral Research Associate Paul Choboter has been working with John Allen and Roger Samelson to evaluate numerical models of coastal circulation, with an emphasis on the dynamics of the poleward undercurrent and wind-driven coastal upwelling.

Wind-driven upwelling remains an incompletely understood process in the coastal ocean. Although there is a rich literature focusing on this process, few theoretical studies have made progress beyond the linear approximation. The work of Pedlosky (JPO, 1978a, b) is a notable exception. He focused on the nonlinear inviscid dynamics of upwelling below the surface Ekman layer, and found analytical solutions to the reduced-dynamics model he derived. However, the solution derived for the steady-state problem contradicted the long-time limit of the time-dependent solution of the initial-value problem. This inconsistency has made the physical interpretation of these solutions difficult, and has limited their utility as illustrative models of the nonlinear upwelling response.

Choboter et al. (JPO, 2005) derived a new analytic solution of the nonlinear, time-dependent Pedlosky upwelling model. This new solution resolves the contradiction between the two previous solutions described above. The new solution displays the characteristic lifting of isopycnals typically observed during upwelling, and contains a surface equatorward jet that develops rapidly in the upper interior, as well as a deep poleward undercurrent that grows slowly to a significant velocity if there is a poleward pressure gradient present to drive it. Subsequent analysis of the steady-state Pedlosky model with topography, supported by numerical simulations using a primitive-equation ocean model, has focused on conditions for which the Pedlosky solution breaks down, and has identified a nonlinear, inviscid mechanism for bottom-intensification of deep onshore flow over the continental shelf break (Choboter et al., in preparation).

The observed poleward undercurrent over the continental slope along the west coast of the U.S. (often called the California Undercurrent) is a persistent subsurface feature found over the continental slope. Poleward undercurrents are ubiquitous features of eastern boundary currents over the globe, but the mechanisms generating and maintaining such undercurrents remain poorly understood. To address these issues, Choboter is analyzing the dynamics of the poleward undercurrent in simulations using the Naval Research Laboratory's Navy Coastal Ocean Model (NCOM). This research includes process studies using NCOM and the Regional Ocean Modeling System (ROMS). The NCOM undercurrent appears to be driven by large-scale alongshore pressure gradients. Work is in progress to identify the mechanism that generates these pressure gradients.

Candidate mechanisms include the interaction of large-scale poleward density gradients with the sloping bottom topography, and the effects of spatial and temporal variations in wind stress. This work applies to the CIOSS Research Theme 3: **Ocean-Atmosphere Models and Data Assimilation**.

Manuscript in preparation
Topographic Effects in a Nonlinear Model of Upwelling, P. Choboter.

*See end section for published papers.

2. Ocean Optics – Ricardo Letelier and Iain MacCallum (post-doc)

Project Description – Remote Sensing of Optical Properties

Remote sensing measurements and recovery algorithms, such as those from the MODIS ocean color products, can be validated if the optical characteristics of the water column are known. Such optical characterization can be achieved using ship borne WetLabs AC9 attenuation and absorption measurements. These measurements have been made off the Oregon coast using two WetLabs AC9s running in parallel, one of which was equipped with a 0.2 micron filter to remove particulate matter. This arrangement makes it possible to separate the contribution of particulates from the contribution of soluble matter to the attenuation and absorption spectra. Similar measurements have been made as part of the Hawaii Ocean Timeseries (HOT) project, and also using an Autonomous Underwater Vehicle (AUV) deployed off the Oregon coast. This falls under the CIOSS Research Themes of **Satellite Sensors and Techniques** and **Ocean-Atmosphere Fields and Fluxes.**

Project Progress and Status

A suite of data algorithms have been developed to process data collected by WetLabs AC9 absorption and attenuation meters. These scripts and algorithms collate and validate AC9 data, and then perform various temperature, salinity and scattering corrections. Additional algorithms have been developed to process WetLabs AC9, Satlantic OCP-200, and Satlantic ISUS data collected using a Bluefin Autonomous Underwater Vehicle (AUV), and to merge this data with the AUV's navigational logs and data from other instruments in the payload (SeaBird CTD, Microsoar scalar turbulence meter). Currently in development are algorithms to process GLOBEC data, which involves merging ship flow thru data with fluorescence data and navigational data – many of these routines are shared with the HOT and AUV processing algorithm libraries.

Reusable and fully automated scripts have been developed to complete end to end processing of HOT and AUV data sets, allowing the easy insertion of additional data as it is collected on future cruises. Similar scripts are under development to control processing of GLOBEC data.

At present, the validation and analysis of remote sensing data has not yet begun. Once the in situ optical data set is assembled, coincident data from the MODIS sensors on both Terra and Aqua satellites will be collated. Data from the SeaWiFS sensor will also be collated for coincident analyses of all three satellites and in situ data. Using these

data sets, methods will be developed to infer in situ particle size distributions from apparent optical properties such as the diffuse attenuation coefficient, which can be estimated from satellite color sensors. Data from the SeaWiFS and MODIS satellite sensors will be compared to *in situ* measurements of particle attenuation, particle size distribution and chlorophyll content. The proposed work will attempt to (1) relate satellite estimates of the coefficients of absorption, scattering, and chlorophyll concentrations to *in situ* measurements of particle size distribution (PSD), particle attenuation and chlorophyll concentrations; (2) relate particle size distributions to very coarse characteristics of phytoplankton species composition; and (3) characterize the spatial and temporal variability of phytoplankton distributions and characteristics in the large-scale coastal ocean off northern California and Oregon during the period when satellite coverage is available. These distributions will also be related to results of the other CIOSS investigations, namely the numerical models of coastal circulation and mesoscale circulation features determined from altimeter and coastal radar fields, the available PAR and the mesoscale surface wind stress fields.

3. Surface Radiation – Jim Coakley and Guang Guo (post-doc)

Project Description – Satellite Derived Climatology of Surface Radiative Fluxes for the Northeastern Pacific

The Clouds and Earth Radiant Energy System (CERES) project has as a goal estimating instantaneous surface radiative fluxes for single CERES fields of view (25-km) to within 20 Wm^{-2}. The project relies on a mix of satellite-observed coarse spatial resolution broadband radiances, which are obtained from the CERES radiometers on Terra and Aqua, high spatial resolution multispectral imagery, analyzed meteorological fields, and radiative transfer modeling to estimate the fluxes. For regions like the northeastern Pacific, there are, as yet, no reliable surface-based observations of the radiative fluxes to be compared with the space-borne estimates. For many years, shipboard pyranometers and pyrgeometers have been deployed for measuring the radiative fluxes at the surface, but the observations are rarely used and they are often thought to be of poor quality. The goal of this study is to assess the usefulness of shipboard pyranometer and pyrgeometer observations in assessing the performance of satellite derived estimates of the surface radiation budget. If the assessment indicates that the shipboard data can be used, then comparisons of the shipboard measurements will be made with the CERES estimates of the fluxes. The broadband and multispectral imagery data used by the CERES project will then be adapted for other sensors such as AVHRR and GOES-West so that ultimately a reliable multiyear climatology of surface radiative fluxes can be constructed for the eastern Pacific. The climatology will be compared with that derived from CERES and also from GEWEX. Similar adaptations should likewise facilitate the extraction of surface radiation budget estimates from the NPOESS VIIRS and could be used to assess the quality of the NPOESS IORD for surface radiative fluxes in the eastern Pacific.

The strategy for assessing the usefulness of the shipboard observations is to begin with observations under cloud-free conditions. Cloud-free conditions offer the best opportunity for understanding the performance of the shipboard radiometers through comparison with the results of radiative transfer models and with the CERES estimates. For the northeastern Pacific, cloud-free conditions entail temporally stable surface radiative fluxes with relatively low humidity and low aerosol burdens. Radiative

transfer models have been demonstrated to predict the surface fluxes under such conditions to within a few percent, close to the accuracies of the shipboard radiometers. This falls under the CIOSS Research Themes of **Satellite Sensors and Techniques** and **Ocean-Atmosphere Fields and Fluxes.**

Accomplishments

Jim Coakley and Guang Guo (post-doc supported jointly by CIOSS and NASA) are pursuing comparisons of the surface radiative fluxes observed with radiometers on the *Wecoma* and other research vessels for the northeastern Pacific. A scheme has been developed to identify cloud-free conditions using the temporal uniformity of the normalized shortwave flux in conjunction with the magnitude of the longwave flux. The normalized shortwave flux is the observed shortwave flux divided by the cosine of the solar zenith angle. As such the normalized flux becomes an index of the broadband transmissivity of the atmosphere. Under cloud-free conditions, the normalized shortwave flux is remarkably stable with time and the longwave flux generally attains a characteristically low value. The temporal uniformity of the shortwave flux is indicative of cloud-free conditions. Because of the broadband emission by water vapor, the longwave flux is relatively insensitive to clouds. While the longwave flux is stable with time under both cloud-free and overcast conditions, it shows only marginal variability under partly cloudy conditions.

Shortwave radiative fluxes have been calculated using an existing broadband radiative transfer model (Coakley et al. 2001). Under cloud-free conditions, the shortwave flux is relatively insensitive to the concentrations of water vapor and ozone in the atmosphere when compared with its sensitivity to the amount of aerosol. The aerosol model used in the calculation is the marine aerosol described by Hess et al. (1998). Comparing the observed shortwave flux identified as cloud-free with model calculations, the atmosphere would appear to have an extremely low aerosol burden and low humidity. The departures of the model from the observations are within 2% of the observed flux, which is probably better than one can expect from unattended radiometers of this class. Nonetheless, the discrepancies between the model and the observations motivates the need to investigate the accuracy of the radiative transfer model through comparison with models having more sophisticated treatments of absorption by the atmospheric gases. This work is currently underway.

Future Work

During the coming year, the accuracy of the shortwave radiative transfer calculations will be verified as discussed above. Once verified, model estimates of both the shortwave and longwave fluxes will be compared with the observed fluxes and with simultaneous estimates by CERES under cloud-free conditions. The algorithm used to find the cloud-free radiative fluxes will be employed to develop an ensemble of cloud-free cases for comparison. A broadband longwave model, similar to the shortwave model will be developed from existing radiation models to use in the comparisons. If results of the cloud-free comparisons suggest that the shipboard measurements are reliable, then a similar strategy will be developed for identifying overcast conditions based on the temporal statistics of the longwave and shortwave shipboard radiometric data. These observations will likewise be compared with model generated surface fluxes and CERES estimates.

An assessment of the performance of the shipboard radiometers will help existing efforts, like that undertaken by the CERES project, to further develop and test the use of satellite observations to infer surface radiative fluxes. In subsequent years, the proposal is to use CERES and MODIS observations to develop reliable methods that use narrow-band imagery data to estimate the surface radiative fluxes for oceans. Such methods can be used with existing geostationary and polar orbiter imagery data, and of course, can also be used with future NPOESS observations. The CERES project is currently exploring the use of narrow-band imagery data to time-interpolate the CERES broadband radiometer observations between measurements and to infer radiative fluxes at spatial resolutions that are finer than the 25-km scale of an individual CERES field of view.

References

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4. GIS - Dawn Wright

Research: GIS Mapping of the Coastal Ocean
(Note: This project was only funded during years 1-2. This represents the "final report" for this project.)

The main highlight was the compilation of oceanographic satellite data appropriate for covering specific areas, time periods of interest and coastal management questions for the Oregon coastal zone and territorial sea, and the successful incorporation of 40 of these satellite data layers into the Oregon Coastal Atlas (OCA, http://www.coastalatlas.net), an interactive map, data and metadata portal for coastal managers and scientists. This activity falls under the CIOSS Research Themes of **Ocean-Atmosphere Analyses** and **Outreach (Informal Education** and **Data Access).**

We started with acquisition of Multispectral Scanner System (MSS) Landsat data obtained from COAS and the OCMP, as well as surface temperature data derived from SeaWifs and AVHRR, which can be used in conjunction with sediment transport, historic buoy wave, and climate model information that are normally used in performing hazards risk analysis. These data sets have been converted to geotiffs or GIS-style grids that the MapServer software within OCA can read, as well as a supplemental ArcIMS site that Bower is preparing that will use these same data layers for the K-12 education modules that he is preparing for SMILE (see Education section below) and for his Master of Science thesis. The search and conversion has been fruitful, but a one-year time period has not been sufficient to incorporate all of the data that we would like to make available. Therefore work continues with the investigation of MODIS, AVHRR, SPOT data (10 m, 4 bands), Landsat 7, and any Ikonos or QuickBird data that we can access for the Oregon coastal zone (we currently have Ikonos data, and forthcoming QuickBird imagery for American Samoa which we may use as a test bed). As part of the deliverable for an FGDC grant that we have leveraged

to supplement Bower's summer funding, we have also set up an Open Geospatial Consortium (OGC)-standard Web Mapping Service (WMS) interface to some of these satellite data sets, and their associated metadata, in the capacity of the OCA as a node of geodata.gov (National Spatial Data Infrastructure). The WMS works by way of the supplemental ArcIMS that Bower has created.

Bower's Master of Science thesis will be completed and defended in the Spring of 2005. In it he will fully describe and document the aforementioned work, acknowledging the NESDIS CIOSS Cooperative Agreement as a source of funding, and discuss the general challenge that we have found in locating data that have been collected for the understanding of mesoscale ocean processes (10's to 100's of km) while many coastal resource management issues, such as coastal hazards occur at the km to m scale. His thesis will also include summary information regarding storage size, cost, refresh frequency and availability of oceanographic satellite data for specified areas and time periods of interest. At that time he will also work with Haddad to redesign and expand the "Ocean Areas" section of the OCA web site to showcase the satellite layers. By then a final version of his supplemental ArcIMS site will also be incorporated, which consist of an educational module targeted at territorial sea and ocean area managers dealing specifically with the range of specific types of oceanographic satellite data available to decision makers.

Also to be included in the OCA in the spring that we would like to report on (as another external leverage to the NESDIS grant) is the new Climate Module of the OCA, which is being completed by NOAA CSC in a cooperative agreement with OCMP and the Oregon Department of Geology and Mineral Industries (DOGAMI). This is essentially a live inundation tool that was funded and rolled into activities implementing the Coastal Storms Initiative. It consists of a built-in ArcIMS that takes live data from buoys and tide gauges on the coast (near real-time to the hour), as well as input from the user via a forms interface, then predicts flooding for a section of beach, predicts flooding (taking input from the user via forms interface). The live buoy and tide gauge data are draped on LIDAR data for beach geomorphology that DOGAMI has post-processed and made available for the tool. Version 2 of the prototype is slated to be released early next year before incorporation into the OCA. This exciting development is further summarized at http://www.csc.noaa.gov/id/grant_sum/or_land.html.

Technical Facilities

This grant made possible the acquisition of an HP ProLiant 380 DP Server, with dual 3.06 GHz Xenon processors, 4 Gb RAM each, 533 MHz FSB, two 70 Gb disk drives, connected by fiber optic card to the College of Science storage area network (SAN) for an additional 1.47 Tb of storage. The operating system of the server is Windows Server 2003, and the software installed is SQL Server 2000 and ArcSDE 9.0 (ArcSDE being a middleware that facilitates managing of large spatial vector data and satellite images in a database management system such as SQL Server). The primary purpose of this equipment is for the rapid storage and retrieval of the aforementioned satellite images, as well as bathymetric grids and other large spatial data sets for other projects in Wright's Davey Jones' Locker lab, and the linkage of these grids to the ArcIMS sites that we are building.

The grant has also made possible the requisite system administration, software upgrades and facility maintenance, GIS support and research assistance up to 200 hours by our Mark Meyers, lab manager. This has included exclusive access for Bower to

workstations with current GIS, image processing, statistical analysis, and publication software in Davey Jones' Locker and the Terra Cognita spatial analysis labs.

Outreach and Education

Under the theme of **Formal Education**, Melissa Feldberg, staff member within the SMILE program, worked with Janine Kobel, CIOSS Administrative Specialist, CIOSS Fellows and graduate students Michele Punke and Peter Bower, supervised by Wright, to develop high school curriculum material, based on the CIOSS Research Themes. Twelve public school districts in Oregon are involved in this activity.

Michele Punke, a Geosciences doctoral student, was hired for fall term 2003 to work with Feldberg on brainstorming and gathering materials for the development of GIS- and remote sensing-related educational materials for use in SMILE activities (e.g., SMILE Clubs and workshop sessions for SMILE K-12 teachers). They also outlined the structure of a year-long program for students and teachers leading up to a final "challenge project" ("Mapping and Understanding Oil Spills with Satellite Data) to take place at the end of the academic year (2005). Punke had applied for another fellowship that was much more in line with her dissertation research, the funding for which was approved near the end of 2003. Bower was then selected to replace Punke and continued work on the project for the remainder of the grant. In winter 2004 he began collecting resources and data sets that were incorporated into the educational program and challenge project.

Bower has assisted with several after-school "SMILE Clubs", and developed an educational module with a remote sensing focus for the SMILE New Teacher Workshop of August 9, 2004. He continues to develop content for the year-end "High School Challenge" and will also have completed the aforementioned ArcIMS site that will provide imagery from the OCA for students to explore.

Student Internships

In addition to the aforementioned activities, CIOSS had pledged as a deliverable geospatial skill development for two summer undergraduate interns at OSU (who were to work with senior personnel on projects involving both satellite data and GIS), as well as two summer minority undergraduate interns to be placed at the NOAA CSC in Charleston, SC. At OSU, Wright recruited and awarded summer internships to two Native American students, Craig Graham and Lisa Reilly. Graham is a geography major and a participant in the Native Americans in Marine and Space Sciences (NAMSS) program. Reilly is a Fisheries and Wildlife major and has participated in programs of the Indian Education Office. Both spent the summer of 2004 working in Wright's Davey Jones' Locker Lab, documenting and integrating new additions to the OCA, including Landsat, MODIS, and AVHRR satellite imagery, as well as working with Bower on setting up an (OGC)-standard WMS interface. To aid them in their work they received ESRI Virtual Campus training modules in ArcGIS (and free ESRI t-shirts).

For the NOAA CSC internships, Wright recruited and awarded internships to two African-American students, John Robinson, a geography major, and Kidus Yared, a computer science major. Both were resident at the CSC from mid June until late August 2004, and were required by Wright to send progress reports by email at least every 2 weeks. Both received introductory GIS and metadata training at the CSC, as well as tours of the facilities. They were then were placed in project teams, Robinson with the

Coastal Hazards group within GIS Integration and Development, and Yared with general CSC database programming and administrative support under the tutelage of developer Jason Marshall. This was a first visit to the east coast for both students, and they "survived" Hurricanes Frances and Gaston moving through the area (which was particularly exciting and relevant for Robinson as was tasked with hazard maps preparation during that time!). Although there were some difficulties in finding housing and transportation for the students in Charleston, it was tremendously valuable for the students and we would like to try this type of arrangement again in the future (given continued funding), ensuring especially that AmeriCorps housing would again be available and finding alternatives to having to rent a car for a 10-week period.

*See end section for published papers.

5. **Ocean Bottom Mapping- Chris Goldfinger**
(Note: This project was only funded during years 1-2. This represents the "final report" for this project.)

Project Status

During the past year under CIOSS funding, we have completed processing of a large bathymetric survey on the northern Oregon continental slope collected under separate NOAA funding in 2002. We have also completed and released new interpretations of sidescan data for Washington. We have worked closely with NOAA managers to identify problem areas and address known issues prior to an upcoming release of the habitat maps. The accurate mapping of all the above datasets is a long process, and the legal issues facing NOAA have required early release of maps that have known deficiencies. We have also continued to incorporate other as yet untapped video, sidescan, and bathymetric data as we progress toward a major new release in the next 6 months. We have also completed interpretations in inshore high-resolution sidescan and bathymetry data collected by ODFW.
For most of the report period the lab employed two full-time people, Research Assistant Chris Romsos, and student, Andrew Lanier who joined the project in the fall of 2003. Lanier has been supported through CIOSS funding for 2004. Laniers work involves processing the RV. Thompson 2002 multibeam survey of ~ 2500 km^2, and performing a nested seabed classification of the bathymetry and sidescan data, as well as existing ground-truth data such as core samples and video transects for habitat assessment. This classification in turn will be rolled in to the next version of the Oregon and Washington Habitat Database further described below. Lanier is also developing a geostability "layer" as part of his MS work in addition to a conventional habitat classification. This work will assess benthic habitat change and stability via oceanographic factors, geologic stability, and catastrophic change via earthquakes, tsunami, submarine landslides and storms (i.e. Kostylev et al., 2005). Data developed under this project and publications can be found at: http://activetectonics.coas.oregonstate.edu/, or our database release is available by CD on request.

Related Efforts

We are working closely with both the NOAA Fisheries Northwest and Southwest Fisheries Science Centers on closely related aspects of benthic habitat mapping in the Pacific Northwest and in the Southern California Borderland. In Southern California we have developed classified benthic habitat maps and products based on multibeam surveys

performed by our lab in October of 2003. In October of 2004, we participated with staff from the Northwest Fisheries Science Center in an Advanced Technologies Cruise in the southern California Borderland aboard the RV Thompson. This cruise was designed to test and develop methods to integrate separate data from ship mounted or towed sonars, ADCP, multibeam, satellite oceanographic data, and ROV data. We are also funded by the northwest center to continue developing habitat maps for the Essential Fish Habitat Environmental Impact Statement to be completed in Spring 2005.

Oregon Groundfish Geological and Geophysical Database

Many types of geological and geophysical data (e.g., seafloor bathymetry, sidescan sonar images, sediment and rock types, active fault zones, observations and measurements from submersibles) have been collected on the Oregon continental margin. While this represents one of the most extensive marine geologic databases in the world, most of these data are not integrated in a Geographical Information System (GIS) so that they can be utilized to characterize, classify and predict the distribution of geological features and associated biological entities. We integrated the datasets listed below into this database, designed for ease of use and interpretation. The interpretations were designed for use by both a lay audience and a scientific audience with no geologic background, however the data themselves were maintained at full resolution so they may be used for quantitative studies of the fisheries habitats of interest.

In November, 2003 we delivered a new release of habitat GIS layers to Pacific States Marine Fisheries Commission for use by NOAA/NMFS. This edition was also released to the public, and distributed at the Habitat Technical committee meeting in November 2003 in Santa Cruz CA. This incremental release is entitled "Active Tectonics and Seafloor Mapping Laboratory Publication 03-01: Seafloor Lithology Maps for Oregon and Washington Version 1.1" The habitat maps are now in use at the Northwest Fisheries Science Center and by numerous NGO's. Investigators there are beginning to integrate fisheries data and benthic habitat data to look for associations, and to assess the state of existing benthic habitat data in terms of future needs. Chris Romsos, who completed his MS in our lab in January 2004, and one of the producers of the habitat maps, is also engaged in this effort, in collaboration with NMFS investigators.

Publications

A manuscript detailing the results, development and techniques in the Groundfish database and has been submitted to the Geohab volume edited by Brian Todd and Gary Greene. Also completed this period was Chris Romsos' MS thesis, which was presented in January, 2004. Three papers were presented at the Geohab meeting in Galway Ireland and one to the 13th Annual Western Groundfish meeting in Victoria, BC.

*See end section for published papers.

C. Task II: Additional Outreach Funded by NESDIS

1. The SMILE Program: Scenario-Based Challenge Event for Underrepresented High School Students

The 2005 SMILE High School Challenge Event featured a realistic oil spill scenario. Students examined data to learn the extent of the spill, the direction of coastal currents, weather impacts, and the marine and coastal ecology of the area involved. Students worked on inter-club teams to collect data pertinent to the developing situation, examine options for oil recovery or remediation, develop a plan informed by the data, and implement strategies to communicate that plan.

Project Goals—The short-term and long-term goals of the NOAA/CIOSS partnership with The SMILE Program, are to: 1) engage researchers and graduate students in the development and delivery of club activities and problem–based scenario in a context of ocean sciences; 2) provide learning opportunities in ocean sciences for high school students in club settings and through an on-campus challenge event; 3) involve undergraduate and graduate students as mentors to facilitate team engagement and progress and to serve as college-student role models; 4) promote greater aspirations for and preparations to enter higher education among SMILE high school students; and 5) increase awareness of science-based careers among SMILE high school students.

Project Accomplishments— During the period of July 2004 – April 2005, the pre-challenge club activities and scenario for the Challenge were being developed and refined. SMILE worked with personnel from NOAA HAZMAT and Oregon Department of Environmental Quality to gain input for the scenario, as well as with COAS and Geosciences faculty and graduate students.

In August 2004, SMILE high school teachers were engaged in workshop sessions to support ocean sciences learning experiences for students in the clubs. COAS graduate students and SMILE faculty delivered activities designed to develop students' general understanding of the oceans as physical systems – making waves, comprehending currents, and tracking tides. Teachers received materials, supplies, and activities to use in the club meetings during October – December 2004. Fourteen of eighteen SMILE high school advisors attended this workshop. In the clubs, high school students engaged in ocean sciences-based activities and began to prepare for the on-campus Challenge.

In January 2005, the workshops sessions for teachers focused on activities to develop additional concepts and skills needed for successful engagement in the Challenge: mapping, oil-spill cleanup, and weather influences. SMILE teachers implemented these activities in the clubs during February and March 2005, using activities, materials and supplies provided by the project. Sixteen of eighteen SMILE high school club advisors attended this workshop. In their clubs, students had added learning opportunities to increase their ocean sciences-related concepts and skills. This was accomplished while the specific details of the Challenge remained unknown to the teachers and students.

On April 15 & 16, 2005, SMILE high school students engaged in the scenario-based challenge within the context of an oil remediation conference in Pete's Bay. Having gathered preliminary information, members from each student team functioned in various specialist roles to gain additional information to inform their teams' proposed plans. The specialist areas included: GIS mapping; oil recovery and remediation; shoreline habitat assessment; communications; oil spill modeling and probability; and weather. Using the information from each specialist area, teams developed and later presented their plans for allocating resources and methods to address the

near-shore oil spill. One hundred and forty-four of 213 high school SMILE students participated in the Challenge.

COAS and College of Science graduate students worked with SMILE to deliver two professional development workshop sessions for high school SMILE Club advisors. Graduate students and COAS faculty supported the delivery of the Challenge through content expertise for specialist areas and career role modeling. Undergraduate students from various departments served as team mentors and college role models. Thirty-six OSU students were engaged in the preparation for and delivery of the 2005 Challenge.

Problems Encountered—A change in SMILE staff occurred at a critical time in the startup of the new NOAA/CIOSS-SMILE partnership. This led to a shortened time frame for identifying and engaging appropriate partners, developing club activities and Challenge scenario, and ensuring a cohesive fit of all elements supporting the Challenge. Roles in the development and implementation of the challenge were not as well defined as they needed to be. As a result, the student event, while quite good, was not the very best it might have been. Learning from the experiences of this first partnership year, SMILE staff will ensure the development of a detailed scope and sequence for the high school challenge – to show: how the professional development activities relate to club activities; how these relate to the Challenge; the role of partners in the planning and delivery; strategies for engaging and supporting the partners; and well clarified roles for those with primary involvement.

Future Plans—The SMILE Program is excited about continuing its partnership with CIOSS and has begun planning for the 2006 High School Challenge. The Challenge will maintain an ocean sciences context with a specific scenario around fisheries management. Additional funding to support the ocean sciences-based challenge may be received through an NSF-funded Science and Technology Center (STC), a proposal that has been recommended for funding and awaits passage of FY2006 federal budget. As an outreach partner for the STC, The SMILE Program will use its high school challenge scenario as a pilot for a larger Coastal Challenge.

The collaboration between CIOSS and The SMILE Program is expected to lead to implementation of the club activities and Ocean Science Challenge with SMILE Clubs in Rhode Island. The Director of the University of Rhode Island's (URI) SMILE Program will travel to Oregon for teacher workshops where she will receive training and materials for use with students in club meetings. She will also receive information and materials for use in implementing the Ocean Science Challenge Event with Rhode Island SMILE students. She will work with scientists from URI and a nearby Environmental Protection Agency (EPA) research facility to bring the ocean science club activities to Rhode Island SMILE students and to host an Ocean Science Challenge Event.

Conclusion—The CIOSS-SMILE partnership used an established program and network to impact pre-college students and K-12 teachers by using the content expertise of ocean sciences faculty and graduate students to expand the learning opportunities for both students and teachers. The SMILE Program's campus-based Challenge Event remains an important part of Oregon State University's efforts to provide opportunities for underrepresented minority and other underserved students to get excited about learning science and math, to prepare for the academics of college, and to develop self-reliance and visions for the future. Challenge problems on oceanography topics will support SMILE students in gaining awareness of oceanography content and related technology far beyond what would be available to them in or out of the classroom. For some, it may spark an interest in pursuing an oceanography career. Through the partnerships CIOSS reached underrepresented students who have demonstrated an

interest in science and mathematics, classroom teachers of mathematics and science, and underrepresented community members around the state of Oregon.

2. COAST Workshops

Monitoring the Coastal Ocean with the GOES-R Hyperspectral Environmental Suite Coastal Waters Imager

Geostationary weather satellites, initiated in the late 1960s, have become a key part of the National Weather Service data stream used for operational weather forecasting. Today, the Geostationary Operational Environmental Satellites (GOES) continually observe the same area on the Earth to provide the near-continuous data that are critical to monitoring present conditions and providing input into weather forecast models. As these environmental satellites are continually being improved, we have an opportunity to develop a corresponding monitoring and modeling capability for the Nation's oceans. The National Oceanic and Atmospheric Administration (NOAA) is planning to include such a capability with the Hyperspectral Environmental Suite (HES) on the next generation GOES satellites, beginning with GOES-R, which is planned for launch in 2012.

The HES will be an instrument, or combination of instruments, that includes a capability for sounding the atmosphere and for imaging Coastal Waters (HES-CW). The HES-CW promises to revolutionize our understanding and management of U. S. coastal waters in the same way that the original GOES imaging has changed weather prediction over the last forty years. Much like the atmosphere, the coastal ocean is highly dynamic with strong currents driven by tides and winds. The current polar orbiting imagers can only provide ocean color images every day or two - too infrequent to characterize coastal variability. This coverage is further reduced by clouds and fog. However, with the increased frequency of sampling possible from a geostationary platform, we can sample when it is clear and frequently enough to see the major coastal events unfolding.

There is a growing concern about the health and future of the coastal ocean as expressed by the U.S. Commission on Ocean Policy in their report to Congress. In response Congress has already initiated an effort to establish an advanced Coastal Monitoring System and to improve coastal management practices to assure the future health of the coastal ocean for its many uses. The monitoring system includes the Integrated Ocean Observing System (IOOS) – the in-situ component, satellite remote sensing, and the development of advanced models of circulation and the transport of materials in the coastal ocean. A key part of that monitoring system is GOES-R HES-CW. HES-CW will provide the frequent imagery of the ocean surface that is needed to extend the in situ observations made by IOOS to the entire coastal zone. Additionally, HES-CW data will be essential for initiating and validating models of coastal ocean dynamics.

How Does A Geostationary Sensor Improve Our Ability to Monitor and Study the Coastal Ocean?

As planned, HES-CW will have significantly improved temporal, spatial and spectral sampling over existing and other planned satellites, which will greatly enhance our

ability to monitor and assess the dynamics of the coastal ocean. The following sections discuss the advantages of these key improvements.

Improved Temporal Sampling

The addition of a capability to view coastal waters from a geostationary platform will provide the management and science community with a unique capability to observe the dynamic coastal ocean environment. Tides, diel winds (such as the land/sea breeze), river runoff, upwelling and storm winds drive coastal currents that can reach several knots. Furthermore, currents driven by diurnal and semi-diurnal tides reverse approximately every 6 hours. A minimum sampling frequency of three hours, as planned for HES-CW, is required to resolve these features, and to track water masses containing harmful algal blooms, oil spills or other features of concern for coastal environmental management that are driven by these currents.

Federal and state agencies are responsible for the management of fisheries, monitoring of water quality, protection of marine sanctuaries and marine mammal habitats, assessing the effects of storm events and other issues related to the use and protection of the coastal ocean. Each of these management responsibilities require an improved understanding of coastal ocean dynamics. Considerable progress has been made in our ability to monitor ocean color and temperature in the open ocean using the polar-orbiting satellites. However, the present once-a-day coverage from polar-orbiting satellites, which is further limited by clouds, is not sufficient to sample the dynamics of the coastal ocean. The geostationary platform with HES-CW will improve our ability to obtain usable imagery several times a day to resolve, among others, the effects of tides and wind events on coastal currents, and to understand changes in coastal water features that occur over a daily cycle. This capability will greatly improve our ability to manage coastal resources just as GOES imagery has improved our ability to monitor and forecast the weather.

Ocean color imaging requires sunlight and cloud free scenes. One advantage of geostationary imaging is the ability to wait until an area is cloud free, rather than sampling at one fixed time as set by the orbit for current polar orbiting ocean color imagers like SeaWiFS and MODIS. Plans for GOES-R include adaptive sampling to optimize cloud free imaging. For example, HES-CW imaging may be scheduled using the cloud maps from the Advanced Baseline Imager (ABI also on GOES-R) that images the entire U. S. and coastal waters every few minutes. The ABI is designed for cloud imaging, it has a limited set of bands and the gain is set to image clouds with the ocean as a black background. While it will not image ocean features it is ideal for queuing HES-CW which will have the appropriate bands and sensitivity for ocean imaging. This approach will maximize the collection of cloud free scenes from HES-CW.

The capability to obtain frequent cloud-free imagery will be an important asset to water quality monitoring because surface currents can alter phytoplankton and sediment distributions near the coast and because phytoplankton growth rates that approach a doubling per day can rapidly alter water quality. Monitoring of water quality parameters from satellite, particularly from coastal regions susceptible to harmful algal blooms, is improved by the capability to access imagery on any given day. Presently, ocean color images are used to estimate the size and extent of *Karenia brevis* blooms in the Gulf of Mexico. For example, the Florida Fish and Wildlife Conservation

Commission is responsible for monitoring hundreds of miles of coastline for this harmful algal bloom species, which causes neurotoxic shellfish poisoning. This monitoring information is used by the state agencies to adapt their sampling strategies to effectively and efficiently monitor beaches and shellfish harvesting areas. These agencies need access to up-to-date cloud-free imagery to design sampling strategies and plan field surveys. The frequent image acquisition available from a geostationary platform will improve the chances of obtaining a cloud-free image and allow imagery collected at different times of the day in a given region to be combined to generate daily cloud-free coastal ocean color scenes for the entire region.

Higher Spatial Resolution

The U. S. coastline is very complex with many sounds, bays and estuaries. In terms of area coverage the 300 m spatial resolution planned for HES-CW is approximately 10 times better than the approximately 1000 m resolution currently available from polar orbiting ocean color imagers (0.1 km^2 per pixel compared to 1 km^2). While the polar orbiting imagers can monitor the centers of only the very largest and widest estuaries in the country, the HES-CW can examine most of the small and tributary estuaries. This higher spatial resolution will provide a new capability for monitoring over 100 significant estuaries and provide sufficient information on complex areas like Chesapeake Bay, Puget Sound and the Florida Keys. The frequent imagery from HES-CW will significantly improve our ability to monitor water quality, large oil spills, harmful algal blooms and other issues that are critical to the management of these areas. The imagery will also aid the development of ecosystem models for these important areas. Applications will include the management of marine sanctuaries, providing harmful algal bloom and other health warnings and improved management of fisheries using the Essential Fish Habitat approach for key commercial and sport fish stocks.

Improved Spectral Resolution and Sensitivity

In addition to the increase in temporal resolution, another advantage of geostationary imaging is that the sensor can stare at an area of interest for extended periods of time. Thus it is possible to do high spectral resolution and high signal-to-noise imaging from geostationary platforms.

River runoff, suspended sediments, colored dissolved organic matter, large phytoplankton blooms and bottom reflectance in shallow water all add to the complexity of the optical signal in coastal waters. Current sensors do not measure the light in enough different wavelengths to permit separating these materials. However, obtaining many wavelengths requires more signal. The HES-CW, by staring, can detect more light at any wavelength. Because there is sufficient signal, the spectra may be divided into more channels increasing the ability to resolve coastal features. While the threshold requirement is that HES-CW is a multispectral instrument with 14 spectral bands, a key goal is that it be a hyperspectral instrument. Experience with airborne systems and Hyperion on NASA's EO-1 spacecraft has shown that the continuous spectra obtained with a hyperspectral instrument can greatly improve our ability to resolve the complexity of the coastal ocean.

Developing Future Applications

HES-CW is primarily an operational instrument designed to meet the needs of NOAA and other agencies responsible for the management of coastal resources. However, the HES-CW capabilities make it possible to address new scientific questions which could lead to future operational capabilities. For example, beyond the physical mixing by winds and tides, the biology of phytoplankton is also changing on an hourly basis. Phytoplankton typically have a daily cycle of photosynthesis and cell division. With HES-CW we will be able to measure changes and the dynamics of phytoplankton chlorophyll concentration and chlorophyll fluorescence over the day. This changing ratio will give new insight into the health and productivity of coastal oceans.

The vertical migration of some key harmful algal bloom species like *Karenia brevis* is another important biological light driven cycle. Frequent sampling with HES-CW will allow us to characterize this cycle which may be valuable for identifying and tracking harmful algal blooms. If there is no visible bloom at 10 AM, and then high levels of sea surface chlorophyll are observed at 1 PM, this will likely indicate that we are observing a bloom of a vertically migrating species in these waters. This approach will be potentially very useful for Florida and California where the common harmful algal bloom species migrate vertically. The information on vertical migration is also a critical input into models that are being developed to track harmful algal blooms.

HES-CW instruments will be included in the long term GOES series beginning with GOES-R. This long term data record can be used to quantify inter-annual to decadal changes in coastal flow patterns, ecosystem dynamics, and organic matter transfer across land-air-sea interfaces. This will require the development of climate quality data records. The use of HES-CW data for this application requires well calibrated data, a very stable sensor and the processing and archiving of climate data records. This data set will be extremely valuable for assessing the effects of global climate change on the U. S. coastal environment.

Finally, the long term goal is the development of now-cast and forecast models for the coastal ocean. Just as weather satellite data has been essential for developing today's weather models HES-CW data and in-water data from the IOOS will be essential for the development of coastal ocean models. HES-CW data will be essential for initiation and validation of models for coastal water quality and phytoplankton biomass and productivity.

What is Happening Now?

Industry is now involved in the process of designing the HES. The HES is any instrument or combination of instruments that meet the following threshold tasks: two atmospheric sounding tasks, which include Disk Sounding (DS) and Severe Weather/Mesoscale sounding (SW/M), and a shelf and coastal waters imaging task (CW). Based on competitive bid proposals, three companies (BAE, ITT and Ball Aerospace) were selected in June 2004 to do two-year initial design and risk reduction studies for HES. During the first year, the contractors will look more at requirements and assess options/trade-offs for implementation. During the second year they will concentrate more on developing their design to build HES. As in any spacecraft system

there will be strong competition between instruments for space, weight, power and other resources on the spacecraft. It is important to monitor this process and assure that the HES-CW requirements will be met by the proposed designs.

To assure that ocean applications and science requirements are met NOAA has established the Coastal Ocean Applications and Science Team (COAST) to create consensus scientific oversight of this process. The immediate task for COAST is to review the nominal coastal ocean threshold and goal requirements being used as the basis for the HES studies. It will be important to clearly articulate the applications, particularly those that are operational, and how each is dependent on specific requirements. If there are to be recommended changes to the nominal requirements, the contractors needed to know those recommendations by January 2005. Following this initial effort COAST will be merged into the GOES-R Risk Reduction Program in 2006. The COAST role within the GOES-R Risk Reduction Program will be to lead the effort to guarantee that the HES-CW data can be effectively used for coastal ocean applications and science. The purpose of the GOES-R Risk Reduction Program is to prepare for the evaluation of the ABI, HES, HES-CW radiances, to develop advanced products, and to assess the utility of the improved measurement capabilities in NESDIS, NWS, NOS and other NOAA Line Office operations. These efforts will demonstrate the GOES-R capabilities to both public and private sector users in an efficient, effective and timely manner. It will pave the way for a subsequent smooth operational implementation.

Future Returns

There is a growing concern about the health and future of the coastal ocean as expressed by the U.S. Commission on Ocean Policy in their report to Congress. Congress has already initiated the effort to establish an advanced Coastal Monitoring System and to improve coastal management practices to assure the future health of the coastal ocean for its many uses. HES-CW will provide critical data for that monitoring effort. HES-CW will provide the frequent views of the ocean surface that is needed to extend the in situ observations made by IOOS. Additionally, HES-CW data will be essential for initiating and validating models of coastal ocean dynamics.

D. Task III: Additional Research, funded by other agencies

1. Oceans and Human Health Grant: Optical tagging and tracking of water masses for prediction of human health hazards - Peter Strutton, Oregon State University and Michelle Wood, University of Oregon

Introduction and Objectives

The incidence of harmful algal blooms (HABs) and the persistence of individual HAB events are increasing along the coast of Oregon. This recently funded Oceans and Human Health project will use signals in remotely sensed sea surface temperature (SST) and ocean color (chlorophyll and MODIS fluorescence) to (1) identify conditions that are favorable to blooms of toxic species, and (2) identify and track the blooms themselves. We will focus on the species responsible for the production of domoic acid (*Pseudo-nitzschia*) and saxitoxins (*Alexandrium*).

Specifically, we plan to couple the existing physical, bio-optical and toxin data to understand the oceanographic and ecological factors leading to the genesis of HABs in the vicinity of Heceta Bank. Our objectives are as follows:

- Perform a retrospective analysis of existing toxin data in conjunction with satellite and *in situ* physical/bio-optical data. Determine the combination of physical and biological precursors leading to the occurrence of toxins in the waters over Heceta Bank and subsequently in coastal shellfish. Identify the time of year at which these conditions commonly occur. Do they occur at the same time every year?
- Use this increased scientific understanding to quantify the likelihood of a HAB event based on the physical and bio-optical properties of the coastal ocean off Oregon.
- Conduct our own sampling to test and refine these ideas.
- Conduct our own sampling to determine the optical characteristics (markers) of toxic blooms so that they can be tracked remotely.
- Extend this knowledge to a large-scale predictive capability by using the remotely-sensed analogs of these physical and biological properties to predict, quantify and track HABs.
- Collaborate with our federal partners (CoastWatch) to develop remote sensing 'products' or 'markers' that can be disseminated for early detection and management of HABs.

Proposed work for 2005

A collaboration has been established with Raphael Kudela at UC Santa Cruz, whereby the two groups will exchange satellite data – mostly archives of SeaWiFS and MODIS ocean color data. We will also share the data processing and analysis of these data. This will consist of archiving the US west coast data into searchable subsets, and performing analyses aimed at detecting SST and chlorophyll fronts – potential sites of HAB generation.

This satellite data analysis component will be combined with an examination of existing data describing the location, timing and duration of saxitoxin and domoic acid in shellfish at sites along the Oregon coast. The database extends back 25 years, but coverage is best for the last 6 years. This time period coincides with the SeaWiFS and MODIS data records. The coastal data will be used to target particular time frames for examination of *in situ* physical and biological data, satellite imagery (the searchable archive just described) and archived plankton samples. Through her collaboration with Deb Cannon of the Oregon Dept. of Agriculture, Michelle Wood will continue to maintain a regularly updated database on the occurrence of toxins in shellfish on the Oregon coast for reference by this project.

Vera Trainer of the Northwest Fisheries Science Center has agreed to share the data set of domoic acid concentrations collected during 1998. For the purposes of determining correlations between toxin concentrations and physical/biological conditions in the coastal ocean, this represents a relatively small data set, but it will enable us to develop initial ideas which can be refined as we incorporate data from field seasons in 2005 and 2006.

Field work planned for 2005 includes day trips aboard OSU's Elakha and participation in two longer cruises via a collaboration with Bill Peterson at NOAA's Northwest Fisheries Science Center. These cruises will be used to refine our field techniques and gather more ground-truth data for comparison with satellite imagery. Also in 2005, we plan to meet with other west coast HAB researchers (UCSC, MBARI, UW, NOAA Fisheries) to ensure that our techniques for detection and enumeration of toxic species are consistent.

E. CIOSS Research Projects Proposed for Year 3

Proposals submitted or planned for submission for year 3 include the following projects.

1. CIOSS Year 3 Omnibus Proposal, PI: Ted Strub, $1,310,000

Project 1. Davis-Butts: Development of an Oceanographic Remote Sensing Curriculum for the SMILE High School Program.

During 2004-05, curricular material developed within the SMILE (Science and Math Interactive Learning Experience) program at OSU are being used in the after school SMILE club activities at high schools in 12 Oregon school districts. SMILE has chosen these districts because of their high proportion of students from groups that are under-represented in college attendance and especially in math and science. These students will come together for the annual High School Challenge on April 14-15, 2005. During this event, teams of the high-school students are presented with a real-life problem that they have to research and address over the two-day period. This is the first year that an oceanographic topic has been used and the students will face an oil spill in the coastal ocean, for which they will have to design a remediation strategy (with multiple demands from teachers, grad students and professors, who will play the roles of advocates for different community and resource interests). Preparation for this event includes participation by the HazMat group located at PMEL in Seattle, including use of their wind-driven model of surface trajectories for spill products.

CIOSS proposes to continue this activity during the 2005-06 school-year. Development of the curricular material will continue and a variation of the Challenge situation will be designed. The funds requested represent approximately half of the cost needed to run the high school program for one year. The program will continue looking for additional sources of funding to fill out the needed support, but the support requested here will assure the continuation of the program for another year.

This project primarily addresses CIOSS Research Theme 5 (A5, outreach, in the form of formal education).

Project 2. Letelier and Strutton: Sensor and Data Intercomparison for GOES-R Risk Reduction: Spatial and Temporal Resolution Thresholds/Goals.

With separate funding from NESDIS, CIOSS is leading the efforts of a multi-institutional team of satellite ocean color specialists and plankton biologists (called COAST, the Coastal Ocean Applications and Science Team) that is charged with establishing the requirements for a hyper- or multi-spectral sensor on the next generation of geostationary satellites (GOES-R). This sensor is part of the

Hyperspectral Environmental Suite, referred to as the Coastal Water Imager (HES-CW). This proposal is for research that will establish the "thresholds" (minimum requirements) and "goals" (preferred requirements) for spectral and spatial resolution of this sensor, within the context of specific coastal ocean applications. It also includes support for workshops that will facilitate communication between those engaged in this research.

The project proposed here will use data from the hyperspectral Hyperion sensor (220 bands covering wavelengths of 0.4-2.5 micrometers) to increase our understanding of the requirements needed for HES-CW to succeed in its intended applications. Data from Hyperion will be averaged and subsampled (in space and wavelength) to produce data with possible GOES-R sampling characteristics, providing input to the COAST program. This work will also use previously collected data from moored optical sensors off Oregon to demonstrate the benefits of the temporal sampling made possible by geostationary coverage (data every 1-3 hours) to resolve dynamic changes in phytoplankton physiology and distributions on time scales shorter than the daily coverage provided by polar orbiting satellites. A specific application of high priority is to identify techniques for identifying and tracking Harmful Algal Blooms (HABs). This effort complements work by P. Strutton and M. Wood on a newly funded 3-year grant to investigate HABs off Oregon.

This proposal addresses CIOSS Research Themes 1 (evaluating future sensors), 2 (improving 2-D fields) and 5 (outreach, informing the community).

Project 3. Barth: SST Fronts in the Northern California Current: The Development of an Ocean Observing System Data Product Based on GOES Imagery.

Jack Barth and his student (Renato Castelao) are collaborating with Tim Mavor in ORAD in mapping frontal locations off the Oregon coast during 2001-2004 (3.5 years). A number of ships surveyed this region during the summers of 2001, 2002, and 2003 and during the winter of 2004, providing ground truth during certain locations and times. The innovation is the use of GOES data, which has larger pixels due to the viewing angle and the distance to the sensor, but also samples every 1-3 hours. With broken and moving clouds, the more frequent sampling allows one to construct daily composites with a greater percentage of cloud-free area. Work with the present GOES data also builds our experience with geostationary data, establishes statistics on the degree of clear pixels, etc.

The proposal is to continue working with Tim Mavor, developing the statistics on seasonal distributions of fronts. Results will be presented at the EGU meeting this spring and in a manuscript will be submitted. We plan to work with Dave Foley at the West Coast node of CoastWatch (in Monterey at PFEL), in order to develop a pilot product (maps of frontal locations) that could be routinely processed and served from the CoastWatch node. This product is of interest to the IOOS Regional Alliances for coastal ocean observing systems along the U.S. west coast.

This project addresses CIOSS Research Themes 1 and 2 (sensors and techniques; fields and fluxes).

Project 4. Chelton: SST Influence on Surface Wind Stress in Operational Forecast Models.

This project will investigate the strong air-sea interactions that are observed between satellite estimates of SST and surface wind stress on scales shorter than about 3000 km. Strong SST fronts affect the curl and divergences of the surface winds, which, in turn, drive the ocean currents and change SST. This coupling between SST and low-level winds is clearly represented in the surface wind stress fields from the ECMWF operational forecast model and, to a lesser extent, the NCEP operational forecast model. The difference between the ECMWF and NCEP representations of this ocean-atmosphere coupling appears to be primarily due to the more accurate and higher resolution SST fields used as the ocean boundary condition in the ECMWF model. Even with the better SST boundary condition, however, the ECMWF model underestimates the intensity of the SST-induced perturbations of the wind stress fields. This is evidently due to inadequacies in the parameterizations of boundary layer processes, or to insufficient horizontal or vertical resolution in the model.

In this proposed project, a post-doc research Fellow will work with Dudley Chelton, in collaboration with the operational forecast group at NOAA/NCEP to implement a better SST boundary condition to improve the accuracy of the NCEP surface wind stress fields. Additional work will include investigating methods of improving the accuracy of these SST-induced effects beyond what can apparently be achieved with an improved SST boundary condition alone. For example, it may be possible to utilize the QuikSCAT data more effectively in the NCEP and ECWMF assimilation processes, thereby compensating for problems with the boundary layer parameterization or grid resolution. It will also be of interest to determine the extent to which this SST influence on low-level winds extends above the atmospheric boundary layer.

This proposal addresses CIOSS Research Themes 2, 3 and 4 (improving 2D fields, improving modeling and analyzing scatterometer and AMSR SST data).

Project 5. Egbert, Kurapov, Samelson and Strub: A Pilot "Real-Time" Oregon Coastal Ocean Simulation System, Validated Using Satellite-Derived Products.

Egbert, Kurapov and Samelson have been developing methods to assimilate various types of data (surface currents from coastal radar, velocities from moorings, etc.) into coastal ocean circulation models (the Regional Ocean Modeling System, ROMS). To move forward with a pilot regional oceanic forecast system, they propose to use a regional implementation of ROMS covering the central Oregon coast. The model will initially be forced by the NOAA/NCEP "Eta" atmospheric model. Later, the possibility of forcing the model with QuikSCAT Wind Fields will be explored. The model will initially be set up as a periodic channel, to eliminate open boundary effects, and will not assimilate data in this pilot study. The model will start from climatological conditions and spin up for three weeks with the Eta model forcing (for the 3 week period prior to present), then continue for 3.5 days with the Eta 3.5 day forecast fields. The model will be run approximately twice per week.

In this pilot phase, the model prediction fields will be evaluated by comparison to available observations (satellite SST, radar surface velocities, moored velocities and temperatures, etc.). Although the fields will not initially be made available to the

general public, this activity will provide experience in running a coastal ocean forecast model and in evaluating the results. The initial model configuration will serve as a test bed for future extensions, including assimilation of satellite data, inclusion of surface and internal tides, inclusion of terrestrial freshwater run-off, implementation of open boundary conditions or nesting within larger-scale operational models and ecosystem modeling.

In parallel, Strub and James will evaluate several new satellite-derived products in the coastal ocean, help in the transition of these products to NOAA labs for distribution, and compare these products to the model forecast fields (above). The initial NOAA partners will be colleagues at the Pacific Fisheries Environmental Lab (PFEL) in Monterey, along with the CoastWatch node co-located at PFEL. This work will be conducted within the context of the IOOS effort in the Pacific Northwest (NANOOS), with the intent to determine which products are most useful. A longer-range goal is to work with colleagues in NOAA/ORAD (Laury Miller is the initial contact) to develop 2-D fields of surface velocities, based on combinations of altimeter fields, coastal radar fields and higher-resolution scatterometer winds (for the surface Ekman component).

The modeling and data analysis activities in this project address the first 4 CIOSS Research Themes (improving techniques for producing 2-D fields from new combinations of models and sensors; improved modeling, leading to DA; analyses of 2-D fields of surface winds, currents, SST, etc.).

Project 6. Freilich: Construction and Evaluation of Surface Wind Forcing Fields from WindSat and QuikSCAT.

In this project, a post-doc will work with Mike Freilich on research designed to compare, and ultimately combine, data from QuikSCAT and WindSat. Initial comparisons have identified specific problems with WindSat and improved retrieval algorithms, in partnership with colleagues at NESDIS and NRL. The proposed work will extend the point WindSat evaluation through analyses of collocated, simultaneous, spatially extensive fields measured by QuikSCAT and WindSat, using large patches of near-simultaneous, collocated measurements. These spatially extensive patches (hundreds to thousands of kilometers) are located over all but the highest latitude oceans.

We will also refine techniques for constructing vector wind fields combining WindSat and QuikSCAT, and accounting for their differences in accuracy, spatial resolution, and sampling.

Challenges exist owing to the differing accuracies and spatial resolutions of the two instruments, in addition to sampling differences near coasts and rain. Approximately 6 months of coincident QuikSCAT and WindSat data are available to calculate combined wind fields. This is similar to the period during which coincident data are available from two near-identical scatterometer instruments (SeaWinds on ADEOS-II and QuikSCAT). Characteristics of wind fields constructed from QuikSCAT and SeaWinds/ADEOS-II will be compared with those constructed from Windsat and QuikSCAT. Intriguingly, 3-satellite wind fields can be constructed during at least September-October 2003 (and possibly for the entire duration of the SeaWinds/ADEOS-II mission).

Reference:
Freilich, M.H. and B.A. Vanhoff, 2005: The accuracy of preliminary Windsat vector wind measurements: Comparisons with NDBC buoys and QuikSCAT. *IEEE Trans. Geosci. and Rem. Sens.*, accepted.

This project addresses CIOSS Research Themes 1 and 2 (improving sensors and techniques; improving 2-D surface fields and fluxes).

Project 7. Samelson and Skyllingstad: Coupled Ocean-Atmosphere Modeling.

This project continues work that has been funded by ONR for the past 2 years, developing high-resolution coupled (ocean-atmosphere) models in coastal domains. It was originally proposed to ONR with 50% support from CIOSS, but ONR funded the entire project. There will be another ONR proposal, but this proposal to CIOSS would keep the work going in the interim. More importantly, it will apply the modeling capabilities that have been developed to a problem directly related to CIOSS' interests – extending scatterometer data across the gap that is found next to the coast.

The effect of upwelling on SST is strongest in the regions immediately adjacent to the coast. In the same region, the structure of the atmospheric boundary layer (including surface winds) is affected by the presence of land and the strong gradients in SST. Unfortunately, satellite scatterometer winds cannot be retrieved in the 30km (approximate) next to the coast, precisely where we expect the strongest gradients in surface winds. Since wind stress curl in this region may enhance or suppress upwelling, it is important to find a method to extend the satellite-derived surface winds from offshore to the coast. High resolution atmospheric models may have this capability, but they must be coupled to the ocean, to provide the feedback between the wind-driven upwelling, SST and the effect of SST on the boundary layer and surface winds.

This project will continue the development of high resolution coupled ocean-atmospheric models over the coastal ocean and land. It will specifically address the degree to which model winds agree with the highest resolution scatterometer winds available (12 km or finer) in the region farther than 30km from the coast and with NDBC buoy winds available approximately 10 km from the coast and at the coast at a few locations. The results will provide a quantitative characterization of the behavior of surface winds in this region during fluctuating upwelling events. The longer-term goal is to develop improved coupled models that assimilate scatterometer winds in the offshore area and provide the winds in the scatterometer gap next to the coast.

This project addresses CIOSS Research Themes 2, 3 and 4 (improved 2-D fields and fluxes; improved modeling; and analysis of oceanic and atmospheric data.

Project 8. Freilich, Milliff and Stamus: Expanding the Impact of Satellite Surface Vector Wind Measurements on Coastal Operational Forecasts Produced by National Weather Service Forecast Offices.

This project was proposed to Dr. Stan Wilson within the context of the "Research to Operations" (R2O) project. Dr. Ralph F. Milliff (CoRA/NWRA) and Mr. Peter Stamus (consultant to CoRA/NWRA) will collaborate with the Principal Investigator, Dr.

Michael H. Freilich (OSU/CIOSS) on this project. Dr. Milliff and Mr. Stamus will develop a survey for coastal Weather Forecast Office (WFO) forecasters, based on prior experience from related surveys at the NOAA Ocean prediction Center and the NOAA Tropical Prediction Center. The survey will be designed to quantify the impact of surface vector wind information from satellite data sets (QuikSCAT; WindSat if available) on coastal forecasts and warnings issued by the WFOs. The survey will be mailed to all coastal US WFOs. Dr. Milliff and Mr. Stamus will follow-up the WFO survey with visits to 8 to 10 selected WFOs (to be determined). Dr. Milliff and Mr. Stamus will summarize survey results and describe illuminating case studies in a paper suitable for publication in a scientific journal.

This proposal is related to the workshops on ocean vector wind measurements and addresses CIOSS Research Themes 2, 4 and 5.

Project 9. Allen, Egbert, Miller and Kurapov. Core Modeling in the GLOBEC NEP Program, with Data Assimilation.

In this project, the PI's will nest a high resolution model of the mesoscale circulation in the Coastal Transition Zone (CTZ) within a model of the entire California Current System (CCS). The CCS model is, in turn, nested within a model of the entire North Pacific (extending to 20°S). The basin-scale and CCS models are run by colleagues at other institutions (Rutgers and the Lamont Doherty Earth Observatory). Solutions from the CCS model will be used to provide boundary information for the CTZ domain. The CCS model does not assimilate data (it may do so in the future). In the higher-resolution CTZ model, data assimilation will take the form of a variational generalized inverse (GI) method, developed under separate funding by Dr. Andrew Bennett at OSU. Data to be assimilated include satellite altimeter data and long-range HF coastal radar surface current measurements. Initial applications of the DA scheme would focus on correction of the boundary and initial conditions obtained from the CCS model.

This project directly addresses CIOSS Research Theme 3 and other criteria that call for modeling and the assimilation of satellite data into ocean models.

Project 10. Batchelder: Synthesis of Euphausiid Population Dynamics, Retention and Loss Under Variable Climatic Conditions.

In this project, data collected in the GLOBEC program (1996-present) on euphausiids off Oregon will be combined with two types of models: coupled bio-physical ecosystem models (Eulerian) and individual based models (Lagrangian IBMs). The physical circulation fields will be obtained from the GLOBEC core modeling efforts (Allen et al. at OSU; others at U. C. Berkeley, Rutgers and the Lamont-Doherty Earth Observatory). The Eulerian ecosystem models produce fields of nutrients and phytoplankton. The IBMs inject large numbers of euphausiid individuals into the models with prescribed behavior and follow the individuals over time. These models will be used to investigate the variability of euphausiid abundances, distributions and vital rates over a range of space and time scales. Further details can be found in the Appendix.

The work proposed in this project addresses CIOSS Research Theme 3 and other criteria related to models that include elements of the marine ecosystem, which will eventually be incorporated into coastal ocean observing and modeling systems.

Project 11. Kosro and Letelier: Latitudinal Variation of Upwelling, Retention, Nutrient Supply and Freshwater Effects in the California Current System.

This is the OSU component of a collaboration with colleagues at the University of Washington and Naval Postgraduate School to: a) synthesize data from moored current meters, shore-based HF radars, ship-based hydrographic surveys, and remotely sensed satellite data from the GLOBEC NEP and other programs into a coherent, best description of the mesoscale variability along the Pacific Northwest coast from 42º to 48ºN; and b) relate this physical variability to primary production, zooplankton distributions, and salmon year-class strength in the region. The long-term moorings will allow quantification of the relevant time scales from internal waves to the inter-annual; the satellite images of sea surface temperature and chlorophyll will show the spatial scales; and the HF surface fields will allow time- and space-varying statistics of the mesoscale currents and quasi-Lagrangian pathways to be assessed. The primary scientific objective will be to characterize the alongshelf variability in the upwelling, the nutrients it supplies to the photic zone for utilization by marine organisms, and the retention times of plankton. This variability is affected by the alongshore distribution of the wind stress and fresh water input, by the changes in the bottom topography and coastline orientation, and by pre-conditioning established by inter-annual variability and climate change.

This project addresses CIOSS Research Themes 3 and 4 (analyses of oceanic and atmospheric data with the goal of improving the 2-D fields by combining satellite and in situ data).

Project 12: Strub: Large-scale Influences on Mesoscale Structure in the CCS, A Synthesis of Climate-forced Variability in Coastal Ecosystems.

This is the OSU component of a collaboration with colleagues at the NOAA Pacific Fisheries Environmental Lab (PFEL) and the University of Maine. Strub provides the expertise in analyzing satellite data (altimeter, SST, winds). Dr. Andrew Thomas at U. Maine also analyzes satellite (color) data. Those at PFEL analyze in situ data and model output. The overarching goal of this project is to characterize the linkages between basin-scale variability indicative of climate events and local changes in mesoscale coastal ocean circulation and structure that impact marine populations, ecosystem structure and productivity. A variety of extreme climate events occurred during the period of the US GLOBEC NEP monitoring and process studies in the California Current System (CCS) (1997-2003). These provide an unprecedented opportunity to examine the full range of climate variability experienced by the CCS and its ecosystems. By relating these climate events to regional physical and biological observations, using multiple data sources (GLOBEC and other recent observations, historical data sets and reanalyses, satellites, circulation and physical-biological models), we can determine how these events affect mesoscale ocean variability in the CCS and its related target populations (the primary goal of the NEP program).

This project addresses CIOSS Research Themes 2 and 4 (improved fields from satellite data; analyses of oceanic and atmospheric data of diverse type).

2. CIOSS Supplemental Proposal (R2O), PI: Ted Strub, $310,000

Project 1: Freilich/Chang Research-to-Operations – Development and Test of 12.5 km resolution near-coastal wind data set from QuikSCAT.

This investigation aims to improve the resolution, accuracy, and near-coastal coverage of the QuikSCAT vector wind measurements, with primary emphasis on the NOAA/NESDIS near-real-time products used by operational marine forecasters. Using NASA funding, improved wind retrieval algorithms have been developed and the entire historical QuikSCAT data set has been reprocessed to ambiguous wind solutions at 12.5 km resolution using the refined algorithms. The resulting data set eliminates small quantization effects that resulted from errors in the standard older processing algorithms, and provides increased accuracy (at reasonable computational cost) by eliminating the need for composite^2 processing. The proposed project – conducted in collaboration with Paul Chang at NOAA – will:

- Fully validate the new wind retrieval algorithm;
- Develop, test, and incorporate a new land mask designed specifically to allow retrieval of accurate, 12.5 km resolution vector winds closer to coasts than the present 30 km land mask (which was based on 25 km resolution backscatter measurements);
- Refine/tune, test, and incorporate ambiguity removal and autonomous rain flag algorithms developed at NOAA and previously tuned for the 12.5 km composite^2 near-real-time product; and
- Provide a full-mission reprocessed data set at 12.5 km resolution and with enhanced coastal coverage for retrospective scientific analyses, along with new algorithm code for incorporation into the standard NOAA/NESDIS near-real-time processing system for contemporary data.

This project addresses COISS Themes 1, 2, and 4 (improving sensors and techniques; improving 2-D surface fields and fluxes; analyses of ocean-atmosphere data). It addresses mutual CIOSS and NOAA priorities in fostering collaborations between CIOSS and NOAA partners, improving products that can be transitioned directly to NOAA activities and leveraging other-agency support (in this case the NASA-funded full-mission wind retrieval and development of the refined algorithm modules). Aspects of this project are integral to the NESDIS/ORAD focus on advancing operational use of satellite vector surface wind measurements.

Project 2: Abbott/Letelier/Strutton Research-to-Operations – Workshops to Develop Consensus on Production of Ocean Color Climate Data Records.

This proposal seeks support for the generation of a written report to NOAA for a plan on the generation of ocean color climate data records (CDRs). NOAA's new mandate to understand climate variability will require the implementation of new tasks and structures to ensure the acquisition, processing, long term archiving, and distribution of CDRs. In order to generate a set of recommendations for the development and implementation of the new tasks, structures, and sensor requirements that will support

ocean color CDRs, we will organize two workshops in which representatives of the research community will be gathered to discuss how best to achieve these goals. While the first meeting to be held by the end of summer 2005, focusing on identifying ocean color CDRs and their requirements, will bring together both users and producers of CDRs, the second meeting, to be held by early winter 2005-2006, will have for a main focus establishing the tasks and mechanisms that will ensure the generation and archiving of ocean color CDRs. The objective and outcome of these meetings will be a written report to NOAA by March 2006 for a plan to produce ocean color CDRs.

Project 3: Davis/Clark Research-to-Operations – Ocean Color – A Workshop to Review Issues Regarding Vicarious Calibration.

Workshop Focus: Given diminishing NASA support for the in-situ MOBY calibration system, as well as the need for a more robust system for the calibration and validation of VIIRS, what are the requirements for such a replacement system and what are the associated design options?

CIOSS proposes to coordinate a workshop in approximately one year to provide an ocean color community review of a design concept and engineering considerations for vicarious calibration of ocean color satellites. The proposed basic construct is an iteration on the Marine Optical BuoY (MOBY) project. The need for this engineering redesign is the transition of the NASA developmental effort to NOAA operational calibration and validation support of the NPP, NPOESS, and GOES-R satellite programs. The workshop will be co-chaired by CIOSS and NOAA/NESDIS/ORA.

Over the coming year, the Marine Optical BuoY (MOBY) that has been located in Hawaii and used in cal/val activities for ocean color sensors (SeaWiFS and MODIS) will be re-engineered under separate funding. This activity will be overseen by Dennis Clark in NESDIS/ORAD, beginning with MOBY's power system and optical sensors. The R2O review group wanted community involvement in this move toward the next-generation platform for cal/val activities related to future color sensors such as VIIRS. The proposed activity is to hold a community workshop in the first half of 2006 to review the status for the component engineering prototypes and to seek input for broader considerations and the next steps for the re-engineering effort. The end goal of this MOBY re-engineering effort is for a smaller, more durable, cheaper, and more easily maintained MOBY2 for long-term calibration of NOAA operational ocean color sensors (NPP, NPOESS, GOES-R). The names listed in the proposal are suggested candidates for participation.

This project addresses the first CIOSS Research Theme of improving future sensors by providing for ongoing cal/val of ocean color. It does this through a community workshop, which is an Outreach activity. It directly helps the ocean color community prepare for both NPOESS and GOES-R color sensors and promotes collaboration between NOAA and academic scientists. It leverages a large amount of previous NASA support and experience and will clearly improve ocean observing systems, especially if it leads to a number of smaller and cheaper MOBY2 systems, allowed their deployment in diverse water types. Besides helping with future operational cal/val activities, it should help to provide the ability to intercalibrate present and future color sensors, as needed to construct consistent, research-quality climate data records for ocean color.

3. **CIOSS Supplemental Proposal: Technical Support for the HES Review Team, PI: Curtiss O. Davis, $130,000**

   This is a proposal from CIOSS for a supplemental project during the period from July 1, 2005 – June 30, 2006. Funding of $131,002 is requested from NOAA-NESDIS from the HES Project for technical support to the HES Review Team. The project is to be managed by John J. Pereira, Requirements Planning and Systems Integration, NOAA/NESDIS. This activity falls under CIOSS Task II: Additional Research and Outreach supported by NESDIS. It specifically addresses CIOSS Research Theme 1 Satellite Sensors and Techniques: Development of satellite oceanography techniques and applications; evaluation of existing and proposed satellite sensors, algorithms, techniques and applications.

   NASA Goddard Space Flight Center (GSFC) requires technical expertise in support of the evaluation of the ongoing Formulation Phase studies for the Hyperspectral Environmental Suite (HES), which will fly on the GOES-R and subsequent satellites. This Proposal is for Oregon State University (OSU) to provide one evaluator in support of the Hyperspectral Environmental Suite (HES) Formulation Phase Source Evaluation Board (SEB) in a non-voting capacity.

4. **The Coastal Ocean Applications and Science Team (COAST): Science Support for Using GOES-R/HES for Imaging Coastal Waters (Year 2), PI: Mark Abbott, $350,000**

   The money for year 2 of COAST will continue to support COAST workshops and activities of the COAST team members. (See subheading C, Task II: Additional Outreach Funded by NESDIS, COAST Workshops for more details.)

5. **GOES-R3, PI: Curtiss O. Davis, $1.5 million**

   The next generation of Geosynchronous Operational Environmental Satellites, GOES-R, is planned for launch in ~2012. This new generation will incorporate the Hyperspectral Environment Suite (HES), a combination of instruments that meet the following threshold tasks: two sounding tasks, which include disk sounding (DS) and severe weather/mesoscale sounding (SW/M), and a shelf and coastal waters imaging task (CW).

   Through CIOSS, and in coordination with NOAA NESDIS, NOS, and NMFS, Curtiss Davis is preparing a comprehensive proposal to develop the risk reduction activities necessary to utilize HES-CW data immediately after the launch of GOES-R. The proposed activities, designed to complement and support the risk reduction activities in those organizations, fall under Task II, additional research and outreach activities funded by NOAA and CIOSS Research Theme 1: Satellite Sensors and Techniques. CIOSS will provide the leadership and management of this effort that will be accomplished by CIOSS faculty and staff and members of the Coastal Ocean Applications and Science Team (COAST), as appropriate for each activity.

F. Funding Levels

In year 1, funding for CIOSS consisted of our base funding for administration, core research and core outreach ($500,000), plus an additional amount of approximately $400,000 for GIS work. The approximate total was $900,000.

In year 2, the base funding (~$520,000) was supplemented by an additional $40,000 for the SMILE program and $300,000 for the COAST activities. The approximate total was $900,000. This does not include $200,000 awarded to Dr. Strutton by OAR/OGP for Oceans and Human Health research (submitted through CIOSS) since OGP made this a separate award (not an amendment to the CIOSS award).

In year 3, funding for our annual omnibus proposal includes $600,000 of base funding, $135,000 for one Research-to-Operations project (NESDIS), and $575,000 for four related GLOBEC projects (funds from NOAA/NOS) ($1,310,000 total). Two supplemental proposals have been submitted and a third is in preparation. The first is for three additional Research-to-Operations projects ($310,000 total). The second is to provide technical support to the HES Review Team ($130,000). In addition, an omnibus proposal is being prepared to support a suite of GOES-R Risk Reduction efforts ($1,500,000 total). Finally, year 2 of the COAST funding will provide $350,000 to continue activities of the COAST team. Thus, we expect approximately $3,600,000 to pass through CIOSS in year 3, compared to $900,000 in each of the first 2 years. This again does not include $200,000 in year 2 for the Strutton proposal.

G. Publications and Presentations by CIOSS Fellows, Post-docs and Students, Addressing the CIOSS Research Themes and NOAA Goals and Missions.

1. Peer Reviewed

Anderson, B. T., and E. D. Maloney, 2005: Interannual Tropical Pacific Sea-Surface Temperatures and Their Relation to Preceding Sub-Tropical Sea Level Pressures in the NCAR CCSM2.0. Journal of Climate, accepted pending major revisions.

Bower, P., Using Internet Map Services and Coastal Remote Sensing for Education, M.S. Thesis, Oregon State University, Corvallis, OR, http://dusk.geo.orst.edu/djl/theses/bower_abs.html , June, 2005.

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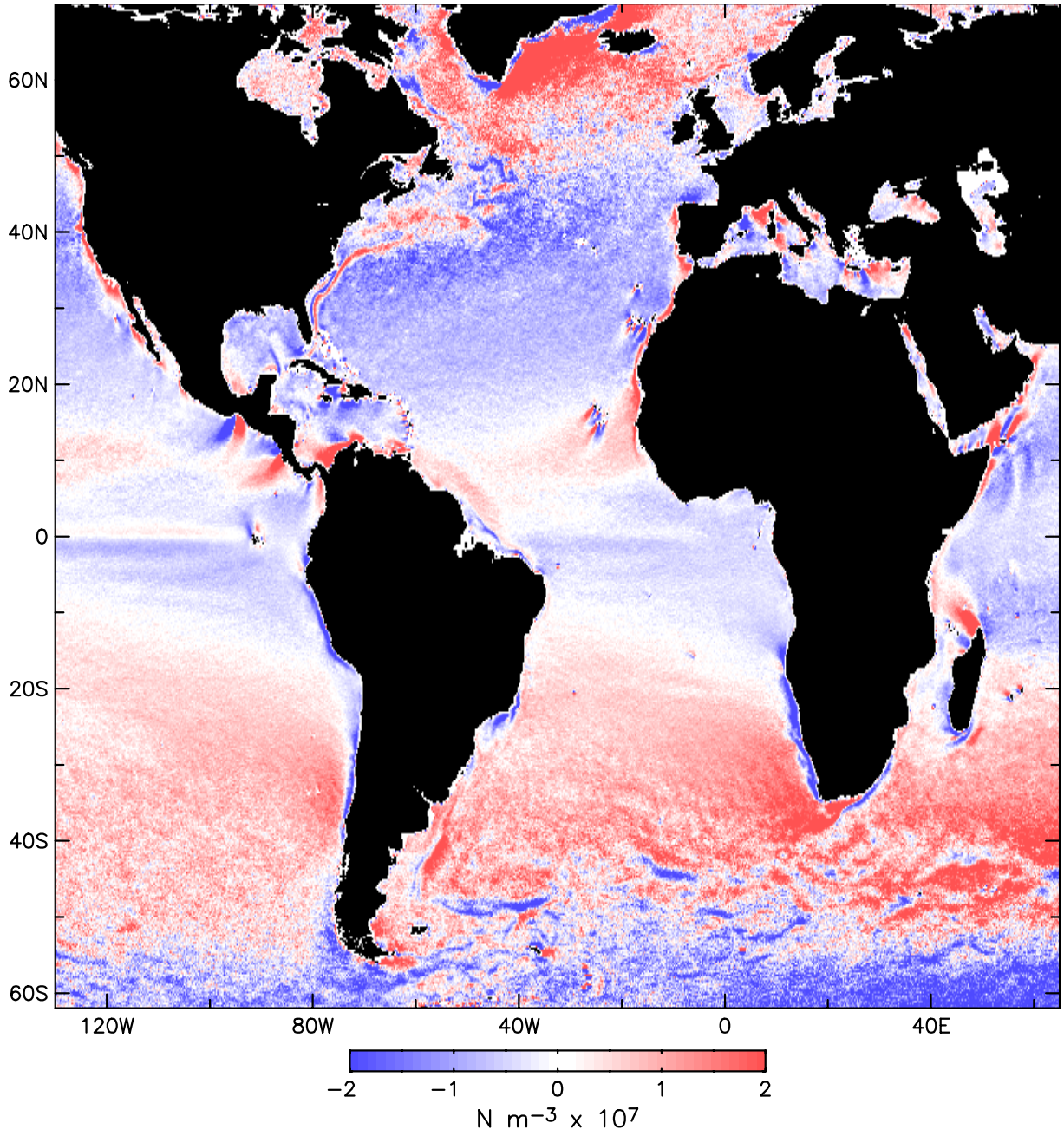
VII. Appendix 2: List of Acronyms

AGU	American Geophysical Union
ASLO	American Society of Limnology and Oceanography
CCS	California Current System
CI	Cooperative Institute
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CIOSS	Cooperative Institute for Oceanographic Satellite Studies
COAS	College of Oceanic and Atmospheric Sciences
COAST	Coastal Ocean Applications and Science Team
CoOP	Coastal Ocean Processes
CoOP COAST	Coastal Ocean Processes – Coastal Ocean Advances in Shelf Transport (Oregon)
CoOP WEST	Coastal Ocean Processes – Wind Events In Shelf Transport (N. California)
CWI	Coastal Waters Imager
DoD	Department of Defense
ECOHAB	Ecology and Oceanography of Harmful Algal Blooms
FRN	Federal Register Notice
GEOSS	Global Earth Observing System of Systems
GIS	Geographic Information Systems
GLOBEC	Global Ocean Ecosystems Dynamics program
GODAE	Global Ocean Data Assimilation Experiment
GOES	Geostationary Operational Environmental Satellites
GOES-R	Geostationary Operational Environmental Satellites – next generation of GOES (~2012)
GOES-R3	GOES-R Risk Reduction
HES	Hyperspectral Environmental Suite
HES-CW	Hyperspectral Environmental Suite – Coastal Waters Imager
HMSC	Hatfield Marine Science Center
IOM	Inverse Ocean Modeling
IOOS	Integrated Ocean Observing System
IR	Infrared
ITR	Information Technology Research
JPO	Journal of Physical Oceanography
MOA	Memorandum of Agreement
MODIS	MODerate resolution Imaging Spectroradiometer
MTDC	Modified Total Direct Cost
NASA	National Aeronautics and Space Administration
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Prediction
NESDIS	National Environmental Satellite, Data and Information Service
NGDC	National Geophysical Data Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NODC	National Oceanographic Data Center

NOPP	National Ocean Partnership Program
NOS	National Ocean Service
NPOESS	National Polar-orbiting Operational Environmental Satellite Systems
NRL	Naval Research Laboratory
NSF	National Science Foundation
NWFSC	Northwest Fisheries Science Center
NWS	National Weather Service
OAR	Office of Oceanic and Atmospheric Research
OCMP	Oregon Coastal Management Program
OCS	Ocean Climate Service
OGP	Office of Global Programs
OHH	Oceans and Human Health
OMSI	Oregon Museum of Science and Industry
ONR	Office of Naval Research
OPPI	Office of Program Planning and Integration
ORA	Office of Research and Applications
ORAD	Oceanographic Research Applications Division
ORION	Ocean Research Interactive Observatory Networks
OSU	Oregon State University
PAR	Photosynthetically Active Radiation
PFEL	Pacific Fisheries Environmental Laboratory
PMEL	Pacific Marine Environmental Laboratory
QuikSCAT	SeaWinds Scatterometer on the QuikSCAT platform
SAR	Synthetic Aperture Radar
SeaWiFS	Sea-viewing Wide Field-of-view Sensor – Color Sensor
SF424	Standard Form 424
SMILE	Science and Math Investigative Learning Experience
SSH	Sea Surface Height
SST	Sea Surface Temperature
STAR	Center for Satellite Applications & Research
SWFSC	Southwest Fisheries Science Center
TOA	Top Of the Atmosphere
TOS	The Oceanography Society
UCLA	University of California Los Angeles



Four-year averages (August 1999–July 2003) of the curl of the wind stress over the Atlantic, eastern Pacific and western Indian oceans computed from QuikSCAT measurements of surface winds. The data were spatially high-pass filtered to attenuate features with scales larger than 30º of longitude by 10º of latitude. The numerous small-scale features are associated with orographic effects (e.g., island wind shadows throughout the world ocean, the Central American wind jets, tip jets off the southern tip of Greenland, the southern tip of Madagascar, Punta Eugenia on the central Baja coast and numerous other points throughout the world), sea-surface temperature influence on the wind stress (e.g., the zonally oriented striations in the high-latitude South Atlantic and Indian oceans), and the effects of ocean currents on the surface stress (e.g., the Gulf Stream and the Agulhas Current where it separates from the African coast). Note also the bands of positive (negative) wind stress curl over the eastern boundary currents in the northern (southern) hemisphere. (See Chelton et al., 2004, *Science*, pp. 978-983 for a detailed discussion of these various features.)