

**Periodic Report: Activities of CIOSS Fellows at the College of Oceanic and Atmospheric Sciences, Oregon State University
September 26, 2006**

*CIOSS Fellows are in bold.

June 2: Renato Castelao, a graduate student working with CIOSS Fellow **Jack Barth**, defended his PhD thesis entitled "Coastal Ocean Response to Alongshore Variations in Topography and Wind Forcing."

*Update: Renato was selected as the recipient of the "2006 OSU Distinguished Dissertation Award," recognizing the unusually significant contribution that his thesis made to a discipline in mathematics, physical sciences and engineering. Renato has begun a Postdoctoral Associate position at the Institute of Marine and Coastal Sciences, Rutgers University, New Jersey.

June 19-July 8: CIOSS Fellow **Jack Barth** co-taught a 3-week course on "Coastal Physical Oceanography and Marine Ecosystems" at the Long Marine Laboratory, University of California Santa Cruz.

Summer 2006: CIOSS Fellow **Dudley Chelton** has recently been involved in the following publications and presentations.

Publications:

Maloney, E. D., and D. B. Chelton, 2006: SST influence on surface wind stress in climate models. *J. Climate*, 19, 2743-2762.

Chelton, D. B., M. H. Freilich, J. M. Sienkiewicz, and J. M. Von Ahn, 2006: On the use of QuikSCAT scatterometer measurements of surface winds for marine weather prediction. *Mon. Wea. Rev.*, 134, 2055-2071.

Risien, C. M., and D. B. Chelton, 2006: A satellite-derived climatology of global ocean winds. *Rem. Sens. Environ.*, 104, doi:10.1016/j.rse.2006.06.017.

Chelton, D. B., M. G. Schlax, and R. M. Samelson, 2006: Summertime coupling between sea surface temperature and wind stress in the California Current System. *J. Phys. Oceanogr.*, accepted.

Presentations:

NOAA Workshop on "Operational Satellite Surface Vector Winds Requirements," June 2006: Climate applications of ocean surface vector winds.

NASA Ocean Vector Winds Science Team Meeting, Salt Lake City, Utah, July 2006: Midlatitude ocean-atmosphere interaction.

CIOSS Short Course on Satellite Remote Sensing for NOAA/NMFS, Corvallis, Oregon, August 2006: Microwave remote sensing of the ocean.

August 1: A new CIOSS postdoc, Qingtao Song, from the University of Rhode Island, arrived at OSU to work with CIOSS Fellow **Dudley Chelton** on ocean-atmosphere interaction.

August 9: The Summer SMILE Highschool Teacher Workshop was held in Corvallis, OR. This workshop prepares teachers involved in the SMILE after-school program to present activities during the coming school year. These activities culminate in the SMILE Highschool Challenge in April of each year. *Update: The activities presented at the Teacher Workshops held in August 2004, January 2005, August 2005, February 2006, and August 2006 are now available for download from the CIOSS website at:

http://cioss.coas.oregonstate.edu/CIOSS/teacher_activities.html.

August 22-24: CIOSS co-hosted a “short course” on satellite data for NOAA Fisheries (NMFS). The course was organized by Cara Wilson (NOAA/NMFS), Dave Foley (CoastWatch) and their colleagues. CIOSS Director **Ted Strub**, and CIOSS Fellows **Dudley Chelton** and **Pete Strutton** gave presentations ranging from a general overview of remote sensing, to altimeter and scatterometer details and applications, to ocean color details and applications. The 30 participants were mostly from NOAA Fisheries, with half a dozen from different NOAA sanctuaries. According to Cara, this class generated quite a bit of enthusiasm within the wet side of NOAA (i.e. NMFS and NOS).

August 26-September 2: Lei Zhou from University of Maryland visited COAS/CIOSS (**Dudley Chelton**) as part of the NESDIS CI Summer Exchange program. A short report of his visit is on the CIOSS web site and is also found at the end of this periodic report.

August 29: CIOSS Director **Ted Strub** and Deputy Director **Mike Freilich** participated in a one-day Climate Data Stewardship Workshop, held in the Washington DC area. Tom Karl (NCDC) led the workshop, which was attended by a number of NOAA scientists involved with climate and the choice of data for Climate Data Records, as well as the NESDIS CI Directors and others from their

CI. Since the choice of sensors for the redesigned NPOESS system will affect the ability to form CDRs, the CI Directors were also involved in follow-up conference calls and revisions to a joint NOAA/NASA white paper on the effects of the NPOESS redesign.

August 31: CIOSS Fellow **Pete Strutton** co-authored the following article that was recently published in Nature: Behrenfeld, M.J., Worthington, K., Sherrell, R.M., Chavez, F.P., Strutton, P.G., McPhaden, M. and Shea, D.M., 2006. Controls on tropical Pacific Ocean productivity revealed through nutrient stress diagnostics. *Nature*, 442, 1025-1028.

September 3-15: CIOSS Fellows **Curtiss Davis**, **Ricardo Letelier** and Burke Hales participated in the first Coastal Ocean Applications and Science Team (COAST) field experiment in Monterey Bay, CA. The experiment was to collect half-hourly airborne hyperspectral imagery and a full suite of in situ data to begin to develop algorithms for future geostationary ocean color imagers. Davis was the overall experiment lead and worked on analysis of the remote sensing imagery. Letelier, with graduate student Maria Kavanaugh, measured chlorophyll, chlorophyll fluorescence and the productivity of the phytoplankton. Hales, with technician Dale Hubbard, measured CO₂ concentrations and addressed the role of the Monterey Bay as a source or sink for atmospheric CO₂.

September 4-8: CIOSS Fellow **Pete Strutton** participated in and gave an invited talk at the Experts Workshop on Bioregionalisation of the Southern Ocean, Hobart, Australia. The workshop was sponsored by the World Wildlife Fund and Peregrine Travel. The goals of the workshop were to use data from the Southern Ocean (mostly satellite data) to define regions of similar environmental characteristics, and present these findings to the Committee for the Conservation of Antarctic Marine Living Resources (CCAMLR).

September 8: Chris Wolfe, a PhD student of CIOSS Fellow **Roger Samelson**, defended his thesis in Physical Oceanography entitled, "Linear Disturbance Growth in a Time-Periodic System."

ABSTRACT

The mathematical and physical connections between three different ways of quantifying linear predictability in geophysical fluid systems are studied in a series of analytical and numerical models.

Normal modes, as they are traditionally formulated in the instabilities theories of geophysical fluid dynamics, characterize the asymptotic development of

disturbances to stationary flows. Singular vectors, currently used to generate initial conditions for ensemble forecasting systems at some operational centers, characterize the transient evolution of disturbances to flows with arbitrary time dependence.

Lyapunov vectors are an attempt to associate a physical structure with the Lyapunov exponents, which give the rate at which the trajectories of dynamical systems diverge. These seemingly divergent ways of quantifying linear disturbance growth are closely related. These connections are studied using a (time-periodic) wave-mean oscillation in an intermediate complexity baroclinic channel model. For time-periodic systems, normal modes may be defined in terms of Floquet vectors. It is argued that Floquet vectors are equivalent to Lyapunov vectors for time-periodic flows. The Floquet vectors of the wave-mean oscillation are found to split into two dynamically distinct classes that have analogs in the classical theories of the baroclinic instability and parallel shear flow. The singular vectors of the oscillation are found to preserve this dynamical splitting. The representations of the singular vectors in terms of the forward and adjoint Floquet vectors display much simpler temporal behavior than the singular vectors or the Floquet vectors individually. It is further demonstrated that while the Floquet vectors point 'onto' the local system attractor, the singular vectors point 'off' the attractor.

September 11-15: CIOSS fellow **James Richman** visited the National Center for Environmental Prediction (NCEP) and Joint Center for Satellite Data Assimilation. Richman presented a seminar at JCSDA entitled, "Error Estimates for Assimilation of Satellite Sea Surface Temperature Data in Ocean Climate Models." Richman discussed collaboration between CIOSS and NCEP on assimilation of satellite data into the Climate Forecast System using techniques developed at OSU.

September 13: Nicolai Thum, A PhD student of CIOSS Fellow **Steve Esbensen**, defended his thesis in Atmospheric Sciences entitled, "Atmospheric Boundary Layer Coupling to Midlatitude Mesoscale Sea Surface Temperature Anomalies."

September 14: CIOSS Fellow **Pete Strutton** gave a seminar at Old Dominion University in Norfolk, VA entitled, "Primary productivity and air-sea CO₂ fluxes in equatorial and coastal upwelling systems."

September: CIOSS held two half-day Internal Review sessions on September 15 and 21. The following schedule was loosely followed. The presenter's name is in bold.

September 15

Radiation and Winds

8:30am Surface radiation estimates from satellite – **Coakley**

8:50am High resolution scatterometer winds – **Freilich**, Chang

Windsat-QuikSCAT winds – **Freilich**

Operational use of SCAT winds – **Freilich**, Milliff

9:30am Two Wind Workshops – **Chelton**, Freilich

9:50am BREAK

10:10am Air-Sea Interaction and Reynolds SST – **Chelton**

10:30am SCAT wind climatology – **Risien**, Chelton

Models

10:50am Coupled ocean-atmosphere model – Skillingstad, **Samelson**

11:10am Pilot ocean prediction system – **Kurapov**, Egbert

11:30am Coastal Ocean Modeling and Data Assimilation – Allen, Egbert,
Kurapov, Miller, **Choi**

11:50am Coastal Ocean Modeling and DA workshop – **Kurapov**, Allen

12:00pm GLOBEC biophysical models – **Batchelder**

12:20pm Interaction with NCEP and JCSDA basin-scale ocean modeling –
Richman, **Miller**

September 21

Outreach

8:30am SMILE – Davis-Butts, **Collay**

8:50am HMSC pilot display - **Phipps**

Ocean Color

9:10am COAST sensors and algorithms, and MOBY redesign – **Davis**

9:30am Hyperion data analysis – **Strutton**, Letelier, Kavanaugh

9:50am CDR workshops – **Letelier**, Abbott

10:00am Oceans and Human Health – Wood, **Strutton**

10:20am Evaluation of X-Band reception of international satellites – **Letelier**

10:30am BREAK

Mesoscale Circulation, Front Analyses and Misc.

10:50am SST fronts – **Barth**

11:10am Mesoscale “coastal” circulation – Strub, Kosro, **Saraceno**

11:30am Multi-sensor fields over the CCS – **Strub**, Barth

11:40am Circulation differences N-S of C. Blanco – **Kosro**

12:00pm Coastal Radar evaluation for IOOS – **Kosro**

September 18: CIOSS Post-doc Martin Saraceno, along with CIOSS Director **Ted Strub**, submitted the following article to the Journal of Geophysical Research Oceans: "Mesoscale circulation in the Northern California Current as seen by satellite altimetry.", M Saraceno and P T Strub.

In addition, Saraceno submitted this article to Geophysical Research Letters: "Low frequency variability of the Zapiola anticyclone as observed from satellite altimetry: indication of possible collapses", M Saraceno and C Provost.

September 21: Angkana Rawichutiwan, a Master's student of CIOSS Fellow **Jim Good**, defended her thesis in Marine Resource Management entitled, "School Group Use of Oregon's Rocky Intertidal Areas: Use, Impacts, and Management."

September 22: Local CIOSS Council members met to discuss the above mentioned Internal Review sessions and the agenda and presentations for the upcoming Formal Review.

September 24-27: Kristopher Karnauskas from University of Maryland visited COAS/CIOSS as part of the NESDIS CI Summer Exchange program. On September 25, Kris presented a seminar entitled, "Interannual Variability of SST and Chlorophyll in the Eastern Pacific Warm Pool: High-Resolution Satellite Observations." After visiting CIOSS, he then attended the EPOC meeting (see below) at Timberline Lodge and presented a poster with the same title.

September 27-30: The 53rd annual Eastern Pacific Ocean Conference (EPOC) will be held at the Timberline Lodge in Oregon. Many CIOSS Fellows and students will attend and give oral or poster presentations. Some examples of presentations that will be given follow.

Pete Strutton and Wiley Evans, oral presentation, EPOC meeting, Timberline Lodge, OR: 'New observations of carbon cycle parameters from the equatorial Pacific'.

Martin Saraceno, "Mesoscale events off the coast of Oregon (US): a satellite point of view.", poster presentation to EPOC meeting.

September 28: Angelique White, a PhD student of CIOSS Fellows **Ricardo Letelier** and **Yvette Spitz**, will defend her thesis in Biological Oceanography entitled, "Phosphorus Physiology and Environmental Forcing of Oceanic Cyanobacteria, Primarily *Trichodesmium* spp."

September 30-October 3: Stephanie Henson, a post doc for Andrew Thomas at the University of Maine, will be visiting COAS and giving a seminar, co-hosted by CIOSS. Her seminar will be based on the theme of satellite observations of the California Current. Stephanie works on GLOBEC issues, and her focus is mainly on SeaWiFS in the California Current.

October 3-5: CIOSS Director **Ted Strub** will attend the "Workshop on Regional Needs for Coastal Remote Sensing" at the University of New Hampshire. This workshop is sponsored by the National Federation for Regional Associations for Coastal and Ocean Observing (NFRA), along with NOAA, NASA and Ocean US. The purpose of the workshop is to pull together representatives of the Regional Associations (RAs) to identify the regional needs for coastal satellite remote sensing, document remote sensing requirements of the RAs, and identify commonalities. This is planned as the first in a series of biennial workshops focused on satellite remote sensing needs for the IOOS Regional Associations. After attending the NFRA workshop, he will visit the University of Maine, Orono, to give a seminar (expanded from his EPOC talk) on "Satellite estimates of transport and SST anomalies during the 2005 'Warm Event' in the northern California Current.

October 17-19: These dates have been finalized for the CIOSS Formal Review to be held in Corvallis, OR. The review consists of 2 days of science review, followed by 1 day of administrative review. The participation of Review Panel Members and the agenda are being finalized at this time. For addition information, please visit the Formal Review web page on the CIOSS website at: <http://cioss.coas.oregonstate.edu/CIOSS/review.html>.

Visit Report
Lei Zhou
CICS/ESSIC, UMCP

I visited CIOSS at Oregon State University from Aug. 26 to Sep. 1, 2006. Prof. Chelton is my main contact. This visit was funded by the CORP CI Exchange Program of NOAA.

Right now, I am working on the intraseasonal oscillation in the southwestern Indian Ocean (SWIO) by examining model data. In addition, I plan to study the influence of Indonesian through-flow on the oceanic circulation and heat budget in the northern Indian Ocean by analyzing satellite data and model data together. In the first day of my visit, I made a presentation on my present work and research plan. Then Prof. Chelton selected some papers for me to read, which are closely related to my research. In the following days, I had fruitful discussions with Prof. Chelton almost every day. Prof. Chelton made many helpful comments. He emphasized the importance of model resolutions for the studies on meso-scale phenomenon. Especially, he suggested that I should be careful in using NCEP reanalysis wind data to drive the model, if I intend to study the meso-scale structure in the SWIO, because NCEP reanalysis data may not be able to resolve the wind fields with horizontal scales smaller than 800 – 1000 km (Milliff et al., 2004). He recommended ECMWF wind data is an alternative choice. However, if for any reasons I have to use NCEP reanalysis data in our model, Prof. Chelton suggested a ‘Poor Man’s Coupled Model’ to improve our model results. According to his research, there are persistent linear relations between small-scale wind stress and small-scale SST, between wind stress divergence and down-wind SST gradient, and between wind stress curl and cross-wind SST gradient (O’Neill et al., 2005; Maloney and Chelton, 2006), because the sea surface wind tends to accelerate over warm water but decelerate over cold water (Chelton et al., 2004). He pointed out that even if NCEP reanalysis data can hardly resolve the small-scale wind stress very well, the wind stress can be modified, where the small-scale wind stress is induced by small-scale SST. Thus, the NCEP reanalysis wind data may be modified during running the model. Actually Larry O’Neill, a graduate student of Prof. Chelton, is now working on the similar modification of the reanalysis wind data. I also discussed with Larry about his present research. Moreover, Prof. Chelton suggested that I should check the properties of the westward propagation signals in our model data carefully before drawing the conclusion that the signals are Rossby waves, because he recently found out that many westward propagations

over the global ocean may be caused by non-linear eddies rather than theoretical free Rossby waves. I am much appreciated that Prof. Chelton shared this unpublished research result with me.

I also learned some technical things about satellite data during the visit. Corinne James taught me the background knowledge of various satellites and the related products, such as PO, DACC and REMSS. She also taught me how to read the HDF data files in MATLAB. Larry O'Neill told me his experience on doing EOF analysis and gave me his MATLAB scripts for EOF analysis. Ricardo Matano talked with me about the inter-ocean exchange between the South Atlantic and South Indian Ocean circulation, on which he is working now.

I think this visit to CIOSS is really helpful to my future research. I have a better understanding of my research topic. I learned the necessary techniques to do my research. I am sincerely grateful for the help of Prof. Chelton, Dr. Matano, Dr. Song, Dr. James, and Larry O'Neill. I also gratefully acknowledge NOAA for providing me this wonderful opportunity.

References

Chelton Dudley B., Michael G. Schlax, Michael H. Freilich, and Ralph F. Milliff, Satellite measurements reveal persistent small-scale features in ocean winds, *Science*, 303, 978 – 983, 2004.

Maloney, Eric D. and Dudley B. Chelton, An assessment of the sea surface temperature influence on surface wind stress in numerical weather, *J. Clim.*, 19, 2743 – 2762, 2006.

Milliff, Ralph E., Jan Morzel, Dudley B. Chelton, and Michael H. Freilich, Wind stress curl and wind stress divergence biases from rain effects on QSCAT surface wind retrievals, *J. Atmos. Oceanic Technol.*, 21, 1216 – 1231, 2004.

O'Neill, L. W., D. B. Chelton, S. K. Esbensen, and F. J. Wentz, High-resolution satellite measurements of the atmospheric boundary layer response to SST variations along the agulhas return current, *J. Clim.*, 18, 2706-2723, 2005.