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1 Welcome

Welcome to the University of Washington! We are delighted that you have joined us for the Fourth Annual International Meeting of Students in Physical Oceanography (IMSPO).

The School of Oceanography at the University of Washington is a national leader in oceanographic research and education. The UW Oceanographic Laboratories, founded in 1930 and directed by Professor Thomas G. Thompson, were the precursor of the School. The School of Oceanography was organized formally in 1951.

We hope you enjoy our time with us here at the University of Washington in Seattle.

2 About IMSPO

2.1 History

This year the fourth annual International Meeting of Students in Physical Oceanography (IMSPO) will be held at the University of Washington in Seattle September 22-24, 2010. The primary goal of IMSPO is to bring together students in physical oceanography and related fields of environmental fluid dynamics, atmospheric physics, biophysical interactions and ocean-atmosphere interactions to engage in scientific discussion and forge future relationships in a friendly and supportive environment. Previous meetings have been held at Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE) in 2007 (http://oceanografia.cicese.mx/personal/cesar/PaginaIMSPO/) and 2009 (http://imspo.cicese.mx/) and at the Scripps Institution of Oceanography (SIO) in 2008 (http://iod.ucsd.edu/imspo2008/).

2.2 Organizing Committee

Feel free to contact one of the members of the IMSPO 2010 organizing committee if you need help during your stay here in Seattle.

- Cecilia Peralta-Ferriz (chair)
  (206-290-9824, ferriz@apl.washington.edu)

- Jesse Anderson
  (785.550.6658, jessea2@u.washington.edu)

- Nick Beaird
  (nlbeaird@u.washington.edu)

- Sam Brody
  (516-241-9927, sbrody@apl.washington.edu)

- Alison Rogers
  (206-225-4991, alison@ocean.washington.edu)

- David Trossman
  (206-550-4365trossd@u.washington.edu)

- Sally Warner
  (206-992-1990, sally2@u.washington.edu)

- Cathy Yang
  (206-465-4097, ykc1208@u.washington.edu)

2.3 Financial Support

We received generous donations to help support IMSPO 2010 from Sea-Bird Electronics, University of Washington School of Oceanography, and University of Washington Applied Physics Laboratory.

3 Venue and meals

All talks will take place on the University of Washington campus in the Ocean Sciences Building, Room 425. Breakfast, lunch and snacks will also be served in the Ocean Sciences Building. Dinner on Wednesday will be held at the Red Door, 3401 Evanston Ave, in the Fremont neighborhood of Seattle. We will travel there together by bus, bike or car. (The conference will pay for meals and non-alcoholic beverages, however, you must pay for your own alcoholic drinks. Please bring cash if possible.) On Thursday, we will go to Sea-Bird Electronics, 13431 NE 20th Street in Bellevue. We will have a tour of the facility and then a buffet dinner with Sea-Bird Electronics employees. On Friday, we will have a barbecue and drinks on the porch of the Marine Science Building which is located across the street from the Ocean Sciences Building. All meals and snacks will be provided as part of your conference fee.
4 Internet access
You may access the UW wireless network.
- username: event0988
- password: 7a3S+3g9K+6b2D

5 Registration
Registration on Wednesday, September 22 will start at 8:15 am in the Ocean Sciences Building, Room 425. At that time, you will be able to pick up a printed copy of the program book and your name tag as well as pay the conference fee of $50. We will only be able to accept cash or checks made out to the University of Washington. Receipts will be available.

6 Transportation
6.1 Getting to IMSPO by car
From the North Take I-5 southbound to exit 169. Follow signs to NE 45th St. At the light, turn left onto NE 45th St. At the light at the corner of 15th Ave NE and NE Pacific St., make sure you are in the right hand lane, and go straight. At the stop sign, turn left onto NE Boat St. The Ocean Sciences Building will be on your left.

From the South Take I-5 northbound to exit 169. Follow signs to NE 45th St. At the light, turn right onto NE 45th St. Turn right at 15th Ave NE. At the light at the corner of 15th Ave NE and NE Pacific St., make sure you are in the right hand lane, and go straight. At the stop sign, turn left onto NE Boat St. The Ocean Sciences Building will be on your left.

6.2 Parking
We do not recommend driving to campus because parking can be expensive and difficult. However, if you do need to park a car near the Ocean Sciences Building during IMSPO, please contact Sally (sally2@u.washington.edu) prior to IMSPO to make arrangements and get directions to the correct lot.

6.3 Getting to IMSPO by airplane
The closest airport to the University of Washington is the Seattle-Tacoma International Airport (SEA), which is located about a half hour drive south of the University of Washington. To get from the airport to the University of Washington, you may take a taxi, which will cost about $60 or the Shuttle Express which will cost about $45. By public transportation, take the Link Light Rail north from the airport. At the International District station, get off the light rail and transfer to the #71, 72 or 73 bus. The light rail will let you off at Bay A and the 71, 72 and 73 will pick you up at Bay A. * Get off the bus at NE Campus Parkway and Brooklyn Ave NE. Bus drivers can help you to make sure you are at the correct stop. From the bus stop, walk east on Campus Parkway. Turn right on 15th Ave NE. Follow 15th Ave NE down hill until you reach the water. Turn left onto NE Boat St. The Ocean Sciences Building will be located on your left. The light rail costs $2.50. Buy your ticket at the airport station. The bus costs $2.25 during rush hour and $2.00 during off peak times. Exact change is needed to pay the driver. Within the downtown tunnel, you may also purchase tickets from the machines. Depending on the time of day, if you get on a bus in the downtown tunnel, you pay the drive as you get OFF of the bus. Otherwise, pay the driver when you get ON the bus. They will have a sign indicating when you should pay.

6.4 Getting to IMSPO by train
Amtrak has train service to Seattle. The Seattle King Street Station is located in downtown Seattle. You may take a taxi from the station to the University of Washington, or you may take the bus. The International District Metro Tunnel Station is located at the corner of 4th Ave S and S Jackson St which is just on the other side of the railroad tracks from the Seattle King Street Station. Take the #71, 72 or 73 bus north from Bay A in the International District Station. Follow airplane directions starting at *.
6.5 Getting to IMSPO by bus

The Greyhound station is located on the corner of 9th Ave and Stewart Street. From the station, walk two blocks SE along 9th Ave (crossing Howell St. and Olive Way) to the Convention Place Station. Once in the tunnel, take the #71, 72 or 73 bus north from Bay A. Follow airplane directions starting at *.

6.6 Transportation within Seattle

In general, public transportation within Seattle is by bus. More information can be found at: http://metro.kingcounty.gov/. The Regional Trip Planner is highly recommended for getting specific directions for your trip.

7 Accommodations

Some IMSPO participants will be staying with UW students. You should have received information from your host already. If you are finding your own accommodations, we recommend the following hotels which are all within walking distance from the Ocean Sciences Building. They are ordered from least to most expensive.

- The College Inn. 4000 University Way NE, Seattle, WA 98105. Phone: 206-633-4441; Fax: 206-547-1335. www.collegeinnseattle.com (Note that most of the rooms do not have private bathrooms. This is the closest hotel to the Ocean Sciences Building.)

- University Inn. 4140 Roosevelt Way NE, Seattle, WA 98105. Phone: 206-632-5055; Toll-free: 1-800-733-3855; Fax: 206-547-4937. www.universityinnseattle.com


8 Weather in Seattle

Weather in Seattle during the month of September can be both sunny and rainy. Please plan for both. In addition, the room where the talks are taking place can get quite cold, so be sure to bring extra layers.

9 Presentation Information

All presentations will be 12 minutes long with 3 minutes for questions and transition to the next speaker. There will be a mac laptop equipped with PowerPoint, Adobe Acrobat and Keynote and a PC desktop with PowerPoint. Please bring your presentation on a thumb drive so it can be transferred to the computer or laptop before your session starts.

10 Acknowledgements

We are grateful for the help we received from the following people: Russ McDuff, Cara Mathison, Kittie Tucker and all of the staff at the School of Oceanography, Norge Larson, Jeff Simmen, Carol Janzen, and Megan Gambs.
## Schedule

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<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
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<tr>
<td>8:15 – 9:00</td>
<td>Breakfast and registration</td>
<td>Breakfast</td>
<td>Breakfast</td>
</tr>
<tr>
<td>9:00 – 9:15</td>
<td>Welcome</td>
<td>Announcements/Intro</td>
<td>Announcements/Intro</td>
</tr>
<tr>
<td>10:15 – 10:45</td>
<td>Coffee/snack break</td>
<td>Coffee/snack break</td>
<td>Coffee/snack break</td>
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<tr>
<td>10:45 – 11:00</td>
<td>Bo Li</td>
<td>Samantha Brody</td>
<td>Kyla Drushka</td>
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<td>11:00 – 11:15</td>
<td>Andrew Lapetina</td>
<td>Gillian Damerell</td>
<td>Megan Gambs</td>
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<tr>
<td>11:15 – 11:30</td>
<td>Maureen Downing-Kunz</td>
<td>Sudip Majumder</td>
<td>Andrew Delman</td>
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<tr>
<td>11:30 – 11:45</td>
<td>Michael Jacox</td>
<td>Chase Stoudt</td>
<td>Jinbo Wang</td>
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<tr>
<td>12:00 – 1:15</td>
<td>Lunch</td>
<td>Lunch</td>
<td>Lunch</td>
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<tr>
<td>1:15 – 1:30</td>
<td>Dove Jige Guo</td>
<td>Sonaljit Mukherjee</td>
<td>Jinting Zhang</td>
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<tr>
<td>1:30 – 1:45</td>
<td>Sally Warner</td>
<td>Andy Pickering</td>
<td>Jessica Anderson</td>
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<tr>
<td>1:45 – 2:00</td>
<td>Yeping Yuan</td>
<td>Cathy Yang</td>
<td>Sarah Purkey</td>
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<tr>
<td>2:00 – 2:30</td>
<td>Coffee/snack break</td>
<td>Coffee/snack break</td>
<td>Coffee/snack break</td>
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<tr>
<td>2:30 – 2:45</td>
<td>J. Paul Rinehimer</td>
<td>Teymour Javaherchi</td>
<td>Cecilia Peralta-Ferriz</td>
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<tr>
<td>2:45 – 3:00</td>
<td>Bonnie Ludka</td>
<td>Peng Wang</td>
<td>David Trossman</td>
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<tr>
<td>3:00 – 3:15</td>
<td>Rachel Horwitz</td>
<td>Transport to Sea-Bird Electronics</td>
<td>Alison Rogers</td>
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<tr>
<td>3:15 – 3:30</td>
<td>Transport to Sea-Bird Electronics</td>
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<tr>
<td>3:30 – 4:00</td>
<td>Tour Seaglider/ARGO</td>
<td>Electronics</td>
<td>Tour GFD Lab</td>
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<tr>
<td>4:00 – 4:30</td>
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<tr>
<td>4:30 – 5:00</td>
<td>Group Photo</td>
<td></td>
<td>Social on the MSB Deck</td>
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<tr>
<td>5:00 – 5:30</td>
<td>Transport to Fremont</td>
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<tr>
<td>5:30 – ??</td>
<td>Dinner at the Red Door and socializing in Fremont</td>
<td>Dinner at Sea-Bird Electronics</td>
<td>Dinner on the MSB Deck and more socializing</td>
</tr>
</tbody>
</table>
12.1 John Lyman

Wednesday, September 22 at 9:15 am

John Lyman was trained and published in the field of physics before he went off to teach math in Zimbabwe through the Peace Corps, and then graduate school in oceanography at Oregon State University where he studied under the supervision of Dudley B Chelton. Dr. Lyman did his postdoc through the NOAA (National Oceanic and Atmospheric Administration)/PMEL (Pacific Marine Environmental Laboratory) as a National Research Council Research Associate before becoming an assistant researcher at PMEL/JIMAR (Joint Institute for Marine and Atmospheric Research), where he is today.

He has been published in journals such as the Progress in Oceanography, Journal of Physical Oceanography, Journal of Climate, Journal of Atmospheric and Oceanic Technology, Geophysical Research Letters, the Bulletin of the American Meteorological Society, and Nature, and has been invited to speak at the American Geophysical Union’s Ocean Science Meeting. Over the years in the field, Dr. Lyman has worked on subfields of physical oceanography such as mesoscale variability; linearizations of instability models; observational analysis using instruments such as radar altimetry, moorings, and profiling drifters; and others. More recently, he has been investigating of mesoscale variability from satellite altimeter data and moored buoys in the Eastern Equatorial Pacific, developing linearized models to explain instabilities in the equatorial oceans, and estimating global heat and fresh water content from in situ observation and satellite altimeter data.

More information about John Lyman can be found at his website: http://www.pmel.noaa.gov/people/lyman/PMEL_Home_page/Home.html.

12.2 Jonathan Nash

Thursday, September 23 at 9:15 am

Jonathan Nash is an Associate Professor in physical oceanography at Oregon State University, Corvallis. His research focuses on measuring small-scale dynamical processes, and quantifying how these act to transport momentum and extract energy from the large scales. In turn, this sets the distribution of turbulent mixing in the ocean, irreversibly transporting heat, CO$_2$, nutrients, and pollution and dissipating wind and tidal energy. In addition, through coupling with the atmosphere, these dynamics may also play a significant role in the long-term climate and in shorter-term El Nino oscillations.

Dr. Nash’s research spans a variety of systems, ranging from (i) the mixing of the shallow Columbia River plume, (ii) the generation of internal waves from topographic and density features in the coastal ocean, (iii) the dynamics of deep gravity currents such as the Mediterranean outflow, (iv) mixing in the upper-equatorial ocean, and (v) the generation, dissipation and mixing of deep-ocean internal tides. By characterizing processes within these systems using conceptual models and theory, it is the ultimate goal that the underlying dynamics will someday be properly incorporated into larger-scale numerical models that are currently unable to resolve them.

More information about Jonathan Nash can be found at his website: http://kai.coas.oregonstate.edu/.
12.3 Gary Lagerloef

Friday, September 24 at 9:15 am

Gary Lagerloef began his career in oceanography as an undergraduate and obtained his Bachelors Degree from Florida Institute of Technology (1971). In the years 1972-1975, he served in the U.S. Coast Guard where he taught marine science at the Coast Guard Academy while earning a Masters Degree in Oceanography at the University of Connecticut. He spent the next nine years working for NOAA, about half that time as a seagoing officer on research ships in the Pacific and half at the Pacific Marine Environmental Laboratory (PMEL) in Seattle, WA where he met his wife, Marcia.

Dr. Lagerloef completed a Ph.D. in Physical Oceanography at the University of Washington in 1984 and later worked in private sector marine science. From 1988-1990, he served as Physical Oceanography Program Manager at NASA in Washington DC in the ocean science remote sensing program. In 1995, he co-founded Earth and Space Research, a non-profit scientific research institute in Seattle where he has developed several research projects devoted to studies of the upper ocean dynamics and climate variability using satellites.

In December 2003, Dr. Lagerloef was appointed by NASA to lead the Aquarius/SAC-D satellite mission as Principal Investigator (launch date in 2009). He played a major role in gaining approval for this program, which will study the interactions between the ocean circulation, global water cycle and climate by measuring ocean salinity from space. The Aquarius mission is being developed in an international partnership with Argentina’s space agency, Comision Nacional de Actividades Espaciales, and is the first NASA satellite mission dedicated to measuring ocean salinity.

For more information regarding the Aquarius/SAC-D satellite mission, visit NASA’s website: http://aquarius.gsfc.nasa.gov/


..........................................................................

7
Near-Surface Observations of Temperature and Salinity from Profiling Floats

Jessica Anderson and Stephen C. Riser
School of Oceanography, University of Washington, Seattle, WA
jessea2@u.washington.edu
Friday, September 24 at 1:30 pm

Observations of near-surface temperature and salinity obtained from profiling floats are presented. High-resolution, near-surface measurements were obtained from an auxiliary CTD added to Argo floats. The auxiliary Surface Temperature and Salinity (STS) unit takes measurements in tandem with the main Argo SBE41 CTD at 10 cm intervals from 30 meters to the sea surface. Below this depth, the Argo float operates normally with measurements every 2 meters. In addition, the use of Iridium satellite system for communication allows the mission of the float to be changed after deployment. This allows both the time interval and maximum depth of the float profile to be altered temporarily. Faster, shallower profiling allows for investigation of short lived upper ocean processes. Data from floats programmed to cycle rapidly (every 2 hours) for several weeks are also presented. To date, 18 floats equipped with STS sensors have been deployed. Data from floats deployed in the tropical western Pacific near Papua New Guinea, the north Pacific near Hawaii, and the Arabian Sea show a strong diurnal signal in temperature. While a strong diurnal salinity signal is not observed, salinity does appear to fluctuate at roughly daily time scales. Distinct temperature and salinity signals from storm events are also observed.

The Internal Tide and Energy Fluxes Within and Entering Monterey Bay Submarine Canyon

Samantha Brody¹, James Girton¹ and Eric Kunze²
(1) Applied Physics Laboratory, University of Washington, Seattle, WA, (2) School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, Canada
sbrody@apl.washington.edu
Thursday, September 23 at 10:45 am

Observations of energy flux $<u'u'p'>$ by the semidiurnal internal tide collected using eXpendable Current Profilers (XCP), a Vertical Microstructure Profiler (VMP), and a CTD/Lowered ADCP during field experiments in August 2006 and August 2008 in Monterey Bay Submarine Canyon and the surrounding area are presented. Using model outputs to supplement observations, an approximate energy budget for the complex and energetic canyon environment can be generated. Previous measurements show an increase in local energy flux along the narrowing and shoaling canyon axis together with a convergence of total (integrated) flux. The direction of energy flux is generally along canyon. Reasons for why the energy flux follows the canyon bathymetry are explored. Evidence for increased dissipation due to near-critical internal wave reflection or direct breaking of the focusing low-mode waves is evaluated.

Energy flux entering the canyon appears to be coming from the south, generated at a ridge west of Pt. Sur. South of the canyon. A high resolution XCP survey within this northbound beam reveals depth-integrated energy flux measurements with unexpected small-scale variability. This variability found in the energy flux from observations does not appear in the output of several models, all of which attempt to model the internal tide with realistic barotropic forcing and relatively detailed bathymetry. The source for this variability is likely to be generation off even smaller scale topography than the models resolve, though complex standing wave interference patterns, and contamination of measurements by tidal advection of geostrophic currents may also play a role.
Temporal Variability of Diapycnal Mixing in the Southern Ocean

Gillian Damerell¹, Karen J. Heywood¹, David P. Stevens¹ and Alberto C. Naveira Garabato²
(1) University of East Anglia, Norwich, UK, (2) National Oceanography Centre, Southampton, UK
g.damerell@uea.ac.uk
Thursday, September 23 at 11:00 am

Diapycnal mixing rates in the oceans have been shown to have a great deal of spatial variability, but the temporal variability has been little studied. Here we present results from a method developed to calculate diapycnal diffusivity from moored Acoustic Doppler Current Profiler (ADCP) velocity shear profiles. An 18-month time series of diffusivity is presented from data taken by a LongRanger ADCP moored at 2400 m depth, 600 m above the sea floor, in Shag Rocks Passage, a deep passage in the North Scotia Ridge (Southern Ocean). The Polar Front is constrained to pass through this passage, and the strong currents and complex topography are expected to result in enhanced mixing. The spatial distribution of diffusivity in Shag Rocks Passage deduced from lowered ADCP shear is consistent with published values for similar regions, with diffusivity possibly as large as $30 \times 10^{-4} \text{ m}^2 \text{ s}^{-1}$ near the sea floor, decreasing to the expected background level of $\sim 0.1 \times 10^{-4} \text{ m}^2 \text{ s}^{-1}$ in areas away from topography. The moored ADCP profiles spanned a depth range of 2400 to 1800 m; thus the moored time series was obtained from a region of moderately enhanced diffusivity. The diffusivity time series has a median of $4.0 \times 10^{-4} \text{ m}^2 \text{ s}^{-1}$ and a range of $2.3 \times 10^{-6} \text{ m}^2 \text{ s}^{-1}$ to $1.1 \times 10^{-2} \text{ m}^2 \text{ s}^{-1}$. There is no significant signal at annual or semiannual periods, but there is evidence of signals at periods of approximately four days, fourteen days, and eighty days. Mechanisms that might cause these are discussed.

“Teddies” (Mesoscale eddies) in the southeastern tropical Indian Ocean

Andrew Delman
Scripps Institution of Oceanography, University of California–San Diego, San Diego, CA
adelman@ucsd.edu
Friday, September 24 at 11:15 am

Intraseasonal variability, in the form of mesoscale eddies observed in the South Equatorial Current (SEC) south of Java, may play an important role in the heat budget of the tropical Indian Ocean, as well as influencing seasonal and interannual variations in the Indian Ocean itself. These eddies develop from mixed barotropic and baroclinic instability, and attain their maximum kinetic energy during July-September, when the Indonesian Throughflow is strongest. The eddy characteristics have previously been inferred primarily from surface data spanning 6 years and from model simulations. In order to gain a fuller understanding of the spatial and temporal characteristics of these eddies, Aviso sea surface height data from 1992-2009 will be analyzed, in addition to Argo CTD profiles in the SEC. It is anticipated that the Argo data will provide more insight into the subsurface features of these eddies. Additionally, the longer sea surface height data set will be analyzed for evidence of interannual variability in the eddy kinetic energy and for possible correlations with climate modes of variability in the larger Indian and Pacific basins, such as the Indian Ocean Dipole and ENSO.
Physical interactions between floating macrophytes and environmental flows: drag and velocity structure in patchy vegetation

Maureen Downing-Kunz and Mark Stacey
University of California–Berkeley, Berkeley, CA
mokunz@berkeley.edu

Wednesday, September 22 at 11:15 am

Invasive floating macrophytes are aquatic weeds that exert strong negative influences on an ecosystem owing to characteristics such as high growth rates aided by asexual reproduction, formation of dense floating mats that out-compete other plant species, and unanchored root systems that allow dispersal by passive drifting on environmental flows. Water hyacinth (Eichhornia crassipes) is one such weed that has invaded freshwater systems worldwide, with detrimental effects to native ecosystems and human activities such as navigation, agriculture, and recreation. This research examines physical interactions between water hyacinth and surrounding air and water flows to better understand the fluid dynamic effects of floating macrophytes and the transport mechanisms that govern regional dispersal. Experiments in an open channel flume and a wind tunnel were conducted using live plants to measure flow-induced forces and observe surrounding flow fields for different mat configurations. Forces were measured directly using a strain gauge and velocities were measured using an acoustic Doppler velocimeter in water and a sonic anemometer in air. Over similar Reynolds number regimes, water drag forces exceed air drag forces for a given mat, and water drag coefficients are greater than wind drag coefficients. The presence of water hyacinth mats in a channel causes deflection of air and water flows around the mat structure and increases turbulence in both fluids. Comparisons of longitudinal (x-direction) velocity transects for different mat lengths (L) suggest similarity in the form of flow perturbation for mean and turbulent flow fields. The vertical profile of mean water velocity sampled near the downstream end of a mat (x/L = 0.8) has an inflection point and resembles a mixing layer. This research builds upon existing studies of terrestrial and aquatic canopies, providing a data set for patch-scale vegetation at the air-water interface.

Argo measurements of Madden-Julian Oscillation mixed layer variability

Kyla Drushka¹, Susan Wijffels², Janet Sprintall¹ and Sarah T. Gille¹
(1) Scripps Institution of Oceanography, University of California–San Diego, San Diego, CA, (2) Center for Australian Weather and Climate Research, CSIRO Marine and Atmospheric Research, Hobart, TAS, Australia
kdrushka@ucsd.edu

Friday, September 24 at 10:45 am

The Madden-Julian Oscillation (MJO) is associated with wind and convective anomalies that exert a profound influence on the upper ocean through fluxes of heat, freshwater, and momentum. In turn, these processes affect the distribution of heat and salt in the ocean mixed layer, which can have implications for weather and climate globally. Although many studies have examined the impacts of MJO forcing on the ocean mixed layer, there has been a paucity of in situ measurements, and the subsurface MJO signal has not been well quantified over a large spatial domain. In this study, we use data from Argo floats to observe MJO-related variations in the tropical Indian and Pacific Ocean mixed layers. Argo offers an advantage over satellite data sets by providing direct subsurface measurements of temperature and salinity. From these observations, along with satellite data sets, we construct composite MJO mixed-layer heat budgets. We also present in situ estimates of MJO variations in mixed-layer depth and mixed-layer salinity throughout the domain.
Impact of Missoula Floods on the Pacific Ocean, 15-13 ka

Megan Gambs, Susan Hautala and LuAnne Thompson
School of Oceanography, University of Washington, Seattle, WA
mfgambs@uw.edu
Friday, September 24 at 11:00 am

The Missoula Floods (15-13 ka) were a series of jökulhlaups (freshwater glacial-outburst floods) from Glacial Lake Missoula, during the Last Glacial Maximum (LGM). These floods carved the Scablands of eastern Washington State and flowed into the Pacific Ocean via the Columbia River. This study investigates the effect of the floods on Pacific Ocean circulation. We use the Community Climate System Model version 3 (CCSM3) with freshwater perturbations to simulate the response of the Pacific Ocean to the Missoula Floods. Before implementing freshwater forcing experiments in the model, we present analysis of the differences in Pacific Ocean circulation, temperature and salinity between the LGM and Pre-Industrial (PI) coupled climate simulations. We also compare the PI run against observations to identify CCSM3 model biases in the North Pacific. We will also describe a series of simulations that will be performed using CCSM3 to investigate the impact of the jökulhlaups on the state of the North Pacific ocean with particular focus on changes in sea-ice cover and oceanic connections to the tropical Pacific.

Effects of channel deepening on tides and currents in Newark Bay from observations and models

Dove Jige Guo
Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ
doveguo@marine.rutgers.edu
Wednesday, September 22 at 1:15 pm

The response of an estuarine system to channel deepening is discussed based on observations and idealized models of Newark Bay. This system has undergone significant deepening to accommodate shipping. Both observations and model show that tidal amplitude in the bay and transport of water to the bay experienced little change so that the tidal current amplitude in the channels was inversely proportional to channel cross-sectional area governed by volume conservation. As the channels are dredged, their cross-sectional area increases and tidal currents in the channels weaken as a result. The data analysis was aided by 3 datasets collected from Acoustic Doppler Current Profiler (ADCP) and 2 datasets collected with Conductivity and Temperature (CT) sensors spanning a decade as well as 30 years record of hourly water level data from NOAA. The results were then confirmed with a linear, analytical model.

While the Hansen and Rattray theory predicts that exchange flow should increase with $H^3$ it also suggests that horizontal salinity gradient should decrease with $H^3$ and thus the exchange flow would remain constant with channel deepening. Results from this study reveal that $ds/dx$ remained nearly constant with deepening due to geomorphological constraints thus allowing the exchange flow to increase with $H^3$. These constraints were demonstrated in a statistical model which captures the magnitude of increasing salinity at Kill van Kull (KVK) site. What's more, under low flow condition, the structure of the exchange flow changed from being vertically more uniform and thus weaker when the channels were shallower to being more vertically sheared and thus stronger when the channels were deeper.

Caroline Harbitz
School of Oceanography, University of Washington, Seattle, WA
charbitz@uw.edu
Wind driven cross-shelf circulation on a seasonally stratified inner shelf

Rachel Horwitz and Steve Lentz
Woods Hole Oceanographic Institution, Woods Hole, MA
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Wednesday, September 22 at 3:00 pm

Wind driven transport in the upper ocean is typically to the right of the wind stress, following classic Ekman (1905) theory, and in this way, along-shelf winds are expected to drive cross-shelf transports of water and suspended material. In contrast, recent observational (Fewings et al., 2008) and modeling (Tilburg, 2003) studies have shown cross-shelf wind stress to be a significant mechanism for cross-shelf transport on the inner shelf. Total Ekman transport is still zero in the direction of wind stress, but within the boundary layer, velocities are in the direction of the wind stress near the surface and opposite the wind stress in the lower part of the boundary layer. When the water is unstratified, Tilburgs and Fewings results agree with each other and with Ekman theory. However, in stratified conditions, Tilburg finds a reduction in cross-shelf transport, circulation entirely confined to the surface mixed layer, and no surface pressure gradient, while Fewings observed enhanced cross-shelf transport and circulation throughout the water column. Fewings suggests a more complicated balance of forces driving the cross-shelf circulation, including cross-shelf pressure and temperature gradients. This study uses three years of observations from the inner shelf of Marthas Vineyard, MA to test Tilburgs predictions and quantify the effect of stratification on the cross-shelf circulation.

Nutrient Supply in Coastal Upwelling Regions: The Importance of Stratification and Topographic Slope

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Wednesday, September 22 at 11:30 am

An idealized, two-dimensional modeling study is presented to investigate the effects of variable shelf slope and stratification on surface mixed layer nutrient supply during upwelling. Using the Regional Ocean Modeling System, numerical experiments are performed with shelf slope and stratification varied to encompass those found in the major global upwelling regions. As reported previously, the physical flow regime is governed by a topographic Burger number. Gradual shelf slope and weak stratification concentrate onshore transport in the bottom boundary layer while steep slope and strong stratification increase the relative interior transport between surface and bottom mixed layers. In 20-day model simulations initialized with a linear nitrate profile, bottom boundary layer nitrate flux decreases with increasing Burger number. The opposite is true for interior nitrate flux. Upwelling source depth is also investigated and increases more rapidly with weak stratification and steep slope. Model experiments representative of specific regions are analyzed to determine event-scale nitrate supply and are discussed in relation to satellite-based primary production estimates. After 5 days of upwelling, nitrate flux into the surface mixed layer is similar at sites off northern California, Oregon, and Peru, and slightly less off northwest Africa. However, in contrast with Oregon and Peru, nearly all onshore transport off northwest Africa occurs close to the sediments. Model results indicate that nitrate fluxes estimated assuming a constant upwelling source depth are strongly dependent on source depth choice in the California Current, and much less so in the Peru and Canary Currents.
Numerical Modeling of Hydrokinetic Turbines and their Environmental Effects*  

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Thursday, September 23 at 2:30 pm  

The search for renewable energy to supply the ever-increasing demand for electricity and displace fossil fuel generation has led to significant interest in tidal currents. Underwater hydrokinetic turbines extract energy from ocean tides in estuaries and narrow channels, in a way similar to wind turbines operating in high wind areas. Although important technological issues still exist, environmental impact assessment is the key source of uncertainty delaying the deployment of pilot projects and, ultimately, commercial scale arrays.  

We study turbine wake dynamics and the potential environmental effects of physical changes introduced in the flow. The velocity deficit in the turbulent wake affects the sedimentation process of suspended particles in the tidal channel. This can lead to deposition into artificial patterns that will alter benthic ecosystem. Similarly, the high velocities associated with the passage of turbine blades near the bottom topography can lead to resuspension of sediment and scouring near the turbine foundation. These devices also introduce a pressure fluctuation across their blades that can damage internal organs of marine species as they swim through the device.  

We have developed a hierarchy of models to simulate the turbulent wake behind a well-characterized two bladed turbine, with different computational cost and fidelity to the underlying physics. The results from these models have been validated against one set of experiments and high fidelity simulations. We use these validated models as our research tool to investigate the potential environmental effects of the devices.  

In this work our numerical methodology for modeling hydrokinetic turbines will be explained. We will present sedimentation statistics to understand the sensitivity of this phenomena to turbine operating conditions and sediment properties. We also show pressure history for slightly buoyant Lagrangian particles moving through the turbine and correlations with damage thresholds for fish obtained from laboratory experiments in the literature.  
*Supported by DOE through the National Northwest Marine Renewable Energy Center  

Simulating the effects of vegetation on flow and turbulent mixing in coastal waters  

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Wednesday, September 22 at 11:00 am  

Vegetation such as tidal marshes and mangroves can significantly affect coastal hydrodynamics, including water levels, wave processes, and turbulent mixing. This presentation describes an ongoing study to simulate the effects of vegetation on flow and turbulence in coastal waters. The study makes use of a one dimensional turbulent kinetic energy (TKE) model developed by Sheng et al (2010) and validated with data from several vegetated flow experiments, including those of Shimizu and Tsujimoto (1994), Nepf and Vivoni (2000), and Neumeier (2007). Comparisons to observations show that the model can accurately simulate the vertical distribution of mean currents and turbulence in vegetated flow. The model is incorporated into a three dimensional circulation model, CH3D, to simulate the ability of vegetation to dissipate storm surge and tides during Hurricane Charley. Model results compare well with data.  

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**Stratification Control on Distribution of the Hypoxia on the Texas-Louisiana Shelf from Towed and Shipboard Observations**

**Bo Li, Steven F. DiMarco and Matthew K. Howard**  
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Wednesday, September 22 at 10:45 am

We examine the vertical structure of water column stability and vertical current shear and their relationship with near bottom dissolved oxygen concentration in the hypoxic zone of the eastern Texas-Louisiana Shelf. Observations are made with an undulating towed vehicle containing a CTD, and fluorometer, turbidity, dissolved oxygen sensors. Current velocity measurements are obtained using a ship mounted 300-kHz ADCP.

Hypoxia, defined as 1.4 ml/L of dissolved oxygen (DO) on the Texas-Louisiana shelf, occurs seasonally and is believed to be largely the result of organic and nutrient loading from the Mississippi River and coastal wetlands and the increased vertical stratification and reduced mixing that occurs in the summer months. Observations presented were taken in summer 2010, when there is a severe oil spill in Gulf of Mexico. Preliminary results show that the hypoxic water mass is not continuous, but has a wavelike structure along the shelf. Also the results show that this wavelike distribution is controlled by the spatial structure of the stratification on the shelf. The observations stress the importance of physical processes in controlling the spatial and temporal distribution of hypoxic waters and are particularly relevant for coastal management decision makers aiming to assess the success of the NOAA/EPA Action Plan to reduce the size of Louisiana Deadzone.

**Seasonal Sand Level Changes in southern California: Beyond Wave Energy**

**Bonnie Ludka, Bob Guza and W. O’Reilly**  
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Wednesday, September 22 at 2:45 pm

Many southern California beaches are exposed to strongly seasonal waves, with relatively energetic waves arriving from the north during winter, and milder waves arriving from the south during summer. Sand levels are also often strongly seasonal, with maximum shoreline erosion in winter and maximum shoreline accretion in summer. Seasonal vertical fluctuations in shoreline sand level of 3 m are not uncommon, and mean subaerial beach width can vary by 50 m. Limited observations and simplistic models suggest the seasonality of beach profiles is caused by seasonal fluctuations in wave energy and the associated cross-shore sediment transport. Energetic winter waves erode the beach face and deposit sand in an offshore sandbar, and mild summer waves return the offshore sand to the beach face. Wave direction, and the alongshore transport of sand, is neglected.

Models based on seasonal wave energy often fail at sites near shoreline irregularities or where the wave field varies strongly alongshore. At these sites, the breaking wave-driven mean alongshore current, and the associated alongshore sediment flux (also known as ”the littoral drift”) vary rapidly alongshore. The alongcoast ”divergence of the drift” can cause accretion or erosion, depending on whether the drift is increasing or decreasing in the downstream direction. The divergence of the drift depends strongly on both wave direction and wave energy. Observations of directional waves and sand levels will be used to assess the importance of the divergence of the drift to seasonal sand level fluctuations on southern California beaches.
Near-inertial frequency response of the transition layer at the Arabian Sea mooring

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Thursday, September 23 at 11:15 am

Ocean General Circulation Model studies (Danabasoglu et al. 2008) have shown that transition layer characterizations are important for climate simulations. A recent study by Johnston and Rudnick (2008) has characterized the transition layer using Seasoar data. Here we characterize the transition layer thickness (TLT) in terms of the statistics of the time variance of mixed layer depth, thickness of enhanced stratification and shear regions below the mixed layer as well as the depth of penetration of the wind stress using Arabian Sea mooring data. The transition layer variations are related to the surface fluxes of momentum and heat during time intervals when heat budgets are one dimensional.

Since near-inertial motions are often the most energetic motion in the ocean, we follow Plueddemann and Farrar (2006) near inertial damped slab energy budget analysis to analyze the near-inertial frequency response of the TLT. A steady state solution of their model gives the Ekman transport distributed over the mixed layer. The damping term (which is assumed to be positive) representing the residual flux, vanishes if the wind stress is completely utilized in deepening the mixed layer.

Our results show a persistent near-inertial shear layer below the mixed layer. The shear is more intense at times when the residual term is negative. Residual flux can enhance the near-inertial shear providing energy below the transition layer. On the contrary when the residual term is positive, near-inertial shear is poorly observed below the mixed layer. This is because most of the near-inertial energy transferred to the ocean interior without enhancing the near-inertial shear layer. Hence residual flux is found to be playing an important role thickening and thinning the near-inertial shear layer below the mixed layer.

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The influence of vertical turbulent mixing on submesoscale processes

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Thursday, September 23 at 1:15 pm

Recent studies and research on the submesoscale has revealed upper ocean ageostrophic circulations with O(1) Rossby and Richardson numbers. It is evident that these processes are not fully in accordance with geostrophic or quasi-geostrophic motion; and low Richardson numbers indicate that mixing plays an important role. From recent studies and observations, it has been inferred that such processes play an important role in altering the upper ocean stratification, and make an important contribution to the vertical mass fluxes and tracers, which in turn influence the transport of nutrient rich matter to the surface.

Such flows are also deeply influenced by both wind stress and atmospheric heating and cooling at the surface. Wind stress elevates the vertical shear at the mixed layer, leading to overturning and turbulent mixing. In addition, atmospheric cooling at the surface would induce convective mixing. In short, submesoscale flows are heavily influenced by vertical turbulent mixing process.

The objective of this work is to analyze the influence of vertical turbulent mixing on submesoscale processes and vice versa. This is being
accomplished by coupling a three-dimensional Process Studies Ocean Model (PSOM) to the General Ocean Turbulence Model (GOTM). PSOM is a non-hydrostatic ocean model that has been used for submesoscale flows. GOTM is a 1-dimensional water column model that implements many different second moment closure schemes to determine momentum, heat and salt diffusion along the water column. Many second moment schemes are included, notable ones being the $k-\epsilon$ model, $k-\omega$ model and the Mellor-Yamada 2.5 closure scheme. This work uses a generic 2-equation model that formulates a transport equation for the turbulent kinetic energy, and another term that contains both the energy and turbulent macro-lengthscale. Some preliminary results from this coupling will be presented.

A new basin-coherent mode of variability in the Arctic Ocean

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Friday, September 24 at 2:30 pm

The ocean bottom pressure (OBP) was measured at the North Pole from 2005 to 2010, as part of the North Pole Environmental Observatory. A collection of in situ OBP observations from other 5 locations in the western Arctic, together with the bottom pressure at the North Pole, suggest that the bottom pressure oscillations from daily to up to few months are highly coherent across the basin. These observations of OBP show a spectral peak at a period of about 19 days, which is consistent with modeling results of OBP from the Pan Arctic Ice-Ocean Model Assimilation System, PIOMAS. Comparison of OBP from PIOMAS, which assumes a perfect inverted barometer, with the observed OBP suggests that departures from the inverted barometer response are small. The fact that the PIOMAS OBP without direct atmosphere pressure loading shows a spectral peak that is similar to observed OBP, suggests that these oscillations are wind driven rather than due to direct atmospheric loading. The basin-averaged OBP variations from PIOMAS are highly correlated with the surface atmospheric pressure over Scandinavia. This is consistent with a correlation between southerly winds in Fram Strait and the basin-averaged OBP, with the pressure lagging the wind by 1-2 days. Through examination of atmospheric pressure data, and PIOMAS model results, we investigate the basin-coherent response of the ocean to the atmospheric forcing, and the origin of the 19-day oscillation.

Observations of near-inertial waves during the Internal Waves Across the Pacific Experiment

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Thursday, September 23 at 1:30 pm

Six moored profilers deployed in summer 2006 as part of the Internal Waves Across the Pacific Experiment (IWAP) repeatedly sampled the upper 1400 m each 1.5 hours for about two months. In this study, the resulting depth-time series of velocity, displacement, shear and strain are used to examine the near-inertial internal wave field. A number of energetic near-inertial packets were identified, and their vertical and horizontal propagation examined.
Antarctic Bottom Water Warming Since the 1990s and Implications for Global Heat and Sea Level Budgets

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Friday, September 24 at 1:45 pm

We investigate global deep ocean temperature trends since the 1990s and assess the role of deep ocean heat storage in the global heat and sea level budgets. We estimate warming rates using twenty-eight full-depth, high-quality hydrographic sections that have been occupied two or more times between 1980 and the present: usually first by the World Ocean Circulation Experiment (WOCE) Hydrographic Program (mostly after 1990) and more recently by various international repeat hydrographic surveys in support of CLIVAR and carbon cycle science. For each repeat section we estimate a warming rate and its uncertainty. We divide the ocean into 32 deep basins based on the topography and climatological ocean bottom temperatures. We find a strong abyssal warming trend in the three southern-most basins, with an abyssal warming signal that weakens northward in the central Pacific, western Atlantic, and eastern Indian Oceans. Basins in the eastern Atlantic and western Indian Oceans show cooling trends. We suggest that the deep warming originates from the Southern Ocean as changes in AABW that propagate around the globe. We use the observed changes in potential temperature to estimate a global heat content change below 4000 m over the last few decades that is equivalent to a heat flux of 0.03 (±0.01) Wm⁻² over the entire surface of the earth at 95% confidence limits. Prominent mid-depth (1000 - 4000 m) warming of cold waters mostly of Antarctic origin found south of the Sub-Antarctic Front adds another 0.09 (±0.02) mm year⁻¹. Abyssal warming of Antarctic origin may account for a substantial fraction of the estimated present global heat flux imbalance (of order 1 Wm⁻²) and sea level rise rate (of order 3 mm year⁻¹), making it a potentially important contributor to the global heat and sea level budgets since the 1990s.

Optical measurements of shallow flows in tidal flat channels

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Wednesday, September 22 at 2:30 pm

Systems of incised channels on tidal flats are the predominant pathway for water, sediment, and nutrient fluxes through the flats. Estimations of these quantities require accurate measurements of channel velocity, however in-situ current measurements are poorly suited to observing these shallow flows. Acoustic instruments, such as ADCPs, become unreliable when the water depth nears the instrument’s blanking distance, and point-measurements may under-sample importance spatial variance. This work presents measurements of surface velocities in an incised tidal flat channel using an optical method. Video observations from a tower-mounted IR camera are Fourier transformed to produce velocity spectra and a time series of surface velocities. These measurements compare well with in-situ ADCP observations and allow the creation of a complete velocity time series when the water depth falls below the ADCP blanking interval (10 cm). The resulting observations show different hydrodynamic regimes with tidal phase, including drainage conditions during the previously data-poor low tides.
Observations of Large-scale Upper Ocean Volume Transport in the Pacific Ocean

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Friday, September 24 at 3:00 pm

Empirical estimates of the large-scale volume transport in the upper ocean have historically been based on a limited number of hydrographic transects. Since 2001, several thousand profiling floats have been deployed in the Pacific Ocean as part of the global Argo array, producing thousands of temperature and salinity profiles. Using the drift of these floats, we compute the absolute geostrophic velocity at 900 db. These velocity estimates are then objectively analyzed using a covariance function determined from the data, giving the large-scale geostrophic streamfunction at 900 db for both the North and South Pacific basins. Combining this estimate with the objectively mapped temperature and salinity profiles allows us to determine the absolute geostrophic streamfunction and corresponding volume transport throughout the upper 2000 db on seasonal, annual, and interannual timescales, for the period 2005 to 2008. Using these results, the zonally-integrated meridional transport in the upper ocean is computed as a function of latitude and compared to previous observational estimates in the Pacific.

How efficient are storms at exciting inertial variability in the upper Arctic Ocean?

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Thursday, September 23 at 11:30 am

The process by which energy is transferred from the atmosphere into the ocean is well understood throughout the non-polar regions, but energy transfer through an ice cover still remains an open fundamental question. This project aims to understand the how the presence or lack of presence of an ice cover affects the mechanical energy transfer into the upper Arctic Ocean as part of the energy cascade from atmospheric storms to ocean turbulence. Energy throughout the interior of the ocean is spread in the form of internal waves and the ultimate source of energy for these waves can be either attributed to tidal or atmospheric forcing. Previously it had been thought that sea-ice isolates the ocean from atmospheric inputs during winter, however new data has shown periodic growth in the internal wave field throughout winter. Internal waves are generated when atmospheric disturbances stimulate inertial oscillations in the mixed layer of the water column. These inertial oscillations bleed off into the stratified ocean below in the form of internal waves. Eventually these internal waves will dissipate in the form of turbulence; therefore the internal wave generation process is an important link in the atmospheric-oceanic energy transfer. To address this link four upward looking Acoustic Doppler Current Profilers (ADCP’s) and Conductivity, Temperature and Depth (CTD) instruments were deployed for one year beginning in the summer of 2008 as part of the Ice Covered Oceanic Response to Atmospheric Storms (ICORTAS) project in the Beaufort Sea. Current work has focused on ice detection and drift through ADCPs and correlation with satellite observations. Preliminary results show energy transfer an order of magnitude smaller during ice covered storm events.
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A Monte Carlo Method to Find Mass Flux Variability in the North Atlantic and Southern Oceans  
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Friday, September 24 at 2:45 pm

Using the concept of transit-time distributions (TTDs), we estimate the volume transports and spreading rates of Labrador Sea Water (LSW), Antarctic Intermediate Water (AAIW), and North Atlantic Deep Water (NADW) through three different repeated cross-sections of the ocean with observations of pCFCs and Helium-3/Tritium. We estimate the TTD using an inverse Gaussian (IG) that is observationally informed from pCFC and Helium-3/Tritium ages. The Helium-3/Tritium ages are estimated using a nonparametric statistical model that works well with sparse observations. In areas where water masses of vastly different ages mix, this representation is extended to a mixture of two IGs. Using a combination of statistical techniques, we arrive at a Bayesian estimate of a multiple-peaked TTD and find the mean ages and Peclet number at each location and depth. We find that once a mean age of about 50 years is surpassed, Helium-3/Tritium serves to add more information than CFCs would have all on, but the uncertainties on the IG parameters below the thermocline can often be large enough to not be able to distinguish the Peclet number from zero. Finally, we demonstrate the sensitivity of volume transport spectra are to the discrepancies between model output, mixture IG representation, and Bayesian estimates of TTDs. We find smaller average spreading rates than those inferred from previous studies with intra-annual variability larger for NADW than AAIW and LSW with the smallest, assuming steady-state for each snapshot.

The influence of a large scale circulation on a boundary current  
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Friday, September 24 at 11:30 am

The wind-driven gyre circulation in the ocean interior varies across large temporal and spatial scales, while the current along the lateral boundary is concentrated in a narrow jet with smaller temporal and spatial scales. These boundary currents are often hydrodynamically unstable and generate mesoscale and sub-mesoscale fluctuations. In this study, we investigate the influence of the large scale circulation (LSC) on an unstable boundary current, for example, the influence of the Pacific subtropical gyre on the California Current System.

The problem is studied in a barotropic and quasigeostrophic framework. The boundary current is represented by a uniform meridional jet $V = \text{sech}(x)$, so called Bickley jet. The LSC is represented by either a uniform zonal onshore flow in the interior with a large inertial boundary layer (Type I) or a double gyre structure (Type II).
A linear stability analysis shows that, in the lowest order, the influence of the large scale circulation on the jet is done through two mechanisms. In the zonal direction, the zonal onshore/offshore flow of the LSC stabilizes/destabilizes the jet. In the meridional direction, the nonuniform meridional flow of the LSC modifies the jet stability through the Doppler effect, increases or decreases the spatial growth rate of perturbations. Including the LSC contributes to the non-uniformity of the boundary jet stability, from which we can infer that some regions might contain stronger eddy activities than others.

This is a first step to highlight the influence of the large scale ocean circulation on the boundary current. We extend the linear analysis to a nonlinear study, which is underway.

Ageostrophic Submesoscale Instability in Rotating Shallow Water

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Thursday, September 23 at 2:45 pm

A new kind of Rotating Shallow Water (RSW) shear instability is studied in an unbounded domain. The properties of four geostrophically-balanced, parallel mean flows: the Bickley jet, the cyclonic and anti-cyclonic 2-jet shear, and the 3-jet shear are examined in a range of Rossby (Ro) and Froude (Fr) numbers. This is an ageostrophic instability, which appears when Fr and Ro are above some critical values, and grows robust as the Fr and Ro get large. The instability can be found in a wide range of downstream wave numbers (kD), with small cross-stream scale structures. It has multiple modes for a fixed (jet-number, kD, Ro, Fr), with discrete, multiple growth-rate peaks. We believe that the criterion of this instability depends on the local Fr, related to the violation of Ripas stability condition [Ripa, 1983].

Towards an understanding of the form drag at Three Tree Point, Puget Sound, WA

Sally J. Warner1, Parker MacCready1, Jim Moum2, Uwe Stoeber2, Jonathan Nash2

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Wednesday, September 22 at 1:30 pm

Three Tree Point is a headland in the Main Basin of Puget Sound, WA. It has been the site for many studies that looked into the role that form drag plays in converting energy away from the barotropic tides to features like internal waves, eddies and eventual turbulence and dissipation. In the current study, we are measuring the bottom pressure with sensitive pressure gauges (PPODs) which can be used to estimate the form drag in a way that’s only just being developed for oceanographic applications. A numerical model of the region that can give a much more detailed picture of the flow has also been built. This talk will highlight important advances from the previous studies and showcase preliminary results from both the PPODs and the numerical model.

Glider-based Observations of Internal Tides near the Luzon Strait

Cathy Yang1, Craig M. Lee1, Luc Rainville1, and Daniel L. Rudnick2

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Thursday, September 23 at 1:45 pm

Internal tides are internal waves of tidal period generated by tidal currents flowing over rough topography. The two meridional ridges in the Luzon Strait, located between the Philippines and Taiwan, are known to be generation sites of large internal
waves. These internal waves have traditionally been observed from satellite remote sensing, in situ shipboard and moored measurements with limited availability of data collected at the relevant temporal and spatial scales. Previous studies mostly focus on the west side of the Luzon Strait, which connects to the South China Sea where the strongest nonlinear internal waves occur. Observations on internal tides east of the Luzon Strait are sparse. This study first employed autonomous long-endurance gliders to collect one-year repeated hydrographic sections with good spatial coverage of the Luzon Strait and east side of the strait. We demonstrate the use of gliders to study internal tides. Diurnal and semidiurnal internal tides were energetic in the Luzon Strait, especially near the west ridge, with amplitudes of isopycnal displacement greater than 60 m. The internal tide signal was comparatively small east of the Luzon Strait. This asymmetric structure might result from the active mesoscale eddies or the Kuroshio Current in the Luzon Strait area.

Contributions to the Seasonal and Interannual Sea Surface Height Anomaly Variability in the North Atlantic Ocean

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Friday, September 24 at 1:15 pm

The causes of variability of altimetric sea surface height (SSH) are explored using simple models of SSH response from wind-stress curl and heat flux forcing. Model SSH from seasonal heating shows an obvious seasonal cycle at all low and mid-latitudes that is consistent with observed SSH. In some special regions where advection is weak, like the North Atlantic Current region is the observed SSH generally consistent with the SSH from heating. SSH is also predicted from a model of first baroclinic mode long Rossby wave propagation forced by wind stress curl calculated from ECMWF and QuikSCAT winds. This model SSH is in phase with the observed westward propagating SSH south of 40N. The flat-bottom Sverdrup balance (with the wind-driven transport assumed to be carried in the upper 500m) is good at reproducing the SSH in the

Laboratory observations of river plume lateral spreading

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Wednesday, September 22 at 1:45 pm

River plumes are an important component in the coastal ocean regions, and are responsible for transport energy and sediment from river into ocean. Most plume studies cite classical laboratory experiments on buoyant gravity currents to understand mixing and propagation. However, these channelized two-dimensional experiments do no account for dynamics induced by lateral spreading of the plume. The relationship between lateral spreading and mixing between the plume and the ambient water remains largely untested by laboratory experiment. As part of the Merrimack River Mixing and Divergence Experiment 2 (MeRMADEx2) project, this laboratory studies is designed to investigate how lateral spreading modifies fundamental mixing processes in the core of the plume and near the front. All experiments are carried out in a 2.5m by 4.0m basin, over a large Froude number parameter range. The basin is filled with saltwater and the plume is generated by discharging freshwater from the constant-head source tank through an estuary-like opening. We combine Particle Image Velocimetry (PIV) and Planar Laser Induced Fluorescence (PLIF) to obtain simultaneous, high-resolution measurements of density and velocity in an idealized buoyant free-spooling plume. The mixing efficiency is calculated from the density and velocity field and used to compare with the spreading rate in different inflow Froude numbers.
subtropics where the flow is mostly baroclinic. In contrast, the topographic Sverdrup balance shows promising results in the subpolar gyre, where the topography is important in controlling the vertically integrated flow. Statistical comparisons of modeled and observed SSH show the regions where the processes examined are the dominant forms of SSH variability. This study does not only indicate the importance of different physical processes on SSH variability, but also can be correlated with Atlantic meridional overturning circulation (AMOC), which is significant for the climate change.
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