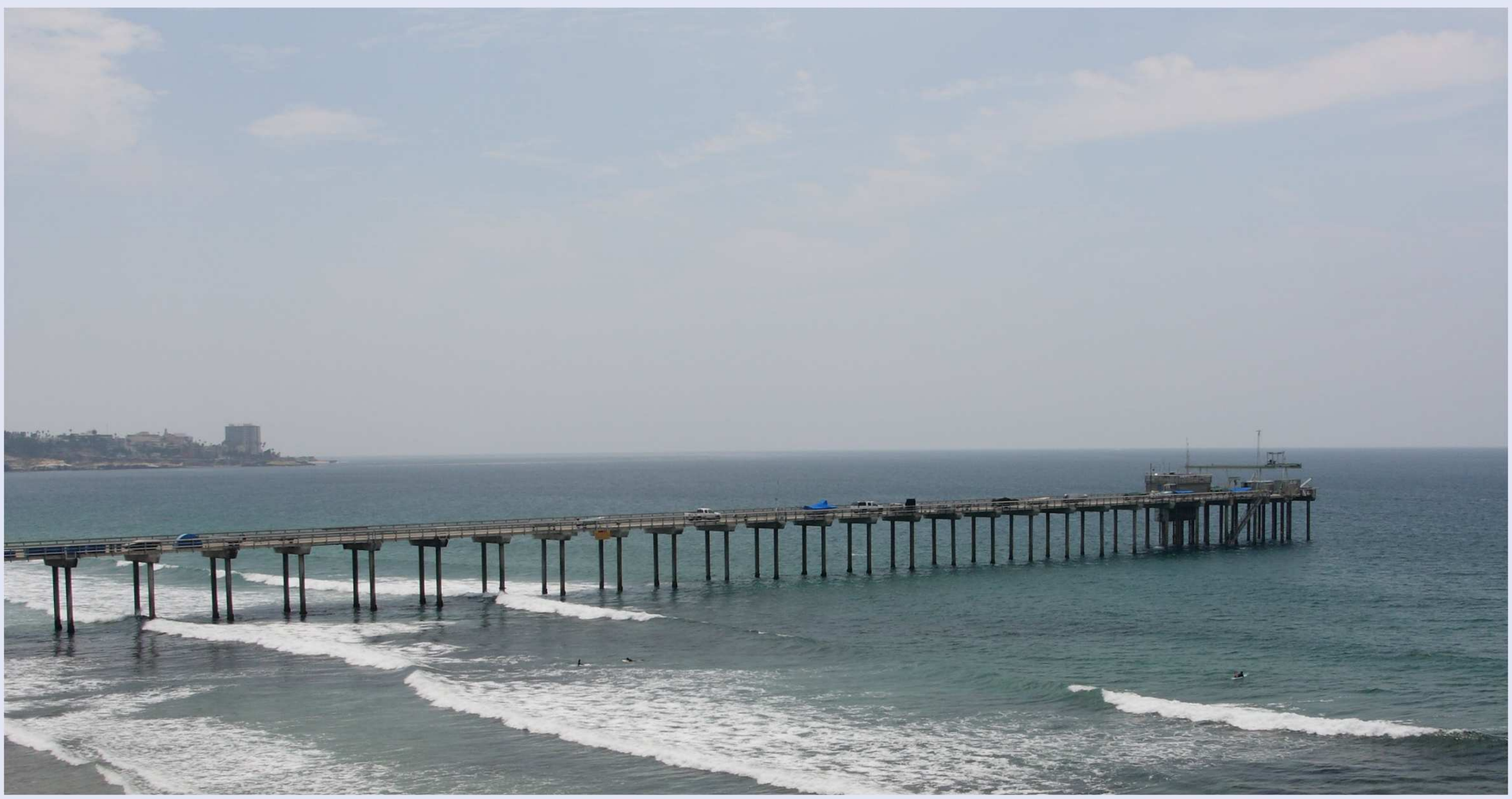
International Meeting of Students in Physical Oceanography

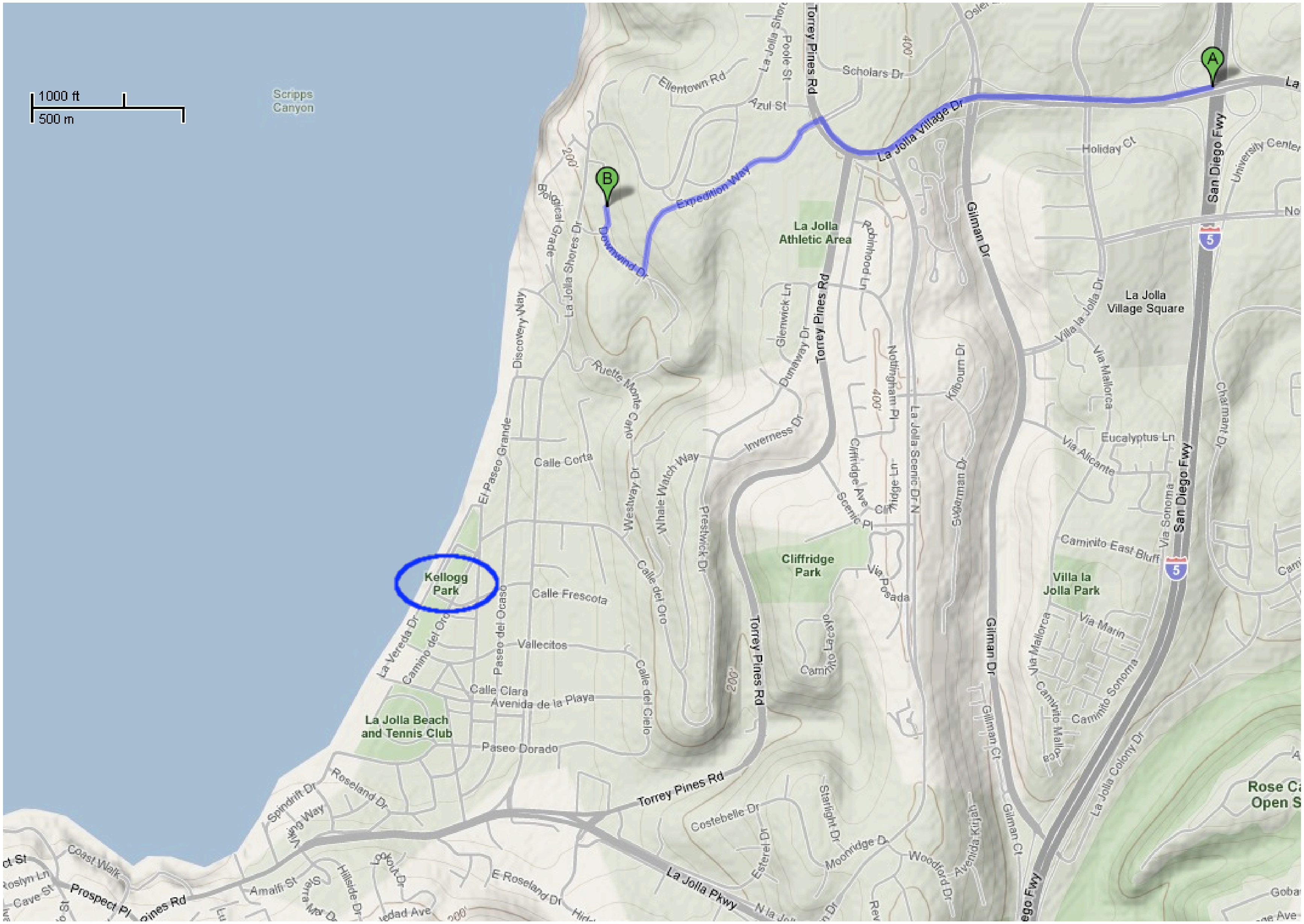
Scripps Institution of Oceanography
22-24 October 2008

Program and Abstract Book



IMSPO 2008

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC SAN DIEGO


1000 ft
500 m
Scripps Canyon
Kellogg Park
La Jolla Beach and Tennis Club
La Jolla Athletic Area
Cliffridge Park
Villa la Jolla Park
La Jolla Village Square
Expedition Way
Downwind Dr
La Jolla Village Dr
Torrey Pines Rd
Gilman Dr
San Diego Fwy
La Jolla Scenic Dr N
La Jolla Shores Dr
El Paseo Grande
Camino del Oro
La Vereda Dr
La Jolla Pkwy
Prospect Pl
Coast Walk

Contents

1 Welcome

Welcome to the Scripps Institution of Oceanography.

For over a century, Scripps has been one of the world's largest, most important centers for marine and earth science research, education and public service. Its preeminence is reflective of its excellent programs, distinguished faculty and research scientists, and outstanding facilities. Scripps' distinction in scientific research is accompanied by its leadership in education, with one of the largest graduate programs in earth and marine science in the country.

The Oceans and Atmosphere Section at Scripps is made up of approximately 70 academics and their staff from four divisions: the Center for Atmospheric Sciences (CAS), the Climate Research Division (CRD), Marine Physical Laboratory (MPL), and the Physical Oceanography Research Division (PORD). Research topics involve many aspects of the atmosphere-land-ocean system, from climate timescales down to daily forecasts and analysis, and from global scales to small-scale turbulence. In addition to the physics of the earth system, the section includes researchers studying acoustic communication, marine mammals, ecosystem dynamics, geochemistry, and geology.

2 About IMSPO

2.1 History

The first IMSPO was held at CICESE (Centro de Investigacion Cientifica y de Educacion Superior de Ensenada) in Ensenada, Mexico June 27-29, 2007 (`http://oceanografia.cicese.mx/personal/cesar/PaginaIMSPO/`). Masters and Ph.D students from 7 schools in Mexico and the US attended as well as faculty from CICESE and SIO. IMSPO developed from the CICESE-SIO Mexican-American Physical Oceanography Summer Student Seminar Series of 2005.

2.2 Organizing Committee

The IMSPO 2008 organizing committee consists of:

- Gabriela Chavez
- Sylvia Cole
- Kyla Drushka
- Aurelien Ponte
- Leonel Romero
- Robert Todd
- Marissa Yates

2.3 Financial Support

Financial support for IMSPO 2008 was generously provided by the International Community Foundation's Sea of Cortez Fund, the Oceans and Atmospheres Section of SIO, and the SIO Graduate Department.

3 Venue

All talks will be held in Hubbs Hall 4500 (Building 8752, map inside back cover). Breakfast and lunch each day will be at the Martin Johnson House (Building 8840), and dinner will be at various locations. Wireless internet access is available in many locations throughout SIO and UCSD. We will provide you with a temporary account to access the network.

4 Registration

A registration table will be set up each morning during breakfast. You may pick up a name tag and program book there. You will also be asked to pay the conference registration fee of $5 at that time. Parking permits will be available for those bringing cars.

5 Travel

Please plan to arrive in time for the beginning of the conference at 0845 on 22 October and stay through TG in the evening of 24 October. We are currently unable to provide travel funds.

5.1 By car

US Interstate 5 provides easy access to SIO from the north and south (including Baja California, Mexico). US Interstate 8 intersects Interstate 5 just south of La Jolla.

From Interstate 5 (A on map on inside front cover), take the La Jolla Village Dr. exit (westbound). Turn left on Expedition Way, then right on Downwind Way, and right on Shellback Way (B on map on inside front cover). Shellback Way will dead end into lot P014 where you may park (see SIO map on inside back cover). Parking permits will be provided at registration. We strongly encourage you to carpool.

5.2 By air

San Diego International Airport (SAN) is most convenient to SIO. Los Angeles International (LAX) has many more international arrivals and departures. Flying into the Tijuana International Airport in Mexico is also a possibility. See Section 6 for information about getting to SIO from San Diego International Airport.

6 Transportation

San Diego has a public transportation network, but the transit times can be very long. Bus 30 (schedules are at `www.sdcommute.com`) provides access to SIO, but we will be at SIO for the majority of the meeting and will organize carpools when needed. If you are flying into San Diego Airport, we suggest `www.supershuttle.com` for an individual (~$54 round trip) or a taxi for a group (~$35 each way - `http://www.driveu.com/yellow_cab.asp` is one example).

7 Accommodations

Those who have requested to will be staying with SIO students. Participants not requesting housing with students are responsible for arranging their own accommodations. If you have any questions about housing please email us (`imspo2008@gmail.com`).

8 Weather in San Diego

The average high in late October is 21°C/71°F, and the average low is 12°C/54°F. Rain is unlikely, but it can be cool and foggy in the evening, so a jacket is recommended. Sunset is at 1800. Surf temperature should be around 18°C/64°F.

9 Presentation Information

Student presenters will be alloted 20 minutes each. We will enforce a 15 minute time limit on talks to provide ample time for questions and discussion after each talk. Please plan your presentation accordingly.

A laptop and projector will be provided. The primary presentation computer will be a Mac laptop with the following software: Keynote 2008, PowerPoint 2004 for Mac (no support for PowerPoint 2007 format,

.pptx), Adobe Acrobat, Preview and Quicktime. PowerPoint presentations made on a Windows computer generally transfer well to Macs, but you may want to check for changes in format. We will have a Windows laptop available if a particular presentation cannot be loaded on the Mac. If you need additional software for movies or other reasons, please contact the organizers as soon as possible.

Please load your presentation prior to the beginning of the session in which your talk is to be given. You may also upload your presentation remotely by placing it on the IMSPO FTP server (ftp://iod.ucsd.edu/imspo2008/dropbox) with your last name and initials as the filename.

10 Refreshments and Social Events

All IMSPO participants are invited to breakfast, lunch, and dinner each day. We will also provide coffee and tea breaks throughout the day. Please let us know if you have any dietary restrictions.

Dinner on Wednesday evening will be held at SIO following the end of the scientific program. On Thursday evening, we will have a picnic dinner by the beach at Kellogg Park on La Jolla Shores. We will arrange carpools from SIO to the beach. On Friday evening, we invite IMSPO participants to join the entire SIO community in our weekly celebration of the end of the week: TG. Food and beverages will be provided at the Martin Johnson House from 1700 until they're gone.

For those who are around on Saturday, we will arrange a tour of the Birch Aquarium at Scripps in the morning.

11 Acknowledgements

We gratefully acknowledge the help and support of the following individuals: Bruce Cornuelle, Dana Dahlbo, Denise Darling, Myrl Hendershott, Anne Middleton, Art Miller, Patty Root, Dan Rudnick, and Bill Young.

12 Schedule

Wednesday 22 October:

0830-0930	Breakfast and Registration
0930-0945	Introductory Remarks
0945-1045	**Plenary Lecture: James C. McWilliams**, Phenomena and dynamical concepts for mesoscale and submesoscale variability in the ocean (p. 8)
1045-1105	Break
1105-1125	**Arno C. Hammann**, What should a subgridscale parameterization look like? (p. 9)
1125-1145	**Stefan Riha**, Methods for computing lateral eddy diffusivity, particle dispersion and Lagrangian eddy scales in an eddy-resolving ocean model (p. 10)
1145-1205	**Sylvia T. Cole**, Seasonal observations of thermohaline structure and the relic mixed layer (p. 10)
1205-1400	Lunch at Martin Johnson House
1400-1420	**Sally Warner**, Dissecting the pressure field in tidal flow past a headland: When is form drag "real"? (p. 11)
1420-1440	**Efraín Mateos-Farfán**, Towards the numerical simulation of the circulation in Todos Santos Bay, Ensenada, B.C. (p. 11)
1440-1500	**Aurélien Ponte**, Wind driven circulation in a semi-enclosed and well-mixed bay, Bahía Concepción (p. 12)
1500-1520	**Gabriela Colorado-Ruiz**, Sensibility in the numerical modeling of the Gulf of California to different parameterization of the vertical diffusion, (p. 12)
1520-1540	Break
1540-1600	**Robert E. Todd**, Seasonal variability at the mesoscale in the southern California Current System revealed by glider surveys (p. 13)
1600-1620	**Melissa M. Omand**, Observations and simple models of an intermediate nitrate maxima generated by nearshore mixing and horizontal advection, (p. 13)
1620-1640	**Eleanor E. Frajka Williams**, Physical controls on the spring phytoplankton bloom in the Labrador Sea using Seagliders (p. 14)
1640-1700	**Marina Frants**, Small-scale turbulent mixing in southern Drake Passage, (p. 14)
1700-??	Dinner at Martin Johnson House

Thursday 23 October:

0845-0930	Breakfast
0930-1030	**Plenary Lecture: Dean Roemmich**, The 2004-2008 mean and annual cycle of temperature, salinity and steric height in the global ocean from the Argo Program (p. 8)
1030-1050	Break
1050-1110	**Mark Carson**, Complications with global ocean heat content trends (p. 15)
1110-1130	**Ana Cecilia Peralta-Ferriz**, Analyzing low frequency variations of bottom pressure in the Arctic Ocean (p. 15)
1130-1150	**Alison Rogers**, Observations of large-scale upper ocean volume transport in the Pacific Ocean (p. 16)
1150-1210	**Thomas Decloedt**, On the power consumed by spatially variable diapycnal mixing in the abyssal ocean (p. 16)
1210-1400	Lunch at Martin Johnson House
1400-1420	**James Holte**, Air-sea fluxes and Subantarctic Mode Water formation (p. 17)
1420-1440	**Gordon Stephenson**, Mixed-layer depth variability in Drake Passage (p. 17)
1440-1500	**Sung Yong Kim**, Preliminary results of poleward propagating features as observed in the U.S. West coast network of HF radar (p. 17)
1500-1520	**Kyla Drushka**, Indian Ocean Kelvin waves in the outflow passages of the Indonesian Throughflow (p. 18)
1520-1550	Break and Departmental Tea
1550-1610	**Pamela De Grau-Amaya**, Numerical modeling of meteotsunamis (p. 18)
1610-1630	**Junhong Liang**, Oceanic responses to Central American gap winds (p. 19)
1630-1650	**Hector Garcia Nava**, Wind stress in moderate to strong wind opposing swell conditions (p. 19)
1650-1710	**Manuel Gerardo Verduzco-Zapata**, Modifications of wave characteristics by submerged obstacles (p. 20)
1710-??	Dinner at La Jolla Shores

Friday 24 October:

0845-0930	Breakfast
0930-0950	**Michael S. Pritchard**, Assessing the diurnal cycle of precipitation in a prototype multi-scale climate model (p. 20)
0950-1010	**Michael Mehari**, Diurnal variation of rainfall over South Africa (p. 21)
1010-1030	**Benjamin D. Reineman**, An airborne scanning LiDAR system for ocean and coastal applications (p. 21)
1030-1050	**Yvonne L. Firing**, Structure of the Antarctic Circumpolar Current in Drake Passage from direct velocity observations (p. 22)
1050-1110	Break
1110-1210	**Plenary Lecture: Manuel López**, Deep inflow and water renewal in the Northern Gulf of California (p. 9)
1210-1400	Lunch at Martin Johnson House
1400-1420	**Gabriela Chavez**, The momentum balance in the continental shelf break of Del Mar, California (p. 22)
1420-1440	**César Coronado**, Current variability observed at the shelfbreak of the Yucatán Channel in the Mexican Caribbean (p. 23)
1440-1500	**Domitilo Nájera**, Low frequency variability at the sills of the northern Gulf of California (p. 23)
1500-1520	Break
1520-1540	**Lilia-Margarita Flores-Mateos**, Barotropic and baroclinic tidal currents at the sills of the Gulf of California (p. 24)
1540-1600	**Nathalie V. Zilberman**, Time-variable conversion of barotropic to baroclinic M_2 tidal energy at the Kaena Ridge, Hawaii (p. 24)
1600-1700	Closing Remarks and Discussion of the Next IMSPO
1700-??	TG at Martin Johnson House

13 Plenary Lectures

PHENOMENA AND DYNAMICAL CONCEPTS FOR MESOSCALE AND SUBMESOSCALE VARIABILITY IN THE OCEAN

James C. McWilliams
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0945 Wednesday 22 October

Mesoscale eddies are known to be everywhere in the ocean, and with newer observing systems we are learning that there is also widespread submesoscale variability that is quite different from inertia-gravity waves. The dynamical paradigm for mesoscale eddies is generation by instabilities of the general circulation with important attendant eddy fluxes; approximate geostrophic, hydrostatic momentum balance; and weak rates of interior energy dissipation and diapycnal material mixing. Submesoscale variability is phenomenologically and dynamically distinctive in many ways, prominently comprising frontogenesis, frontal instability, intense vortices, vertical fluxes, the breakdown of diagnostic force balance, and routes to interior dissipation.

THE 2004-2008 MEAN AND ANNUAL CYCLE OF TEMPERATURE, SALINITY AND STERIC HEIGHT IN THE GLOBAL OCEAN FROM THE ARGO PROGRAM

Dean Roemmich and John Gilson
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0930 Thursday 23 October

The international Argo Program (`http://www.argo.net`) has achieved nearly five years of global ocean temperature and salinity sampling, 0-2000 m. Argo has grown from a sparse global array of 1,000 profiling floats in early 2004 to 3,000 instruments provided by 24 nations in late 2007. Using 400,000 Argo profiles, we constructed an upper-ocean climatology and monthly anomaly fields for the 5-year era of global coverage, 2004-2008. A basic description of the modern upper ocean based entirely on Argo data is presented here, to provide a baseline for comparison with past datasets and with ongoing Argo data, to test the adequacy of Argo sampling of large-scale ocean variability, and to examine the consistency of the Argo dataset with related ocean observations from other programs. The Argo mean is compared to the World Ocean Atlas, highlighting the middle and high latitudes of the southern hemisphere as a region of strong multi-decadal warming and freshening. Moreover the region is one where Argo data have contributed an enormous increment to historical sampling, and where additional Argo floats are needed for documenting large-scale variability. Globally, the Argo-era ocean is warmer than the historical climatology at nearly all depths, and increasingly so toward the sea surface; it is saltier in the surface layer and fresher at intermediate levels. Annual cycles in temperature and salinity are compared, again to WOA01, and to the NOC air-sea flux climatology, the Reynolds SST product, and AVISO satellite altimetric height. These products are consistent with Argo data on hemispheric and global scales, but show regional differences that may point either to systematic errors or to physical processes that need further investigation. The present work is an initial step toward integrating Argo and other climate-relevant global ocean datasets.

A data viewer (PC version at present) is being developed for researchers to display horizontal maps, vertical sections, time-series plots, and line drawings from gridded global Argo data. An installation file is available, including the NetCDF Argo gridded dataset, at: `ftp://kakapo.ucsd.edu/pub/argo/Pacific_Marine_Atlas` Argo data are being used for a broad range of basic oceanographic research, including studies of water mass properties and formation, air-sea interaction, ocean circulation, mesoscale eddies, ocean dynamics, and seasonal-to-decadal variability. Students are encouraged to use Argo data in their research and to join the multi-national effort in global ocean observations.

Deep inflow and water renewal in the Northern Gulf of California

Manuel López and Julio Candela
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1110 Friday 24 October

Moored current, temperature and salinity observations at the sills of the Northern Gulf of California have been used to estimate the deep transport entering the northern gulf. Deep water, entering the northern gulf, passes through two sills that lead to two separate basins, which are not connected below 200 m depth in the southern region. Although the transport through each of the two sills is approximately 0.09 Sv, the transport mechanism is markedly different. Water entering the shallowest sill (400 m depth) overflows through very steep slopes (∼17%) from sill depth all the way to the bottom of Ballenas Channel (∼1500 m), whereas deep transport through the deepest sill (600 m depth) is accomplished by tidal pumping, that is, by a rectification of the transport by the positive correlation between flood tidal currents and upward movement of isopycnals. At this sill, the mean, along-gulf currents are in the opposite direction to the deep transport. All of the deep water that enters the northern gulf through the two southern sills eventually overflows into the two deepest basins in the northern gulf (Ballenas Channel and Delfín Basin). Since these two basins are connected, water flows through the southern and northern sills of this two-basin system. The deep convergence at the bottom is compensated by a divergence at the surface, both in the mean and in the subinertial current fluctuations. The total transport that enters the deepest basins is estimated to be 0.17 Sv which gives a residence time of about 150 days for both basins and a mean vertical velocity of 4.6 m/day. These short residence time and large vertical velocity appear to cause the low SST and high productivity of the Ballenas Channel basin.

14 Student Talks

What should a subgridscale parameterization look like?

Arno C. Hammann and Anand Gnanadesikan
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1105 Wednesday 22 October

The problem of parameterizing small-scale mixing is often cast in terms of finding a mixing coefficient to drive viscous or diffusive mixing with a Fickian formulation. Yet in a bigger sense the role of subgridscale parameterization is really to characterize the total impact of the subgridscales on the resolved flow, effects which may not be characterized by downgradient transport of tracer or momentum. This is well established on global scales, where the necessity of including eddy-driven advective effects in coarse-resolution models of the ocean general circulation has been known for many years, and where eddies can pump energy into large-scale mean flows as well as extracting energy from such flows.

We argue that in the quest for better parameterizations, we should not confine ourselves to one single mathematical model, and to that end present a flexible method that allows us to search among a much larger set of functional forms. The method involves running a coarse-resolution model in parallel with a fine-resolution model and computing the corrections to the coarse-resolution model required to make it evolve like the fine-resolution model. A temporal subset of the resulting forcing on momentum and layer thickness is then regressed against the coarse-resolution velocities and thicknesses to develop a single spatially averaged model for subgridscale forcing.

We developed this method in the context of a simple two-layer model of the Antarctic Circumpolar Current, in which case a distinct functional dependence (which includes, but is not limited to, diffusive effects) emerges. The flexibility and generality of the approach, however, gives us confidence that it can easily be extended to other settings and aplications.

Methods for computing lateral eddy diffusivity, particle dispersion and Lagrangian eddy scales in an eddy-resolving ocean model

Stefan Riha and Carsten Eden
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1125 Wednesday 22 October

The quality of eddy flux parametrizations in models with coarse resolution depends on whether the generated diffusivity is similar to that of reference solutions produced by eddy resolving models. It is therefore essential to accurately describe the diffusive properties of eddy resolving ocean models. Results from a high resolution model (1/12°) are presented and compared to observational data in the Atlantic Ocean. Statistical tools are used to relate particle trajectories of Lagrangian floats to the effective eddy diffusivity. The underlying theoretical framework relies on several assumptions about the statistics of the flow field, and a correct interpretation of the results needs to take account of these restrictive conditions. We give an overview of the different approaches to compute the statistics of the flow field, and address various computational problems that must be handled when computing characteristic timescales of dispersion and Lagrangian length scales. We will show how the resulting diffusivities differ, depending on which computational method is used.

Seasonal observations of thermohaline structure and the relic mixed layer

Sylvia T. Cole and Daniel L. Rudnick
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1145 Wednesday 22 October

Relationships between temperature, salinity, and density in the mixed layer and thermocline show the effects of stirring and mixing in these different regions. Observations of temperature and salinity from the surface to 300-400 m depth along a 1000 km section in the North Pacific were taken in winter (March-April 2005), spring (June 2004), and summer (September 2004) with 3-14 km horizontal resolution. Horizontal temperature and salinity gradients were common on depth and isopycnal surfaces, and were largest above the winter mixed layer base in the mixed layer or relic mixed layer. Gradients along isopycnal surfaces decayed with depth below the winter mixed

layer base in all seasons. In the relic mixed layer between spring and summer, stratification increased, horizontal length scales increased, and the magnitude of horizontal gradients along isopycnals decreased. Stirring occurred at horizontal length scales of 20-40 km in the thermocline and 50-85 km above the winter mixed layer base. Horizontal diffusivity in the relic mixed layer between spring and summer was 2 m^2s^{-1} on 6-8 km scales and 210 m^2s^{-1} on 50-85 km scales. In the mixed layer, density compensation of temperature and salinity was observed in all seasons, and was more common in winter than in spring or summer. In the relic mixed layer, compensation was observed in winter and spring, but not in summer. In the thermocline, temperature gradients exceeded salinity gradients in all seasons. Larger thermohaline gradients had a stronger tendency towards compensation in the mixed layer and towards temperature dominance in the thermocline.

Dissecting the pressure field in tidal flow past a headland: When is form drag "real"?

Sally Warner and Parker MacCready
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1400 Wednesday 22 October

In previous measurements of form drag over topography in the ocean, drag that is much larger than a typical bluff body drag estimate have been consistently found. In this work, theory combined with a numerical model of tidal flow around a headland in a channel give insight into why form drag in the ocean is often found to be so large. The total pressure field is divided into two parts: the pseudo part which is based on the irrotational, inviscid streamfunction, and the dynamically active part which accounts for flow features such as eddies. The pseudo drag can have a large magnitude, yet it cannot do work on the flow because its phase is in quadrature with the velocity. Whereas, the dynamically active drag has a magnitude equal to the bluff body drag, and accounts for all of work done on the flow by the topography. This method not only explains why form drag is often found to be so large in the ocean, but it also gives a method for separating the parts of the pressure field that can and cannot extract energy from the flow. Furthermore, the dependence of the pseudo and dynamically active drags on the tidal excursion distance and the slope aspect ratio of the headlands was determined.

Towards the numerical simulation of the circulation in Todos Santos Bay, Ensenada, B.C.

Efraín Mateos-Farfán and Silvio G. Marinone Moschetto
Departamento de Oceanografía Física, Centro de Investigación Científica y de Educación Superior de Ensenada, Ensenada, Baja California, México
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1420 Wednesday 22 October

The general circulation of Todos Santos Bay was studied using the ROMS numerical model for the summer season. The model was forced with the California Current System and by synoptic winds, which are mainly towards the equator. The circulation is characterized by two systems: one at the exterior and the other at the interior of the bay. The exterior system has a strong surface southward flow and is limited by the 35 m isobath. The interior system oscillates between two circulations structures: (i) the general circulation is anticyclonic for a few days overall the bay producing a large eddy, then (ii) this eddy evolves and splits into two counter rotating eddies making the anticy-

clonic one to be the original limited to the northern side of the bay. The southern cyclonic eddy appears when the inflow at the northwest boundary of Todos Santos bay is more intense. Such conditions are a consequence of small changes in the position of an eddy outside the bay. The (i) and (ii) transition occurs between two-three days and (ii) and (i) transition takes place approximately in three to four days. The time average circulation was also analyzed and the circulation with the two eddies dominates as it is of stronger currents and last longer.

Wind driven circulation in a semi-enclosed and well-mixed bay, Bahía Concepción

Aurélien Ponte, G. Gutierrez de Velasco, A. Valle-Levinson, C. Winant, and K. Winters
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aponte@coast.ucsd.edu
1440 Wednesday 22 October

Bahía Concepción is a semi-enclosed bay of 30 kilometers long by 5 kilometers wide, 30 meters deep and oriented along a nearly north-south axis with the entrance at the north. In Fall and Winter, temperature measurements suggest that the water is well-mixed due to strong (>1Pa) 3-5 days wind events blowing parallel to the axis of the bay toward its closed end. Raw observations of pressure, currents and winds are here used to understand the response of the bay to wind stress.

The response of the low passed sea surface to wind stress is a set up in the downwind direction which is observed and well correlated with wind stress measurements. The quarter wavelength resonance of the bay is estimated around 4 cpd and the hypothesis that the wind forces a resonant response is tested through an analysis in the frequency domain.

A lagged linear regression analysis show that wind driven axial currents are downwind on the western shallow side of the bay with a return flow at depth. A strong lateral circulation, consistent with a Coriolis effect, is observed with currents at the right of the wind at the surface and in the opposite direction at depth. Because the winds are diurnally modulated along with the tide and inertial frequency being near diurnal, an attempt is made to extract the current frequency response to the wind.

An idealized model is used in order to explain the observational results.

Sensibility in the numerical modeling of the Gulf of California to different parameterization of the vertical diffusion

Gabriela Colorado-Ruiz and Alejandro Pares Sierra
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1500 Wednesday 22 October

Two important features of the Gulf of California are the presence of a cold pool of water around the area of the largest islands in the northern Gulf and the existence of large eddies at the central and southern part of the Gulf. We are investigating, through numerical modeling, the dependence of these two phenomenons on vertical diffusion. We will analyze, using ROMS, the ways different parameterization of the vertical diffusion, and the closure problem in general, affect SST and the intensity and longevity of the generated eddies.

Seasonal variability at the mesoscale in the southern California Current System revealed by glider surveys

Robert E. Todd, Daniel L. Rudnick, and Russ E. Davis
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rtodd@ucsd.edu

1540 Wednesday 22 October

The California Current System is rich in mesoscale variability. Since late 2006 we have used Spray gliders to measure temperature, salinity and chlorophyll fluorescence to 500 m depth along CalCOFI Lines 80 and 90 in the Southern California Bight. Measurements at horizontal resolutions of 3 km over two years now allow us to examine seasonality at the mesoscale in this region. Geostrophic velocities referenced to measured vertically-averaged currents show the equatorward California Current offshore, the poleward California Undercurrent along the shelf, and a second poleward undercurrent further offshore. This offshore undercurrent is strongest in summer at Line 90 and in fall at Line 80 where it reaches the surface off Point Conception. Multiple fronts are apparent on both Lines 80 and 90 after averaging seasonally and over all surveys, especially near the low salinity California Current. We investigate the horizontal variability along level surfaces and isopycnals within the mixed layer, near the mixed layer base and within the thermocline using horizontal structure functions. Variability of temperature and salinity are generally greatest near the base of the mixed layer and in summer. A concentration of energy at scales of 100-200 km is apparent in many cases. Chlorophyll fluorescence shows somewhat shorter scales with greatest variability in spring.

Observations and simple models of an intermediate nitrate maxima generated by nearshore mixing and horizontal advection

Melissa M. Omand, J. L. Leichter, F. Feddersen, P. J. S. Franks, and R. T. Guza
Scripps Institution of Oceanography, UC San Diego, La Jolla, California, USA
momand@ucsd.edu

1600 Wednesday 22 October

When strong stratification reaches depths less than 15 m, breaking internal and surface gravity waves, rip cells and wave-driven currents transport, and vertically mix nutrients and micro-organisms within the euphotic zone. Vertical mixing and advection may be important for nutrient delivery and phytoplankton growth into deeper, offshore waters. A month-long study at Huntington Beach CA in Fall 2006 explored the connections between physical dynamics and chlorophyll-a (Chl) fluorescence, nutrients, phytoplankton taxa and abundance in the nearshore and surfzone. Instrumentation included two cross-shore mooring transects (CTD,U,V), a directional wave buoy, small boat CTD+Chl, optical nitrate, Wire-Walker CTD+Chl. Within the surfzone, currents, temperature, and waves were measured on 7 bottom-mounted tripods deployed between the shoreline and 4 m depth. In situ Chl fluorescence was observed at 4 cross-shore locations. A novel jetski platform provided high spatial resolution maps (m to kms) of Chl and temperature, 20 cm below the water surface.

On some occasions, an intermediate maxima in Chl (6 μg/L) and nitrate (4 μM) was observed in a thin ($<$ 3 m width) layer approximately 10 m below the surface and approximately 20 m above the deep Chl maximum and nitracline. We speculate that this layer was formed through enhanced dipycnal mixing in shallow water ($<$ 15 m total depth) and formation of a water mass con-

taining higher nitrate than water of the same density further offshore. Over the course of hours, the nitrate-enhanced water spread along isopycnals forming a thin intermediate layer. This mechanism is potentially important for delivery of deep-water nutrients upwards in the euphotic zone and horizontally offshore. The formation of an intermediate nitrate maxima will be explored through a simple two-dimensional ROMS model with a cross-shore dependant vertical diffusivity, and compared with HB06 field observations. Offshore fluxes in euphotic zone nitrate are estimated and their dependance on stratification, bottom slope, nitracline and euphotic depth will be explored. Finally, future directions, model improvements and pitfalls, and implications for a 'real' coastline will be discussed.

Physical controls on the spring phytoplankton bloom in the Labrador Sea using Seagliders

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1620 Wednesday 22 October

We have investigated the spring phytoplankton bloom in the Labrador Sea, which is a dominant feature of the western subpolar gyre. The offshore advection of low-salinity water by the subpolar gyre circulation and eddies suppresses deep wintertime convection and promotes the intense early bloom in the northeastern Labrador Sea. An autonomous seaglider deployed in the Labrador Sea in the spring and summer of 2005 collected over 1000 profiles of temperature, salinity, vertical velocity, and oxygen to 1000 m depth and fluorescence and optical backscatter to 300 m. Several distinct bio-physical regions were identified: in a fresh eddy in the northeastern bloom, along the Labrador Slope, in a thin layer on the Labrador shelf and in the Labrador shelf-break front. Broad haline stratification due to the lateral flux of freshwater and mesoscale upwelling of nutrients by the eddy and fronts promote and prolong biological activity after the large scale bloom has decayed. These features are often not resolved by satellite or sparse ship data. Furthermore, downwelling currents measured by Seaglider in eddies and fronts may play an important role in exporting carbon and biological products from the surface waters. High resolution *in situ* data such as from the seaglider are critical to understand the effects of global warming and other decadal variability on the entire ecosystem.

Small-scale turbulent mixing in southern Drake Passage

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1640 Wednesday 22 October

In southern Drake Passage, the Shackleton Fracture Zone (SFZ) marks a transition, with consistently low chlorophyll-a (Chl-a) values to the west and high values in the Ona Basin to the east. Iron incubation experiments in the region suggest that the elevated Chl-a levels are the result of iron that is entrained into shelf waters along the Antarctic Peninsula and then advected offshore. However, the year-round persistence of the Chl-a gradient cannot be explained by a simple horizontal advection model, implying that additional processes, such as small-scale vertical mixing, may contribute to the process. We examine the spatial pattern of vertical mixing in the SFZ using shipboard observations of temperature and salinity profiles. Profiles were sampled with expendable CTD probes in winter 2006, and with rosette-mounted CTDs in winter 2006 and summer 2004. Diapycnal eddy diffusivities are computed from Thorpe-scale density overturns in the profiles, and vertical velocities are computed from the diffusivities to estimate the rate at which iron can be entrained into the mixed layer by small-scale mixing.

Complications with global ocean heat content trends

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Global sampling patterns and rates for historical ocean temperature measurements suggest that estimating a global temperature trend is problematic if there is significant regional interdecadal variability. Long term temperature trends in the few upper hundred meters of the ocean are calculated from gridded observed data to explore spatial and temporal trend variability. There is strong regional interdecadal variability both at the surface and subsurface, which can be characterized by overlapping 20-year trends; almost every region studied shows both warming and cooling trends over a 50-year period. Such interdecadal variability is reduced somewhat by globally averaging data and by applying instrument bias corrections to the raw data. However, averaging data from a fairly sparse data set creates a new set of errors. One way around this problem is to produce a "complete" data set by objective interpolation of the raw data. This interpolation procedure is shown to potentially cause new biases in the final product, and it remains unclear if there is a definitive answer to the long-term global heat content trend question.

Analyzing low frequency variations of bottom pressure in the Arctic Ocean

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1110 Thursday 23 October

Accurate measurements of ocean bottom pressure (OBP) anomalies can be obtained with global coverage from the satellite mission GRACE (Gravity Recovery and Climate Experiment), from August 2002 to May 2008. In this work, empirical orthogonal functions (EOF) are used to understand the most important patterns of variability, from seasonal to inter-annual time scales, of the monthly OBP measured by GRACE in the Arctic Ocean. The first two modes of the EOF analysis both correspond to the annual cycle of the Arctic Ocean mass. It will be shown that the first mode, which has a basin-scale spatial pattern, is a barotropic response to the seasonal river discharge into the Arctic Ocean. The second mode, which shows a sea-saw between the East Siberian Sea and the Barents and Kara Seas, can be attributed to seasonal variations of regional to large scale geostrophic winds. Extended empirical orthogonal functions (EEOF) are also performed to extract propagating features of ocean mass, after the annual cycle is removed. The first mode of the EEOF analysis reveals a large scale and slow propagating feature, with a period of about one year and three months. The second mode does not reveal a propagating pattern, but shows a higher frequency oscillation presumably associated to atmospheric pressure variations. The physics of the EEOF modes are investigated. From this work, we have gained a deeper understanding of mass variation and associated circulation patterns in the Arctic.

Observations of large-scale upper ocean volume transport in the Pacific Ocean

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1130 Thursday 23 October

Historically estimates of the large-scale volume transport in the upper ocean have 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 the "parking depth" (1000 db) and then objectively analyze these data to determine the large-scale geostrophic streamfunction at that depth, for both the North and South Pacific. Combining this estimate with the measured temperature and salinity profiles allows us to determine the absolute geostrophic streamfunction throughout the upper 2000 db on seasonal, annual, and interannual timescales. In order to examine the contribution of wind forcing to the observed transport, we compare the total computed meridional transport with that expected from the curl of the wind stress, according to the canonical Sverdrup relation.

On the power consumed by spatially variable diapycnal mixing in the abyssal ocean

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1150 Thursday 23 October

The power required to maintain the observed abyssal stratification is re-examined in light of the growing body of microstructure data revealing bottom-intensified turbulent mixing in regions of rough topography. A direct and non-trivial implication of the observed intensification is that the turbulent diapycnal diffusivity, K_ρ, is depth-dependent and patchily distributed horizontally across the world's oceans. Theoretical and observational studies show that bottom-intensified mixing is dependent upon a variety of energy sources and processes whose contributions to mixing are sufficiently complex that their physical parameterization is premature. Currently, only rudimentary parameterizations of tidal mixing have been implemented in OGCMs, although the tides likely supply no more than half of the power available for mixing in the abyssal ocean. We here discuss a simple scheme describing the mean spatial distribution of total diapycnal mixing depending only on height above bottom and seafloor roughness. The vertical structure of K_ρ decays as a power law with height above bottom based on theoretical work examining the energy balance of the finescale internal wave field. Allowing the maximum boundary diffusivity and decay scale height, the two key parameters governing the vertical decay structure to vary with seafloor roughness, we find that a large collection of microstructure data from several oceanic regions is adequately collapsed by the scheme. Futhermore, resulting basin-averaged diffusivities are consistent with spatial averages derived from hy-

drographic data inversions. The power consumed by the nonuniform mixing scheme is found to be roughly 0.5 TW, a requirement easily met by the estimated power input into the deep ocean by the winds and tides.

Air-sea fluxes and Subantarctic Mode Water formation

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Recent observed freshening of Antarctic Intermediate Water (AAIW) may signal the continued onset of climate change. However, the implications of this freshening are difficult to deduce without knowledge of AAIW's formation mechanisms. Two hydrographic surveys from the Southeast Pacific Ocean provide high quality, synoptic views of the Subantarctic Mode Water (SAMW) and AAIW formation region during winter and summer. The winter cruise, from August 23 to October 5, 2005, occupied 135 full depth CTD/Rosette stations and deployed 371 XCTDs. This data set is used to assess the role of atmospheric forcing in forming the deep SAMW and AAIW mixed layers. Forty-two SAMW mixed layers deeper than 400 m were observed on the winter cruise. The potential density of these mixed layers varies by 0.05 kg m^{-3} along the front, such that two clusters of deep SAMW mixed layers are visible in T-S diagrams. The deepest mixed layers occur immediately north of the Subantarctic Front (SAF) and are associated with oceanic heat loss to the atmosphere (maximum of 250 W m^{-2}). To assess the importance of heat fluxes, the observed fluxes are used to verify model heat fluxes (NCEP and ECMWF). The model fluxes are compared to backwards heat flux calculations and used to force a one-dimensional mixed layer model, KPP, to model the mixed layer's seasonal cycle and examine downfront changes in SAMW.

Mixed-layer depth variability in Drake Passage

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Long-term monitoring by repeat XBT and XCTD transects across Drake Passage are used to examine mixed-layer variability in the region. Two geographical regimes are noted, with the Polar Front serving as an approximate division point. South of the Polar Front, mixed-layer depth varies nearly uniformly in space. To the north, the mixed layer reaches its greatest depths and exhibits small-scale (O(50 km)) features. A strong seasonal cycle is evident in both regions, with minima in mean and variance of mixed-layer depth coincident with the start of austral summer. Preliminary results show substantial interannual variability. Possible mechanisms governing this variability will be explored.

Preliminary results of poleward propagating features as observed in the U.S. West coast network of HF radar

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Surface current observations using high-frequency radars along the U.S. West coast are analyzed for the potential presence of coastal trapped waves (CTWs). The approximately 54 radar systems comprising the network created by the Coastal Ocean Currents Monitoring Program (COCMP) and Oregon State University (OSU) provide a unique, high-resolution and broad scale view of ocean surface currents on the U.S. West coast. Poleward propagating features, assumed to be coastal trapped waves, are found to propagate at varying speeds (O(10) and O(100) km day^{-1}) within the frequency band described by waves of 5–40 day periods. These propagating features are examined in the context of other sea level features observed by tidal gauges. The generation of the CTWs is examined with the remote forcing and local wind setup as well as the bottom bathymetry and climatological data (the baroclinic Rossby radius).

Indian Ocean Kelvin waves in the outflow passages of the Indonesian Throughflow

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Equatorial Kelvin waves generated by westerly wind anomalies over the central Indian Ocean propagate eastward to Indonesia, where they can enter the outflow passages of the Indonesian Throughflow (ITF) and affect the transports of mass and heat. This has potential consequences for local thermohaline properties and may also be related to larger scale phenomena such as the Indian Ocean Dipole (IOD) and Madden-Julian Oscillation (MJO).

Moorings were deployed in Lombok and Ombai Straits, two ITF exit passages, as part of the International Nusantara STratification ANd Transport (INSTANT) program, giving three years of direct measurements of temperature and velocity. These data provide the first comprehensive, full-depth, high-resolution measurements of Kelvin waves in the exit passages of the ITF, allowing us to thoroughly characterize their properties. Here, we discuss the relationship between ITF Kelvin waves and the structure and timing of the wind forcing over the Indian Ocean. In particular, we focus on the mode-1 versus mode-2 vertical structure of the Kelvin waves and the connection between wind forcing, MJO, IOD, and monsoon dynamics.

Numerical modeling of meteotsunamis

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The numerical solving of the shallow water equations will be used to research different atmospheric mechanisms to generate meteotsunamis in the Mazara del Vallo port, Sicily, Italy and in the Bahia de Todos Santos, Ensenada, B.C. This work is a thesis project proposed to validate modeling results, comparing synthetic meteotsunamis v.s sea level and atmospheric pressure data in Sicily and in Ensenada

Oceanic responses to Central American gap winds

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1610 Thursday 23 October

The impact of strong mountain gap wind events on the northeastern tropical Pacific outside of Central America is studied by integrating multiple satellite, reanalysis products, and numerical solutions. Mountain gap winds with a time scale of a few days superposed on the well-studied climatological gap wind are identified using daily sea level wind and sea level pressure (SLP). Strong gap wind blowing the Pacific triggers unique oceanic response. Sea-surface temperature (SST) responses are local and mainly controlled by vertical processes. Sea-surface chlorophyll-α responses are also local and controlled by both physical and biogeochemical processes. The sea-surface height (SSH) responses, however, appear to involve both local coastal circulations as well as regional mesoscale activities. There are two bands of high SSH variability emanating westward from the mountain gaps. Numerical solutions reveal that both the transient wind-curls during high-frequency wind events and the unstable currents forced by low-frequency gap winds and regional circulations are responsible for the high SSH variability.

Wind stress in moderate to strong wind opposing swell conditions

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The fluxes of momentum, heat and mass through the sea surface are key parameters for the understanding of oceanic and atmospheric processes. In particular the momentum flux, or wind stress, drives surfaces currents, controls the development and evolution of wave field, and influences storm development and atmospheric circulation. It is well known that wind stress depends on the sea state. Underdeveloped wind waves increases the sea surface roughness leading to an enhancement of drag. The presence of swell can modify the wind stress directly, releasing to or accepting momentum from the wind; and indirectly, by altering the wind sea part of the spectrum which cause a change on sea surface roughness. However, last conclusions are mainly based on data acquired in low wind speed conditions and it is not clear to what extent an effect of swell persists at higher winds. During the Gulf of Tehuantepec air-sea interaction experiment (intOA) simultaneous data of wave field and wind stress, along with other atmospheric and oceanic variables, were acquired from a moored ASIS buoy. The observations made at high wind conditions point out that the swell causes significant reduction of wind stress at winds as high as 20 ms-1. The current hypothesis is that swell causes a reduction of drag by modifying the wind-sea roughness. Discussions of this hypothesis in the light of field data along with measurements of wind stress, wave field, and form drag made in a wave tank in similar conditions will be presented here.

Modifications of wave characteristics by submerged obstacles

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The interaction between surface gravity waves and submerged obstacles is examined in a theoretical study case under specific conditions. The wave spectrum and parameters such wave height, period and direction are predicted using the SWAN model which is a third-generation wave model that describes the wave energy spectrum evolution with arbitrary wind, current and bottom conditions (Ris et. al., 1999, The SWAN Team, 2007). Because of SWAN doesnt allow obstacles floating in the water column, it is necessary to modify it in order to do the study. The main objective of this research is to obtain a transfer function that represents the effect of the obstacle in the directional wave spectrum. This function is going to be deducted from several runs in programs like SOLA-VOF modified (Rahman et al. 2006) and/or from the literature. Once the transfer function has been obtained for several obstacles geometries, it will be placed into the SWAN code in order to analyze the wave directional spectra proposing different spatial arrays of the obstacles.

Assessing the diurnal cycle of precipitation in a prototype multi-scale climate model

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0930 Friday 24 October

The Center for Multi-Scale Modeling of Atmospheric Processes (CMMAP; www.cmmap.org) employs a new approach to climate modeling whereby a nested cloud system resolving subdomain handles the subgrid fluxes and atmospheric boundary layer processes in each GCM grid column that are ordinarily handled by cumulus parameterization. This approach effectively relaxes the rigid dependence of simulated precipitation on instantaneous measures of large-scale instability, which typifies conventional cumulus parameterization.

One promising result in the Multi-scale Modeling Framework (MMF) is a global improvement in the timing of peak precipitation over the continents, which is suggestive of improved moist dynamics at diurnal timescales. We explore the realism of the MMF simulated diurnal cycle of precipitation in detail, by comparing a comprehensive suite of diurnal cycle precipitation diagnostics - ranging from harmonic and empirical orthogonal function decomposition to local metrics of the broadness of the maximum precipitation in the mean summer day - to rainfall retrievals from the Tropical Rainfall Measuring Mission (TRMM) and to a control simulation that employs conventional cloud and boundary layer parameterizations.

Diurnal variation of rainfall over South Africa

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0950 Friday 24 October

Ten years of 86 stations hourly rainfall data obtained from South African Weather Service (SAWS) and 3B42 (V6), Tropical Rainfall Measuring Mission (TRMM) and other satellites rainfall product, are used to study the diurnal cycle of rainfall in South Africa. The results from both datasets show that areas over the western half of the country experience no appreciable diurnal cycle of precipitation, while those over the eastern half of the country exhibit different patterns of diurnal cycle. The eastern coastal areas have maximum rainfall amounts and frequencies around midnight, probably due to local offshore mountain-plain winds blowing from the surrounding mountains to the ocean. Regions away from the coast show late afternoon to evening peak in rainfall amounts and frequencies, as a result of strong influence of diurnal heating and atmospheric instability on the development of convective process. Intense rainfall in these inland areas tend to happen earlier, from early to late afternoon hours. The 3B42 product tends to overestimate precipitation over most areas of the country. Comparisons of diurnal cycle between wet and dry years are also done using only the gauge data for few selected stations. The rainfall amounts and frequencies in majority of the stations were found to be much higher in the wet years than the dry years during all hours of the day, however there were no much difference in the rainfall intensities between the wet and dry years. These indicate there were less rain events during the dry years compared to wet years.

An airborne scanning LiDAR system for ocean and coastal applications

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1010 Friday 24 October

We have developed an airborne scanning LiDAR (Light Detection And Ranging) system and demonstrated its functionality for terrestrial and oceanographic measurements. Differential GPS (DGPS) and an Inertial Navigation System (INS) are synchronized with the LiDAR, providing end result vertical rms errors of approximately 6 cm. Flying 170 m above the surface, we achieve a point density of $\sim$0.7 m^{-2} and a swath width of 90 to 120 m over ocean and 200 m over land. Georeferencing algorithms were developed in-house and earth-referenced data are available several hours after acquisition. Surveys from the system are compared with ground DGPS surveys and existing airborne surveys of fixed targets. Twelve research flights in a Piper Twin Comanche from August 2007 to July 2008 have provided topography of the Southern California coastline and sea surface wave fields in the nearshore ocean environment. Two of the flights also documented the results of the October 2007 landslide on Mt. Soledad in La Jolla, California. Eight research flights aboard a Cessna Caravan surveyed the topography, lagoon, reef, and surrounding seas of Lady Elliot Island (LEI) in Australia's Great Barrier Reef in April 2008. We describe applications for the system, including coastal topographic surveys, wave measurements, reef research, and ship wake studies.

Structure of the Antarctic Circumpolar Current in Drake Passage from direct velocity observations

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The structure of the Antarctic Circumpolar Current (ACC) in the upper 1000 m of Drake Passage is examined using nearly three years of shipboard Acoustic Doppler Current Profiler (SADCP) velocity data. The principal fronts of the ACC are visible, with the Subantarctic Front (SAF) and Polar Front (PF) jets having widths of about 100 km and 150 km, respectively. Depth-mean current speeds in the SAF and PF jets are $\sim$40 cm s^{-1}, while the eddy kinetic energy (EKE) has a maximum of $\sim$700 cm^{2}s^{-2} between the PF and the SAF. The transport estimated from the mean section between the surface and 1030 m is $\sim$100 Sv, about 70% of canonical total transport. The horizontal spectral peak is found at 400 km.

The mean current is largely barotropic, while EKE and shear variance exhibit strong depth dependence. In cross-sectional averages current shear is small and nearly constant to 600 m, below which depth the current speed drops off more quickly. EKE is intensified above 600 m between the SAF and PF. Shear variance is strongest in the surface layer. Vertical spectra of currents and current shear reveal negligible rotation.

The momentum balance in the continental shelf break of Del Mar, California

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The Southern California Bight (SCB) is the region where the relatively straight Pacific West coastline bends almost 90 degrees. The continental shelf is shallow and narrow, with complex topographic features in the area such as islands, basins and ridges. All of these characteristics have an effect in the distribution and dissipation of the oceanic energy. Two years of near full-depth current velocity data from a mooring deployed 3 miles offshore of Del Mar, California, in 100 meters of water, as well as meteorological and sea level data are analyzed in order to study the linear subinertial alongshore momentum balance. The five terms included in this balance are: the local derivative, the Coriolis term, the pressure gradient and the stress terms related to wind and bottom forcing. A low but significant (over 90% confidence level) correlation coefficient of around 0.4 is found for the fall of 2007, between the bottom stress and the pressure gradient terms. This result largely agrees with previous observational studies of the SCB outer shelf. The Coriolis term has the largest variance and is uncorrelated with other terms in the momentum balance equation. In previous studies, this term is often neglected under the assumption that the depth-integrated cross-shore velocity must be zero. Each term of the along-shore momentum balance will be examined and discussed, and possible reasons for differences from earlier studies will be explored.

Current variability observed at the shelfbreak of the Yucatán Channel in the Mexican Caribbean

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High-resolution current measurements were made in the Mexican Caribbean by CICESE as part of its CANEK project. The major goal of this experiment is to understand the mechanisms that transfer properties across the shelf slope. Eight shallow water and moored acoustic Doppler current profilers (ADCPs) were deployed along a transect southeast of the shallow fringing reef lagoon of Puerto Morelos, along the narrow continental shelf and down the slope of the Yucatán Channel. The dataset span 22 months, starting in May 2006, and includes full water column current profiles. Currents were found more variable on the shelf than on the slope but in the mean strongly tended to follow bathymetry, particularly on the slope. During the measurement time period currents were driven by both local and remote winds, by the passage of mesoscale anticyclonic eddies and by tropical storms. Currents were highly barotropic, accounting for more than 80% of the eddy kinetic energy (EKE). The analysis suggest that the transition between deep and shallow water current regimes is driven by the coupling of the lateral boundary layer imposed by the shelfbreak, and the shallow surface and bottom boundary layers originated by wind stress, tidal currents, and wind wave bottom stress.

Low frequency variability at the sills of the northern Gulf of California

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Moored currents, salinity and temperature observations at the three most important sills of the northern Gulf of California (NGC) are used to describe the mean and low-frequency flow. The San Lorenzo (SL) and Ballenas Channel (BC) sills mark the along-gulf boundaries of the deepest basin in the NGC (1500 m). At these sills, the mean and low-frequency currents suggest a two layer pattern with flow into the basin at depth and out of the basin near the surface (i.e., opposite flows within each layer). The strongest relationship of the low-frequency currents is between deep flow into the basin through the southern SL sill and near-surface flow out of the basin through the northern BC sill. The san Esteban (SE) sill marks the southern entrance to a separate, much shallower (440 m) basin in the NGC. At this sill, the mean flow has a markedly different structure with outflow near the surface and a strong cyclonic rotation near the bottom such that the near-bottom mean flow is almost perpendicular to the gulf. However, the low-frequency currents at the SL and SE sills are mainly aligned along the gulf and the deep currents are coherent between both sills and with cool and fresh waters coming from the Pacific Ocean. The surface currents at these two sills have a strong fortnightly modulation, suggesting that the surface outflow is responding to the deep tidal transport. Currents at the two southern sills and surface

currents at the BC sill have a significant correlation with the across-gulf pressure gradient. Therefore, the exchange of the NGC and the water renewal at the deepest basin of the NGC, respond to two different time scales, one related to low-frequency variability that is in approximate geostrophic balance, and another one influenced by the fortnightly modulation of the near bottom tidal transport. Estimations of the vertical eddy viscosity based on the Richardson number and the velocity near the bottom give values of the order of Av = 0.03m^2/s, with larger values near the bottom.

Barotropic and baroclinic tidal currents at the sills of the Gulf of California

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The main goal of this research is to study barotropic and baroclinic tidal currents at the sills where the inflow and outflow of water to the northern Gulf of California takes place. We will study the vertical structure of the tidal currents, the barotropic currents and we will estimate the baroclinic tidal currents. The phase difference between sea level and tidal currents will be investigated. The vertical structure and the possible time variation of the baroclinic tidal currents will be studied as well as their possible relation with the low frequency, near-bottom, inflow currents. We will also estimate the energy flux due to barotropic tidal currents in the Ballenas Channel.

Time-variable conversion of barotropic to baroclinic M_2 tidal energy at the Kaena Ridge, Hawaii

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The temporal variability of internal tide generation is examined for the Kaena Ridge, the site of the near-field component of the Hawaii Ocean Mixing Experiment. Barotropic to baroclinic energy conversion for the dominant M2 tidal constituent is obtained using moored observations of currents, temperature and salinity over a six-month deployment (December 2002- May 2003). The energy conversion exhibits low frequency variability with amplitudes ranging by a factor of two (0.5 to 1.1 Wm^{-2}) over the record. Similar amplitude variations are found for the M_2 energy density at the ridge and just off the ridge as the internal tide radiates to the southwest. The observed energy conversion correlates with stratification variations near the bottom, suggesting that deep stratification over the ridge flank modulates the internal tide generation. Comparisons of numerical model simulations with the observed energy conversion will be presented.

Index

University of California, San Diego

SCRIPPS INSTITUTION OF OCEANOGRAPHY

(Alphabetical)

2300	Birch Aquarium at Scripps	D7
8650	Center for Coastal Studies	A7
9310–9393	Coast Apartments	G3
2310	Deep Sea Drilling East	D6
2350	Deep Sea Drilling West	C6
8620	Director's Office	A8
8645	Experimental Aquarium, Kaplan Laboratory	B8
8750	Hubbs Hall	B6
8752	Hubbs Hall Conference Room	B6
8825	Hydraulics Laboratory	C4
8800	IGPP Munk Laboratory	B5
8795	IGPP Revelle Laboratory	C5
8855	Isaacs Hall	C4
8865	Isaacs Hall Trailer #1	C4
8867	Isaacs Hall Trailer #2	C4
8885	Isaacs Hall Trailer #3	C3
8831	Keck Center for Ocean Atmosphere Research	D4
8614	Lifeguard Station	A9
8610	Marine Sciences Development Shop	A9
8622	New Scripps Building	A8
8810	Nierenberg Hall	D5
8820	Nierenberg Hall Annex (NTV Building)	D4
8670	Old Director's House	B7
8630	Old Scripps Building	A8
8635	Ritter Hall	B8
8875	Satelite Oceanography Facility	C4
8655	Scholander Hall	B7
8648	Scripps Pier	A7
2215	Seaweed Canyon Quonset Storage	E9
8755	SIO Library (Eckart Building)	C6
2285	SIO Warehouse	E8
8632	Snackropolis (food)	A8
8904	Southwest Fisheries Science Center (U.S. Govt.)	C2
8625	Sumner Auditorium	B8
8606	Surfside	A9
8615	Sverdrup Hall	B9
8612	T-3 SIO Administrative Computing	A9
8830	T-25 Digital Imaging Analysis Laboratory	B4
8840	T-29 Martin Johnson House	B4
8850	T-30	B4
8860	T-31 California Special Reference Center	B4
8660	T-40 Diving Locker, PPS Services	B6
8662	T-42 SIO Storehouse	B7
8664	T-43 Facilities Support Shops, Benthic Laboratory	B7
2225	T-44 Seaweed Canyon, Storage and Staging	E8
2205	T-45 Geoscience Rock Collection	E9
2265	T-46	E8
8675	Vaughan Hall	B8

(Numerical)

2205	T-45 Geoscience Rock Collection	E9
2215	Seaweed Canyon Quonset Storage	E9
2225	T-44 Seaweed Canyon, Storage and Staging	E8
2265	T-46	E8
2285	SIO Warehouse	E8
2300	Birch Aquarium at Scripps	D7
2310	Deep Sea Drilling East	D6
2350	Deep Sea Drilling West	C6
8606	Surfside	A9
8610	Marine Sciences Development Shop	A9
8612	T-3 SIO Administrative Computing	A9
8614	Lifeguard Station	A9
8615	Sverdrup Hall	B9
8620	Director's Office	A8
8622	New Scripps Building	A8
8625	Sumner Auditorium	B8
8630	Old Scripps Building	A8
8632	Snackropolis (food)	A8
8635	Ritter Hall	B8
8645	Experimental Aquarium, Kaplan Laboratory	B8
8648	Scripps Pier	A7
8650	Center for Coastal Studies	A7
8655	Scholander Hall	B7
8660	T-40 Diving Locker, PPS Services	B6
8662	T-42 SIO Storehouse	B7
8664	T-43 Facilities Support Shops, Benthic Laboratory	B7
8670	Old Director's House	B7
8675	Vaughan Hall	B8
8750	Hubbs Hall	B6
8752	Hubbs Hall Conference Room	B6
8755	SIO Library (Eckart Building)	C6
8795	IGPP Revelle Laboratory	C5
8800	IGPP Munk Laboratory	B5
8810	Nierenberg Hall	D5
8820	Nierenberg Hall Annex (NTV Building)	D4
8825	Hydraulics Laboratory	C4
8830	T-25 Digital Imaging Analysis Laboratory	B4
8831	Keck Center for Ocean Atmosphere Research	D4
8840	T-29 Martin Johnson House	B4
8850	T-30	B4
8855	Isaacs Hall	C4
8860	T-31 California Special Reference Center	B4
8865	Isaacs Hall Trailer #1	C4
8867	Isaacs Hall Trailer #2	C4
8875	Satelite Oceanography Facility	C4
8885	Isaacs Hall Trailer #3	C3
8904	Southwest Fisheries Science Center (U.S. Govt.)	C2
9310–9393	Coast Apartments	G3

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