First International Meeting of Students in Physical Oceanography

Ensenada, B.C. Mexico **June 27-29 2007**

Bringing Together Physical Oceanography
Students From All Over the World

Program & Abstract Book

CICESE

OCEANOGRAFÍA FÍSICA

IMSPO Organizing Committee

Héctor García – Dept. of Physical Oceanography, CICESE
Julien Jouanno – Dept. of Physical Oceanography, CICESE
Miguel Tenreiro – Dept. of Physical Oceanography, CICESE
César Coronado – Dept. of Physical Oceanography, CICESE
David Rivas – College of Oceanic and Atmospheric Sciences, Oregon State University
Leonel Romero – Scripps Institution of Oceanography, UCSD

Welcome to CICESE

Created in 1973 by the federal government in order to decentralize scientific activities and modernize the country, the Center for Scientific Research and Higher Education of Ensenada (CICESE by its acronym in Spanish) is part of a system of public research centers of the National Council of Science and Technology (CONACYT), and over three decades has become one of the main scientific centers of the country. CICESE is in a privileged location: only 100 kilometers separate it from the border with California, the principal economy of the U.S. Our research and teaching activities focus on aquaculture, biology, biotechnology, climatology, computer science, ecology, electronics, geophysics, geology, instrumentation, meteorology, microbiology, biological oceanography, physical oceanography, optics, optoelectronics, seismology, informational technologies, telecommunications and telematics.

Over the years CICESE has gained prestige both nationally and internationally. We have a faculty of nearly 180 researchers and 200 technicians who are highly specialized in areas of national priority; we maintain excellent academic relations with other institutions in the country and abroad; our 17 graduate programs are of excellence and are completely research-oriented, and the material infrastructure is of the first level, including eight modern buildings which house over 115 laboratories, classrooms, a specialized library, supercomputing equipment and connection to Internet 2, as well as the oceanographic vessel Francisco de Ulloa, and valuable seismological and oceanographic instrumentation.

Oceanology Division

The Division of Oceanology has the most consolidated ocean sciences research group in Mexico. It is also the only division of its kind in the public research centers of CONACYT, and one of the most highly recognized oceanographic institutions in Latin America. Research in this division involves the majority of the seas of Mexico, the coastal region of northwestern Baja California, the California Current System, the Gulf of California and its islands, the tropical Mexican Pacific, the Gulf of Tehuantepec, the Mexican Caribbean region and the Gulf of Mexico, which permits us to respond to fundamental questions and to apply our knowledge to the solution of regional and national problems. The participation of the personnel and students of this division generates collaborative activities with a large number of national and foreign institutions. The division's graduate programs incorporate over 110 students at the master's and doctoral levels, and offer three major disciplines: Aquaculture, Marine Ecology and Physical Oceanography.

Department of Physical Oceanography

The research in this department is oriented towards understanding and predicting ocean dynamics. Studies are made relating to sea level, waves, tides and tsunamis. Other studies are related to the physical properties of the sea, the wind, atmospheric pressure, large scale climatic changes, as well as ocean currents, from shoreline and coastal circulation in lagoons and bays to circulation and formation of water masses in gulfs, deep basins and the continental platform.

IMSPO 1

Arisen after the 2005 CICESE-SIO Mexican American Physical Oceanography Summer Student Seminar Series, the First International Meeting of Students in Physical Oceanography (IMSPO 1) is targeted to open an international forum where students of all countries in any field of physical oceanography can expand their scientific and professional outlook and forge lifelong, interdisciplinary collegial relationships with their peers. The main goals of the Meeting are to promote the scientific discussion and experience sharing among students, and to forge future professional relationships, based on a friendly, informal social-gathering environment.

General Information

The IMSPO 1 is being held in the Pedro Ripa Auditorium, at the Division of Oceanology of CICESE. Information on how to get to CICESE is available at:
`http://www.cicese.mx/cicese/routes/`

Climate

Ensenada has a warm Mediterranean climate, sunny, mild and dry. The average high temperature for the months of June, July and August is comfortable 76 °F. It's always a good idea to bring along a light jacket or sweater because of the morning and evening fresh breeze.

Currency

The official currency in Mexico are the pesos, but US dollars are widely accepted. The exchange rates are published at the entrance of all banks and on currency exchange offices "Casa de Cambio". At retail you can expect your US dollar to be worth about $10.50±$0.50 pesos. Please be aware you cannot use any other currency. Visa, Mastercard and (to a lesser extent) American Express credit cards are accepted in Ensenada.

Dress Code

Meeting – Smart Casual
Evening gatherings – Smart Casual, bring a coat or sweater

Electricity

The electrical supply is 110 volts, 60 Hz. The connection for appliances is a flat 2-pin plug with a round ground (US style).

Mexico Entry Visas

Citizens from USA, Canada and the European Union do not need entry visas (among other countries). If you hold other nationality, you should check with your local Mexican Embassy for entry requirements. Please be aware that if you are entering to Mexico by car through the US border, there is no Immigration control at crossing, but you must have your documents in order because there are checkpoints further south.

About your security

You might have heard some concerns on security problems in Mexico. Most of these concerns are false and Ensenada is one of the safest cities in Mexico. With normal precautions and *common sense*, you will not be at risk even at late hours at night. If you get lost, just ask someone on a store for directions. If your stomach gets easily upset, don't eat stuff on the street, and always drink bottled water. If you need to use a public telephone, only use the ones labeled TELNOR. In case of an **emergency**, you can call:
Committee Members
Héctor **044 646 9477524** or
César **044 646 1137271**;
Cruz Roja Ensenada **066** (Red Cross);
Policía **060** (Police).

Internet

The Student Computer Room is located on the Third Floor of the Oceanology building, next to the Department of Physical Oceanography Secretary office, and it is open from 8 am to 3 pm. After this hour you can get internet connection on one of the plenty Internet Cafes (Café Internet) in the city, where they will charge you around 1 US dollar per hour of connection.

Name Badges

You will be provided a Name Badge on registration to the Meeting. Please wear your name badge at all times.

Parking

There is no charge for parking at CICESE facilities, but you have to check in at the Entrance Security gate. Be aware that if you arrive after 9 am it is likely that you will not find a parking space near the Oceanology Building, and you will have to park near CICESE's Library (follow the road uphill, it's the building on your right).

Public Transport

Ensenada has an old, yet reliable public transportation system, with a service between the city and CICESE.

One line of yellow buses, called "Transportes Brisa" serves the *Boulevard* route, which will take you near the Harbour, the Flag, and First Street. To get from Downtown to CICESE, look for the "Sauzal" (northbound) direction. When going from CICESE to Downtown, take the "Maneadero" (southbound) direction.

There is another bus line, with white buses, called "Transportes Vigia", which have a more frequent schedule, running through the *Calle 9* route, which oddly, runs by 10th Street and finishes at the 6th Street. If you take this route, get off at the bus station in Downtown and walk to your destination; normally is only a few blocks away. The directions of this route are the same as described above.

The bus will charge you $6.50 pesos, and it is wise to tell the driver where are you going, and he might tell you where to get off the bus. Remember, not everyone speaks English, so speak slowly and clearly, and use keywords, i.e. CICESE, Universidad, "BAJAN" (get down). Both lines runs from 6 am till 10 pm.

Refreshments

All registered students at IMSPO 1 are invited to breakfast and lunch break organized by the Committee.

Breakfast (9 am – 10 am)

Light breakfast will be offered in the Foyer of the Oceanology Building, next to the Pedro Ripa Auditorium, from 9 am to 10 am. Coffee and cookies will also be available throughout the morning.

Meal (1 pm – 3 pm)

Lunch break will be held at the Earth Sciences Building front patio (if weather is good) or in the Board Room of the Oceanology Division (fourth floor of the building). If you don't know where these venues are located, just follow the crowd.

Registration Desk

The Registration Desk is located on the Foyer of Oceanology Building, first floor, next to the Pedro Ripa Auditorium, and will be open at the following times:

Wednesday 27 June	9am-10am
Thursday 28 June	9am-10am
Friday 29 June	9am-10am

Smoking

CICESE is a non-smoking facility. If you like to have a smoke, there are a couple of nice benches just outside the building.

Time

Local time in Ensenada during June is on the Pacific Daylight Time, which is Greenwich Mean Time minus 7 hours.

Speaker Preparation

Speakers are asked to report to the Registration Desk preferably the day prior to their presentations or if this is not possible, at least one hour prior to their Talk Session starting time. Further, if you wish to save even more time, upload your talk (along with any supporting files), naming the file with your last name, to:
`ftp://ftp.cicese.mx/pub/divOC/ocefisica/IMSPO`

Social Program

To provide a change of pace from scientific sessions, the Speakers and fellow students will have many opportunities to meet socially and to renew or develop friendships. Excellent company, fine wines, delicious food and a relaxed atmosphere will ensure three nights of entertainment and good memories to take home.

Welcome Gathering

Date: Wednesday 27 June 2007
Starting Time: 17:00 pm
Place: Héctor's beach house, El Sauzal
Suggested cooperation: USD$10

The Welcome Gathering will be a time for Speakers and Fellow Students to meet with old and new friends in an unique Norteño Mexican environment. The menu will be Pozole and Ceviche, two off the most typical Mexican ways to eat meat and fish. Your cooperation includes food, beer/wine and soft drinks.

Oceanographic Cruise on Todos Santos Bay, followed by a gathering at Bar la Taberna

Date: Thursday 28 June 2007
Starting Time: 17:00 pm
Place: Baja Fiesta pier, Ensenada Harbour, almost in front of the "Mercado Negro" (Black Market).
Suggested cooperation: USD$6

Designed for those of you finishing your PhD, but have never actually been on a boat. The *Royal Pacífico* will show you the main attractions of the Port of Ensenada, and will cruise in the Bay to watch an amazing sunset. Please be aware that this event is strictly BYO, but you can buy inexpensive beverages on board. After the Cruise, we will gather at the Bar la Taberna, which is located on First St, between Riveroll and Miramar.

Winery tour and BBQ at Guadalupe Valley

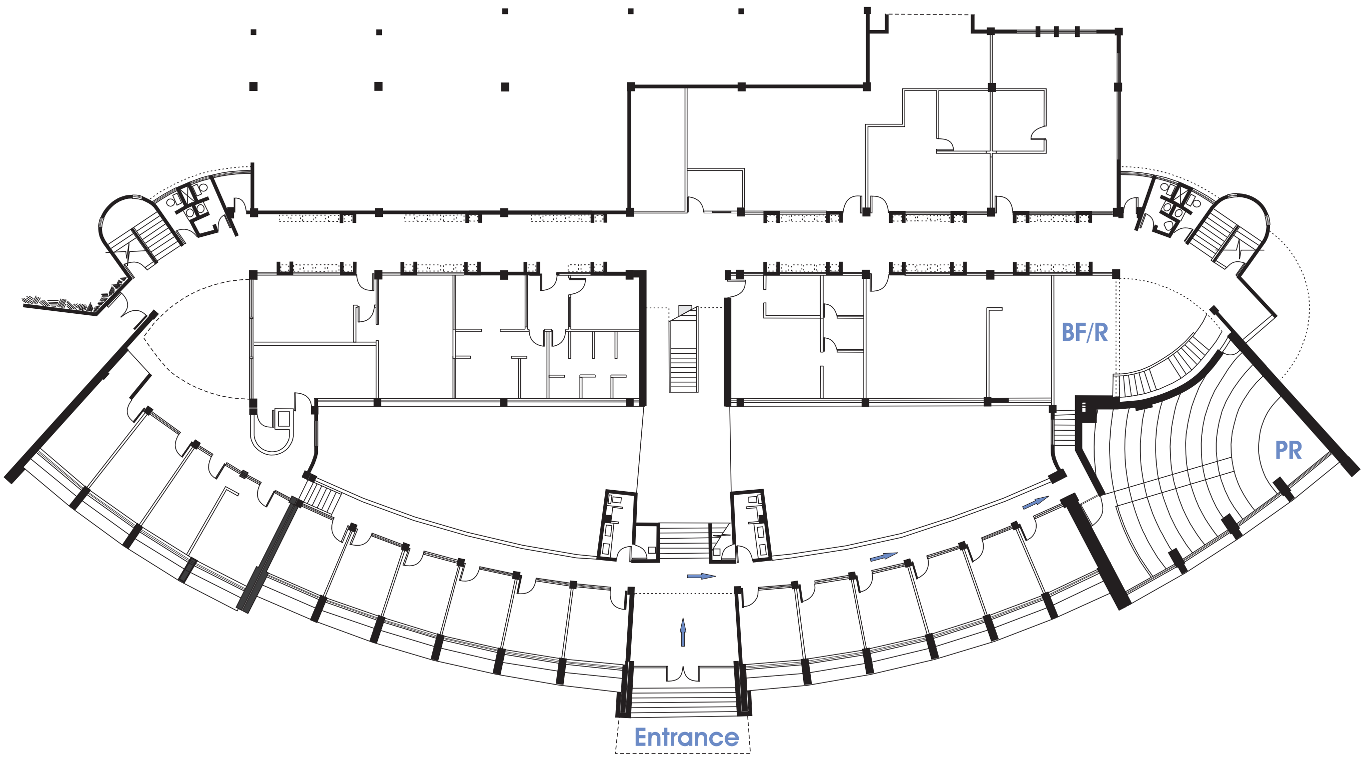
Date: Friday 29 June 2007
Starting Time: 14:00 pm
Place: Guadalupe Valley
Suggested cooperation: USD$10

We will visit the Wine Route in Guadalupe Valley, to have a taste of world-class Baja California grape products. After wine tasting, we will gather to have a delicious dinner. Please be sure to keep with the group to organize the transportation of all people to Guadalupe Valley, since public transportation is scarce.

Acknowledgments

The IMSPO Organizers would like to thank to all the people that, in a way or another, made this meeting a reality. With special thanks to: CICESE in the persons of Dr. Federico Graef, Dr. Edgar Pavía, Dr. Oscar Sosa, Dr. Julio Candela, Dr. Luis Zavala, Dr. Modesto Ortiz, Dr. Oscar Velasco, Dr. Luis Delgado, Guadalupe Rodríguez and Alina Morales; to all the physical oceanography students and their work institutions whose new way of looking to the future made this meeting possible.

Meeting Floor Plan



First floor of the Oceanology Building, showing the location of the Pedro Ripa Auditorium (PR), Registration Desk and Breakfast Foyer (BF/R)

IMSPO Program at a Glance

Wednesday	Thursday	Friday
Breakfast/Registration	Breakfast/Registration	Breakfast/Registration
Opening and Welcome		
Keynote Lecture 1	Keynote Lecture 2	Keynote Lecture 3
Session 1	Session 3	Session 5
Lunch	Lunch	Discussion
Session 2	Session 4	Lunch
Evening Gathering 1	Evening Gathering 2	Evening Gathering 3

Wednesday 27 June

9:00-10:00	**Breakfast and Registration**
10:00-10:15	Venue: Pedro Ripa Auditorium (PR) **Opening and Welcome**
10:15-11:15	Venue: PR **Keynote Speaker Lecture** *Why did the ocean do that?* **Prof. Bruce Cornuelle *SIO,UCSD***
11:15-11:40	**Coffee**
	Session 1: *Marginal Seas and Nearshore Circulation*
11:40-12:00	*Observations of an effluent plume from an ocean outfall using spray gliders* **Robert E. Todd** 1
12:00-12:20	*Wind and bathymetric influences on the subtidal circulation in San Quintin Bay, Mexico.* **Xavier Flores** 2
12:20-12:40	*Circulation in a semi-enclosed bay driven by sea level variations and wind* **Aurélien Ponte** 3
12:40-13:00	*Sea surface temperature anomalies in the Gulf of California* **Felipe Gómez** 4
13:00-15:00	Venue: Earth Sciences Building front Patio **Lunch**
	Venue: PR **Session 1 continued:** *Marginal Seas and Nearshore Circulation*
15:00-15:20	*On the origin of mesoscale variability in the Caribbean Sea* **Julien Jouanno** 5
15:20-15:40	*The death of two eddies against the shelf* **Bárbara Zavala** 6
15:40-16:00	*North Pacific variability from a data assimilating model* **Elizabeth Douglass** 7
16:00-16:20	**Coffee**
	Session 2: *Ocean-Atmosphere links*
16:20-16:40	*Meteorological bias in satellite estimates of aerosol-cloud relationships* **Guillaume Mauger** 8
16:40-17:00	*Interannual Variability of the Pacific EUC* **Natalia Stefanova** 9
17:00-17:20	*The use of MODIS satellite SST data as the lower boundary condition of a numerical model of the North American Monsoon* **Cuauhtemoc Turrent** 10
17:20-17:40	*The impact of Hurricane Wilma on the circulation along the Mexican Caribbean* **Cesar Coronado** 11
18:00-??:00	Evening Gathering at El Sauzal **BBQ on the beach**

Thursday 28 June

9:00-10:00	**Breakfast and Registration**
10:00-11:00	Venue: PR **Keynote Speaker Lecture** *On the topology of vortex lines and tubes* **Dr. O.U. Velasco Fuentes** ***Dept. Phys. Oceanogr., CICESE***
11:00-11:20	**Coffee**
	Session 3: *Eddying flow*
11:20-11:40	*Evolution of an horizontal vortex in a linear stratified fluid* **Rita Guevara** 12
11:40-12:00	*Dispersion in a bidimensional turbulent flow in the presence of a boundary* **Axel Rosas** 13
12:00-12:20	*Horizontal diffusivity coefficients in the Pacific coast region between Mexico and USA, taking data of HF radar.* **Tihui I. Núñez** 14
12:20-12:40	*Avenues and distribution points for larvae and contaminants in the Caribbean Sea and Gulf of Mexico* **Fernando Andrade** 15
12:40-13:00	*Quasi two-dimensional turbulent flows and dipolar structures over discontinuous topography* **Miguel Tenreiro** 16
13:00-15:00	Venue: Earth Sciences Building front Patio **Lunch**
	Venue: PR **Session 4:** *Upper Ocean*
15:00-15:20	*Recent advances to measure surface winds using HF radar system in the Gulf of Tehuantepec* **Evaristo Rojas** 17
15:20-15:40	*SAR observations of ocean swell at the Gulf of Tehuantepec* **Guillermo M. Díaz** 18
15:40-16:00	*Airborne Observations of fetch-limited waves in the Gulf of Tehuantepec* **Leonel Romero** 19
16:00-16:20	**Coffee**
16:20-16:40	*On the influence of sea state on wind stress: Air-sea interaction study at the Gulf of Tehuantepec, México.* **Héctor García** 20
16:40-17:00	*Wave energy budget on Pacific islands nearshore environments* **Anne-Christine Pequignet** 21
17:00-17:20	*On the detection of semi-diurnal tidal signatures in Synthetic Aperture Radar images of Delaware Bay* **Gustavo H. Oliveira** 22
17:30-??:00	Port of Ensenada **Oceanographic Cruise on Todos Santos Bay** followed by a gathering at Bar La Taberna

Friday 29 June

9:00-10:00	**Breakfast**
10:00-11:00	Venue: PR **Keynote Speaker Lecture** *Secular changes in the harmonic tidal components. Global warming? Man-made changes?* **Dr. Modesto Ortiz *Dept. Phys. Oceanogr., CICESE***
11:00-11:20	**Coffee**
	Session 5: *Tides*
11:20-11:40	*On spectra and other demons* **Carlos Vargas** 23
11:40-12:00	*Improvements to the method of altimeter calibration using tide gauges: Addressing the problem of land motion* **Kara Sedwick Doran** 24
12:00-12:20	*Low frequency variability at the sills of the northern Gulf of California* **Domitilo Nájera** 25
12:20-12:40	*Variability of M2 and K1 tidal constituents in the Mexican Caribbean* **Gerardo A. Sosa** 26
12:40-13:00	*Observations of tidal internal wave beams and energetics at Kauai Channel, Hawaii* **Sylvia T. Cole** 27
13:00-13:30	**General discussion on the future of the IMSPO**
13:30-13:40	Closing Ceremony
14:00-??:00	Valle de Guadalupe **Winery Tour**

Keynote Speaker Lectures

Why did the ocean do that?

Bruce Cornuelle
Scripps Institution of Oceanography, UCSD
Author email: bdc@ucsd.edu

Westward intensification, thermocline structure, and equatorial undercurrents are classic oceanographic observations that have been addressed and somewhat explained by relatively simple models that isolated the important physics. As time has gone by, the complexity of both the phenomena to be explained and the models has increased. Many interesting features seen in modern observations, such as the westward propagation of sea surface height (SSH) features or the detailed structure of the equatorial current structure or cold tongue, have been explored in "kitchen sink" models that include most of the terms in the equations of motion and have realistic topography and forcing and are meant to reproduce the real ocean. The output of these models is determined by the initial conditions, boundary conditions, forcing, topography, and the model approximations, including the parameterizations of mixing. Because they determine the model output, they are sometimes called control parameters. When a particular model does not reproduce the desired feature, it is hard to pinpoint the reason. The source of error may be the approximations, the model code, or just the poorly-known initial conditions, boundary conditions, and forcing. The control parameters are generally so numerous that varying them one at a time to try to achieve a match to the observations is overwhelming. Modern methods of model fitting ("data assimilation") are ways to address the problem of fitting the model to the observations, and to understand the sensitivities of particular features to the control parameters. I will try to give an introduction to the philosophy and techniques of these methods, and their use as a tool for physical understanding.

On the topology of vortex lines and tubes

O.U. Velasco Fuentes
Department of Physical Oceanography CICESE
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Vortex lines and tubes have been essential in describing and understanding the motion of fluids ever since Helmholtz (1858) published his seminal memoir on vortex motion: Über Integrale der hydrodynamischen Gleichungen, welche den Wirbelbewegungen entsprechen. There, he established the fundamental dynamical laws of vorticity as well as a number of kinematic theorems. In particular, he proved that the vorticity flux is constant along a vortex filament and from this he concluded, incorrectly, that vortex filaments must close on themselves or extend to the boundary of the fluid. Soon afterwards similar deductions were made about vortex tubes (Thomson, 1869) and vortex lines (Lamb, 1879). Naturally, these assertions are found in most classic textbooks on fluid mechanics and, although their incorrectness has already been pointed out, they continue to appear in modern texts and in research papers published in the leading journals in the field. An analysis of simple flows show that these display vortex lines and tubes which do not fit into the traditional shapes. Two types of vortex-lines are discussed: dense, which comprise open lines of infinite length but confined in a finite region, and separatrix, which comprise lines that begin or finish within the fluid, at points where the vorticity is null. The presence of these vortex lines in a vortex tube affects its topology in the following ways. Vortex tubes formed by dense vortex-lines have infinite length, they self intersect an infinite number of times but do not close on themselves. Vortex tubes formed by separatrix vortex-lines (and either closed or open vortex-lines) are torn apart at the points where the vorticity is null. Vortex tubes exclusively composed of separatrix vortex-lines begin or finish at points or surfaces within the fluid; in this particular situation the vortex tube has zero strength.

Secular Changes in the Harmonic Tidal Components. Global warming? Man made changes?

Modesto Ortiz
Department of Physical Oceanography, CICESE
Author email: ortizf@cicese.mx

Long series of sea-level observations 1901-2006 around the world are analyzed to search for secular changes in the tidal harmonic components. The results confirm long term trends in both, the amplitude and phase of the semidiurnal tide in the Pacific and in the Atlantic Oceans. Significant trends up to 40 millimeters per century in amplitude, and phase shifts of 6 degrees per century were found in the principal semidiurnal tide. Considering some results of Cartwright, the possible effects of instability of the tidal modes due to the general increase in world temperature, with its associated recession of polar ice boundaries and rising of mean sea level, are investigated. Also, the possible effects of modern harbour developments, as suggested by Doodson are discussed.

Speaker Abstracts

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[1] Observations of an effluent plume from an ocean outfall using spray gliders

Todd, Robert E., D.L. Rudnick and R.E. Davis
Scripps Institution of Oceanography, UCSD, 9500 Gilman Drive, La Jolla, CA 92093-0213, USA.
Author email: rtodd@ucsd.edu

Two spray gliders were deployed off of Huntington Beach, CA as part of the Huntington Beach 2006 (HB06) experiment. The gliders surveyed the upper ocean over the San Pedro Shelf and San Pedro Basin for 27 days in September and October 2006 and recorded profiles of temperature, salinity, chlorophyll fluorescence, doppler currents, and acoustic backscatter with horizontal resolution of 3 km or less. One glider repeatedly surveyed the outer continental shelf (depth >50 m) near Huntington Beach while the second glider surveyed over the San Pedro Basin and along the east side of Santa Catalina Island, an island approximately 40 km off the coast. The mixed-layer base was 10-25 m deep over the San Pedro Basin and 5-15 m deep over the San Pedro Shelf. A layer of low salinity water characteristic of California Current waters of subarctic origin was centered at approximately 50 db throughout the region with minimum salinities near 33.2 psu and potential temperatures near 15°C. Depth-integrated current velocities were primarily alongshore to the northwest. Variability at weekly time scales and horizontal scales of 10-20 km was apparent. The survey pattern of the glider over the outer continental shelf took it in the vicinity of the Orange County Sanitation District's ocean outfall where on the order of 10^6 m^3d^{-1} of treated wastewater is discharged at a depth of 60 m. The effluent plume rose to a mean depth between 20 and 50 m over the outfall due to buoyancy and was diluted significantly. After initial dilution, negative salinity anomalies still existed, allowing the effluent plume to be distinguished from the subsurface salinity minimum by salinities near 33.2 psu at potential temperatures below 14°C where typical salinities were 33.3-33.4 psu. The effluent plume is identified in 283 of the 716 profiles measured by the glider over the continental shelf. No evidence of the effluent plume was observed in the profiles measured by the second glider that was 20-40 km offshore. The majority of profiles that showed evidence of the plume were to the northwest of the outfall pipe, consistent with advection of the plume by the alongshore currents. The plume was consistently found below the mixed-layer base, and no observational evidence was found for the plume reaching the surface during the survey period.

[2] Wind and bathymetric influences on the subtidal circulation in San Quintin Bay, Mexico.

Flores-Vidal, Xavier, R. Durazo, A. J. Souza, A. Mejía-Trejo and V. F. Camacho.
Facultad de Ciencias Marinas. UABC, Ensenada, B.C., México
Author email: xflores@cicese.mx

San Quintin Bay is a Y-shape coastal lagoon with almost no fresh-water runoff, and with an open connection to the Pacific Ocean. Besides the large oyster aquaculture industry inside, the lagoon is almost pristine with no large man-made alterations. In order to study the subtidal circulation, bottom mounted and underway ADCPs were used in June-August 2005 to profile ocean currents at the main entrance and along the secondary entrance of each of the two channels. Also, underway current profiling was conducted to measure cross-channel currents near the main entrance. Over the inner bay, a two layer residual circulation was observed, closely linked to changes in sea level and wind forcing. At the entrance, inflow was always present with a clear intensification during springs. In close agreement with theoretical expectations (Ekman Number 1), underway measurements found that the inflow is mostly restricted to the deepest channel while outflow was limited to the shallowest portions of the entrance. A 3D numerical model (POLCOMS) was used to reproduce the observations and to study the response of the inner waters to long periods of no wind (NOW), cross-shore winds (CSW), and periods with intermittent winds (IW).

[3] Circulation in a semi-enclosed bay driven by sea level variations and wind

Ponte, Aurélien
Scripps Institution of Oceanography, UCSD, 9500 Gilman Drive, La Jolla, CA 92093-0213, USA.
Author email : aponte@ucsd.edu

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. Observations of pressure and currents, numerical experiments (ROMS) and a theoretical model are combined in order to understand the sea level and wind driven circulation inside the bay. In the frequency domain, the response of the bay to sea level variations is centered around 5cpd, the quarter wavelength resonance, while higher resonant modes are also observed. At lower frequencies, the pressure response is slightly amplified inside the bay and currents amplitude decreases with frequency. Between resonant frequencies, the response is damped. The response of the sea surface to wind stress is a set up in the downwind direction observed and well correlated with wind stress measurements. 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 and may drives through nonlinearities the amplification of the currents on the western side of the bay.

[4] Sea Surface Temperature Anomalies in the Gulf of California

Gómez Valdivia, Felipe and A. Parés Sierra
Depto. de Oceanografía Física, CICESE, Ensenada, B.C., México.
Author email: fgomez@cicese.mx

A set of twenty years of sea surface temperature measurements, taken by Pathfinder V5 satellite between January 1985 and December 2004, reveals that, in average, the lowest temperatures inside the Gulf of California occur between the 28^oN and 30^oN. This is the region where the large islands and sills, in the middle gulf, are located. It has been shown that this is an important factor in the oceanography of the region. The Regional Ocean Modeling System (ROMS) has been used to identify the relevant factors involved in the latitudinaly cooling of the region. We are particulary interested on the relevance of tides. Heat balances have been calculated using ROMS run with and without tidal forcing to isolate the different mechanism and components of the heat balance equation. Preliminary results are presented.

[5] Influence of the NBC rings on the Caribbean Sea eddy production

Jouanno, Julien, J. Sheinbaum, B. Barnier and J.M. Molines
Depto. de Oceanografía Física, CICESE, Ensenada, B.C., Mexico.
Author email: jouanno@cicese.mx

The influence of the NBC rings on the Caribbean mesoscale variability could be resumed as follows: NBC rings act as finite perturbations which trigger the instability of the mean flow in the vicinity of the Lesser Antilles. We wish to emphasize the subtlety of how NBC rings appear to be linked to the Caribbean eddies. Results, from two-way nested high resolution configurations of the Océan Parallélisé (OPA) primitive equation model, support the idea that the Caribbean Sea is intrinsically unstable and that NBC rings trigger an instability which would occur anyway. For one side NBC rings advect potential vorticity through the Lesser Antilles Passages, as "seeds" which result in the formation of Caribbean eddies. In addition, model and altimetry data show that two maxima of eddy kinetic energy occur in the Colombia Basin during the year and have distinct origins. In particular there is one during September-November which has a clear link with the shedding of more energetic NBC rings during winter of the year before: energetic incoming rings giving rise to energetic Caribbean eddies, albeit perhaps in an indirect manner. So we suggest that more energetic incoming rings help the formation of more energetic Caribbean eddies. On the other side, comparing the outputs from 3 simulations which present very different variability west of the Antilles, we show that a cut off of the NBC ring production (and more generally of the Atlantic waves and eddies) does not stop the formation of large and energetics Caribbean eddies, and Caribbean eddy population or mean eddy kinetic energy are very similar in the different experiments.

[6] The death of two eddies against the shelf

Zavala Trujillo, Bárbara and A. Badan
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A set of five moorings deployed off the coast of Tamaulipas, western Gulf of Mexico, provided fourteen months (from August 2004 to November 2005) of surface to bottom observations of currents and temperature that document the processes associated with the collision and dissipation of two warm mesoscale eddies with the continental slope. Two Loop Current eddies (*Titanic* and *Ulysses*) were identified reaching the study area during the observation period. On September 2004, the two southernmost 2000 m moorings show that temperature and salinity increases throughout the entire water column, related to eddy *Titanic*. Similarly, on April 2005, eddy *Ulysses* caused a strong increase of temperature in the 3500 m mooring. The velocity field suggests three different regimes: a coastal region, the continental slope currents, and the abyssal circulation. Over the slope, three different layers can be identified: a surface layer (above 500 m depth), influenced by eddies and transients, a deep layer (under 1900 m) with a persistent southerly current and a transition layer (from 500 to 1900 m) that separates them. The variance ellipses at ∼700 m at the 3500 m mooring have no predominant orientation of the mayor axis. At the northernmost 2000 m mooring, the axis of maximum variation is oriented with the bathymetry, but at the southernmost 2000 m mooring it is perpendicular to the coast. The spectral characteristics of the measurements are also discussed.

[7] North Pacific variability from a Data Assimilating Model

Douglass, Elizabeth
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A regional version of a data-assimilating model is used to study variability of circulation and property transports in the North Pacific from 1992-2004. The Estimating the Climate and Circulation of the Ocean (ECCO) model is a one-degree general circulation model which uses the adjoint method of data assimilation to determine a dynamically consistent time-varying estimate of the ocean state constrained by satellite and hydrographic data. In this study, different weighting schemes for the assimilation process are tested to determine the model's sensitivity and to improve the estimate in the region of interest. The resulting model output is compared with a long-term high resolution expendable bathythermograph (XBT) dataset. Time-varying budgets of heat and freshwater are calculated from the model and from the data for the closed region north of the XBT transect in the North Pacific. The heat budget shows large variability in advective transport leading to changes in heat storage in the region, while surface heat fluxes remain relatively constant. In freshwater, changes in advective transport are of similar magnitude to changes in surface fluxes. The largest signal in both heat and freshwater storage occurs during the 1997-98 El Niño event, when a northward meander of the North Equatorial Current causes an influx of heat and freshwater into the region of study. Further connections between these changes in advective transport, surface fluxes, and long-term modes of climate variability are explored.

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[8] Meteorological bias in satellite estimates of aerosol-cloud relationships

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Several recent studies have reported a substantial correlation between satellite retrievals of aerosol optical depth (AOD) and cloud fraction, which is ascribed to an aerosol microphysical mechanism. Another possible explanation, however, is that the history of meteorological forcing controls both AOD and cloud fraction. The present study examines the latter hypothesis by comparing meteorological conditions along parcel back-trajectories for cases of large and small AOD and cloud fraction. Cloud and aerosol observations are obtained from the MODIS instrument aboard Terra, and meteorological information is obtained from ECMWF analyses. For continuity with previous investigations, the analysis focuses on the stratocumulus cloud region of the Northeast Atlantic during June through August 2002, the season of maximum cloud cover. Results show that scenes with large AOD and large cloud fraction had origins closer to Europe and experienced greater lower tropospheric static stability (LTS) during the past 2-3 days than did scenes with small AOD and small cloud fraction. Controlling for variations in LTS reduces the dependence of cloud fraction on AOD by at least 54%. We conclude that meteorological forcing must be accounted for in assessing aerosol impacts on cloud forcing, and that doing so requires a Lagrangian analysis of parcel histories.

[9] Interannual Variability of the Pacific EUC

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The Pacific Equatorial Undercurrent (EUC), which is a fast subsurface current flowing east in the upper thermocline along the equator, is a key component of the complex equatorial current system. Understanding its dynamics in a climate context is crucial because the EUC feeds equatorial upwelling and affects the sea surface temperature, which in turn is an important driver of the climate system. In addition, because the EUC varies significantly on ENSO time scales, further insights into its dynamics might help improve El Niño predictions, especially in a changing climate. In this study, we examine the interannual variability of the Pacific Equatorial Undercurrent (EUC). We analyze direct measurements of zonal velocity from the Tropical Atmosphere Ocean (TAO) buoy array to understand how the wind stress, pressure gradient, and vertical diffusive processes combine to produce the observed variability of the EUC and how the low-frequency variability of the EUC relates to the ENSO cycle.

[10] The use of MODIS satellite SST data as the lower boundary condition of a numerical model of the North American Monsoon

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An attempt to increase the modeling accuracy of the North American Monsoon, thru the use of MODIS AQUA and TERRA satellite SST data as a more realistic forcing of the lower boundary of the MM5 regional atmospheric model than the skin temperature produced by the North American Regional Reanalysis project, is presented as a stepping stone towards broader goals which include: (a) an objective definition of the land-sea thermal contrast associated to the monsoon onset; (b) analyzing the thermodynamics of the initial period of monsoon development; (c) achieving a reliable modeling methodology that can be used to test hypothesis on the principal causes of monsoon interannual variability.

[11] The impact of hurricane Wilma on the circulation along the Mexican Caribbean

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On the 21st of October 2005 category 4 hurricane Wilma made landfall on the coast of Quintana Roo (Mexico) near Puerto Morelos and, for the next 24 hours, proceeded to drift slowly north before emerging into the southern Gulf of Mexico at Cabo Catoche. Wilma was a record breaking hurricane: it had the lowest atmospheric pressure ever recorded in a tropical cyclone, the most rapid phase of intensification on record, and was the 3rd category 5 storm to develop in a single hurricane season in the Atlantic Basin. This combination of

low forward velocity, large size and double eyewall structure produced the most devastating hurricane ever recorded in the state of Q. Roo and led to unprecedented damage to natural resources, property and infrastructure. In its trajectory through the region Wilma interacted with the Yucatan Current, one of the most intensive boundary currents in the World at these latitudes. The presence of an array of nine deep water current meter moorings, three pressure subsurface sensors distributed along the Mexican Caribbean coast, and five shallow water current and wave recorders in a reef lagoon, lends a unique ensemble of observations to analyze the response of the Yucatan Current and shallow water reef systems to the passage of Wilma. When Wilma was passing over the Island of Cozumel, the current along the Cozumel Channel reversed for about 15 hours to depths of more than 100m and, 50 km away from shore. Ten days after the passage and lasting more than 40 days, an intense southerly surface to bottom flow is established in Chinchorro. This latter circulation pattern is found to be related to the presence of a cyclonic meso-scale eddy around Chinchorro which intensified by direct vorticity transfer from Wilma to the ocean.

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[12] Evolution of an horizontal vortex in a linear stratified fluid

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Langmuir cells and Cloud Streets are two examples of horizontal vortices that occur in nature. The aim of this work is to study, trough laboratory experiments, these kinds of vortices in a stratified fluid and to analyze their response to changes in controlled variables of interest that take part in their evolution. In order to do this, the two tank method is used to create a linear stratification in the medium through which a horizontal cylinder moves to generate vortex structures. The density fluctuations are obtained both qualitative and quantitatively with the Shadowgraph and the Synthetic Schlieren methods, respectively. These techniques utilize image processing technology; they are a simple and very useful tool for visualizing experimental flows.

[13] Dispersion in a bidimensional turbulent flow in the presence of a boundary

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The problem of particle dispersion from a point-source in a bidimensional turbulent field is studied by means of a series of laboratory experiments with a thin layer of conducting fluid. The turbulent field is generated by placing an arrangement of permanent magnets with alternating magnetic field direction under the water tank and passing an electrical current through it. The interaction between the current and the magnetic field of each magnet generates a Lorentz force, which induces an array of vortices that circulate in alternating directions. The point-source of fluid is placed adjacent to one of the boundaries of the tank. Then, a group of small, passive particles is placed inside the tank and followed for a fixed period of time. From this information relative particle dispersion is measured, as well as the corresponding Finite Scale Lyapunov Exponents. The results are oriented to determine the particle dispersion as a function of the turbulence characteristics.

[14] Horizontal diffusivity coefficients in the pacific coast region between Mexico and USA, taking data of HF radar.

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From HF radar data localized in the Pacific coast between Mexico and USA, we obtained the surface current velocity, and by taking the second order of the Taylor series, we calculated the coefficient of horizontal diffusivity, using the method from Yanagi et al. (1982). These results were compared with those of Okubo (1971), and were introduced in a computer model that follows trajectories to view how was the behavior of any number of “drifters” in terms of turbulence. The data are of January to June of 2003. This research is of special interest because with HF radar is easier to have many data in a good series of time, we can have less error of calculating statistics and helps in contingence in case

of any pollution spill from human activities of all the cities that are localized in the coast.

[15] Avenues and distribution points for larvae and contaminants in the Caribbean Sea and Gulf of Mexico

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The lagrangian analysis of the velocity field in an oceanic region is essential to understand transport and mixing processes. This analysis uses techniques from dynamical systems theory, which allow to identify regions where particles remain trapped for long periods (eddies or elliptic points), and regions where particles approach or move away from them (hyperbolic points). To investigate the trajectories of particles regions in the Caribbean Sea and Yucatan Channel, we use surface velocities from ROMS (Regional Ocean Modelling System) model. Three different methods are employed to identify regions or manifolds with different dynamical properties. First we use the Okubo-Weiss criterion to visualize regions where the strain or vorticity dominate. Then, the finite scale Lyapunov exponent (FSLE) technique is applied to determine regions of maximum mixing.From the FSLE it is posible to identify the faster particle separation regions associated to stable and unstable manifolds. Finally , time-slice and lobe dynamics methods are applied to the problem which allow quantification of the mass exchange between different regions of the flow. A hyperbolic point, found in the Yucatan Channel, and the stable and unstable manifolds associated whit it are identified. Both manifolds approach the hyperbolic point which suggest the existence of a hyperbolic trajectory in the Yucatan Channel. The intersection of stable and unstable manifolds produces lobes, which are responsible for transport between eddies and the ambient flow.

[16] Quasi two-dimensional turbulent flows and dipolar structures over discontinuous topography

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Decaying turbulent flows with topography are studied in two different ways. First, experiments and simulations on the interaction of dipolar structures with a step-like topography were performed, in which one of the sides of he domain is shallow and the other one is deep. Two step heights were considered and two very different results were obtained. In both cases, the interaction of the dipolar vortex with the topography originates a flow along the step that maintains always shallow water on its right. Additionally, numerical simulations with more complex initial conditions over the same bottom topography were performed and an inverse energy cascade observed. It was found that the flow evolution gives rise to an equilibrium state characterized by four structures, two cyclones and two anticyclones, alternately disposed. The flow along the step with shallow water on its right is responsible for the vortex distribution in the final state. It is proposed that the dynamics involved in the interaction of a dipole with a step-like topography helps to explain the final state of the turbulent flow where these behaviours are due to stretching and squeezing effects associated with the (quasi) material conservation of potencial vorticity.

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[17] Recent advances to measure surface winds using HF radar system in the Gulf of Tehuantepec

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HF Radar wind measurements over the Gulf of Tehuantepec are shown. Methods for obtaining both wind speed and direction are discussed. The temporal variability of surface wind direction was estimated for a single point. The method is based on the principle that the Bragg peak ratio of the echo spectral energy from HF Radar gives information about the directional properties of Bragg waves. Assuming that Bragg waves are locally generated wind waves, the wave directional distribution also describes the wind direction. The accuracy of the wind direction measurement was validated using data from an ASIS buoy. In addition, preliminary results for estimating the surface wind speed have been obtained. An empirical algorithm for wind speed using an integral over the central part of the Doppler spectrum has been developed. Further work should focus on the theoretical relationship between the central part of the Doppler spectrum and the wind speed.

[**18**] SAR observations of ocean swell at the Gulf of Tehuantepec

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Synthetic Aperture Radar (SAR) has been referred to as one of the remote sensing techniques with the largest potential to provide weather and ocean forecasting systems with wave information on an operational basis. Spaceborne SAR sensors have the capacity to acquire images from the sea-surface independently of sunlight or cloud cover on a variety of formats, with swath widths ranging from 5 to 500 km and spatial resolutions from 5 to 100 meters. The analysis of a set of SAR images upon the Gulf of Tehuantepec acquired on February and March of 2005 by the European satellite ENVISAT have revealed ocean wave spectra that agree fairly well with in-situ records: ocean swell propagates mostly in a northern direction, suffering little deviation along its trajectory. Integral wave parameters (swell wave heights peak periods) retrieved from these images coincide with those recorded by three Nortek ADCPs deployed close to the coast at 20 m of water depth. Collocated records show a general decrease on the wave height during strong offshore-wind conditions as compared to low wind conditions. Analyses on the evolution of the wave spectrum directional spreading through the continental shelf are currently being performed.

[**19**] Airborne Observations of Fetch-Limited Waves in the Gulf of Tehuantepec

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The Gulf of Tehuantepec is well known for having strong offshore winds during the winter time, when an atmospheric pressure difference develops between the Gulf of Mexico and the Pacific Ocean, forcing winds through a mountain gap at the head of the gulf. During the Gulf of Tehuantepec Experiment (GOTEX), conducted in February 2004, we collected surface-wave measurements using a scanning lidar (Airborne Topographic Mapper, ATM) on the NSF/NCAR C-130 aircraft. We present the observed evolution of directional wavenumber spectra for fetch-limited waves at various stages, from young to mature seas. The observed evolution of the significant wave height and peak wavenumber (wavenumber at the peak to the spectrum) with fetch are consistent with previously reported growth rates from wind-wave observations, e.g. Kahma and Calkoen (1992). Our measurements show various features within the spectrum which support the idea of an evolution that is approximately self-similar. Some of the spectral features of wind-waves observed, such as an equilibrium range of the omnidirectional spectrum proportional to $k^{-2.5}$ and bimodal directional distribution, were previously observed in the field (e.g Hwang et al.,2000) and reported in theoretical investigations (e.g. Badulin et al. 2005, Dysthe 2003). The self-similar features of the spectrum are exploited in formulating a complete 2-dimensional model of the spectrum for fetch-limited waves.

[**20**] On the influence of sea state on wind stress: Air-sea interaction study at the Gulf of Tehuantepec, México.

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Generation and evolution of wind waves depends on the force exerted by wind over the sea surface i.e. on wind stress (drag). However, the dependence is not straightforward and the sea state can modify the wind stress in several ways. Underdeveloped wind waves increase sea surface roughness leading to an enhancement of drag. On the other hand, 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. In this talk an overview of the Gulf of Tehuantepec 2005 air-sea interaction field experiment and a description of the effects of sea state observed are given. Particular emphasis is made at the high wind conditions in which the presence of swell running against wind and underdeveloped wind seas caused a complex interaction between wave field components and wind stress.

[**21**] Wave energy budget on Pacific islands nearshore environments

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With the prospect of increased storm activity and rising sea level associated with climatic changes, islands are becoming particularly vulnerable to erosion and inundation due to the impact of waves. Observations of wave-driven inundation have been made primarily on continental US. sandy beaches that are mildly sloping with wide surf zones. The goal of this study is to understand the transformation of waves on steep and complex island nearshore bathymetry in an effort to assess the energy available at the shoreline for inundation and erosion. A cross-shore array of single pressure sensors and collocated pressure sensors and acoustic current meters was deployed across the Ipan reef, Guam, as part of the PILOT (Pacific Island Land Typhoon Ocean Experiment) project. These data are used to estimate reflection, transmission, dissipation, and nonlinear energy transfer of the wave energy as it propagates across the reef. Preliminary work suggests that porosity and reef geometry both affect wave transformation across the reef. The amount of energy transmitted to the reef platform, reflected by the reef face and dissipated at the reef edge are strongly frequency dependent. Transmission of energy to the shoreline seems to present a minimum for the wave conditions most frequently observed in Guam, but varies significantly as the peak wave period increases.

[**22**] On the detection of semi-diurnal tidal signatures in Synthetic Aperture Radar images of Delaware Bay

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The Synthetic Aperture Radar (SAR) is a high resolution sensor flown on many satellites. It provides synoptic views of several oceanic processes such as surface gravity and internal waves, density fronts, and shallow water bathymetry. The backscattering from the ocean is to the first-order proportional to the spectral energy of short gravity-capillary waves. The spectral energy in turn, interacts with currents modulated by the mentioned processes. The theories of weakly non-linear wave-current interaction and Bragg scattering tell us that areas of current convergence (divergence) will have enhanced (reduced) spectral density and thus will produce higher (lower) backscattering values. In Delaware Bay, several physical processes oscillate at the M_2 tidal frequency. We report here the changes detected in the radar signatures of RADARSAT-1 Standard Mode SAR images that resulted from this tidal modulation. The most distinctive changes occur in the signatures of salinity fronts and bottom topography. The spatial oscillation of the frontal signatures agrees well with previous high resolution in-situ sampling. The modulation in the signal of a prominent topographical feature led us to a new interpretation of an important radar signature at the bay's mouth. The main influence of the semi-diurnal tide was an indirect effect on the spatial position of the signatures, however we could not establish a complete oscillation of the backscattering values for one tidal period. Next, we investigated the response of ocean radar imaging models to M_2 modulations on one of the topographical signatures. Despite several limitations, hourly samples across the shoals show that the backscattering anomalies fluctuate at the M_2 frequency when some stationary parameters are set. We suggest that this particular disagreement between the model results and the SAR images could be explained by the fact that other processes which are not included in the model are saturating the radar signal. Aerial photography showing foam-lines and enhanced local wave-breaking on the study area support this idea. Continuous airborne radar surveys could provide more insights of this apparent limitation. The detection of tidal modulations of the mentioned processes can be especially important on areas of difficult access.

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[23] On spectra and other demons

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Nowadays, remote sensors and smaller low-cost oceanographic instrumentation facilitates the measurement of the physical variables but data remain insufficient. For this reason, the previous planning of the experiment and the posterior data analysis should provide us the biggest possible information. Spectral analysis is a powerful tool for both tasks. In this work I show some examples of the kindness of this tool on the design of space arrays and on the wavelength-frequency space analysis of even and unevenly sampled time series obtained in rest or while on moving, using data from direct measurements and from idealized experiments.

[24] Improvements to the method of altimeter calibration using tide gauges: Addressing the problem of land motion

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In the past decade, the use of tide gauges in calibrating satellite altimeters has become widely accepted. Because tide gauge sea levels are referenced to a datum on land, an estimation of land motion at each tide gauge must be made in order to compare tide gauge sea levels with altimeter heights. The errors due to land motion at the tide gauges are the largest remaining source of uncertainty in determining global mean sea level rise rates from altimetry. Since the last calibration method was described (Mitchum, 2000) more GPS and DORIS stations have become available, many near to the tide gauges presently used for altimeter calibration. Through careful examination of tide gauge derived land motion estimates and land motion estimates from nearby GPS stations, we can make an estimate of land motion and its uncertainty at any tide gauge. Because tide gauge and GPS time series often have low frequency variability that cannot be removed by fitting a model, we develop a method to estimate the error inflation that is due to serial correlation in the time series. By estimating land motion and its error at each tide gauge, we reduce the error on the tide gauge-altimeter differences and reduce the uncertainty when computing linear sea level trends from altimetry.

[25] 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.

[**26**] Variability of M2 and K1 tidal constituents in the Mexican Caribbean

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It is generally accepted that harmonic components are not constant. In the Mexican Caribbean (MC) we have an array of 7 deep moored ADCPs and 6 subsurface pressure sensors, where the tidal signal in the currents, the sea level and their relationship with sub-inertial phenomenons are analyzed. Dynamics MC is dominated by the Yucatan Current and the constant flow eddy's of meso-scale, while the tidal range is micro-tidal <10 cm in the sea level. The percentage of variability that tides contribute to Yucatan current is 0.5 - 3.0 %. For the tidal currents, the diurnal K1 component with a semimajor axis of 1.6 cm/s dominates over the semidiurnal M2 component which has a semimajor axis of 0.4 cm/s. However for the sea level the situation is opposite, the semidiurnal component M2 with amplitude of 7.5 cm dominates the K1 component with an amplitude of 4.4 cm. In this study we have observed that amplitude and phase of these components change in space and time, resulting in an annual variation of the M2 amplitude with a maximum during March and also an semidiurnal variation for the K1 amplitude. The phase and amplitude variations are due to the motion of the point of amphidromy of each component which is affected by sub-inertial changes in sea level and by the patterns of the atmospheric pressure over the Caribbean Sea and the Gulf of Mexico.

[**27**] Observations of Tidal Internal Wave Beams and Energetics at Kauai Channel, Hawaii

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The generation, propagation, and dissipation of internal tides transfers energy from the basin scale to turbulence, helping to maintaining open ocean stratification and global overturning circulation. To observe the across ridge structure of internal tide energetics, density and velocity were measured using SeaSoar and Doppler sonar over the upper 400-600m of the ocean extending 150km on each side of the Hawaiian ridge at Kauai Channel. Eighteen sections across the ridge were completed in 18 days with sampling intentionally detuned from the lunar semi-diurnal (M_2) tide so that averaging over all sections approximates phase averaging the M_2 tide. Velocity and displacement variance show M_2 internal wave beams that originated from both sides of the ridge, and reflection of the beams off of the surface. Energy flux estimates show internal wave propagation was away from the ridge and along tidal beams, consistent with internal wave generation at the ridge. Turbulent dissipation as parameterized from vertical velocity shear was elevated over open ocean values near tidal beams. A reasonable balance between energy dissipated near the ridge and energy traveling away from the ridge was obtained. Vertical shear-strain and kinetic to potential energy density ratios were consistent with two-dimensional, inviscid, linear dynamics. Influences of diurnal and near-inertial frequencies were observed. Interactions between upward and downward tidal beams caused a covariance between across ridge velocity perturbations and displacement, as well as momentum fluxes and momentum flux divergences. Through the momentum flux divergence, internal waves forced a mean horizontal velocity of $1-4 cm/s$ along the tidal beams.