OS41A-06 0915h

Development of Ocean Noise "Budgets"

Gerald L. D'Spain[1] (858-534-5517; gld@mpl.ucsd.edu)

James H. Miller[2] (401-874-6540; miller@uri.edu)

George V. Frisk[3] (508-289-2383; gfrisk@whoi.edu)

David L. Bradley[4] (814-863-9916; dlb25@psu.edu)

[1]Marine Physical Lab, Scripps Institution of Oceanography, 291 Rosecrans St., San Diego, CA 92106, United States

[2]University of Rhode Island, Department of Ocean Engineering, Narragansett Bay Campus, Narragansett, RI 02882, United States

[3]Woods Hole Oceanographic Institution, Mail Stop 11 98 Water Street, Woods Hole, MA 02543, United States

[4]Applied Research Laboratories, Penn State University, P.O. Box 30, State College, PA 16804, United States

The National Oceanographic Partnership Program recently sponsored the third U.S. National Academy of Sciences study on the potential impact of manmade sound on the marine environment. Several recommendations for future research are made by the 11-member committee in their report titled Ocean Noise and Marine Mammals (National Academies Press, 2003). This presentation will focus on the subset of recommendations related to a "noise budget", i.e., an accounting of the relative contributions of various sources to the ocean noise field. A noise budget is defined in terms of a specific metric of the sound field. The metric, or budget "currency", typically considered is the acoustic pressure spectrum integrated over space and time, which is proportional to the total mechanical energy in the acoustic field. However, this currency may not be the only one of relevance to marine animals. Each of the various ways in which sound can potentially impact these animals, e.g., temporary threshold shift, masking, behavior disruption, etc, probably depends upon a different property, or set of properties, of the sound field. Therefore, a family of noise budgets based on various currencies will be required for complete evaluation of the potential impact of manmade noise on the marine environment. Validation of noise budgets will require sustained, long term measurements of the underwater noise field.

OS41A-07 0930h

The Use of Normal Mode Analysis to Extend HF Radar Coverage Over Enclosed Bays

Hector Aguilar[1] (915-747-7530; hector@codaros.com)

Mike E Miszczak[1] (915-747-7530; memiszczak@utep.edu)

Rosa M Fitzgerald[1] (915-747-7530; rfitzgerald@utep.edu)

Donald Barrick[2] (408-773-8240; COSDon@aol.com)

[1]The University of Texas at El Paso, 500 W. University Ave., El Paso, TX 79968-0515, United States

[2]CODAR Ocean Sensors, Ltd, 1000 Fremont Ave., Los Altos, CA 94026, United States

A technique referred to as Normal Mode Analysis (NMA) has recently been developed for representing total vector CODAR HF radar data. This technique has been applied to Corpus Christi Bay. These modes satisfy the coastal boundary constraint of no flow normal to the shore, and inherently represent both divergent and rotational flow as two sets of ortho-normal basis functions. The use of NMA allows the measurement of flows in mostly enclosed bays, like Corpus Christi, where wind-driven and tidal currents predominate. Furthermore, it extends the measurement coverage into regions where only one, or even no radar is able to provide coverage. The PDE2D software, which is based on a Finite Element Method, is used to obtain the eigenfunctions for the Corpus Christi Bay. Comparisons are made with the real-time total-vector maps produced by the HF Radar data over the common coverage area.

OS41A-08 0945h

Toward Better High Frequency Dealiasing in altimeterMeasurement of Sea Level Heights

Ahmed Haider Ali[1] (626-744-5441; aali@pacific.jpl.nasa.gov)

Victor Zlotnicki[2] (818-354-5519; vz@pacific.jpl.nasa.gov)

[1]Raytheon ITSS, 299 N Euclid Ave, Pasadena, CA 91101, United States

[2]JET Propulsion Laboratory, 4800 live Oak Ave, Pasadena, CA 91101, United States

Ocean motions that has High Frequency (HF) with periods less than 20 days are aliased in the TOPEX and JASON measurement of sea level heights. Previous research has showed that most of these motions have a barotropic signals especially in high latitudes and a barotropic model is needed to dealiase these signals. We are visiting back this subject in which we show that in the tropics there are HF motions that cannot be captured by a barotropic model. Hence, a baroclinic model is needed for the removal of HF signals from the sea level height spectrum observed by satellite altimetry.

OS41B MCC: Level 2 Thursday 0830h

General Ocean Sciences: Tropical Oceanography and the Impacts of El Niño II Posters *(joint with A)*

Presiding: **W Han,** Program in Atmospheric and Oceanic Sciences, University of Colorado**; C L Perez,** Columbia University

OS41B-0801 0830h POSTER

The Ocean Response to a Brief Westerly Wind Event in the Tropical Pacific Ocean

Alexander Kochurov[1] (agkochur@bechtel.com)

Lewis M Rothstein[2] (lrothstein@gso.uri.edu)

[1]Bechtel Corporation, 5275 Westview Drive, Frederick, MD 21703, United States

[2]Graduate School Of Oceanography, University of Rhode Island, 215 South Ferry Road, Narragansett, RI 02882, United States

The ocean response to atmospheric intraseasonal variability in the tropical Pacific Ocean is investigated using the URI Ocean General Circulation Model. The model performance in simulating the oceanic annual cycle so important for providing the background variability upon which the intraseasonal time scales can be properly studied, is evaluated by examining its sensitivities to 1) details of the air-sea flux parameterization, 2) different sources for the wind forcing products, and 3) the meridional extent of the model domain. The model fields of temperature, salinity and currents in the tropical Pacific agree reasonably well with observations and thus provide adequate initial conditions for the model experiments with anomalous intraseasonal atmospheric forcing. We build up our understanding of how high-frequency forcing of wind affects the ocean's annual variability by increasing the complexity of experiments. We start with a simple experiment in which a resting ocean is forced with a brief (10-day) wind burst and proceed with experiments for a circulating ocean forced with wind anomalies superimposed upon climatological air-sea fluxes. The main effect of the realistic background ocean conditions is that the strongest response to anomalous wind forcing is observed along the equator in the vicinity of the eastern edge of the western Pacific warm pool. The largest ocean anomalies result from the displacement of the strong temperature and salinity gradients in the Eastern Warm Pool Convergence Zone (EWPCZ). It is argued that this zonally non-uniform ocean response is primarily due to significant vertical and longitudinal variations of the salinity field associated with the western Pacific freshwater pool. Eastward advection, by remotely forced Kelvin waves and nonlinear interactions between these waves and a zonally-varying background ocean stratification, is identified as an important mechanism of the EWPCZ displacement.

OS41B-0802 0830h POSTER

An Uneven ENSO Oscillator From Changes in Climatology

William W Hsieh[1] (604-822-2821; whsieh@eos.ubc.ca)

Zhengqing Ye[1] (zye@eos.ubc.ca)

Aiming Wu[1] (awu@eos.ubc.ca)

[1]Dept. of Earth and Ocean Sciences, University of British Columbia, 6339 Stores Road, Vancouver, BC V6T 1Z4, Canada

A new 'uneven ENSO oscillator' concept is introduced to describe the uneven changes in the ENSO warm phase and cool phase due to changes in the climatology, e.g. the Pacific climate regime shift around 1976. Using a neural network model for nonlinear canonical correlation analysis of the tropical Pacific wind stress anomalies and sea surface temperature anomalies, we compared the 1981-99 period to the 1961-75 period. During 1981-99, the location of the equatorial easterly anomalies during the ENSO cool phase was unchanged from the earlier period, but westerly anomalies during the warm phase were shifted eastward by up to 25°. Based on the delay oscillator theory, such an eastward shift would lengthen the duration of the warm episodes by up to 45%, but leave the duration of the cool episodes unchanged, hence an uneven ENSO oscillator. The Lamont coupled model of the tropical Pacific was then used to study how changes in the model climatology would produce an uneven oscillator. The eastward shift in the westerly anomalies during the warm episodes and the lengthening of the warm episode duration were indeed found in the coupled model when the 1981-99 climatologies were used instead of the 1961-75 climatology. In particular, it was mainly the change in the wind stress climatology rather than the change in the upper ocean climatology which caused the eastward shift in the westerly anomalies. The uneven ENSO oscillator theory has implications not only for how ENSO changed under decadal/interdecadal variations in the climatology, but also under longer term climate change.

OS41B-0803 0830h POSTER

Fast and slow ENSO modes

Soon-Il An[1] (808 956 5016; sian@hawaii.edu)

Fei-Fei Jin[2] (jff@soest.hawaii.edu)

[1]International Pacific Research Center, Univ. of Hawaii, 1680 East West Rd., POST 401, Honolulu, HI 96822, United States

[2]Dept. of Meteorology, Univ. of Hawaii, 2525 Correa Rd., Honolulu, HI 96822, United States

Climate variability in the tropical Pacific has a rich frequency spectrum that partly results from coupled modes with different time scales. We examined the contributions of the thermocline feedback (the vertical advection of anomalous subsurface temperature by the mean upwelling) and zonal advective feedback (the zonal advection of mean sea surface temperature by anomalous current) in determining the time scales of the coupled modes. Firstly, using a dynamical ocean model, we study the dependence of maximum amplitudes and locations of equatorial zonal current and thermocline on the time scales of the wind forcing. Then we examine in a linearized intermediate air-sea coupled model the impacts of these feedbacks on the co-existence of leading coupled modes of different time scales. For slowly varying wind forcing, amplitudes of zonal currents are very weak and locate at western Pacific, whereas the thermocline response is strong. The zonal advective feedback thus tends but to be of secondly importance in a slow mode of interannual periodicity although it plays a dominating role in a fast coupled mode of near annual periodicity. The changes in the basic state of the coupled system can have significant impacts on the relative importance of the two main feedbacks and thus the periodicity and stability of the leading modes the coupled tropical Pacific climate system.

OS41B-0804 0830h POSTER

Monthly mapping of temperature and salinity by objective analysis with Argo floats and TRITON buoys data in the Pacific Ocean

Shigeki Hosoda (81-468-9456; hosodas@jamstec.go.jp)

Shinya Minato (81-468-9463; sminato@jamstec.go.jp)

Objective analysis was applied to derive monthly temperature and salinity fields in the Pacific Ocean, using the Argo float, the TRITON buoy and other available CTD cast data. These products were opened to the public in JAMSTEC-Argo web site. Error of the estimated values by the objective analysis based on optimal interpolation (OI) method had become smaller because of increasing number of the Argo floats. To confirm the capability of this objective analysis, we compared our mapped data with observed CTD data along 137E routinely obtained by Japan Meteorological Agency, which were excluded from the objective analysis for this comparison. The analyzed fields are generally corresponding well with the CTD temperature and salinity sections. Thus, in spite of some assumptions in statistical parameters for salinity field due to sparse historical salinity data, salinity distribution is reproduced well. From these products, we calculated dynamic height anomaly, and compared with sea surface height data from Topex/Poseidon satellite. The patterns of both maps are consistent, although we found large difference in regions of small

number of the Argo data. These products captured well the temperature and surface salinity variations in the western tropical Pacific associated with the El-Nino event in late 2002. Furthermore, the dynamic height anomaly correlated well with tide station data in Naha, Japan including extraordinary high tide period in Jul. 2001. From these results, we think that the objective analyses can be used for monitoring basin wide ocean variations.

OS41B-0805 0830h POSTER

Island mass effect in Marquesas Islands

Elodie Martinez[1] ((689) 803 844; Martinez@upf.pf)

Keitapu Maamaatuaiahutapu[1] ((689) 803 805; Keitapu.Maamaatuaiahutapu@upf.pf)

[1]Geodetic Observatory of Tahiti/JETO/Universite de la Polynesie Francaise, BP 6570 Faaa, Faaa 98702, French Polynesia

As part of the Subtropical Gyre of the South Pacific Ocean, waters of the Exclusive Economical Zone of French Polynesia are poor in chlorophyll a. However, analysis of Ocean Color data from around the Marquesas Islands (135°W-145°W; 6°S-12°S) sometimes shows water with high chlorophyll a content reaching the surface. This type of event is noticeable after an El Niño period and is stronger during a La Niña period. The appearance of water with high chlorophyll content at the sea surface has been attributed to the island mass effect which consists of a combination of turbulent mixing and advection from the South Equatorial Current. We investigate the phenomenon in the Marquesas Islands using sea surface height, ocean color, wind and sea surface temperature data available from the period of 1997-2002. Conditions favorable to the set up of the island mass effect are determined with regard to the variability in each data set.

OS41B-0806 0830h POSTER

On the South Pacific subtropical overturning cell in October/November 1999 and comparison with a climatology.

mansour Ioualalen[1]

Roger Lukas[2] (rlukas@hawaii.edu)

Yves Gouriou[1] (gouriou@noumea.ird.nc)

Gerard Eldin[1] (eldin@notos.cst.cnes.fr)

[1]IRD, BP A5, Noumea 98848, New Caledonia

[2]SOEST, University of Hawaii at Manoa, 1000 Pope Road, Honolulu, HI 96822, United States

Two sections, 165°E and 180°, and along the equator in between, were sampled during WESPALIS 1 cruise in Oct./Nov. 1999. The high salinity tongue of the South Pacific subtropical overturning cell (STC) is described. In particular the pathways of the circulation are exhibited. Then a comparison with a 10-year climatology is performed and the deviations from the climatology are described in terms of heat content exchange between the upper ocean surface layers. It is shown that the heat exchange between the STC and the equatorial mixed layer is more intense during Warm events of ENSO.

OS41B-0807 0830h POSTER

Intrabasin Comparison of Surface Radiocarbon Levels in the Indian Ocean Between Coral Records and Three-Dimension Global Ocean Models

Nancy S. Grumet[1] (ngrumet@stanford.edu)

Michael E. Wickett[2] (wickett@llnl.gov)

Phillip B. Duffy[3] (duffy2@llnl.gov)

Ken Caldeira[3] (kenc@llnl.gov)

Robert B. Dunbar[1] (dunbar@stanford.edu)

[1]Department of Geological and Environmental Sciences , Stanford University, Stanford, CA 94305, United States

[2]Center for Applied Scientific Computing, Lawrence Livermore National Laboratory, Livermore, CA 94551, United States

[3]Energy and Environment Directorate, Lawrence Livermore National Laboratory, Livermore, CA 94551, United States

We have conducted a model-data comparison between time histories of surface radiocarbon from three-dimension ocean models that participated in the second phase of the Ocean Carbon-Cycle Model Intercomparison Project and observed radiocarbon variability recorded in coral records from the coasts of Kenya and Sumatra. Our coral results show the Kenyan radiocarbon response leading the Sumatran response by 2-3 years during the initial input of bomb C-14. These coral records comprise the first intrabasin record of surface water radiocarbon variability in the equatorial Indian Ocean and provide an independent evaluation of model performance across the Indian Ocean basin. Oceanic uptake and transport of bomb produced radiocarbon is a useful diagnostic in global ocean models to test parameterization of interior mixing and air-sea gas exchange between the ocean and atmosphere. Those models that include a more sophisticated vertical mixing scheme are apparently more capable of matching observed coral radiocarbon time-series. Yet, the large range of model simulation at both sites imply factors such as resolution, topography and physical forcing are more important than choice of mixing parameterization in explaining inter-model differences. None of the models reproduce the time-lag in the rate of bomb C-14 response between the Kenya and Sumatra coral sites. The simulation failure suggests that the lead/lag relationship in the coral records may be a function of small scale processes and/or coastal processes, such as lateral advection, coastal upwelling and rapid mixing with subsurface water, that are difficult to model with a coarse resolution OGCM.

OS41C MCC: Level 2 Thursday 0830h

General Ocean Sciences: Ocean Circulation Posters

Presiding: **X Liang,** Harvard University**; P Rhines,** University of Washington

OS41C-0808 0830h POSTER

A numerical simulation of eastern subarctic circulation in the North Pacific

Yiyang Shen[1] (81-45-7785629; shen@jamstec.go.jp)

Nozomi Sugiura[1] (nsugiura@jamstec.go.jp)

Shuhei Masuda[1] (smasuda@jamstec.go.jp)

Toshiyoki Awaji[2] (awaji@kugi.kyoto-u.ac.jp)

[1]Frontier Research System for Global Change, 3173-25 Showa-machi, Kanazawa-ku, Yokohama 236-0001, Japan

[2]Department of Geophysics, Kyoto University, Kitashirakawa Oiwake-Cho, Sakyo-Ku, Kyoto 606-8502, Japan

The Subarctic Pacific Ocean, the terminal point of the deep thermohaline circulation, is a productive ecosystem which experiences large seasonal and interannual changes in upper ocean physics, and is considered to be very important in the global organic carbon cycle. In the present study, a primitive equation model (Geophysical Fluid Dynamics Laboratory's MOM 3) with high horizontal and vertical resolution is applied to simulate the mechanism of eastern sub-arctic Pacific (including the Alaskan Stream and Alaska Coastal Current, which influence the Bering Sea). In addition, we present quantitative estimates of the subarctic Pacific ocean circulation features, which include the description of volume and heat transports. By analysis of velocity, temperature and salinity fields, we also give a brief discussion of the interaction between the eastern subarctic water and neighbour water masses in North Pacific.

OS41C-0809 0830h POSTER

Non-hydrosatatic Effects in Exchange Flows

Yuliya Kanarska (380442642891; kanarska@ukrpost.net)

An important class of stratified flows is exchange flows in which fluids of different densities move in opposite directions through a channel. These flows are studied mainly in the frame of an internal hydraulic theory. However geophysical flows are more complicated than a two-layer hydraulic solution. In this paper the hydrodynamics of exchange flows is investigated with focusing on the role of non-hydrostatic effects, friction, mixing and an impact of an unsteady barotropic tide forcing on hydrodynamics of water exchange in the straits. Special attention is given to design of physically relevant time-dependence boundary conditions at the open boundaries. The numerical tool for investigations is a three-dimensional, non-hydrostatic, numerical model of free surface stratified flows (Kanarska Y., Maderich V, 2003). The model is a non-hydrostatic extension of the free-surface primitive equation POM model. A mode splitting technique, decomposition of pressure and velocity fields into hydrostatic and non-hydrostatic components and sequential calculation of these components are the base of numerical algorithm of the model. At first the model is used to investigate different regimes of exchange flows ranging from dispersive gravity waves in the seiche flows to shear instability in the lock-exchange flows including transition regimes where both mechanisms occur. The investigation of the energetics and the resulting diapycnal mixing is carried on the base of the analysis of available potential energy. Then the model is applied for an investigation of the exchange flows in a long and narrow strait with a sill or contraction for the configuration of experiments of Maderich (2000) and to the simulation of the water circulation in the Dadanelles strait. Calculations and analysis based on a three-layer decomposition with an intermediate layer of variable density showed the importance of entrainment and friction in the long straits. As a result the composite Froude number is significantly lower in comparison to predictions of two-layer hydraulic theory. Developed time-dependent boundary conditions at the open boundaries allow simulating the unsteady exchange with barotropic tidal forcing. For the first time the seasonal changes for the water exchange in the Dardanelles were simulated. The obtained results show strong mixing in most narrow zone of the strait. It was found that both baroclinic an barotropic variability are important for flow hydrodynamics.

OS41C-0810 0830h POSTER

The Ocean's Abyssal Mass Flux Sustained Primarily By the Wind: Vector Correlation of Time Series in Upper and Abyssal Layers

Lucy O. Hancock (202-473-7863; lhancock@worldbank.org)

World Bank, MSN H-5-503 1818 H Street, Washington, DC 20433, United States

As Wunsch has recently noted (2002), use of the term "thermohaline circulation" is muddled. The term is used with at least seven inconsistent meanings, among them abyssal circulation, the circulation driven by density and pressure differences in the deep ocean, the global conveyor, and at least four others. The use of a single term for all these concepts can create an impression that an understanding exists whereby in various combinations the seven meanings have been demonstrated to mean the same thing. But that is not the case. A particularly important consequence of the muddle is the way in which abyssal circulation is sometimes taken to be driven mostly or entirely by temperature and density differences, and equivalent to the global conveyor. But in fact the distinction between abyssal and upper-layer circulation has not been measured. To find out whether available data justifies a distinction between the upper-layer and abyssal circulations, this study surveyed velocity time series obtained by deep current meter moorings. Altogether, 114 moorings were identified, drawn from about three dozen experiments worldwide over the period 1973-1996, each of which deployed current meters in both the upper (200<z<1000) and abyssal (z>3750) layers. For each pair of current meters, the Kundu and Crosby measures of vector correlation were estimated, as well as coherences for periods from 10 to 60 days. In the North Atlantic, for example, Kundu vector correlation (50-day window): 0.48 +/- .03
Crosby vector correlation (absolute value, 50 day window): 0.46 +/- .07
Coherence at 60 days: .36 +/- .07
- at 30 days: 0.40 +/- .06
- at 10 days: 0.22 +/- .05
Most figures for the South Atlantic, Pacific and Southern Oceans are similar. Those obtained in the Indian Ocean or near the Equator are somewhat different. The statistics obtained here are consistent with the work of Wunsch (1997), and tend to confirm Wunsch's result that current velocities at depth are linked with those in the upper layers. Energetics of the circulation that do not take this into account are making an unjustifiable approximation of the physics. These results do not tell us whether time averaged flow on longer time scales might permit distinction of upper layer and abyssal flow components. Some intriguing corollaries do follow. First, the abyssal circulation is not identically the same thing as a global conveyor belt driven by temperature and density differences. Rather, as Wunsch noted (2002), the ocean's mass flux is sustained primarily by the wind. We may add that these wind patterns are about as robust as the temperature differences between equator and pole; this major driver of circulation is not a frail phenomenon. Second, the classical notion of a level of no motion that is also a constant-density surface, an LNM, is inconsistent with the results presented here. Such an LNM would wall off the upper layer circulation from the lower, and as

OS