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Coastal French Guiana lies within the Amazon - Guianas mobile mud belt and is characterized by intensely reworked migrating mud waves. Diatoms are the primary source of autochthonous organic matter in these deposits and are rapidly remineralized under suboxic diagenetic conditions. The siliceous diatom frustules are subject to dissolution and recycling, burial, or diagenetic alteration. Pore water profiles demonstrate that mudwave deposits are undersaturated with respect to biogenic silica, reaching values ranging from 200-600 μM at depth. Overall, dissolved Al varies inversely with dissolved Si between sampling sites but inverse relations are not discernable within individual cores. Dissolved K is often depleted with depth. Analyses indicate that frustules may be stored as whole or partially dissolved diatoms, metal-oxide coated frustules, authigenic clay-coated frustules, or completely altered particles. Operational leaches of sediment indicate that the commonly used (1% Na_2CO_3) alkaline procedure underestimates biogenic silica content in these sediments, presumably by failing to react with metal-oxide coated frustules and alteration products. A combined mild acid (0.1 N HCl) / mild alkaline (1% Na_2CO_3) leach procedure, used previously in the Amazon delta, was presumed to more accurately quantify reactive Si. Total reactive Si and K extracted from mudwave sediments lies on the regional trend for the Amazon delta (K/Si = 0.19 mol/mol), implying similar authigenic minerals. SEM observations of experimentally incubated diatoms demonstrated the potential for rapid alteration of diatoms into authigenic clays in the mudwave deposits.

OS31D MCC: 3000 Wednesday 1020h

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

Presiding: **D Yuan,** NASA Goddard Space Flight Center**; P Rhines,** University of Washington

OS31D-01 1020h

MODIS Ocean Primary Productivity and the Thermocline Circulation During the 2002-2003 El Niño

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Global ocean primary production anomalies, estimated using data acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on board of Terra satellite, and results from an ocean general circulation model during the 2002-2003 El Niño are analyzed to study the influence of ocean circulation on the interannual variations of ocean productivity. As the El Niño progresses from 2002 into 2003, the interannual anomalies of the primary production show marked decrease in the eastern equatorial Pacific, whereas the northern off-equatorial Atlantic and the western Indian Ocean reveal a strong increase. The model results show that the thermocline was anomalously depressed in the eastern equatorial Pacific whereas it is significantly lifted in the northern off-equatorial Atlantic and in the western Indian Ocean during the 2002-2003 El Niño. It is, therefore, suggested that the enhanced productivity may be induced significantly by the ocean upwelling anomalies. We also make a preliminary assessment of the possible impact of atmospheric aerosols (retrieved by MODIS) on the ocean primary productivity.

OS31D-02 1035h

Simulated Sea Surface Salinity Variability in the Tropical Pacific

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Sea Surface Salinity (SSS) variability simulated by an oceanic general circulation model forced by daily NCEP-NCAR reanalysis from 1990 to 2001 is analyzed in the research. With daily forcing, the model can reproduce SSS change of the tropical Pacific on different time scales. The model-simulated SSS compares well with the Tropical Atmosphere Ocean (TAO) mooring observation. Correlation coefficients between the model output and observation are around 0.6 and significant at a level of 99% for selected sites that have relatively long observations. The western tropical Pacific is a large variability center on different time scales. On the interannual time scale, the standard deviation of SSS in the region could reach 0.4 practical salinity unit (psu). The 1997-1998 ENSO event is associated with a freshening of the whole equatorial Pacific with an amplitude as large as 0.6 psu. However, the eastern equatorial Pacific shows relatively weak SSS variability (0.1 psu), implying that the western tropical Pacific and the eastern tropical Pacific have quite different mechanisms of SSS changes. On the seasonal time scale, the western tropical Pacific has variability around 0.3 psu. On the intraseasonal time scale (time scale shorter than 50 days), SSS variability in the equatorial Pacific has an amplitude of 0.1 psu. There is pronounced SSS variability associated with the Tropical Instability Waves (TIWs) in the eastern equatorial Pacific on intraseasonal time scale. The activity of TIWs has seasonal and interannual modulation. TIWs tend to be weak during boreal spring and early summer and strong during fall and winter. During the 1997-1998 ENSO event the westward propagating TIWs disappear completely. Relevance to the upcoming *Aquarius* satellite mission to measure SSS from space is discussed.

OS31D-03 1050h

The Influence of Multiplicative Stochastic Forcing on a Coupled Ocean-Atmosphere Model of the El Niño-Southern Oscillation

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The El Niño-Southern Oscillation (ENSO), while exhibiting variability on interannual to decadal timescales, interacts with atmospheric phenomena which have lifetimes of weeks to months. Many observational studies have suggested that the intraseasonal Madden-Julian Oscillation (MJO) may play an important role in regulating the development of El Niño events. It is known that the MJO couples intermittently to the ocean through the deep convection which accompanies it over the western to central Pacific which leads to the possibility that ENSO may be responding to multiplicative stochastic forcing by the MJO. "Multiplicative" means that the stochastic forcing depends on a function of the current state of the model (e.g. Niño 3 index) whereas an "additive" forcing does not and is thereby is uncorrelated with the deterministic part of the model. Diverse model studies already support the idea that the tropical Pacific is an inherently stable system and ENSO variability is maintained by additive stochastic atmospheric forcing. We derive stochastic forcing from observations of surface wind and SST which we apply to an intermediate coupled model of ENSO in both multiplicative and additive scenarios. Our experiments show that the ENSO model's underlying probability distribution function (PDF) changes significantly depending on the nature of forcing in conjunction with the stability of the model. We compare time series of the model Niño 3 index for various forcing experiments to the observed 51-year record of the monthly Niño 3 index and find that it is a strong possibility that multiplicative stochastic forcing, and by extension the MJO, plays an important role in creating the observed ENSO variability.

OS31D-04 1105h

Impact of Atmospheric Intraseasonal Variability in the Equatorial Indian Ocean: Low-Frequency Rectification in Equatorial Surface Currents

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An ocean general circulation model (OGCM) is used to investigate the low-frequency rectification of atmospheric intraseasonal variability (10–90 day periods) in surface currents of the equatorial Indian Ocean. A hierarchy of OGCM solutions are found in an actual tropical Indian Ocean basin for the period of 1988–2001. To isolate the contribution from various nonlinear processes, a $4\frac{1}{2}$-layer intermediate ocean model is also used. Results from the OGCM solutions suggest that the intraseasonal atmospheric forcing causes episodical, swift eastward surface currents during spring and fall. These eastward currents are commonly referred to as the Wyrtki Jets (WJs). Of particular interest is that except for this intraseasonal behavior there are low frequency rectification in zonal surface currents. Amplitudes of the spring and fall WJs and westward surface flow during January–March are weakened by as much as 15-25 cm s^{-1} with intraseasonal forcing. These rectified currents exhibit significant interannual variabilities and they result primarily from intraseasonal wind forcing. Processes that determine the rectification are: asymmetric response of mixed layer depth to easterly and westerly winds, entrainment and advection of subsurface water into the surface mixed layer, and horizontal advection. During an intraseasonal event, westerly wind deepens whereas easterly wind shoals the surface mixed layer. A net, westward current is produced over an event mean because easterly wind acts onto a thinner surface mixed layer whereas westerly wind acts onto a thicker one. This effect is especially strong and dominates other processes during spring and fall, when the seasonal westerly winds are strong, the WJs are intense, and mixed layers are relatively thick. Meanwhile, the strong, episodical westerly winds enhance the entrainment of the slower subsurface water into the surface mixed layer, also tend to weaken the WJs. Zonal and meridional advections contribute somewhat to the WJs weakening near the WJs maxima. In contrast, during January–March when the seasonal winds are equatorial easterlies, surface currents are westward, equatorial undercurrents (EUC) develop, and mixed layers are thin. The rectified surface currents are eastward, which act to reduce the westward surface flow. This eastward rectification results largely from the vertical advection and entrainment of the EUC. During the Indian Ocean Zonal Mode events, surface winds are weak easterlies and EUC reappear during summer and fall. The rectified currents are westward in the OGCM solutions, because effects of the asymmetric response dominate the entrainment and vertical advection of the EUC.

OS31D-05 1120h

Surface Water Processes in the Indonesian Throughflow as Documented by a 115-Year High-Resolution Coral Δ^{14}C Record

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Radiocarbon has been used as a tracer to study global ocean circulation through the distribution of natural and bomb-derived ^{14}C. In order to get a complete picture of the temporal variation of ^{14}C, proxy records, such as those provided by corals are needed. Corals can provide time series of seasonal and interannual ^{14}C variations of the surface ocean over time scales of hundreds of years. Bi-monthly radiocarbon values from a 115-year time series have been recovered from a coral in the Indonesian Seaway in order to better understand seasonal, interannual and decadal variability in the surface water masses that contribute to the Indonesian Throughflow. The radiocarbon time series occasionally displays a small seasonal signal (10-15 per mil) from 1890 to 1954, with the time period 1875-1880 displaying higher radiocarbon possibly due to a strong El Nino. After 1954 the radiocarbon record increases rapidly, a response to the increased atmospheric ^{14}C caused by nuclear weapons testing. From 1954 to 1986 the record displays clear seasonal variability from 15 to 60 (per mil). The quick response to the increased atmospheric ^{14}C and the high post-bomb peak (+160 per mil) indicate a North Pacific source to the waters entering the Indonesian Throughflow. Sensitivity tests were run to investigate the role of surface mixed layer depth and parameterization using an atmosphere/ocean coupled model (GFDL MOM) and compared to the coral radiocarbon time series. The model results exhibit a post-bomb peak that is too high and slightly early but displays the seasonal signal shown by the coral. The model also retains too much radiocarbon after the bomb-peak suggesting the model is exchanging too much CO_2 and not mixing it through the water column rapidly enough.

OS31D-06 1135h

The Effects of the Indonesian Throughflow on the Indian Ocean Meridional Overturning Circulation and Heat Budget

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The sensitivity of the Indian Ocean meridional overturning circulation (MOC) and heat budget to the Indonesian Throughflow (ITF) transport variability is investigated in an ocean general circulation model that is coupled to an atmospheric mixed layer model. Four experiments are performed: (1) ITF blocked, (2) 10Sv ITF, (3) 20Sv ITF and (4) 10Sv ITF but with vertical transport profile more thermocline intensified. The Indian Ocean MOC responses to the net transport input of ITF by introducing net southward transport south of the entrance latitude of ITF to the Indian Ocean (about 10S). The compensating southward transport in the southern Indian Ocean occurs mostly in the upper 1000m within the Agulhas Current with minor proportion within the Leeuwin Current. The deep overturning cell (below 1500m) south of 10S is insensitive to the ITF transport variability. The ITF heat flux into the Indian Ocean associated with its transport is mostly compensated by the ocean meridional heat flux (OMHF) in the southern Indian Ocean, while surface heat fluxes over the Indian basin plays a minor role and insignificantly varies with the ITF transport. The anomalous OMHF, comparing any ITF-open scenario with the ITF-blocked scenario, caused by the velocity anomalies dominates that caused by the temperature anomalies. Between the two components of the OMHF, the meridional overturning component and the horizontal gyre component, the former is more important in delivering the ITF heat flux southward out of the Indian basin than the latter. The magnitudes of both components are positively correlated with the magnitude of ITF heat flux. With more ITF transport in the thermocline rather than in the surface layer and hence less ITF heat flux, the magnitudes of both the OMHF and net surface heat fluxes decline.

OS31D-07 1150h

The Ocean Circulation of the Ross Sea, Antarctica during the 1990s

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During the 1990s several major United States and Italian research programs worked concurrently in the Ross Sea. Here we take advantage of recent hydrographic and current meter data collected over the Ross Sea continental shelf to describe the ocean circulation and its interannual variability during the 1990s. The hydrographic data reveal a well-defined cyclonic gyre in the southwest Ross Sea and in many locations this result is supported by direct current meter observations. The most notable departure from the simple circulation pattern portrayed by the hydrographic data occurred in the Ross Sea Polynya where strong, wind-forced, upper-ocean flow opposed the baroclinic circulation. The atmospheric circulation over the Ross Sea during the 1990s appears to have been strongly modulated on interannual time scales by the El Niño-Southern Oscillation (ENSO) phenomenon. Evidence is presented here suggesting that the upper-ocean currents within the Ross Sea Polynya respond on interannual time scales to changes in the strength of the imposed wind forcing (i.e. years with stronger atmospheric forcing appear to have stronger upper-ocean flow). Sea ice adjacent to the Ross Ice Shelf (RIS) also varied on interannual time scales and achieved its minimum values during 1996 and 1999, the two La Niña years. Ocean currents near the shelf break (mooring B') during those two years showed northward export of a thick layer of shelf water, presumably in response to stronger buoyancy forcing near the RIS. In contrast, large changes in the near-bottom shelf flow north of Ross Island (mooring A'/Adelie) occurred during 1997-1999 roughly in phase with the development and later relaxation of the 1997/1998 El Niño. It is suggested that remote forcing through interactions with the subice cavity are responsible for the observed interannual changes at A'/Adelie.

OS31D-08 1205h

Decadal Variability of Shallow Cells and Equatorial SST in a Numerical Model of the Atlantic

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The relative role of extra-equatorial mechanisms modulating decadal SST anomalies in the equatorial Atlantic is investigated using an ocean general circulation model (OGCM) forced by observed wind stress and/or computed heat flux from the associated advective atmospheric mixed layer model. Longterm variability of the shallow meridional overturning circulation, the Subtropical Cells (STCs), which conduit subducted water to lower latitudes, can lead to potentially relevant SST anomalies in the eastern tropics by either (1) equatorward advection of temperature anomalies formed by the subduction process in the subtropics or (2) by changes in the strength of the STCs themselves, varying the amount of cold water that is transported into the tropics. A suite of sensitivity studies is applied to isolate each of the mechanisms at work and to estimate their particular impact on equatorial SST anomalies in the model.

OS32A MCC: Level 1 Wednesday 1330h

Recent Advances in Understanding Submarine Environments and the Future of Submergence Research and Facilities Posters *(joint with B, T, V)*

Presiding: **P Fryer,** University of Hawaii**; D Fornari,** Woods Hole Oceanographic Institution

OS32A-0224 1330h POSTER

The New Alvin and the Scheduling/Planning Processes for the National Deep Submergence Facility Jon C. Alberts, Barrie B. Walden, Richard F. Pittinger

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The United States Deep Submergence Facility is in the process of obtaining support for construction of a new manned submersible as a replacement for DSV Alvin. A new 6000+ meter manned submersible will provide U.S. scientists with access to an additional 35 per cent of the ocean floor including some currently unreachable portions of the U.S. EEZ. Researchers will have a vehicle designed for the missions currently conducted and those of the foreseeable future having the power and endurance to maximize the usefulness of available research time. They will have a more comfortable vehicle with a larger interior, improved viewport placement, greater battery capacity, and generally better able to handle the burgeoning scientific equipment requirements. Lastly they will have a vehicle that builds on the experience and improvements of 35 years that have made ALVIN the most successful research submersible in the world. The adaptability of the National Deep Submergence Facility (NDSF) to a wide variety of science needs is its strength, but this complexity can also confuse and intimidate new users. The NDSF maintains strong science liaison services and provides potential users with assistance throughout the process of cruise planning, proposal preparation, and execution of field programs. Procedures for gaining access to these vehicles are not difficult and potential users are assisted both directly by the NDSF personnel and also through a user group of scientists dedicated to providing the benefit of their experience. A successful mechanism for obtaining feedback between users and operator has been established through the Deep Submergence Science Committee (a UNOLS oversight committee) and the science community. Programs are selected for funding on a competitive basis through various federal funding agencies by standard agency review processes. DSV ALVIN and its support ship R/V ATLANTIS are owned by the U.S. Navy and operated under charter agreement with the Office of Naval Research. Operation of the NDSF remotely operated vehicle (ROV) assets can be arranged in a fly-away mode on appropriate vessels within the UNOLS fleet or on commercial vessels or foreign research vessels provided they are suitably equipped. Scheduling of the R/V ATLANTIS is arranged through UNOLS, as is the use of the ROVs on UNOLS ships. Coordination between funding agencies and the UNOLS scheduling process strives to provide the users with the optimal scheduling of the assets in a given year. Requests for at-sea use of these assets remain strong for the foreseeable future.

OS32A-0225 1330h POSTER

Navigation Upgrades to the National Deep Submergence Facility Vehicles D.S.V. Alvin, Jason 2, and the DSL-120A

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We report on recently completed enhancements to the navigation systems employed on the 4500m submersible Alvin and the 6500m ROV Jason 2 and DSL-120A sonar system of the UNOLS National Deep Submergence Facility (NDSF) of the Woods Hole Oceanographic Institution (WHOI). Over the last two years we have significantly improved the accuracy and update rate of the six degree-of-freedom vehicle position and velocity navigation data available for these vehicles, thus improving the quantitative accuracy of acoustic surveys, optical surveys, and sampling operations. The navigation upgrades have also enabled improvements in the closed-loop dynamic positioning accuracy of the Jason 2 ROV, thus improving the vehicle tracking precision during survey and sampling operations. We have sought to employ more a uniform suite of navigation instruments, navigation data processing software systems, and data logging format standards for NDSF vehicles to improve the utility and ease-of-use of data by science users. Improved navigation instruments deployed on each of these vehicles in 2001 and 2002 include the following: (a) A 1200 KHz Bottom Lock Doppler Sonar (RDInstruments Inc.) providing three dimensional vehicle velocity information with respect to the ocean floor and the water column at an update rate of up to 10 Hz, providing a single-ping beam-velocity error standard deviation of 0.3% for a nominal advance velocity of 1 meter/sec. (b) A north-seeking fiber-optic gyroscope (IXSEA Inc.) providing true-north heading, pitch, and roll with a rated accuracy of 0.1 degree. Improved navigation data processing software systems deployed on these vehicles in 2001 and 2002 includes Dvlnav, an interactive navigation program developed at JHU for precision navigation of underwater vehicles and submersibles. DVLNAV employs a variety of sensors including bottom lock Doppler sonar, long baseline (LBL) acoustic navigation, gyro compasses, magnetic compasses, depth sensors, altimeters, and (when available) GPS. All navigation data are logged in ASCII data files time-stamped to 0.001 second, and also logged in simple spreadsheet files with headers containing navigation data at one second intervals, enabling simplified transfer to popular data processing programs. Operational results (e.g. Rzhanov et. al. poster in OS-10 session) indicate the utility of this navigation system. Elements of this navigation system have been adopted for use by the University of Southampton's (UK) new ISIS ROV. We anticipate that future improvements to this navigation system will include improved LBL navigation hardware, an improved LBL navigation processing software application, inertial navigation sensors, and improved post-processing software tools. http://www.whoi.edu/marops/vehicles http://robotics.me.jhu.edu/dscl/dvlnav