OS32A-02 1045h

Can Luzon Strait Transport play a role in conveying the impact of ENSO into the South China Sea?

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Water exchange between the SCS and the Pacific through the Luzon Strait is examined using results from a high-resolution ocean general circulation model. Its transport (called the Luzon Strait Transport or LST below) from the model has a mean value of 2.4 Sv, and reaches its seasonal maximum (6.1 Sv, westward) in winter and minimum (0.9 Sv, eastward) in summer. Both the annual mean value and seasonal variation are in good agreement with observations. On interannual time scale, LST tends to be higher during El Nino years and lower during La Nina years, with its maximum (minimum) leading the mature phase of El Nino (La Nina) by about 1 month. Since water leaving the SCS in the south is of higher temperature than that with LST, horizontal advection is equivalent to a surface heat flux of -19 W m-2 in the mean. Most of this cooling advection is balanced by atmospheric heating (17 W m-2). From late spring to early fall, surface heat flux is the primary heating process; only a small part of the heat content change can be explained by heat advection. But, in winter, heat advection is the only important process responsible for the cooling in the upper-layer of the SCS. The upper-layer heat content of the SCS has a strong signature of ENSO, and LST seems to be a key process conveying the impact of ENSO into the SCS.

OS32A-03 1100h

Assessing the Impact of Stochastic Forcing on ENSO Events

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Previous work suggests that ENSO is influenced by a highly chaotic, essentially stochastic, component of atmospheric variability. To assess the impact of this "noise" on ENSO evolution and forecasts, we perform a suite of ENSO hindcasts spanning the past two decades. The hindcast model consists of an ocean general circulation model (GFDL MOM4), coupled to a statistical atmosphere derived by regressing historical air-sea fluxes onto historical sea surface temperature anomalies (SSTAs). The residual fluxes not captured by the statistical atmosphere are linearly independent of large-scale SSTAs, providing a rough estimate of the historical stochastic forcing. An ocean data assimilation provides initial conditions for a suite of year-long stochastic ensemble hindcasts. In a given hindcast, ensemble members begin from identical initial states but are forced by residual fluxes taken from different years. One particular member, a "cheatcast," is forced by the actual residual observed during that year, and an additional "noise-free" hindcast is performed with the residual fluxes turned off. The results show that both the initial conditions and the noise forcing affect the subsequent evolution of ENSO. The initial state preconditions the tropical Pacific toward the development of ensemble-mean SSTAs, while the noise forcing induces a rapid dispersion of the hindcasts about their ensemble mean. The noise-free hindcast in all cases closely tracks the stochastic ensemble mean, suggesting that the system is reasonably linear. To some extent, the residual fluxes induce similar effects regardless of the ocean preconditioning; in particular, the ensemble member forced by the 1997 residual is always among the warmest hindcasts, while that forced by the 1988 residual is always among the coldest. However, initializing from different years does alter the dispersion of the ensemble, indicating that some weak nonlinearity is present. The season of initialization also affects the ensemble dispersion. Implications of the results and limitations of the method are discussed.

URL: http://www.gfdl.noaa.gov/~atw/research/conf/agu_spring_2004

OS32A-04 1115h

Modulation of Interannual SST by the Seasonal Cycle in the Tropical Indian Ocean: A Study of Physical Processes

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Modulation of sea surface temperature (SST) patterns by interactions between seasonal and interannual variabilities in the Indian Ocean (IO) region are studied via a hierarchy of experiments utilizing both a 4-1/2 layer ocean model in a realistic tropical Indian Ocean basin, and a version of this same ocean model coupled to a model of the atmospheric mixed layer (AML). Results demonstrate that seasonal atmospheric forcing enhances positive (negative) SSTa in the western (eastern) IO basin associated with both the 1994 and 1997 Indian Ocean Zonal Mode (IOZM) events, $\sim 1^{\circ}C$ respective to a control run. Additionally, when seasonal forcing is removed from the system, the 1994 cool event in the eastern basin is prolonged by about 2 months. This indicates the seasonal cycle of atmospheric forcing is at least partly responsible for the timely termination of IOZM events at the end of an event year. To determine the specific physical processes leading to interannual IO SSTa modulation by seasonal variability, the coupled ocean-AML model is used to examine the effects on SSTa of each of the following in isolation: (1) thermocline variability and horizontal advection forced by seasonal wind stress variability; (2) vertical mixing due to seasonal wind speed; (3) changes in surface heat flux due to seasonal wind speed; and (4) variation in radiative forcing via seasonal cloud variability. Of these processes, those driven by seasonal wind stress variability prove most significant to IOZM amplification by the seasonal cycle, and to the timing of event termination. An analysis of the thermodynamics associated with seasonal wind stress forcing is presented, in which the relative contributions of each process represented in the model mixed layer temperature equation are compared, for both a control run and a run in which seasonal variability is removed from the wind stress forcing.

OS32A-05 1130h

Contradictions to Darwin's Evolution of Reef Types in Barrier Reef Relationships

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The Darwinian progressive subsidence model for the evolution of fringing reefs, barrier reefs and atolls has been generally accepted following the indisputable proof of subsidence provided by drilling results in the Pacific. Nonetheless, there are data that do not fit the expectations of the model, such as the similar lagoon depths of barrier reefs and atolls as opposed to the subsidence theory's implicit prediction that atolls should have significantly greater depths. In contrast, much evidence supports the influence of meteoric-water solution on barrier reef morphology. For example, the maximum lagoon depth of the 56 modern barrier reefs is statistically correlated with the lagoon catchment area for modern annual rainfall. These modern rainfall patterns are a reasonable proxy for relative geographic differences in glacial lowstand rainfall, even though the absolute amounts of such rainfall are unknown. The correlation therefore stongly suggests the importance of Pleistocene subaerial solution in contributing to barrier reef morphology. Further support for antecedent influence occurs in the form of barrier reef passes in which the depth of the reef pass is correlated with onshore drainage volumes. On a larger scale, the Cook Island of Mangaia provides evidence that solution can produce barrier reef morphology independent of reef development. In contrast, there are no examples of the Darwinian subsidence-predicted lagoon transition of fringing reefs to barrier reefs to atolls. Moreover, the common occurrence of fringing reefs within barrier reefs negates subsidence as a causal factor in their presumed progressive evolutionary development. Consequently, the evidence points to a solution morphology template which has been accentuated by reef construction to produce the diagnostic barrier reef morphology we see today. Rapid subsidence of seamounts by flexural loading during their early history, combined with Pleistocene sealevel fluctuations results in permanent drowning of older barrier reef. The importance of slower, thermal subsidence is in accounting for the overall thickness of the resulting carbonate caps.

OS32A-06 1145h

Dynamics of Chlorophyll Concentration over the Oceans using MODIS Data

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Chlorophyll concentration data derived from satellite borne ocean color sensors provide information of the distribution of phytoplankton and help us to understand their spatial and temporal dynamics. The changes in the patterns of distribution and abundance of the plankton have significant impact on the entire ecosystem and play a key role in the global carbon cycle. In this paper, we have analyzed annual and seasonal chlorophyll concentrations retrieved from MODIS data for the periods March 2000- October 2003, which reveal the spatial and seasonal distribution of chlorophyll concentrations across the global oceans. Chlorophyll concentration anomalies indicate that chlorophyll concentrations in almost all the ocean regions examined have responded similarly, maybe with different magnitudes to non-seasonal factors.

OS33A CC: 220 C-E Wednesday 1330h

Coastal Region Dynamics IV Posters

Presiding: **W Alex,** Naval Research Laboratory, Stennis Space Center**; K Lamb,** University of Waterloo

OS33A-01 1330h POSTER

Numerical Modeling of Thermal-Mechanical Niche Formation and Block Failure on Herschel Island, Yukon Territory, Canada.

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Wave action is the critical variable influencing coastal erosion rates in Arctic environments. Melting of interstitial ice and/or massive ice results in the addition of fine-grained sediment to the swash zone. This sediment is then held in suspension and transported along the coast by longshore currents. Removal of the insulating layer of unfrozen material exposes frozen cliff sediments directly to wave action, increasing the rate of thaw. Development of a thermoerosional niche proceeds until either (a) the storm abates and direct heat conduction to the coastal sediment stops, or (b) the overburden pressure exceeds the shear stress of the material, in which case a cohesive block of frozen sediment will fall directly onto the beach. In the case of (b), mechanical erosion of the cliff sediments will cease until the block material has been fully eroded and transported away, allowing the waves to again interact directly with the cliff sediments. A numerical model originally proposed by Kobayashi et al. (1999) was further developed to simulate the horizontal retreat associated with thermoerosional niche formation and block failure on Herschel Island during the annual 3-4 month ice-free period extending from mid-June to late September. The model was parameterized using data obtained from oblique aerial photographs, video footage and existing geomorphological data. Herschel Island was classified into three distinct categories based on cliff height, cliff angle, and ice content. Low frequency, high-magnitude storm events generate several metres of coastal backwasting in a very short time. Values for storm frequency and storm surge were modified from the existing model to reflect the 30-year mean. Results were compared with measured rates of coastal retreat in each distinct category for the previous 30 years. A high level of correlation is demonstrated between model results and existing data. A climate change factor was then introduced, predicting an increase in storm frequency and storm surge height.

URL: http://www.geog.mcgill.ca/grad/turner

OS

OS33A-02 1330h POSTER

Improved technique for the measurement of ammonium species to marine and fresh waters and its application to coastal and saltmarsh environments

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Since elevated nitrogen deposition has been identified as a critical environmental problem of global concerns, sensitive determination methods for ammonia are needed to improve our temporal and spatial resolution of coastal ecosystems. Because of the high variability of physical and chemical proprieties of coastal waters and problems linked to the conservation of samples, the accurate determination of ammonia in estuaries and brackish waters remains an acute analytical problem not entirely solved. We present here an automated application of the fluorometric technique recently published by Holmes et al., (1999) using a transportable microplate fluorescence reader. The proposed technique is simple, rapid, free from amine interferences and salt effects, and can be used in the nanomolar to micromolar range on almost all types of water matrices. Compared to the manual Holmes's method, our protocol offers a simplified sampling procedure with an accurate calibration curve for each sample analysis, and allows an adequate analytical blank determination for each series of measurement. To illustrate the precision and the efficiency of this technique, water samples were collected at many stations on the St. Lawrence Estuary and analysed on board the Coriolis II oceanographic ship. Measurements were also conducted in salt marshes along the south shore of the Estuary. Preliminary results show ammonia concentrations ranging between <0.01 and 4.24 $\pm$ 0.01 μM in the estuarine waters following a distinct concentration pattern related with both indigenous and exogenous sources. Moreover, measurements obtained on reddish turbid waters sampled in salt marshes near Rimouski show an important release of ammonium during tidal flushing. Observed ammonium concentrations varies between 0.74 $\pm$ 0.01 μM at low tide and 10.61 $\pm$ 0.08 μM at high tide. The analytical error remained lower than 1% in spite of strong salinity gradients and high load of particulate matter. Knowing physicochemical proprieties of sampled waters, the improved ammonia technique is used within the framework of a broad study concerning the characterisation of the nitrogen cycle in high latitude coastal waters and the influence of anthropogenic inputs...

OS33A-03 1330h POSTER

Generation and Propagation of Internal Bores and Solitons in the South China Sea.

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The generation of internal bores and solitons by the interaction of the barotropic tide with sills in the Luzon Strait was studied with numerical models, along with their westward propagation across the South China Sea. The model domain extends from 116E-123E and 18N-23N, and includes the sills, gaps and islands of the Luzon Strait between Taiwan and the Philippines. Two classes of initial conditions were considered: (1) horizontally homogeneous density profiles representing an average over the domain, obtained from CTD's and/or climatology; (2) geostrophically balanced 3-D fields obtained from model solutions. Resolutions were typically 100m in the horizontal and 10-20 m in the vertical. The primary generation region was found to be the sill just south of Taiwan, and the sills between islands of the Batan Group in the Strait. The simulation results were compared with current meter records and CTD observations taken during the 2000-2001 ASIAEX experiments; these observations included both shallow and deep water locations.

OS33A-04 1330h POSTER

Seasonal Evolution of the Circulation, Heat and Salt Budgets in the North Water Polynya, Baffin Bay

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From 1997 to 1999 an international field program was conducted in the North Water (NOW) polynya, in Northern Baffin Bay, Canada. For three consecutive years, this polynya was sampled by a large community of scientists concerned about impacts of global changes on this fragile ecosystem. The objective of this work is to obtain a better understanding of the seasonal circulation, heat and freshwater transports in the NOW polynya. To attain this objective, we developed heat and freshwater budgets using a box model. The region was divided in 3 layers (12 boxes) between which exchanges were allowed. The box configuration was chosen to reproduce and distinguish the two main currents: the Baffin current flowing South from Nares Strait and the northward flowing, warmer West Greenland current flowing along the West Greenland coast. Current speeds were estimated from mass distribution and current meter data, using the geostrophic method and a variant of Wunsch (1977)'s inverse method. The freshwater content includes the melting ice cover given by satellite observations data. The heat budget include the surface exchanges (short and long waves and turbulent fluxes) obtain from the GEM (Global Environmental Multiscale) model. We present preliminary results based on a set of freshwater discharge scenarios.

OS33A-05 1330h POSTER

SUNTANS on Monterey Bay

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An elevated level of tidal energy dissipation in coastal regions has been observed, yet it is largely unexplained. One such location is Monterey Bay, CA, where the bathymetry consists of rough and complex terrain that is critical in some areas of the canyon, ridge, and slope regions. It is also an area that experiences strong oceanic internal tides. It has been postulated that the interaction of internal tides and non-tidal internal waves (collectively known as internal waves) with the bathymetry may be responsible for the heightened dissipation within Monterey Bay. Previous numerical internal tide simulations of this area using the Princeton Ocean Model (POM) have not been able to fully confirm or deny this hypothesis. To better simulate the life cycle of the internal wave field we have used the Stanford Unstructured Nonhydrostatic Terrain-following Adaptive Navier-Stokes Simulator (SUNTANS). SUNTANS is applied to Monterey Bay and the surrounding area to produce results of the internal wave velocity field in three dimensions. SUNTANS uses an unstructured grid in the horizontal plane (structured in the vertical). With unstructured grids it is relatively easy to efficiently include strong variations in grid density so that coarse grids can be used away from highly refined grids in the critical areas needed to capture internal wave formation, propagation and breaking. By defining the offshore and lateral boundaries far from the Bay, sensitivities of these boundary conditions are minimized. The resulting large domain allows for the identification of possible offshore generation sites. Locally-generated internal waves may then interact with bathymetry, which scatter further internal waves. SUNTANS is nonhydrostatic, which allows the high frequency internal wave field to be more accurately represented and makes breaking processes a numerical reality. It is hoped these improvements will provide a much improved picture of the evolution of internal tides in the vicinity of complex bathymetry. Preliminary results are encouraging; they show internal waves locally generated within the Monterey submarine canyon.

URL: http://suntans.stanford.edu/

OS33B CC: 220 C-E Wednesday 1330h

Extreme Waves and Dynamics of Ocean Circulation Posters

Presiding: **E A OKAL,** Northwestern University**; D Straub,** McGill University

OS33B-01 1330h POSTER

Three-dimensional Energy Transfers in Quasi-horizontal Flow

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The transfer of energy between balanced and unbalanced modes has important implications for large-scale ocean dynamics. It is known that the inertial runaway of QG models arises from an insufficient transfer of balanced energy towards dissipative, small-scale modes. Yet uncertainty remains as to the magnitude of these transfers and their importance compared to processes such as bottom friction. In this talk we examine a mechanism – the so-called hyperbolic instability – whereby unbalanced or 3-D motion can be generated from random straining by balanced or 2-D flow. Using numerical simulations of freely-decaying 2-D turbulence, it is shown that the growth can be described with a pressureless analysis wherein the horizontal pressure gradient is neglected: the perturbation grows where the pressureless approximation holds, and the growth rate of the perturbation can be estimated from the strain and vorticity of the base flow (i.e., variants of the well-known Weiss criterion). From the numerically-determined spectral eddy viscosity, it is also shown that the perturbation exerts an appreciable influence on the base flow, even for small aspect ratios. Applications to ocean modelling are discussed.

OS33B-02 1330h POSTER

Mesoscale Variability in the Black Sea: Satellite Observations

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The circulation in the Black Sea is characterized by a strong basin-wide cyclonic current along the shore known as the Rim Current, which exhibits important mesoscale transient features such as meanders, intense jets, eddies and filaments triggered by baroclinic instabilities. A new method is developed to infer the velocity field and its variability by analyzing series of subsequent satellite observations of the sea surface temperature made by NOAA AVHRR during 2000-2002 years. The analysis is based on the Maximum Cross Correlation (MCC) and Particle Image Velocimetry (PIV) methods. The application of these two techniques to the Black Sea reveals the large scale dynamic features of the circulation, as well as many details of mesoscale vortical activity. Analysis of the instantaneous velocity and vorticity fields further reveals a distinct seasonal variability of the circulation and provides the means to estimate important characteristics of the variability of the Black Sea such as basin-integrated kinetic energy, number of eddies, and fluctuation of the Rim Current width.

OS33B-03 1330h POSTER

Energy Transfer in Internal Waves Generated by Tidal Flow over Topography

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