Such intensity is sufficient to drive not only local Ekman currents at the surface but also geostrophic currents in response to Ekman pumping. Using a simple Sverdrup balance, we show that in the case of Hawaii, 2 counter-rotating gyres are spun up west of each major island, extending to the western boundary of the Pacific, with an eastward zonal transport centered at the latitude of each island. The stronger one is the one associated with the Big Island, the surface expression of which coincides with the Hawaiian Lee Counter Current. Similar gyres are anticipated to form in the Atlantic Ocean, but remain to be observed experimentally.

This suggests that strong mesoscale patterns in the wind field of such islands can have a profound impact on the ocean circulation, and must therefore be resolved to force island ocean circulation models.

OS42T-02 1345h

The Development of a Slippery-Sack Ocean Model

Patrick T Haertel (970-491-5237; haertel@atmos.colostate.edu)

Dept. of Atmospheric Science, Colorado State University, Ft. Collins, CO 80523-1371, United States

Three phases in the development of a Lagrangian ocean model are described. The model represents water as a collection of slippery sacks that slide over one another.

In Phase I equations that govern sack motions are derived. The equations are based on the following assumptions: (1) the horizontal mass distribution of a sack is independent of time within the sack's frame of reference; (2) when sacks slide over one another they conform so that there are no vertical gaps; (3) pressure is hydrostatic within the pile of sacks; (4) density is a non-decreasing function of height within the pile; and (5) a sack is accelerated in the horizontal by the integrated force of pressure acting on the surface of the sack. The equations conserves mass, energy, and momentum.

In Phase II a discretization of the equations of motion is developed. It conserves mass exactly, and it conserves energy in the limit as the time step approach zero. The number of operations required to solve the discrete equations is proportional to the number of sacks. The discrete system is solved in order to simulate inviscid circulations in one- and two-layer systems including a non-linear deformation, internal and external gravity waves, and Rossby waves. The simulations are compared to analytic and finite-difference solutions, and the former converge to the latter as the sizes of the sacks are decreased.

In Phase III the sacks are made to be slightly sticky; they are allowed to exchange momentum through a parameterization of the vertical eddy flux of horizontal momentum. The parameterization is tested within a simulation of wind-induced upwelling in a large lake. The simulated circulations and density profiles are similar to those within comparable simulations carried out using the Princeton Ocean Model and the Dietrich/Center for Air Sea Technology model.

The slippery-sack method appears to be well suited to ocean modeling for the following reasons: (1) it perfectly conserves a fluid's distributions of density and tracers, (2) in contrast to existing isopycnic models the slippery-sack method is capable of representing a continuum of fluid densities and resolving neutral regions; (3) the inclusion of bottom topography adds no numerical complexity to the method; and (4) the slippery-sack method is computationally efficient.

OS42T-03 1400h

Nonhydrostatic Simulations of Entrainment in Rotating and Nonrotating Overflows.

Alistair J Adcroft[1] (617 253 5938; adcroft@mit.edu)

Sonya A Legg[2] (508 289 2801; slegg@whoi.edu)

[1]Earth Atmospheric and Planetary Sciences, MIT, 77 Massachusetts Ave, Cambridge, MA 02139, United States

[2]Woods Hole Oceanographic Institute, Mail stop 21, Woods Hole, MA 02543, United States

The entrainment of ambient water into a dense overflow plume significantly modifies its tracer properties, and ultimately determines the properties of the ocean's densest water masses. Despite its importance, entrainment in dense overflows is represented only crudely in large scale numerical models. Even the most sophisticated parameterizations adopt a representation of entrainment derived from nonrotating laboratory experiments, yet oceanic overflows are often strongly controlled by rotation.

Here we assess the influence of rotation on entrainment in overflows by carrying out very high resolution calculations of idealized overflow scenarios. We use the non-hydrostatic MIT ocean model, in which the physics responsible for entrainment and mixing is explicitly represented. Without rotation a gravity plume descends the slope with entrainment of ambient fluid triggered by shear instability. Strong rotation inhibits the initial descent of dense fluid, and instead baroclinic instability of the shelf break front carries fluid down the slope. The resultant flow on the slope is largely barotropic, without the shear necessary to induce mixing by Kelvin-Helmholtz billows. However, entrainment can still continue in the lateral plane, as the vortices associated with the dense fluid wrap filaments of ambient fluid into their cores.

OS42T-04 1415h

The Thermohaline Circulation in an Isopycnal Ocean Model With Bulk Surface Forcing

Balasubramanya T. Nadiga (505-667-9466; balu@lanl.gov)

Los Alamos National Lab. , MS-B296, Los Alamos, NM 87545, United States

We consider the long term behavior of the modelled thermohaline circulation (THC) when an isopycnal coordinate ocean model (MICOM) is coupled to a specified climatological atmosphere and a simple thermodynamic ice model. Rather than restore the tracer values at the ocean surface to observed climatology or use fixed fluxes of tracers, we use more realistic bulk forcing wherein fluxes of tracers are based on the evolving sea surface temperature. Preliminary results show that the modelled THC drifts significantly from the present climactic state. We will focus on a diagnosis of the processes responsible for the drift and discuss our efforts to fix them.

OS42T-05 1430h

Improvement of Ocean Mixed Layer Models Embedded in OGCM

Takahiro Toyoda[1] (+81-75-753-3924; ttoyoda@kugi.kyoto-u.ac.jp)

Yoichi Ishikawa[1]

Toshiyuki Awaji[1]

Yian Noh[2]

[1]Department of Geophysics, Kyoto University, Kyoto 606-8502, Japan

[2]Department of Atmospheric Science, Yonsei University, Seoul, Korea, Republic of

A new diagnostic method for estimating a seasonally-varying mixed layer depth is developed using the '98 World Atlas monthly data (Boyer et al., 1998) and a recent turbulent closure mixed layer model (Noh and Kim, 1999). Our method provides a good statistical criterion for identifying density change values which separete the mixed layer from below with sea surface temperatures. This enables us to better reproduce spatio-temporal variabilities of mixed layer depth in a global ocean for all seasons than in previous studies. Then we examined the impact of improved mixed layer model on large-scale circulation using an OGCM, with a focus on subduction processes. In the North Pacific, our results show that the annual march of the averaged mixed layer depth is in a quantitatively good agreement with the observational findings so far, with a maximum of approximately 100 m in February and a minimum of 40 m in July. Associated with this improvement, the estimated volumes of North Pacific Subtropical, Central and Eastern Subtropical Mode Waters, which provide good indications of a shallow overturning in the North Pacific, are 3.3, 11.2, 2.6 $\times 10^{14}$ m^3, respectively. These values are basically similar to the recent estimates obtained using the HydroBase (Macdonald et al., 2001). In addtion, close similarities between formation areas and watermass properties of the modeled and observed mode waters were found. Further, the mesothermal and the dichothermal waters characterizing the subsurface structure of the North Pacific subarctic region (Ueno and Yasuda, 2000) are well reproduced. These results suggest that a combination of our mixed layer model and an OGCM is a very powerful tool for understanding water mass formation and transformation.

OS42T-06 1445h

Transit-Time and Tracer-age Distributions in an Ocean General Circulation Model

Francois W Primeau (949-824-9435; fprimeau@uci.edu)

Dept. of Earth System Science, UCI, Room 227 Rowland Hall University of California, Irvine, Irvine, CA 92697-3100, United States

The pathways and time-scales for fluid elements to be transported from the ocean surface to the interior and from the interior back to the surface are explored using a global ocean general circulation model. The diagnostic tool used to summarize the transport properties of the modeled ocean circulation is the probability density function (pdf) of transit time computed as a function of position in the ocean interior. Through the combined use of a forward and adjoint global tracer transport model, the location and time at which water masses formed in the surface mixed layer can be efficiently mapped out. The combined use of the forward and adjoint tracer transport model also permits one to efficiently map out where and when fluid parcels in the deep ocean will make next contact with the surface mixed layer. Such information might be important in identifying potential sites for carbon sequestration.

OS42T-07 1520h

The Sensitivity of Thermally Driven Circulation on Horizontal Resolution in a Depth Level Ocean Circulation Model

Young-Gyu Park (+82-31-400-6123; ypark@kordi.re.kr)

Korea Ocean Research and Development Institute, Ansan P.O.Box 29, Seoul 425-600, Korea, Republic of

The sensitivity of thermally driven circulations from a depth level coordinate (GFDL/MOM) on horizontal resolution is investigated in an ideal spherical sector (0-60$^\circ E$, 0-60$^\circ N$) of 4km deep. The horizontal resolution was varied from 2° to 0.25°, and the model is forced by Newtonian damping condition for temperature in the absence of surface wind stress. When the resolution is low, as in earlier studies watermass formation occurs near the northeastern corner of the basin. Therefore, the stratification of subsurface water is zero along the northern half of the eastern boundary. In the interior, there is a eastward surface zonal flow that is due to the meridional temperature gradient at the surface. When the zonal flow encounters the eastern boundary of zero stratification, the most of the flow from the western boundary sinks to subsurface, and the remaining part forms a weak eastern boundary current that flows to the north. As the horizontal resolution becomes higher, the stratification along the eastern boundary and the eastern boundary current becomes stronger. This eastern boundary current, which continues cyclonically along the perimeter of the basin, supplies warm water to the northeastern coner of the basin and enhances the vertical stratification along its path. The flow pushes the convection site to the west along the northern boundary so that the watermass formation region occurs near the northwestern corner when the horizontal resolution is 0.25°.

OS42T-08 1535h

Global Characterization of Rossby Waves at Several Spectral Bands

Paulo S. Polito[1] (55-12-3945-6484; polito@ltid.inpe.br)

W.Timothy Liu[2] (818-354-2394; liu@pacific.inpe.br)

[1]Instituto Nacional de Pesquisas Espaciais (INPE), Divisao de Sensoriamento Remoto Av. dos Astronautas, 1758, Jd. da Granja, Sao Jose dos Campos, SP 12227-010, Brazil

[2]Jet Propulsion Laboratory/California Institute of Technology , 4800 Oak Grove Dr., MS 300-323, Pasadena, CA 91109, United States

Global sea surface height anomaly signals from the TOPEX/Poseidon satellite altimeter from 1992 to 2000 are filtered into several spectral bands. These bands include propagating (Rossby, Kelvin, and tropical instability waves) and non–propagating (annual and interannual basin–scale variability, and eddies) signals. These signals are decomposed through a series of finite impulse response band pass filters. Phase speed, period, wavelength, and amplitude are estimated. Signal to noise ratio, methodological errors, and natural variability are also estimated. Results are shown for the Pacific, Atlantic and Indian basins for four Rossby wave components with periods between 3 and 24 months. Equatorial Kelvin waves and tropical instability waves are shown as peripheral results. The clearest and most energetic wave signals are generally observed for annual Rossby waves. Semiannual Rossby waves often have the largest amplitudes near the tropics. The Rossby wave phase speeds are in agreement with the linear theory, except for a $\sim$ 25% bias toward high speeds found in mid to high latitudes. This revitalizes the idea that in average the Rossby wave signal in the ocean is in the form of free waves.

OS42T-09 1550h

Global patterns of heat storage from TOPEX/POSEIDON

Olga T. Sato[1] (55-12-3945-6484; olga@ltid.inpe.br)

Paulo S. Polito[1] (55-12-3945-6484; polito@ltid.inpe.br)

[1]Instituto Nacional de Pesquisas Espaciais (INPE), Divisao de Sensoriamento Remoto Av. dos Astronautas, 1758, Jd. da Granja, Sao Jose dos Campos, SP 12227-010, Brazil

Global patterns of oceanic heat storage derived from sea surface height anomaly signals from the TOPEX/Poseidon altimeter data are investigated. The height anomaly data spanning the period from 1992 to 2000 are decomposed through 2D finite impulse response filtering. The filtered components are the basin-scale (seasonal,ENSO), westward propagating (Rossby waves), eastward propagating (Kelvin waves), meso–scale eddies, and a small-scale residual. This decomposition results in a set of 316 global maps per component.

To analyze the spatial patterns of each spectral band the correlation between each map and a reference map was calculated. This reference map corresponds to a non-El Nino and a non-La Nina state. That choice avoids most of the predictable biases. Maps that result in a positive correlation are added and maps with a negative correlation are subtracted from the reference map. As a result we obtained a mean pattern for each component. The amplitude and the spatial regularity of these patterns are commensurate with the persistence of the filtered signals. That allows for the detection of areas where the waves are more likely to occur. The tropical instability waves are very intense in eastern tropical Pacific as meridionally coherent signals. Rossby waves patterns are relatively weak in the Atlantic. In all basins they form regular patterns indicating the meridional dependence of their phase speed. The basin-scale signal is dominated by seasonality and clearly shows the presence of the ITCZs.

OS42T-10 1605h

Deviation of Long Period Tides from Equilibrium: Kinematics and Geostrophy

Gary Egbert[1] (541-737-2947; egbert@coas.oregonstate.edu)

Richard D. Ray[2] (301-614-6102; richard.ray@gsfc.nasa.gov)

[1]COAS, OSU, 104 Ocean Admin Bldg, Corvallis, OR 97331-8563, United States

[2]Space Geodesy Branch, Code 926, NASA GSFC, Greenbelt, MD 20771, United States

New empirical estimates of the long period fortnightly (Mf) tide obtained from TOPEX/Poseidon (T/P) altimeter data confirm significant basin-scale deviations from equilibrium. Elevations in the low-latitude Pacific have reduced amplitude and lag those in the Atlantic by 30 degrees or more. These inter-basin amplitude and phase variations are robust features, which are reproduced by numerical solutions of the shallow water equations, even for a constant-depth ocean with schematic interconnected rectangular basins. A simplified analytical model for co-oscillating connected basins also reproduces the principal features observed in the empirical solutions. This simple model is largely kinematic. Owing to blocking of zonal flow by continents, elevations within a closed basin would be nearly in equilibrium with the gravitational potential, except for a constant offset required to conserve mass. With connected basins these offsets are mostly eliminated by inter-basin mass flux. Because of rotation this flux occurs mostly in a narrow boundary layer across the mouth and at the western edge of each basin, and geostrophic balance in this zone supports small residual offsets (and phase shifts) between basins.The simple model predicts that this effect should decrease roughly linearly with frequency, a result that is confirmed by numerical modeling and empirical T/P estimates of the monthly (Mm) tidal constituent. This model also explains some aspects of the anomalous non-isostatic response of the ocean to atmospheric pressure forcing at periods of around 5 days.

OS42T-11 1620h

Constant potential vorticity hydraulically controlled flow-complexities from passage shape

John A. Whitehead ((508) 289-2793; jwhitehead@whoi.edu)

Department of Physical Oceanography, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, United States

Velocity, surface height profiles, and volume flux are calculated for critically controlled channel flow of a layer of rotating fluid. A variety of channel cross-stream bottom profiles are considered. The upstream fluid possesses constant potential vorticity. Velocity and surface height distributions, and control criteria are presented for three features that seem to be unique to rotating fluid. These are: sizeable gyres that appear upstream of controlled passages; the existence of more than one critical flow configuration for a single passage (with bottoms of certain special shapes); and strict limits to the value of volume flux for a passage with small bottom slope at right angles to flow direction. In addition, examples are shown of cases in which multiple exits allow flux to exceed a rigorous bound that has been derived for flux out of a passage

OS42T-12 1635h

Mechanisms and Predictability of Midlatitude SST Anomalies.

Robert B Scott[1,2] (1 609 452 6519; rscott@princeton.edu)

Geoffrey K Vallis[1,2] (1 609 452 6528; gkv@princeton.edu)

[1]Princeton University, AOS Program, P.O. Box CN710, Sayre Hall, Princeton, NJ 08544, United States

[2]GFDL, Princeton Forrestal Campus, Route 1, P.O. Box 308, Princeton, NJ 08542, United States

The predictability of sea surface temperature (SST) on seasonal to longer timescales is investigated using an idealized, stochastic, climate model and analysis of observational data. It is argued that the crucial factor determining the SST anomaly predictability is the fraction of SST anomaly variance that can be attributed to deterministic forcing. A simple relation is derived to give the predictability in terms of the variance of the stochastic and deterministic portions of the SST anomaly time series. Analysis of observational data of terms in the upper ocean temperature tendency equation, obtained from Bo Qiu of SOEST, was based on a variety of data sources: surface geostrophic currents from the TOPEX/Poseidon altimetry, subsurface data from the Joint Environmental Data Analysis Center, and other surface marine data from the NCEP/NCAR reanalysis project. It was revealed that for the Kuroshio Extension Region, the advection of the time mean temperature gradient by anomalous geostrophic currents is the dominant source of variability. This suggests that the predictability of the anomalous geostrophic currents in the Kuroshio Extension may be the limiting factor determining the SST predictability of that region. This analysis was extended to other regions and different length scales and timescales.

URL: http://www.gfdl.noaa.gov/∼rbs

OS42U HC: 323 B Thursday 1330h

Suspended Material

OS42U-01 1330h

Error model for PUV wave direction and spreading measurements

Lee Gordon (858-586-0900; lgordon@nortekusa.com)

NortekUSA, 9948 Hibert St. Suite 102 www.nortekusa.com, San Diego, CA 92131, United States

We present a Montecarlo error simulation for PUV wave direction and directional spreading measurements, and we evaluate the model by comparing wave measurements using an Aquadopp Current Profiler and a Vector Velocimeter. The uncertainties of both direction and spreading depend on the actual wave spreading, plus the signal/noise ratio and the amount of averaging. Three separate wave generation events are apparent in the data. The error model predicts an uncertainty of 0.5° for the computed mean wave direction for each of these events, and the data are consistent with this result.

URL: http://nortekusa.com/prin-waves.html

OS42U-02 1345h

Empirical Light Scattering by Natural, Randomly Shaped Particles from 0.1 to 20 Degrees - Counterpart to Mie Theory

Yogesh C Agrawal[1] (4258672464; yogi@sequoiasci.com)

Ole A Mikkelsen[2] (45 35 32 25 00; oam@server1.geogr.ku.dk)

Henry C Pottsmith[2] (4258672464; pottsmith@sequoiasci.com)

[1]Sequoia Scientific, Inc., Westpark Technical Ctr 15317, NE 90th St., Redmond, WA 98052, United States

[2]Institute of Geography, University of Copenhagen Oester Voldgade 10, DK-1350 Copenhagen K Denmark Institute of Geography, University of Copenhagen Oester Voldgade 10, DK-1350 Copenhagen K Denmark Institute of Geography, University of Copenhagen, Oester Voldgade 10, Copenhagen DK-1350, Denmark

There are no known empirical data on the light scattering properties of randomly shaped natural particles in the near-forward region. The most thorough prior work in this context is reviewed and done by Volten et al.(JGR v106, D15, pp17,375-401). They did not address the size-resolved properties, as a counterpart to Mie theory for spheres.

We have obtained the multi-angle scattering properties of narrow size-ranges of particles. Natural particles were separated by hydrodynamic size in a stratified column. This permitted size separation as small as 0.1ϕ (or 8 per cent), down to a size of a few microns. Multi-angle scattering was observed with the LISST-100 instrument that covers the range 0.1 to 20 degrees. By filtering withdrawn samples, we have established absolute scattering strengths.

The results are intriguing. For particles with ka larger than about 200, the main scattering lobe matches Mie predictions. However, beyond the first, no subsequent minima are seen. For finer particles, scattering signatures depart dramatically from Mie predictions, altogether lacking a well-defined minimum of the first diffraction peak.

We shall discuss these observations in light of known theoretical models. Evidently, this strong difference with Mie theory invites questions regarding backscatter properties.

URL: http://www.sequoiasci.com

OS42U-03 1400h

Bottom Boundary Layers and the Jungian Distribution of Particle Sizes Strangers in the Night?

Ole Aarup Mikkelsen[2] (+ 45 35 32 25 00; oam@geogr.ku.dk)

Yogesh C Agrawal[1] (425-867-2464 ext 106; yogi@sequoiasci.com)

Morten Pejrup[2] (+ 45 35 32 25 00; mp@geogr.ku.dk)

[1]Sequoia Scientific, Inc., WestPark Technical Ctr 15317, NE 90th St., Redmond, WA 98052, United States

[2]Institute of Geography, University of Copenhagen Oester Voldgade 10, Copenhagen K DK-1350, Denmark

The assumption of a Jungian form for the size-distribution of suspended particles in marine boundary layers is common in literature. This power-law form has been employed to infer gross apparent optical properties also. With the large sets of field data on size distribution in bottom boundary layers that have been obtained with the LISST series instruments, the use of a canonical form for the size distribution is called into question. Furthermore, there are fundamental reasons rooted in availability of suspended particles in boundary layers that argue against the likelihood of a canonical form. In this paper, we shall review field measurements in contrast to Jungian forms. When Jungian distributions are fitted to published size distribution data, we find that the Jungian fit can hardly ever be transformed back into the original size distribution without a significant error in including all the suspended volume. The magnitude of the error and its importance for the use of Jungian fits is discussed.

OS42U-04 1415h

The Impact of Higher Tidal Ranges on Assessing Marsh Surface Condition Using Thematic Mapper Data

Michael S. Kearney[1] (301-405-4057; mk11@umail.umd.edu)

J. Court Stevenson[2] (410-221-8442; court@hpl.umces.edu)

David C. Stutzer[1] (301-405-4050; dstutzer@glue.umd.edu)

[1] University of Maryland, Department of Geography, College Park, MD 20742, United States

[2]University of Maryland Center for Environmental Science, P. O. Box 775, Cambridge, MD 21613, United States

The rapid degradation and loss of coastal marshes in many areas of the US Atlantic and Gulf Coasts calls

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