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One of the bottlenecks of the Okhotsk study is the uncertainty of the transport from/to the North Pacific. The Bussol Strait is the largest gap between these two basins, but estimate of the transport through the strait is difficult because of strong tide, severe winter condition etc. Intensive direct current measurements were performed with a lowered ADCP across the strait from 29th Aug.to 15th Sep.2001 on R/V Professor Khromov. The narrowest part of the strait (roughly 80km wide) was covered by 13 stations. At each station, the lowered ADCP mounted on a CTD profiler is cast successively for at least 25 hours. At least 6 casts were made at one station (which gives 12 observations at one depth with up and down cast). From the time series thus obtained, diurnal and semi-diurnal components of tide are filtered out. Casts at 6 stations were repeated for neap and spring tides. The velocity measured by the lowered ADCP is converted to absolute velocity with GPS data and bottom track data. Following features are found with preliminary analysis. The tidal flow turns out to be barotropic in the deep part and baroclinic in the shallow part. K1 tide shows larger amplitude than M2 tide, and both along- and across- strait components have similar magnitude. At the spring, the amplitude of K1 tide can reach 50 cm/s even at deep part of the strait. The strait has two deep passages separated by a sill of depth roughly 600m. Stronger residual component is seen in the southwestern passage and it is a two-layer exchange flow. The upper layer flows out from the Sea of Okhotsk to the North Pacific, while the lower layer flows in the opposite direction. The two-layer structure is also found in the northeastern passage, although the residual flow is much weaker than the southwestern passage.

## OS31P-08 1040h

### Outflow of the Okhotsk Sea Water Through the Bussolf Strait From the Mooring Observations

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Mooring observations were carried out in three stations in the Bussol' strait, which has a sill and openings in the northeast and the west of the sill. These stations are called Stas.US1, US2, and J1, which are in the western opening, at the deepest of the northeastern opening, and on the northeastern slope of the northeastern opening, respectively. We analyzed every one-hour data of current velocities, temperature, and salinity observed from July 1998 to June 2000 at around 300m and 500m depth, whose densities are 26.6-27.0, 26.8-27.2$\sigma_\theta$, respectively.

We filtered out the diurnal and semidiurnal tidal components for northward, west-northwestward, and northwestward components of current velocity to investigate their seasonal variations for the 300m layer at Stas.US1, US2, and J1, respectively. The outflow from the Okhotsk Sea occurred throughout the observational period for Sta.US1 having maxima in late December 1998, late April, mid June, early August, and late December 1999 in Sta.US1. On the other hand, the inflow occurred almost throughout the period in Stas.US1 and J1. Significant seasonal variation cannot be seen for these inflow components.

Most of T-S relationships from the moored CTDs are between cold and low salinity water in the northern Okhotsk Sea and warm and saline water southeast of the strait, which were observed by R/V Khromov. This suggests that mixed water called the Oyashio Water is formed between the Okhotsk Sea water and the Pacific water around the strait or its upstream region. Mixing ratio of the Okhotsk Sea water is calculated for the moored CTD data on the assumption of isopycnal mixing between these two waters. The ratio tends to increase from early January to early April for the 300m layer in Sta.US1, from early December to late March for the 300m layer in Sta.US2 and the 300m and 500m layers in Sta.J1. The Okhotsk Sea water flowed out without mixing in the shallower layer in winter and spring mainly through the west opening of the strait.

The mixing ratio is multiplied by the inflow component to estimate mass flux of the Okhotsk Sea and Pacific waters. The Okhotsk Sea water significantly flowed out from the sea throughout the observational period having maxima in late January, late April, mid June, early August in 1999, and mid February 2000 in Sta.US1. The Pacific water flowed into the Okhotsk Sea in Stas.US2 and J1 throughout the period but the flux is smaller than inflow of the Okhotsk Sea water. Estimated outflow of the Okhotsk Sea water is about 1.0Sv between isopycnals of 26.6-27.0$\sigma_\theta$ at most.

## OS31P-09 1055h

### Influence of Okhotsk Sea Intermediate Water on the Oyashio and NPIW

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Exchange volume transports between the Okhotsk Sea and the western subarctic North Pacific were estimated on the basis of the direct current measurements with Lowered Acoustic Current Profiler (LADCP) combined with hydrographic data observed in August-September 1999 in the area around Kuril Islands. The southwestward Oyashio transport was 14-16 Sv (=106m3/s) in the density of 26.6-27.5, in which the net Okhotsk Sea water (OSW) was 4.2Sv. 2.9Sv of OSW was out from the Krusensterna Strait and additional 1.3Sv joined from the Bussol' Strait. 0.6Sv of OSW recirculated along the western subarctic gyre. Another 3.5Sv joined the formation of North Pacific Intermediate Water (NPIW) as a cross subarctic front (SAF) transport along the coast (1.4Sv) and across the offshore SAF (2.1Sv). The production rate of dense shelf water (DSW) through sea-ice formation was estimated to be at least 0.9Sv.

## OS31P-10 1110h

### Numerical modeling on the pathways of the Okhotsk-outflow water into the subtropical gyre

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The outflow water from the Sea of Okhotsk is a major source of the North Pacific Intermediate Water that exhibits a well-defined salinity minimum in the subtropical North Pacific. The water from the Okhotsk first flows along the Kuril Islands and Japanese coast as a part of the Oyashio water, and finally reaches the subtropical gyre via the Mixed Water Region (MWR) where the water is vigorously mixed with the Kuroshio water and transformed. In this study, the pathways of the Okhotsk water in the MWR is discussed using a high-resolution regional model based on POM. Major features of the Kuroshio and Oyashio System, such as sharp separation of Kuroshio followed by the Kuroshio Extension (KE) and the Oyashio southward intrusion off the northeastern coast of Japan, have been well represented in this model.

As well as in reality, the Okhotsk water in the model is characterized by low potential vorticity (PV), and exhibits complicated pathways in the MWR. Once the low PV water reaches the northeastern coast of Japan advected by the Oyashio, it is first entrained into an anticyclonic circulation associated with a major warm core ring that semi-permanently exists in the region. It then bifurcates into three pathways with the low PV water being transported out from the warm core ring, which are: (1) Northern pathway southward from the subarctic front, (2) Coastal pathway near the Japanese coast which is finally to be entraind by the KE at the first crest, and (3) Offshore pathway to be linked to the KE at the second crest. In the geostrophic mean flow field, there are flow regimes associated with the subarctic gyre, the warm core ring and the above three pathways, with distinct boundaries characterized by their intersections, i.e., hyperbolic stagnantion points. The low PV water pathways cross the geostrophic regime boundaries around the stagnation points, indicating that the cross-frontal exchange by transient flows and eddies - so-called chaotic transport - is an essential mechanism for forming the low PV water pathways.

## OS31P-11 1125h

### Effects of the Anticyclonic Eddies on the Water Masses, Chemical Parameters and Chlorophyll Distributions in the Oyashio Current Region

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A detailed survey of the area off the Kuril Islands was conducted in May-June, 2000 by R/V Mirai. The survey included continuous underway measurements of current, temperature, salinity, nutrients, dissolved oxygen, carbonate parameters (dissolved inorganic carbon and pCO2) and fluorescence in the surface water. XCTD profiling and deep hydrocasts were also carried out. The data obtained gave us an opportunity to consider the distributions of physical and chemical parameters in the surface and intermediate water layers of the Oyashio Current region. We show that these distributions are significantly affected by an anticyclonic eddy located in the front of the Bussol Strait through the advection and water mixing. Topex/ERS data are used to explore the pathway of the eddy. By using SeaWifs chlorophyll data we also discuss the impacts of the Oyashio eddies on the spatial variations in the biological production of the study area.



## OS31Q HC: 316 A Wednesday 0830h

### Maintaining Deep Ocean Stratification II

*Presiding:* **R Pinkel,** Scripps Institution of Oceanography**; J Ledwell,** Woods Hole Oceanographic Institution

## OS31Q-01 0835h

### New Climatology Suggests Zonal Asymmetry of Non-Conservative Effects Over the Mid-Atlantic Ridge in the South Atlantic

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We have constructed new hydrographic and tracer climatologies of the South Atlantic by adjusting modern section data in repeat-sampling regions, using locally defined temperature ranges of minimum property variability. The resulting isopycnal fields contain significantly less small-scale features at all depths and show much better agreement between different tracers than existing climatologies. The distributions of some tracers (e.g. oxygen and salinity) at the level of North Atlantic Deep Water (NADW) are characterized by large zonal gradients on both the eastern and the western flanks of the Mid-Atlantic Ridge (MAR). Potential vorticity (PV) maps (f / layer thickness) at the same level derived from the new climatology show a surprisingly simple pattern, with the zonal gradients almost entirely restricted to the eastern ridge flank, i.e. with zonal PV contours in the abyssal basins and on the western ridge flank. East of the MAR the isohalines (and, in parts of the domain, the isopleths of oxygen as well) are essentially parallel to the PV contours while, south of about 15°S, they are at a significant angle on the western flank, consistent with a different net effect of mixing above the two flanks of the ridge. We relate the tracer observations to the velocity field derived using the $\beta-$spiral method applied to the new climatology.

## OS31Q-02 0850h

### Parameterizing Tidal Disspation and Diapycnal Mixing Over Rough Topography

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It is widely hypothesized that enhanced diapycnal mixing occurs near areas of rough topography in the ocean. In these areas, it is believed that internal waves are generated by tidal flow over topography. While some internal wave energy radiates away as low baroclinic modes, a fraction of the generated energy flux dissipates locally as turbulence through internal wave breaking. In this work we present a sequence of parameterizations meant to characterize these dynamics in ocean general circulation models.

A parameterization for the internal wave drag over rough topography is presented as a dissipative mechanism in a model for the barotropic tides. Model results suggest that the inclusion of this dissipation mechanism improves hydrodynamical models of the barotropic tide. It also substantially increases the amount of modeled tidal dissipation in the deep ocean, bringing dissipation levels there into agreement with recent estimates from TOPEX/POSEIDON altimetry data. The tide model is used to examine the amount of deep-ocean baroclinic tidal energy for both the present day and for the Last Glacial Maximum, when sea level was substantially lower. Long period variations in tidal forcing are also examined.

The calculated tidal dissipation from the barotropic tide model is utilized to estimate diapycnal mixing rates arising from local wave breaking of the baroclinic tides. This is accomplished through a simple parameterization relating a fraction of the available baroclinic tidal energy to local turbulence levels that support an enhanced diapycnal diffusivity. The parameterization allows us to evaluate the impact of tidally forced diapycnal mixing on the ocean's circulation.

## OS31Q-03 0905h

### Export of Mixing-Driven Flows from a Rotating Channel

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Oceanic observations indicate that abyssal mixing is intensified in regions of rough topography and can be localized within canyons. How the locally mixed fluid moves out of the canyons is an open question. Laboratory tank experiments are used to explore the effects of mixing a rotating, linearly stratified fluid at the closed end of a channel open to a larger body of water. Turbulence is generated by means of a single bar located at middepth and oscillated with frequency $\omega$. Initially the turbulence forms a region of mixed fluid which intrudes into the channel and turns to the right forming a boundary current along the right wall (looking out of the channel). In addition, a cyclonic recirculation develops in front of the bar, spreads outward and eventually spans the channel. The mixed layer height near the mixing bar and within the recirculating front quickly reaches a steady state of $h \sim (\frac{\omega}{N})^{1/2}$, independent of the tank Coriolis frequency $f$. Here $N$ is the initial buoyancy frequency. The front moves out from the bar at a speed proportional to $Nh$ and its plan view area scales as $A \sim L_R L_C (ft)^{1/2}$ where $L_R = \frac{N}{f} h$ is the deformation radius and $L_C$ is the channel width. The boundary current covers a far smaller fraction of the channel than the frontal region but it advances more rapidly, also at a speed proportional to $Nh$. Over long times the boundary current forms the main pathway for export of mixed fluid from the channel. For $L_R/L_C \sim 1$ the advancing front merges with the boundary current and both exit the channel. For $L_R/L_C << 1$ the front becomes unstable and its advance down the channel is arrested. Vertical density profiles across the channel indicate only slight variations in the height of the mixed layer. Calculations of geostrophic currents from these profiles agree with the circulation patterns inferred from dye released in the mixing zone.

## OS31Q-04 0920h

### Intermediate Water Links Between the Southern Ocean and the North Atlantic Thermohaline Overturning

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Sub-surface water mass formation has generally implied deep water formation, referring to either Antarctic Bottom Water or North Atlantic Deep Water. This definition leaves out intermediate and mode waters that underlie the thermocline and influence both the uppermost ocean stratification and the formation of deep water. Ocean models that focus solely on North Atlantic Deep Water without adequate intermediate water formation have a recirculated component of NADW at mid-depths in the North Atlantic and no intermediate water from the Southern Ocean. In our OGCM study, a small component of Antarctic Intermediate Water is advected into the North Atlantic and has a strong effect on the mid-depth (400-800m) stratification. The presence of this Southern Ocean water mass greatly increases the stability of the North Atlantic overturning circulation. To explore this link between the Southern Ocean and North Atlantic further, we used freshwater pulses in the North Atlantic to turn the overturning circulation off and then used freshwater pulses in the Southern Ocean to turn the North Atlantic overturning back on.

We applied melt-water pulses of increasing magnitude to the surface in the North Atlantic for 30 years and analyzed the response. Smaller pulses cause the overturning to collapse for an extended period of time and eventually recover. Larger pulses cause the overturning to remain collapsed indefinitely. From this collapsed state, we added fresh water anomalies to the Southern Ocean and then ran the model for a further 500 years. A large Southern Ocean anomaly caused convection in the northern North Atlantic to recover after only 50 years, while a smaller Southern Ocean anomaly caused the North Atlantic convection to recover after 200 years. The fresh water anomaly in the Southern Ocean is incorporated into the model's Antarctic Intermediate Water making it relatively less dense. When this water mass reaches the North Atlantic, the stratification is eroded from below, thereby reinitiating convection and deep water production.

## OS31Q-05 0935h

### Enhanced Vertical Mixing Over the Mid-Atlantic Ridge in the Western North Atlantic

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Anomalous conditions exist in the salinity, oxygen and nutrient fields over the western flank of the northern hemisphere Mid-Atlantic Ridge. We examine potential advective sources for this anomaly, but determine that vertical mixing is the most likely cause. We proceed to use knowledge gained from the Brazil Basin Tracer Release Experiment in the South Atlantic — where density microstructure and finestructure were obtained to examine the intensity, spatial distribution and mechanisms of mixing in the deep ocean — to interpret density finestructure from common CTD data in the North Atlantic. These data support the hypothesis that the anomalous hydrographic conditions are associated with enhanced levels of vertical mixing. The inferred levels of vertical diffusivity over the northern hemisphere Mid-Atlantic Ridge are as high as in the South Atlantic: $1 - 10 \times 10^{-4}$ m$^2$/s.

## OS31Q-06 0950h

### Sensitivity of Basin-Wide Meridional Overturning in an Idealized Atlantic-Southern Ocean Geometry

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Recent numerical experiments indicate that the rate of meridional overturning associated with North Atlantic Deep Water is controlled both by mixing and by windstress in the Southern Ocean, where the zonal periodicity of the domain alters the nature of the flow. We find a simple approximate expression for meridional overturning as a solution to Gnanadesikan's (1999) cubic scale relation. We compare the predicted overturning to coarse-resolution numerical experiments with an idealized Atlantic-Ocean/Southern Ocean geometry. The scaling accurately predicts the sensitivity to forcing for experiments with a level model employing isopycnal diffusion of temperature, salinity, and "layer thickness". A layer model produces similar results, increasing our confidence in the numerics of both models. Level model experiments with horizontal diffusivity have similar qualitative behavior but somewhat different sensitivity to forcing.

We highlight the difference in meridional overturning induced by changes in windstress or vertical diffusivity. Wind-driven circulation anomalies outside the region of windstress perturbation include strongly cross-isopycnal flow near the surface and approximately along-isotherm flow in the thermocline. Overturning anomalies far from the windstress perturbations are not completely determined by windstress in the zonally-periodic Southern Ocean: windstress outside the periodic region strongly influences the transport of heat across the equator primarily by changing the temperature of the flow across the equator. Most of the total meridional heat transport across the basin can be decomposed into contributions due to the westerlies, easterlies, and vertical diffusivity; here we show how the westerlies contribution is related to the surface temperature profile.

## OS31Q-07 1005h

### The Sensitivity of Deep-Ocean Heat Uptake to the Oceanic Diffusivity in the MIT Adjoint OGCM

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The sensitivity of deep-ocean heat uptake (DOH) below 700 m to the diapycnal and isopycnal diffusivities is studied using the MIT adjoint ocean general circulation model with idealized basins. The DOH sensitivity to the diapycnal diffusivity occurs mainly in the tropics and subtropics in both the Pacific and Atlantic. The sensitivity is positive, and its maximum is near 700 m. The sensitivity decreases towards the upper and lower ocean and towards the higher latitudes. Further analysis indicates that the positive sensitivity of DOH is dominantly associated with downward diffusive heat flux. It does not seem to be associated with the heat fluxes owing to convection, Gent-McWilliams (GM) mixing, and vertical advection.

The DOH is also sensitive to the isopycnal diffusivity, although it occurs only in the Southern Ocean south of 40S. The DOH sensitivity is negative in the South Pacific south of 40S and in the South Atlantic south of 55S, but is positive in the South Atlantic between 55S and 40S from 500 m to 3 km. The negative sensitivity of DOH is clearly associated with the isopycnal diffusivity, since the heat flux owing to the GM mixing is upward and proportional to the isopycnal diffusivity. The positive sensitivity, however, seems to be associated with the reduction of the GM mixing owing to the flattening of the slope of the isopycnal surface.

Assuming a 50% error bar of the observed diffusivities, the DOH uncertainty is estimated based on the adjoint sensitivities. It is about 0.4K and 0.7K, respectively, for the diapycnal and isopycnal diffusivities.

### OS31Q-08 1020h

## Diapycnal Mixing and Deep Stratification in an Idealized Ocean General Circulation Model

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The effect of diapycnal mixing on deep stratification and abyssal flow is examined in an idealized single-hemisphere ocean general circulation model. Horizontally, diapycnal mixing is confined to the margins, crudely mimicking boundary mixing. Where deep mixing is located, the stratification is maintained largely through vertical advective-diffusive balance with the vertical velocity a function of the mixing strength. We present three runs, control (diapycnal diffusivity independent of depth), strong deep mixing (exponential increase in diffusivity with depth below the thermocline), and weak deep mixing (exponential decrease in diffusivity with depth below the thermocline). As compared to our "control" run, stratification is weaker for both our experimental "strong" and "weak" deep mixing scenarios. Diffusive mixing plays only a small role in the deep ocean heat budget. Rather, the balance is largely between advective transport of downwelling buoyant flow into the abyss and cooling through convective mixing and vertical eddy transport (the latter represented through the Gent-McWilliams mesoscale eddy parameterization). These results suggest that deep mixing is not necessary to support a strong deep MOC, as is widely thought; moreover, these results question whether strong deep mixing in the real ocean can explain the observed deep stratification, implying that other mechanisms for stratification may be necessary.

### OS31Q-09 1035h

## Spurious diapycnal mixing of the deep waters in an eddy-resolving global ocean model

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Recent idealized studies have shown that both explicit horizontal diffusion and the implicit diffusion associated with the advection scheme in high resolution $z$-coordinate models may drive unrealistically high rates of diapycnal mixing. Our aim here is to see whether the diapycnal mixing associated with the advection scheme in a global eddy-permitting (1/4° by 1/4°) $z$-level model is sufficiently strong to corrupt the thermohaline circulation. We diagnose the diapycnal fluxes by using the ideas of water mass transformation.

In the Southern Ocean, the model deep and bottom waters drift rapidly away from the Levitus climatology, with dense isopycnals moving downwards at rates of up to 35 m year$^{-1}$. The strong upward flux (up to 50 Sv) through the dense isopycnals cannot be explained by the incorrect surface forcing (as a result of poor surface fluxes and no ice model) as most of the anomalous diapycnal fluxes are occurring in the deep ocean far from surface forcing. Hence, the excessive diapycnal flux is driven by diffusion in the model, both explicit and implicit.

The 'effective' diapycnic diffusivity driven by the numerical diffusion (associated with the horizontal advection scheme) is found to be the same order, 1–10 cm$^2$s$^{-1}$, as that driven by the explicit horizontal diffusion. For strong vertical velocities ($\sim$ 20 m day$^{-1}$) as in models forced by high frequency winds, the vertical advection scheme also gives similar effective diffusivities. These effective diffusivities are considerably greater than suggested by observations. To alleviate these problems, we suggest that eddy-resolving $z$-level climate models will require (1) less diffusive horizontal advection schemes and (2) better vertical resolution throughout much of the water column.

### OS31Q-10 1050h

## Water mass formation and transformation in the Pacific

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Water mass formation is defined in terms of subduction, calculated by following the Lagrangian trajectories downstream for one year. The process opposite to water mass formation is water mass elimination: it is defined in terms of obduction, calculated by following the Lagrangian trajectories upstream for one year (backward in time and space). The subduction and obduction rates integrated over a closed basin should be balanced, while diapycnal mixing can only transform water masses within different density ranges. Although subduction has been widely accepted as the accurate way for counting water mass formation, so far an appropriate counting method for the water mass elimination has not been adopted in our community.

Using the Lagrangian definitions of subduction and obduction, water mass formation and elimination rates for the Pacific are calculated, based on results obtained from an oceanic general circulation model. There is strong subduction and obduction in both the tropics and the subtropics, and they contribute to strong tropical–subtropical cells and a subpolar cell of intermediate strength in the Pacific.

### OS31Q-11 1105h

## Southeast Pacific Subtropical Mode Water

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In the eastern subtropical South Pacific south of 15°S, the mixed layer in the boreal winter reaches a depth of at least 150 dbar and has high surface salinity values. In the boreal summer, a warmer and fresher layer caps off the water column, but the winter mixed layer characteristics persist as a subsurface mode with a core potential density anomaly near $\sigma_\theta$ = 25.3 kg m$^{-3}$. This feature is called Southeast Pacific Subtropical Mode Water. Within the formation region, the mode water core is generally cooler, fresher, and denser towards the southeast. The mode water is swept northwestward by the South Pacific subtropical gyre, and underlies the subtropical salinity maximum north of about 15°S. We study these shallow subtropical water masses, their circulation, and their formation using a combination of historical hydrographic data, synoptic WOCE sections and Argo float profiles.

### OS31Q-12 1120h

## The Effect of Mesoscale Eddies on the Subtropical Thermocline

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Understanding the structure of the subtropical thermocline is an important, indeed classical, problem in dynamical oceanography. Such classical theories have fallen into two camps — diffusive theories, following Robinson and Stommel, and advective theories, following Welander. And more recently it has been shown that, at least in the absence of mesoscale eddies, the subtropical thermocline consists of an advective upper part (a 'ventilated thermocline') with a diffusive base — that is, the lower part of the main thermocline is an internal boundary layer.

However, these theories are not complete. Among the most egregious omissions is that of the potential effect of mesoscale eddies, and here we explore that problem. We integrate to equilibrium a wind- and buoyancy-driven eddy resolving primitive-equations ocean model, set in idealized basin. We find that mesoscale eddies do have a significant quantitative affect on the structure of the subtropical thermocline, but that the signature of the two-thermocline model (an advective upper thermocline and a diffusive base) remains, even in the presence of vigorous eddying activity. We discuss the dynamics and thermodynamics of the flow, and present some simple theoretical ideas, drawing on notions of geostrophic turbulence, to partially explain some of our results.

# OS31R HC: 316 C Wednesday 0830h

## Transport and Transformation of Biogeochemically Important Materials in Coastal Waters II

***Presiding:*** **B J Eadie,** NOAA - Great Lakes Environmental Research Laboratory**; S A Green,** Michigan Technological University

### OS31R-01 0835h

## The Use of a Mesoscale Meteorological Model to Downscale Observations in Coastal Waters

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In coastal waters, the transport of materials is strongly linked to meteorological conditions. However, owing to the difficulty of maintaining observing platforms in the marine environment, meteorological observations are relatively sparse. In this work, we will show how a mesoscale meteorological model can be used to downscale existing meteorological observations in a way that enhances the characterization of hydrodynamic conditions in coastal waters.

The process is as follows. All available observations are incorporated into a gridded meteorological analysis. This analysis then used in a meteorological model simulation employing the four dimensional data assimilation technique known as Newtonian Relaxation or nudging. This technique, in which the model solutions are weakly forced towards the analysis, provides a dataset in which time continuity and dynamic coupling among the various model fields is achieved. Hence, the model solution remains bounded by the observations and the horizontal resolution of the observations is effectively enhanced by the added time dimension.

This process is described for the passage of a major storm (cyclone) across the lower Great Lakes, an event that led to substantial resuspension of sedimentary material in Lake Michigan. A triply nested model domain structure was established, with an outer domain covering the Continental United States at 54 km grid spacing and an innermost domain covering Lake Michigan and surrounds at 6 km grid spacing. The four dimensional data assimilation was applied only on the 54 km domain, to ensure that the synoptic-scale meteorological conditions remained consistent with the analysis over a 7-day simulation period prior to and following the passage of the cyclone. By nudging only on the outermost domain, however, the solution on the interior domain is allowed to evolve within the constraints provided by the synoptic environment along the boundaries and the high-resolution model physics within the interior. Verification results, supplied by in-situ current observations for this case, show that the output from the hydrodynamic model forced by the meteorological model is significantly better than the output from this same model when forced by interpolated observations.

### OS31R-02 0850h

## Coastal Circulation and Exchange Characteristics During Winter in Southern Lake Michigan

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The intermittent satellite images has revealed episodic late winter-spring sediment plumes coinciding with northerly storms in southern Lake Michigan. A major inter-disciplinary observational program (Episodic Events Great Lakes Experiment, EEGLE)

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