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There is little question that on annual to possibly decadal time scales, the AO/NAO has an important influence on climate of the Arctic Ocean and northern North Atlantic; however, it has been widely debated whether the same is true on much longer time scales of multi-centuries to millennia. Some authors claiming NAO dipole or tripole patterns on those time scales in the northern North Atlantic have refuted those claims in later publications. Adding to the problem is the possibility that reduction in thermohaline overturning, local buildup of sea ice, or response to solar variations might produce patterns similar to those of the NAO. Certainly, it is far from clear how a pattern resulting purely from atmospheric forcing can be maintained on long time scales. A compilation of temperature-related records spanning most or all of the Holocene together with new data from cores our group has analyzed does not appear to produce geographic patterns of temperature change that are consistent with the AO/NAO. Those records extend from the Laptev Sea to about 40 degrees N in the North Atlantic and are, with the exception of the Laptev Sea, from the open ocean. The sense of temperature change appears to be the same at all of the coring sites; that is, there is no evidence of multipole patterns. Records from the Labrador Sea and from near-shore areas off the Scotian margin, however, exhibit more complicated patterns, but still not those expected from the AO/NAO. In those more restricted areas, the complicated patterns may reflect local climate dynamics and/or the influence of sea ice cover on near surface ocean temperatures.

OS11B-04 1110h

Orographic and Geographic Constraints on a Modeled Siberian Snow - Arctic Oscillation Teleconnection Pathway

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Land surface anomalies have recently been recognized as influential to the Arctic Oscillation (AO), and thus represent a potentially important but relatively untapped research direction, with possible ramifications for seasonal prediction. Previous publications by the authors have identified a surface-troposphere-stratosphere teleconnection pathway linking observation-based early season Siberian snow perturbations to a modulation of the winter AO mode. In this study, the key roles of orography and geography in producing this modeled teleconnection is explicitly investigated using numerical GCM experiments. First, the climatic response to the same snow perturbation is compared between observed and suppressed orographic barriers in southern and eastern Siberia. Second, the AO mode response to realistic land surface snow forcings is evaluated for two different forcing regions, Siberia and North America. Results indicate that the combination of a large snow-forced local diabatic heating anomaly over a region of substantial (orographically-forced) stationary wave activity is required to produce strong upward wave activity flux anomalies which initiate the teleconnection pathway. These features are unique to Siberia, making it a critical region for reproducing the snow - winter AO statistical relationship evident in the observational record, and potentially for improving seasonal prediction of the winter AO mode.

OS11B-05 1125h

From NAO to AO: A distinctive process between two phenomena

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Toward understanding the physical origin of the so-called Arctic Oscillation (AO), we performed a singular vector analysis to the dynamical operator of the primitive model linearized about winter 3D state. The leading singular mode having the longest lifetime resembles, though not perfectly, the AO in many aspect, suggesting that the AO is a dynamical mode of the northern winter atmosphere. Furthermore, the evolution of the mode reveals the Atlantic signal rapidly propagating to East Asia along the jetstream, reminiscent of stationary Rossby waves trapped on the jet waveguide. Analysis of monthly observed fields does indicate that the North Atlantic Oscillation (NAO) accompanies such a zonally oriented wavetrain in late winter, when the NAO is virtually indistinguishable from AO. Thus the energy propagation along the Asian jet waveguide appears one of processes which realize the regional NAO extending toward the hemispheric AO.

OS11B-06 1140h INVITED

Predicting the Extent of Summer Sea Ice in the Arctic

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The summers of 1998 and 2002 had the least sea ice extent (SIE) in the Arctic. These observations seem to agree with the trends noted by Parkinson, et al. (1999, hereafter P99) for the period 1979-1997, but the spatial pattern of these recent decreases in summer SIE were different. The summer trends shown by P99, exhibit large decreases in SIE primarily in the East Siberian Sea (ESS), while the decreases observed during 1998 and 2002 were much larger in the Beaufort and Chukchi seas (BCS). We now show that the trends for the period 1979 - 2002 are much smaller in the ESS than the trends shown by P99, and the largest decreasing trends have shifted from the ESS to the BCS. Rigor, et al. (2002) showed that the changes in SIE that P99 noted were driven by changes in atmospheric circulation related to the phase of the prior winter Arctic Oscillation (AO, Thompson and Wallace, 1998) index. Given that the latest trends in SIE are different than those shown by P99, one could ask whether the affect of the AO on sea ice noted by Rigor, et al. (2002) has also changed, and whether some large scale climate modes other than the AO has influenced the climate of the Arctic Ocean more? To answer these questions, we applied Empirical Orthogonal Function (EOF) analysis on the September SIE data from microwave satellites, and found that the first two modes SIE were most highly correlated to the prior winter AO, and the AO index of the summer months just prior to each September. These modes explain more than 45% of the variance in SIE, and show that the influence of the winter and summer AO dominates Arctic climate from 1979 - 2002. Using data from the International Arctic Buoy Programme and the National Centers for Environmental Prediction, we will show that the changes in sea ice extent are primarily driven by dynamic changes in sea ice thickness and discuss the implications for predicting summer SIE.

URL: http://iabp.apl.washington.edu/SeaIceAO/

OS11B-07 1155h INVITED

Freshwater Budget of the Arctic and High Latitude Modes of Atmospheric Variability

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A simple model simulating the basin-scale barotropic response of the Arctic Ocean to changes North Atlantic Oscillation (or Arctic Oscillation) is presented. The model distills concepts developed by Hunkins, Proshutinsky and others into an anylitic calculation of the balance between inputs of vorticity to the surface of the Arctic Ocean and their dissipation within the Ocean-Ice system. The results of the model are compared with tide-gauge data from various coastal stations and with a new synthesis of isotope tracer data collected during the last 15 years. The observations and theory are applied to the problem of freshwater storage in and export from the Arctic Ocean. Using this simple model, preliminary 3-D coupled ice-ocean model simulations, (validated against tracer and sea-surface height observations) we discuss potential links between atmospheric variability, Arctic Ocean dynamics and the export of freshwater to the Nordic Seas.

OS11B-08 1210h

Decadal Variability of Circulation in the Arctic Ocean Retrieved From Climatological Data by Variational Method

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An inverse 3D finite-element ocean circulation model has been designed and used to study variability of the Arctic Ocean circulation in the last four decades. We obtained stationary model solutions with the temperature and salinity fields close to the ones given in the Environmental Working Group (EWG, 1998) Atlas. Transports at the open boundaries, wind forcing and hydrographic fields are treated as unknowns, which are varied to minimize a quadratic cost function subject to model constraints. The inverse problem is solved for ten gridded hydrographic data sets that were obtained as winter and summer averages of EWG data over each of the four decades (50's to 80's) and over the whole period of observations (1948–1993) documented in the Atlas. The results show that Arctic circulation in the last four decades has undergone significant changes, which manifest themselves in a) 10% reduction of the ventilation rate in the Atlantic sector of the Arctic Ocean; b) substantial decrease of the advective heat and freshwater import at the lateral boundaries; c) spinning down of the cyclonic gyre in the northern Greenland sea, which is partly driven by deep convection; d) 3400 km^3 increase of the net fresh water storage, with 75% taking place in the Atlantic sector of the Arctic Ocean. Most of these changes are similar to the ones observed on seasonal transition from winter to summer climatologies, and indicate that Arctic Ocean is experiencing a shift towards a warmer state.

OS12A MCC: Level 1 Monday 1330h

Geological and Biogeochemical Processes in a Wet Tropical Setting: New Guinea, Source to Sink II Posters *(joint with B, H)*

Presiding: **R C Aller,** State University of New York at Stony Brook**; C A Nittrouer,** University of Washington

OS12A-0183 1330h POSTER

Benthic Communities as Indicators of Geological and Biogeochemical Processes in the Gulf of Papua

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Benthic communities inhabiting Gulf of Papua deposits play important roles in determining remineralization and material cycling processes at the seafloor. Faunal abundances, size-frequency distributions, functional groups, and vertical distributions reflect a spectrum of diagenetic depositional environments produced by variations in local sediment transport dynamics and coastal morphology. Thus faunal properties provide a basis for comparison of factors influencing sediment - overlying water interactions, elemental cycling, and material storage. During mid NW monsoon periods (Jan-Feb), macrofaunal densities at Gulf stations are generally low (260 to 1270 m^{-2}), large macroinfauna are absent in the upper ~25 cm, and small (< 0.5 mm) surface deposit-feeding polychaetes and tubiculous amphipods dominate, reflecting a frequently destabilized

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seabed and high sedimentation / erosion rates. Although significant numbers of macrofauna have generally been found to be absent over large areas due to frequent physical disturbance, sedimentary structures demonstrate that many regions of the GoP deltaic complex are periodically extensively bioturbated by relatively large and deep-burrowing infauna. Additionally, faunal samples from February 2003 have significantly increased numbers of opportunistic polychaete and crustacean species relative to 1999 and 2000, indicating that there are periods of faunal colonization and community expansion. These changes may correlate with decreased riverine sediment input associated with El Niño conditions. While the macrofaunal community is relatively depauperate and apparently subject to inhibition by inhospitable physical conditions, the microbial community is highly active, diverse, and abundant throughout the upper ∼1m. The dominance of bacteria and microfauna rather than macrofauna in wet tropical environments like the GoP, contrasts with many reactive continental shelf mud deposits in temperate regions.

OS12A-0184 1330h POSTER

Biogeochemical and Sedimentary Processes in the Wet Tropics

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Surface sediments were collected from the clinoform of the Fly River (Papua New Guinea) as part of a multidisciplinary effort to understand the sources, transport and fate of sediments and organic matter. Sediments from the area northeast of the Fly River mouth, which appears to be a zone of temporary storage, were characterized by organic carbon contents (%OC) of 1.0 to 1.4 wt. %, atomic organic carbon:total nitrogen ratios ([C/N]a) of 14 to 24 and stable organic carbon isotopic compositions (d13Coc) of -26 to -27 per mil. The sediments from the delta front region adjacent to the Fly River Delta, on the other hand, displayed %OC values of 0.4 to 0.8 %, [C/N]a ratios of 12 to 24 and d13Coc values of -24 to -25 per mil. These compositions indicate that a large fraction of the organic matter in the surface sediments originated from terrigenous C3 plant sources, including vascular plant fragments from the delta and soil organic matter from the Fly River drainage basin. The contrasts between the northeast and the delta front regions suggest differential deposition and transport conditions between the two areas. On-going analyses of organic biomarkers (e.g. lignin phenols) and sediment characteristics (e.g. mineral surface area) will be used to further refine these initial interpretations.

OS12A-0185 1330h POSTER

Carbon Cycling And Diagenetic Carbonate Formation in the Gulf of Papua, Papua New Guinea

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The Gulf of Papua, Papua New Guinea, receives roughly 350 million tons of sediment each year, comparable to the largest river depocenters in the world. Although the proportion of carbonate is low (<5%), Fe - carbonate authigenesis, cycling and burial in this tropical deltaic system could be important due to rapid net sedimentation and a dominance of nonsulfidic diagenetic conditions. Most carbonate, however, is present as calcite (40-540 mol/g, average 165mol/g), with less than 35% siderite (25-40mol/g). Carbon isotope analyses were performed on pore water and operationally separated carbonate minerals. The del-13C of pore water total CO2 varies from 0?near the surface to -25 at depth (1-2m), reflecting the progressive contribution of diagenetic CO2 from the decomposition of marine and terrestrial organic matter during burial. Both terrestrial and marine derived organic matter are effectively remineralized, with the decomposition of marine organic material dominating the upper few decimeters. Biogenic carbonate has del-13C values near that of overlying seawater whereas del-13C of diagenetic siderite varies from -2.5 to -12.5 Isotopic patterns of pore water profiles and carbonate fractionation factors indicate that most siderite forms in the upper 10 - 20 cm of Gulf deposits. Compared with the tropical Amazon delta system, authigenic carbonate formation in the Gulf of Papua deposits is not well developed.

OS12A-0186 1330h POSTER

Preliminary Characterization of Organic Geochemistry in the Fly-Strickland River System, Papua New Guinea

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The Fly-Strickland fluvial dispersal system comprises one of the largest river basins in tropical Oceania, ranking among the top 20 rivers in the world for water and sediment discharge. From the New Guinea highlands, these rivers flow >1000 km across lowland tropical floodplains to the Gulf of Papua, with an average annual depth of runoff 100 times that of the Amazon. Within the system, the Strickland has greater sediment discharge and a steeper gradient than the Fly, providing an opportunity to investigate biogeochemical differences associated with particulate flux. For eight lowland sites across the Fly-Strickland river system, we analyzed water and suspended sediment (SS) samples for an initial survey of various carbon cycle parameters. Both the Fly and Strickland Rivers were strongly supersaturated with carbon dioxide (2008-10,479 uatm CO2) and undersaturated with oxygen (1.10-5.48 mg/l O2), with the Fly having higher CO2 and lower O2 concentrations than the Strickland River. These pCO2 and O2 concentrations are comparable to and lower than (respectively) typical values in the Amazon. Measured Fly-Strickland alkalinity values fell in the range of 0.893-1.888 meq, and pH measurements were neutral to slightly alkaline (6.916-7.852). In a sample from a sediment-impoverished tributary from Lake Murray to the Strickland (Herbert R.), pH was neutral (7.060), and alkalinity and pCO2 had their lowest observed values at 0.234 meq and 1407 uatm, respectively. Nutrient concentrations were generally higher in the Strickland ([NO3]=3.36±0.69 uM, [PO4]=0.09±0.10 uM, and [Si(OH)4]=176.6±41.7 uM) than in the Fly River ([NO3]=1.09±0.04 uM, [PO4]=0.01±0.01 uM, and [Si(OH)4]=110.6±4.8 uM). NO3 and PO4 concentrations in the Fly-Strickland river system were lower than in the Amazon, and silicate was comparable. SS concentrations were higher in the Strickland than in the Fly (49.4-231.1 mg/l vs. 19.5-59.6 mg/l). Coarse particulates were organic-poor in the Fly and Strickland rivers, with <1% organic carbon (OC). Fine particulates contained more OC in the Fly (2.32-9.03%) than in the Strickland (0.99-3.08%). In aggregate, the average OC concentration of Fly-Strickland river SS samples is 3.75±3.07%, which is substantially higher than %OC values measured in fine particulates in the Amazon. C/N ratios for fine particulate organic matter (FPOM) are higher in the Fly (13.0-24.1) than in the Strickland (9.5-14.4), suggesting a greater contribution of N-poor, terrestrial organics to the Fly River. FPOM δ^{13}C values in the Fly are more depleted (-31.1–30.3$^{o}/_{oo}$) than in the Strickland River (-29.6–28.4$^{o}/_{oo}$). We intend to estimate the total biogeochemical fluxes associated with these reported concentrations. Collectively, these preliminary data on carbon cycling in the Fly and Strickland rivers suggest that this fluvial dispersal system outgases a substantial volume of CO2 each year relative to its area, much like the Amazon River. However, in contrast to the Amazon, where the majority of the sediment from the Andes is trapped in sub-aerial, intracratonal basins, most fluviatile sediment is advected beyond the Fly River mouth. Therefore, due to the higher organic content of the fine suspended sediment in this river system, it seems probable that a relatively greater export and burial flux of organic carbon may occur within the delta and shelf deposits of the Gulf of Papua.

OS12A-0187 1330h POSTER

Sediment Deposition and Accumulation in a Seasonal Repository of the Fly River Shelf Clinoform, Papua New Guinea

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Cores collected from the seabed northeast of the Fly River delta exhibit sedimentary structures and radioisotope profiles that indicate both seasonal deposition and longer-term sediment accumulation. Cores were collected in a grid pattern from an area 45 km × 30 km northeast of the Fly River mouth in water less than 9 m deep. X-ray photography was used to reveal sedimentary structure, and grain size and ^{210}Pb activities were measured from selected samples to produce down-core profiles of those parameters. Data indicate that during the relatively quiescent monsoon season, a surficial mud bed of ∼30 cm persists on the shelf. Sediment within the mud bed exhibits variable ^{210}Pb activities and higher porosity than sediment below. ^{210}Pb activities decay logarithmically below the mud bed indicating sediment accumulation rates of ∼1.5 cm/y. Profiles of porosity and ^{210}Pb activity suggest that wave and tidal currents in the shallow area sampled are sufficient to inhibit consolidation of the surficial mud bed. Sedimentary structures are almost entirely physically stratified probably reflecting physical processes that destabilize the seabed and exclude biological colonization. The area northeast of the Fly River mouth is a vital part of the morphologically diverse sediment dispersal system that feeds the development of the Fly River clinoform. Temporary deposition of relatively unconsolidated sediment creates a repository of sediment hypothesized to be transported (primarily as fluid mud) during energetic trade-wind conditions, which are competent to resuspend sediment in high concentrations. Transport of sediment by wave-supported fluid mud results in the observed high accumulation rates on the foreset of the Fly River clinoform. Sediment accumulation on the shallow topset of the clinoform indicates that sections of the clinoform are aggradational rather than exclusively progradational.

OS12A-0188 1330h POSTER

Controls on Subaqueous-Delta Clinoform Development

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Rivers discharge sediments and associated carbon to continental shelves around the world, and many factors are important to the dispersal of these materials. Seaward of some river mouths are subaqueous-delta clinoforms (SDC), and studies have identified a similar accumulation pattern associated with these morphological features (i.e., large sediment accumulation rates on foreset beds). This pattern and the geometry of SDC (i.e., the rollover point) are thought to be regulated by "wave base", the theoretical depth at which sediments are not resuspended. Quantitively, this can be viewed as the depth where critical bed-shear stress of sediment supplied is equaled by that from mean (tide-, wave- and current-dependent) transport conditions. As a result, wave base will vary on every continental margin, as will the potential for SDC development. To test this hypothesis and evaluate factors critical to SDC development, a GIS database with information on tidal range, mean significant wave height, river-sediment load, and continental-shelf width at >100 major river mouths was developed. These data combined with additional measurements from several marine river-dispersal systems indicate that SDC development requires a large sediment load (∼100 million tonnes), significant tidal range (>2 m) and moderate wave climate (>1 m mean significant wave height). Also, strong correlations exist between tidal range and mean significant wave height and the distance and depth of nearest maximum shelf sediment accumulation, respectively. These relationships highlight the connection between transport conditions and SDC morphology. Sediment dispersal at the Margins Source-to-Sink focus areas, the Fly and Waiapoa rivers, supports these findings.

OS12A-0189 1330h POSTER

Characterization and Timing of Siliciclastic Sediment Fluxes to Continental Slopes of the Coral Sea During the Late Quaternary

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The continental margins of southern Papua New Guinea and northeastern Australia together form the world's largest extant tropical mixed siliciclastic-carbonate depositional system where both rivers and shallow marine organisms supply large amounts of sediment to the shelf. The flux and composition of sediment shed from these margins to surrounding slopes and basins changes dramatically over the late Quaternary. This is to be expected given mixed sediment sources and large amplitude variations in sea-level and climate during this time. Importantly, though, the observed accumulation of the siliciclastic material on slopes deviates significantly from generic sequence stratigraphic models. Recent studies on the northeast Australian margin clearly show greatly increased fluxes coincident with late transgression ca. 12-7 ka rather than lowstand ca. 25-18 ka (Dunbar and Dickens, Sed. Geology, in press; Page et al., Geology, in press). In this study we examine the mineralogy and grain size of the siliciclastic fraction down a series of well-dated cores along the slope of the northeastern Australian margin to further characterize this phenomenon. Sediment samples were taken at 10 cm intervals down drill cores (collected on ODP Leg 133) and piston cores. Each sample was reacted with weak acetic acid to digest the carbonate component. The remaining siliciclastic component was analyzed for mineralogy using an XRD and for grain size using a Laser Particle Size Analyzer. Preliminary results from ODP Site 820 show that the siliciclastic component deposited during early transgression is dominated by silt but that, from ca. 10 ka until present, the sand percent of this component increased. These results may support either of two end-member models to explain elevated siliciclastic accumulation during late transgression. In the first model, margin physiography controlled siliciclastic accumulation, whereby sediment was stored behind an exposed barrier reef during lowstand, and released to the slope ca. 12-7 ka when flooding of the shelf enabled remobilization. In this case, winnowing of the stored siliciclastic sediment from ca. 10 ka to present may explain the reduced off-shelf flux and greater sand fraction. Alternatively, significant variations in climate may have controlled fluvial discharge to the slope. An arid climate during the Last Glacial, resulting in low river discharge, was followed by intensified precipitation ca. 12-7 ka, vastly increasing river fluxes and siliciclastic accumulation on the slope. In either case, these results could have profound implications for interpretations of mixed siliciclastic-carbonate sequences in the geological record, which are often made on the basis of sediment properties without detailed age constraints. Results from other cores along the northeast Australian margin will be presented at the meeting, and cores from the southern Papua New Guinea margin applicable for this research will be collected in the spring of 2004.

OS12A-0190 1330h POSTER

A Tropical View of Quaternary Sequence Stratigraphy and a Dynamic View of the Sink Along the Northeast Australian Margin: The Accumulation of Riverine Material on Slopes Since the Last Glacial Maximum

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The northeast Australian continental margin, extending from central Queensland to southern Papua New-Guinea (PNG) and including the Great Barrier Reef, is the outstanding modern example of a tropical mixed siliciclastic/carbonate system, where rivers discharge significant amounts of terrigenous material onto a shelf and marine organisms produce enormous amounts of carbonate material. The long-term sink for this sediment lies in adjacent slopes and basins. Generic models of continental margin evolution predict that siliciclastic fluxes to this sink should be maximal and minimal during major sea-level lowstands and transgressions, respectively. Here we unequivocally show that the opposite occurs. Cores from slopes of this northeast portion of this margin contain a m-scale siliciclastic-rich interval in the upper few meters, with the thickness and depth related to sedimentation rate and proximity to the shelf. Planktonic foraminiferal AMS radiocarbon dates and oxygen isotope records in all cores examined to date consistently show that this interval was deposited ca. 12 to 7 ka, and represents a 4 to 6 fold increase in siliciclastic fluxes. This massive terrigenous discharge to slopes occurred when sea level rose above the shelf/slope break and can be documented along at least 450 km of the margin (essentially where quality cores are available for study), irrespective of modern variations in bathymetry or climate. Either tropical Australia (and presumably PNG) had a significantly different early Holocene climate with greatly enhanced sediment discharge or rivers aggraded on the shelf during lowstand with terrigenous material released to slopes only when waves and tidal currents could remobilise sediment. In this region, quantified sediment discharge from present-day rivers and/or quantified sediment accumulation on the present-day shelf cannot be extrapolated over moderate time frames. This complexity provides an intriguing challenge for source-to-sink studies.

OS12A-0191 1330h POSTER

Response of the Ganges dispersal system to climate change: a source-to-sink view since the last interstade

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The forcing of sediment dispersal systems by climate is widely accepted, but our understanding of source-to-sink responses remains limited. Here, a comprehensive overview of climate impacts on the Ganges River dispersal-system is provided since the last interstade. Evidence from multiple source-to-sink components reveals major, coeval responses to variation in the South Asian monsoon. At >3000 km from its mountain headwaters to deep-sea fan, the Ganges dispersal system is immense and yet shows tight coupling between source area, catchment basin, and coastal and marine depocenters. Furthermore, sedimentary signals appear to propogate through the entire system at least as fast as our current chronological resolution of 1-2 kyr. This tight linkage of source-to-sink components is considered a function of the southwest (summer) monsoon's overwhelming control on regional hydrology. About 80% of the Ganges discharge and 95% of its sediment load are delivered to the margin during only four months, making the system extremely sensitive to this seasonal forcing. Also, the regional scale and distribution of the monsoon weather system means that changes in atmospheric circulation affect the entire drainage basin rather than local subcomponents. Finally, despite its present intensity, strength of the summer monsoon has varied significantly over the past 150 kyr under orbitally driven changes in insolation and global (glacial) boundary conditions. The resulting changes in precipitation, both well above and below modern values, have forced responses of glacier advance/retreat, riverine alluviation/incision, and varying sediment fluxes to the margin and deep-sea fan. Overall conclusions are that (1) this immense dispersal system responds to multimillennial-scale ($<10^4$ yr) climate change in a system-wide and largely contemporaneous manner and (2) that major sedimentary signals can be transferred rapidly from source to sink with little apparent attenuation. Furthermore, these acute responses to climate change have produced sedimentary/stratigraphic features that diverge from traditional sequence models in their nature and timing.

OS12A-0192 1330h POSTER

The Role of Conjoining (Tie) Channels in Lowland Floodplain Development and Lake Infilling

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In simple models of lowland river systems, water and sediment enter the main stem via tributary and secondary channels and are only redistributed to the floodplain during overbank and crevasse splay events. Along numerous river systems across the globe, however, water and sediment are regularly exchanged between the river and off river water bodies via stable, narrow channels. These channels, known as tie channels on the Fly River in Papua New Guinea and batture channels along the lower Mississippi, are largely overlooked but important components of floodplain sediment dispersal where they exist. These channels become pathways of sediment dispersal to the floodplain system when elevated river stages force sediment-laden flows into the off-river water bodies. On the Fly River, it is estimated that about 50% of the sediment delivery to the floodplain is via these channels, and along low gradient tributary channels during flood driven flow reversals. During low flow, tie channels serve to drain the floodplain. With the outgoing flows, large amounts sediment can be carried and lost to the floodplain; floodplain lakes progressively infill with sediment as the mouth of these channels steadily prograde lakeward. These lake deposits not only become significant stratigraphic components of floodplains (traditionally referred to as clay plugs), but are important local sinks recording hundreds to thousands of years of river history. As with all sinks, the proper interpretation of these stratigraphic records requires understanding the processes by which sediment is delivered to the sink and how these processes alter the paleohydraulic and climatic signals of interest. We have conducted field investigations of conjoining channels in Papua New Guinea (the Fly and Strickland Rivers), Louisiana (Raccourci Old River 65 km upriver of Baton Rouge) and Alaska (Birch Creek). These field investigations include extensive surveys of both cross and along channel morphological trends, grain size characteristics, water levels and geochronological sampling using optically stimulated luminescence (OSL). Across all systems channel morphology is similar and exhibit scale independence, however, channel size and rates of progradation are directly related to the size of the main stem river. Through these studies and ongoing scaled modeling we are examining the morphodynamics that lead to the formation, advancement and stability of these unique self formed channels.

OS12A-0193 1330h POSTER

Mapping the Extent and Rate of Overbank Deposition Using Mine-Derived Sediment Tracers Along the Strickland River, Papua New Guinea

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As part of collaborative investigation among an NSF sponsored Margins Source to Sink research group, University of Papua New Guinea (PNG) researchers, Porgera Joint Venture (PNG), Ok Tedi Mining Ltd (PNG) and CSIRO (Australia), a field study is being conducted to map the extent and rate of overbank deposition along the Strickland River, which is the dominant drainage to the Fly River delta, Papua New Guinea. A key question is what proportion of the river's sediment load is deposited on the lowland floodplain before the river joins the Fly. Previous studies on the Fly River above the junction with the Strickland concluded that about 40% of the lowland sediment load is lost to the floodplain. It was hypothesized that the historically much higher load on the Strickland had lead to more rapid infilling of accommodation space and consequently current rates of deposition would be proportionately smaller than on the Fly. The Strickland River receives inputs of mine tailings and waste rock from the Porgera gold mine, which is situated at an elevation of 2,500 meters in the upper catchment of the river system. While the contribution to the overall sediment load of the river is small, the mine-derived sediments contain elevated concentrations of several metals and there is both a need to understand their transport, fate and the potential release of dissolved metals as they are transported through the system and an opportunity to use these metals as tracers of sediment transport and deposition. This paper summarizes studies undertaken to examine the extent of overbank deposition of mine-derived sediments in the lower reaches of the Strickland River. Sediment cores were collected along transects

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at six key points on the lower Strickland River floodplain during 1997 and 2003 and analyzed for a suite of trace elements. In 2003, additional cores were collected at 5 other transects and duplicate cores were collected at all transects for analysis of 210Pb. Particulate silver and lead were used as tracers of mine-derived sediments because a previous investigation had indicated that these metals were present at elevated concentrations in mine tailings relative to pre-mining floodplain sediments. Using these relatively simple chemical tools, it was possible to obtain information on mine-derived sediment dispersion and overbank deposition rates in an extremely complex, diverse aquatic system.

OS12B MCC: 3000 Monday 1340h

Changes in the Heat and Fresh Water Budget of the Ocean From Decades to Centuries I *(joint with H, C, GC)*

Presiding: **I Yashayaev,** Bedford Institute of Oceanography**; A Proshutinsky,** Woods Hole Oceanographic Institution**; B Dickson,** Centre for Environment, Fisheries and Aquaculture Science**; R W Schmitt,** Woods Hole Oceanographic Institution

OS12B-01 1345h

World Ocean heat content, 1955-1999

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We update our earlier estimates (Levitus et al., 2000) of ocean heat content for the world ocean with the additional 1.7 million temperature profiles that have become available as part of "World Ocean Database 2001". The results are quantitatively similar through the early 1990s but the newer estimates are lower for the 1990s due to an error in processing the XBT data for the earlier results. This difference does not affect any previous conclusions regarding the dominance of ocean heat content in the earth's heat balance for this period or possible causes of the heat content variability. The results of multivariate analyses of ocean heat content are presented.

OS12B-02 1400h INVITED

Recent Changes in Large Scale Ocean Salinity Distributions in the Context of Climate Variability

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The oceans serve both as a global reservoir and agent of redistribution for several important constituents of Earth's climate system, among them heat, freshwater, and CO_2. Whereas these ocean components are themselves freely exchanged with the atmosphere, salt is a component that is not. As a widely measured and approximately conserved property, the distribution of salinity in the ocean can be used to diagnose rates of freshwater transport, local ocean mixing, and surface freshwater fluxes. In the lengthening timeline of the instrumental record we are beginning to identify decadal to multi-decadal changes in ocean salinity distributions that appear to have a global structure. In particular, water masses ventilated in the low latitude oceans, where evaporation rates are strong, have become distinctly more saline and warmer in recent decades, while an opposite freshening has been observed in water masses ventilated at higher latitudes of both hemispheres. Because the tapestry of climate variability is richly colored by the interweaving of many threads, it has not yet been feasible to precisely partition the observed changes into their causal components. Nonetheless, certain aspects of the climate system – regional modes of wind and precipitation patterns, a melting cryosphere and enhanced hydrologic cycle associated with warming surface temperatures – stand out as leading candidates and will be discussed in a global ocean context.

OS12B-03 1420h

Contribution of Thermal Expansion to Observed Sea Level Rise During the Past Decade

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Recent studies by Cabanes et al. (2001) and Cabanes (2003) have suggested that thermal expansion of the oceans is likely to be the main cause of observed sea level rise during the recent years. These results were based on a single ocean temperature data set (Levitus et al., 2000) and the comparison with the Topex/Poseidon global mean sea level rise was limited to a 6-year period (1993-1998). In this study, we have compared 3 different ocean temperature data sets to investigate more precisely the steric contribution to sea level rise : the Levitus et al.'s (2000) and Ishii et al.'s (2003) data, which both provide $1^\circ \times 1^\circ$ gridded temperature fields for the upper 500m over 1950-1998, and in situ hydrographic data (temperature and salinity from various sources) collected during the WOCE experiment over 1993-2001. We analysed these data in terms of both temporal global mean steric sea level variations and spatial steric sea level trends. Over 1993-1998 (the period of overlap with Topex/Poseidon observations), computed steric sea level trends based on Ishii et al. and Levitus et al. data show similar spatial patterns. However the Ishii et al.'s map appears smoother, showing less high-frequency signal than Levitus et al.'s trend map. In addition, significant difference between temporal global mean sea level curves is observed, reflecting possible differences in both analysis schemes. When such a comparison is extended over the 1950-1998 time span, less difference is noticed between the two data sets prior to 1990. Inclusion of numerous in situ data over the central Pacific during the 1990s in the Ishii et al.' objective analysis may be the cause of the discrepancy observed with Levitus et al's data set. In another analysis, we compared both data sets with in situ hydrographic data from WOCE, by interpolating the Ishii and Levitus grids at the locations of the in situ temperature measurements on their overlapping period 1993 -1998. A very good agreement was found between steric sea level curves based on WOCE data and Levitus data. Finally we computed the steric contribution over 1993-2001 using the WOCE data and compared with the Topex/Poseidon sea level observations. This comparison confirmed earlier results from Cabanes (2003), i.e., during the past decade, thermal expansion appears to be the dominant contribution to the observed sea level rise.

OS12B-04 1435h

Contribution of Climate-Driven Change in Continental Water Storage to Recent Sea-Level Rise

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Using a global model of continental water balance, forced by interannual variations in precipitation and near-surface atmospheric temperature for the period 1981-1998, we estimate the sea-level changes associated with climate-driven changes in storage of water as snow pack, soil water, and ground water; storage in ice sheets and large lakes is not considered. The 1981-1998 trend is estimated to be 0.12 mm/yr, and substantial interannual fluctuations are inferred; for 1993-1998, the trend is 0.25 mm/yr. At the decadal time scale, the terrestrial contribution to eustatic (i.e., induced by mass exchange) sea-level rise is significantly smaller than the estimated steric (i.e., induced by density changes) trend for the same period, but is not negligibly small. In the model the sea level rise is driven mainly by a downtrend in continental precipitation during the study period, which we believe was generated by natural variability in the climate system.

OS12B-05 1450h INVITED

Freshwater Flux Variations and Impacts on the North Pacific Ocean

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Salinity profiles measured 100 km north of Oahu during the past 15 years as part of the Hawaii Ocean Time-series (HOT) reveal important changes in the upper ocean and thermocline. A prolonged freshening started first on shallower isopycnals within the thermocline during the mid-1990s, occurring progressively later on deeper isopycnals. The freshening trend was reversed in the upper pycnocline during 1998 in concert with a pronounced increase in mixed layer salinity. The increased upper ocean salinity was attributed to the regional drought associated with the 1997-98 El Niño event, however the trend continued after that event ended and through 2001 resulting in a salinity change of approximately 1 psu. The ECCO data assimilation results show corresponding large-scale high salinity anomalies in the North Pacific for the period 1998-2001. The impacts of the salinity variations at ALOHA include a pronounced reduction of the stratification of the upper ocean during this period (with deeper wintertime mixing), as well as a significant reduction in the oceanic CO_2 sink. A pattern of drought associated with the Pacific Decadal Oscillation appears to be responsible for the persistence of the HOT salinity anomaly. The pycnocline freshening has been attributed to the subduction and subsequent southward advection of earlier wintertime precipitation anomalies in the storm track region north of Hawaii. The apparent time scale of these variations is about a decade. The 1998-2001 North Pacific surface salinity anomaly pattern roughly corresponds to the precipitation and net freshwater flux anomalies for the same period from the CMAP rainfall and the NCEP/NCAR reanalysis evaporation.

OS12B-06 1510h

The Hydrologic Cycle, Ocean Mixing and Abrupt Climate Change: What do we Need to Measure?

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The hydrologic cycle occurs mostly over the oceans, yet research programs purporting to address the global water cycle focus largely on the much smaller terrestrial water cycle. (E.g.: a mere one percent of Atlantic Ocean rainfall would double the discharge of the Mississippi river.) This is understandable in the context of societal concern for freshwater supplies, but there is now strong evidence that significant changes are underway in the oceanic water cycle that may have dramatic effects on climate. Specifically, evidence from paleoclimatic data indicates that high latitude freshening caused abrupt circulation and climate changes in the past, and model results suggest that the ongoing freshening of the Northern Atlantic could lead to regional cooling in the future. However, the threshold for abrupt change in the oceanic thermohaline circulation is crucially dependent on the relationship between the intensity of hydrologic forcing and the rate of interior ocean mixing. As both these variables are poorly known, concerted efforts to understand the oceanic hydrologic cycle and mixing processes are required. One approach to both tasks must be a better assessment of the variations in oceanic salinity. The upper ocean salt content reflects the history of air-sea water exchange and is thereby an integral measure of the difference between evaporation and precipitation. The salinity distribution also controls the density stratification at high latitudes and thus has large impacts on mixing rates, air-sea exchange and sea-ice formation. However, aside from a handful of time-series sites and diminishing numbers of research cruises, the database for salinity is sparse. An expanded program of systematic salinity measurements is called for, to provide the data necessary to discern variability in the global water cycle, and to assess the impact on oceanic mixing and dynamics. The salinity sensing capabilities of profiling floats along with developing technology for long-lived sensors for surface drifters can contribute to the formation of a robust in-situ salinity-monitoring network. Long-term maintenance of such a network is required to assess the salinity variations of consequence for climate and will also be an important ground-truth-provider during the period of the Aquarius satellite mission.

OS12B-07 1525h

The Sensitivity of Ocean Circulation and Carbon Uptake to the Rate of CO2 Increase and the Resultant Changes in Climate and Hydrological Cycle

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