the NCAR CCM3.10. An array of localized SST anomalies is specified throughout the Tropics, and the responses to these experiments are summarized in "sensitivity maps" (e.g. Barsugli and Sardeshmukh, J. Climate, Dec. 2002). For the JFM season we find that warm SST anomalies in the Indian Ocean lead to a circulation pattern which projects onto the NAO and AO patterns. In contrast, warm SST anomalies in the western Pacific warm pool produce roughly the same pattern with opposite polarity. This circulation pattern is associated with large surface air temperature anomalies that have a non-zero global mean. SST anomalies in the tropical Atlantic produce an atmospheric response over the North Atlantic which, even though it projects onto the NAO, is structurally quite different. The relevance of these sensitivities is confirmed when limited regions of the observed 1950-1999 SST trend patterns are used to force the GCM. The global trend patterns that are tropically forced result mainly from cancellation of the responses to SSTs in the Indian and western Pacific Oceans. The implication is that regional patterns of climate change, and even the global mean signal, will depend sensitively on the spatial pattern of historical and projected SST change across a "nodal line" of sensitivity separating the tropical Indian and Pacific Oceans.

OS21B-1129 0830h POSTER

Dynamical Nonlinearity in the Atmospheric Response to Atlantic Sea Surface Temperature Anomalies

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Large ensembles (100 members) of atmospheric general circulation model experiments are forced throughout the Northern Hemisphere cold season by four different sea surface temperature (SST) fields: the observed climatology, the so-called SST tripole pattern, and its subcomponents. Late winter responses to the component anomalies are of modest amplitude but are, because of the large ensemble size, significant. Despite their modest amplitudes, the responses display additive nonlinearity, in that the sum of the separate responses to the component anomalies differs significantly from the response to the tripole. Neither the heating field nor the basin averaged zonal winds display this nonlinearity. It is most evident in a sub-basin scale wave train, and most significant in its impact on the amplitude of the geopotential response. These results indicate that even for modest forcing, responses to patterns of SST anomalies cannot necessarily be understood as the sums of responses to constituent anomalies.

OS21B-1130 0830h POSTER

Granger Causal Analysis between the NAO and SSTs in the North Atlantic basin

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This paper uses Granger causality test techniques to investigate the causal order of the air-sea interactions between the anomalous NAO index and the NCAR/NCEP SST anomalies over the northern hemisphere. Compared to the simple lead/lagged correlation, the Granger causality analysis is generally more reliable since it ensures that any apparent oceanic influence upon the atmosphere is uniquely provided by the ocean and is not related to preceding anomalies in the atmosphere itself (and vice versa when looking at the atmospheric influence upon the ocean). Using this technique, it is found that on seasonal timescales, preceding SST anomalies around the Gulf Stream region show significant Granger causality with the wintertime NAO. In contrast, the preceding NAO anomalies' influence on the wintertime SST field is rather restricted. Additional findings show that regions of the SST field can cause up to 20% of the variance in the winter NAO. Importantly the regions that show significant causality with the wintertime NAO are limited to the Gulf Stream extension. In contrast to simple correlation analysis, our analysis does not show significant causality related to SST anomalies in either the Greenland or subtropical regions. These results suggest that the Gulf Stream SSTs have an important influence in initiating disturbances of the atmospheric circulation over the wintertime North Atlantic. The dynamics related to this influence still need to be investigated further.

OS21B-1131 0830h POSTER

The wintertime AO influence on early season Indian Ocean Monsoon intensity

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The Indian Ocean Monsoon (IOM) exhibits considerable year-to-year to variations that have previously been attributed to a number of forcing mechanisms including the El Niño/Southern Oscillation (ENSO) and Eurasian snowcover anomalies. In this study, we analyze spatial data of Eurasian spring land surface temperatures, summer IOM precipitation, and summer IOM 850 mb zonal winds for the 1979-99 period to isolate well correlated modes of variability. The results indicate the existence of a prominent mode that appears to be related to the boreal winter Arctic Oscillation (AO); this mode projects strongly on the June precipitation and 850 mb zonal wind fields in the vicinity of the IOM region. Its projection on the temperature fields shows springtime surface warming and drying in the region to the north and west of the Indian subcontinent and cooling over the higher Eurasian latitudes during years of anomalously intense June monsoon rainfall. Such surface signatures are consistent with the negative phase winter AO. It is hypothesized that preconditioning of the spring season surface conditions may be associated with an AO-induced quasistationary tropospheric circulation anomaly: the impact of this anomaly is to displace the mid-Eastern jet polewards during AO-negative phases, resulting in anomalous surface heating and drying that persists into the later spring season and finally affects the rainfall over the IOM region in June.

OS21C MCC: Level 2 Tuesday 0830h

Changes in the Heat and Fresh Water Budget of the Ocean From Decades to Centuries III Posters *(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

OS21C-1132 0830h POSTER

Ocean Evidence for a Shifting Atlantic Fresh Water Balance Over the Past Four Decades

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Two long meridional transects through the western and eastern deep basins respectively are used to investigate salinity differences throughout the water columns of the North and South Atlantic Ocean over the past forty years. Toward both poleward limits of these sections we observe freshening over much of the water column, while within the intervening tropics and subtropics, the upper water column in particular has become markedly more saline. Where the dataset permits, it supports the idea that this growing contrast between high and low latitudes is the result of a progressive, if non-steady, evolution throughout the time period examined. For the low latitudes, an evaluation of the amount of annual fresh water loss that could be attributed to evaporation-minus-precipitation (E-P) changes suggests a 5-10% increase in net evaporation rates in recent decades. The radical freshening of the Northern subpolar seas is linked, at least in part, to enhanced efflux of ice and freshwater from the Arctic. In the South Atlantic, freshening is observed in the watermasses that are ventilated in regions where precipitation dominates evaporation. Combined with recent studies in the Mediterranean, Indian and Pacific Oceans, the present investigation extends the evidence that shifts in ocean salinity and fresh water distributions are occurring globally in ways that could reflect an amplification of the hydrologic cycle in recent decades.

OS21C-1133 0830h POSTER

Changes in the deep and intermediate waters of the sub-polar gyre of the North Atlantic since the 1950s

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A retrospective analysis of water mass properties along the northern boundary of the North Atlantic shows that the sustained freshening of the deep waters during the past 4 decades was preceded by a decade of increasing salinity (the late 1950s through the late 1960s). These decadal-scale signals can be traced from the various sills around the sub-polar gyre to the Newfoundland Basin, however the interannual oscillations seen in the Denmark Strait Overflow Water (DSOW) in the upstream regions fade out after the overflow passes south of Flemish Cap. This highlights a key role of the deep inter-gyre recirculation in the southward transport of cold and fresh waters. Successive hydrographic sections indicate that the volume of DSOW increases after entering the Newfoundland Basin while its vertical stratification decreases. Both this volume increase and the smoothing out of the interannual variation in properties are likely a consequence of further entrainment and mixing of DSOW in the Newfoundland Basin that is associated with recirculation in the deep layers. Maps of temperature and salinity on selected density surfaces for different decades show how the recent freshening of the deep layers is carried around the subpolar gyre by the deep western boundary current and is then returned to the northeast by the North Atlantic Current. The freshening has extended into the subtropical gyre and is also being returned to the subpolar gyre through the Gulf Stream - North Atlantic current exchange. While the dramatic salinity changes in the water mass properties are, to a large extent compensated by inverse changes in their temperatures, there have also been profound changes in the density distributions in the sub-polar gyre. The thickness of the density layer associated with the Labrador Sea waters have increased significantly between the 1960s and the 1990s. The waters in the upper 1.5 km have become denser while those deeper than 2 km have become less dense as this thick mass of intermediate water formed in the early 1990s has displaced the waters both lighter and denser than itself. Since these changes are largely confined to the sub-polar gyre, they impact the strength and deep structure of the North Atlantic current. By comparing volumetric T-S analysis of the subpolar gyre from the 1960s and the 1990s, we estimate that the average gain of fresh water over the intermediate to bottom waters exceeds 4 metres. The Labrador Sea Water has gained about 2.52 metres, while the Northeast Atlantic Deep and DSOW have gained 0.63 m and 0.31 m, respectively.

OS21C-1134 0830h POSTER

Modelling changes in the North Atlantic caused by long-term variability in freshwater input

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Our recent studies have revealed a large scale freshening in the North Atlantic since the 1960s and documented the contemporaneous changes in the density

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stratification in the intermediate, deep and bottom waters. Through the 1990s the intermediate layers became denser due to an increase in winter convection in the Labrador Sea, while the deep and bottom waters became less dense due to freshening. There was also a notable increase in fresh water transport along the Labrador shelf (by at least 20%). To investigate the causes and impacts of these large changes in the hygrographic characteristics, we conduct a series of sensitivity experiments using a coarse-resolution North Atlantic model. The model is forced by NCEP/NCAR reanalysis surface flux products and inter-annual variations in T-S properties in the upper layer of the Labrador Sea and in the overflow region derived from the hydrographic data. We examine the ability of the model to reproduce long-term changes in temperature and salinity consistent with observed signals. The model solution also shows interannual variations in ocean meridional circulation. Sensitivity experiments are analyzed for better understanding of the dynamics connecting the long-term changes in circulation and hydrography.

OS21C-1135 0830h POSTER

Multi-year variability of salinity of the northern hemisphere oceans

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We use the data in "World Ocean Database 2001" to composite salinity data for multi-year periods for the northern hemisphere oceans with emphasis on the North Atlantic Ocean. Many of the data used are available as a result of the IOC sponsored "Global Oceanographic Data Archaeology and Rescue" project. Our analysis documents and expands the work of Dickson et al. (1988) and Belkin et al. (1998) which were mainly based on coastal time series which have good temporal resolution. Our composite fields have better spatial resolution but much poorer time resolution. Our results clearly show gyre and basin scale changes in salinity. For example, a crude description of some of our results can be summarized as: high salinity occurred in all or part of the Labrador Sea during 1959-63, 1974-78. Low salinity occurred during 1967-71 and 1980-86. The outlook for the continued acquisition of historical salinity data is good which will allow improved temporal resolution for our future analyses.

OS21C-1136 0830h POSTER

What is the impact of the observed freshening of the Labrador Sea on its convective cycle?

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As a region of intermediate water formation, the Labrador Sea plays an important role in the North Atlantic's meridional overturning circulation and poleward heat transport. Given the recently reported freshening of the high-latitude North Atlantic and of the Labrador Sea, in particular, this study investigates the impact of such changes on deep convection in the Labrador Sea. A 'typical' convective cycle for the upper 1500m of the central Labrador Sea is constructed for two time periods three decades apart: from 1964 to 1974 (using hydrographic data collected at Ocean Weather Station Bravo) and from 1996 to 2000 (using P-ALACE float temperature and salinity profiles). The two cycles are compared using a dynamical framework which separates the seasonal cycle into a convection and a restratification phase and vertically partitions the water column into three layers: surface, intermediate and convective. The mechanisms of convection and restratification in the two periods are found to be similar, suggesting that these are strongly controlled by isopycnal dynamics and that the freshening has been compensated by a cooling. The comparison, however, also shows that changes in the heat and freshwater transport through the convective region may have occurred between the two periods.

OS21C-1137 0830h POSTER

Identifying Sources of Fresh Water in the East Greenland Current

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It has been speculated that climate change will increase the fresh water outflow of sea ice meltwater and river runoff from the Arctic Ocean to the deep-water formation regions of the Nordic and Labrador Seas. Fresh water flowing from the Arctic Ocean via the East Greenland Current influences deep water formation in the Nordic Seas as well as the salinity of the surface and deep waters flowing from there. Fresh water flowing from the Arctic Ocean has three sources: Pacific origin water (relatively fresh cf. Atlantic water), river runoff, and sea ice meltwater. Nutrient relationships distinguish Pacific source water from Atlantic source water and total alkalinity distinguishes river runoff from the other sources. We use these tracers, water samples collected in May 2002, to determine the relative amounts of the three sources of fresh water in sections along the East Greenland Current from 81.5 oN to the Irminger Sea south of Denmark Strait. In northern parts of the East Greenland Current near Greenland, Pacific source water dominated in the upper 100 m, comprising up to 70% in some regions, with river runoff contributing more than 7% of the total. River runoff contributed the largest part of the fresh water, up to the equivalent of 7 m of fresh water. It was also located closest to the deep-water formation areas of the Greenland and Iceland Seas, with the front extending over the continental slope. Pacific source water fresh water (taking Pacific source water S = 32.75 cf. Atlantic source water S = 34.85) typically provided about 1/3 of the river runoff contribution and was generally found closer to the coast. Sea ice meltwater was very nearly nonexistent in most parts of all sections, likely at least in part as a result of the samples being collected at the onset of the melt season.

OS21C-1138 0830h POSTER

Freshwater content of the Beaufort Gyre: Observations from the Canada Basin in summer 2003

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The Canadian Basin of the Arctic Ocean contains approximately 45,000 km3 of fresh water, relative to a reference salinity of 34.80 (cf. Aagaard and Carmack, 1989) and is thus the major reservoir of fresh water stored in the Arctic Ocean. Its freshwater volume is 10-15 times larger than the total annual river runoff to the Arctic Ocean and at least twice that stored in sea ice. It follows that a release of only 5% of this freshwater would be sufficient to cause a salinity anomaly with the magnitude of the Great Salinity Anomaly observed in the North Atlantic in the 1970s. A substantial fraction of this freshwater storage is constrained by the dynamics of the anticyclonic Beaufort Gyre (BG), and is thus influenced by variability in wind forcing. Prior observations and models suggested that the freshwater content of the Canadian Basin had decreased by approximately 20,000 km3 during the later half of the 20th century. Here we will present an estimate of the freshwater content in the BG, based on observations collected during an international expedition (Canada, Japan, and USA) aboard the Canadian icebreaker CCGS Louis S. St-Laurent in the Canada Basin in summer 2003. We will also assess changes of BG water properties and sea ice conditions relative to climatology. Preliminary data show that, relative to the climatology: (a) the center of the BG is shifted toward Alaska; (b) there is a significant decrease of fresh water content in the intermediate layers of the BG; (c) the upper ocean (0-20 meters) is less saline; and (d) the concentration and thickness of sea ice is significantly less. We conclude that the amount of fresh water stored in the Canada Basin, which could be available for export to the North Atlantic, has decreased. On an interannual basis, recent positive trends in Arctic precipitation and river runoff may not compensate this freshwater loss by wind forcing. These facts should be taken into account in climate change assessments and scenarios.

OS21C-1139 0830h POSTER

An Ice-Tethered Instrument for Sustained Observation of Arctic Upper-Ocean Freshwater and Heat Content Variability

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To address the Arctic gap in the global ocean observing system, we are developing an expendable, ice-tethered instrument capable of making long-term observations of freshwater and heat content variability beneath the ice pack. The system will consist of a small surface package that will support a weighted tether extending down 500 or more meters into the water column along which a variant of the now-operational Moored Profiler instrument will travel. Conductivity-Temperature-Depth data from the Profiler will be transmitted to the surface unit via an inductive modem, be combined with any additional sensor data (such as atmospheric pressure and temperature) and relayed to shore using a satellite data telemetry unit. We envision a loose array of these Ice-Tethered Profilers repeatedly sampling the thermohaline properties of the upper ocean below the perennial ice pack at daily to weekly time scale. Beyond estimating vertically-integrated quantities such as freshwater anomalies, the better-than 1-m-vertical-resolution data will also be valuable for documenting and assessing double-diffusive layering, thermohaline intrusions and mesoscale eddies, all possibly important to the evolution of the Arctic ice-ocean system. Multi-year lifetime and modest cost will permit basin-scale coverage (about 20 or more systems) to be maintained through regular seeding of replacement units as necessary, similar to the surface ice buoys (measuring sea ice drift, sea level atmospheric pressure, and 2-meter air temperature) of the International Arctic Buoy Program (IABP). Operationally, the array will serve as the Arctic analogue of the ARGO float program now being initiated at lower latitudes. Further information on the Ice-Tethered Profiler system is available at http://ioeb.whoi.edu/itp.

OS21C-1140 0830h POSTER

Latitudinal and Longitudinal Basin-scale Surface Salinity Contrasts and Freshwater Transport by Ocean Thermohaline Circulation

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The role of sea surface salinity (SSS) contrasts in maintaining vigorous global ocean thermohaline circulation (THC) is revisited. Relative importance of different generalizations of sea surface conditions in climate studies is explored. In numerical experiments using an ocean general circulation model, we have aggregated the observed sea surface temperature (SST) and SSS in several different ways: we used observed unchanged SST with SSS taken as constant (34.25 psu) everywhere; SST unchanged, and SSS zonally averaged globally, i.e., in the whole World Ocean; SST averaged globally, and SSS unchanged; SST zonally averaged globally and SSS zonally averaged basin-wide in individual basins, i.e., in the Atlantic, Indian, Pacific, and Southern Oceans separately; and, finally, both SST and SSS zonally averaged in individual basins. Global zonal averaging removes all longitudinal differences in sea surface climatology among ocean basins. However, latitudinal profiles of zonally averaged parameters preserve the main character of large-scale equator-to-pole sea surface variability. Basin-wide zonal averaging does an even better job of preserving latitudinal distributions within each basin. The results of the experiments could hardly be anticipated a priory. Surprisingly, SST could be used as a 2-D field, or as a zonally-averaged field without much difference in the THC dynamics. Moreover, SST could be averaged either globally, or basin-wide, and it also did not change the overall character of THC. At the same time, THC responded vigorously to how the SSS has been changed. It appeared that the THC structure with the globally averaged SST and basin-wide averaged SSS was very close to the one obtained in the control run (control run operates with 2-D observed SST and SSS). Our main conclusion is that ocean-wide inter-basin sea surface salinity contrasts serve as the major controlling element in global thermohaline circulation. Thermal inter-basin

contrasts, as well as longitudinal variation in SSS, are less important than latitudinal thermal gradients and inter-basin salinity contrasts. Details of SSS also decrease in importance as soon as its inter-basin contrasts are retained. This is especially important for paleoclimate and future climate simulations, as only the large-scale inter-basin contrasts of the sea surface conditions really matter.

URL: http://www.personal.psu.edu/dxs60

OS21C-1141 0830h POSTER

Progress in Modeling the Gulf Stream in a Duo Grid North Atlantic Ocean/Caribbean Sea/Gulf of Mexico model

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The DieCAST ocean model is applied to the combined North Atlantic Ocean, Caribbean Sea and Gulf of Mexico, using two two-way coupled grids between 10 deg N and 75 deg N. Open boundary conditions derived from a one degree resolution global adaptation of DieCAST are applied at 10 deg N. Climatology based open conditions are applied at 75 deg N and combined with a northern sponge layer. The two grid resolutions are: 1/2 deg east of 60 deg W; and 1/6 deg west of 60 deg W. Vertical resolution is 30 levels. Annual cycle wind stress climatology and surface heat and freshwater fluxes are applied at the surface. The fluxes are derived from surface temperature and salinity climatology, using no unphysical transient damping (restoring toward climatology). The derived fluxes are such that the model multi-year *ensemble mean annual cycle* matches the observed surface annual cycle climatology. An idealized shelfbreak near the open northern lateral boundaries avoids unphysical vortex stretching effects caused by conventional vertical walls. Using annual cycle Hellerman wind stress climatology, the model results give: correct Gulf Stream (GS) separation and path; vigorous transients including cold- and warm-core GS rings; and a steep front in the Denmark Strait between a northward flowing fragment of North Atlantic Gyre water near Iceland and southward flowing East Greenland Current that feeds into the Deep Western Boundary Current (DWBC). The model DWBC strongly affects the GS separation and path. Labrador-Sea-modified dense DWBC water arrives in the Grand Banks shelfbreak area after ∼ 10 model years, leading to: GS separation and path much closer to observations; offshore thermocline outcropping along an intense GS front; and relatively flat time mean isopycnals between the strongly sloping GS and DWBC isopycnals. Such flattening is clearly seen in Yashayaev's non-diffused climatology, and indicates eddy dynamics characteristic of baroclinic instability rather than diffusive lateral mixing between the GS and DWBC.

OS21C-1142 0830h POSTER

Interannual Variability of Sea-ice over the Eurasian Shelf Seas and its Interaction with Large-scale Atmospheric Circulation

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It has been documented that the sea-ice over the Eurasian shelf seas has large variance on interannual time scale. Not only does the sea-ice in this area serve as a freshwater source in solid form but also its variability considerably affect oceanic freshwater distribution. In this study, we detected dominant spatiotemporal modes of the interannual variability of sea-ice over the Eurasian shelf seas (from the Barents Sea to the East Siberian Sea) by a frequency domain singular value decomposition of monthly sea-ice concentration data from HadISST1.1 from 1979-2002. Three significant oscillatory modes, with periods of quasi-biennial, 4.5 year and 5-6 year, are isolated. These modes explain about 60-70% of the total variance at their respective local frequency. The reconstructed time evolution of spatial patterns show that the 5-6 year mode has stationary characteristics with large fluctuations over the Barents and Kara Seas, the 4.5 year mode has two centers of action in the Barents-Kara Sea and the western Laptev Sea, respectively, with the larger fluctuations in the Barents-Kara Sea, and the quasi-biennial mode has two centers of action located over the Barents-Kara Sea and the western Laptev-East Siberian Sea, respectively. Apparent feature of eastward propagation of sea-ice anomaly appears in the quasi-biennial mode. This analysis extends to sea level pressure and surface air temperature to examine coherence of sea-ice and atmospheric variability and to investigate their interactions.

OS21C-1143 0830h POSTER

Variations of Oceanic Evaporation Derived from SSM/I

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Variations of the oceanic evaporation of recent years were examined using latent heat flux derived from Special Sensor Microwave Imager (SSM/I) on board the Defense Meteorological Satellite Program (DMSP) satellites. Analysis of the version 2 of the Goddard Sea Surface Turbulent Flux (GSSSTF2) data set shows an increase of global oceanic evaporation of 17 percent over the period July 1988-December 2000. Data gaps exist in the major rain belts due mostly to non-retrieval in heavy rain, but there are no trends in temporal coverage. The first Emprical Orthogonal Function (EOF) of the non-seasonal data, which explains 9.2 percent of the variance, is characterized by changes of the same sign in most regions, dominated by changes in the subtropics oceanic dry regions. The time series shows an increasing trend that starts around 1990 of 1.5 percent per year. An Empirical Mode Decomposition (EMD) shows a long-term mode that shows similar pattern as the global trend. The first EOF pattern is interpreted as an enhanced Hadley type circulation. The second EOF, explaining 5.7 percent of the variance, is characterized by an equatorial east-west and a mid ocean north-south dipole in the Pacific, and its ssociated time series is correlated to a Southern Oscillation Index at 0.74, significant at the 95 percent confidence level.

OS21C-1144 0830h POSTER

Circulation and Fluxes in the Nordic Seas and Exchanges with the Arctic and Atlantic Oceans

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The Nordic Seas provide the main oceanic connection between the Arctic and the deep global oceans via dense overflows between Greenland and Scotland, into the North Atlantic. The inflow of warm, salty Atlantic waters and the outflow of ice and cold, fresh Arctic waters form two major components of the Nordic Sea circulation, and influence both the long-term variability of the overflows into the North Atlantic, and the formation mechanisms of Denmark Strait Overflow Water. We have a unique data set, collected under the auspices of the UK Natural Environment Research Council's thematic programme ARCICE (Arctic Sea Ice and Environmental Variability), of near synoptic hydrographic and LADCP (lowered acoustic doppler current profiler) measurements across the entire region during summer 1999. The box inverse method has been applied to the hydrographic data, using computed geostrophic velocities referenced to detided LADCP measurements. Our work aims to quantify the full Nordic Sea flux field (volume, heat and freshwater), studying the exchanges between the Nordic Seas and the Arctic Ocean to the north, the Barents Sea to the east, and North Atlantic to the south, via North Atlantic Current inflow and the Denmark Strait and Iceland-Scotland overflows. An understanding of the circulation and exchanges of this region is vital for any consideration of the implications of high latitude climate change to variability in the Atlantic thermohaline circulation and consequences for regional (European) climate.

URL: http://www.soc.soton.ac.uk/JRD/HYDRO/shb/arcice/arcice.php3

OS21C-1145 0830h POSTER

The Viability of COADS Data Assimilation in Coupled Ocean Atmosphere Models

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COADS data from 1950 through 1997 are tested using the coherence squared method to determinine their suitability for data assimilation into coupled ocean / atmosphere models. The results of these tests are then compared to the least squared method to ascertain any benefits of coherence testing for data assimilation.

OS21D MCC: 3000 Tuesday 1020h

Progress in Tsunami Research and Mitigation II *(joint with T)*

Presiding: **E N Bernard,** NOAA Pacific Marine Environmental Laboratory**; C Synolakis,** University of Southern California

OS21D-01 1020h

Vulnerability Assessment and Prevention Measures for Tsunami Flooding of Coastal Areas in Mexico

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The Middle-America Trench subduction zone adjacent to the southwestern coast of Mexico accounts for a consistent and regular history of locally destructive tsunamis generated by large earthquakes. 3 and 5 meters are the maximum wave heights representative of low and middle risk for the most frequent of these tsunamis. This coast is the site of industrial ports, tourist resorts and urban communities. The main industrial port, located on the sand shoals of a river delta, has two steel mill plants, a fertilizer factory, container, metal and mineral docks, grain storage silos, and a fuel oil terminal. An important element for the vulnerability assessment is the determination of probable tsunami wave elevations and expected inundation limits. The two cases mentioned above were computer simulated. An ocean water disturbance produced by a sea-floor earthquake was assumed. Linear wave theory for the deep ocean, and non-linear one for the near shore and interaction with the coast, were used. Non-fixed boundaries were considered. The equations were solved by a finite-difference algorithm for interconnected grids of different sizes. The model was validated comparing the results with sea level data, run-up and flooding extensions measured from past tsunamis. Results of the numerical simulations show maximum water levels and boundaries of the inundation areas under threat. Inundation maps were produced. Vulnerability assessments for two cases, an urban settlement and the main industrial port, are described. A low risk event will produce slight damage, railroad tracks destroyed, access bridges washed out, and ledges of sand removed or deposited on the beaches; and a middle risk event will produce major and extensive damage to the installations and danger to life. Recommendations include the relocation of urban settlements, installations and services, and the establishment of evacuation routes and emergency shelters.