OS32F HC: Hall III Wednesday 1330h

The North Atlantic Ocean and Its Changing Climate VI

Presiding: **B Dickson,** CFEAS, The Laboratory**; T M Joyce,** Woods Hole Oceanographic Institution

OS32F-187 1330h POSTER

A Nested Coupled Ice-Ocean Model for the Beaufort Sea

Qinzheng Liu[1] (907-474-6469; fnql@uaf.edu)

Jia Wang[2] (907-474-2685; jwang@iarc.uaf.edu)

Meibing Jin[1] (907-474-6877; ffmj@uaf.edu)

[1]Instiute of Marine Science, SFOS, University of Alaska Fairbanks, 115 O'Neill Building, Fairbanks, AK 99775-7225, United States

[2]International Arctic Research Center-Frontier Research System for Global Change, University of Alaska Fairbanks, 408F IARC, Fairbanks, AK 99775-7335, United States

A nested coupled ice-ocean model is being developed under the CMI/MMS project entitled A Nowcast/Forecast Model for the Beaufort Sea Ice-Ocean-Oil Spill System (NFM-BSIOS). At the first step, the nested ocean model (3.4375km) is described. We developed a transport- conserved nested scheme to pass the information from the coarse model to the fine model. The fine (-resolution) ocean model was run for several months, far beyond the need for the operational purpose (Wang 2001). We found that the surface circulation follows the wind direction (to the west), while the slope current along the Beaufort Sea slope is reproduced below 100m, flowing to the east, just opposite to the surface current. There are some mesoscale eddies in the fine model. Some eddies extend to a deep layer. Neither the slope current nor the mesoscale eddies are captured in the coarse model. The simulated warmer core layer (Atlantic Water) lies between 500 1000m. Low salinity layer exists at the surface and it can reach a depth of 200m. The simulated temperature and salinity profiles show that the vertical mixing is deep mixing-type for temperature and salinity in the shallow water region, and shallow mixing-type for salinity and advection-Type for temperature in the deep water. Thus, this fine nested model preliminarily captures some dynamical features in the Beaufort Sea and its shelves.

OS32F-188 1330h POSTER

An Estimate of Carbon Transport at 24.5°N in the Atlantic

Alison M. Macdonald[1] (508 289 3507; amacdonald@whoi.edu)

Molly O'Neil Baringer[2] (305 361 4345; baringer@aoml.noaa.gov)

Kitack Lee[3] (82 054 279 2285; ktl@postech.ac.kr)

Douglas W.R. Wallace[4] (49 431 600 4200; dwallace@ifm.uni-kiel.de)

Rik Wanninkhof[5] (305 361 4379; wanninkhof@aoml.noaa.gov)

[1]Alison M. Macdonald, University of Miami Cooperative Institute for Marine and Atmospheric Studies Rosenstiel School of Marine and Atmospheric Science 4600 Rickenbacker Causeway, Miami, FL 33149, United States

[2]Molly O'Neil Baringer, PHOD/AOML/NOAA 4301 Rickenbacker Csway, Miami, FL 33149, United States

[3]Kitack Lee, School of Environmental Science and Engineering Pohang University of Science and Technology San 31, Nam-gu, Hyoja-dong, Pohang, KOR 790-784

[4]Douglas W. R. Wallace, Forschungsbereich Marine Biogeochemie Institut fr Meereskunde an der Universitt Kiel Dsternbrooker Weg 20, Kiel D-24105, Germany

[5]Rik Wanninkhof, OCD/AOML/NOAA 4301 Rickenbacker Csway, Miami, FL 33149, United States

In the winter of 1998, when an unprecedented fourth repetition of the zonal hydrographic transect at latitude 24.5°N in the Atlantic was undertaken, a full section of carbon measurements was obtained for the second time in less than a decade. The field of total inorganic carbon (TIC) along this section is compared to that provided by the summertime 1992 transect. Using a simple box inverse analysis to determine estimates of absolute velocity, the TIC transport across 24.5°N is estimated to be -0.74±0.91 $PgC\,yr^{-1}$ and -1.32±0.99 $PgC\,yr^{-1}$ in 1998 and 1992, respectively. These new estimates reduce the large regional divergence in the meridional carbon transport suggested by previous studies. and bring into question the idea that the tropical Atlantic is outgassing carbon, while the subpolar Atlantic is sequestering it. Seasonal effects are likely important and uncertainty in the carbon transports themselves are a hindrance to determining the "true" picture.

The flux of anthropogenic carbon (C_{ANTH}) across the two transects is 0.20±0.08 $PgC\,yr^{-1}$ and 0.17±0.06 $PgC\,yr^{-1}$ for 1998 and 1992, respectively. At 24.5°N the net transport of C_{ANTH} s strongly affected by differences in concentration between the northward flowing, shallow Florida Current and the mass balancing return flow dominated by the deep interior. The net northward transport of C_{ANTH} is opposite the net flow of total carbon and suggests, as has been found by others, that the pre–industrial southward transport of carbon within the Atlantic was stronger than it is today.

OS32F-189 1330h POSTER

Coherency of Multi-Scale Abrupt Changes Between the NAO, PDO, and NPI

Jianmin Jiang[1,2,3] (831-648-9035; jjiang@pfeg.noaa.gov)

Franklin B. Schwing[1] (831-648-9034; fschwing@pfeg.noaa.gov)

Roy Mendelssohn[1] (831-648-9029; rmendels@pfeg.noaa.gov)

[1]Pacific Fisheries Environmental Laboratory, NOAA, NMFS, 1352 Lighthouse Avenue, Pacific Grove, CA 93950, United States

[2]Joint Institute for Marine and Atmospheric Research, University of Hawaii, Honolulu, HI 96822, United States

[3]Beijing Meteorological College, 46 Baishiqiaolu, Beijing 100081, China

Employing an algorithm of the scanning t-test and coherency detection, the authors carried out a coherency analysis of multi-scale abrupt changes in monthly normalized time series of the North Atlantic Oscillation (NAO), Pacific inter-Decadal Oscillation (PDO), and North Pacific Index (NPI). The monthly NAO data (1821-1999) are from Jones et al. (1997), the NPI data (1899-1999) are from Trenberth and Hurrell (1994), and the PDO data (1900-1999) are from Mantua et al. (1997). The detection method is designed to test for abrupt changes in the level of a time series, for all data points over a broad range of time scales, and determine the statistical significance of the change. The analysis suggests links between the Atlantic and Pacific Ocean regions in the fluctuations of atmospheric and ocean circulation on decadal time scales. The NPI and PDO show a negative correspondence on decadal scales, with statistically significant change points found at about 1925, 1943, and 1976. These dates are similar to previously reported regime shifts found by other statistical methods. The NAO also displays significant decadal change points around 1925 and 1943, in (out of) phase with the NPI (PDO). The NAO then appears to become uncoupled with the other indices, with change points in 1961, 1977, and 1994. Another decadal abrupt change point was revealed around 1881 in the longer NAO series. The NAO shows additional higher-frequency change points prior to 1900. The results indicate the relationship between the NAO and the NPI (and PDO) changed around 1960. Decadal changes in the NAO and NPI were in phase prior to 1960, but have been roughly out of phase in recent decades.

OS32F-190 1330h POSTER

Assimilation of along-track altimetry data into an eddy-permitting primitive-equation model of the North and Tropical Atlantic ocean using isopycnal-EOF order-reduction

Pascal Faucher[1] (33 (0)5 61 33 27 88; Pascal.Faucher@cnes.fr)

Pierre J. De Mey[1] (33 (0) 5 61 33 29 28; Pierre.De-Mey@cnes.fr)

Michel Gavart[2] (Michel.Gavart@cnes.fr)

[1]Laboratoire d'Etudes en Geophysique et Oceanographie Spatiales (LEGOS), 18 ave. E. Belin, Toulouse Cedex 4 31401, France

[2]Bureau de Recherches et d'Etudes SHOM-Meteo, LEGOS, 18 ave. E. Belin, Toulouse Cedex 4 31401, France

We present and discuss altimetric assimilation experiments into a primitive-equation model of the North Atlantic using isopycnal EOFs to propagate the altimeter signal downwards and to the other model variables. Faucher, Gavart and De Mey (2000) showed from a set of historical hydrographic data that the dominant isopycnal EOF accounts for most of the surface dynamic height variability in the North Atlantic ocean. In addition the reduced-order observability problem for altimetry is more naturally studied in isopycnal coordinates because the displacement of isopycnals is the largest contribution of deep ocean dynamics to the sea-level changes.

The 1/3 degree ocean model from the CLIPPER and MERCATOR projects (based on OPA 8.1 code developped at LODYC, Paris) was used to solve the primitive equations from 20S to 70N. The assimilation experiments were performed with the combined along-track TOPEX-POSEIDON and ERS-1 data sets between 1 january 1993 and 31 december 1993. We implemented a multivariate reduced-order optimal interpolation method (SOFA: De Mey and Benkiran, 2001) with a vertical projection of altimetry data using data-based isopycnal EOFs.

This paper will show and discuss compared results from several approaches in different regions of the North Atlantic.

OS32F-191 1330h POSTER

Climate Variability In The Atlantic Sector: Three Phenomena One Challenge

CLIVAR Atlantic Implementation Panel[1]

Roberta Boscolo[2] (rbos@iim.csic.es)

[1]M. Visbeck (Chair), A. Busalacchi, A. Clarke, T. Delworth, R. Dickson, J. Hurrell, K.-P. Koltermann, Y. Kushnir, A. Piola, C. Reason, G. Reverdin, F. Schott, R. Sutton and I. Wainer

[2]ICPO, SOC, Empress Dock, Southampton SO14 3ZH, United Kingdom

The Atlantic Implementation Panel of CLIVAR (Climate Variability and Predictability Study) is addressing issues relative to the Atlantic climate variability and its predictability. It deals with climate phenomena that ranges from interannual to decadal and centennial timescales such as: North Atlantic Oscillations, Tropical Atlantic Variability and Atlantic Thermohaline circulation. The Panel oversees observational and modelling activities in the North Atlantic as well as coordinate process studies whose aim is to monitor and understand the atmosphere-ocean coupled mechanism that govern the climate variability.

The CLIVAR Atlantic Panel promoted a series of initiatives during last year: Shallow Tropical and Subtropical Overturning Cells Workshop, North Atlantic Oscillations Chapman Conference and Tropical Atlantic Variability Workshop Through invited talks, posters presentations and working groups, these meetings helped to assess the present understanding of these phenomena upon which recommendations were drawn for developing strategies for future observational and modelling studies.

An overview of main issues and recommendations raised at the CLIVAR meetings will be presented together with the status of CLIVAR Implementation in the Atlantic Ocean. By addressing the up-to-date achievements of the CLIVAR Atlantic Panel, this presentation aims to promote discussions and encourage input for defining the future challenge of predicting climate variability in the Atlantic Ocean.

URL: http://www.clivar.org/organization/atlantic

OS32F-192 1330h POSTER

Migrations in Northern Populations of Arctic Charr, Salvelinus alpinus (L.), in Greenland as Derived From Otolith Microchemistry

Richard L Radtke[1] ((808)956-7498; radtke@hawaii.edu)

Jonathon David Carl[2] (jonathon.carl@biology.au.dk)

[1]University of Hawaii-Manoa, Institute of Geophysics and Planetology, School of Ocean and Earth Science and Technology, 2525 Correa Rd, Honolulu, HI 96822, United States

[2]National Environmental Research Institute, Vejlsovej 25 PO Box 314, Silkeborg DK-8600, Denmark

Arctic charr are salmonids of circumpolar distribution. Currently, there is a general lack of information on growth and migrations particularly for Northern Greenland. Difficulty in field access because of the remoteness of many areas makes the study of life history adaptations in this species both difficult and impractical. However, analyses of calcium carbonate concretions (otoliths) in the inner ear by microscopic and microprobe techniques offers a multitude of insights into their life history. Information from the otoliths

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can be used to quantify both the patterns of growth and environmental life history of individuals.

The purpose of the present study is to gather information on Arctic charr using the structural and chemical characteristics of their otoliths as indicators of physiological and habitat characteristics. The otoliths of Arctic charr caught in Northwestern and Northeastern Greenland were studied. Measurements by wavelength dispersive electron microprobe have confirmed the presence of strontium in otolith tissue. A direct relationship between strontium/calcium (Sr/Ca) concentration ratio and salinity has been suggested. Electron microprobe analyses of otoliths from charr provide a life history profile for individual fish. Findings were correlated with climate variations.

These studies hold obvious ramifications for fisheries management. Such information is vital to our understanding of the processes underlying recruitment and growth rate and make it possible to link growth and mortality rates to environmental occurrences. In a general ecological sense, such information is of even greater and more fundamental importance since it will allow us to reconstruct the complex environmental and species interactions that are integrated beyond the individual specimen to provide for both the short-term stability and the long-term evolution of species and populations. The techniques applied present an innovative approach to management-related problems, and the combination of chemical analyses with structural analyses promises to expand our knowledge of the life history of migratory fish.

OS32F-193 1330h POSTER

The Ventilation of the Arctic Ocean and Its Relationship to the Ventilation of the Deep World Ocean

James H Swift (858-534-3387; jswift@ucsd.edu)

UCSD Scripps Institution of Oceanography, 9500 Gilman Dr. Mail Code 0214, La Jolla, CA 92093-0214, United States

The Arctic Ocean and Nordic Seas transform their source waters to higher density and send the modified waters south to the other oceans. In the early 1980s thinking was that the primary northern components of the dense outflow from Denmark Strait were Nordic Sea waters from intermediate depth that were annually replenished from the sea surface, and not, for example the Nordic Sea deep waters earlier supposed for this role. When the water masses and circulation of the Arctic Ocean began to be better realized in subsequent years, it became apparent both that water mass transformations there also reached to densities of the Denmark Strait outflow waters and also that circulation pathways existed to carry dense Arctic Ocean waters to the Greenland-Scotland sills.

Dissolved oxygen data from the Arctic Ocean and Nordic Seas have now been brought together and examined with an eye toward the issue of providing a better understanding overall of the ventilation of the dense outflows to the North Atlantic. Results show that ventilation within the Norwegian Atlantic Current is substantial, but the Nordic gyre regimes and Arctic shelf seas both contribute effectively to the transformation and ventilation of dense outflow waters. In particular the northern Greenland Sea is a prominent ventilator of Arctic Ocean intermediate waters. Both the gyre and shelf sea contributions to dense water ventilation are episodic in nature and so are sensitive to shifts in winter surface conditions on interannual and longer time scales.

OS32F-194 1330h POSTER

What Determines the Decadal Variability of the Eastern North Atlantic Central Water?

Roberta Boscolo[1] (rbos@iim.csic.es)

Fiz F Perez[1] (fiz@iim.csic.es)

[1]IIM-CSIC, Eduardo Cabello 6, VIGO 36208, Spain

A timeserie of hydrographic properties of the Eastern North Atlantic (around 42°N-10°W) from 1952 to 2001 is presented with the aim of studying the variability of the Eastern North Atlantic Central Water (ENACW). ENACW is identified by the minimum of isopycnic potential vorticity in the water column with mean depth = 200m, mean potential density = 27.1 kg m^{-3} and mean potential temperature and salinity of 12.18 °C and 35.68. ENACW thermohaline properties record exhibits decadal variability with two maxima identified in early 70s and early 90s. Correlations with large-scale atmospheric forcing (from NCEP/NCAR reanalysis), teleconection indices and Gulf stream position were performed and the results are herein discussed. EOF analysis of the buoyancy fluxes give an indication of the ENACW formation area as well as atmospheric conditions associate to ENACW changes reveal the causes the its variability. Preliminary results show that local air-sea interaction and circulation plays an important role in modulating the signal of the large-scale atmospheric forcing.

OS32F-195 1330h POSTER

Mediterranean Influence on the Climate of the North Atlantic

Rachel A Potter[1] (919-684-6227; rap6@duke.edu)

M Susan Lozier[1] (919-681-8199; s.lozier@duke.edu)

[1]Earth and Ocean Sciences, Duke University, Box 90230, Durham, NC 27708-0230, United States

Recent studies (Bryden et al., 1996; Joyce et al., 1999) of repeated hydrographic sections in the North Atlantic have revealed significant property changes centered around 1000m. To determine the extent to which the Mediterranean overflow waters contribute to the observed property changes, we are examining NODC historical hydrographic data that spans the last century. Temperature changes on both isopycnals and isobars throughout the water column are being used to assess the temporal variability in the eastern North Atlantic at the depth of the overflow waters and the degree to which these changes are correlated with depth. To date we have found significant changes in the waters of the eastern North Atlantic over the last fifty years. A warming trend of approximately 0.7°C/century is centered around the depth of the overflow waters, while there appears to be a cooling trend of approximately 0.5°C/century in waters just below the mixed layer. In addition to the warming trend, the overflow waters are characterized by a strong temporal oscillation, which may be related to the penetration of a surface NAO signal. Remaining work includes determining the relative extent to which heaving and/or water mass changes contribute to the observed warming. Additionally, we aim to define the spatial extent of the Mediterranean warming signal in an attempt to understand the source of the deep North Atlantic's climate variability.

OS32F-196 1330h POSTER

Looping ACCE RAFOS Floats in Eddies

Philip L Richardson[1] (508-289-2546; prichardson@whoi.edu)

Deb Slater[2] (44 023 8059 6666; www.soc.soton.ac.uk)

Amy S Bower[1] (508-289-2781; abower@whoi.edu)

H. Thomas Rossby[3] (401-874-6521; trossby@gso.uri.edu)

[1]Woods Hole Oceanographic Institution, Dept of Physical Oceanography, Woods Hole, MA 02543, United States

[2]Southampton Oceanography Centre, Waterfront Campus European Way, Southampton SO14 3ZH, United Kingdom

[3]University of Rhode Island, Graduate School of Oceanography, Narragansett, RI 02882-1197, United States

ACCE RAFOS float data near the 27.5 density level were analyzed to investigate discrete eddies in the northern North Atlantic. Floats that made two or more consecutive loops in the same direction (loopers) were considered to have been in an eddy. Overall 16% (25 float years) of the float data were in loopers. One hundred eight loopers were identified in 96 different eddies. Roughly half of the eddies were cyclonic (49%) and half were anticyclonic (51%), although the percentages varied in different regions. Some eddies were stationary for long times (up to 251 days) and others clearly translated, often in the direction of the general circulation as observed by non-looping floats. Several floats were trapped in eddies just upstream (west) of the Charlie Gibbs (52N) and Faraday (50N) Fracture Zones which seem to be preferred routes for flow crossing the mid-Atlantic Ridge. Six floats looped in five anticyclones which translated southwestward away from the eastern boundary near the Goban Spur near 47N-50N. These could be weak Meddies forming from remnants of warm salty Med Water advected northward along the eastern boundary. The trajectories of deeper RAFOS floats and surface drifters provide information on the vertical structure of some of the eddies.

OS32F-197 1330h POSTER

Using a Global Tidal Model for Removing Tides From Direct Velocity Measurements in the Faroe Bank Channel

Daniel J Torres[1] (508-289-2845; dtorres@whoi.edu)

Cecilie Mauritzen[1] (508-289-2660; cmauritzen@whoi.edu)

[1]Woods Hole Oceanographic Institution, 266 Woods Hole Road MS 21, Woods Hole, MA 02543, United States

In June of 2000, a process study of the Faroe Bank Channel Overflow system was undertaken. One of the goals of the field program was to obtain a high resolution data set of direct velocity measurements in order to determine transports along the Channel. A total of 217 Conductivity, Temperature, and Depth (CTD) stations were occupied. Direct velocity measurements included lowered Acoustic Doppler Current Profiler (LADCP) casts, expendable current profiler (XCP) drops, and underway shipboard ADCP. All of these direct velocity measurements provide "instantaneous" snapshots of the water column at the given time of measurement. One of the difficulties of analyzing such measurements is separating the desired low frequency signal from the often energetic high frequency "noise". Among the sources of noise are barotropic tides, internal tides, inertial oscillations from sporadic wind events, mesoscale eddies, etc. Here we evaluate the ability of the 1/6 degree resolution and 1 degree resolution OSU Topex/Poseidon global inverse tidal model to estimate and remove the barotropic tidal signal from the LADCP data. The model was first compared to current meter data in the Faroe Bank Channel region and other North Atlantic locations to determine its ability to predict tidal currents. The rate of change in filtered shipboard ADCP velocity was then compared to the rate of change in tidal velocity in order to see if at least some component of the measured absolute velocity changed on the same time scale as the tide. It is determined that using the OSU tidal inverse models to detide the LADCP velocity measurements prior to making transport estimates is advantageous in most of the Faroe Bank region.

OS32F-198 1330h POSTER

Does convection take place above the Labrador slope?

Jerome Cuny[1] (206-543-0769; jcuny@ocean.washington.edu)

Peter Rhines[1] (206-543-0593; rhines@ocean.washington.edu)

[1]School of Oceanography, University of Washington, Box 355351, Seattle, WA 98195-5351, United States

An 18-month long record (1996-1998) from a mooring located in the core of the deep boundary current above the Labrador slope shows the vanishing of the Irminger Sea Water warm signal every winter. Combining this record with numerous hydrographic casts collected between May 1996 and May 1997, we describe possible mechanisms to explain the cooling in the different parts of the Labrador Current. In the more barotropic 'deep'Labrador Current, centered above the lower Labrador slope, the vertical homogenization of the column over 800m is responsible for the mixing of the warm water. Close to the mooring location, the water column heat content change between October 1996 and March 1997 is $2.9 * 10^9$ $J.m^{-2}$. During the same period, the air-sea heat fluxes account only for $9.6 * 10^8$ $J.m^{-2}$. Hence, it is necessay to consider other buoyancy forcing such as Ekman transport of denser water from offshore. In the more baroclinic 'classical' Labrador Current, centered close to the shelf break, the ISW is also mixed away but the vertical and horizontal stratification remains significant throughout winter. In this case, the cooling is due to along isopycnal intrusions of cold water coming from the surface. Surface drifters and PALACE floats provide pathways, estimate of transit times and the water column evolution for the waters encircling the Labrador Sea. A 20-year temperature and velocity record from bottom instruments above the 1000m isobath and the repeat spring AR7W section during the 90s, help to understand the interannual variability of these winter processes. We emphasize the comparison between a low (1995/96) and a high (1988/89) NAO winter index year.

OS32F-199 1330h POSTER

A Bayesian Hierachrical Model Testbed for Air-Sea Interaction

Ralph F Milliff[1] (303-415-9701 x216; milliff@colorado-research.com)

Mark Berliner[2] (614.292.0291; mb@stat.ohio-state.edu)

Christopher K Wikle[3] ((573)882-9659; wikle@stat.missouri.edu)

[1]Colorado Research Associates , (a division of NWRA) 3380 Mitchell Lane, Boulder, CO 80301-5410, United States

[2]Statistics Department , Ohio State University 1958 Neil Ave, Columbus, OH 43210-1247, United States

[3]Statistics Department, 222 Mathematical Sciences Bldg University of Missouri, Columbia, MO 65211, United States

The Bayesian Hierarchical Model (BHM) methodology is applied in a testbed model of air-sea interaction

on the scale of an ocean sub-basin (e.g. the Labrador Sea). The methodology is demonstrated in the context of an Observing System Simulation Experiment (OSSE), wherein simulated scatterometer and altimeter data are combined with prior probability distributions based on quasigeostrophic dynamics for surface winds and upper ocean circulation, respectively. Surface winds are designed to represent forcing by an intense atmospheric cyclone as it propagates across the ocean domain (e.g. as in the case of a "polar low"). The BHM ocean model response is compared to a high-resolution "truth" simulation from a primitive-equation shallow-water model solution, driven by a complete wind dataset (i.e. not sub-sampled to mimic scatterometer data). The BHM air-sea model generates posterior probability distributions for surface winds, ocean streamfunction, and various model parameters. Distributional information quantifies model uncertainty as a function of space and time throughout the simulation.

OS32F-200 1330h POSTER

Surface Variability in the North and Tropical Atlantic Ocean in Response to the Seasonal Atmospheric Forcing

Nadia K. Ayoub (+33 5 61 33 29 24; nadia.ayoub@cnes.fr)

LEGOS/CNRS, 18 avenue Edouard Belin, Toulouse 31401, France

The objective of this work is to investigate the North and Tropical Atlantic Ocean response to atmospheric forcing in terms of Sea Surface Temperature (SST) and Sea Surface Height (SSH) variability. The interest is on large scales motions (> O(100 km)) and seasonal time scales. The work is based on a simulation from a primitive equations model (the MIT-GCM). The adjoint of the MIT-GCM is used to perform sensitivity studies. It allows us to explore the space-time structures of the wind and heat flux forcing on the SST and SSH at different time scales and to compare quantitatively the signature on both variables (SST and SSH) of the forcing. The underlying goal is to determine the constraint that SST and SSH observations can exert on the model when they are assimilated using an adjoint method.

OS32F-201 1330h POSTER

Weakly Nonlinear Interaction of Forced-Dissipated Flow and Basin Modes in the Barotropic Quasi-geostrophic Wind Driven Circulation.

Mahdi Ben Jelloul[1] (33 (0) 1 44 27 27 07; benjello@lodyc.jussieu.fr)

Thierry Huck[2] (33 (0) 298-016510; Thierry.Huck@univ-brest.fr)

[1]Laboratoire d'Oceanographie Dynamique et de Climatologie, (Case 100) Univ. P. et M. Curie, 4, place Jussieu, Paris CEDEX 05 75252, France

[2]Laboratoire de Physique des Ocans, Universit de Bretagne Occidentale, BP 809,, Brest cedex 29285, France

The linear solution of the barotropic quasi-geostrophic wind driven circulation can be decomposed in a steady forced solution and a time dependent component. The steady wind forced solution consists in a classical Sverdrup flow dissipated in a thin western boundary layer where the viscosity is active. The homogeneous time dependent solution is a sum of basin modes with arbitrary amplitudes.

The effect of the nonlinear term is handled through a weakly nonlinear analysis providing a set of evolution equations for the modes amplitudes. It can be proven that mode stability is related to wind stress symmetry and saturation amplitude can be computed in this case. Pure basin modes interactions yield triads with cycling energy and sub-harmonic instabilities.

OS32F-202 1330h POSTER

COAPEC (Coupled Ocean Atmosphere Processes and European Climate): An Overview

Alan Thorpe[1] (44-118-9316979; A.J.Thorpe@reading.ac.uk)

Helen Mary Snaith[2] (44-23-8059; h.snaith@soc.soton.ac.uk)

Matthew Collins[3] (44-118-987 5123; mat@met.reading.ac.uk)

Pierre-Philippe Mathieu[3] (44-118-987 5123; mathieu@met.reading.ac.uk)

Bablu Sinha[2] (44-23-80597742; B.Sinha@soc.soton.ac.uk)

[1]NERC Centre for Atmospheric Science, University of Reading, PO Box 243, Earley Gate, Reading RG6 6BB, United Kingdom

[2]Southampton Oceanography Centre, European Way, Southampton SO14 3ZH, United Kingdom

[3]Department of Meteorology, University of Reading, PO Box 243, Earley Gate, Reading RG6 6BB, United Kingdom

The UKs NERC Thematic Programme COAPEC (http://coapec.nerc.ac.uk/) started in 1999 and will run for five years. The goal of COAPEC is to determine the impact on climate, especially European climate, of the coupling between the atmosphere and the Atlantic Ocean on seasonal to decadal timescales. The work programme has four main elements, each of which is identified by a key question. 1. What are the observed characteristics of seasonal-to-decadal climate variability in the Atlantic Sector? 2. How do the mean climate and climate variability in the Atlantic Sector simulated by a Coupled General Circulation Model differ from that observed? How do we correct model deficiencies? 3. What are the physical mechanisms that determine the mean climate and seasonal-to- decadal climate variability in the Atlantic Sector? 4. What processes determine the predictability of climate fluctuations in the Atlantic- European region? A fifth element targets meeting user needs. 5. Bridging the gap between scientific output and societal needs Within the framework of the COAPEC programme, there are two avenues of funded research: the funding of projects submitted by UK researchers through Announcements of Opportunity and also through the COAPEC core team. This core team consists of four researchers, fully funded through COAPEC, who each follow a personal research programme designed to benefit COAPEC science. In addition, the core team provide scientific support to the COAPEC community. This poster presents the COAPEC programme, together with some results from the core team research and funded projects.

OS32F-203 1330h POSTER

Convective Submesoscale Coherent Vortices in the Greenland Sea

Tor Eldevik[1] (+47 55297288; tor.eldevik@nersc.no)

Helge Drange[1] (helge.drange@nersc.no)

Truls Johannessen[2] (truls.johannessen@gfi.uib.no)

Jean-Claude Gascard[3] (gascard@lodyc.jussieu.fr)

Guttorm Alendal[1] (guttorm.alendal@nersc.no)

[1]Nansen Environmental and Remote Sensing Center, Edvard Griegs vei 3a, Bergen 5059, Norway

[2]Geophysical Institute, Bjerknes Center, University of Bergen, Allgt 70, Bergen 5007, Norway

[3]LODYC, University Pierre et Marie Curie, 4 place Jussieu, Paris 75252, France

The Greenland Sea Gyre, with its interior doming of isopycnals, is a hot spot for ocean convection. Deep convection in the area is traditionally associated with the erosion of the gyre dome by strong wintertime buoyancy loss, leaving the weakly stratified interior exposed. Convection will thus ventilate the waters within the gyre to great depths. During the last decade, however, such deep convection has only been observed in very localized areas. Maps of float trajectories and hydrographic measurements from the Greenland Sea during the winter 1996-1997 (cf. ESOP2/MAST3 Final Scientific Report), unambiguously associate thick homogeneous anomalies in that period with submesoscale coherent vortices (SCVs). These long-lived (1 year or more) anti-cyclones populate the gyre. Their homogeneous cold core reaches a depth of 2000 m, has a relative vorticity of $-f/2$, and a radius of a few kilometers (aspect ratio 0.1 to 0.2).

We suggest a simple conceptual model for the generation and evolution of Greenland Sea SCVs, based on a gyre jet separating a stratified exterior from a more homogeneous interior. This configuration is continuously prone to baroclinic instabilities. A result is (sub-)mesoscale anomalies with weakly stratified cores, amiable to both stretching and mixing. When subject to buoyancy loss, homogenization and stretching of thecore may take place, and an SCV is the result.

Non-hydrostatic numerical experiments are being set up to validate this and similar models of SCVs and deep convection. Preliminary results will be compared with the above observations, and their implications will be discussed.

URL: http://www.nersc.no/~torel/

OS32F-204 1330h POSTER

Direct Lagrangian Estimates of the Absolute Velocity Field in the Main Thermocline of the Northeast North Atlantic, North of 38N.

T. Rossby[1] (trossby@gso.uri.edu); Amy Bower[2] (abower@whoi.edu); Bernard LeCann[3] (bernard.le-cann@univ-brest.fr); Mark Prater[1] (mprater@gso.uri.edu); Phil Richardson[2] (prichardson@whoi.edu); Michael Sparrow[4] (mdsp@soc.soton.ac.uk); Kevin Speer[5] (kspeer@ocean.ocean.fsu.edu); Walter Zenk[6] (wzenk@ifm.uni-kiel.de); Huai-Min Zhang[1] (hzhang@gso.uri.edu)

[1]Graduate School Of Oceanography , University of Rhode Island, Narragansett, RI 02882, United States

[2]Woods Hole Oceanographic Institution, Woods Hole, MA, United States

[3]CNRS , Laboratoire de Physique des Oceans, Brest, France

[4]WOCE CLIVAR Project Office, Southampton Oceanography Centre, Southampton, United Kingdom

[5]Dept. of Oceanography , Florida State University, Tallahassee, FL, United States

[6]Department of Institut fur Meereskunde , Dusternbrooker Weg 20, Kiel, Germany

As part of the U.S. WOCE Atlantic Climate Change Experiment (ACCE), the European EUROFLOAT experiment, the German SFB Subpolar program and the French ARCANE experiment, several groups in the US and Europe collaborated in a major initiative to determine the absolute velocity field in the northeast Atlantic using acoustically tracked, eddy-resolving RAFOS and MARVOR floats. Floats were deployed on two levels. In this paper we discuss the results from the measurements on an upper ocean isopycnal representing the northward spread of subtropical thermocline waters. The paper following this one focuses on the waters at 1500-1750 m, the depth range of the main body of Labrador Sea Water (LSW). Unlike subtropical and tropical gyres which are substantially shaped by the prevailing winds, the circulation patterns in the northern North Atlantic reveal the dynamic straightjacket imposed by the shape of the ocean basins. A very striking result to emerge is how the warm thermocline waters originating in the Gulf Stream are restricted to crossing the mid-Atlantic ridge at the Charlie-Gibbs and Faraday Fracture Zones, and subsequently spread into the Iceland Basin and back west into the Irminger Sea. Waters from the eastern margin, with some contribution from the Mediterranean, spread north just west of the Rockall Plateau and essentially wrap around the entire Iceland Basin, turning west and south along the Reykjanes Ridge before crossing over into the Irminger Sea.

The eddy kinetic energy distributions are similar for the two surfaces ranging from high levels in the center of the Iceland Basin, O(200) cm^2/s^2, to very low values over the eastern flank of the Reykjanes Ridge as well as over the mid-Atlantic Ridge south of the fracture zones, O(10) cm^2/s^2. Over large areas in the western European Basin both the mean flow and the eddy kinetic energy levels are quite low. Due to the stabilizing effect of bathymetry, the ratio of mean to eddy kinetic energy can approach unity in certain areas such as over the fracture zones and along the eastern slope of the Reykjanes Ridge.

OS32F-205 1330h POSTER

Sources of Interannual Variability in the Barents Sea

Sarah L. Zimmermann[1] (907 - 474 - 2456; sarahz@ims.uaf.edu)

Mark A Johnson[1] (831 - 656 - 3269; majohnso@nps.navy.mil)

[1]Institute of Marine Sciences, University of Alaska Fairbanks PO Box 757220, Fairbanks, AK 99775, United States

The Barents Sea plays an important role in the Arctic Ocean's thermohaline structure by modifying inflowing Atlantic water. The influence of atmospheric systems on ocean circulation is examined using hydrographic data from the Barents Sea. Atlantic derived water is the largest water mass in the Barents Sea, advected from the Norwegian Sea via the Norwegian Atlantic Current (NAC). Results show that following removal of the annual signal, Barents Sea waters have interannual variations in temperature of $\pm 1^{\circ}C$ and in salinity of ± 0.1. The source and fate of these anomalies are examined for the period 1975 to 1995. Temperature and salinity anomalies have been tracked in the NAC as it flows north along the Norwegian coast (Belkin et al., 1998). The NAC anomalies are compared with those

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within the Barents Sea. The two show similar patterns below 50m. Within the Barents Sea, a larger anomaly is found in the top 30m than in deeper waters during the summer and is due to Arctic influences such as the addition of polar water and ice melt. We examined the local and central arctic wind velocity to understand the effects on ice growth and transport. We also examined the NAO index and storm tracks to asses the delivery of heat and precipitation. Results show the winter NAO index correlates with the temperature anomaly, consistent with other studies. However, salinity, which dominates the density in the Barents Sea, does not correlate after 1985. An explanation for these anomalies will be presented. Long term trends of anomalies were calculated and show a freshening but no change in temperature.

OS32F-206 1330h POSTER

Hindcasting the Uptake of Anthropogenic Trace Gases with an Eddy-Permitting Model of the Atlantic Ocean

Lars Czeschel[1] (lczeschel@ifm.uni-kiel.de); Claus W. Böning[1] (cboening@ifm.uni-kiel.de); Jens-Olaf Beismann[1] (jobeismann@ifm.uni-kiel.de); Christoph Völker[2] (cvoelker@awi-bremerhaven.de); René A. Redler[3] (redler@ccrl-nece.de); Joachim Dengg[1] (jdengg@ifm.uni-kiel.de)

[1]Institut für Meereskunde Kiel, Düsternbrooker Weg 20, Kiel 24105, Germany

[2]Alfred-Wegener-Institut für Polar- und Meeresforschung, Columbusstr., Bremerhaven 27568, Germany

[3]C&C Research Laboratories, NEC Europe Ltd., Rathausallee 10, Sankt Augustin 53757, Germany

The ocean takes up a large fraction of the perturbation CO_2 that enters the atmosphere by human activity. A realistic representation of this uptake in numerical models is essential for future climate studies. Uptake of CO_2 or other atmospheric trace gases depends on circulation features such as thermocline ventilation that are strongly influenced by oceanic physical variability at spatial scales between 20 and 100 km. Our main goal is to study the effect of this mesoscale variability on the cumulative uptake of anthropogenic CO_2 and chlorofluorocarbons during the last century using an existing model of the Atlantic ocean that resolves a significant part of that variability explicitly because of its grid spacing of about 20 km. Both CO_2 and CFC-11 inventories are compared to observational estimates and to solutions obtained with a medium-resolution ($4/3^\circ$) configuration of our model. While the total uptake of anthropogenic CO_2 does not differ strongly between the two models, regional distributions are strongly affected by an explicit representation of oceanic mesoscale variability. The simultaneous simulation of CFC-11 and anthropogenic CO_2 at sufficiently high resolution will be used to explore whether a correlation between CFCs and anthropogenic CO_2 - as observed in the North Atlantic - can be established and to which degree CFCs can be used as proxies for anthropogenic CO_2 concentrations.

OS32F-207 1330h POSTER

Lagrangian Measurements of the Faroe Bank Channel Overflow

Mark D. Prater (401-874-6512; mprater@gso.uri.edu)

Graduate School of Oceanography, University of Rhode Island, South Ferry Road, Narragansett, RI 02882-1197, United States

A dozen acoustically tracked, nearly neutrally-buoyant bottom-following RAFOS floats were deployed in the Faroe Bank Channel Overflow in the summer of 2000. The purpose was to examine the overflow current in a Lagrangian framework – that is, to tag and follow the water parcels as they flow over the sill and along topography into the Iceland Basin. A bottom-following instrument was required to obtain truly Lagrangian measurements since overflow waters do not flow along constant pressure (isobaric) or constant density (isopycnal) surfaces. Instead, the waters mix with and entrain the overlaying warm and more saline properties of the Iceland Basin, and thus the overflow waters change depth, properties, and density as they move downstream. At the Faroe Bank Channel, the flow drops at least 400 m in the first 250 km downstream of the sill and warms from nearly -1°C to over 3°C.

These floats were equipped with wings that served as drogues, and maintained height above the bottom by means of a thin 100-m long tagline (or "tail") of monofilament line and stainless steel wire beneath it. The floats were ballasted to be slightly heavy for the water density at the sill, so slightly over a meter of wire was laying on the bottom (with the float suspended nearly 100 m above). As the floats were carried downstream, they remained "heavy" compared to the surrounding waters, and thus the taglines remained in contact with the bottom. However, as the floats descended following the outflow, the difference in compressibility with that of seawater caused the floats to become more buoyant and thus lift some wire off the bottom. This continued until all the wire had been lifted, at which time the floats became neutrally buoyant, lost contact with the bottom, and followed the flow of water on an isobaric surface.

The results of these depoyments will be presented, along with plans for an improved bottom-following float. Unfortunately, during this experiment several floats' taglines became snagged on the bottom and prevented them from following the current. A more sophisticated bottom-follower is planned that would use an acoustic altimeter and a buoyancy-changing mechanism to maintain its height above the bottom, and thus would not require direct contact via a tagline.

OS32F-208 1330h POSTER

Real-time forecasting of biophysical interactions at the Iceland-Faeroes Front in June 2001

Ekaterina E Popova[1] (+44-23-8059-6346; ekp@soc.soton.ac.uk)

Meric A Srokosz[2] (+44-23-8059-6414; mas@soc.soton.ac.uk)

David A Smeed[2] (+44-23-8059-6407; das@soc.soton.ac.uk)

[1]George Deacon Division for Ocean Process, Southampton Oceanography Centre, Empress Dock, Southampton SO14 3ZH, United Kingdom

[2]James Rennell Division for Ocean Circulation and Climate, Southampton Oceanography Centre, Empress Dock, Southampton SO14 3ZH, United Kingdom

Real-time physical and biological forecasting was carried out at sea in June 2001 at the Iceland-Faeroes Front using a 3D coupled physical and biological model. The biological model includes the following state variables: phytoplankton, two size classes of zooplankton, nitrate, ammonium and detritus. The aims of the forecasting were a) to enable better understanding of the asynoptically acquired data, and b) to optimise the cruise sampling strategy in near real-time.

Data collected during three repeated mesoscale surveys were used for model initialisation, data assimilation and forecast verification. The forecast successfully predicted the evolution of an anti-cyclonic meander and associated biological processes. The model proved to be a valuable tool for optimisation of the cruise strategy and synthesising the different biological and physical data, thus aiding the interpretation of the coupled processes.

OS32F-209 1330h POSTER

On the Interaction Between the Gulf Stream and the New England Seamount Chain.

Angelique Haza[1] (305 613 2851; ahaza@rsmas.miami.edu)

Nathan Paldor[1] (305 361-4816; npaldor@rsmas.miami.edu)

Arthur Mariano[1] (305 361 4193; amariano@rsmas.miami.edu)

[1]RSMAS / MPO, University of Miami, 4600 Rickenbacker csw, Miami, FL 33149, United States

The influence of the New England Seamount Chain (NESC) on the Gulf Stream's path and transport cannot be captured easily by ocean general circulation models, because the small scale of a seamount requires both high vertical and horizontal resolutions, as well as non-hydrostatic physics. A significant impact of the seamount chain on the Gulf Stream would however affect the slope-water circulation, lateral displacement of the Stream, water masses and heat distributions. Two idealized studies relevant to this topic are presented.

The development of linear wave-like instabilities on a geostrophic surface front in a 2-layer shallow water configuration is studied analytically and numerically, as a function of the layer-thickness aspect ratio, geostrophic velocity and distance between a vertical wall and the outcropping point. It is shown that for a range of parameters corresponding to the Gulf Stream over the NESC at a distance L from the continental slope, the fastest growing wave has a wavelength of 200km and a downstream propagation phase speed of 30cm/sec. Such meanders have been detected by satellite observations of the Gulf Stream.

As a complementary study, a 2D-numerical simulation of a stratified flow over a seamount with a non-hydrostatic code is conducted in order to quantify the vertical mixing on the lee side of the obstacle. The averaged vertical velocity downstream the seamount is roughly calculated as a function of the Froude number and the ratio of the height of the seamount to the total fluid depth. Results suggest that vertical velocities and mixing at seamounts' locations should be considered and parameterized in OGCMs in order to represent upper-layer topographic coupling.

OS32F-210 1330h POSTER

Descent and Modification of the Denmark Strait Overflow Plume

James B Girton[1] (206-685-9670; girton@sigmaxi.org)

Thomas B Sanford[1] (206-543-1365; sanford@apl.washington.edu)

[1]Applied Physics Laboratory, University of Washington 1013 NE 40th Street, Seattle, WA 98105-6698, United States

In two high-resolution surveys with expendable (XCP/XCTD) profilers in 1997 and 1998, we collected velocity, temperature and salinity data from the region of the Denmark Strait sill and initial overflow descent. It is in this first descent that most entrainment occurs and the properties of the subsequent deep boundary current are effectively determined. In the same region, a persistent train of cyclonic surface eddies appears, generated by the deep flow through either an instability during the transition of the broad sill or vortex stretching of the overlying water during the initial descent.

Despite the presence of considerable short-term variability, we find that the pathway and evolution of the plume density anomaly are remarkably steady. Bottom stress measurements from logarithmic fitting of the velocity profile show that the pathway of the plume core matches well with a rate of descent controlled by friction. The estimated entrainment rate diagnosed from the rate of plume dilution with distance is consistent with previous reports of a doubling of overflow transport measured by current meter arrays. In addition, there is a marked increase in entrainment at approximately 125 km from the sill, a location that is also marked by the appearance of the surface cyclones. This increased entrainment is likely related to the increased topographic slopes in the region, compounded by a decrease in interface stratification as the plume is diluted and enters a denser background.

URL: http://ohm.apl.washington.edu/~girton/working/paper/plume.pdf

OS32F-211 1330h POSTER

Distribution of Chlorofluorocarbons in the North Atlantic, 1996-1998

Deborah A. LeBel[1] (1-845-365-8655; lebel@ldeo.columbia.edu); William M. Smethie[1]; John L. Bullister[2]; E. Peter Jones[3]; Dong-Ha Min[4]; Monika Rhein[5]; Wolfgang Roether[5]; Denise Smythe-Wright[6]; Ray F. Weiss[7]

[1]Lamont-Doherty Earth Observatory of Columbia University, 61 Route 9W P.O. Box 1000, Palisades, NY 10964-1000, United States

[2]NOAA/Pacific Marine Environmental Laboratory, 7600 Sand Point Way N.E. Bldg. 3, Seattle, WA 98115-6349, United States

[3]Bedford Institute of Oceanography, 1 Challenger Drive P.O. Box 1006, Dartmouth, NS B2Y 4A2, Canada

[4]School of Oceanography, University of Washington, P.O. Box 355351, Seattle, WA 98195-5351, United States

[5]Institut für Umweltphysik der Universität Bremen, Kufsteiner Strasse, Geb.NW 1, Bremen 28359, Germany

[6]Southampton Oceanography Centre, Empress Dock, European Way, Southampton SO14 3ZH, United Kingdom

[7]Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, LaJolla, CA 92093-0220, United States

During the 1996-98 North Atlantic WOCE period, chlorofluorocarbons were measured on sixteen sections in the North Atlantic. Data were collected primarily in 1997 and include a late winter cruise in the Labrador Sea during a period of active convection. As part of the initial basin-wide synthesis of the CFC measurements in the North Atlantic, we present maps of CFC-11 distribution on a number of key neutral density surfaces. These surfaces were selected to highlight the formation and circulation of several important water masses. In the subtropical region, these include the Eighteen Degree Water and the Overflow Water transported in the Deep Western Boundary Current south of the Grand Banks. In the subpolar region, we show the distribution on surfaces corresponding to two vintages of Labrador Sea Water, Iceland-Scotland Overflow Water which enters the western basin through the Gibbs Fracture Zone, more dense Iceland-Scotland Overflow Water restricted to the eastern basin, and Denmark Strait Overflow Water.