Abstracts - Workshop #9 (AOMIP)

1. Arbetter, T.
   NSIDC Data: Sea Ice and Ocean products.

   An overview is given of NSIDC web-based products, as well as instructions on how to navigate the NSIDC site. A few key datasets are highlighted. One purpose of the talk is to solicit feedback from the AOMIP group on what data they might use from NSIDC and what they might like to see in the way of improvements.

2. Gerdes, R.
   Improved results in the 1/12-degree resolution NAOSIM

   The new member of AWI's NAOSIM hierarchy of ocean-sea ice models has 8km horizontal resolution and 50 levels in the vertical while covering the same area as the 1/4-degree model. The model physics and the boundary conditions are the same as in the corresponding 1/4-degree version from which initial conditions (January 1990) were taken. Especially large changes compared to the lower resolution version occur in the circulation and hydrography of the Nordic Seas. In Fram Strait a strong recirculation develops that is associated with higher temperatures in the West Spitsbergen Current as well as the return Atlantic Water. The East Greenland Current occupies a smaller region over the Greenland Shelf and is shallower than its counterpart in the 1/4-degree model. Reasons and consequences (e.g. for Arctic Ocean fresh water balance) of these differences are not yet clear.

3. Gerdes, R.
   CORE experiments

   The CLIVAR Working Group on Ocean Model Development has initiated the so-called CORE (Common Ocean Reference Experiments). Part of this initiative was the generation of global forcing data sets for ocean-sea ice model integrations. Documentation can be found at http://data1.gfdl.noaa.gov/nomads/forms/mom4/CORE.html. I shall present features of these forcing data sets and highlight the differences compared to the AOMIP forcing.

4. Golubeva, E., and G. Platov
   The study of the Arctic water circulation on the basis of numerical experiments with different parameterizations

Three numerical experiments were carried out for the period of 1948-1978 on the basis of the ICMMG model in order to investigate the role of some key parameterizations widely used in modern sea-ice modeling: Neptune parameterization and restoring of surface salinity. The first experiment, which is considered as the basis for further comparison, had none of them. The second experiment was to examine the effect of Neptune parameterization. The latter was compared and analyzed against the third one incorporating restoring of surface salinity (without Neptune). The general circulation pattern in all three cases is found to be substantially different and each of them has its particular faults and advances. The key characteristic, we focused on in our study of model results, is the propagation of Atlantic-Layer Water in the Arctic Ocean. The analyses shows that results are very sensitive to the examined parameterizations and should be treated with some extra care whilst interpreting the consequences.

5. Hibler, W.D.
   Tidal Forcing and sea ice

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6. Holland, D.M., and C. Konig
   Modeling Landfast Ice in the Arctic

   Landfast ice is sea ice which forms and remains fast along a coast, where it is attached either to the shore, an ice wall, an ice front, or between shoals or grounded icebergs. Landfast ice is important because it fundamentally modifies, relative to pack ice, the momentum exchange between atmosphere and ocean and thus the location of upwelling and downwelling zones. It also affects the heat and freshwater exchange between air and ocean and consequently impacts where dense waters are produced. Current-generation sea-ice models are not capable of reproducing certain aspects of the processes of landfast ice formation, maintenance, and disintegration. In this presentation, we demonstrate an alteration to a standard formulation of sea-ice rheology so as to include tensile stresses. These stresses are formulated as a function of sea-ice salinity, temperature, age, and thickness. Using a limited-domain, high-resolution model, an ability to model some aspects of landfast ice features is demonstrated.

7. Holloway, G., and A. Proshutinsky
   The role of tides in arctic ocean/ice climate

   We utilize one of the AOMIP (Arctic Ocean Model Intercomparison Project) models to examine the influence that Arctic tides may exert upon the long term climate of the ocean and ice system. Output from a previous tidal model provides a parameterization of vertical mixing in the water column as well as affecting lead opening and mobility of sea ice. Results include loss of heat from the Atlantic Layer, leading to sea ice reduction which is offset by higher growth due to fracturing the ice cover. Climatic consequences are considered within and beyond the Arctic.

8. Holloway, G.
   A survey of present efforts improving AOMIP models

Among the greatest challenges for AOMIP is the perception, ours and others', that a main goal of, and reason for, AOMIP is to somehow improve arctic models. How are we, as AOMIP, doing at this? What can we do? The purpose for this talk is to open the topic for discussion. We'll visit a short survey of improvements following virtual workshop #8 and consider differences among our models' formulations that may invite further improvment. Then the big question, appreciating inadequacies in both forcing and validation data, is to see how (if?) AOMIP can proceed with respect to improving models.

9. Hunke, E.
GM vs biharmonic ocean mixing in the Arctic

As part of the Arctic Ocean Model Intercomparison Project (AOMIP), the LANL ice-ocean modeling team completed two 55-year, global, ice-ocean simulations forced with reanalysis atmospheric data for 1948-2002. These two simulations differ only in the parameterization used for lateral mixing of tracers (potential temperature and salinity) in the ocean, but the resulting circulation and kinetic energy of the simulated oceans are very different, particularly at high latitudes. The differences can be traced to two effects, (1) scale selectivity, in which the Laplacian form of the Gent and McWilliams (GM) parameterization damps wave energy more quickly than the biharmonic mixing formulation, and (2) grid dependence of the diffusion coefficient, which appears in the biharmonic formulation but not in GM and is particularly important at high latitudes, where the grid scale decreases dramatically on the sphere. Future global simulations using the GM parameterization should include a diffusivity scaling factor given by the square root of the grid cell area, to prevent diffusion from dominating advection in the evolution of high latitude tracers and circulation.

10. Karcher, M., and F. Kauker
Atlantic Water movement in the Arctic - the state of the AOMIP analysis and an update on AOMIP relevant results with NAOSIM

We will present the current state of analysis on the stability and sense of rotation of AW in the Arctic. In addition to a direct comparison of 3 AOMIP models (AWI/UW/LANL) we will present results from dedicated sensitivity experiments with changed advection schemes. A switch from FCT to centered differences leads to a flow reversal of AW even when started with fully developed cyclonic flow. In the second part some resent results with the AWI NAOSIM model are presented, which are relevant for the AOMIP study: the advance of a new warming signal from the Nordic Sea into the Arctic, and the release of a large freshwater release following the 1990s restructuring of Arctic hydrography.

11. Kauker, F., R. Gerdes, R. Giering, T. Kaminski, and M. Karcher
The NAOSIM Data Assimilation System (NAOSIMDAS) - Project aims and first obstacles

The EU-funded project "Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies" (DAMOCLES), embedded in IPY, will compile observations from the atmosphere, cyrosphere, and ocean in an unprecedented way in the years 2006 to 2009. DAMOCLES aims at reducing the uncertainties in our understanding of climate change in the Arctic and their impacts. Part of this effort is to establish a monitoring system of the Arctic. Numerical Modelling will support the design of this systm by (i) identifying key regions of interest (sensitivities) and by (ii)integrating the observations compiled during DAMOCLES by

means of data assimilation. The AWI model NAOSIM will be used for 4d variational data assimilation. The adjoint of NAOSIM will be generated with the automatic differentiation tool TAF (Transformation of Algorithms in Fortran by FastOpt) and a data assimilation system will be established around the adjoint (NAOSIM-DAS). A 'finite difference experiment' will be presented which may serve to illustrate which kind of problems we will have to face to achieve this ambitous objective.

12. Koeberle, C.
Arctic sea ice and fresh water budget and the performance of climate models with regard to these variables in the Arctic

This talk will present ice and fresh water budgets of the Arctic, and the Nordic Seas and Baffin Bay. The budgets will be compared to the numbers of Aagaard and Carmack. The role of the restoring term and some causes for its size and shape will be discussed. The same analysis will be shown for one or two IPCC experiments.

13. Lemieux, J.-F., J. Sedlacek, B. Tremblay, D.M. Holland, and L. A. Mysak
Arctic sea-ice modeling: the UVic model with a granular sea ice model

Arctic sea-ice cover observations and earlier modeling results will be presented. The talk describes the difficulties in Arctic sea-ice modeling and the importance of a sophisticated thermodynamic/dynamic sea-ice model to appropriately simulate the interactions of sea ice with the other climate components. We specifically focus on the different sea-ice rheologies used in sea-ice modeling. We next introduce the granular sea-ice model (Tremblay and Mysak, 1997) and describe its advantages and weaknesses. We have converted the granular sea-ice model to spherical coordinates. The spherical-coordinates granular sea-ice model has been coupled to the UVic earth system model version 2.6 (Weaver et al., 2001). Preliminary modeling results of the climatologic Arctic sea-ice cover obtained with the UVic-granular model will be shown.

14. Maqueda, M.
Numerics of scalar advection in ocean-sea ice models

The AOMIP project motivates and provides a basis for advancing the fidelity of Arctic ocean-ice models. This talk will focus on the numerics of scalar advection. An advection scheme must strike a delicate balance between implicit numerical diffusion and dispersion in order to preserve crucial features of the tracer distribution, notably horizontal and vertical frontal structures, while, at the same time, avoiding the creation of unrealistic noisy patterns that are likely to adversely affect the model physics. In this presentation, we demonstrate the major impact that the use of a high-quality advection scheme can have in the simulation of ocean and sea-ice fields. We have recently implemented in the IOS model the Second-Order-Moment advection scheme of Prather (1986), a method that is regarded as a reference in the atmospheric GCM community. Ocean climate simulations for the period 1948-2003 have been carried out using (1) a Flux-Corrected-Transport (FCT) method, (2) the Prather's original SOM scheme, and (3) a series of modifications of the SOM algorithm aiming at bettering its monotonicity properties. Salient among our results is the fact that the SOM method, and some of its monotonic variants, lead to a representation of the vertical structure of the water column that are significantly more realistic than in previous model versions. In

particular, the depth, thickness, temperature and salinity of the modelled Atlantic Layer are significantly closer to the observed climatology.

15. Maslowski, W.
On use of surface restoring in AOMIP - a sensitivity study

We have recently completed an ensemble of 4 runs forced with realistic daily 1979-2002 ECMWF data and with variable surface restoring, in partial contribution to the AOMIP efforts. The initial analysis suggests that the mean sea ice thickness and volume is only slightly less in the case without any surface restoring compared to the strong (i.e. 30-day) restoring case. However, the overall sea ice conditions are quite robust among the four cases. In contrast, the interannual variability in the freshwater content and fluxes changes dramatically when results with and without surface restoring are compared. This points to the importance of missing buoyancy source (i.e. P-E flux), which must be included when no surface restoring is applied. The need for realistic interannually variable P-E fluxes for use in future AOMIP runs is emphasized.

16. Meier, M., R. Döscher, K. Wyser, and K. Döös
The Rossby Centre Ocean model applied to the Arctic Ocean using ERA-40

A coupled atmosphere-ice-ocean model has been developed for the Arctic based upon the Rossby Centre Atmosphere-Ocean model (RCAO). The ice-ocean component of RCO is a regional version of OCCAM (Ocean Circulation Climate Advanced Modeling project) coupled to the Los Alamos Sea Ice Model (CICE). The ocean model covers the central Arctic Ocean and the North Atlantic roughly to 50N. The Bering Sea is also included in order to get a realistic description of the transport variability through the Bering Strait. The horizontal resolution is 0.5 degrees or approximately 50 km in a rotated coordinate system centered over the North Pole. 59 vertical levels are utilized. The atmosphere model covers the same area as the ocean model and additionally some of the surrounding landmasses. The horizontal resolution of the atmosphere model is about 50 km as well. The first model configuration consists of 24 vertical levels but an increase to 31 levels is planned. The atmosphere model is driven at the boundaries by 6-hourly ERA-40 fields. Sensitivity studies with modified initial conditions, ice parameters, and radiation formulations have been performed. In addition to coupled runs simulations with RCO offline using 6-hourly ERA-40 data at the surface have been carried out for 1958-2002. First results of RCAO and RCO will be shown.

17. Miller, P.A., S. W. Laxon, D. L. Feltham
Using remote-sensed sea ice thickness, extent and speed observations to optimise a sea ice model

We describe the first attempt to optimise a sea ice model using simultaneous, remote-sensed observations of sea ice thickness, extent, and motion. This is the first time that satellite-derived sea ice thickness data have been used for this purpose, so we will describe how sea ice thickness is derived from ERS-1 and ERS-2 measurements of sea ice freeboard, and explain how we have compared it to model predictions of sea ice thickness. The observations of Arctic sea ice are used to constrain the parameter values in the Los Alamos sea ice model, CICE. CICE has 5 ice thickness categories, energy-conserving, 4-layer thermodynamics,

EVP dynamics, a fixed-depth mixed layer model, and it is forced by both atmospheric data from the ECMWF ERA-40 reanalysis and 1980-2001 surface air temperatures from the IABP-POLES data set. Primary focus is on tuning the parameters governing the ice strength, albedo, and the air-ice drag coefficient. The method used to optimise the model and to constrain its parameters using these data sets is explained, and the benefits of using multiple data sets for this purpose highlighted. Finally, we review the future prospects for satellite observations of sea ice thickness, particularly ICESat, ENVISAT and CryoSat.

18. Panteleev, G.
Investigation of the Arctic Ocean circulation employing a variational data assimilation technique

In order to investigate major features of the Arctic Ocean circulation, two numerical experiments have been performed employing methods of the variational data assimilation technique. In the first experiment, the quasi-stationary circulation was reproduced as a variational inverse solution of the recently developed non-linear model of the Arctic Ocean. The Polar Science Center Hydrographic Climatology (PHC; winter water temperature and salinity fields) with some additional information about prevailing surface currents and water transport via major straits has been used for this purpose. Model results show that in the Nansen and Amundsen Basins the cyclonic circulation dominates in all layers of the ocean. In the Canadian Basin, the anticyclonic flow dominates from the surface to the bottom. These results are in agreement with some AOMIP model results reproducing anticyclonic circulation of Atlantic Water (AW) in the Canada Basin and contradict the observationally-based hypothesis that Atlantic waters circulate cyclonically in this basin. In the second experiments, a "hypothetical cyclonic current" concentrated along the shelf break of the Canada Basin was artificially introduced and, respectively, assimilated by the model. This experiment allowed this model to reproduce cyclonic flow of Atlantic waters in the Canada Basin and to obtain water temperature and salinity fields responsible to this circulation regime (anticyclonic in the surface layers and cyclonic at the depths of Atlantic water distribution). Preliminary analysis of numerical experiments versus existing observational data will be presented as well.

19. Proshutinsky, A.
The Beaufort Gyre Observing System (BGOS) first results.

Major results from an observational program, established in the Beaufort Gyre of the Canada Basin in 2003, will be presented and discussed focusing on how to use these data for AOMIP model validation and calibration.

20. Proshutinsky, A.
Sea level time series for AOMIP model validation

Monthly time series of sea level variability from 71 tidal gauges in the Barents, Kara, Laptev, East Siberian and Chukchi Seas are available for AOMIP model validation and calibration. Additionally, it is proposed to use satellite altimetry data for the northern part of the Atlantic Ocean to validate model results. Several scientific aspects of sea level variability will be discussed as well.

21. Proshutinsky, A.
Some considerations on the origin of Atlantic Water properties and circulation variability

Several preliminary hypotheses concerning the origin of Atlantic Water penetration to the Arctic Ocean will be presented for discussions and criticism. Also it will be proposed how to test this hypotheses via numerical experiments using AOMIP models.

22. Sedlacek, J., J.-F. Lemieux, B. Tremblay, D.M. Holland, and L.A. Mysak
Sensitivity of the spherical granular sea-ilce model to the ice strength and the angle of friction

The granular sea-ice model, developed by Tremblay and Mysak (1997), has been converted to spherical coordinates and coupled to the UVic Earth System Climate Model, version 2.6 (Weaver et al, 2001). We recently started to investigate the impact of the ice strength and the angle of friction on the ice thickness, ice velocity, and the sea-ice export through Fram Strait. From this preliminary study, it seems that the response of the model is more sensitive to changes in ice strength than to changes of the angle of friction. This insight will help to give a better understanding of the model behaviour and will be useful for our future investigation on the interactions of the sea-ice cover with the ocean circulation during the Little Ice Age.

23. Simmons, H.
On the energy extracted from the tide in high latitude oceans available for mixing

Recent numerical process studies oriented toward the modelling of internal tide generation and subsequent barotropic/baroclinic energy budgets will be presented in light of the energy available to support mixing in high latitude oceans. Comparisons will be made with low-latitude theoretical and numerical predictions, and implications for mixing in the Arctic will be discussed.

24. Steele, M.
The role of mixing in the simulation of Canadian Basin Atlantic Water circulation

What influences the direction of Atlantic Water circulation in the Canada Basin of the Arctic Ocean? We have performed some model intercomparison and sensitivity studies to investigate this question. We looked at output from the year 1978, the final AOMIP "spin-up" year, from severalmodels. We also ran a series of sensitivity studies with our coupled sea ice - ocean model at the University of Washington, in which the vertical diffusion and vertical viscosity coefficients were varied by an order of magnitude. We compared salinity sections across the Canada Basin, and also considered ocean velocities at several depth horizons. We found that (unrealistic) anticyclonic AW circulation at depth is found in those models with (unrealistic) deep anticyclonic freshwater Beaufort Gyre pools. This overly deep freshwater pool can be caused by a number of factors, of course. In our sensitivity experiments, it is created by strong vertical mixing. Overly weak mixing, on the other hand, leads to a very thin freshwater Beaufort Gyre anticyclone and cyclonic circulation that extends unrealistically upwards from the AW all the way to 100 m depth or even shallower.

25. Wang, J.

Modeling the 20th century Arctic ice ocean circulation using a coupled atmosphere-ice-ocean global model

The simulations of the Arctic ice-ocean circulation using the high resolution global coupled atmosphere-ice-ocean model with 1/6 x 1/4 degrees and 48 vertical layers on the 'Earth Simulator' supercomputer was evaluated to determine the model performance, physics soundness, and its sensitivity to different process parameterizations. The model was parameterized by GM (Gent McWilliams 1990) parameterization to the north of 45N. The statistical time series of the total oceanic and ice kinetic energy and ice areas suggest that there is an equilibrium without any T/S restoring or flux adjustment, and no model drifting is found. The model climatology (mean over all the model years) and variability were examined and compared with the available observations, such as ice area, temperature and salinity at certain key depths and transects. Several important physical features in the Northern Hemisphere, such as the thermohaline in the Arctic Ocean, Atlantic Water, meridional thermohaline overturning, transports from Bering Strait, Fram Strait etc., were examined to determine physical soundness of the model. An important achievement is that the Atlantic Layer in the Arctic can be reasonably reproduced with no restoring temperature and salinity to observations. An important criterion of reproducing the Atlantic Layer variability is measured by the core (max) temperature of the layer of 500-1500m. The model produces reasonably the 20th century Atlantic Water core temperature that compares well with observation by Polyakov et al. (2004). The model catches the 1930s-40s warming and the 1990s warming, similar to the observation. These results indicate that this coupled global model captures most important dynamic and thermodynamic processes in the Arctic Ocean. Further analysis of the model performance is under way.

26. Yang, J.
Seasonal and interannual variability of Ekman transport and its contribution to the heat and salt fluxes In the Arctic Ocean

In the ice-covered Arctic Ocean, the surface stress that forces the Ekman layer dynamics consists of both air-water and ice-water stresses. The data required to estimate these stresses are now available from satellite and buoy observations. In this study, a suite of satellite and buoy observations of key variables (ice motion, ice concentration, surface wind, etc.) will be used to compute the daily ice-water and air-water stresses over the whole Arctic Ocean from 1978 to 2003 on a 25-km resolution. The seasonal and interannual variability of these variables and how they affect the Ekman transport and upwelling field will be examined. In addition, we also use a recent hydrographic data set (Steele et al., 2001) to estimate the horizontal and vertical advections of heat and salt associated with the Ekman transport.

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