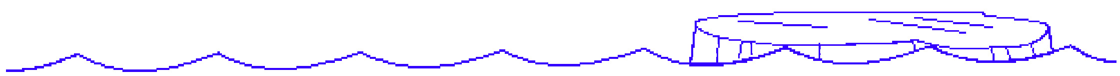
Arctic Ocean Model Intercomparison Project (AOMIP):

Report of the Third Workshop, 23-24 May, 2001



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1.0 Executive Summary (AOMIP)

The third Arctic Ocean Model Intercomparison Project (AOMIP) workshop was held during 23-24 May 2001 at the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA. Fifteen individuals participated, nine as core AOMIP researchers and six others as invited experts. The purpose of the workshop was to elaborate the design of a multi-year, coupled ice-ocean simulation, under interannual atmospheric forcing, that is soon to be performed by the AOMIP modeling groups. This report describes the agreed upon experiment design and also serves as the reference document for actually performing the experiment. As details of the experiment design are further refined, an up-to-date version will be disseminated via the AOMIP website.

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2.0 Workshop Activities (AOMIP)

2.1 Day 1 – May 23, 2001

The meeting was opened with a welcome by Andrey Proshutinsky, AOMIP's Principal Investigator. He gave an overview presentation of AOMIP to newcomers, an update to all on the project's scope, schedule, and budget, and a list of framework topics for the meeting. The list of the participants is given in Appendix A, the workshop schedule in Appendix B, and the framework topics in Appendix C.

During the past year, AOMIP has been officially adopted as a core project of the Arctic Climate System Study / Climate and Cryosphere Numerical Experimentation Group (ACSYS/CliC NEG). The Chair of that Group, Gregory Flato, was invited to the workshop to discuss the role of AOMIP within the ACSYS/CliC NEG framework. His presentation is given in Appendix D. He described the ACSYS/CliC NEG initiative and the connection between AOMIP and the World Climate Research Program (WCRP) Working Group on Ocean Model Development (WGOMD), and in particular it's Ocean Model Intercomparison Project (OMIP).

The goal of the WGOMD is to improve the representation of the ocean in global climate simulations. At their last meeting (March 2001), they launched a pilot OMIP. Seven groups are planning to participate in this project. The first OMIP activity has been the creation of a global, climatological atmospheric forcing data set derived from the European Center for Medium-Range Weather Forecasting (ECMWF) reanalysis project, ERA-15. The next OMIP activity is to run various global ocean general circulation models (OGCMs) for a 100-year integration period, all using the common atmospheric forcing data set. Initial results are to be presented at a meeting tentatively scheduled for May 2002. It is expected that an AOMIP representative will attend.

As the pilot OMIP phase is concurrent with AOMIP, and as both projects include the Arctic Ocean basin, it is advantageous to coordinate these two projects so to facilitate an intercomparison of the simulation of the Arctic Ocean basin in each project. This will determine whether there exist substantial differences between the Arctic Ocean of the regional domain AOMIP simulations versus the global domain OMIP simulations. This intercomparison activity provides an important pathway for the AOMIP research findings to become connected to the global ocean modeling community, and hence to the global climate modeling community.

Frank Bryan at NCAR is coordinating the OMIP activity and it was decided that AOMIP will contact him to begin collaboration between OMIP and AOMIP. To facilitate intercomparison, a common atmospheric forcing data set needs to be employed in both projects. Since the OMIP has already created a global climatological forcing data set, it was agreed that AOMIP would ask for permission to use that data set as well. That permission has since been acquired, and so AOMIP modeling groups will soon perform a 30-Year Spinup using this OMIP forcing. The use of a common forcing data allows AOMIP investigators to directly compare their simulation results against OMIP, and vice versa. Another anticipated benefit of linking OMIP and AOMIP activities is the economy to be realized by developing and exchanging common validation data sets and analysis tools for model output.

Currently pilot OMIP activities are being carried out between the Alfred Wegener Institute (AWI) for Polar and Marine Research, Bremerhaven, and the Max-Planck-Institute (MPI) for Meteorology, Hamburg. As a representative of those activities, Rudiger Gerdes, who is also an AOMIP co-principal investigator, gave a presentation about organization, goals, approaches, and some results of the pilot OMIP activities. The current project is an intercomparison of two global OGCMs, the Modular Ocean Model (MOM2) of the Geophysical Fluid Dynamics Laboratory (GFDL) and the Hamburg Ocean Primitive Equation (HOPE) model of the MPI. Both ocean models are coupled to a sea-ice model. The intercomparison is restricted to an analysis of the mean annual cycle as obtained using the OMIP climatological atmospheric forcing data set. A summary of the preliminary conclusions to be drawn from the pilot OMIP simulations is presented in Appendix D.

The remainder of the first day discussion focused on defining a universal forcing and validation data set and is reported on in greater detail in the description of the 50-Year Experiment.

2.2 Day 2, 24 May, 2001

The morning session gave recent research results of Arctic sea-ice and ocean modeling. Six presentations were made and were followed by discussions. Titles and brief abstracts are provided as Appendix E.

Following the science presentations, discussion was given to identifying how to maximally integrate AOMIP activities with other, ongoing synergistic Arctic research programs. During the first day of the workshop, considerable effort was devoted to achieving some integration between AOMIP and OMIP. Subsequent discussion centered on strategies to more closely involve AOMIP with the (i) Community Arctic Modeling Project (CAMP), (ii) the Nansen and Amundsen Basin Observational Systems (NABOS), and (iii) the Arctic Regional Climate Modeling Intercomparison Project (ARCMIP). The results of the discussion are summarized as part of the Action Items given below.

The remainder of the second day discussion focused on model data output and data management and is reported on in greater detail in the description of the 50-Year Experiment.

2.3 Action Items

The goals for the current year of AOMIP activity were set as follows:

- Determine the forcing and validation data sets required for the AOMIP 50-Year Experiment.
- Carry out the 50-Year Experiment, consisting of a 30-Year Spinup (climatological forcing) and a 50-Year Integration (interannual forcing).
- Use the model intercomparison results to identify current model deficiencies and to seek model improvements.
- Create at the AOMIP website a digital and animated atlas of the AOMIP 50-Year Experiment, including forcing, validation, and model output fields.
- Hold the Fourth AOMIP Workshop, tentatively scheduled for Spring 2002, in Sweden as a joint meeting with the ARC-MIP project.
- Establish working links with OMIP by carrying out a 30-Year Spinup using the OMIP Climatological Forcing and sharing data and model analysis techniques.
- Contribute to CAMP activities by performing the AOMIP 50-Year Experiment, archiving the model data, and making it available to CAMP for analysis.
- Provide AOMIP model output that is as compatible as possible with the measurements obtained from the future NABOS moorings.

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3.0 50-Year Experiment (AOMIP)

This section describes the protocol for any modeling group wishing to carry out the AOMIP 50-Year Experiment. It will be updated in response to feedback from the modeling groups. In the following, a "model" implicitly refers to a three-dimensional ocean general circulation model that is coupled to a dynamic-thermodynamic sea-ice model and is forced by varying atmospheric fields. While each ocean and sea-ice model involved in the AOMIP is obviously distinct, the forcing fields and validation data are quite intentionally, common to all models. Collectively, that common data is referred to as the "AOMIP Universal Forcing".

This section is in four parts. First, the milestones to be reached in the coming year are listed; secondly, the AOMIP Universal Forcing data set is defined; thirdly, the archiving of model output is described; and fourthly, the desired analysis of the model output is given.

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3.1 Milestones

Although it is referred to as the “50-Year Experiment”, the actual number of simulated years for the model integrations is significantly longer. A list of activities, in chronological order, that constitute the 50-Year Experiment is given in Table 3.1. Activities 1 and 2 are expected to be completed this coming year while activity 3 will be undertaken if time and resources permit.

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3.2 AOMIP Forcing

To ensure that differences between model output are due to identifiable differences in parameterizations of physical processes in the individual models, it is necessary to force and validate all models in as identical a manner as possible. Accordingly, we define a common forcing and validation data set and refer to it as the "AOMIP-Forcing". Incidentally, we also adopt the convention that any upward directed flux is a positive quantity.

3.2.1 Atmosphere

We have investigated a number of atmospheric forcing data sets in an effort to find one suitable to AOMIP purposes. No data set was found ideally matched to our goals, and indeed all data sets have serious deficiencies of one sort or another. We have instead developed a strategy that uses a combination of these data sets for our 50-Year Experiment.

For the 30-Year Spinup we will use the climatological OMIP-Forcing and for the follow-on 50-Year Integration we will switch to the interannual NCEP/NCAR reanalysis product. As the 30-Year Spinup is our first activity, we presently report only on the OMIP forcing fields relating to the 30-Year Spinup. In a future report, we will outline our strategy for using the NCEP-NCAR reanalysis product in our 50-Year Integration.

The OMIP-forcing is a global data set with a horizontal spatial resolution of 1.125 º x 1.125 º (Roeske, 2001). The temporal resolution is daily and the year is defined to have 360 days. A copy of the data set, in NetCDF format, is available from the AOMIP website. There are thirteen forcing fields in the data set (Table 3.2.). We will use a subset of these fields to compute the exchange of momentum, heat, and freshwater between the ice-ocean surface and the atmosphere. The exact manner in which each AOMIP model performs the exchange of these quantities over a heterogeneous ice-ocean surface is reported in the coupler model details.

DO WE WANT TO WORK ONLY WITH A 365-DAY OMIP FORCING? THAT DATA IS NOT YET AVAILABLE BUT ONLY CURRENTLY UNDER DEVELOPMENT AT AWI/MPI.

3.2.1.1 Momentum Transfer

We use directly the zonal and meridional OMIP wind stress fields. The drag coefficients used by each AOMIP model for the sea-ice and ocean stress calculations, separately, are reported at our website. OMIP also provides the wind speed, and the standard deviation of the wind speed, which we will use in our calculations of turbulent surface exchanges as noted below.

DO WE PREFER TO USE SURFACE PRESSURE TO DERIVE WIND STRESS (RATHER THAN USE WINDSTRESS DIRECTLY)? IN THAT CASE WE HAVE TO AGREE ON HOW SURFACE PRESSURE IS CONVERTED TO WIND STRESS.

3.2.1.2 Heat Exchange

For the turbulent sensible and latent heat flux exchanges, we use the formulas (9) of the OMIP-Forcing report (p. 14). These formulas require knowledge of certain fields from the OMIP forcing data: namely, the air temperature (at 2 m), the specific humidity of the air (computed from dewpoint temperature), and the wind speed. They also require knowledge of certain AOMIP model output: namely, surface temperature and specific humidity exactly at the ice and ocean surfaces, separately. The exchange coefficients used by each AOMIP model for the atmospheric turbulent exchanges are reported at our website.

For the shortwave radiative flux we use the OMIP total shortwave radiative flux. We apply our own sea-ice and ocean albedo definitions to arrive at the net shortwave radiative flux.

For the longwave radiative flux we use the formula (12) of the OMIP-Forcing report (p. 14). That formula requires knowledge of the following OMIP forcing data: air temperature (at 2 m), dewpoint temperature, and cloud cover. We will use the latitudinal dependent cloudiness factor as given by formula (13) of the OMIP-Forcing report. It also requires knowledge of the surface temperature over ice and ocean, separately, from the AOMIP model output. Emissivities are to be specified according to our own sea-ice and ocean model definitions.

3.2.1.3 Freshwater Exchange

We use directly the OMIP precipitation fields. For evaporation, we diagnose the evaporation rate based on our turbulent latent heat flux calculation. River runoff is considered below.

DO WE PREFER TO USE THE NET QUANTITY P-E DIRECTLY (RATHER THAN COMPUTE E)?

3.2.2 Ocean

There are seven ocean models participating in AOMIP. They represent a wide cross-section of Arctic Ocean models as well as the kinds of ocean models currently in use in fully-coupled global climate models.

For the 30-Year Spinup, we will initialize all models with the annual-averaged Polar Hydrographic Climatology (PHC), a merged product of the Environmental Working Group (EWG) Atlas and the World Ocean Atlas (WOA98) (Steele et al., 2001). The initial model flow field will be zero flow. For the 50-Year Integration the initial ocean state will be the final state of the 30-Year Spinup.

Some AOMIP ocean models will have restoring conditions at their surface or along their lateral boundaries. For models so configured, the monthly varying hydrographic fields of the PHC atlas will serve as the restoring data.

DO WE WANT PHC DATA TO BE MADE AVAILABLE IN NETCDF FORMAT?

Depending upon the native-domain of an AOMIP model, certain straits or passageways may not be properly resolved. In the instance that a passageway is not so resolved then an explicit volume flux to be assigned as given in Table 3.3.

WHAT VOLUME FLUXES FOR DENMARK AND FAROE-SHETLAND PASSAGEWAYS?

3.2.3 Sea Ice

The 30-Year Spinup will be initialized with a climatological sea-ice concentration, a uniform 2.0 m ice thickness cover, no snow cover, no flow velocity, and a –20 ºC surface ice temperature. The climatological sea-ice cover will be constructed from the WHAT data set. It will be made available in NetCDF format through our Sea-Ice Forcing webpage. The 50-Year Integration will use the sea-ice state as simulated at the end of the 30-Year Spinup.

The AOMIP sea-ice models employ different physical parameterizations and parameter values. A sea-ice model is consider as “forcing” in the AOMIP context, in the sense that we are focusing interest on the behavior of the liquid ocean, and so we will attempt to make all sea-ice models as similar as possible. This will be achieved by encouraging the use of as similar sea-ice parameters as possible.

WHERE DO WE GET CLIMATOLOGICAL NETCDF FORMAT SEA-ICE CONCENTRATION, THICKNESS, VELOCITY, SNOW COVER, ETC (FOR INTIALIZATION AND VALIDATION OF THE CLIMATOLOGICAL RUN?

WHERE DO WE GET THE SAME AS INTERANNUAL DATA (FOR VALIDATION OF OUR INTERRANNUAL SIMULATIONS)?

3.2.4 River Runoff

The AOMIP river-runoff models currently employ a range of treatments for coupling river-runoff to the ocean. To enforce some level of consistency between AOMIP models, we adopt a common river-runoff database and coupling algorithm. We will use R-ArcticNET, a database of river discharge covering all the major catchment basins surrounding the Arctic Ocean (Lammers, 2000). We define our catchment basins to be the same as in the R-ArcticNET database (Table 3.4). The runoff will be applied as a grid-point source of freshwater to the AOMIP ocean models at the native model grid-point that is closest to the geographic location of the river mouth. The geographic locations are given in Table 3.4.

We will extract a climatology from that database for the purpose of forcing our 30-Year Spinup. We will subsequently extract the interannually varying discharge data to force our 50-Year Integration. Those data sets will be made available in NetCDF format at our River-Runoff Forcing webpage.

If the sum of the runoffs from our catchment basins does not equal the currently estimated runoff into the Arctic Ocean, then we will distribute the difference in volume as a costal freshwater flux. The distribution will be done uniformly for all coastal, model grid points north of the Arctic Circle (~ 66 ºN).

ACTUALLY, WHICH RIVER-RUNOFF DATA SET TO USE (R-ArcticNET, OMIP, GRDC, AWI)?

WHAT IS THE CURENTLY ACCEPTED ESTIMATE FOR FRESHWATER RUNOFF TO THE ARCTIC OCEAN? WHAT IS THE LITERATURE REFERENCE FOR THAT NUMBER?

WHO WILL CREATE THE RUNOFF CLIMATOLOGY, AND INTERANNUAL DATA? WILL IT BE IN NETCDF?

3.2.5 Bathymetry

We intend that all AOMIP models use the same bathymetric database. For this purpose we have merged the International Bathymetric Chart of the Arctic Ocean (IBCAO) and the Earth Topography Five Minute (ETOPO5) databases (Holland, 2000). This product is available from our Topographic Forcing webpage.

DO WE WANT MERGED IBCAO/ETOPO5 DATA TO BE MADE AVAILABLE IN NETCDF FORMAT?

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3.3 Model-Output Archives

The success of an intercomparison experiment depends upon the facility with which modelers from one group can access and manipulate the model output from another group. To this end, we have agreed upon a common (i) grid, (ii) data format, and (iii) suite of model output.

3.3.1 AOMIP Grid

All AOMIP models will differ in their native, geographical domains, coordinates, and grid discretization. To overcome this inconsistency, we have defined a common AOMIP Grid to which all AOMIP model outputs are to be interpolated. The purpose of the grid is to facilitate the analysis of model output.

The AOMIP Grid is defined over a geographic domain (Figure 3.1) that includes the Arctic Ocean, the Bering Strait, the Canadian Arctic Archipelago, the Fram Strait and the Greenland, Iceland, and Norwegian Seas.

The horizontal coordinate system is in spherical coordinates and is rotated by the Euler angle set (-30, -90, 0). This places the model coordinate system north pole along the real earth's equator at a longitude of 30 ºW. The AOMIP Grid horizontal spacing is 1º in latitude and longitude. The AOMIP Grid extends to ± 30 º N and ± 30 º E (Figure 3.2), and fully covers the geographic domain described above. All AOMIP models compute their basic prognostic quantities on staggered horizontal grids. The AOMIP grid, however, requires that all prognostic quantities be reported at collocated points. This arrangement is often referred to as the A-Grid (Arakawa, 1966).

The AOMIP ocean models represent a variety of different vertical coordinate schemes, namely, height, sigma, and isopycnal. This raises the question whether to convert all model outputs to a standard vertical coordinate system, or to have each model output represented in its native-vertical coordinate system. We have decided to convert all model output to height coordinates. The AOMIP Grid vertical spacing is defined at the 30 depth levels specified in Table 3.5. These levels are similar to those used in the PHC hydrographic atlas, the difference being that in AOMIP we desire a slightly greater vertical resolution in the upper part of the water column.

MAYBE INSTEAD WE WANT TO ARCHIVE EACH MODEL ON ITS NATIVE-VERTICAL COORDINATE?

The remapping of scalar and vector model-output quantities from a model's native grid to the AOMIP grid is achieved by a two-step process: (i) a coordinate rotation to the AOMIP coordinate system, and (ii) an interpolation from the "rotated" native-grid points to the AOMIP-grid points. The coordinate rotation from a model's native coordinate system to the AOMIP-grid coordinate system is to be achieved via Euler Angles. The individual modeling groups will choose their own preferred interpolation scheme and report their choice at the Model Details webpage.

3.3.2 Temporal Resolution

The various AOMIP models update their basic prognostic model fields at differing time intervals, and generally falling within the range from one hour to one day. We archive, however, only monthly-mean model output.

One possible exception is during the SHEBA year, October 1997 to September 1998, for which we will consider a secondary archive of daily or even finer temporal resolution. One reason to do this is that SHEBA data set offers an unprecedented quality of temporally-resolved Arctic oceanographic data, albeit of limited spatial extent. A second reason is that the ARC-MIP effort will simulate exactly that time period. A secondary AOMIP archive, dedicated solely to the SHEBA year, would so facilitate intercomparison between ARC-MIP and AOMIP simulations.

ARE WE REALLY SERIOUS ABOUT PERFORMING AND STORING THE SHEBA-YEAR DATA? SHOULD THIS BE AN OPTIONAL EXERCISE ONLY FOR THOSE GROUPS SO INTERESTED?

3.3.3 Ocean Archive

We archive only the most basic quantities, as all other quantities of interest are to be analyzed based on the archive. The ocean archives are split into two files, namely quantities that pertain to two-dimensional fields (Table 3.6) and those to three-dimensional fields (Table 3.7).

3.3.4 Sea Ice Archive

We archive the most basic two-dimensional sea-ice fields (Table 3.8).

3.3.5 Format

We write all data in NetCDF format.

3.3.6 Storage

At present we do not have the ability to archive the entire model output data from all participants at the AOMIP website. Accordingly, we have adopted the approach of using a “distributed active archive center ” (DAAC) for accessing all model output. In this setup, each AOMIP modeling group is responsible for making all of their AOMIP model output available on their own local web site. A link from the AOMIP website then makes the data available to all others, thus facilitating the intercomparison activities, and ensuring only access to a consistent set of model output.

An estimate of the data-storage requirement for the AOMIP 50-Year Experiment is given in Table 3.9.

3.3.6.1 JOSS Archive?

Because of the anticipated volume of the model output data, a more desirable approach would be to have all the model output data archived at a high-capacity, efficient data server such as that provided by the Joint Office of Scientific Support (JOSS). We are currently investigating whether JOSS services might be available to AOMIP.

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3.4 Model-Output Analysis

The AOMIP model-output archives are to be analyzed for surface flux, storage, transport, streamfunction, and sea-ice quantities.

3.4.1 Surface Fluxes

We analyze the exchange of heat, freshwater, and momentum across the Arctic Ocean surface. These quantities are given in Table 3.10.

3.4.2 Storage

We analyze the storage of freshwater and heat in the upper portion (i.e., 0 to 1000 m depth) of the Arctic Ocean. These and other related quantities are given in Table 3.11.

3.4.3 Transports

For the purpose of tracking the amounts of water, heat, and tracers into and out of the Arctic Ocean, we define five transects that demarcate all major entrance and exit pathways. They are listed in Table 3.12 and illustrated in Figure 3.3. All transports will be reported as: inflowing, outflowing, and net quantities. The sign convention adopted is that transport out of the Arctic Ocean is considered a positive quantity. The transport quantities, as given in Table 3.13, will be analyzed for each of the five transects.

3.4.4 Streamfunctions

We analyze the horizontal and overturning streamfunctions as listed in Table 3.14.

3.4.5 Sea Ice

We analyze the sea-ice quantities as listed in Table 3.15.

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4.0 Publications Strategy (AOMIP)

For balancing the research workload, and for efficient dissemination of scientific results, we have assigned some specific science themes to the various AOMIP investigators as listed in Table 4.1.

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5.0 Website Management (AOMIP)

To facilitate the exchange of scientific ideas and electronic data between AOMIP researchers, and also to promote a larger community awareness of the AOMIP, a home website has been established at http://fish.cims.nyu.edu/project_aomip/overview.html. The site provides an online access to the AOMIP 50-Year Experiment much along the lines as presented in this report. That electronic version will be updated as the experiment design is improved over the coming months.

All AOMIP forcing, verification, and model output data will be accessible through the site, either as data archived locally at the site or through links provided to other sites. To the greatest extent possible we want to ensure that the AOMIP experiment is a controlled one, for example, we want all modeling groups to use exactly the same forcing data sets for their ice-ocean models. By directly placing, or directly linking, all the forcing and verification data sets at the AOMIP web site we can ensure that all participants are using precisely the same data.

The web site will be continually updated as new intercomparison experiments are carried out. At this time all data management will be organized with David Holland serving as our website data manager.

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Figure 3.1 The AOMIP geographic domain in rotated spherical coordinates.

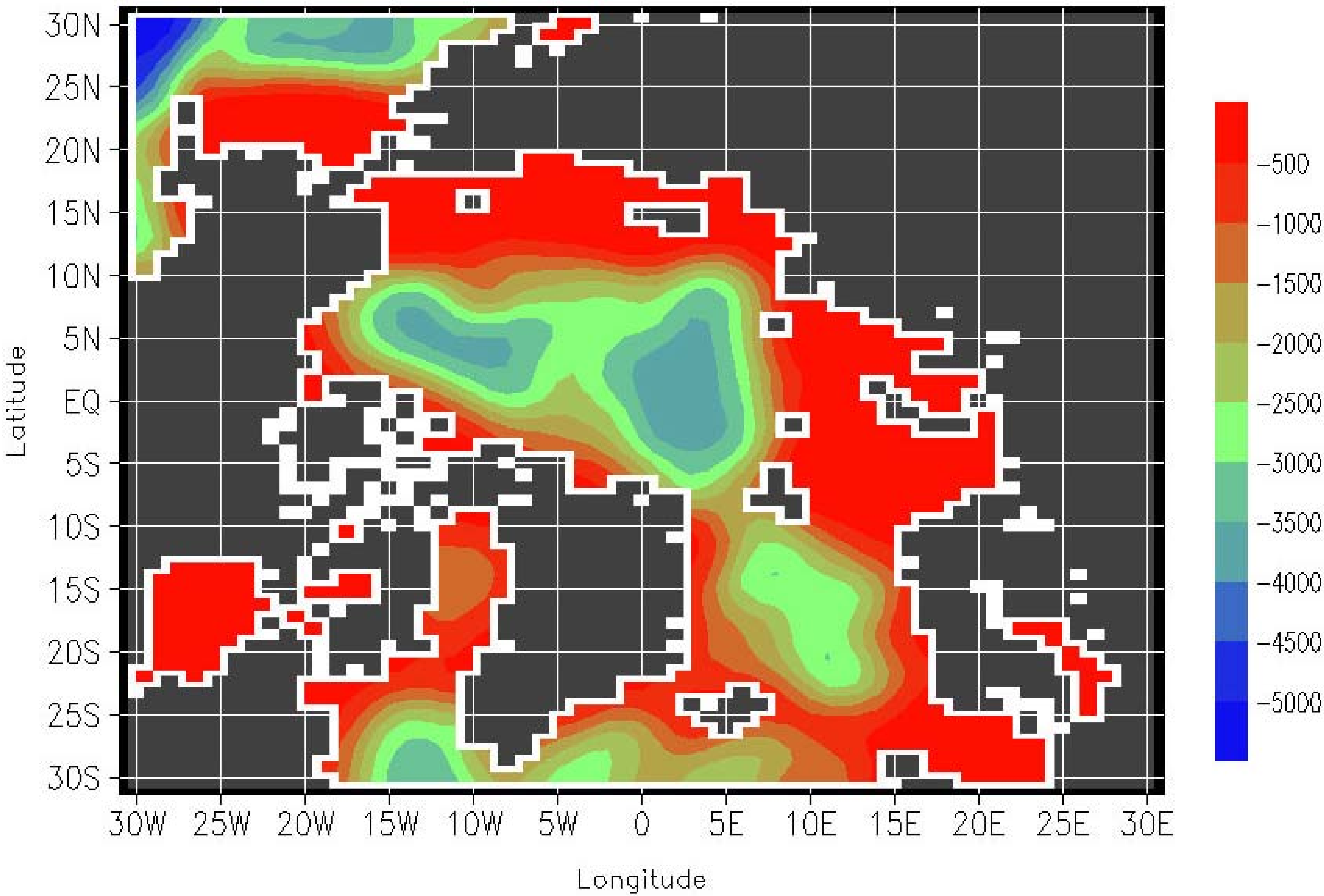

Figure 3.2 The horizontal component of the AOMIP Grid.

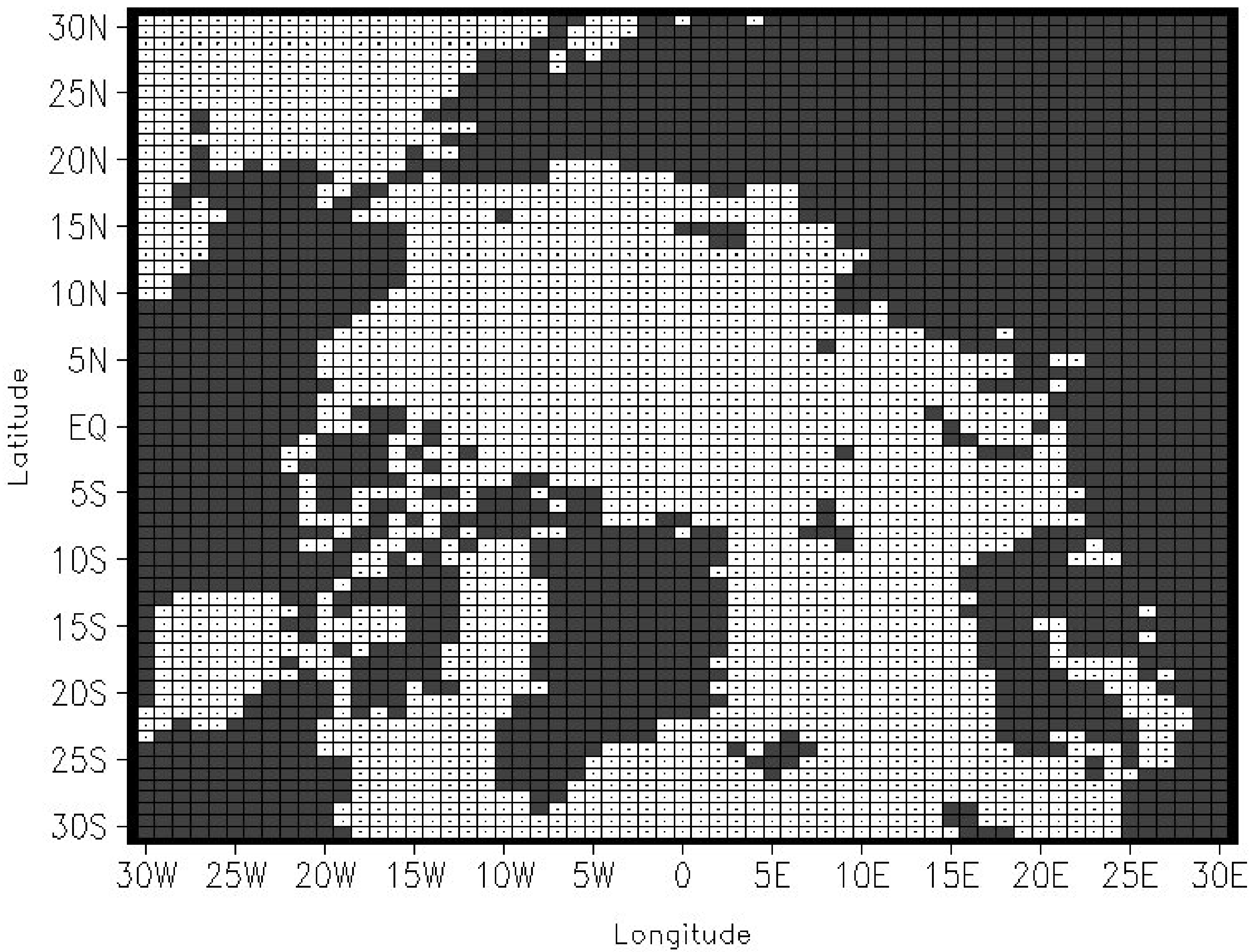

Figure 3.3 Location of AOMIP vertical transects.

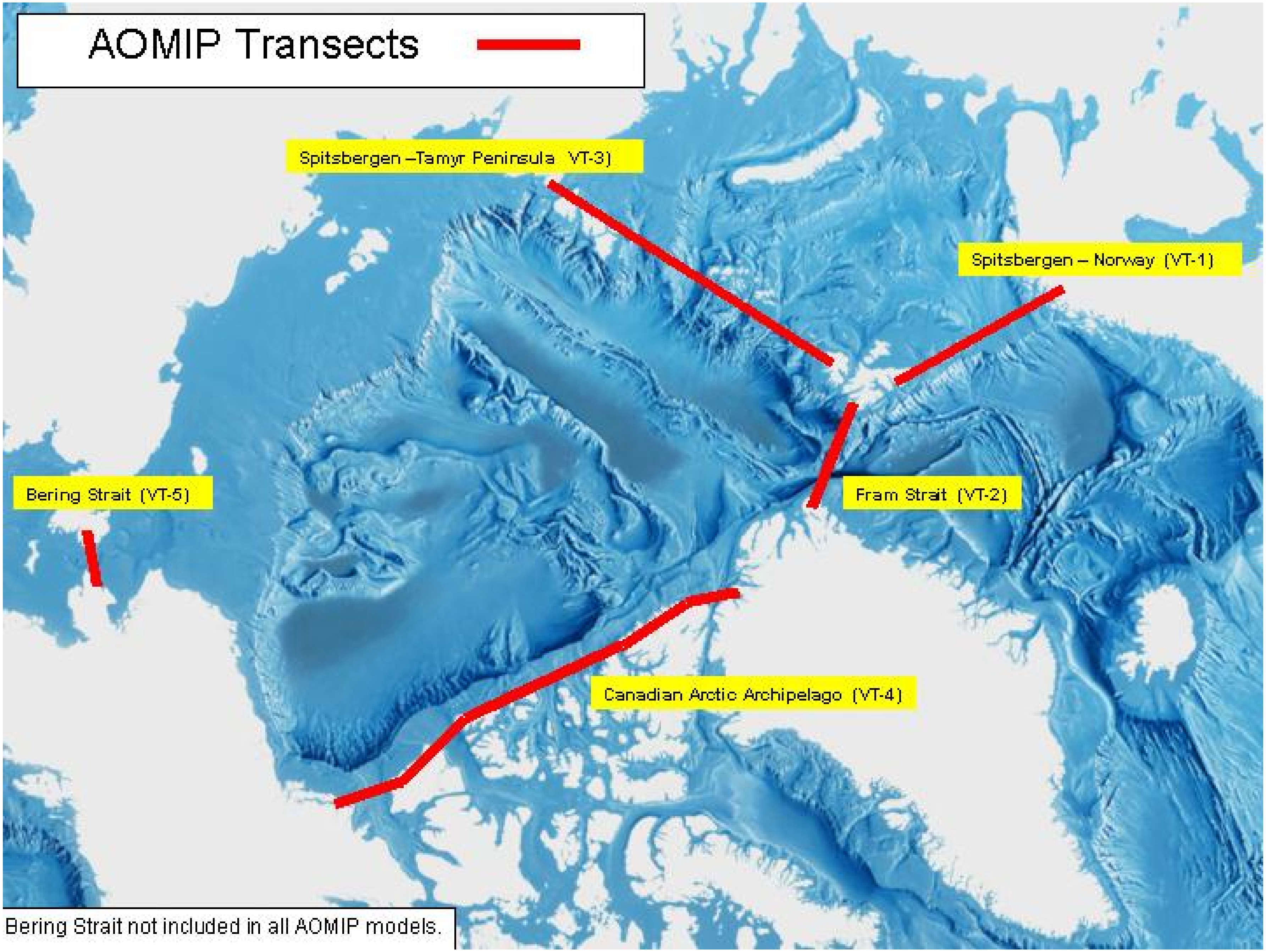

Table 3.1 Activities of the 50-Year Experiment

ID	Activity	Notes
1A	Run the model for 30 years under the OMIP Climatological Forcing.	OMIP Climatological Forcing to be repeatedly applied year-by-year. OMIP Climatological Forcing uses a 360-day calendar year.
1B	Analyze the model output during the final year of the integration. Compare results to (i) other AOMIP simulations, and (ii) other OMIP simulations.	Analysis always refers to monthly-mean quantities except when noted otherwise.
2A	Run the model for 53.5 years (1948-2001) under the NCEP/NCAR 50-Year Forcing.	The model initial conditions are given by the model final conditions in 1A.
2B	Analyze the model output annual climatology and interannual variability. Compare results to other AOMIP simulations.	
2C	Compare the model output with observations during the period 1979-2001.	
3A	Rerun the model for 53.5 years (1948-2001) under the NCEP/NCAR 50-Year Forcing.	The model initial conditions are given by the model final conditions in 2A.
3B	Analyze the model output annual climatology and interannual variability. Compare results to other AOMIP simulations.	

Table 3.2 OMIP-forcing fields. The columns "ADD" and "FAC" refer to offset and multiplicative factors to be applied to the native data.

ID	OMIP Forcing Fields	Units	ADD	FAC	Notes
OF1	Zonal Wind Stress	Pa	-4.3	8.6	
OF-2	Meridional Wind Stress	Pa	-3.3	6.0	
OF-3	Scalar Wind	m/s	0.	27.	
OF-4	Daily Std. Dev. Scalar Wind	m/s	0.	20.	
OF-5	Air Temperature (2 m)	K	190.	130.	
OF-6	Dewpoint Temperature (2 m)	K	190.	120.	
OF-7	Sea-Surface Temperature	K	180.	165.	
OF-8	Total Shortwave Radiation	W/m^2	0.	910.	
OF-9	Net Shortwave Radiation	W/m^2	0.	410.	
OF-10	Total Cloud Cover	(0-1)	0.	1.1	
OF-11	Precipitation	m/s	-4.1e-7	2.8e-6	
OF-12	Evaporation	m/s	-2.8e-7	3.2e-7	
OF-13	River Runoff	m/s	0.	1.7e-5	

Table 3.3 Flow volume ($m^3/s \times 10^6$) imposed at non-resolved passageways.

ID	Passageway	Flow Volume	Flow Direction	Notes
PW-1	Bering Strait	0.8	Inflow	
PW-2	Denmark Strait		Outflow	
PW-3	Faroe-Shetland Passage		Inflow/Outflow	
PW-4	Nares Strait	0.7	Outflow	
PW-5	M’Clure Strait	0.8	Outflow	

Table 3.4 River-runoff catchment basins.

ID	Catchment Basin	Longitude, Latitude	Notes
CB-1	South, East Hudson Bay		
CB-2	Nelson		
CB-3	Northwest Hudson Bay		
CB-4	Mackenzie		
CB-5	Yukon		
CB-6	Anadyr Kolyma		
CB-7	Lena		
CB-8	Yenisei		
CB-9	Ob		
CB-10	Barents, Norwegian Sea		

Table 3.5 Depth levels of the AOMIP Grid.

ID	Depth Level (m)
DL-1	0
DL-2	5
DL-3	10
DL-4	15
DL-5	20
DL-6	25
DL-7	30
DL-8	40
DL-9	50
DL-10	75
DL-11	100
DL-12	125
DL-13	150
DL-14	200
DL-15	250
DL-16	300
DL-17	350
DL-18	400
DL-19	500
DL-20	600
DL-21	750
DL-22	1000
DL-23	1250
DL-24	1500
DL-25	2000
DL-26	2500
DL-27	3000
DL-28	3500
DL-29	4000
DL-30	5000

Table 3.6 Ocean-archive two-dimensional quantities.

ID	Ocean 2-D	Units	Grid	Archive	Notes
O2-1	Land Mask	None	2-D XY	Yes	0 is land; 1 is ocean.
O2-2	Bathymetry	m	2-D XY	Yes	Depths in negative numbers.
O2-3	Sea-Surface Height	m	2-D XY	Yes	Rigid-lid models convert rigid-lid pressure to height.
O2-4	Surface Temperature	ºC	2-D XY	Yes	Weighted mean of surface snow/ice and leads.
O2-5	Mixed-Layer Depth	m	2-D XY	Yes	WHAT CRITERION?
O2-6	Freshwater Flux	m/s	2-D XY	Yes	At liquid ocean surface. Positive flux is upward.
O2-7	Heat Flux	W/m^2	2-D XY	Yes	At liquid ocean surface. Positive flux is upward
O2-8	Momentum Flux	Pa	2-D XY	Yes	At liquid ocean surface. Positive flux is upward
O2-9	Dynamic Height	m	2-D XY	Yes	Depth range 0 to 200 m for direct intercomparison to EWG Atlas (1997, 1998). Computed on native-grid.

Table 3.7 Ocean-archive three-dimensional quantities.

ID	Ocean 3-D	Units	Grid	Archive	Notes
O3-1	Potential Temperature	ºC	3-D XYZ	Yes	Reference depth for potential temperature is 0.0 m.
O3-2	Salinity	psu	3-D XYZ	Yes	
O3-3	Zonal Velocity	m/s	3-D XYZ	Yes	AOMIP-Grid orientation.
O3-4	Meridional Velocity	m/s	3-D XYZ	Yes	AOMIP-Grid orientation.
O3-5	Vertical Velocity	m/s	3-D XYZ	Yes	Upward is positive.

Table 3.8 Sea-ice-archive two-dimensional quantities.

ID	Sea-Ice 2-D	Units	Grid	Archive	Notes
I2-1	Thickness	m	2-D XY	Yes	At ice density. Effective thickness.
I2-2	Concentration	Fraction	2-D XY	Yes	Range is [0..1].
I2-3	Zonal Velocity	m/s	2-D XY	Yes	AOMIP-Grid orientation.
I2-4	Meridional Velocity	m/s	2-D XY	Yes	AOMIP-Grid orientation.
I2-5	Snow Thickness	m	2-D XY	Yes	At freshwater density.
I2-6	Divergence	1/s	2-D XY	Yes	Derivatives computed on native model output grid.

Table 3.9 Estimated disk-storage requirement for AOMIP 50-Year Experiment.

Item	Multiplicative Factor	Notes
Single Precision Word	4	Bytes
Horizontal Grid	60 x 60	Grid Points
Vertical Grid	30	Grid Points
Ice-Ocean Variables	~10	T, S, U, V, etc.
Modeling Groups	7	
Monthly Means	12	
Simulated Years	80	30 Year Spin-up
Total Storage	~ 30	Gigabytes (GB)

Table 3.10 Surface-Flux analysis

ID	Surface Fluxes	Units	Grid	Archive	Notes
SF-1	Net Freshwater Flux	m/s	0-D	No	
SF-2	Net Heat Flux	W/m^2	0-D	No	
SF-3	Net Momentum Flux	Pa	0-D	No	

Table 3.11 Storage analysis

ID	Storage	Units	Grid	Archive	Notes
ST-1	Dynamic Height	m	2-D XY	No	Depth range 0 to 1000 m.
ST-2	Freshwater Content	m	2-D XY	No	Reference salinity is 34.80 psu.
ST-3	Atlantic-Layer Heat Content	J	2-D XY	No	Waters above 0.0 ºC and salinity above 33.50 psu. Reference potential temperature is 0.0 ºC.
ST-4	Atlantic-Layer Upper Boundary	m	2-D XY	No	Depth to first temperature maximum and salinity above 33.50 psu.
ST-5	Atlantic-Layer Thickness	m	2-D XY	No	Bounded by waters above 0.0 ºC and salinity above 33.50 psu.
ST-6	Kinetic Energy	J/m^2	2-D XY	No	Depth range 0 to 1000 m.
ST-7	Buoyancy Inventory	m^2/s^2	2-D XY	No	Depth range 0 to 1000 m.

Table 3.12 Location of Vertical Transects for transport analysis.

ID	Vertical Transects	Notes
VT-1	Spitsbergen to Norway	
VT-2	Fram Strait	
VT-3	Spitsbergen to Severnaya Zemlia	Includes Vilkitsky Strait, if resolved by model.
VT-4	Canadian Arctic Archipelago	Defined by a line drawn from western mainland Canada to Greenland along the Arctic Ocean side of the islands.
VT-5	Bering Strait	Some models impose this transport as a boundary condition and report it is as specified.

Table 3.13 Transport Analysis

ID	Transport	Units	Grid	Archive	Notes
TR-1	Water Volume	m^3/s	2-D YZ	No	
TR-2	Freshwater Volume	m^3/s	2-D YZ	No	Reference salinity is 34.80 psu.
TR-3	Heat	W	2-D YZ	No	Reference potential temperature is 0.0 ºC. Reference depth for potential temperature is 0.0 m.
TR-4	Sea-Ice Volume	m^3/s	2-D YZ	No	At freshwater density.
TR-5	Snow Volume	m^3/s	2-D YZ	No	At freshwater density.

Table 3.14 Streamfunction analysis

ID	Streamfunction	Units	Grid	Archive	Notes
SR-1	Ocean Horizontal	m^3/s	2-D XY	No	
SR-2	Ocean Overturning	m^3/s	2-D YZ	No	
SR-3	Sea-Ice Horizontal	m^3/s	2-D XY	No	

Table 3.15 Sea-Ice analysis

ID	**Sea Ice**	**Units**	**Grid**	**Archive**	**Notes**
SI-1	Mean Thickness	m	0-D	No	Based on effective thickness.
SI-2	Mean Concentration	fraction	0-D	No	Specified between [0..1].
SI-5	Volume	m^3	0-D	No	
SI-6	Area	m^2	0-D	No	Excludes lead area.
SI-7	Extent	m^2	0-D	No	Includes lead area.
SI-7	Kinetic Energy	J/m^2	2-D XY	No	
SI-8	Mean Kinetic Energy	J	0-D	No	

Table 4.1 Targeted scientific publications.

Science Theme	Lead Author(s)
Community Awareness of AOMIP	Proshutinsky
Sea Level Variability	Proshutinsky
Horizontal and Vertical Streamfunctions	Holloway
Vertically-Integrated Heat and Freshwater Contents	Holloway
Kinetic and Potential Energy Budgets	Holland
Transports Through Lateral Boundaries	Häkkinen, Maslowski
Volumetric Temperature and Salinity Analysis	Steele, Zhang
Surface Heat and Freshwater Fluxes	Steele, Zhang
Sea-Ice Deformation Fields	Hibler
Sea-Ice Thickness and Concentration	Gerdes, Tremblay