

High resolution runs user guide

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1 Introduction¹

This note describes the directory structure and content of the high-resolution model run configuration and output data portal <https://arcticdata.io/data/10.18739/A26T0GX63>. The monthly outputs cover the period 01/Jan/2014 through 31/Dec/2014. The model high resolution runs are only used for sensitivity study to investigate the change in the mean ocean and sea ice states in response to tides and atmospheric winds. The model main trajectories have not been well calibrated with observations.

This document briefly describes the model configuration in Section 2, the data portal in Section 3, the monthly averaged model fields in Section 4, and matlab software to reorganize model outputs for efficient storage and post-analyses in Section 5.

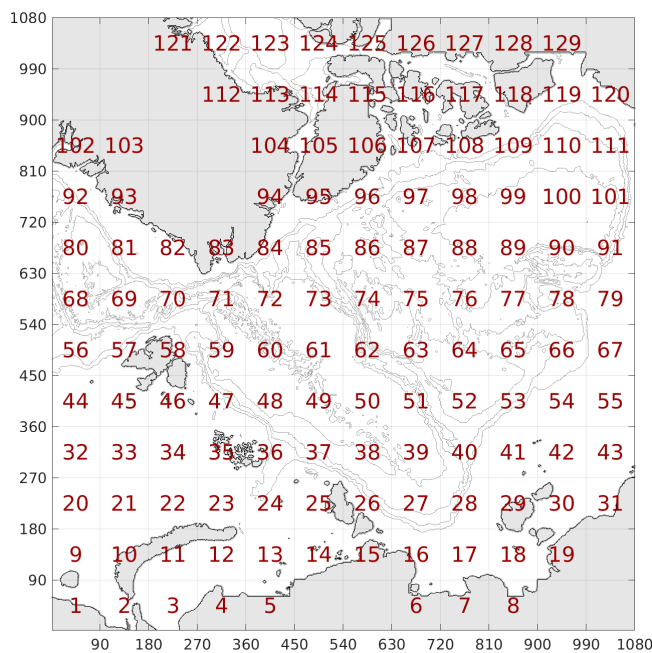


Figure 1 The dimensions of the distributed grid, broken down to 129 tiles of size 90x90. The 3D tiles contain 83 vertical levels spanning depths 0-6000m.

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2 Model

The model is checkpoint67 of the open-source MIT general circulation model (MITgcm).

The checkpoint can be downloaded from

<https://github.com/MITgcm/MITgcm/archive/checkpoint67.zip>.

Additional code modification and required inputs for the configuration are available in the “code_c67”, “NAMELISTS_c67”, and “input_binaries” subfolders. The forcing fields come from JRA55 for surface and ASTE Release 1 (Nguyen et al., 2021) for open boundaries. The low frequency winds were obtained by applying a 48-hr running mean on JRA55 full 10m winds. All forcing fields are available in the [input_binaries](#) subfolder.

The dimension for the distributed domain is 1080 x 1080 and is broken down further into tiles of dimensions 90x90 (**Fig. 1**). The horizontal resolution is nominally 3.5km in the Arctic. The deepest ocean bottom is set to 6000 m below the surface, with the vertical grid spacing increasing from 1 m near the surface to ~200 m near the ocean bottom.

3 Data Server

The data are hosted by the Arctic Data Center (articdata.io) at

<https://articdata.io/data/10.18739/A26T0GX63>. The data are also mirrored at the data

portal https://web.corral.tacc.utexas.edu/OceanProjects/CRIOS_Projects/NSF_1708289/

of the NSF-supported Texas Advanced Computing Center (TACC). The Arctic Data Center portal offers an interface for users to browse and download data through their browser.

4 Directory Structure

In this section, we describe the directory structure of the high-resolution model outputs.

4.1 Model Grid

The model grid information can be found in the subdirectory [nctiles_grid](#). The Arctic domain is split into 129 regional tiles (**Fig. 1**), with each variable saved in 129 separate files in NetCDF format (GRID.0001.nc to GRID.0129.nc). These NetCDF files can be read by using various NetCDF tools in Python, MATLAB, FORTRAN.

4.2 Monthly Average Fields

The model state on the model native grid is provided for three runs: (1) with tides and full winds (labeled “**tides**”), (2) without tides and full winds (labeled “**notides**”), and (3) without tides and 48-hr filtered winds (labeled “**notides_LFwinds**”, where LF stands for low-frequency). The model time stamps are included in each NetCDF file header.

The primary product consists of monthly-averaged model fields ([nctiles_monthly_tides](#), for the run with tides). Each subdirectory inside contains NetCDF files for a model state variable, as indicated by the name of the subdirectory. The files of each variable are organized by tiles. Each file for the first two runs contains all 12 records of monthly output, spanning 01 Jan 2014 to 31 Dec 2014. The third run (notides_LFwinds) only

have 11 monthly records covering 01 Jan 2014 to 30 Nov 2014. As an example, the sea ice area subdirectory [SIarea](#) contains 129 tiles with names [SIarea.0001.nc](#) to [SIarea.0129.nc](#). Only basic model output variables were produced, and all velocity components are located at the cell center. Variables include ocean velocity components (centered so that they are co-located at the tracer point) [UVELMASSc](#), & [VVELMASSc](#), potential temperature [THETA](#), salinity [_SALT](#), SSH (corrected for sea ice and snow loading) [ETANcor](#), atmospheric forcing including 10-m winds (centered) [EXFuwindc](#) & [EXFvwindc](#), 2m air temperature and surface precipitation and pressure [EXFatemp](#), [EXFpreci](#), [EXFpress](#), downward long- and short-wave radiation [EXFlwdn](#) and [EXFswdn](#), ocean surface wind stress (centered) [oceTAUXc](#) & [oceTAUYc](#), ocean net heat and freshwater flux [oceQnet](#) and [oceFWflx](#), sea ice thickness [SIheff](#), area [SIarea](#), and velocity components (centered so that they are co-located at the tracer point) [SIuicec](#) & [SIvicec](#), and snow thickness [SIhsnow](#).

The variable [ETANcor](#) is the height of the model’s liquid ocean surface in unit meter. In the absence of sea ice, this is equivalent to sea surface height (SSH). In the presence of sea ice, a correction for the ice and snow loading is done as follows:

$$\text{ETANcor}(i,j) = (\text{ETAN}(i,j) + \rho_{\text{ice}}/\rho_{00} \cdot \text{SIheff}(i,j) + \rho_{\text{snow}}/\rho_{00} \cdot \text{SIhsnow}(i,j)) \cdot \text{hFacC}(i,j,1)$$

where $\rho_{\text{ice}} = 910 \text{ kg/m}^3$, $\rho_{\text{snow}} = 330 \text{ kg/m}^3$, $\rho_{00} = 1029 \text{ kg/m}^3$, and ETAN the model’s native variable (not distributed, but can be recovered from ETANcor, SIheff, SIhsnow using the formula above).

4.2.1 Native and Geographical Velocity Components

Users are advised to be aware of the directional convention of the vector fields of the model’s grid. Within each tile, the x- and y-directions point left-to-right and bottom-to-top in the figure, respectively. In the domain shown in **Fig. 1**, the x-direction points to the Pacific Ocean, away from the Atlantic, whereas y-direction points to North America, away from Russia. For users who wish to convert the model’s velocity to true eastward and northward velocity components, the rotation to the geographical velocity components requires the model projection geometry [AngleCS](#) and [AngleSN](#) provided in the [nctiles_grid/GRID.*.nc](#) files and can be calculated as follows, for this example with sea ice velocity:

$$\begin{aligned} u_{\text{East}}(i,j,\text{itime}) &= \text{SIuicec}(i,j,\text{itime}) \cdot \text{AngleCS}(i,j) - \text{SIvicec}(i,j,\text{itime}) \cdot \text{AngleSN}(i,j) \\ v_{\text{North}}(i,j,\text{itime}) &= \text{SIuicec}(i,j,\text{itime}) \cdot \text{AngleSN}(i,j) + \text{SIvicec}(i,j,\text{itime}) \cdot \text{AngleCS}(i,j) \end{aligned}$$

4.2.2 Ocean and sea ice state variables

Detailed description of model variables can be found in the file [available_diagnostics.log](#), and are listed below in Tables 1—3.

Table 1 Velocity components for ocean, sea ice, and atmospheric forcing

Filename	Description
UVELMASSc	X-component of ocean velocity, mass weighted (m/s), cell center

VVELMASSc	Y-component of ocean velocity, mass weighted (m/s), cell center
Sluicec	X-component of sea ice velocity, (m/s), cell center.
Slvicec	Y-component of sea ice velocity, (m/s), cell center.
EXFwindc	X-component of 10m atmospheric wind, (m/s), cell center.
EXFvwindc	Y-component of 10m atmospheric wind, (m/s), cell center.
oceTAUXc	X-component of surface wind stress (N/m ²), cell center.
oceTAUYc	Y-component of surface wind stress (N/m ²), cell center.

Table 2 State variables

Directory name	Description
ETANcor	Model sea surface height anomaly (m), corrected for sea ice and snow load.
SIarea	Fractional sea-ice covered area (m ² /m ²)
SIheff	Effective sea-ice thickness (m) that is defined as actual sea-ice thickness scaled by fractional sea-ice area (SIarea).
SIhsnow	Effective snow thickness (m).
oceQnet	Net surface heat flux into ocean (W/m ²)
oceFWflx	Net surface FW flux into ocean (kg/m ² /s)
THETA	Ocean potential temperature (°C).
SALT	Ocean salinity (g/kg).

Table 3 Atmospheric forcing variables

Directory name	Description
EXFatemp	2m air temperature [°K]
EXFpreci	Surface rain (m/s)
EXFpress	Surface pressure (N/m ²)
EXFlwdn	Downward longwave (W/m ²).
EXFswdn	Downward shortwave (W/m ²)
EXFtidep	Tidal geopotential, (m ² /s ²), only in tides run

4.3 Input Files

The subdirectories [code_c67](#) contains modified code to compile with the MITgcm checkpoint 67, [NAMELISTS_c67](#) contains runtime input parameters, and [input_binaries](#) includes all files in raw binary formats that are needed to re-run the model (Table 4).

The atmospheric forcing used is [JRA55](#) (Kobayashi et al., 2015). The precipitation field has further been adjusted to remove excess rain in the tropics, as described in Nguyen et al. (2021), and is included in [input_binaries](#) under the name with extension “it12xx”. All eight 3-hourly atmospheric forcing fields (uwind, vwind, 2 m air temperature, specific humidity, adjusted rain, downward short and long wave radiations, surface pressure) for the year 2014 of the model run are provided in JRA55 native grid in [input_binaries](#) and

pointed to in [NAMELISTS_c67/data.exf](#). The low-frequency winds were calculated by performing a 48-hr running mean on both the JRA55 uwind and vwind fields.

In addition to the JRA55 forcing fields, two additional forcing being input at the surface are the river runoff (Nguyen et al., 2011) and tidal potential (see Table 3). The tidal potential field for 2014 are calculated for a coarse resolution 2-deg global field using open-source python wrapper (<https://github.com/joernc/tidal-potential>) and the NASA SPICE software (<https://naif.jpl.nasa.gov/naif/>).

Table 4 Input files are needed to re-run the model.

Directory or file name	Description
README.txt	A readme file on how to download the code and link input files.
code_c67	Code required to compile with the MITgcm for high-res configuration.
NAMELISTS_c67	Namelist such as file “ data ”, “ data.exf ”, etc.
jra55*_2014	JRA55 forcing fields at 3-hourly frequency for year 2014
pot_tide_1deg_2014	Tidal potential for 2014, 1° horizontal resolution, at hourly frequency
bathy_v2.bin	Bathymetry (m).
pickup*0001577880* files	Pickup files for Jan 01, 2014.
OB[E,S]{t,s,u,v}* files	Open boundary extracted from Nguyen et al., 2021. Monthly frequency.
OB[E,S]{am,ph}	Open boundary tidal amplitude and phase, extracted from TPXO 7.2 (Egbert & Erofeeva, 2002, tpxo.net).
diffkr3d_aste.bin*	Vertical mixing coefficients, m ² /s
tile* files	Grid files needed to run the model.
runofflp2472-360x180x12.bin	Climatology river runoff (m/s). Positive to increase sea level.

5 Software

When re-running the model using input files from Section 4.3, the full domain outputs have dimension 1080 x 4140 and contain lower-latitude regions not relevant to the project. A post-processing toolbox written in matlab is provided in the directory [matlab_tools/](#) and subdirectory [matlab_tools/mitgcm_tools/](#) to enable the users to reduce the dimension as well as re-organize the model outputs to facilitate efficient storage and post-analyses. The wrapper [get_data_arcticdata_io_wrapper.m](#) calls several functions

within the subdirectory `mitgcm_tools/` to extract only model wet points, reduce the dimension, re-organize into tiles of size $90 \times 90 \times (xNz) \times 12$ as described in Sections 4.1-4.2, and write the re-processed outputs out to binary or NetCDF files. Scripts in `mitgcm_tools/` relevant to binary data I/O are from of the open-sourced MITgcm standard distribution on GitHub (e.g., http://mitgcm.org/public/source_code.html, https://github.com/MITgcm/MITgcm/tree/master/utils/matlab/cs_grid/read_cs), while those relevant to NetCDF I/O are modified code from the open-sourced standard distributed ECCO gcmfaces software (https://gcmfaces.readthedocs.io/en/latest/prep_install.html, <https://github.com/MITgcm/gcmfaces>).

Questions:

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