

## Arc2kmTM: Arctic 2 km Tide Model

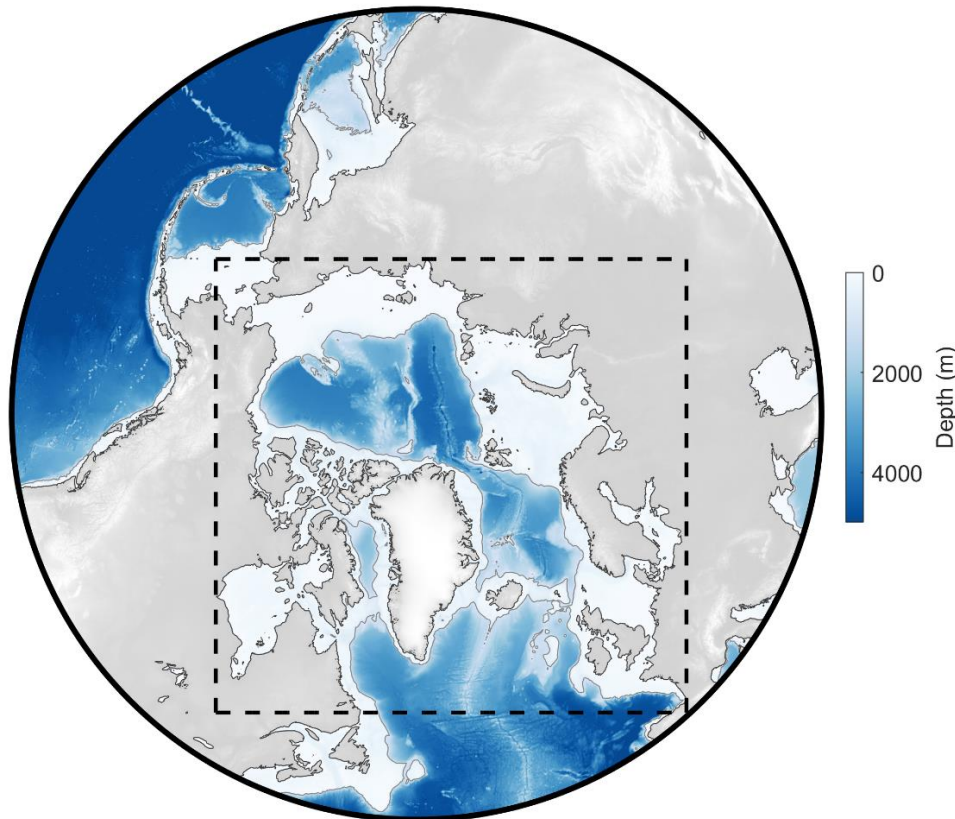
### Summary

The Arctic 2 km Tide Model (Arc2kmTM) is a barotropic ocean tide model on a 2x2 km polar stereographic grid. The model domain is shown in Figure 1. Development of the model is explained in the Methods section, below. Arc2kmTM consists of spatial grids of complex amplitude coefficients for sea surface height and depth-integrated currents (“volume transports”) for 8 principal tidal constituents: 4 semidiurnal (M2, S2, K2, N2) and 4 diurnal (K1, O1, P1, Q1).

Model bathymetry is based on the 2014 30 arc-second General Bathymetric Chart of the Oceans (GEBCO\_2014) grid, with updates in three areas around Greenland.

The Arc2kmTM gridded files are in binary format and are designed to be used with the following open-source software packages: the Matlab “Tide Model Driver” (TMD) toolbox, the Python “pyTMD” package, and the FORTRAN “OSU Tidal Prediction Software” (OTPS). These packages allow the user to browse the model for different constituents, and to make tidal predictions of sea surface heights, volume transports and currents for any time at any location within the model domain.

**NOTE:** Please also check the [ESR Polar Tide Model webpage](#) and our [Arctic Data Center Portal](#) for other Arctic-region barotropic tide models and more information on software packages.



**Figure 1:** Domain for Arc2kmTM (dashed black line); grid is polar stereographic (standard latitude and longitude of 70°N and 45°W) with uniform spacing of 2 km. Color scale shows depth in meters.

## Arc2kmTM: Model Summary

Build Date:	2021
Version Number:	1
Model type:	Forward (dynamics-based); barotropic (depth-integrated)
Grid:	2-km uniform polar stereographic (70°N, 45°W)
Constituents:	$M_2, S_2, N_2, K_2, K_1, O_1, P_1, Q_1$
Units:	$z$ (surface height; meters); $u, v$ (currents; cm/s); $U, V$ (transports; $m^2/s$ )
Coordinates:	Currents and transports are in East ( $u, U$ ) and North ( $v, V$ ) components

### **Files**

Model_Arc2kmTM_v1	Model control file, used by TMD and OTPS to identify gridded bathymetry and constituent files
h_Arc2kmTM_v1	Complex amplitude coefficients for sea surface height
UV_Arc2kmTM_v1	Complex amplitude coefficients for volume transports
grid_Arc2kmTM_v1	Grid of bathymetry
xy_ll_Arc2kmTM	File for converting between polar stereo native grid and lat, lon
Arc2kmTM_v1_README.pdf	(This file) Readme file for the Arc2kmTM model
Arc2kmTM_FileFormat.pdf	Document describing format of files included in this model package

Contact Susan Howard ([showard@esr.org](mailto:showard@esr.org)) or Laurie Padman ([padman@esr.org](mailto:padman@esr.org)) for advice about the use of this model.

## Methods

Arc2kmTM was developed using the Regional Ocean Modelling System (ROMS) version 3.7 (Haidvogel et al., 2000; Shchepetkin and McWilliams, 2005; Budgell, 2005), solving the depth-integrated shallow water equations on a 2 km x 2 km polar stereographic grid of the Arctic Ocean and adjacent regions. ROMS is a hydrostatic, 3-D primitive equation numerical model that uses a terrain-following (sigma-level) coordinate system. For producing tidal coefficients for a barotropic model, we are interested in the depth-integrated solution. The model was forced at the open boundaries with depth-averaged tidal currents and elevation values from the TOPEX/Poseidon global barotropic tidal solution version 9.1 ([TPXO9.1](#)). We applied potential tides (equilibrium tides plus self-attraction and loading (SAL)) as forcing across the domain. The inclusion of the potential tides significantly improves the accuracy of the tidal solutions. Although ROMS can be run as a purely barotropic 2-D model, the inclusion of potential tides in current versions requires that a baroclinic (depth-dependent) solution be calculated. Therefore, we ran our simulations with 5 levels and constant temperature and salinity (i.e., a homogeneous ocean), to mimic a barotropic model but to allow for inclusion of potential-tide forcing.

Model bathymetry is based on the 30 arc-second General Bathymetric Chart of the Oceans (GEBCO) grid GEBCO\_2014, version 20150318 (<http://www.gebco.net>). This grid includes the International

Bathymetric Chart of the Arctic Ocean (IBCAO), version 3.0 ([www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html](http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html)), described by Jakobsson et al. (2012). Based on more recent fieldwork, we revised the bathymetry for our model in three key regions around Greenland: Northeast Greenland, Petermann Fjord and the adjacent area of Nares Strait, and the Northwest Greenland coastal region. A high resolution (100 m) coastline file from J. Mouginot (Rignot and Mouginot, 2012) was used to define the Greenland land mask, with adjustments for the Petermann ice shelf. Other ice shelves in Greenland are not included in Arc2kmTM but are included in our Greenland 1 km Tide Model (Gr1kmTM).

## Validation

The model was validated using tide height amplitude and phase coefficients from coastal and benthic tide gauge records within the model domain, extracted from the Kowalik and Proshutinsky (1994) dataset.

## Known Issues

- For tide heights, this model provides ocean tide only; i.e., sea surface height change relative to the seabed. Some applications will require adjustment for seabed deformation (“ocean tide loading”). Users require a separate ocean load tide model for this calculation.
- Bathymetry in some areas is poorly constrained by data. For barotropic currents, we recommend that the user calculates depth-integrated volume transport, then divides by the latest depth data to get depth-averaged currents.
- The grid is polar stereographic. To convert from (x,y) to (lat,lon) and vice versa, Matlab TMD users should use the `xy_ll_Arc2kmTM.m` script. For OTPS and pyTMD, use available code with standard latitude and longitude of 70°N, 45°W.

## File Formats

The files are written as Fortran binary sequential files, formatted to match the Oregon State Tidal Inversion Software (OTIS) format. These files can be easily accessed using ESR’s Matlab “Tide Model Driver” (TMD) toolbox (<https://github.com/EarthAndSpaceResearch>), the community Python-based pyTMD software (<https://github.com/tsutterley/pyTMD>), and OSU’s FORTRAN “OSU Tidal Prediction Software” (OTPS) (<https://www.tpxo.net/otps>). For full details of our file format, please refer to `Arc2kmTM_FileFormat.pdf` included in the model download.

## Related Links

Arctic Tides Portal at ADC:	<a href="https://arcticdata.io/catalog/portals/ArcticTides/">https://arcticdata.io/catalog/portals/ArcticTides/</a>
ESR Polar Tide Models:	<a href="https://www.esr.org/research/polar-tide-models/">https://www.esr.org/research/polar-tide-models/</a>
OSU Tidal Prediction Software (OTPS):	<a href="https://www.tpxo.net/otps">https://www.tpxo.net/otps</a>
pyTMD package:	<a href="https://github.com/tsutterley/pyTMD">https://github.com/tsutterley/pyTMD</a>
TMD Matlab Toolbox:	<a href="https://github.com/EarthAndSpaceResearch">https://github.com/EarthAndSpaceResearch</a>

## References

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