ACME
Accelerated Climate Modeling for Energy

Ocean/Sea Ice/Land Ice/Marine BGC

Capabilities relevant to v1/v2 Tropics and Arctic campaign

U.S. DEPARTMENT OF ENERGY

What new features will be in V2?

v1 MPAS-Ocean, Sea-Ice and Land-Ice components, plus ….

MARBL — MARine Biogeochemical Library — for development of a hierarchy of ocean-model agnostic marine ecosystem modules.

BGC / Land-Ice into standard ACME / MPAS-Analysis workflow

Continued build out of ocean and sea-ice diagnostics in standard workflow

Quasi-isopycnal vertical coordinate for improved static coupling of ocean / land-ice shelves — including support of massless layers.

Non-Boussinesq primitive equations — for capturing the steric component of sea-level rise.

Iceberg calving - transport - melt processes

Improve sea-ice snow model

Significant performance improvements — specifically targeting Cori / Theta

(coupled land-to-river-ocean transport of trace constituents would be nice. Possible?)

Multi-resolution V2 grids for Tropics / Arctic

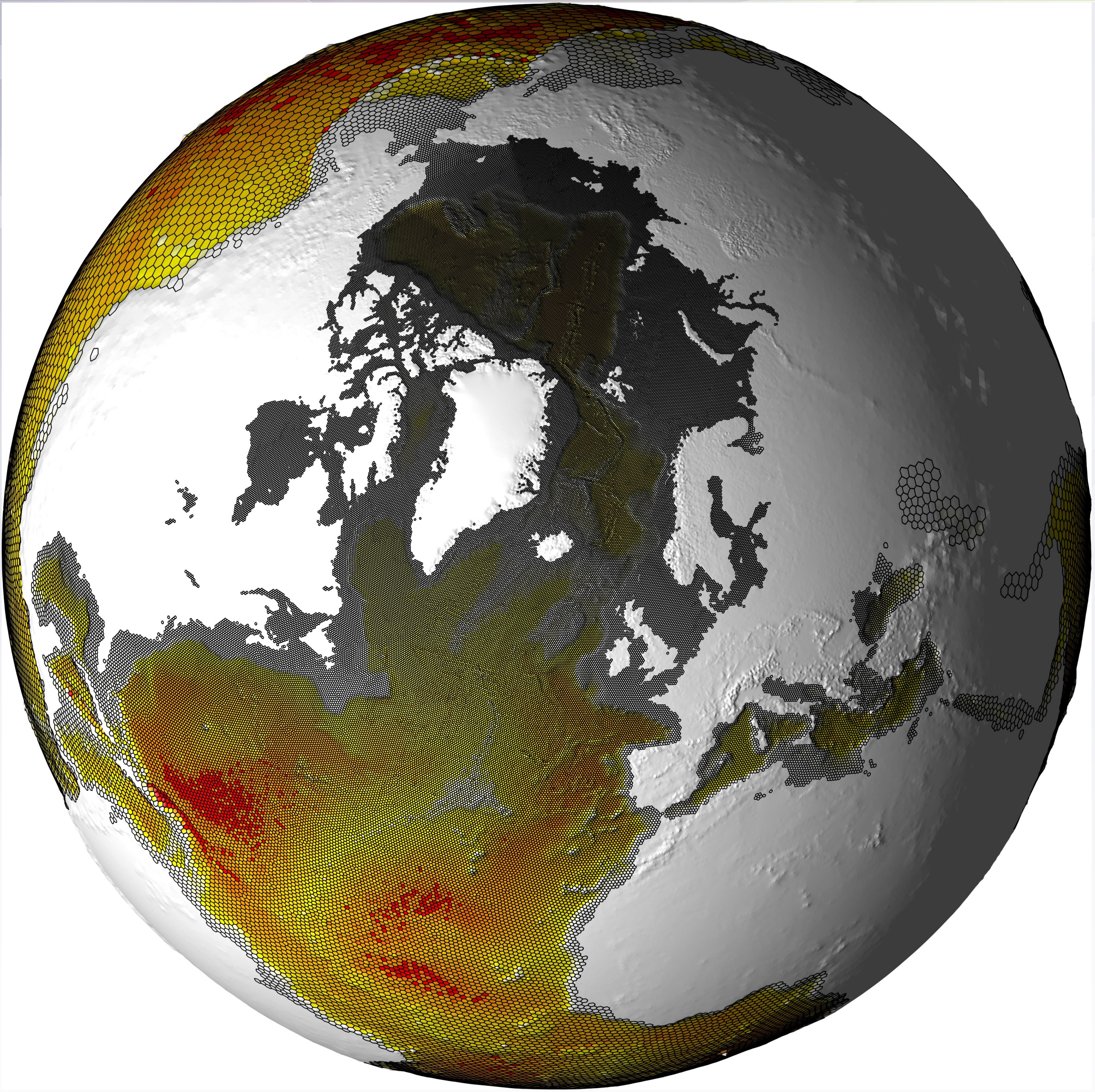
Tropics: We could focus ocean (and some atmosphere) resolution off the west coast of South America to better resolve the ocean eastern boundary current, influence of the Andes on atmosphere circulation and the coupling of these ocean/atmosphere processes.

Arctic: We would focus ocean / sea-ice resolution toward the North Pole to better resolve the changes in seasonality of sea-ice extent and water mass transformation.

A (rough draft) multi-resolution ocean/sea-ice mesh for Arctic science applications.

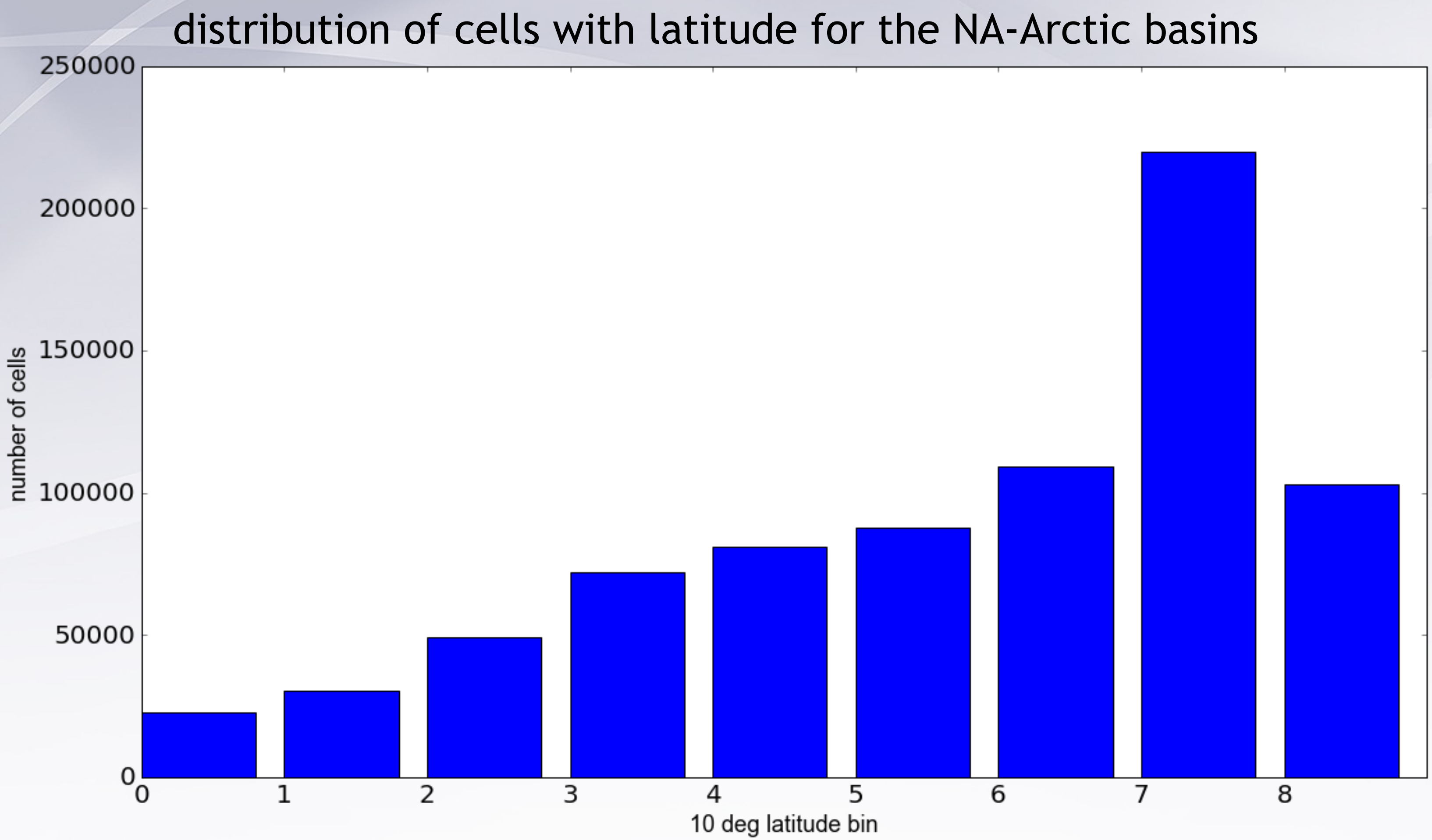
This mesh is a hybrid of the ACME v1 high- and low-resolution water cycle meshes.

North Atlantic / Arctic ocean domain scales from 18 km at Equator to 6 km in the Arctic.



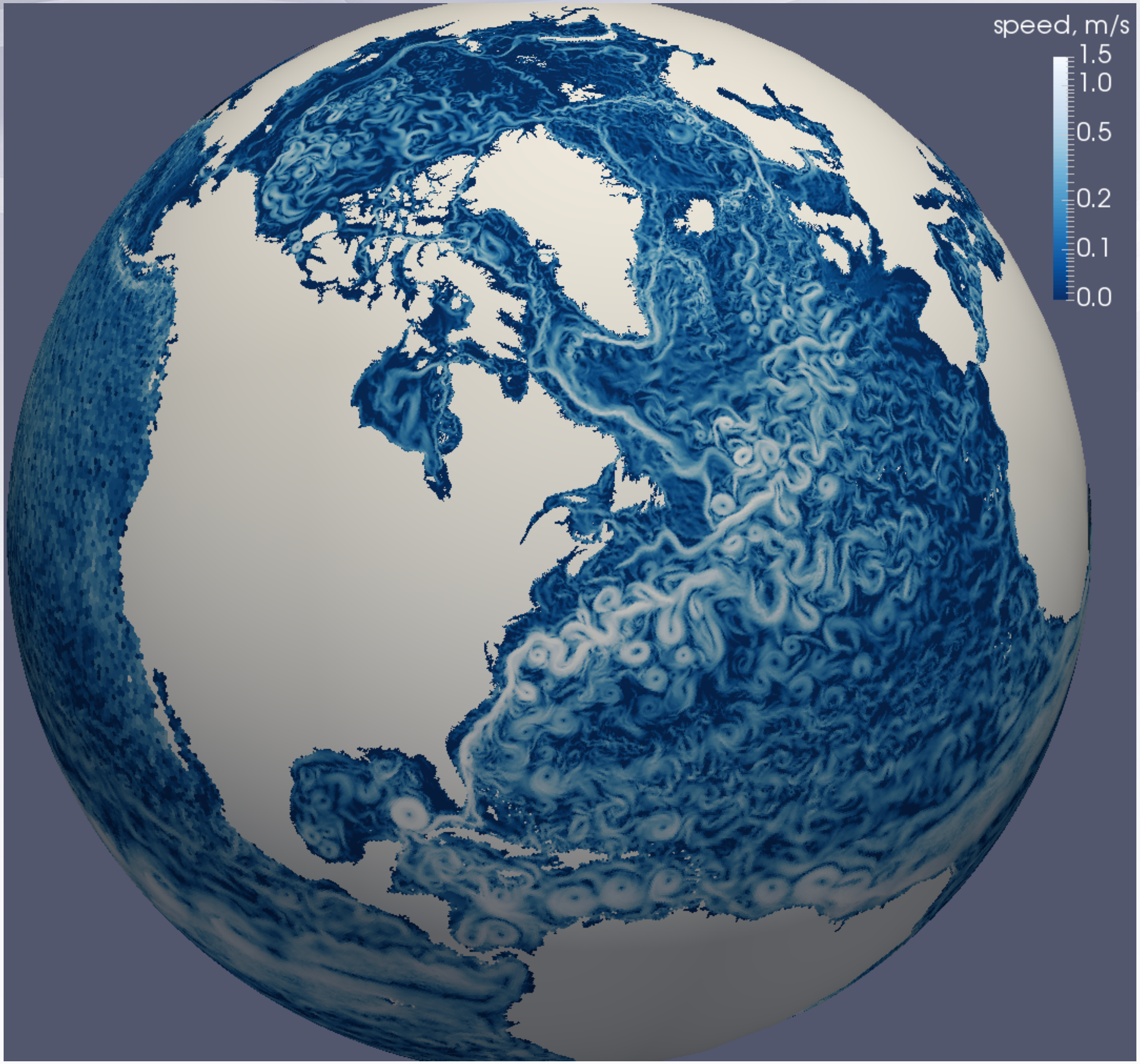
Mesh produced by Darren Engwirda (GISS) using his JIGSAW-GEO software.

Distribution of cells in NA-Arctic focused mesh



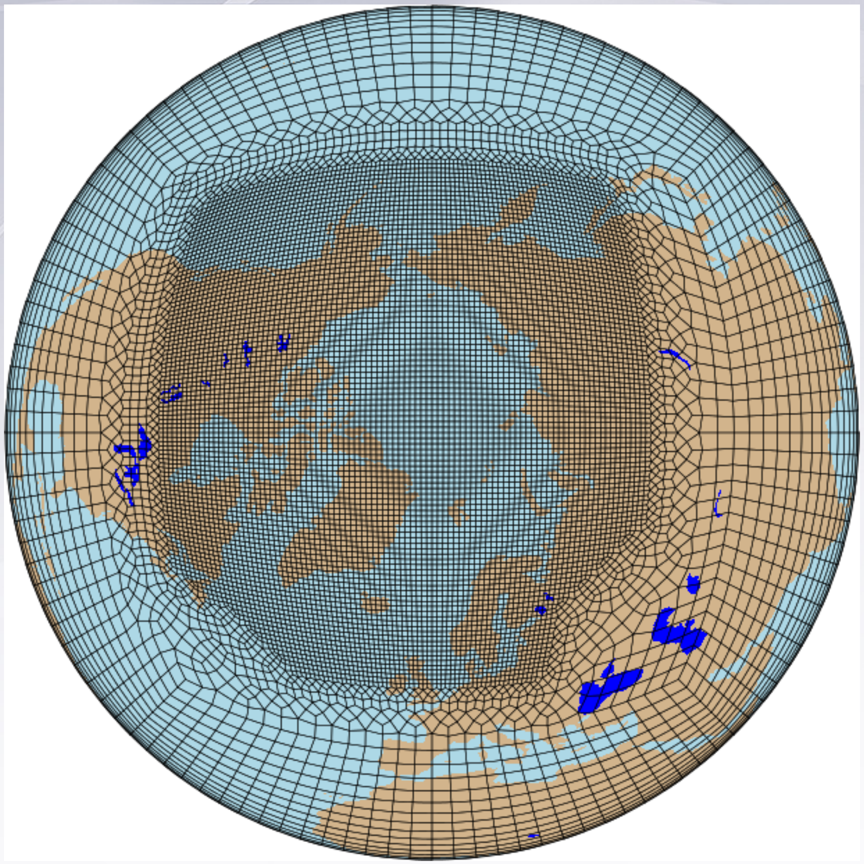
2/3 of the cells are poleward of 50N.

Snap-shot (after 2 years of spin up from rest) of ocean surface current speed using a NA-Arctic focused mesh.

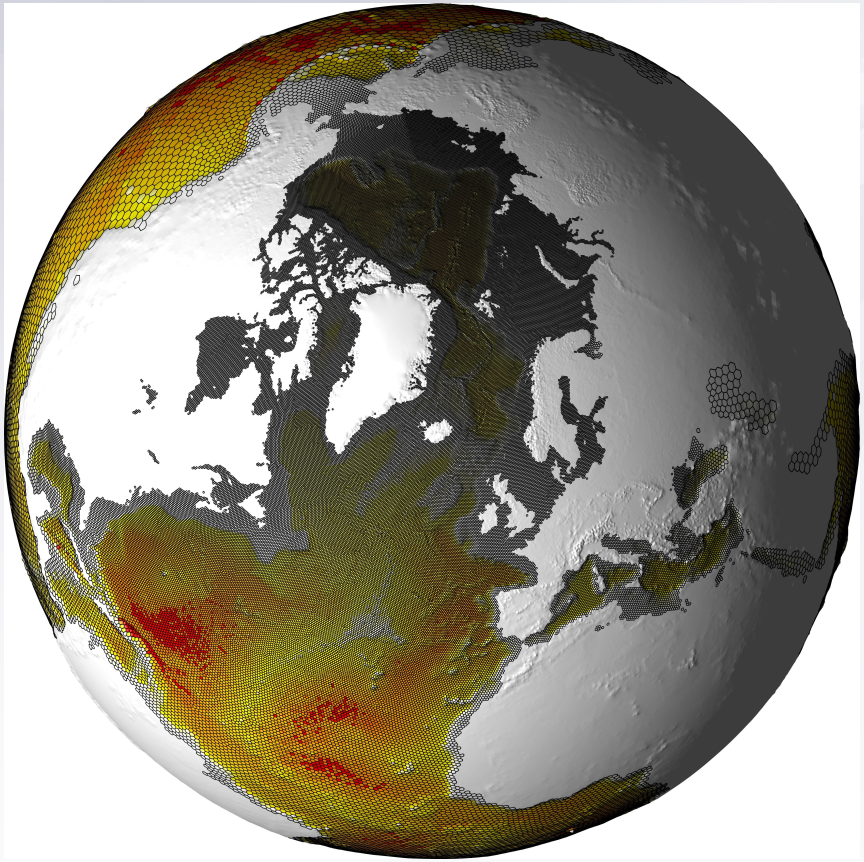


(CORE-II wind stress, no sea-ice)

ACME v2 can address some of the tension between resolution and ensemble size ….



ACME Spectral Element Atmosphere Model
25 km resolution in Arctic
~7X saving in compute over global high-res



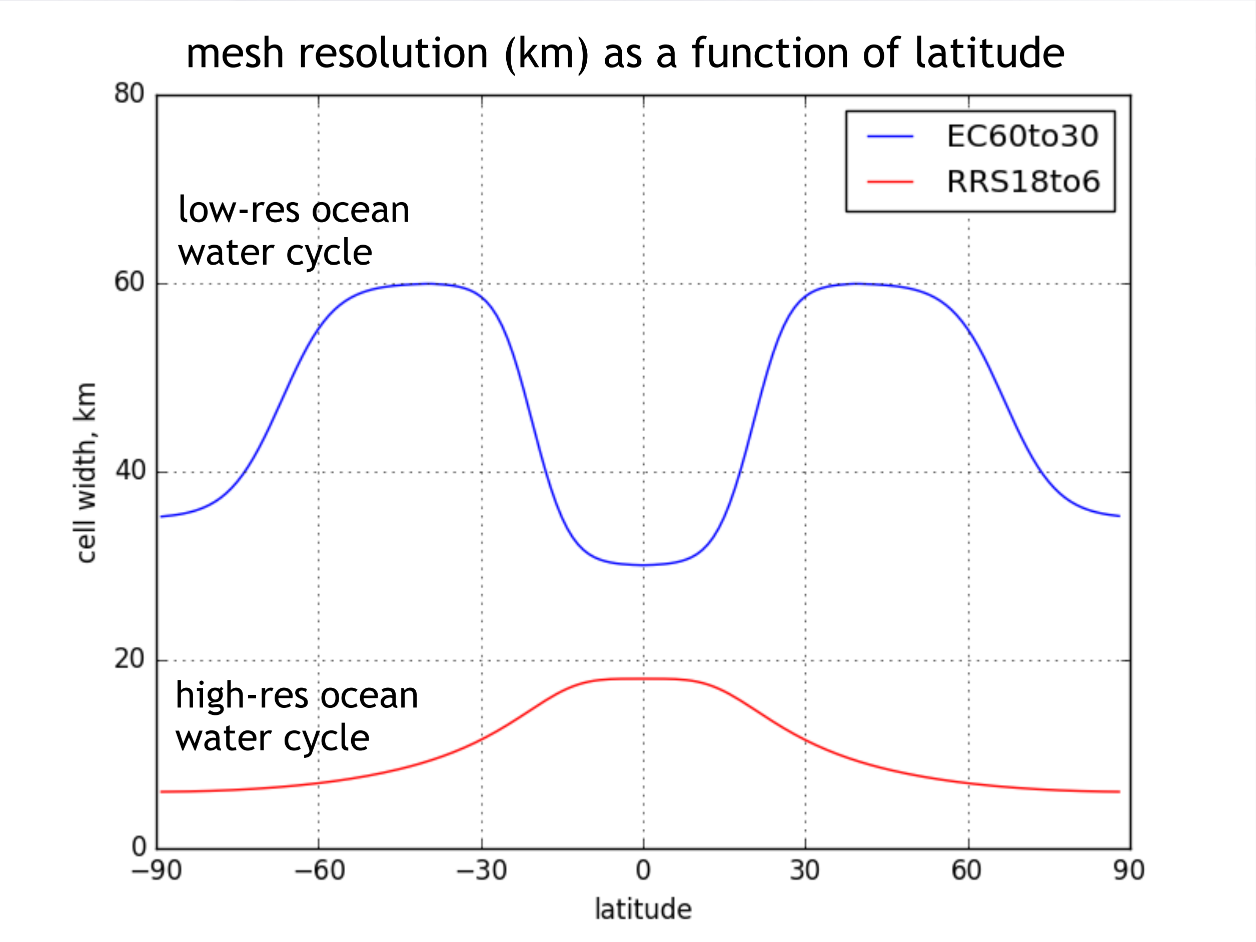
ACME Model for Prediction Across Scales - Ocean
6 km resolution in Arctic
4X saving in compute over global high-res

Additional slides

Resolution of ACME v1 high- and low-resolution water cycle configurations:

atmosphere
- low-res: ~100 km
- high-res: ~25 km

ocean
- low-res: EC60to30
- high-res: RRS18to6



Why develop an multi-resolution, Arctic-focused ESM configuration?

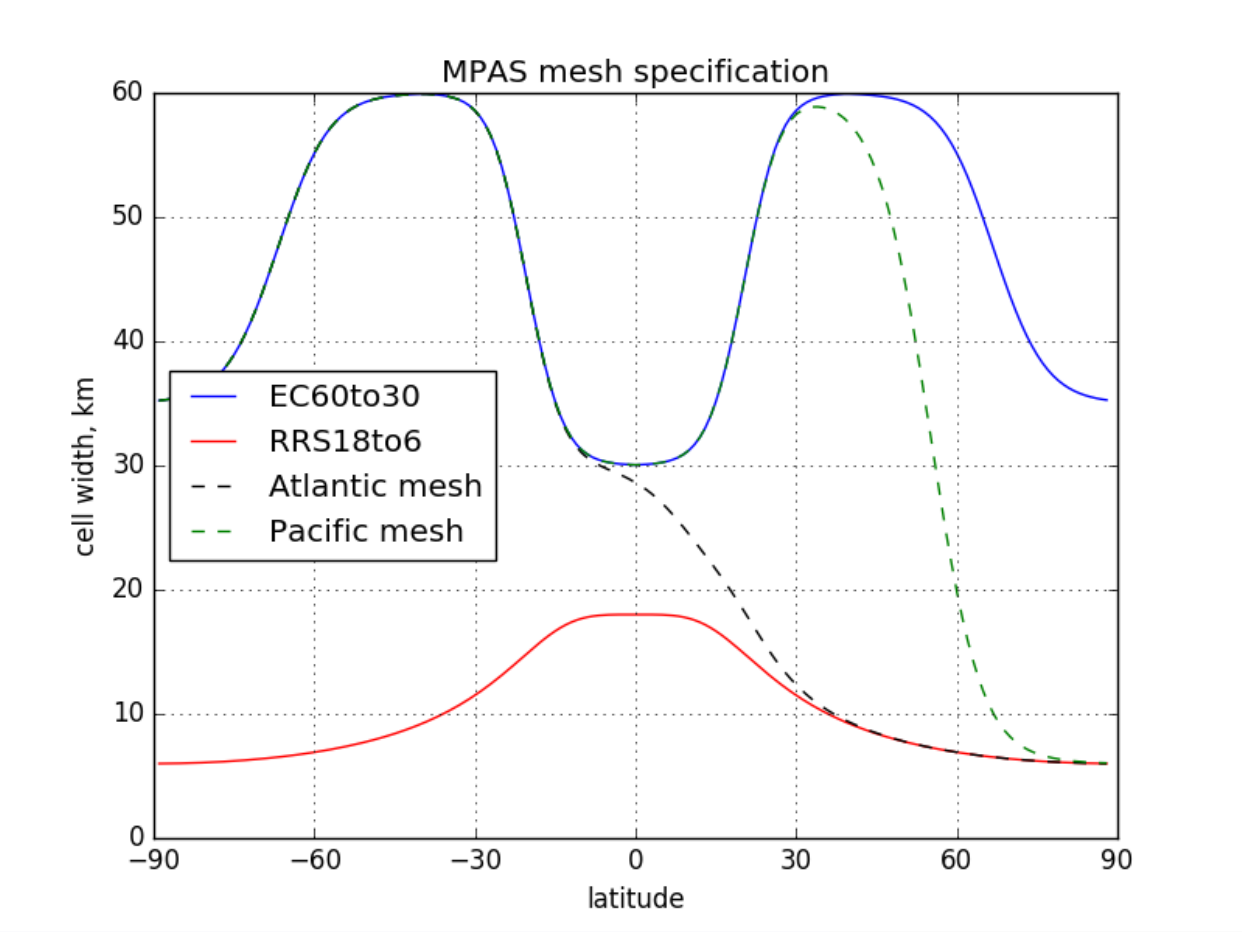
This configuration with ~5X cheaper than the ACME v1 high-resolution water cycle configuration.

We can “re-invest” our 5X savings toward increasing ensemble size.

The lowest hanging fruit for demonstrating value of a fully-coupled, multi-resolution ESM configuration is probably in the Arctic region.

NA-Arctic focused mesh is a blending of the low- and high-res water cycle meshes:

NA-Arctic focused mesh is equal to the low-res water cycle mesh everywhere except in NA and Arctic basins where it is equal to the high-res water cycle mesh.

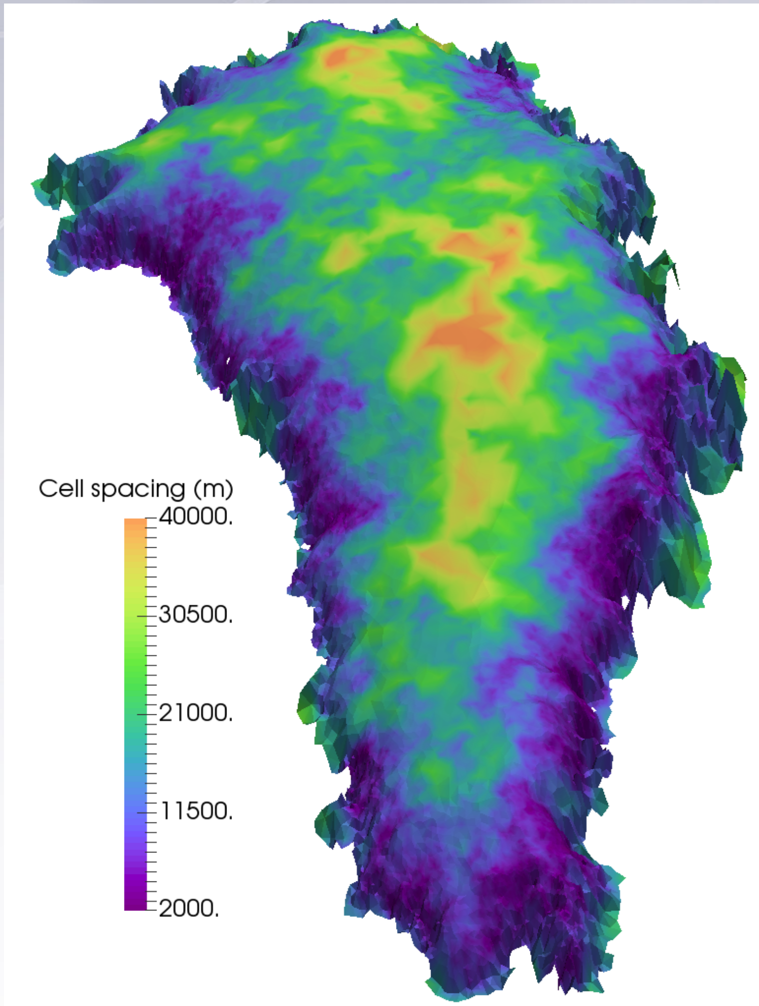


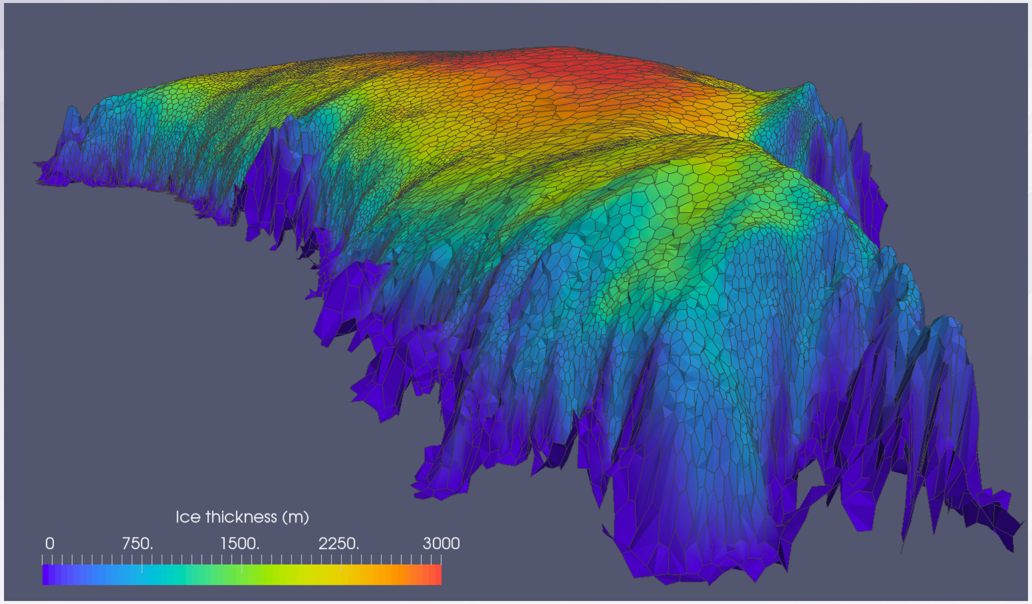
Allocation of computational resources

Mesh	Total number of cells	Number of cells in NA-Arctic	Faction of cells in NA-Arctic region
low-res water cycle mesh	234,988	37,196	0.16
high-res water cycle mesh	3,697,425	775,382	0.20
NA-Arctic focused mesh	973,174	775,382	0.78

We are intending to reallocate the 4X in computational savings over the high-res water cycle configuration toward increasing the ensemble size.

Greenland Ice Sheet resolution





resolution ranges from 40 km in low ice-velocity regions along ridge lines to 2 km in high ice-velocity ice streams.