Model for Prediction Across Scales: An Unstructured Modeling Framework

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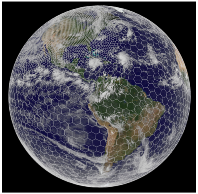
What is MPAS?

The Model for Prediction Across Scales (MPAS) is a collaborative framework for developing atmosphere, ocean and other earth-system simulation components for use in climate, regional climate and weather studies.

Developed in collaboration between:

- Los Alamos National Laboratory (LANL)
- The National Center for Atmospheric Research (NCAR)

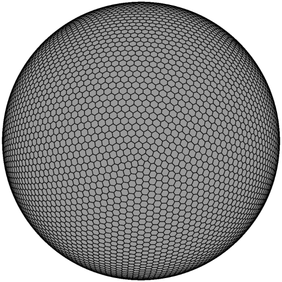


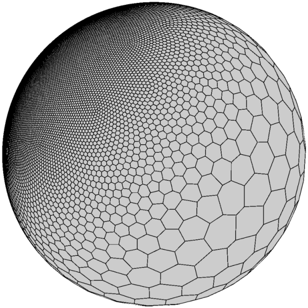
It is developed to allow a model developer to:

- Leverage improvements made to shared code.
- Rapidly prototype and develop new model components.

What is MPAS?

The MPAS framework utilizes arbitrary polygon unstructured meshes. This means the framework supports running a dynamical core on anything from triangles, to quadrilaterals, to mixed shape grids. Most MPAS components employ Spherical Centroidal Voronoi Tessellations (SCVTs) as their horizontal meshes.





What is MPAS?

The MPAS framework has made two public releases to date, including the following models:

- Atmospheric Model (NCAR)
- Land Ice Model (LANL)
- Ocean Model (LANL)
- Shallow Water Model (LANL/NCAR)

In addition to these publicly released models, LANL is in the process of developing a next generation sea ice model within the MPAS framework.

MPAS Releases

MPAS is publicly available through github.

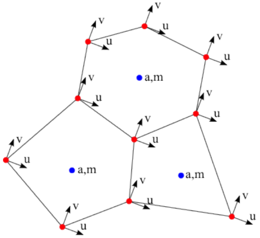
http://mpas-dev.github.io

The above website includes source code, and input files for all versions of MPAS.

MPAS-Ice Models

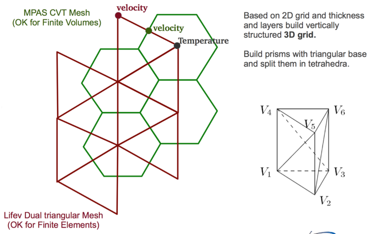
MPAS-CICE

- Dynamics are based on the Los Alamos Sea Ice Model, CICE
- Includes EVP Rheology
- Will include column physics from CICE:
  - Shortwave
  - Thermodynamics
  - Mechanical Redistribution
- B-Grid; C-Grid for advection



MPAS-Land Ice

- Hierarchical suite of FEM dycores (Stokes, 1st-order, L1L2, SSA, SIA)
- Nonlinearity handled with Picard and/or Newton-based methods
- Uses Trilinos solver library
- Scales to 9000+ procs
- A-grid; C-grid discretization used for advection
- Utilizes the triangular SCVT-dual mesh, for use with Finite Element Models (FEM).

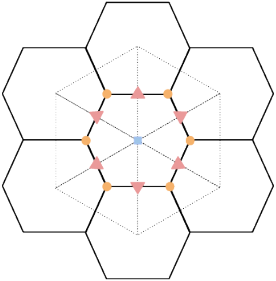


MPAS Ocean Numerics

MPAS Ocean is implemented using a C-Grid Staggering. The figure

below shows the spatial layout of data:

- Primary Mesh (Voronoi, Black Solid Hexagons)
- Dual Mesh (Delaunay, Black Dotted Triangles)
- Scalar Quantities (Blue Squares)
- Vector Quantities (Red Triangles)
- Vorticity Quantities (Orange Circles)



MPAS Ocean Numerics

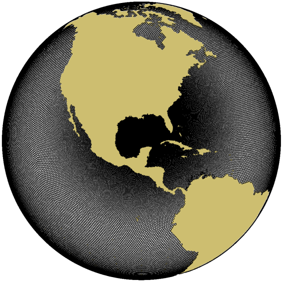
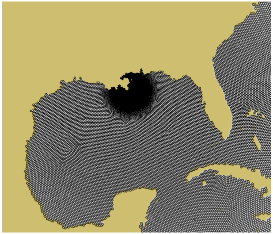
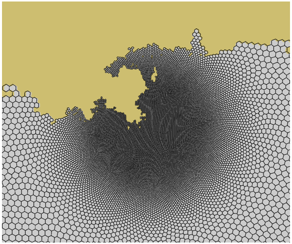
MPAS-Ocean solves the Hydrostatic, Boussinesq, Primitive Equations:

- Solves the Hydrostatic, Boussinesq, Primitive Equations
- Conserves mass, total energy, and potential vorticity
- Is mesh agnostics
  - Can simulate on different sized polygons within the same simulation
- Uses FCT for monotonic advection
- Has two explicit time integration schemes:
  - RK4
  - Split-explicit

MPAS Ocean Variable Resolution Meshes

As mentioned earlier, MPAS ocean can simulate on arbitrary polygonal meshes, including variable resolution meshes.

Below is an example of a mesh refined around the Mississippi Delta

MPAS Ocean Vertical Coordinate

The vertical coordinate in MPAS-Ocean is Arbitrary Lagrangian-Eulerian (ALE), and currently has support for the following:

- Z-Level (Fixed vertical interfaces, aside from sea surface)
- Isopycnal (No flux across vertical interfaces)
- Sigma (Layer thickness proportional to depth)
- Z-Star (Distributed Sea Surface perturbation)
- Z-Tilde (Frequency Filtered Thickness)

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MPAS Ocean Vertical Coordinate

For coupled Ice Shelf - Ocean simulations, we need to depress the ocean surface with the weight of the ice shelf.

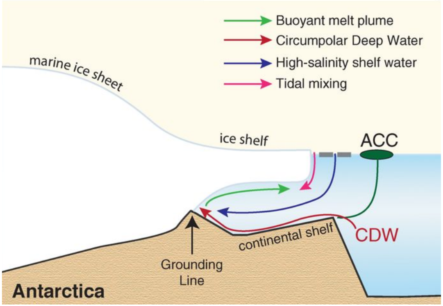
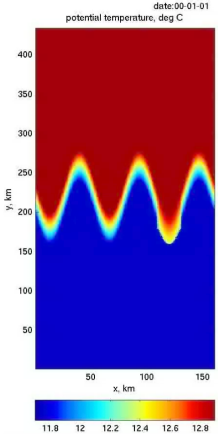
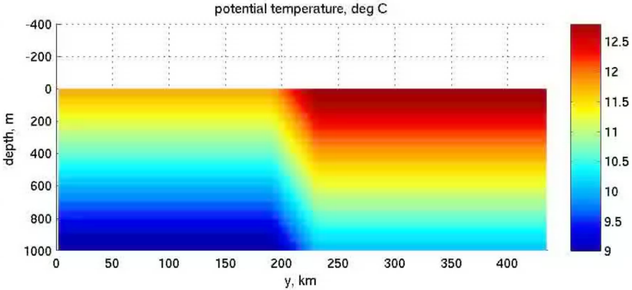


Figure from Joughin ea. Science, 2012

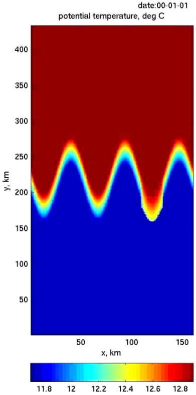
MPAS Ocean Test Case Setup

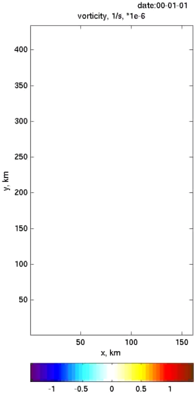
Test domain: Baroclinic Eddies Test Case from Ilicak, et al. 2012.
1km mesh spacing, 20 50km vertical levels, Zonally periodic

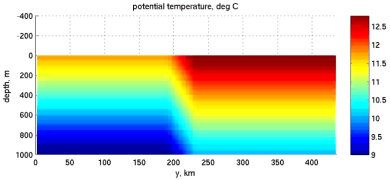




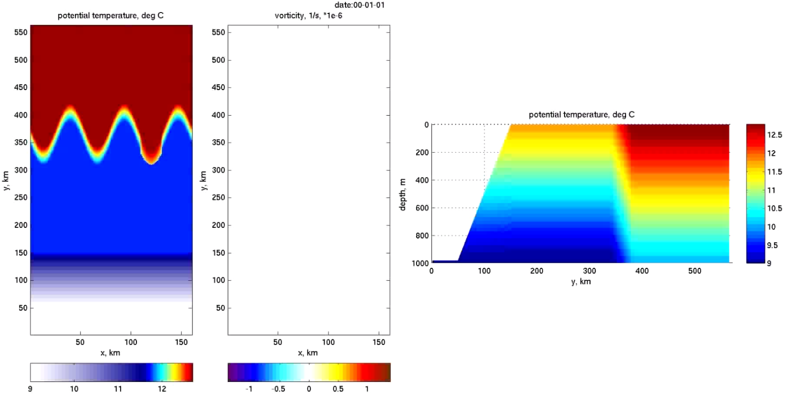
MPAS Ocean - Baroclinic Channel Test





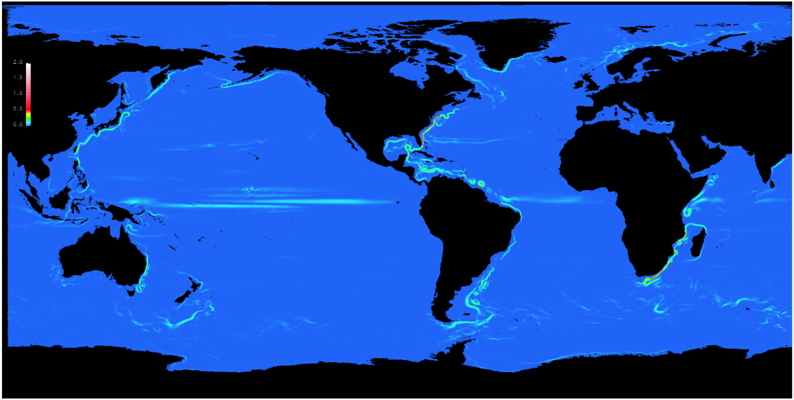


MPAS Ocean - Baroclinic Channel Depression Test



The End

Questions?



MPAS Ocean References

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