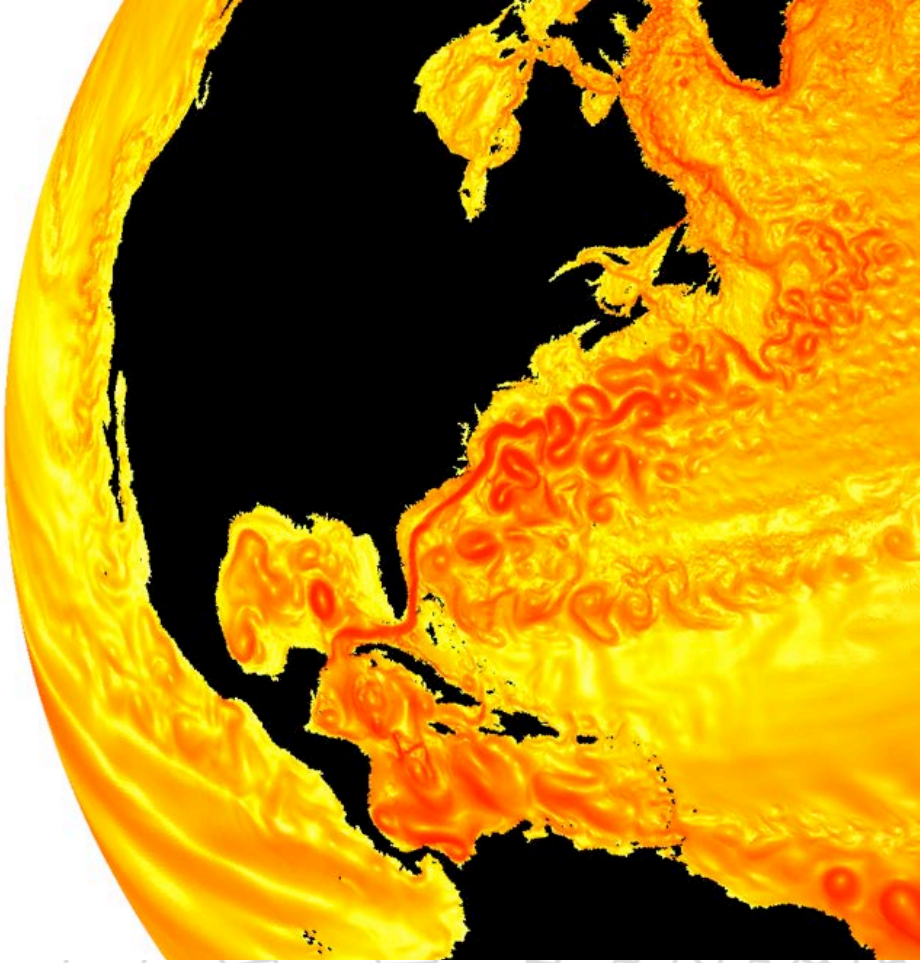
The MPAS-Ocean
Progress Report



Mark Petersen

and the MPAS-Ocean development team

Los Alamos National Laboratory

MPAS
Model for Prediction Across Scales

MPAS-Ocean: Progress since June 2013

- Regular, coordinated MPAS releases every six months:
  - Release 1.0 in June 2013, 2.0 in December 2013
- First MPAS-Ocean publication appeared September 2013

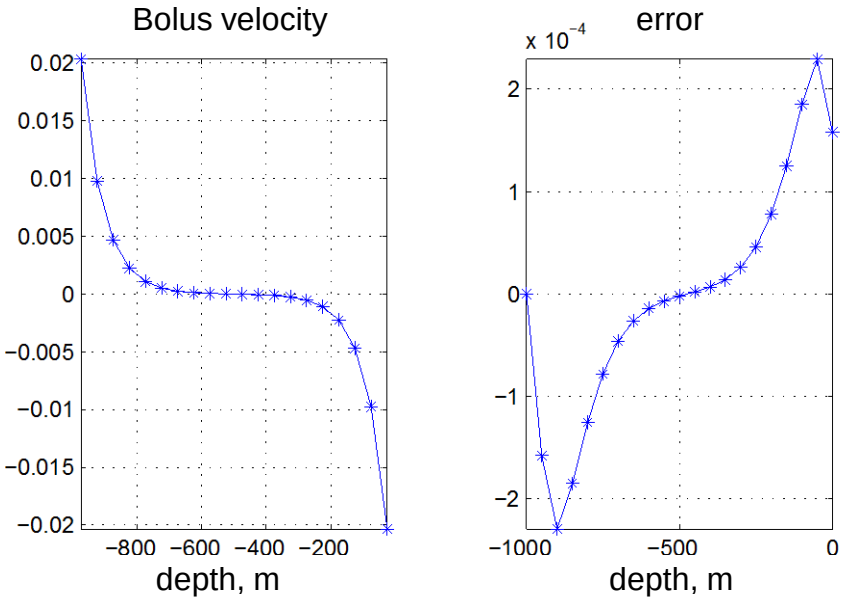
Major improvements in release 3.0, planned for July 2014

- Physical parameterizations:
  - GM
  - KPP
- Code infrastructure:
  - Analysis mode
  - more flexible i/o capability
  - major data structure revisions
- Modeling capability:
  - ALE vertical coordinate, with validation

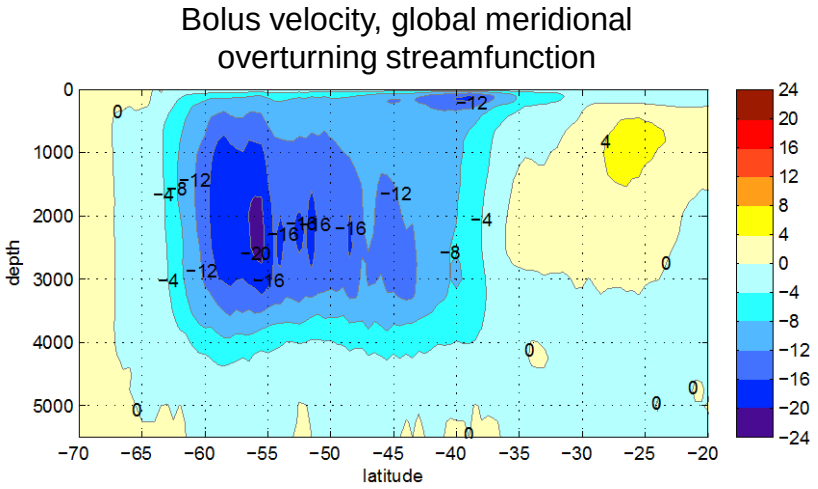
MPAS-Ocean 3.0: GM eddy parameterization

- GM fully implemented
- Bolus (eddy-induced) streamfunction solved with boundary value problem in each column, following Ferrari et al 2010.
- Formulated for general coordinate system (i.e. tilted layers).
- Validation using analytic solution
- Currently testing in idealized and real-world configurations

Idealized test, vs analytic solution



Global real-world simulations

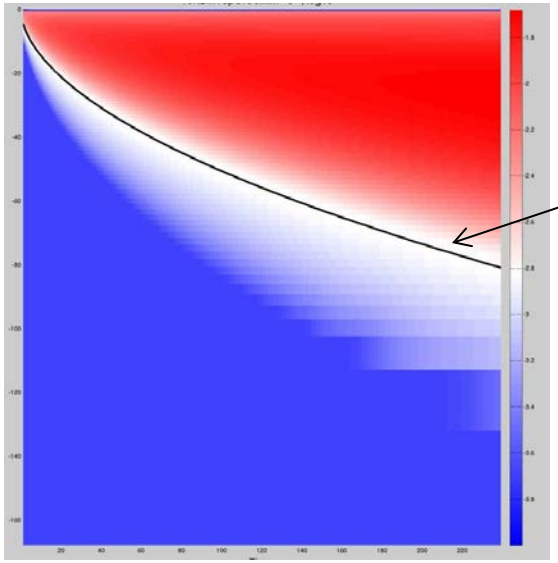


MPAS-Ocean 3.0: KPP vertical mixing parameterization

- CVMix is incorporated into MPAS-Ocean
- We have connected to background, convective, shear-based mixing, and KPP modules
- Comparison between MPAS-Ocean and CVMix versions of Richardson Number-based mixing underway.
- We are currently working with NCAR and GFDL to develop verification and validation test cases.

1D test case,
shear-driven flow

Vertical Diffusion, m^2/s, log scale



MPAS-Ocean 3.0: Analysis Mode

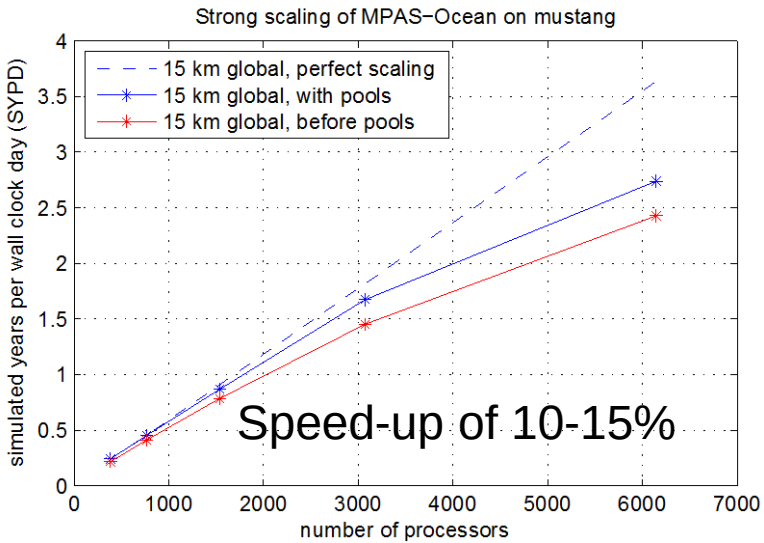
Problem: Our ability to produce data is outstripping our ability to manipulate and analyze this data.

Solution: Analysis tools fully integrated into the model, that may be applied in-situ or post-processing

- Analysis members written within MPAS, using native variables, operators, parallel domain decomposition, i/o
- Analysis is fully parallelized, scales with code.
- Each analysis member is a separate module, begun from a template.
- Easy for MPAS users to contribute analysis tools back to released code through repository tools, using pull request and review.

MPAS-Ocean 3.0: infrastructure and i/o improvements

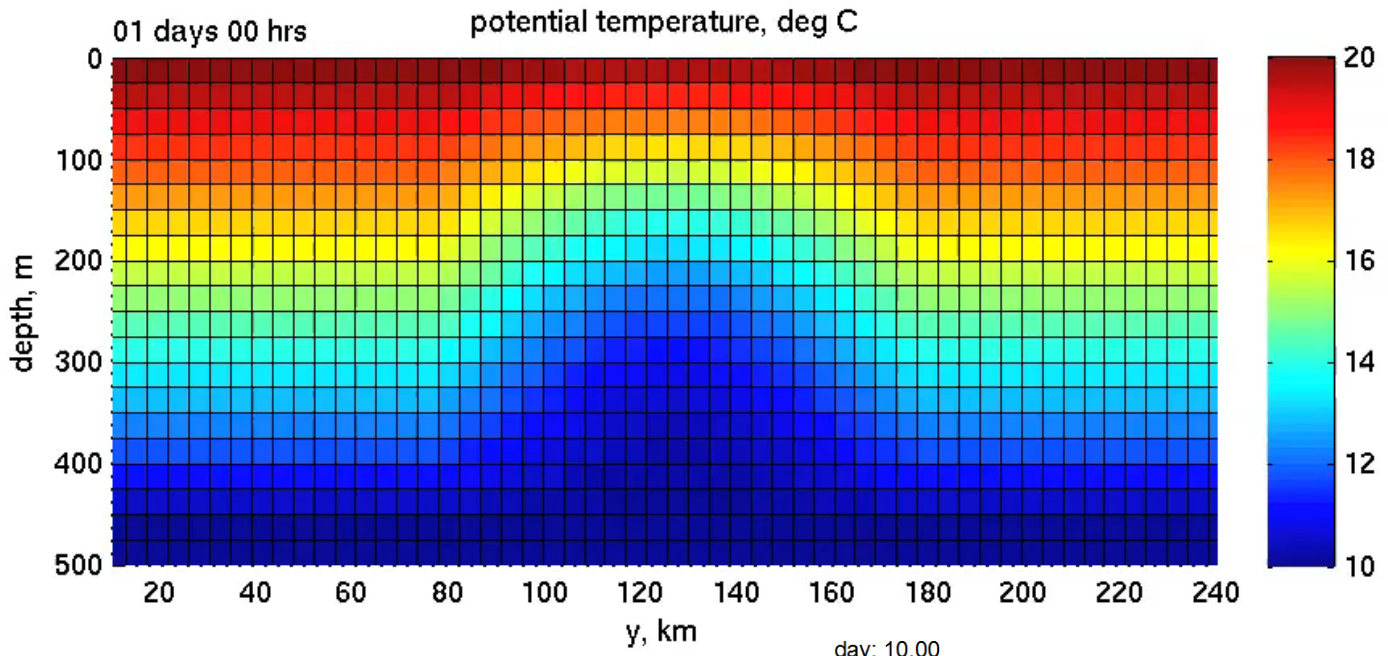
- Multiple i/o streams
  - Each i/o stream reads or writes a sequence of files.
  - New streams are created at build-time.
  - User may specify the frequency and variables for each stream at run-time
- Major data structure revisions
  - Avoid name-space conflicts for multiple MPAS cores in coupled models.
  - Allocate memory for variables only when needed



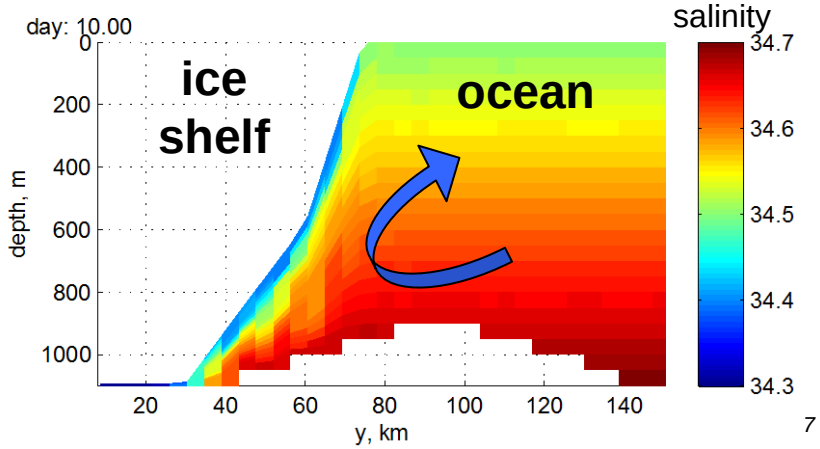
See talk by Doug Jacobsen
9:20 Thursday
Software Eng.

Arbitrary Lagrangian-Eulerian (ALE) Vertical Coordinate

- Series of test cases quantify spurious mixing, compare to MOM, POP, MITgcm
- z-t [illegible] aves



- sub ice-shelf tests: ALE layers may be compressed to cm thickness



See poster OMWG-12

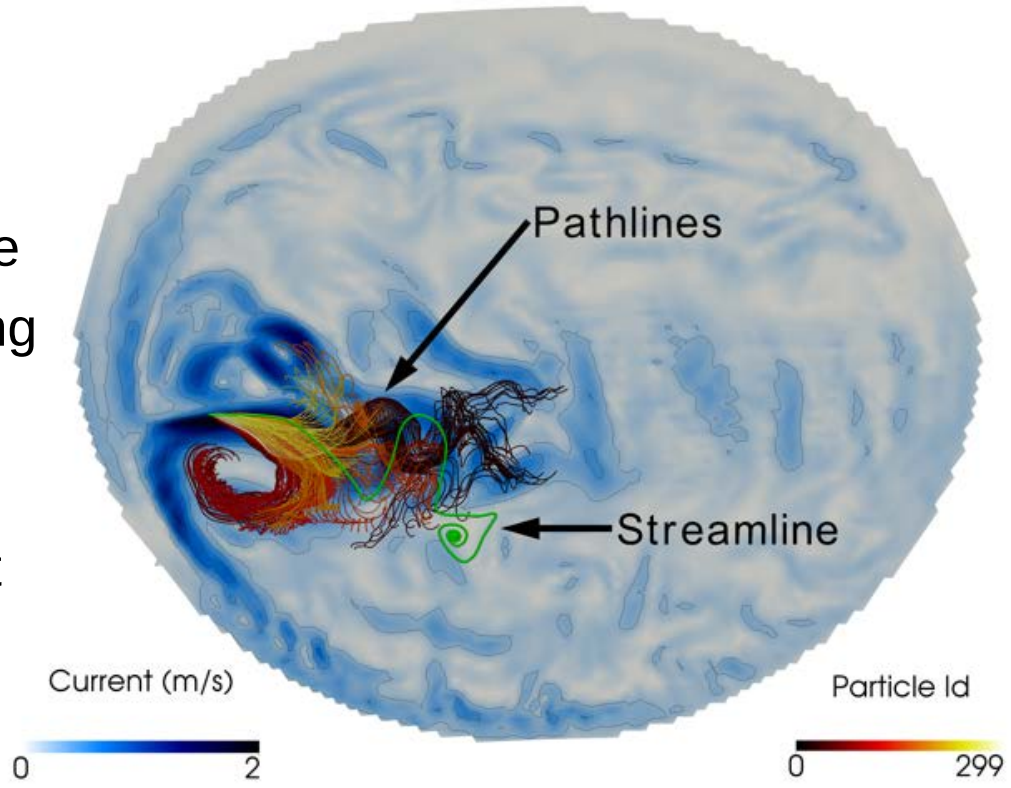
Plans for next 12 months

Work underway:

- Lagrangian particles
- Eliassen-Palm flux tensor diagnostics
- Paraview Catalyst in-situ images and analysis

In-Situ Lagrangian Particle Tracking

- Purpose: Compute regional patterns of fluid mixing, i.e. diffusivity tensor
- HPC implementation
  - Extensible particle data type
  - Linked list for efficient inter-processor communication
- Particle tracking modes
  - ARGO mode
  - Passive particles
  - Fixed z-level / index space
  - Buoyancy surface following
- Visualization
  - Offline: Paraview
  - Online: Paraview Catalyst



See poster OMWG-18 by Phillip Wolfram

Eliassen & Palm flux tensor diagnostics

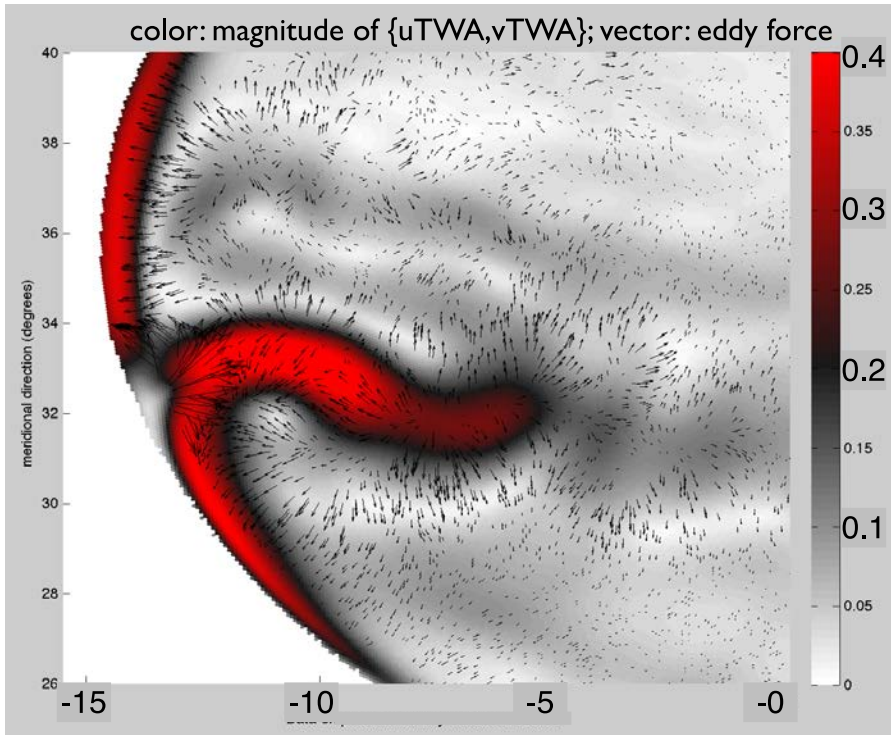
We are using the Eliassen & Palm flux tensor (Young 2012, Maddison and Marshall 2013) to diagnose

- energy,
- momentum and
- Ertel potential vorticity

fluxes between meso-scale eddies and the residual mean flow.

We are using these diagnostics to inform and develop scale-aware meso-scale eddy parameterizations.

See poster OMWG-14 by Juan Saenz



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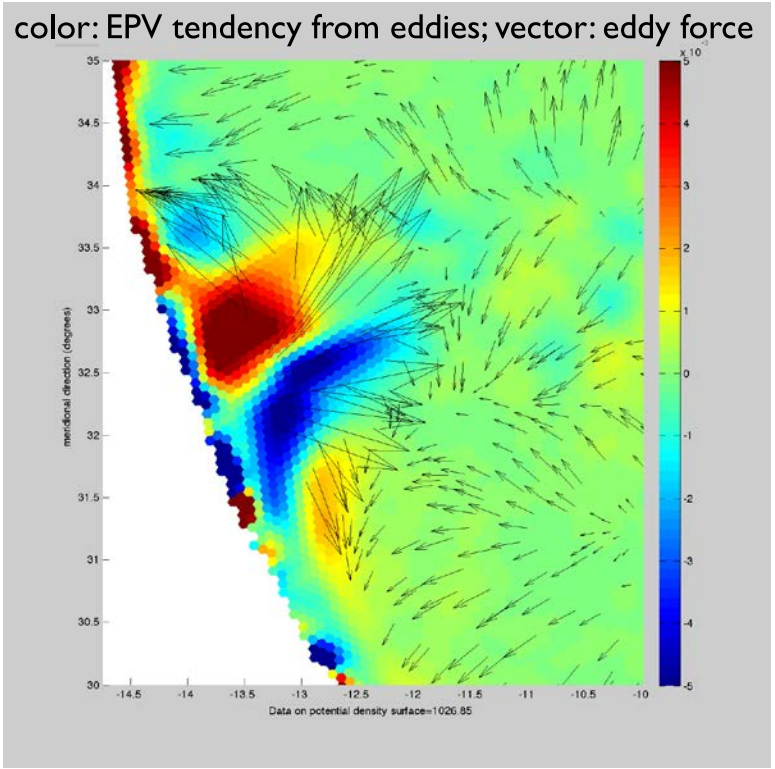
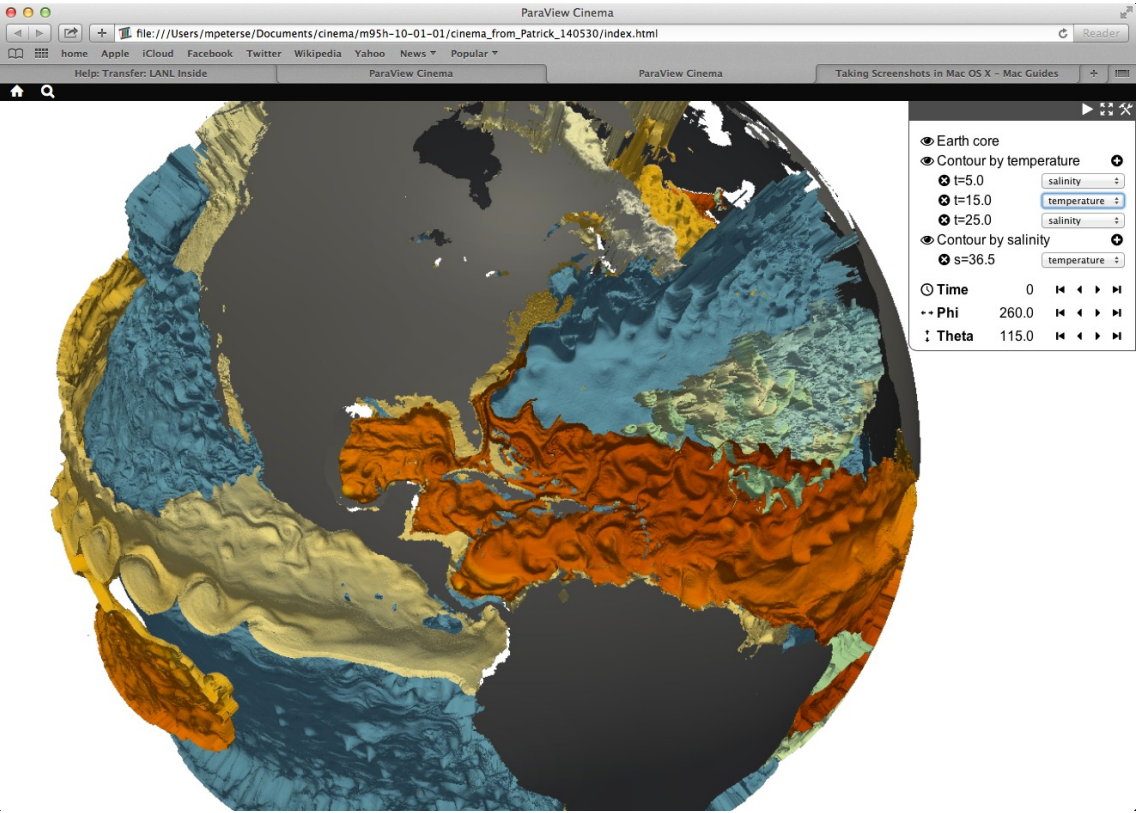
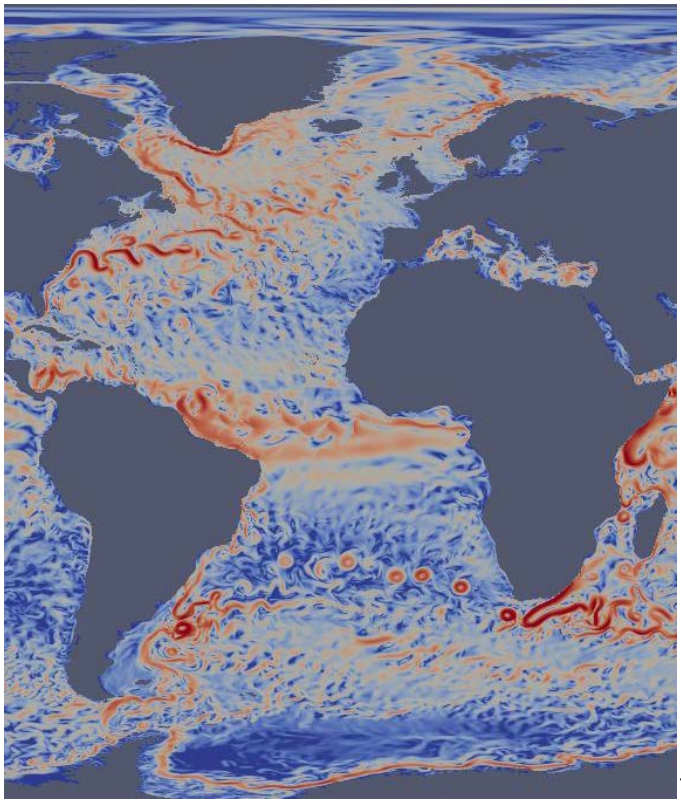


Paraview Catalyst in-situ image creator and analysis

- Run-time image generation using Paraview
- Link to Paraview libraries during compile time (optional)
- Image parameters specified in python script in run directory
- All Paraview analysis tools are available to run-time scripts
- Cinema: interactive data exploration from web browser





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Additional goals:

- CORE-forced simulations
- Improve performance metrics and tracking
- Port POP biogeochemistry to MPAS-Ocean
- Higher-order advection: Characteristic Discontinuous Galerkin
- Recast MPAS-O to solve residual-mean velocity as prognostic variable
- Publish POP/MPAS comparison with SOMA test case
- Publish verification study of ALE vertical coordinate