Ocean/Ice Status and Plans

Phil Jones, Todd Ringler, Steve Price

Regime Change

- Phil Jones
  - Stepping down to spend more time with family

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  - Last official act

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- New co-leads finally confirmed by Council
  - Todd Ringler, Steve Price
  - Hard questioning over critical path through NCAR

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Goals

- MPAS ocean, sea-ice and land-ice components
  - Variable-resolution capability

- Ocean – ice sheet/shelf coupling
  - Cryosphere experiment
  - Likelihood of rapid Antarctic ice collapse and sea-level rise

- BGC experiments
  - Ocean and sea-ice BGC exchange

- Water cycle
 - High-res ocean w/ eddies, improved fronts, etc.

MPAS-Ocean

- Shakedown – looking for mines
- MPAS-Ocean Version 3.0
  - released on November 18th, 2014
  - Initial in-situ capability (Patchett, Woodring)
  - CVMix vertical mixing (community, Ringler)
- MPAS-Ocean vertical coordinate validation
  - Test z, z*, z~, publication (M. Petersen)
- MPAS-Ocean testing within ACME with data atmosphere (M. Petersen)
  - successful to 10 years
  - Validating coupling data fields and initial adjustment
  - Pull request for inclusion in ACME
- MPAS-Ocean initialization core
  - More efficient generation of meshes and initial conditions (D. Jacobsen)
- Ocean BGC: stand-alone module (Maltrud)
- Validation and analysis

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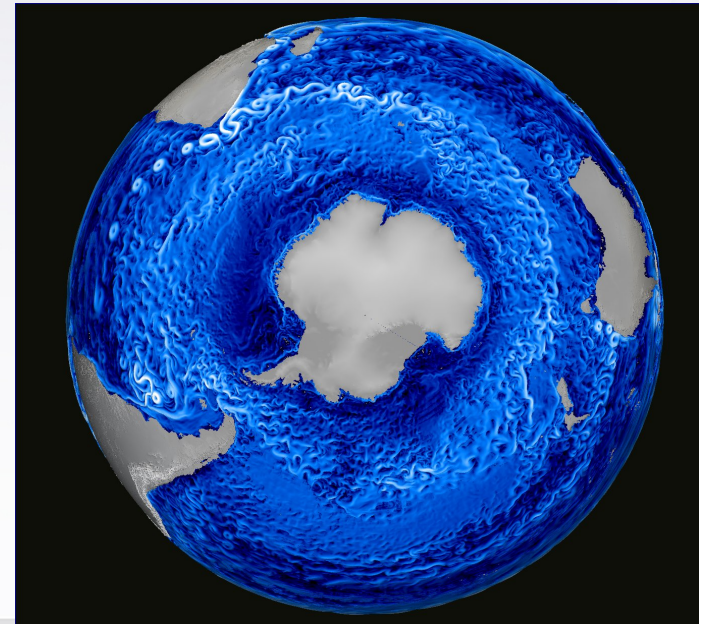
MPAS-Ocean at high resolution

- high-resolution MPAS-Ocean simulations (15-5km grid spacing): initial conditions made, spin-up underway
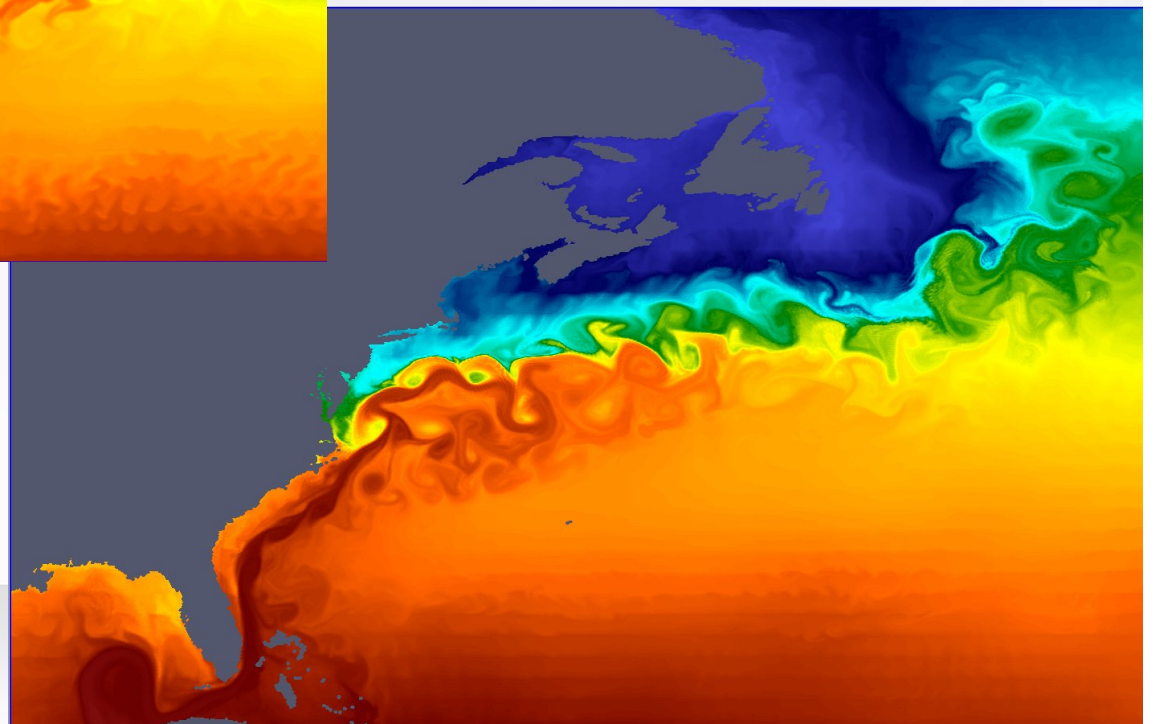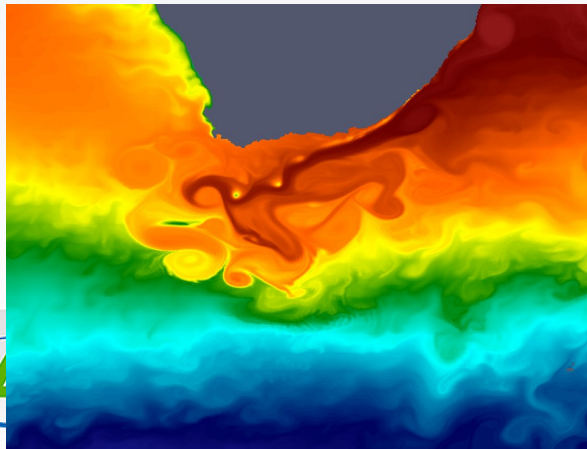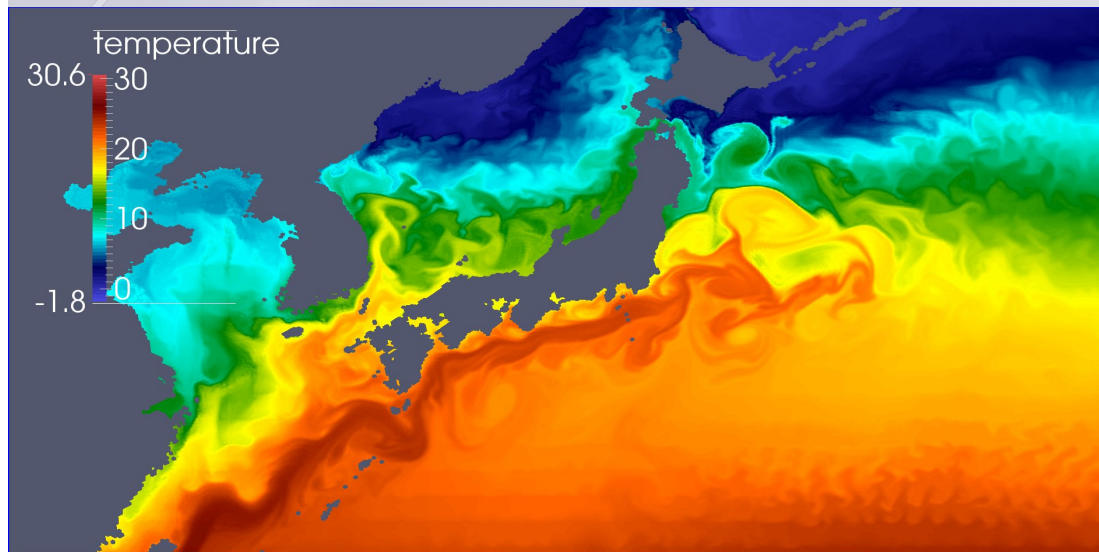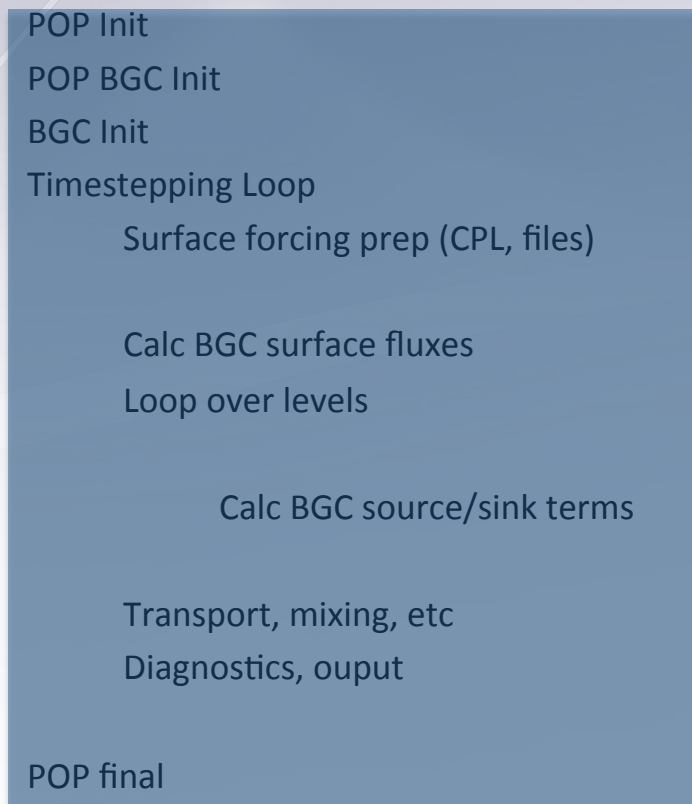
Ocean BGC for ACME
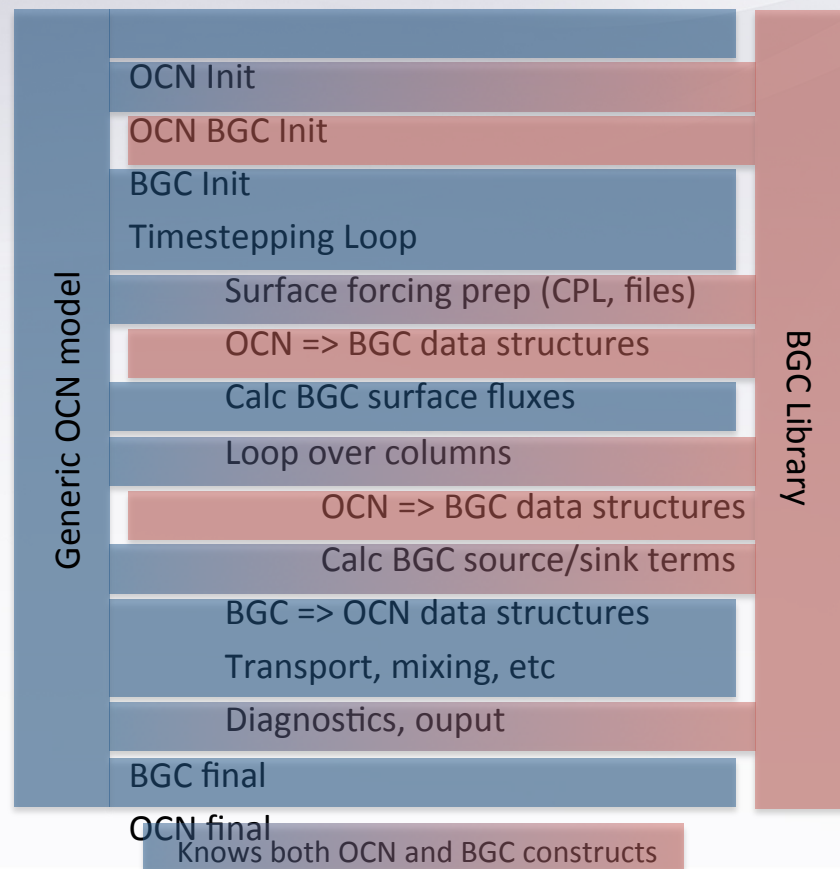## design for port from POP to MPAS-O

BGC forcing, source/sink routines need:

POP data structures and array names

POP global scatter and I/O routines

POP Init

POP BGC Init

BGC Init

Timestepping Loop

    Surface forcing prep (CPL, files)

    Calc BGC surface fluxes

    Loop over levels

        Calc BGC source/sink terms

    Transport, mixing, etc

    Diagnostics, ouput

POP final

Library version validated in POP

Move to MPAS, add trace gases, organics

BGC forcing, source/sink routines need:

Nothing about OCN data structures and array names

Nothing about global scatter and I/O routines

Generic OCN model | BGC Library

OCN Init

OCN BGC Init

BGC Init

Timestepping Loop

    Surface forcing prep (CPL, files)

    OCN => BGC data structures

    Calc BGC surface fluxes

    Loop over columns

        OCN => BGC data structures

        Calc BGC source/sink terms

    BGC => OCN data structures

    Transport, mixing, etc

    Diagnostics, ouput

BGC final

OCN final

Knows both OCN and BGC constructs

Knows only OCN constructs

Knows only BGC constructs

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MPAS-CICE development progress (Adrian Turner)

- Velocity Solver
  - Variational operators: Implemented and tested
  - Weak operators: Implemented and tested
- Advection
  - Upwind: Implemented and tested
  - Incremental remapping: Development in progress
- Column physics
  - CICE column physics package: Implemented and tested
  - Column package integration in MPAS: 90% complete
- Column BGC
  - Not started
- Forcing
  - Implemented and tested
- Coupling
  - Development in progress (50% complete)
  - Compiles in ACME but does not yet run successfully
- Full model standalone testing
  - Not started
- Full model coupled testing
  - Not started
- Performance
  - Analyze current performance compared to CICE: Not started
 - Improve performance bottlenecks: Not started
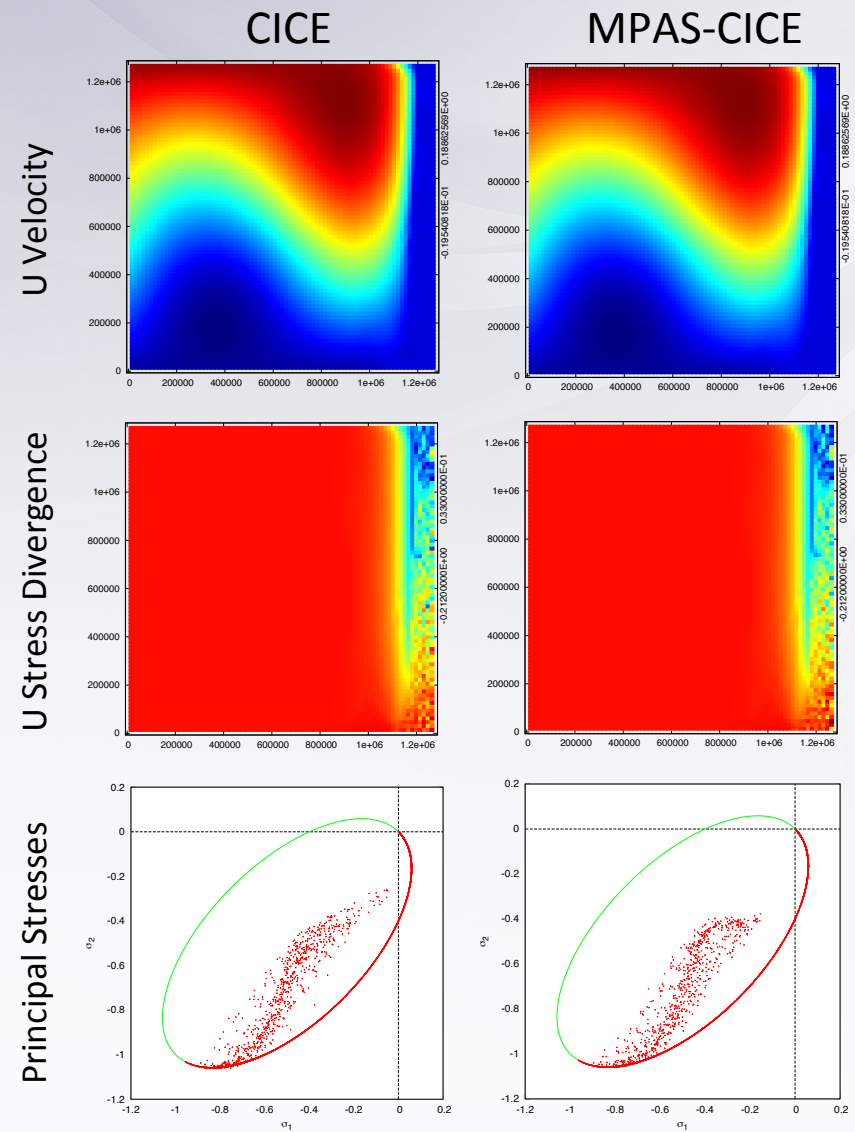
Comparison of CICE and MPAS-CICE velocity solution on a simple square test case.

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Meanwhile…CICE support (Hunke)

- Release of CICE v5.1 (continued community support)
  - Improved atmosphere-ice stress for high-frequency coupling (RASM)
  - Optional variable coefficient for the ice-ocean heat flux
  - Several new namelist options improve flexibility, especially for coupled model configurations:
    - Ice-ocean heat flux
    - Ocean freezing temperature
    - Virtual or real topo melt pond water
    - High-frequency coupling
    - Coupling and computational grids may be different
    - and more…
  - Additional enhancements improve flexibility and compatibility with CESM, Hadley Centre, and U.S. Navy coupled models
  - New diagnostics and updated documentation
  - Various bug fixes

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Snow on sea ice

- Improved representation of snow, distribution, radiative feedbacks
- Redistribution, compaction of snow by wind
  - utilizing modeled sea ice topography.
  - snow loss through leads
  - varying snow depths over sea ice.
- Snow grain metamorphism
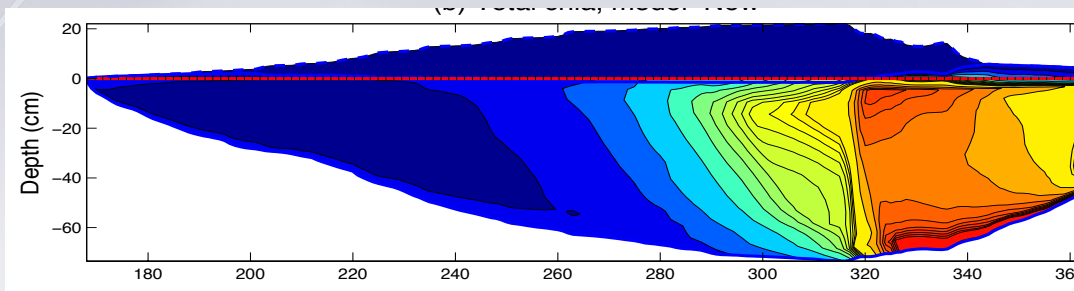 - Grain radius used in albedo and radiative transfer
- Part of column physics
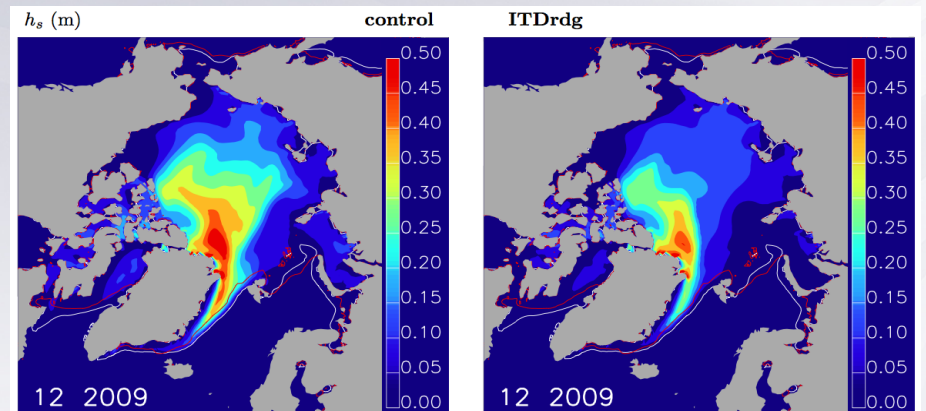
Snow depth over sea ice in the Arctic Ocean for CICE simulations: (left) control, (right) including wind compaction and redistribution, accounting for the deformed sea ice thickness distribution.

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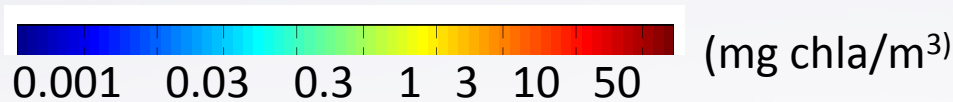# "Bi-polar" sea ice biogeochemistry:
new capability implemented and vertically resolved in CICE
N. Jeffery, S. Elliott

Chlorophyll profiles in Antarctic sea ice with *upper ice blooms*

Arctic algae with *bottom ice blooms*

Julian Day

(mg chla/m^3)

0.001   0.03   0.3   1   3   10   50

Avg Bottom Ice chla (mg/m^3) April, 1980-1989

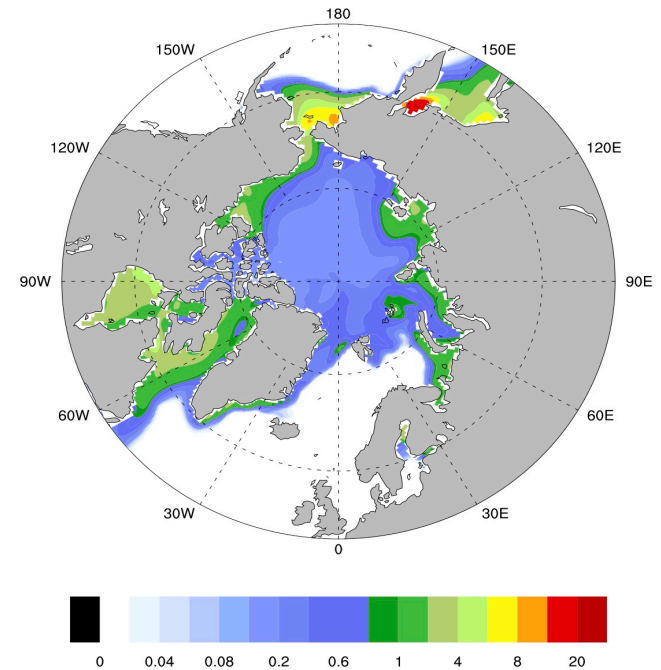

0   0.04   0.08   0.2   0.6   1   4   8   20

Expanded Ice biogeochemistry tracers:
3 algal types, 2 dissolved organic carbon, proteins, nitrate, silicate, ammonium, dissolved iron, particulate iron, DMSP (particulate and dissolved), and DMS

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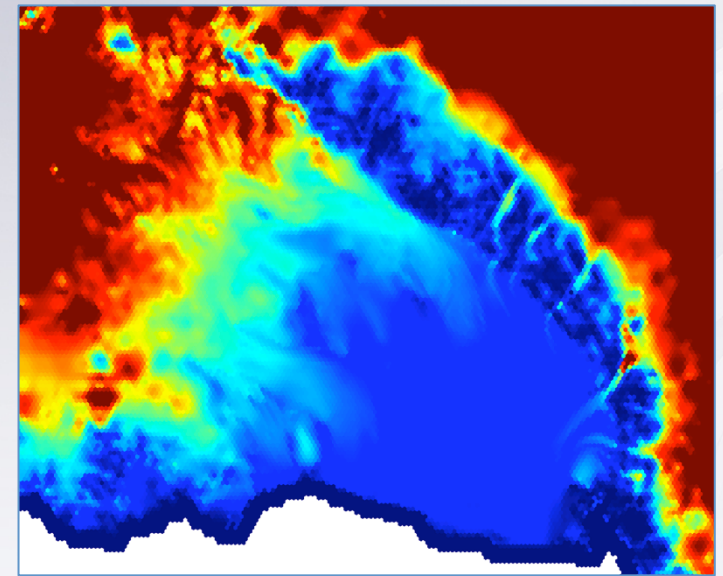
Land Ice

- Completed coupling to external higher-order velocity solver through PISCEES project (Matt Hoffman, Mauro Perego)

- Automated test suite completed with 26 testing scenarios using 6 test cases of standard ice sheet analytic or benchmark validation solutions (MH, Doug J.)

- Exploring creation of variable resolution meshes and generation of initial conditions (Matt Hoffman, Steve Price)

- Created adaptive time stepper (Matt Hoffman)

- Updates to MPAS framework to allow multiple MPAS cores running in the same executable (Doug J., MH)
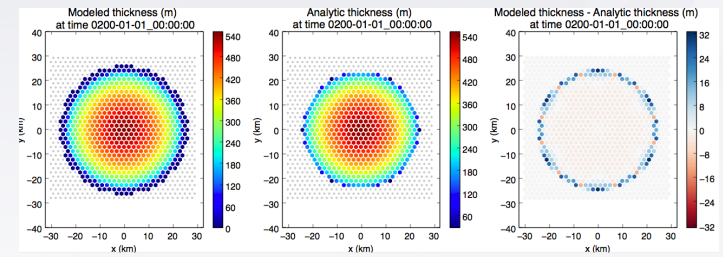
Modeled thickness, analytic thickness, and model error for the Halfar analytic solution test case after 200 years.

Land ice coupling

- MPAS-LI has been added as new GLC component and can run to completion (testing ongoing). (MH)

- Pull request for MPAS-LI in ACME (SIA)

- Basic GLC-OCN and OCN-GLC coupling developed and ready for testing (Jeremy Fyke).

- Evolving grounding lines (which change OCN and GLC masks) a longer-term objective.

- GLC-LND coupling (ice sheet surface mass balance) a high risk issue due to missing GLC functionality in ACME and possible changes in CLM.

- Verified current SMB form over Antarctica

Zoom into Ross Ice Shelf region for a moderate resolution MPAS-LI mesh (ice thickness is plotted), to be used in initial tests of land ice and ocean coupling in ACME.

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Testing land ice/ocean interactions

- New idealized test cases designed for a community effort with ACME participantion
- WCRP Climate and Cryosphere activity
  - **MISMIP+**: latest Marine Ice Sheet MIP (land ice only)
  - **ISOMIP+**: latest Ice Shelf-Ocean MIP (ocean only with shelf cavities)
  - **MISOMIP1**: Marine Ice Sheet-Ocean MIP (coupled land ice-ocean)
- MIPs will be used to validate MPAS-O,MPAS-LI
  - Work out boundary layer issues
- Currently validating MPAS-O with **ISOMIP**:
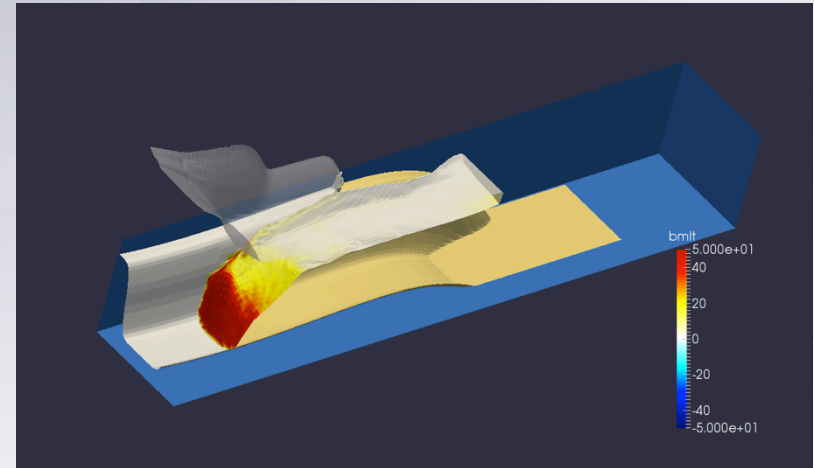
Example result from MISOMIP using POP-BISICLES
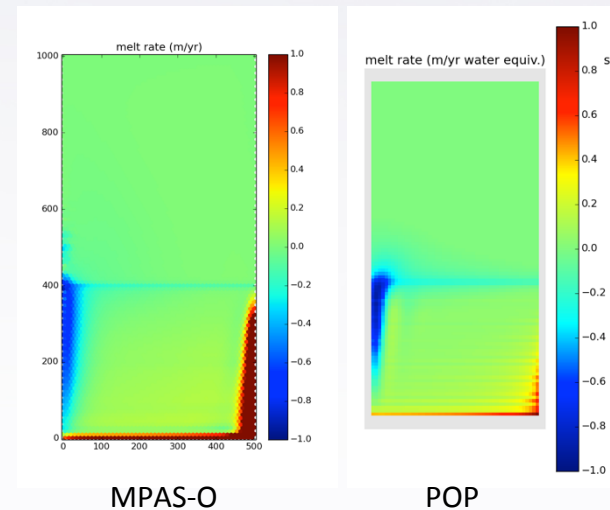
ISOMIP temperature (vertical slice)
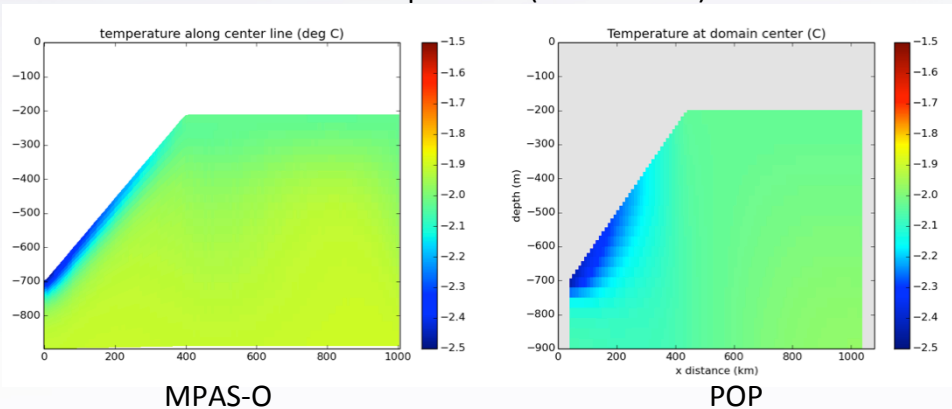
MPAS-O   POP

ISOMIP melt rate

MPAS-O   POP

Plans for Rest of CY15

- Continue validation of MPAS-Ocean
  - High-res, low-res, variable-res configs
  - Adding new analysis members
- Complete, validate MPAS-CICE and couple to ACME
- Complete MPAS-LI
- Work out ocean-ice coupling details
- Add BGC in ocean, couple in ACME
- Plans in JIRA, making effective use of ACME tools

Last slide as ocean-ice co-lead

LEAP into Performance

MPAS–Ocean: EC.60–30km mesh (234k cells, 60lev), no i/o, wolf (LANL)