Vertical coordinate modification and accommodation of ice-shelves

reported by

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Why modify vertical coordinate?

- From the CESM2 Ocean Model Requirements document, we must accommodate:
  - Natural boundary condition on freshwater and tracers
  - Small vertical scale structures in upper ocean
  - Floating sea ice
  - Floating ice shelves

http://www.cesm.ucar.edu/working_groups/Ocean/agendas/pop2.requirements.pdf

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Workshop in Boulder next week on sea ice/ocn coupling; RACM workshop last month in Monterey

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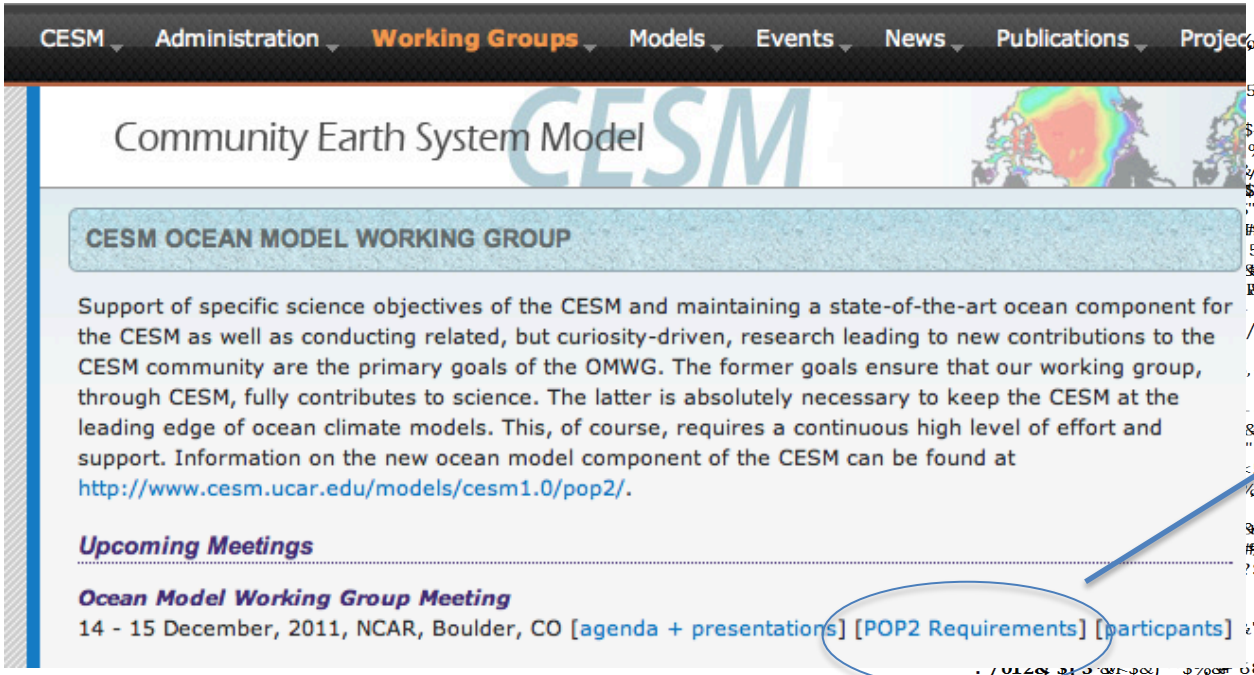
Ocean Mod requirements for CESM.2 set at Dec. meeting, posted online:



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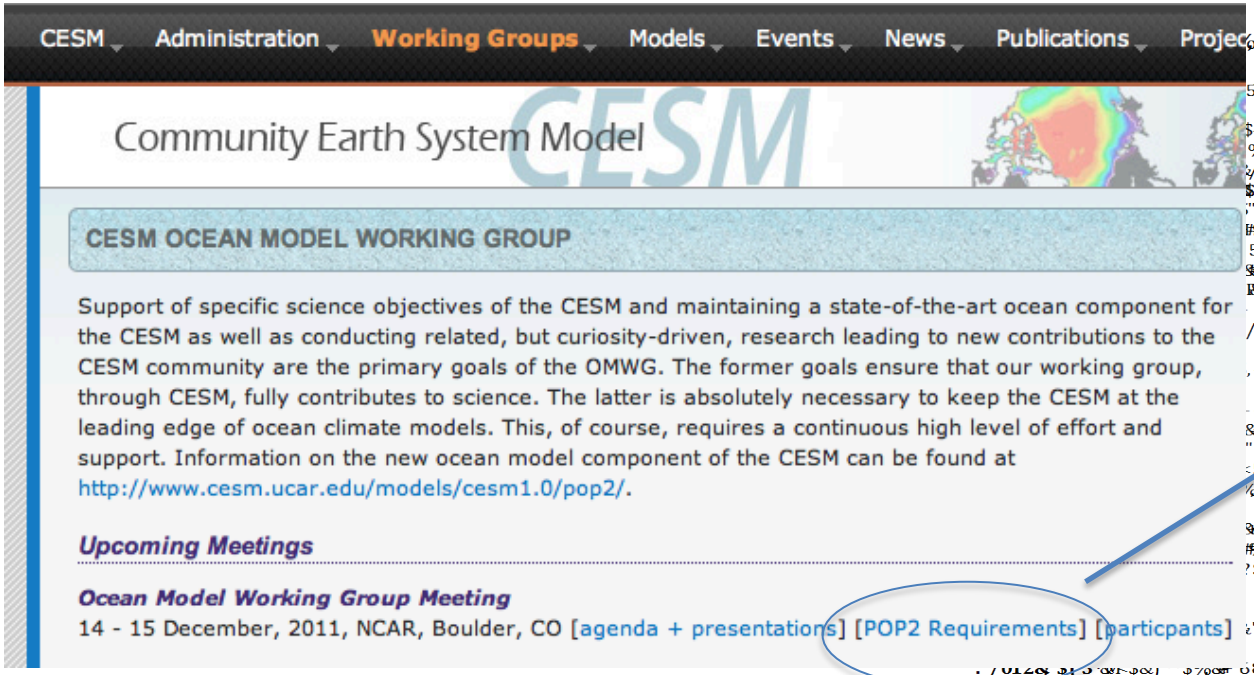
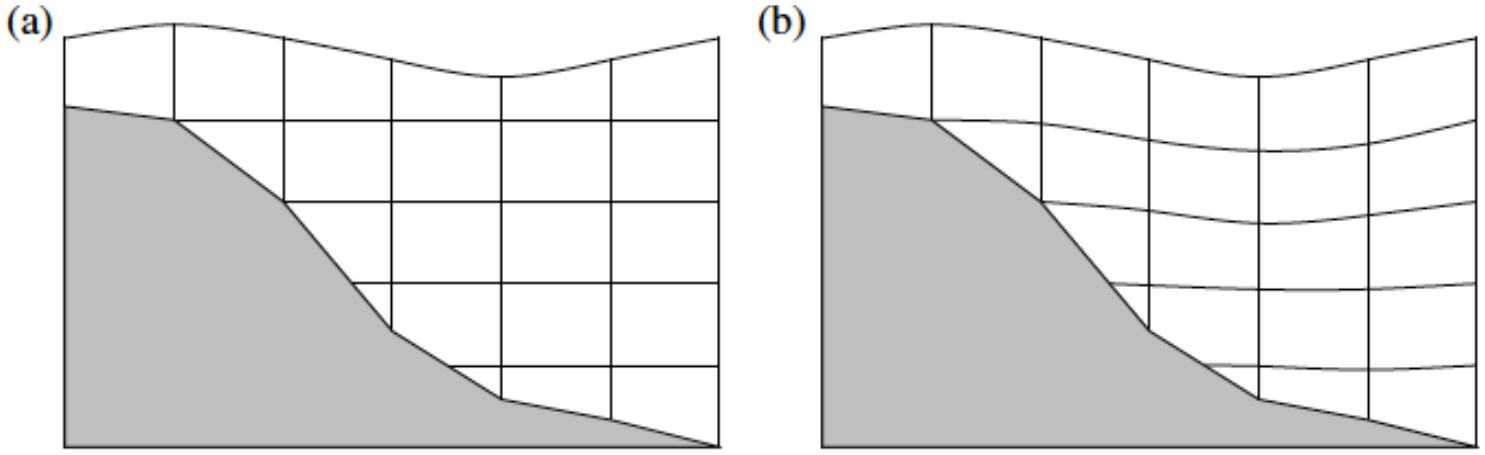


Time stepping to accommodate frequent coupling (preceding presentation) is the other development that came out of these req's

z-star: allow all levels to respond in a proportional way to external mode

A. Adcroft, J.-M. Campin / Ocean Modelling 7 (2004) 269–284



How POP does it now

Z-star

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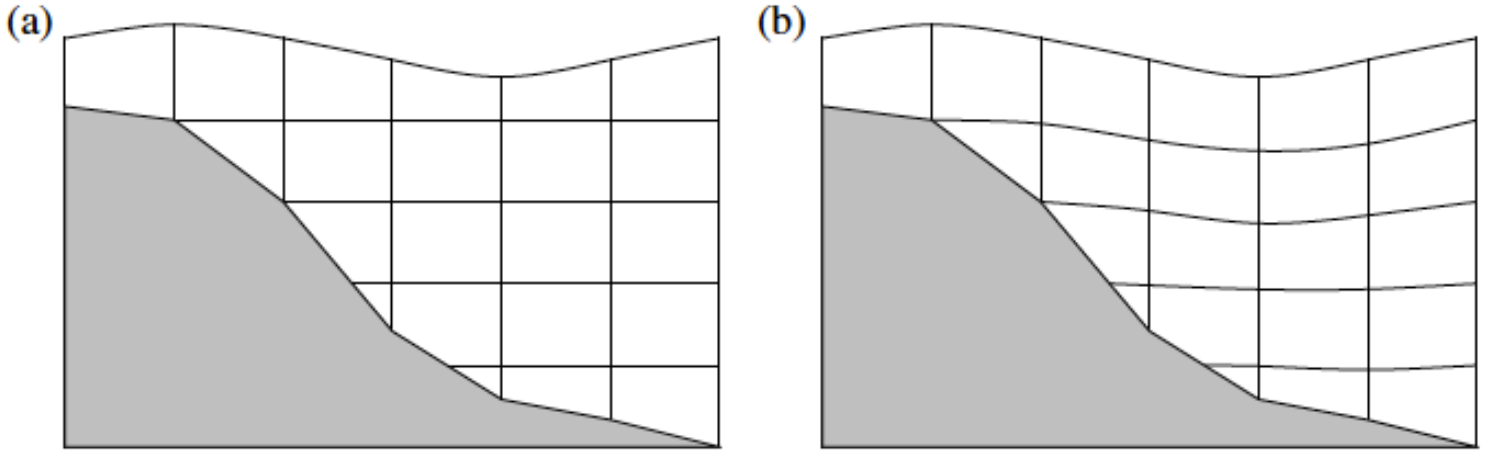

How POP does it now

Z-star

As per MITGCM, MOM, NEMO

Modification of vertical coordinate is underway:

- Start from CESM version cesm1_1_beta08
- Design document, based on requirements
  - as per Mark's MPAS z-star/z-tilde design document
- Phil modified code for stand-alone use
- Propagate 3-D DZ(t), as Wilbert did in HyPOP
- Add thickness variable, as per HyPOP
  - Test in diagnostic mode

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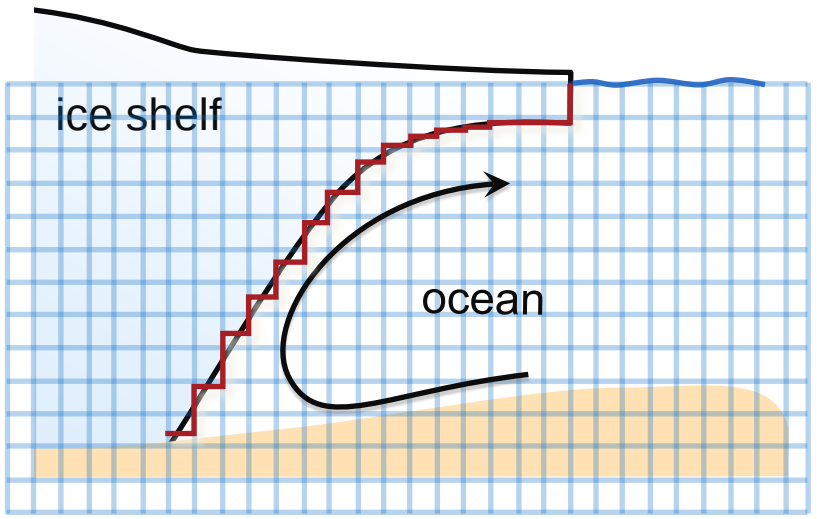
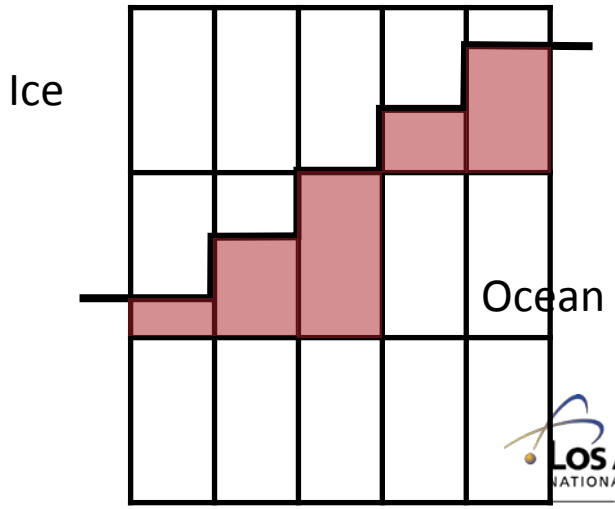
Ice sheet/ocean coupling also involves the vertical coordinate

- Just as we use partial bottom cells to better resolve the bottom slope, can use partial top cells to resolve the ice sheet/ocn interface
- Simpler than the Immersed Boundary Method
  - IBM still an attractive option… for later.
  - Xylar has partial top cells working, now.
  - Currently in a separate code branch. Will merge, once z-star has been implemented and vetted.

Ice-sheet/Ocean interface in POP

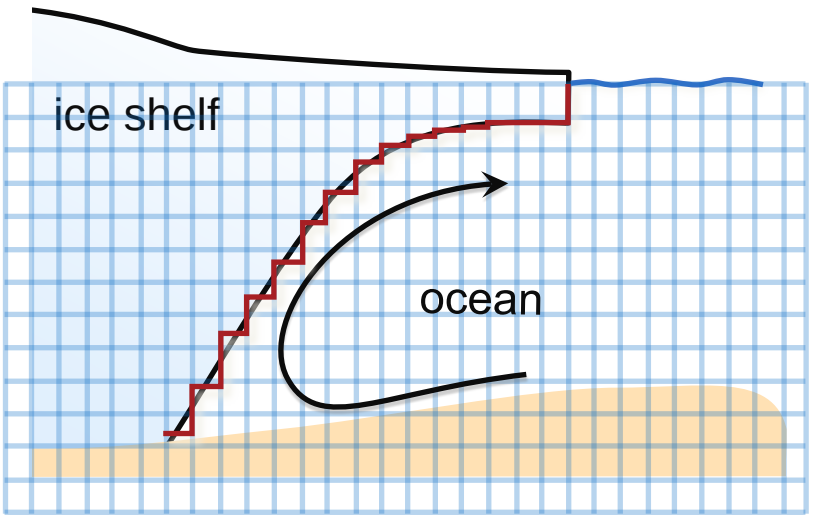
- See Asay-Davis talk in LIWG on Thursday for more details
- Modified version of POP: POP2X includes ocean cavities under ice shelves
- Ice/ocean boundary defined by partial-top cells (analogous to partial-bottom cells)
- Based on Losch 2008: static ice shelves in MITgcm

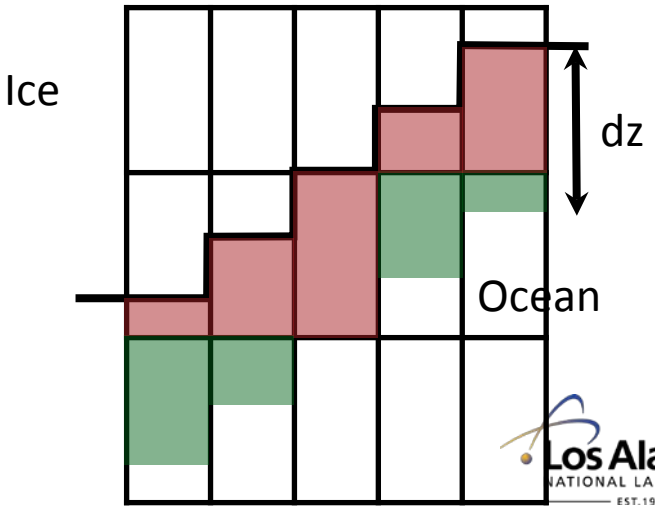




Partial Cells Method

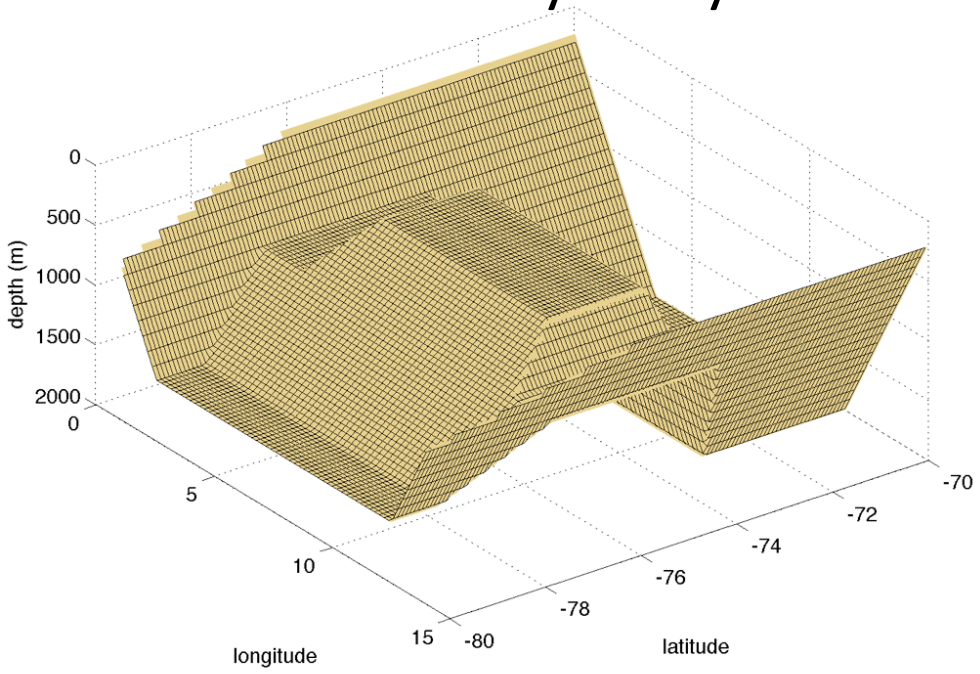
- Following Losch 2008, “boundary layer” below partial top cells:
- Salt/heat from melting/freezing mixes into both partial cell and next cell below (reduces noise at expense of extra mixing)
- “boundary layer” does not resolve true boundary layer physics



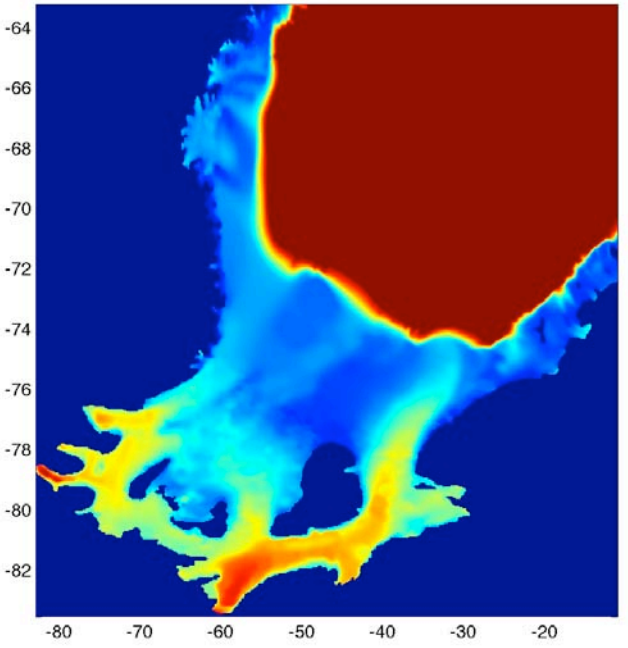


Sim. with Idealized Geometry

Idealized Bathymetry



Ronne-Filchner

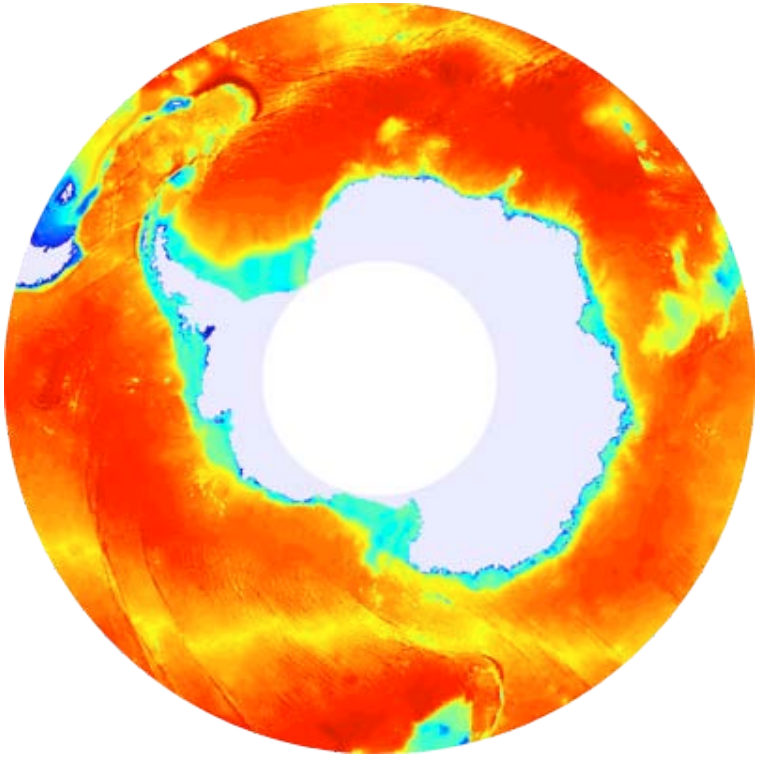


- Expt. 6 from Grosfeld et al. 1997
- Bathymetry mimics Ronne-Filchner: troughs; deepens to the south; northern basin (Weddell Sea)
- Closed box (not periodic in either direction)

In progress: sim. of Southern Ocean (no ice shelves yet)

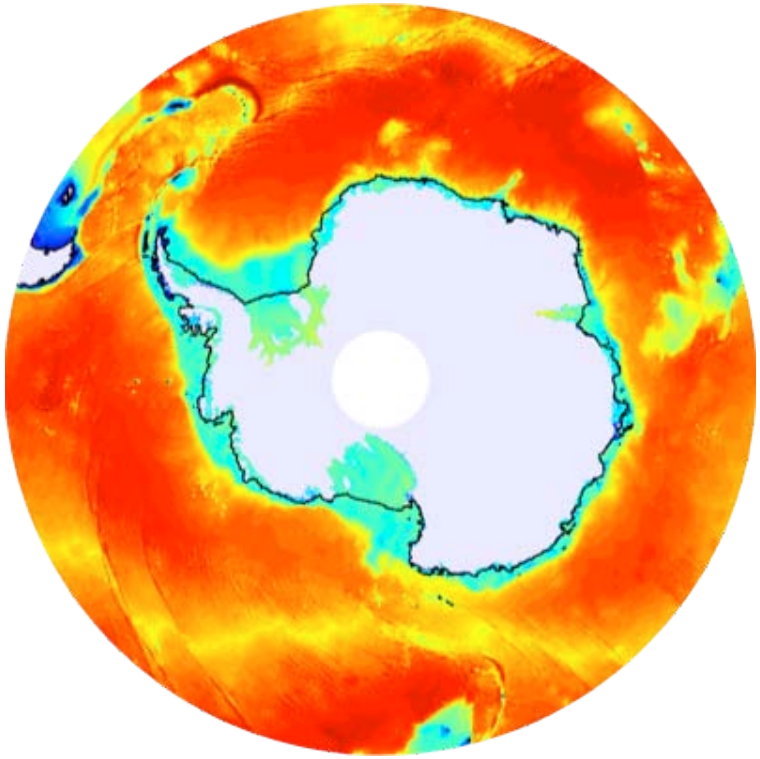
- Existing POP grid: No cavities under ice shelves

Mathew Maltrud
has set this up



In progress: sim. of Southern Ocean (no ice shelves yet)

- Existing POP grid: No cavities under ice shelves
- New POP grid: Ice shelves replace by open ocean
- Bathymetry from RTOPO-1 data set (Timmermann et al. 2010)



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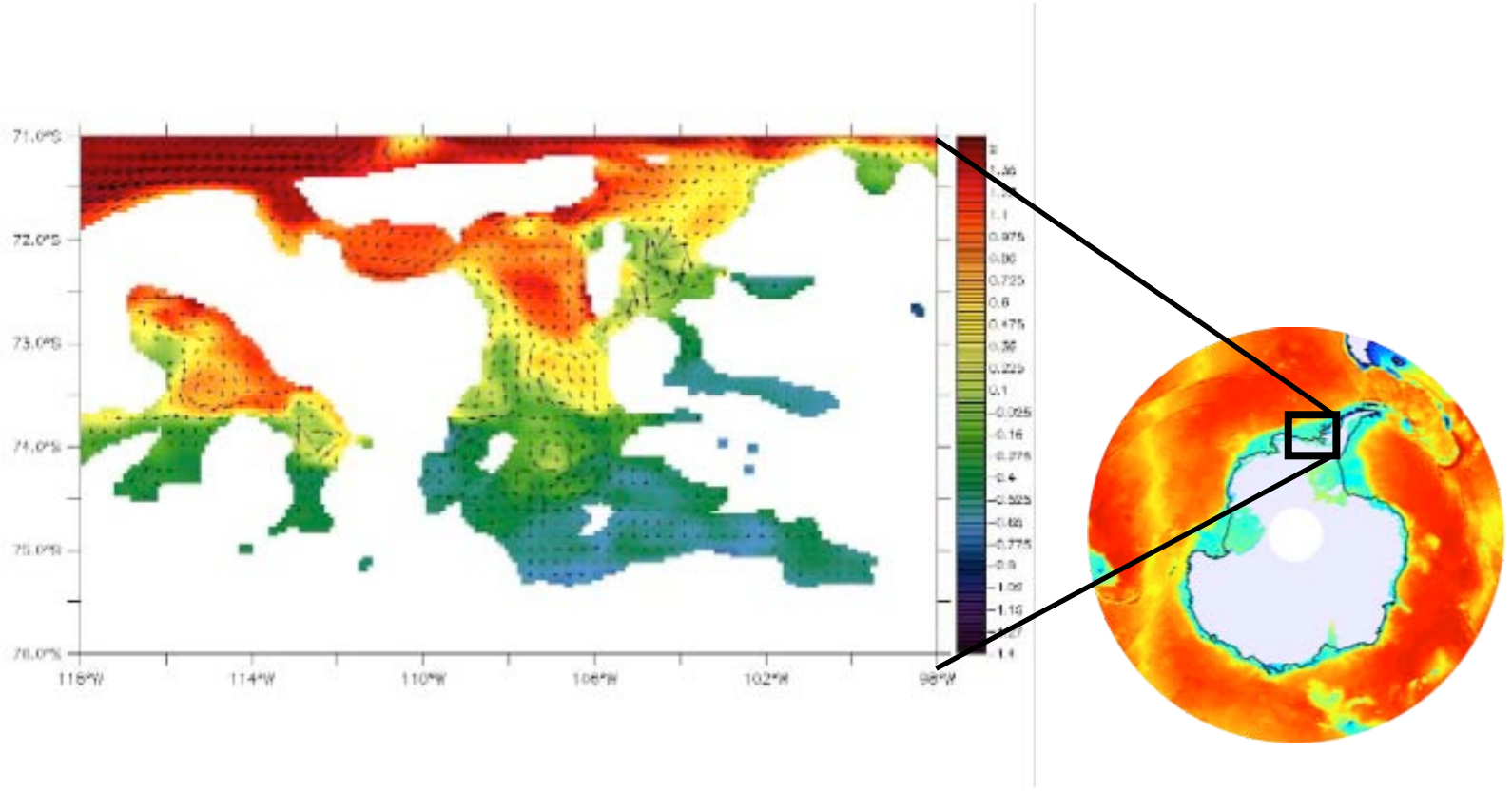


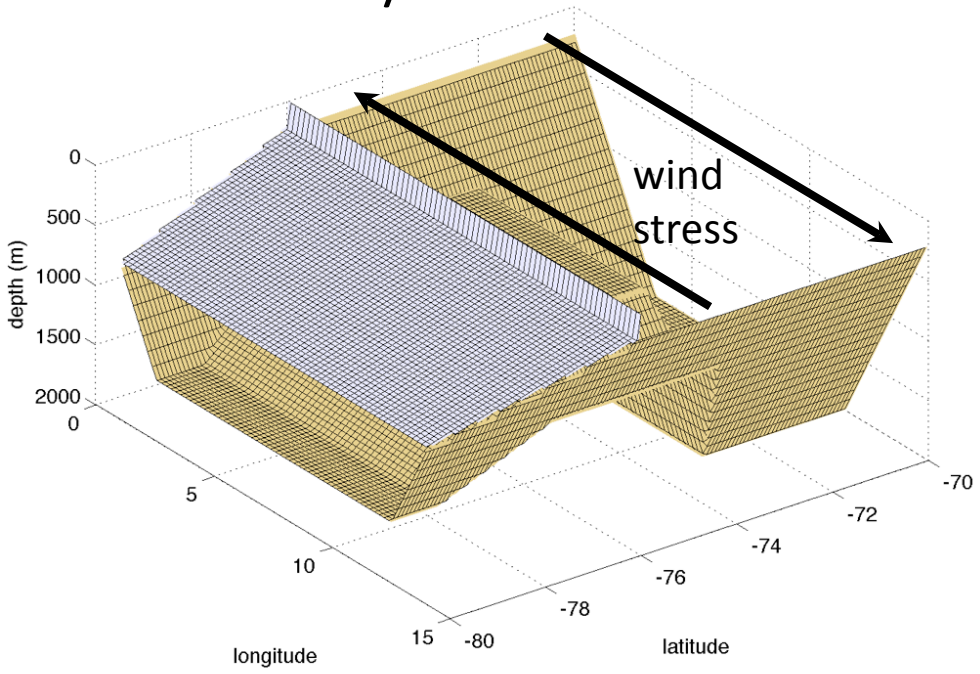
Model temperature and velocity vectors in the Amundsen Sea at 579 m depth after 2 years.

Summary

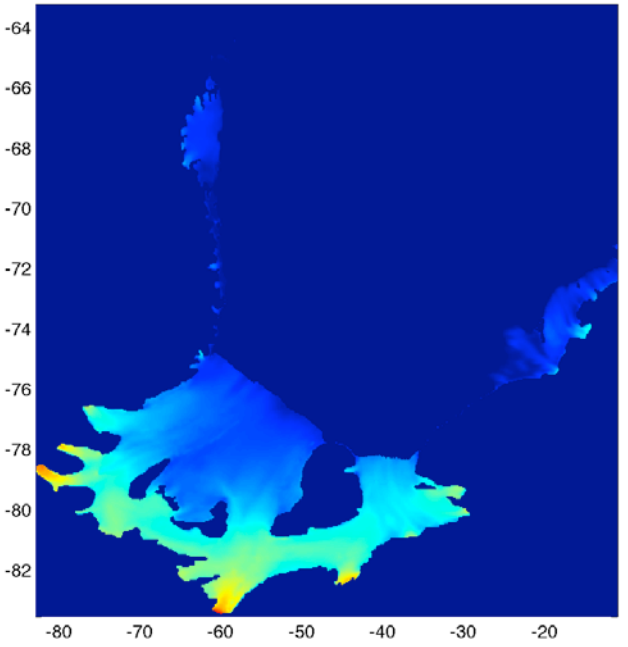
- Conservative Robert filter implemented, being evaluated -- as Mathew Maltrud explained
- Partial top cell approach to ice sheet/ocean coupling also implemented, going through evaluation – to be presented to Land Ice Group (Thurs)
- Implementation of z-star vertical coordinate underway

Sim. with Idealized Geometry

Idealized Ice/ocean interface



Ronne-Filchner



- Linearly sloped ice shelf covers southern 40% of domain
- Open ocean:
  - zonal wind stress
  - melting/freezing by simplified sea-ice model

Sim. with Idealized Geometry

Expt. 6 from Grosfeld et al. 1997