Next generation ocean and sea-ice models

Presented by

Alistair Adcroft

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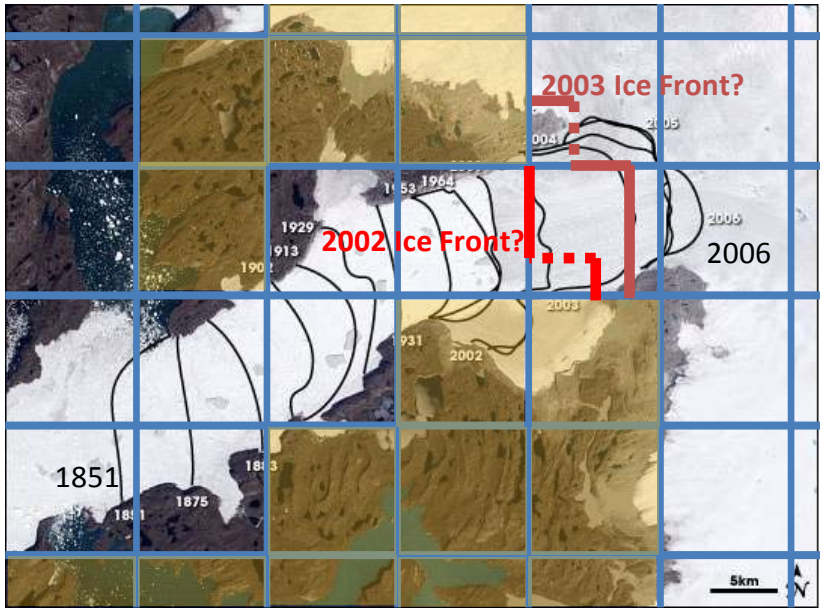
Ocean Working Group: Objectives

- **Eddying-resolution** (¼°) ocean component
  - Admit **large eddies** and **internal ocean variability**
  - Better **resolve boundary regimes**, e.g. Labrador Sea boundary currents
  - Allow interactive dynamic **sub-ice shelf cavities**
  - Strategy: z*-coordinate first, explore options later
- Basis for branching up/down in resolution

- **Address biases** of previous models
  - **Heat uptake/sea level**
  - Processes/coupled interact[ns]: **overflows**, **cryosphere**

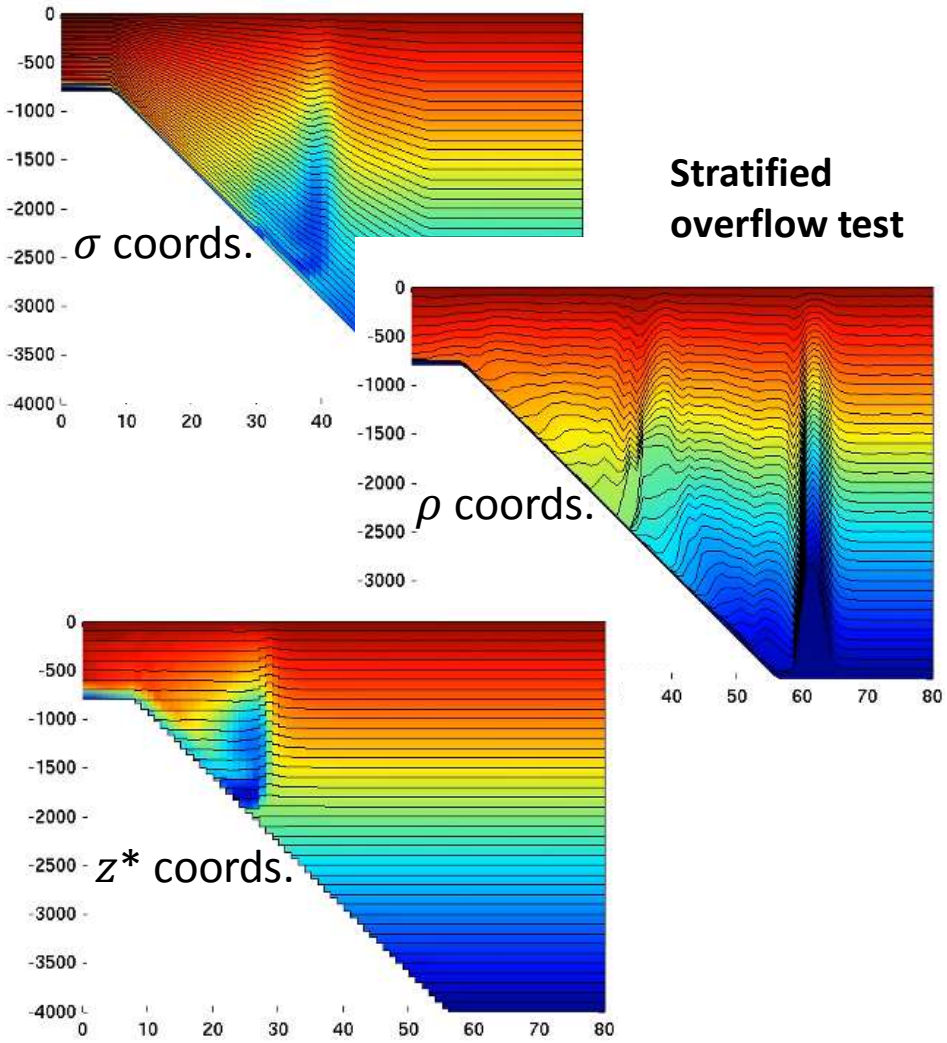
Jakobshavn & ¼° Mercator grid



MOM6 development: Objectives

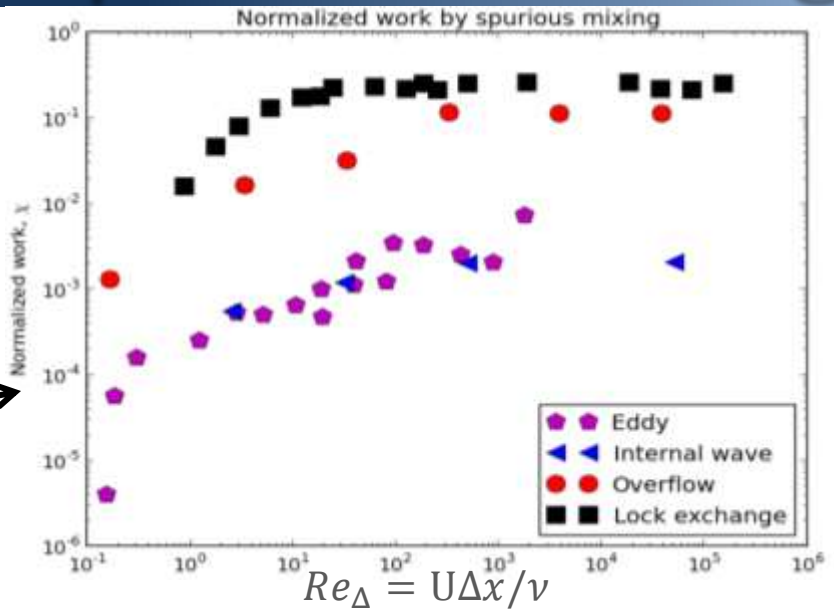
- Unification of MOM4.1/ MOM5/GOLD ocean models
  - C-grid, Finite Volume, …
- Arbitrary Lagrangian Eulerian Method (ALE) *Bleck, 2002*
  - General vertical coordinates
  - Efficiencies – biogeochemistry
  - Wetting & drying
- Energetically consistent
  - Physically based parameterizations *c.f. morning talk*
- Collaborations
  - CVmix, CORE, 4 x CPTs

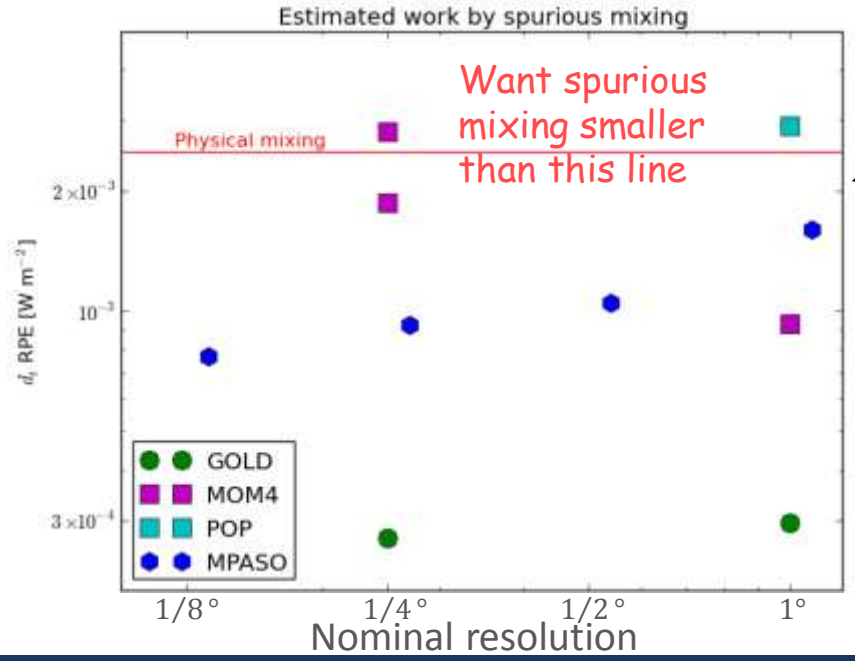
White et al., 2009



Spurious mixing

- Spurious mixing depends on:
  - Vertical coordinate
  - Cell Reynolds number
- Extensively demonstrated in idealized experiments





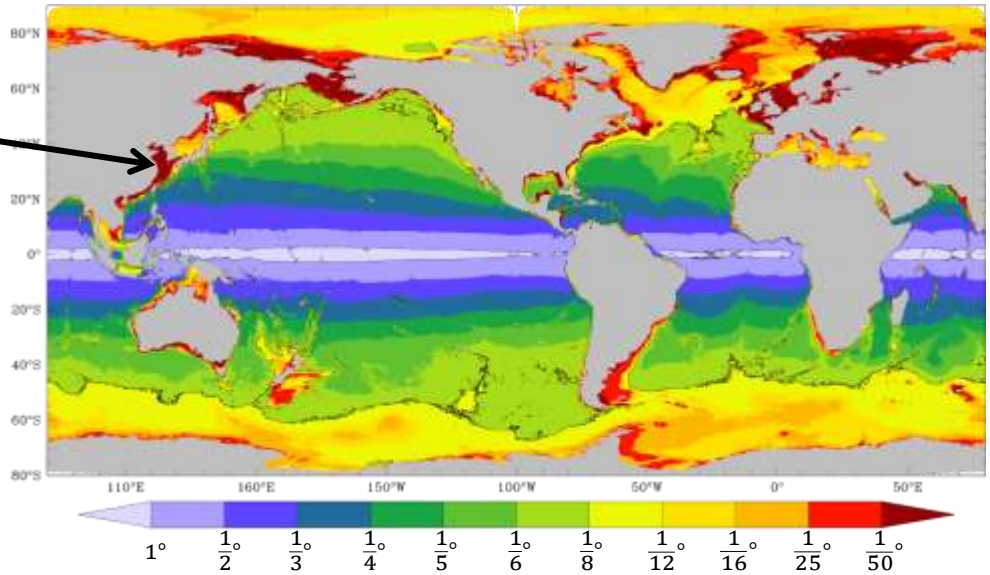
- Realistic global models
  - Choosing parameters to maximize eddy energy can lead to high spurious mixing
- Does not address representation of overflows

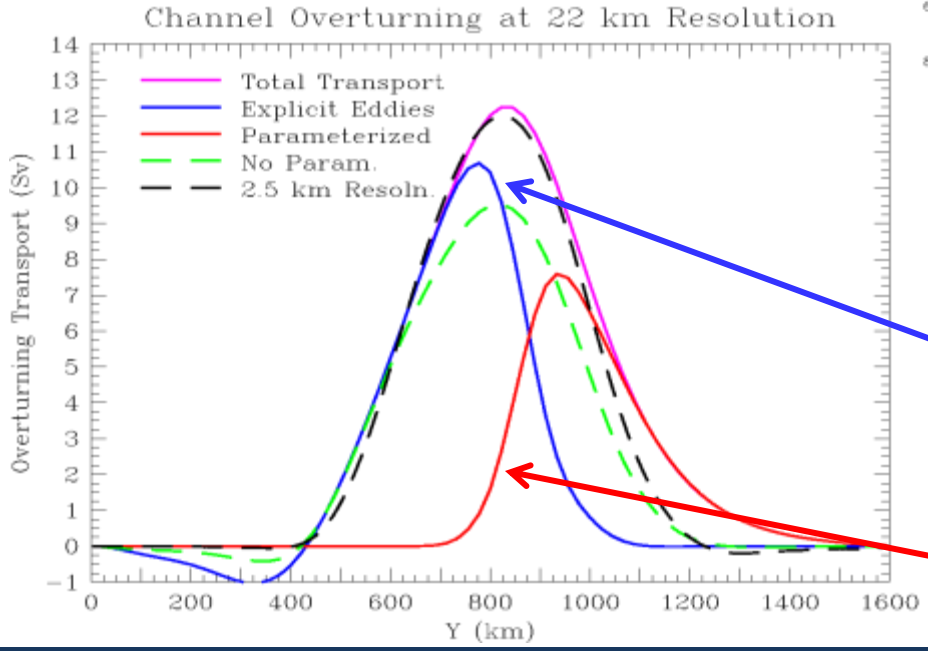
Ilicak et al., 2012; Petersen et al., 2014

Eddy parameterization I

- Even “fine-resolution” ocean models cannot resolve first-mode eddies everywhere
- Adding a global eddy parameterization dampens resolvable eddies

Mercator resolution that resolves deformation radius





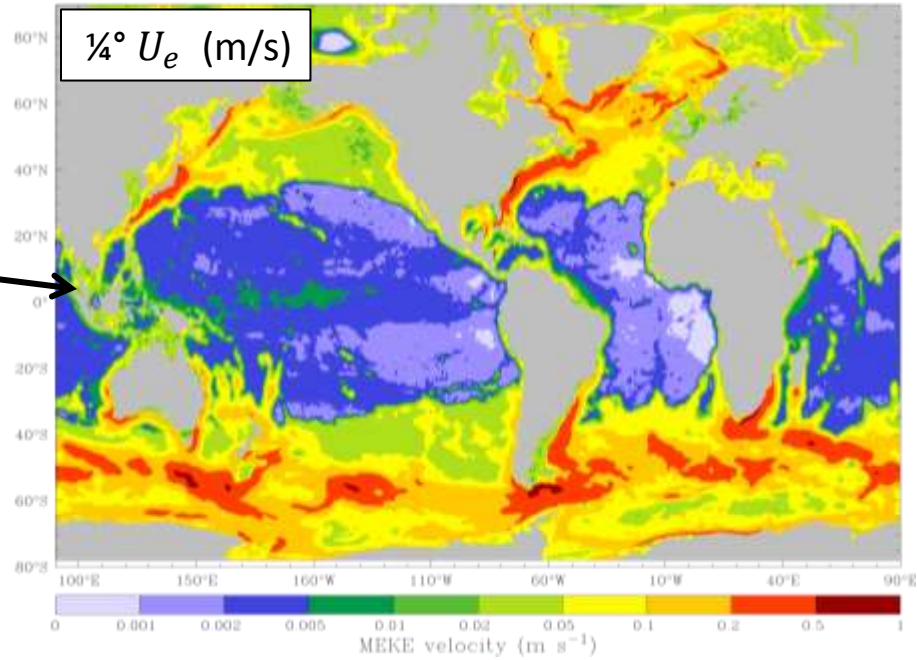
- Resolution-aware eddy parameterization
  - Allows baroclinic instability to proceed when resolution is sufficient
  - Parameterizes eddy fluxes otherwise

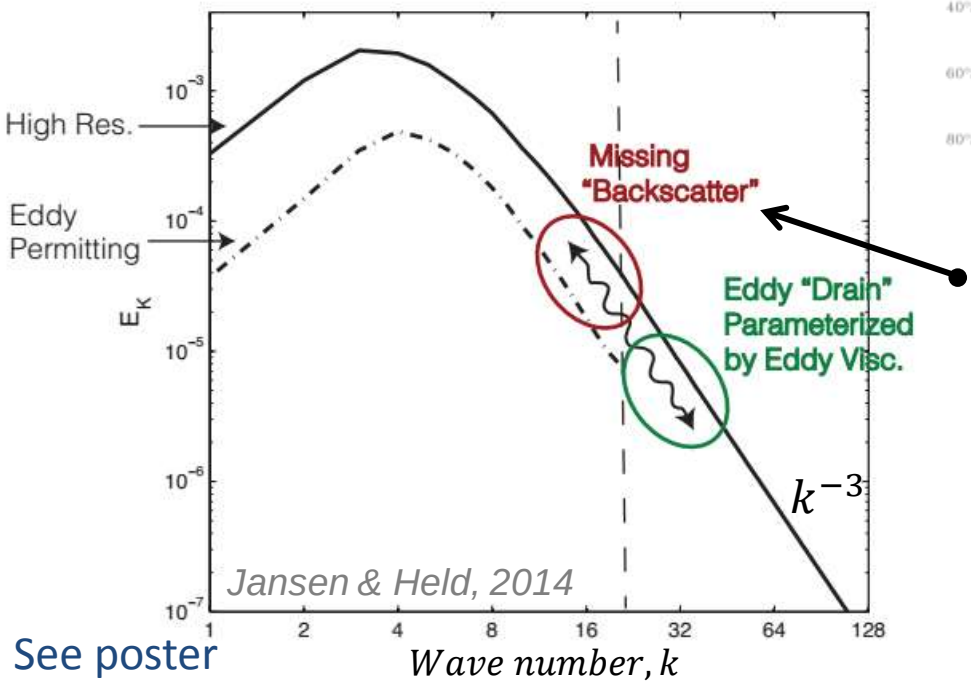
Hallberg, 2013

Eddy parameterization II

- Higher order closures
  - Predicts scales to use in eddy parameterization

e.g. $\kappa_h \propto U_e L_e$





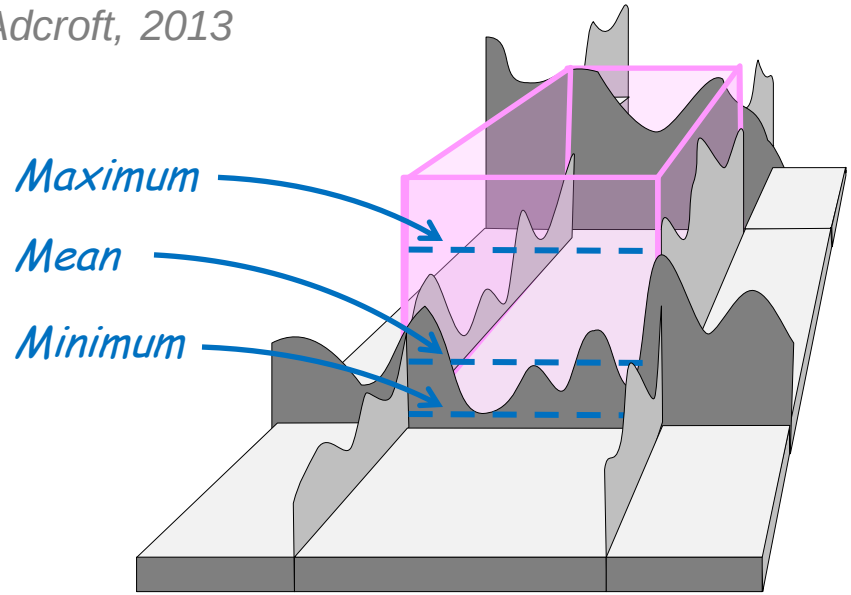
See poster

- Influence of small scales on large scale
  - Backscatter of energy from unresolved scales to resolved scales

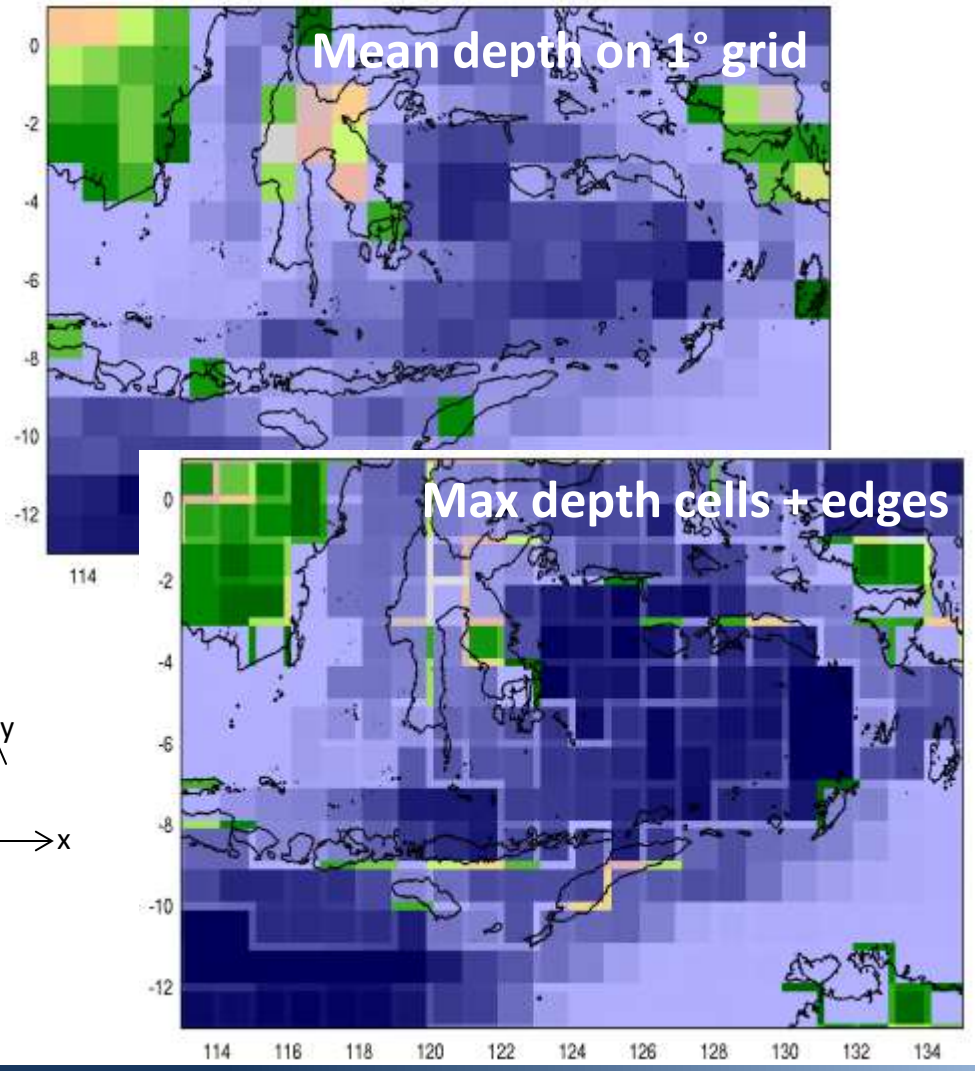
Porous barrier representation

- Use PDF of topography along edges (and within column)
- Real-world "actual" values:
  - areas/volumes
  - sill-depths/ridge-heights

Adcroft, 2013

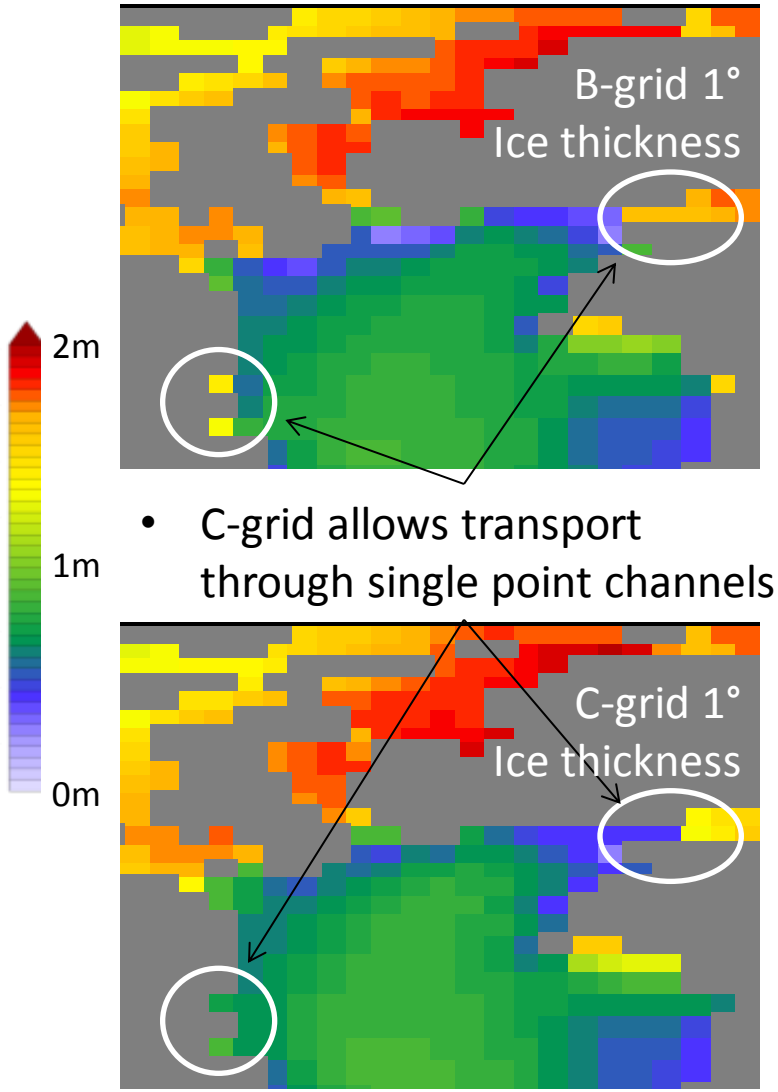


e.g. **Indonesian Through Flow**



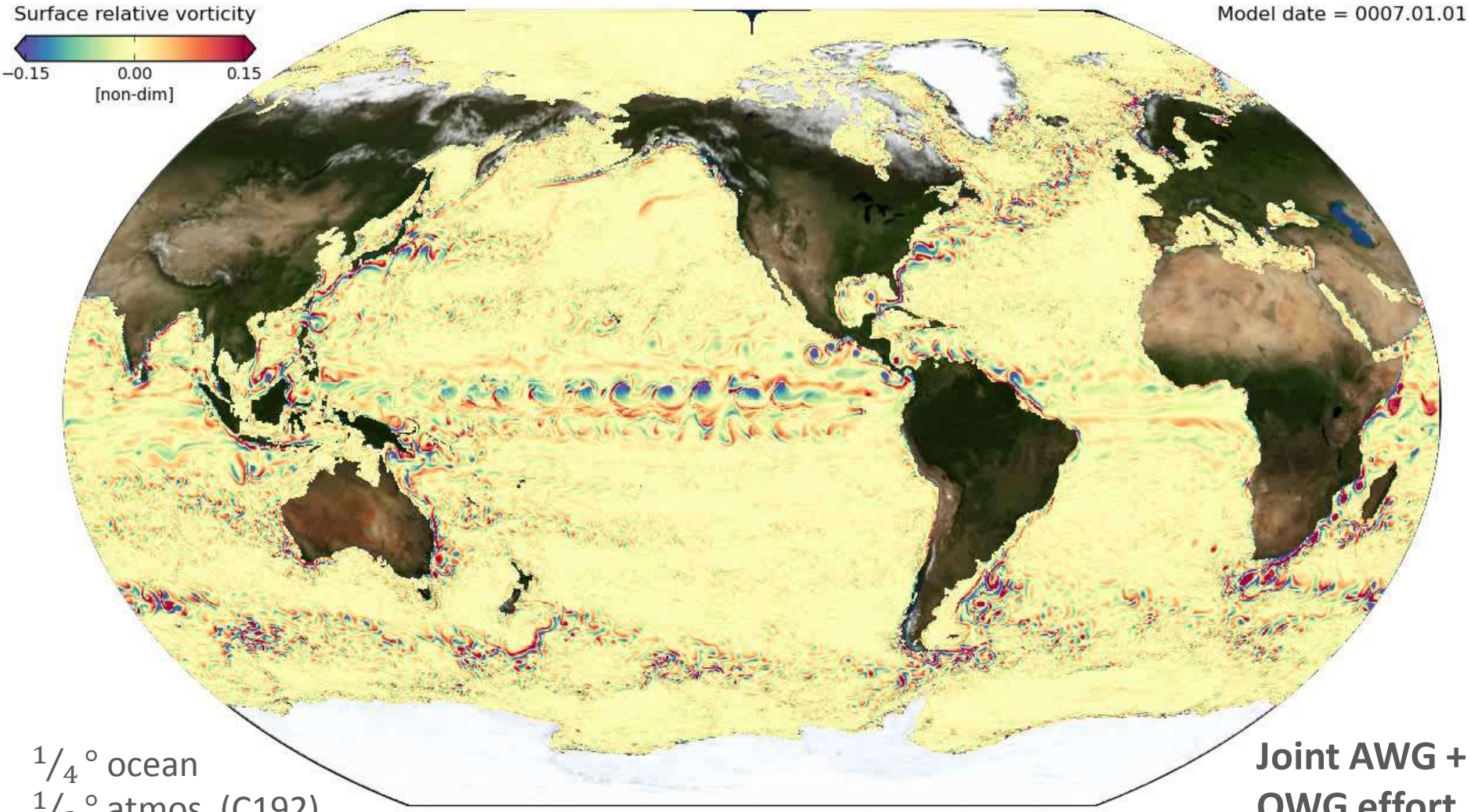
Revised sea-ice model: SIS2

- Avoid high-resolution coupling instabilities
  - Dynamics part of ocean
  - Essential for **ice-shelf** front movement
- Compatible with MOM6
  - C-grid; moving “coasts”
  - Multi-layer; variable salinity
  - Delta-Eddington radiation (from CICE)
- Collaborations: MIT, LANL



- C-grid allows transport through single point channels

CM4 working prototype



$^1/_4$° ocean
$^1/_2$° atmos. (C192)

Joint AWG + OWG effort

Summary

- GFDL Ocean Working Group
  - Built ¼° resolution ocean component; now refining
  - Aim to address biases of previous models (1° and ¼°)
- MOM6
  - Newer algorithms (more accurate/more efficient)
  - Innovative formulations and parameterizations
- SIS2
  - Update to be compatible with MOM6 + newer physics
    - Address [numerical] stability of high-resolution models