Overview of MOM6

From the MOM6 team

CESM winter workshop, Ocean Model Working Group, Boulder, CO

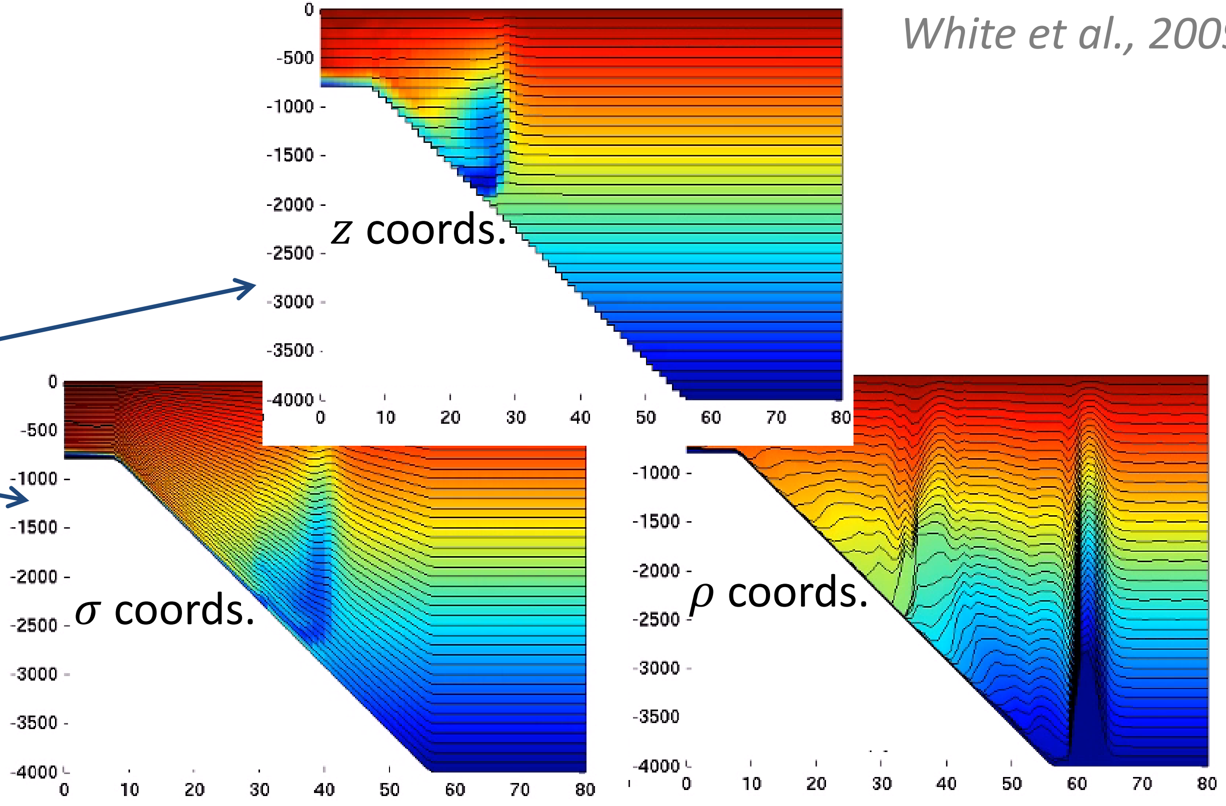
Feb 28, 2017

MOM6 dynamical core

- Finite volume solver
  - Hydrostatic Boussinesq or non-Boussinesq equations
- Arakawa C-grid in horizontal
  - Allows single-point channels
- Arbitrary-Lagrangian-Eulerian
  - General coordinate
  - No vertical CFL limit
    →ultrafine vertical resolution
  - Sub-cycled gravity waves
  - Wetting and drying is built-in

- Scalable on large parallel computers
- Range of transport schemes *(new)*

White et al., 2009



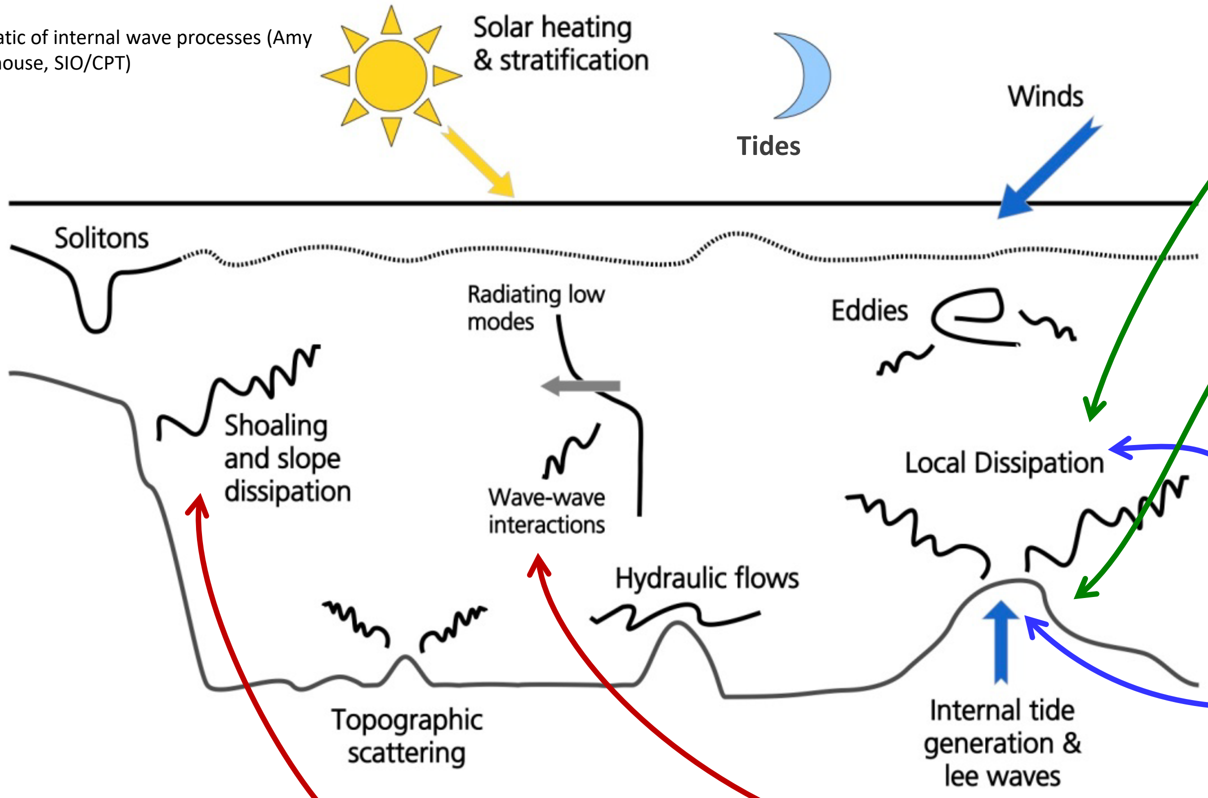
MOM6 sub-grid scale parameterizations

- Planetary boundary layer
  - KPP (via CVmix) (Large et al., 1994)
  - ePBL (Hallberg & Reichl, 2017)
  - Bulk mixed layer
- Mixed layer re-stratification by sub-mesoscale eddies
  - Fox-Kemper et al., 2008
- Shear dependent mixing
  - Jackson et al., 2008
  - CVmix (LMD94)
- Sub-grid mesoscale eddies
  - Gent & McWilliams, 1990 / TEM
    - Various prescriptions for diffusivity
    - Ferrari et al., 2010
  - Stirring (aka Redi tensor)
    - Monotonic scheme
- BBL (LOTW)
- Geothermal
- SW penetration (ocean color)
- Internal tide-driven mixing

Physically-based, energetically-consistent parameterizations of diapycnal mixing

- NOAA/NSF Internal Wave-Driven Mixing **C**limate **P**rocess **T**eam;
- Parameterizations of sub-grid-scale mixing which allow mixing to vary spatially and **evolve in a changing climate**.

Schematic of internal wave processes (Amy Waterhouse, SIO/CPT)



Vertical profile of local dissipation. *Polzin, 2009; Melet et al, 2013a*

Parameterization of lee-waves. *Nikurashin and Ferrari, 2011; Melet et al, 2013b*

Local dissipation at tall steep topography. *Klymak, Legg and Pinkel, 2010; Klymak et al, 2012*

Contribution to generation from abyssal hills. *Melet et al, 2013c*

Low-mode shoaling and reflection. *Legg, 2013*

Latitudinal dependence of wave-wave interactions. *Nikurashin and Legg, 2011*

Ocean component of CM4 (OM4) design

Objectives:

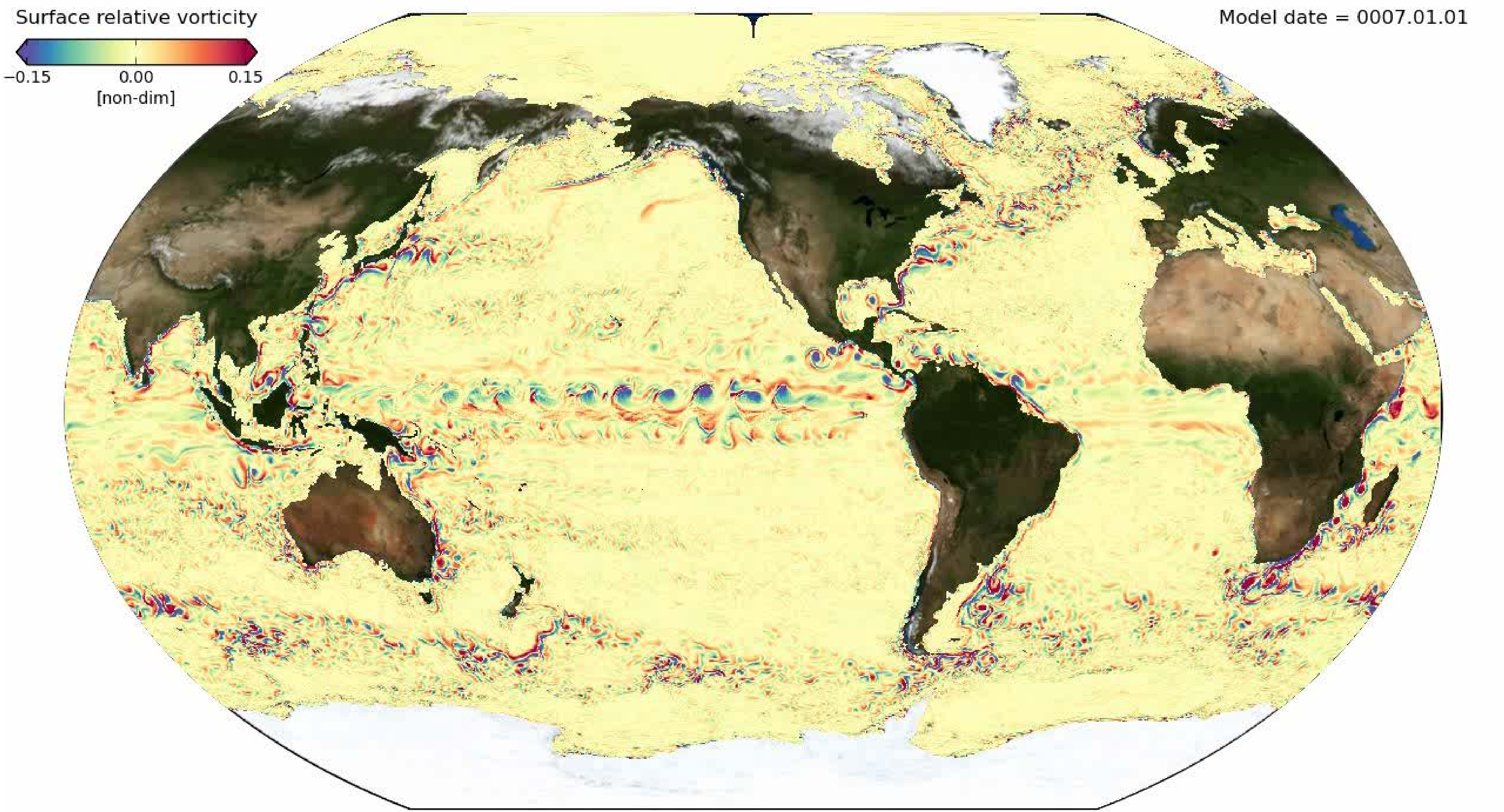
- Build a ¼° ocean model with fidelity of CM2.6 (0.1°)
- Can we build models that are "configured" the same way at all resolutions?
  - scale aware parameterizations

Starting point:

- From scratch
- Every parameterization re-written to work in general coordinates

- Notionally ¼° horizontal resolution
  - Also building 1° and ½° for ESMs and other MIPs
  - ⅛° already developed for global coupled ocean-ice-shelf
- What finer resolution might get us
  - Resolve boundary currents - ½-⅓°?
  - Meanders (standing eddies) - ¼°?
  - Resolve upwelling zones - ⅛°?
  - Overflows – $^1/_x$° + vertical coord.?
  - Mesoscale eddies - $^1/_{20}$°?

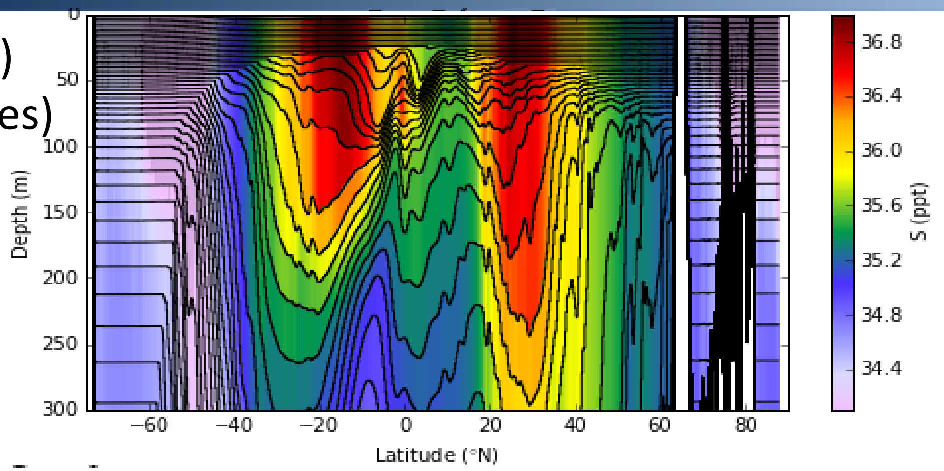
Ocean component of CM4 (OM4)

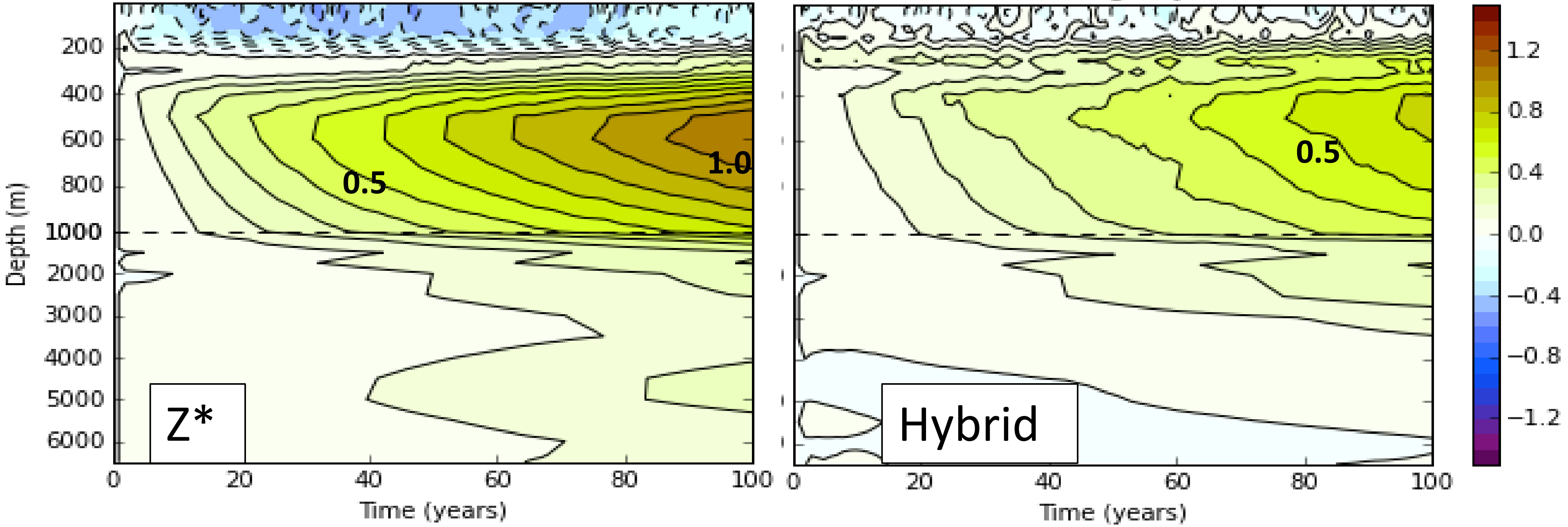


Role of vertical coordinate (¼° ocean in CM4)

- Changing vertical coordinate alone
  - – z^* to hybrid z^*/ρ_2 (aka HYCOM)
  - – Identical parameterization/atmos
  - – Reduced heat uptake by 0.27 Wm^{-2}

Salinity (shaded)
Vertical grid (lines)



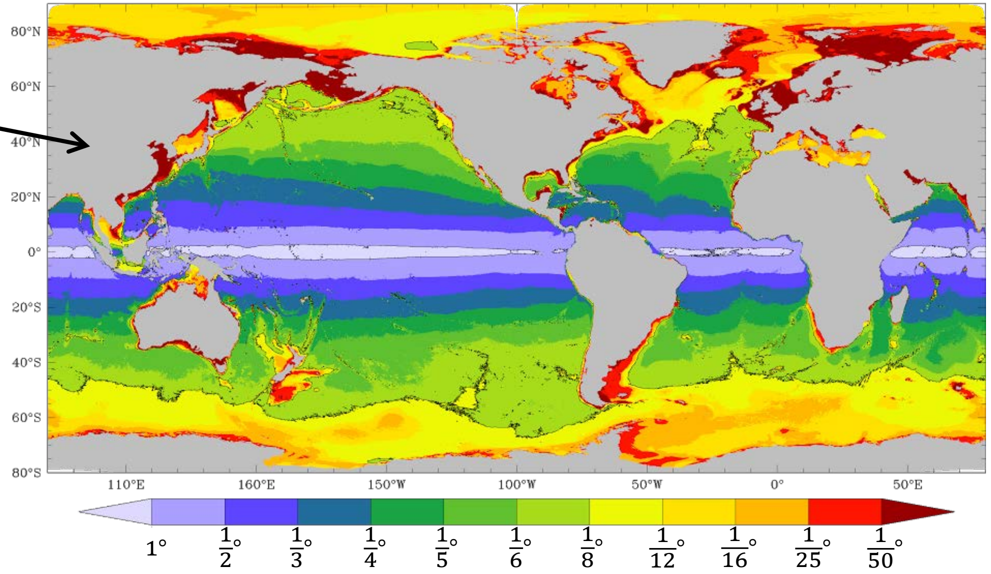


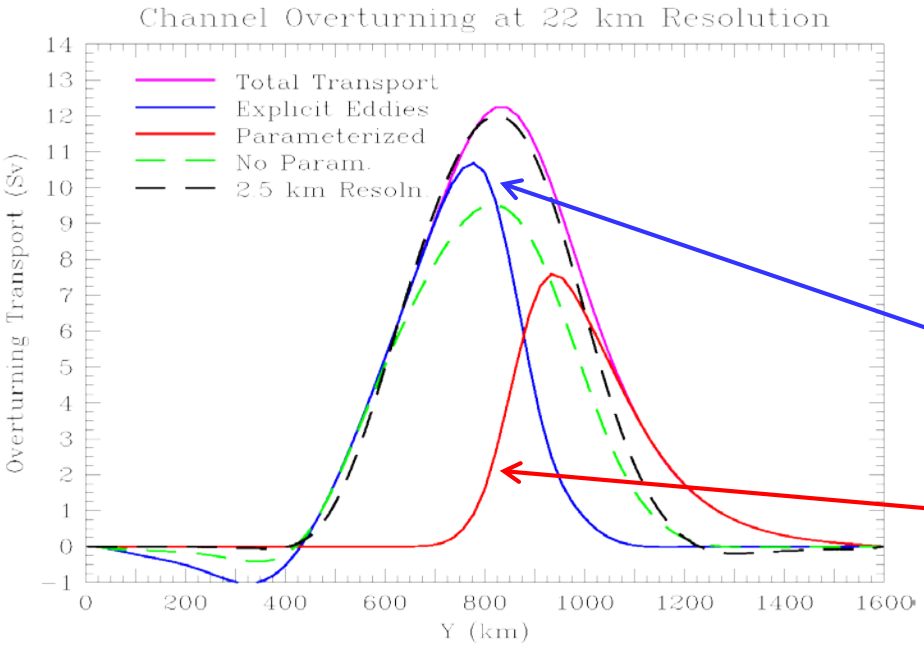
Chassignet et al., 2003; Megann et al., 2010; Ilicak et al., 2012

When to parameterize sub-grid mesoscale eddies

- 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

Accounting for sub-grid mesoscale EKE

- Mesoscale EKE equation
  - Eden and Greatbatch, 2008
  - Depth integrated (Jansen et al., 2015)

$$\partial_t E = \langle \kappa_h S^2 N^2 \rangle - \frac{c_d}{H} |\bar{u}_b + u_e| \gamma E$$

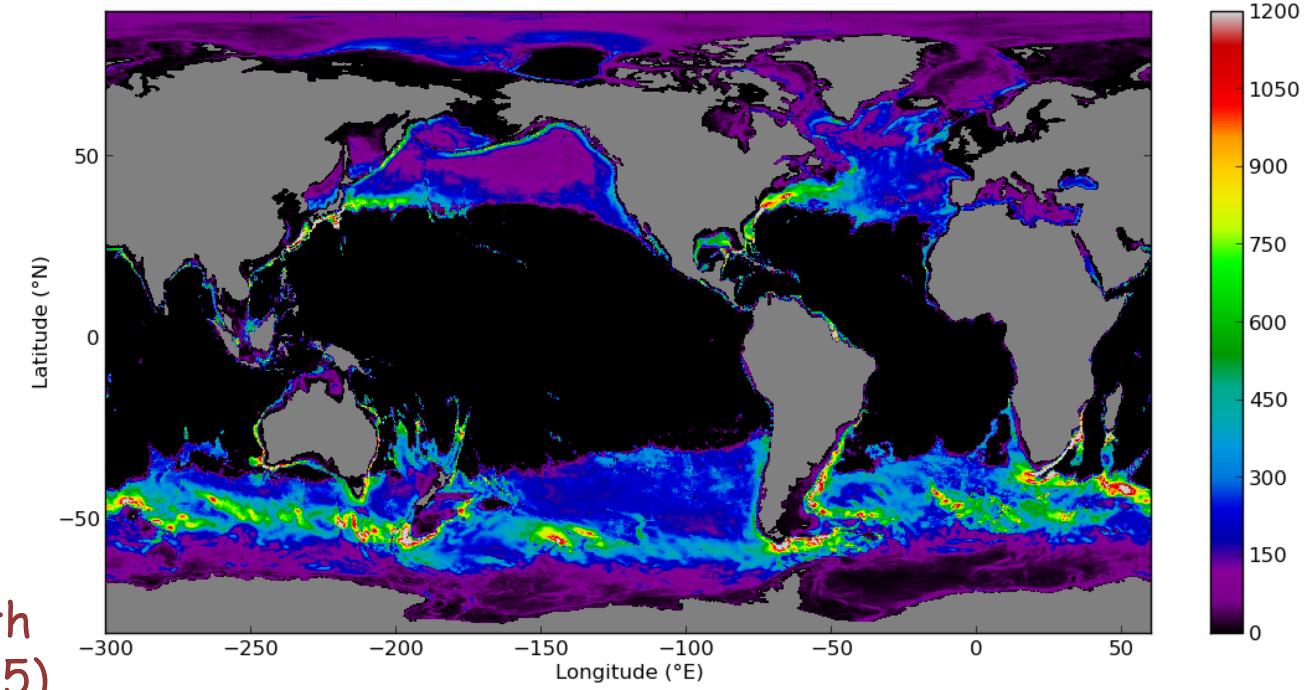
Eddy kinetic energy (E); Isopycnal slope (S^2); Stratification (N^2); Thickness diffusivity (κ_h); Bottom drag (c_d); Mean bottom flow + … ($\bar{u}_b$); Eddy velocity scale (u_e)

$$E = \frac{1}{2} u_e^2 \qquad \kappa_h = r_\Delta u_e L_e$$

Resolution function (Hallberg, 2013) (r_Δ); Eddy mixing length (Jansen et al., 2015) (L_e)

- γ = bottom EKE / barotropic EKE
- L_e is combination of length scales
  e.g. Held-Larichev (1996), Rhines

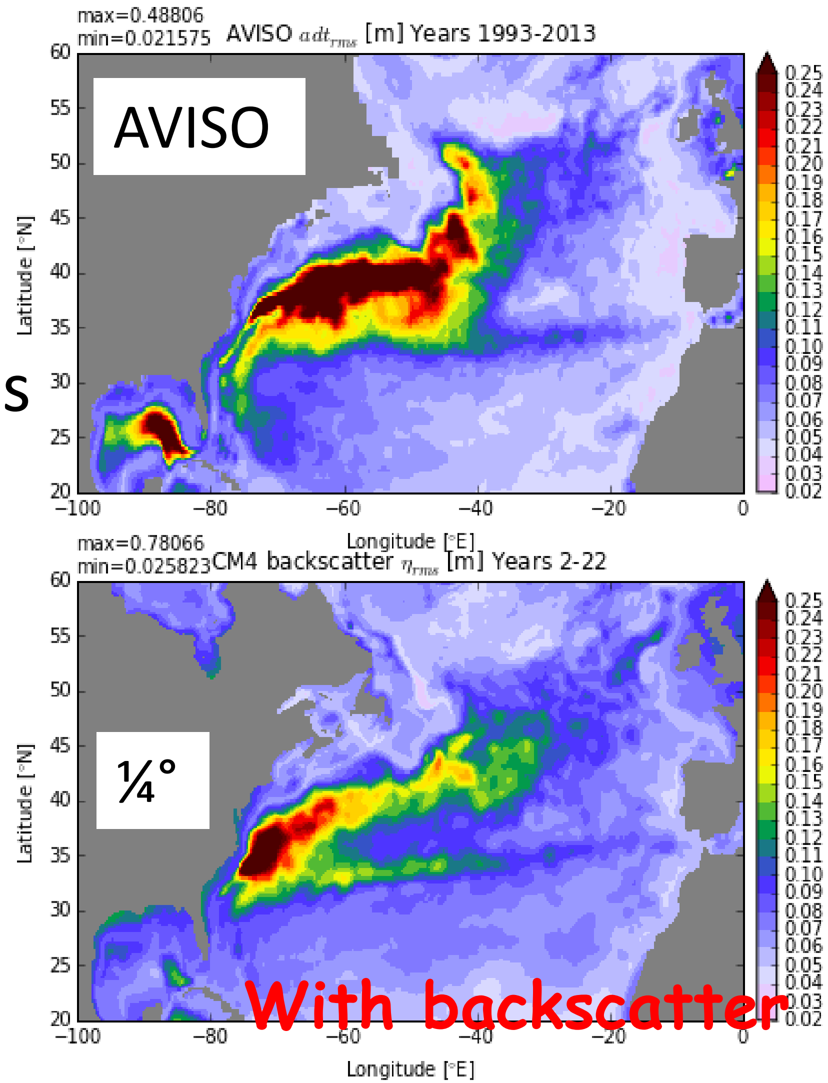
Thickness diffusivity resulting from MEKE (m^2s^{-1})



Energizing the “resolved” eddies

- Backscatter improves some features
  - Sometimes better than our $^{1}/_{10}°$ model
- There are other aspects that are “not right”
  - e.g. Aleutian eddies appear but have wrong sign
- We do not understand these results yet

… but are working on it



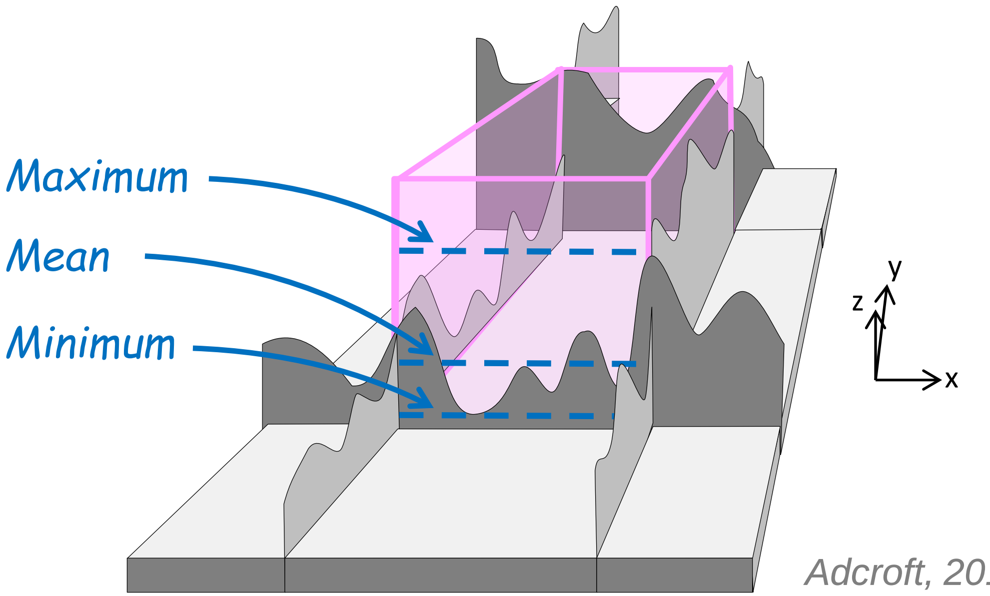
Iceshelf cavities

- Ice shelf cavities simulated with evolving iceshelf model coupled to ocean
  - Moving upper boundary
  - Moving grounding line
- Note ocean squashed between shelf and bottom
- Preparing ⅛° coupled ocean-ice-shelf global simulations

Gustavo Marques

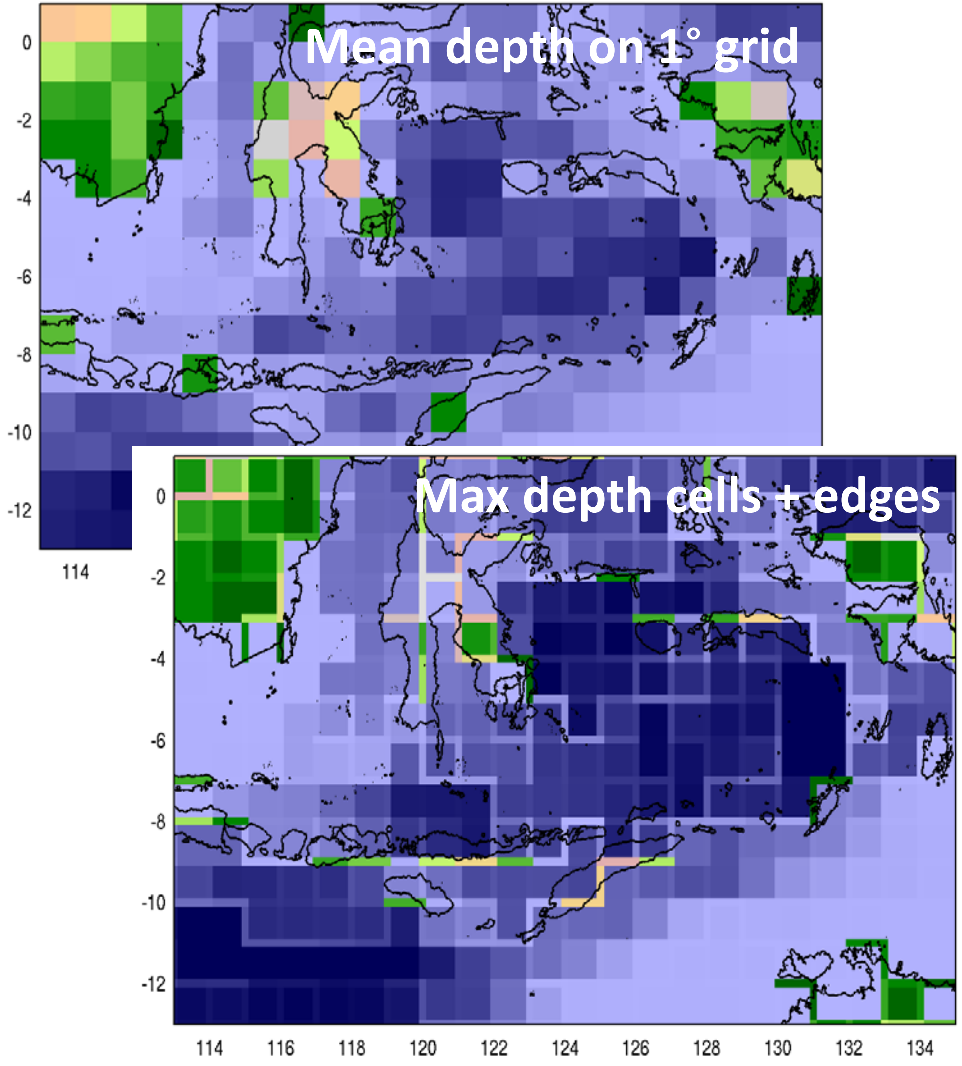
In the pipeline: porous barrier representation

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



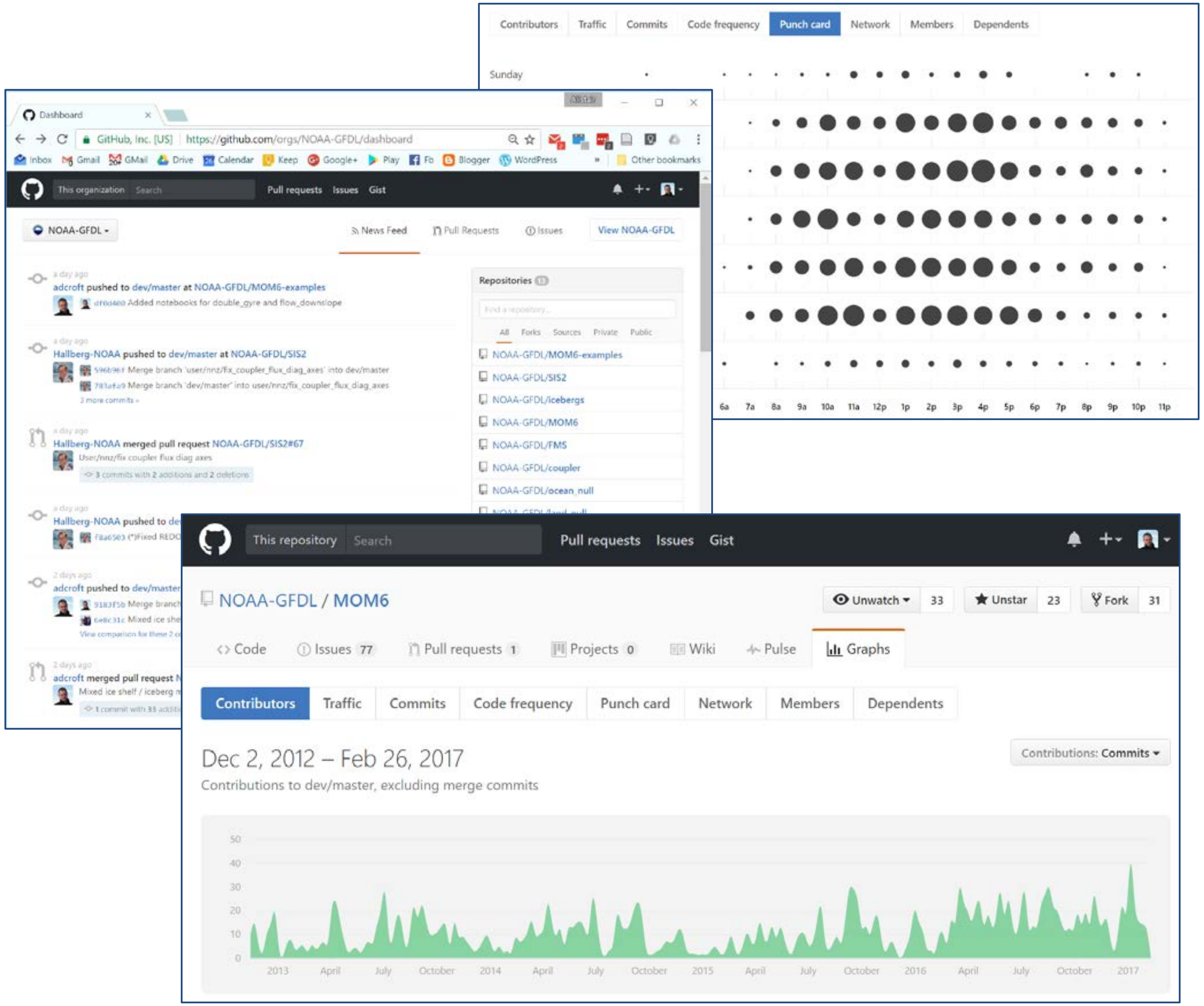
Adcroft, 2013

- e.g. **Indonesian Through Flow**



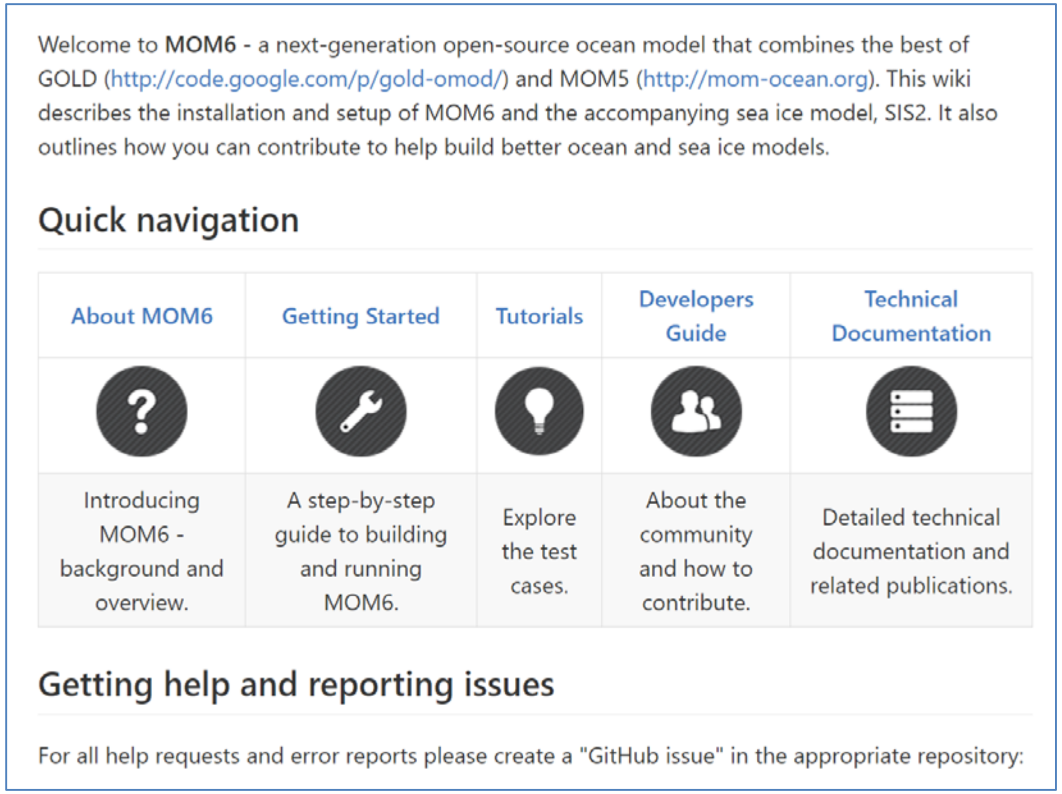
Open development

- Open development
  - Not just open source + releases
  - All activity visible via GitHub
    - Anyone can contribute at anytime
- Version control using "git"
  - Fully distributed
  - Powerful
    - Not file-by-file (CVS) but as whole
    - In particular, use sub-modules
- Everything is under version control
  - code, inputs, tools, tests, pp, …



Documentation

- Getting started (aka installing and running)
  - User-driven wiki
  - Google "MOM6 wiki"


Welcome to **MOM6** - a next-generation open-source ocean model that combines the best of GOLD (http://code.google.com/p/gold-omod/) and MOM5 (http://mom-ocean.org). This wiki describes the installation and setup of MOM6 and the accompanying sea ice model, SIS2. It also outlines how you can contribute to help build better ocean and sea ice models.

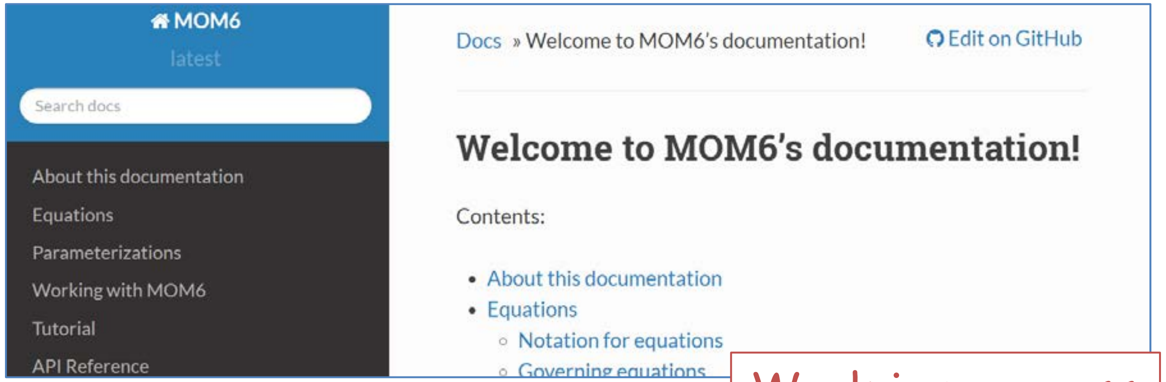
Quick navigation

About MOM6	Getting Started	Tutorials	Developers Guide	Technical Documentation
Introducing MOM6 - background and overview.	A step-by-step guide to building and running MOM6.	Explore the test cases.	About the community and how to contribute.	Detailed technical documentation and related publications.

Getting help and reporting issues

For all help requests and error reports please create a "GitHub issue" in the appropriate repository:

- User guide and API reference


MOM6
latest
Search docs
About this documentation
Equations
Parameterizations
Working with MOM6
Tutorial
API Reference

Docs » Welcome to MOM6's documentation! Edit on GitHub

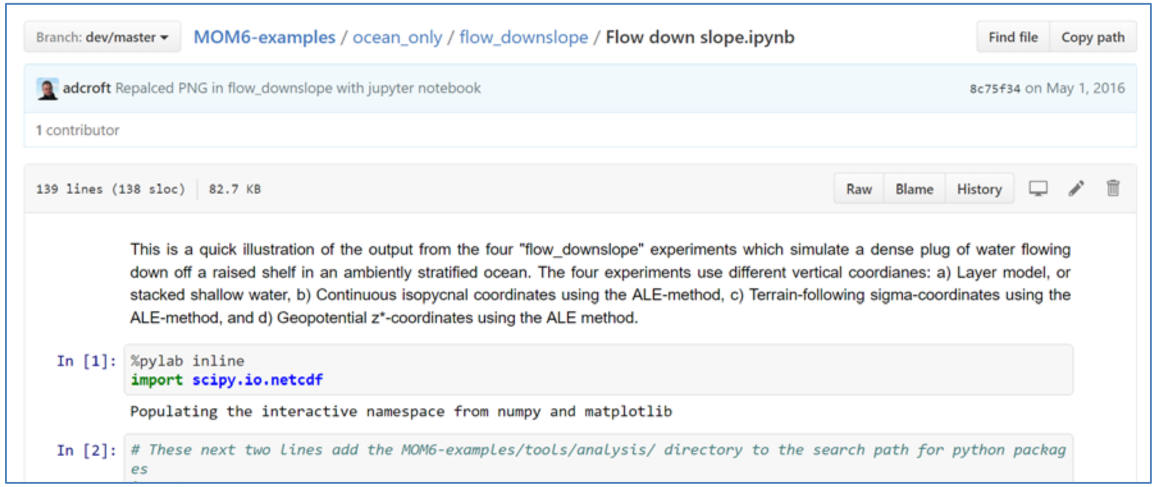
Welcome to MOM6's documentation!

Contents:

- About this documentation
- Equations
  - Notation for equations
  - Governing equations

Work in progress

- Tutorials (mostly analysis)


Branch: dev/master MOM6-examples / ocean_only / flow_downslope / Flow down slope.ipynb Find file Copy path

adcroft Repalced PNG in flow_downslope with jupyter notebook 8c75f34 on May 1, 2016

1 contributor

139 lines (138 sloc) 82.7 KB Raw Blame History

This is a quick illustration of the output from the four "flow_downslope" experiments which simulate a dense plug of water flowing down off a raised shelf in an ambiently stratified ocean. The four experiments use different vertical coordianes: a) Layer model, or stacked shallow water, b) Continuous isopycnal coordinates using the ALE-method, c) Terrain-following sigma-coordinates using the ALE-method, and d) Geopotential z*-coordinates using the ALE method.

```
In [1]: %pylab inline
        import scipy.io.netcdf

        Populating the interactive namespace from numpy and matplotlib

In [2]: # These next two lines add the MOM6-examples/tools/analysis/ directory to the search path for python packag
        es
```