CESM2 Ocean will have a modified vertical coordinate

Exactly what sort of modified vertical coordinate? Depends on this week's discussions.

Options from the community

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Ocean Modelling 7 (2004) 269–284

Ocean Modelling

www.elsevier.com/locate/ocemod

Rescaled height coordinates for accurate representation of free-surface flows in ocean circulation models

Alistair Adcroft [*,1], Jean-Michel Campin [2]

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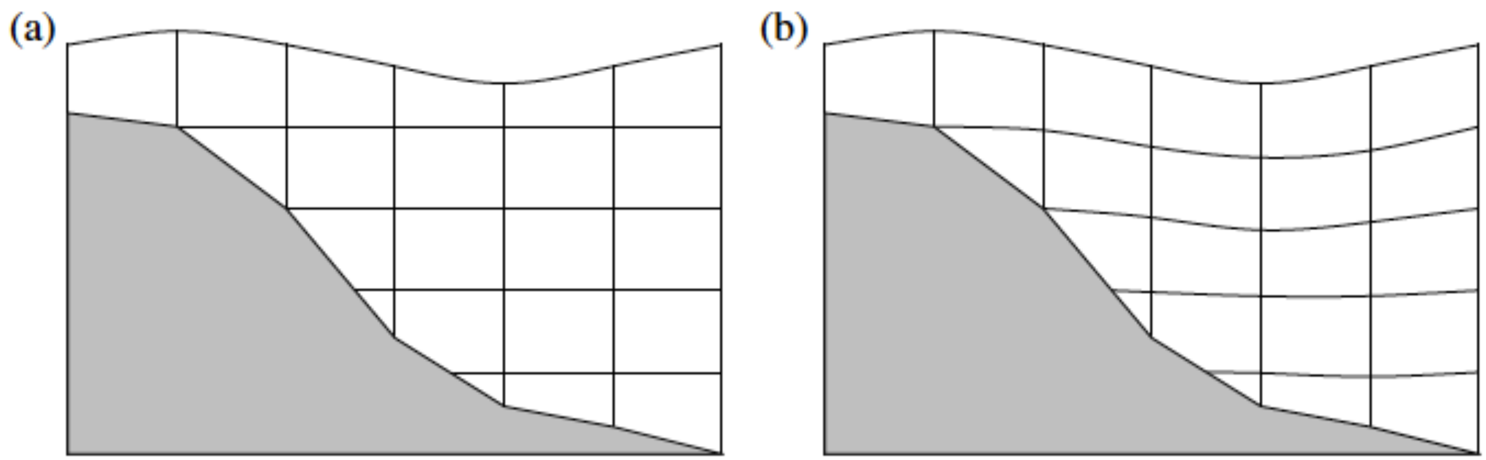
z-star: allow all levels to respond in a proportional way to external mode

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



How POP does it now

Z-star

A note in the appendix on the non-Boussinesq "p-star" variant:

Here on, we will use the symbol p^* rather than the conventional symbol η for the vertical coordinate to avoid confusion with the dependent variable used in the oceanic equations. This will also remind us that the p^* takes the same form as the rescaled height coordinate z^* and at the same time is most closely related to pressure, p. The common factor required to describe the coordinate transformation is

$$\partial_{p^*} p = \frac{p_s}{p_s^o}$$

so that the equations of motion using p^* as the vertical coordinate becomes

$$D_t \vec{v}_h + f \hat{k} \wedge \vec{v}_h + \alpha \nabla_{p^*} p + \nabla_{p^*} \Phi = \vec{F} \quad \text{(B.17)}$$

$$\partial_{p^*} \Phi + \alpha \frac{p_s}{p_s^o} = 0 \quad \text{(B.18)}$$

$$\partial_t \frac{p_s}{p_s^o} + \nabla_{p^*} \cdot \left(\frac{p_s}{p_s^o} \vec{v}_h \right) + \partial_{p^*} \left(\frac{p_s}{p_s^o} \dot{r} \right) = 0 \quad \text{(B.19)}$$

$$\partial_t \left(\frac{p_s}{p_s^o} \theta \right) + \nabla_{p^*} \cdot \left(\frac{p_s}{p_s^o} \theta \vec{v}_h \right) + \partial_{p^*} \left(\frac{p_s}{p_s^o} \theta \dot{r} \right) = Q_\theta \quad \text{(B.20)}$$

$$\partial_t \left(\frac{p_s}{p_s^o} q \right) + \nabla_{p^*} \cdot \left(\frac{p_s}{p_s^o} q \vec{v}_h \right) + \partial_{p^*} \left(\frac{p_s}{p_s^o} q \dot{r} \right) = Q_q \quad \text{(B.21)}$$

$$\alpha = \theta \partial_p \Pi \quad \text{(B.22)}$$

To apply these equations to the non-Boussinesq ocean (following Losch et al., in press), we simply replace q by s and the ideal gas equation (B.22) with

$$\alpha = \alpha(s, \theta, p) \quad \text{(B.23)}$$

Is this a significantly advantageous capability?

How difficult an extension is this?

Options from the community

Elements of MOM4p1

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WITH CONTRIBUTIONS FROM
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MIKE HERZFELD (CSIRO-HOBART, AUSTRALIA)

- MOM4.1 was most recently released in December 2009 (click here for the MOM4.1 manual: ~7Mb). This code allows for the following added functionality relative to MOM4.0:
  1. the inclusion of non-Boussinesq effects (relevant for studying sea-level)
  2. alternative vertical coordinates such as p* and z*.

  We highlight also the release of the CM2.1 climate model as a test case with the December 2009 version of MOM4p1.

Options from the community

Ocean Modelling 37 (2011) 139–152

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$\tilde{z}$-Coordinate, an Arbitrary Lagrangian–Eulerian coordinate separating high and low frequency motions

Matthieu Leclair [a,*], Gurvan Madec [a,b]

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$\tilde{z}$-Coordinate, an Arbitrary Lagrangian–Eulerian coordinate separating high and low frequency motions

Matthieu Leclair [a,*], Gurvan Madec [a,b]

A B S T R A C T

A new geopotential based vertical coordinate, named $\tilde{z}$, is presented, that treats external motions as a z^*-coordinate, internal low frequency motions in a Eulerian way and high frequency ones in a Lagrangian way. To that purpose, a prognostic equation for the low frequency horizontal flux divergence is added in the system in order to discriminate between low and high frequency parts of vertical motions. This

Z-star minimizes vertical velocities associated with external waves. Z-tilde also minimizes vertical velocities associated with “high frequency” internal wave motions.

Note: nothing on our draft requirements document points to this. But requirements are being firmed up here, now.

Options from the community

CCSR Ocean Component Model (COCO)

Version 4.0

April 16, 2007

Hiroyasu Hasumi

Center for Climate System Research,
The University of Tokyo

In the ocean component of MIROC they usually limit z-star to the uppermost 50 meters, in order to limit impact of pressure gradient errors.

Note that COCO is very similar to POP: B-grid, leapfrog-in-time.

In preparation for modified vertical coordinate:

- Starting point: CESM's latest version of POP
- Design doc, based on requirements
  - as per Mark's MPAS z-star/z-tilde design doc
- Propagate 3-D DZ, as per HyPOP
- Add thickness variable, as per HyPOP
  - Test in diagnostic mode

Rough sketch of division of labor for this and related POP developments

- Phil Jones: local devel config of CESM POP
- Mathew Maltrud: implementation of conservative Robert (Williams variant?) filter
- Beth Wingate: consideration of POP's barotropic solver with the new vertical coord.
- Wilbert Weijer: 3-D DZ and testing.
- Matthew Hecht: Implementation of the modified vertical coordinate.