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Discussions

Interactive comment on “Influence of numerical schemes on current-topography interactions in 1/4° global ocean simulations” *by* T. Penduff et al.

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The paper follows on the footsteps of many similar studies of recent years which evaluate various numerical aspects of ocean models using sensitivity experiments with different parameterizations or configurations. As such, the paper does not provide new insights on ocean dynamics, but nevertheless is an important contribution in making numerical ocean models more realistic. In particular, the problem of how to treat bottom topography in z-level models with stepped topography has been the subject of considerable research. This study clearly demonstrates three elements that significantly improve current-topography interactions in z-level models: partial steps, a low viscosity advection scheme and reduction of sidewall friction (no-slip BC). The results are interesting and practical, and thus should be published. However, considering previous literatures (some have not been cited, but should have), the results are not unexpected or completely new.

Specific comments and suggestions:

1. An interesting point that may be discussed is that the 3 elements tested here all bring the z-level model closer to a terrain-following-like model (i.e., sigma models do not have steps, usually do not have side walls if extend to coastal areas and can run with low horizontal viscosity due to the smooth bottom). In fact, the improved results here, such as more intense bottom currents and recirculation gyres resemble to large extent the results from early basin-scale terrain-following ocean models (e.g., Ezer and Mellor, 1997, discuss those elements when compared their sigma model to the z-level CME model).

2. The introduction discusses the DYNAMO program, but another recent program, the Dynamics of Overflow Mixing and Entrainment (DOME) is also very relevant as it compares topography-current interaction in overflows in isopycnal, z-level and terrain-following models (Legg et. al, 2006; Ezer and Mellor, 2004; Ezer, 2005). In this context it may be useful to mention that the improvements done in the DRAKKAR model here are likely also to help in improving overflow simulations (has this been tested?). The more intense deep boundary currents seen in the EENP experiment may not be only due to better treatment of local topography, but also due to better deep water formation. This should be looked into. Also, in Fig. 7 the fact that partial cells cause the large Ts values to shift into deeper ocean depths relative to a step topography case may be related to dense bottom waters that extend further downslope. This is similar to results seen in the DOME experiments where terrain-following and isopycnal models transport dense plumes further downslope compared with stepped topography z-level models of the same resolution.

3. P. 496, first par.- if turbulence closure model is used, does the artificial large vertical mixing imposed in static instability cases really needed?

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4. Fig. 1 shows mean transports, but this does not tell the whole story. It may be useful to show the MOC stream function, say for the Atlantic (is it shown in the previous paper?).

5. Fig. 3- it may be a little easier to compare model and observation figures when using similar color scales (at least add the zero contour to distinct between different flow directions).

6. P. 500 & Fig. 4- It is interesting to note that despite the improvement in the re-circulation gyres, the Gulf Stream separation off Cape Hatteras is still not satisfactory and resembles (though to lesser degree) the problems experienced in the early CME model. The fact that isopycnal models and terrain-following models of comparable or even coarser resolution get better GS separation indicates that there is still something missing in the treatment of topography in z-level models.

7. P. 503- The tropostrophy analysis is interesting. However, mesoscale turbulence may not be the main reason to align mean currents along topography in partial cells experiments, but that slopes and topographic features are simply better resolved and are not distorted by stepped topography. One point that should have been mentioned is the fact that the models do not resolve bottom boundary layers. If BBLs were resolved, the direction of the near bottom flow would have been affected.

8. It is difficult to see the details in Fig. 9a.

References

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