MPO776 - Mesoscale Oceanography

Tiago Carrilho Bilo

C# 11950866

Paper Review: Danabasoglu, G., J. C. MacWilliams, P. R. Gent (1994), The Role of Mesoscale Tracer Transports in the Global Ocean Circulation, Science, 264, pp. 1123-1126

Dear editor, bellow you will find my Danabasoglu et al. manuscript review. This document is organized in eight topics: (1) Paper's overview, (2) Importance, (3) Methodology, (4) Originality, (5) Results summary, (6) Implications, (7) Critics, and (8) My recommendation.

(1) Danabasoglu et al. study basically evaluates the changes in the outputs of a widely used large-scale ocean model due to the implementation of a new, and more physically consistent, parameterization scheme of mesoscale motions. The manuscript focus in the assessment of the circulation patterns and how close they are to what is expected in the real ocean. The authors found that the change in the parameterization scheme have improved significantly the representation of the mesoscale impact in some large scale features.

(2) It is well known that the transport of tracers (e. g., heat, salt, gases) by mesoscale eddies have an important impact in the large scale circulation and distribution patterns of such properties, therefore it is imperative that ocean models resolve or realistically represent (i. e., parameterize) the effects of the mesoscale activity.

(3) The authors compare two different parameterization schemes (referred as HOR and ISO) performance in a long-term integration (10,000 years) of the widely used GFDL non-eddy-resolving GCM (resolution of 4° in longitude, 3° in latitude, and 20 levels in the vertical). The comparison is focused on the time and zonal mean potential temperature and overturning stream function distributions, time mean of the zonally integrated meridional heat transport, and the global distribution of the deep convection zones in the ocean.

Parameterizations:

- **HOR:** It corresponds to the early common practice to assume that the effect of mesoscale eddies as a simple down-gradient horizontal and vertical diffusions with constant or depth-dependent coefficients.
- **ISO:** This scheme is the new approach proposed by Gent & McWilliams (1990) and tested in this study. Based on the well-established observations that tracers are more uniformly distributed along constant density surfaces, the scheme assumes non-constant along/cross-isopycnals diffusivity coefficients. Additionally the advective transport of tracers are due to the mean and eddy-induced velocities.

(4) This manuscript is the first study that tests the performance of the new parameterization scheme proposed by Gent & McWilliams (1990) in a global simulation. Therefore the study is original.

(5) Basically, the results consist in presenting the most evident advantages of using ISO and why. The new parameterization produces a global ocean with a sharper thermocline and cooler abyssal region consistent with the Levitus (1982) climatology, a meridionally expanded overturning circulation that is surface intensified in the Northern Hemisphere (i. e., higher meridional heat transport) in agreement with estimates found in the literature, an eddy-induced cancellation of the Deacon cell in the Southern Ocean

(similar to results obtained from higher resolution numerical simulations), and confinement of deep convection to regions where it is known to occur.

(6) As well mentioned by the authors *"eddy-resolving global ocean models cannot be used routinely in climate simulations, even in modern supercomputers"*. Therefore, the exposure of the old simple horizontal diffusion scheme limitations and the advantages of using the Gent & McWilliams (1990) parameterization can lead to significant improvements in future global ocean simulations, climate models and its reliability.

(7) I believe the study was conducted well and the authors succeeded in pinpoint where and why the new parameterization scheme improved tracer transports in global ocean simulations. However the authors could have mentioned more details about the limitations of the new scheme that are relevant to tracer transports, even though the ISO is undoubtedly more physically consistent and advantageous than HOR.

Although the manuscript goals are not to discuss numerical problems and/or the physics behind the parameterization, it would be useful for colleagues that are interested in applying ISO in their codes to know where the scheme fails in terms of tracer transports (e. g., is the meridonal dimension of the subtropical gyres well represented? Are there any improvements in the Gulf Stream extension?). Even if the physical reasons for such problems are not well understood the future users of the ISO must be aware where to expect problems. Additionally a mention on how dependent the large-scale features are to changes in the parameterization parameters is welcome (**big problem in HOR**).

(8) Finally, based on the observations above I recommend accepting this article. It fulfills the Science's expectations and characteristics, being adequate for publication.