Reviewer's comments on the manuscript entitled

The effect of various vertical discretization schemes and horizontal diffusion parameterisation on the performance of a 3-D ocean model: the Black Sea case study

submitted by

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for possible publication in

Ocean Science

This study discusses the performance of NEMO used with various vertical grid systems for dealing with idealised problems as well as the realistic simulation of the Black Sea circulation. The manuscript is somewhat sloppy and the research achieved is far from original. However, this manuscript should be deemed acceptable for publication if the Authors improve some of its aspects in accordance with the suggestions listed below. The latter may be either taken into account or rebutted by having recourse to relevant arguments.

The literature on vertical grid systems is far more extensive than is suggested in the present manuscript. A number of articles should have been referred to and possibly taken advantage of. For instance, generalised vertical coordinate systems were introduced by Kasahara (1974) and implemented numerically by Gerdes (1993). Adapting the σ-coordinate system to a domain of interest encompassing both shelf and deep seas has been considered in Beckers (1991) and Deleersnijder and Beckers (1992). Recently, adaptive coordinate systems were suggested (e.g. Hofmeister et al. 2010) and should not have been ignored by the Authors of the present study.

From the abstract onwards, there are seemingly confusing statements about diffusivity and viscosity. The article by Luneva and Holt (2010) is referred to in the core of the text, but is missing in the bibliography. On page 3654, it is stated that "Griffies and Hallberg (2000) recommend values for the Smagorinsky diffusivity coefficient $C>2.2$". However, to the best of my knowledge, Griffies and Hallberg (2000) do not use Smagorinsky's approach for parameterising fluxes of scalar variables due to subgrid-scale phenomena. The aforementioned sentence and, in general, the way the Authors of this study use Griffies and Hallberg (2000) is confusing, if not simply wrong. These problems must be fixed.

It should be made clear that condition (1) on page 3646, i.e. the "hydrostatic consistency" condition, is not directly to the truncation error of the scheme used. To the best of my knowledge, expression (2) is the leading order term of the truncation error of a given discretisation of the pressure gradient force.

Page 3645, line 24: replace "Prinston" by "Princeton".

Page 3645, line 24: replace "Proudaman" by "Proudman".

Page 3645, line 28: the paper by Haney (1991) must be referred to in relation with the concept of “hydrostatic consistency”.

Page 3649, line 10: the “hydrostatic consistency” condition is relation (1) and not (2).

Page 3649, line 27: Fig. 5f is referred to, but is missing on page 3667.

Page 3649, line 27: the “computational errors” might well be discretisation/truncation errors. Please check.

Page 3651, line 15: replace “describedas” by “described as”.

Page 3660, line 5: replace “sdvantages” by “advantages”.

Additional references

Beckers J.-M., 1991, Application of the GHER 3D general circulation model to the Western Mediterranean, *Journal of Marine Systems*, 1, 315-332

Deleersnijder E. and J.-M. Beckers, 1992, On the use of the sigma-coordinate system in regions of large bathymetric variations, *Journal of Marine Systems*, 3, 381-390

Gerdes R., 1993, A primitive equation ocean circulation model using a general vertical coordinate transformation. 1. Description and testing of the model, *Journal of Geophysical Research*, 98(C8), 14,683-14,701

Haney R.L., 1991, On the pressure gradient force over steep topography in sigma coordinate ocean models, *Journal of Physical Oceanography*, 21, 610-619

Hofmeister R., H. Burchard and J.-M. Beckers, 2010, Non-uniform adaptive vertical grids for 3D numerical ocean models, *Ocean Modelling*, 33, 70-86

Kasahara A., 1974, Various vertical coordinate systems used for numerical weather prediction, *Monthly Weather Review*, 102, 509-522