Interactive comment on "Evaluating two numerical advection schemes in HYCOM for eddy-resolving modelling of the Agulhas Current" *by* B. C. Backeberg et al.

Anonymous Referee #1

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In this paper the authors analyze the effect of a 4th order momentum advection scheme in the HYCOM on the dynamics of the Agulhas region. They compare their results with the original (2nd order) scheme, and the truth is given by altimetric data (or in situ measurements). They focus on the Agulhas current and meanders. They find that the 4th order scheme significantly improves the results. This permits some physical analysis on the remote control of the Indian Ocean / South Atlantic ocean exchanges occuring in the Mozambique channel.

This paper is well organized and very clear. The previous work is correctly summarized and the novelties of the study well underlined and is of interest for the oceanographic

community.

I however believe some additional analysis are necessary to complete the work : sensitivity study to viscosity (see main comments below) and analysis of vorticity. This does not require a lot of work and is thus not a major correction. I therefore recommend publication of this article in Ocean Science provided the result of these additional test/analysis are added. I also propose some additional (and easy to do) analysis that are left to the authors' choice (specific sugestions).

My rating of the paper is :

Scientific Significance: fair to good

Scientific Quality: good

Presentation Quality: good to excellent

Main comments : ──────

As mentioned above, my main concern is the role of viscosity on the dynamics of the Agulhas current in your simulations. Indeed, any advection scheme is associated with (implicit or explicit) diffusion/viscosity. Viscosity is known to have some direct influence on the dynamics of boundary currents. The "real" QUICK scheme (Farrow and Stevens 1995) has implicit diffusion/viscosity. Webb (1998) has developped an explicit version of the QUICK where diffusion/viscosity is proportional to the magnitude of the velocity. In Winther et al, some modifications have been done to this term. 1/ You have to detail the viscosity function you use in your simulations, and the boundary conditions (free slip?). Is it the same as in Winther 2007? Please give more details on your numerical configuration. 2/ Given the possible impact of viscosity on boundary currents, I think it is necessary to test the sensitivity of your results to viscosity. It may well be that the improvements are partly due to modifications of this term instead of the higher order advection. I suggest modifying the viscosity parameters (typically multiply/divide it by two) in both the 2nd and fourth order simulations.

Initial tests of the influence of high order advection for momentum where done by Webb (1998), who concluded it has no positive effect. Winther et al (2007) conclude exactly the opposite and you too. Some explanations have to be given : is the fact that Webb tested this in equatorial regions the explanation? If yes why? 3/ Winther et al associate this effect to a better representation of the vorticity dynamics. Is it the explanation here too? you have to add some comparison of the vorticity fields in your paper. I agree the sea-level skewness is an interesting, and novel, quantity for your analysis, but when studying processes where vortex have a major influence, analyzing vorticity is, in my opinion, necessary.

Specific (less important) suggestions/comments : ——————————————————

As mentionned in Webb (1998) the QUICK scheme is actually equivalent to a fourth order advection term and a biharmonic viscosity whose coefficient is a function of the velocity magnitude. Webb showed that this is the term that imposes the predictor/corrector approach in the QUICK scheme and his analysis allowed to define a numerical scheme that is equivalent to the latter, but fully explicit without the need of a predictor/corrector approach. This is the version that has been retained in Winther et al 2007 (with some modifications of the viscosity term), and if I understand correctly your introduction, the version that has been retained here too. 1/ So the scheme you use is not the QUICK scheme and you should correct your manuscript (use simply "high order scheme"?).

P 432 your quotation of Barnier et al (2006) is a bit misleading. We understand you use this reference to justify the fact that higher order advection is necessary for momentum. I think the modifications of advection scheme proposed in Barnier et al is not higher order : it remains 2nd order but they use a conservative approach (which is what exists in HYCOM). Close to boundaries, such a scheme can even become 1st order. 2/ Please Check their paper and correct your paragraph if I am correct.

3/ I suggest you add some precise indications of the computational cost of the low and

high order HYCOM.

4/ P. 438, lines 7-9 : This is hardly visible in Fig. 3, how do you measure the south-westward penetration?

5/ P. 440 : Your analysis of the vertical section is very interesting. I suggest you also add vertical sections of stratification (density and/or temperature). Also explain why you mean by lack of vertical resolution (what resolution do you have in this area)?

6/ P. 444, I was puzzled by the fact you use SSH as a measure for energy. Why don't you use EKE instead? Also you mention Fig. 6a represent EKE, which is not true, is it?

7/ P. 445, line 11-12 : not so clear in your figures, explain?

Trivias: ———

P. 431, lines 17-20 : I do not understand your justification of the interest of density coordinates: PE models are all 3D. Do you mean you do not have to calculate the vertical velocity? What advantage does this represent?

P. 442, line 4 : what is a Q-Q plot? Difficult to understand if it is not shown ...

P. 443, line 11 : the mean SURFACE circulation.

P. 454. line 23 : "of the of"

P. 455, line 3 : "In addition [TO] this Fourier transform relies ..."

P. 455, line 20 : " was choseN"

Fig. 5 : I suggest you keep the same colors for O2/O4 as in Fig. 2 (reversed here).

Fig. 6 : the black lines are hardly visible, modify the colorbar (to have white instead of blue) or make two plots.

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