

Interactive comment on “Effects of mesoscale eddies on global ocean distributions of CFC-11, CO₂ and $\Delta^{14}\text{C}$ ” by Z. Lachkar et al.

Anonymous Referee #1

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This paper deals with the impact of eddies on uptake of the anthropogenic gases, as CFC-11 and CO₂. It is based on offline global simulations of tracers with two different resolutions: a climate type of resolution and an eddy resolving type. The main conclusions of this study propose that the eddies can be important for the uptake of tracers, their impact being larger when the gas considered is quickly transferred from the atmosphere to the ocean mixed layer.

This study is interesting and addresses a very important issue : the role of the medium scales on the ocean dynamics and on the transport of matter. As high resolution (satellite or in situ) data are more and more produced and as computers are more and more powerful, works on eddies are becoming easier and their number tends to strongly increase lately. Most of these works tend to show that these scales are indeed important

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to quantify oceanic fluxes correctly. Based on previous studies, and new numerical and original simulations, this paper follows the same line.

The simulations and the analysis proposed in the paper are important and bring new information. Moreover, the presentation is quite clear and convincing. Therefore, this paper should be published. Nevertheless, from my point of view, the apparent quality of the paper, and more specifically of the analysis, results also from a major drawback : the “good” points given to the eddy resolving simulation come only from the analysis of the thermocline of the Southern Ocean; although this water masses (AAIW) are extremely important, and although large problems remain in numerical simulations of the Southern Ocean, this cannot be all the story. In terms of anthropogenic gases (time scale : several tens of years), besides the northern North Atlantic Ocean and the southern border of the Antarctic ocean, it is true that the major “regions” of the ocean to consider are the mixed layer and the thermocline water masses. But in terms of climate change (time scale : one century and more), deep ocean is also very important, and nothing is said about that issue (certainly difficult to tackle with the vertical resolution and the z coordinate chosen for this run).

I have several more specific remarks.

In general, the validation is quite crude. Besides section 19S, there is no information about the vertical structure of the tracer distributions (the inventories give integrated numbers). Linked to the remark above, it would be interesting to see a section across western boundaries, in the North Atlantic for instance, or the South Atlantic as well.

Concerning the numerics of the runs, nothing is said about using off line tracer models with relatively high resolution, although it is explained that there is almost no difference at low resolution between on - line and off-line simulations. Moreover, when it is said that the subgrid-scale eddy parameterization is avoided for both runs, that is not entirely true: the horizontal viscosities are different (Laplacian vs. biharmonic), and it must have an impact, although difficult to quantify.

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What is the most surprising in these simulations is the fact that the model is not really a high resolution model, and that the modifications in the tracer uptake are so important. As a matter of fact, most of the basin scale models have shown that, in order to begin to represent correctly the eddies and their impact on transports and water mass transformations, a resolution of at least $1/10^\circ$ is needed. Moreover, the Rossby radius of the Southern Ocean is small. Therefore, the impact of this rather “poor” resolution is amazing. As there is no real discussion on the changes in the circulation, neither figures showing the modification of the dynamics and the stratification (besides the mixed layer depth in the Southern Ocean), it is difficult to realize really why this does happen. Once again, one wonders whether this still holds for other regions or depths (deep North Atlantic Ocean for instance).

Finally, the core of the paper, which is the discussion about the ventilation of AAIW, is not easy to understand, and the different paths of ventilation are not clear with only fig. 16.

In conclusion, this paper is interesting and presents potential important results. Nevertheless, either the authors should really focus on the ventilation of the thermocline of the Southern Hemisphere and the AAIW, without drawing too general conclusions in terms of other water masses or in terms of climate (rather minor revisions), or they should widen their paper to deeper layers (NADW, AABW, Deep Western BC), in order to be consistent with some of their general conclusions (rather major revisions).

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