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Ocean Science Discussions

Interactive comment on "Southern Ocean overturning across streamlines in an eddying simulation of the Antarctic Circumpolar Current" *by* A. M. Treguier et al.

Anonymous Referee #2

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The authors describes in a very detailed discussion the resulting circulation of an eddy resolving global model in the Southern Ocean. Emphasis is put on eddy processes, in particular those affecting the meridional overturning in either zonal or streamwise averaging, and the main aim is to sort out — if existing — the relation between the driving surface buoyancy flux and the residual streamfunction structure and amplitude. The paper is the most precise work on this subject that I have read so far, and before spreading out my critics I should like to mentioned that I enjoyed reading the paper. Nevertheless I cannot accept it for publication in the present form.

My first major concern is eq. (3) from Marshall (1997), relating the amplitude of the

residual circulation ψ_{res} and the surface buoyancy flux D, which the author set up as test of 2dim theoretical models. Most of their work is actually devoted to find this relation in the their numerical results of two different experiments, and indeed, it fails. However, eq. (3) is fairly uncomplete, even in the 2dim model Marshall and Radko (2003, MR) and clearly in Olbers and Visbeck (2005, OV) it becomes evident that the divergence of the meridional eddy transport of mean buoyancy must be included and is very large in he surface layers. In my view the authors put up a strawman which must be burned right at the beginning: even the simple 2d models of MR and OV show no strict relation between ψ_{res} and D. Shooting down 2dim models, as written in the last paragraph of the paper, is not acceptable with the present analysis. It might be true, though.

The second concern is the definition (and restriction to this form in all of the paper) of the eddy-driven streamfunction to the part presented in eq. (1). This form clearly suffers from its inapplicability in the mixed layer. There are definitions without this deficit. Moreover, diagnosing an eddy flux from a numerical output is effected by the problem of arbitrary rotational fluxes which might be added (see *e.g.* the recent discussion in Eden *et al.* (2007, JPO)). Hence, there is a multitude of residual streamfunctions all of which are acceptable in transporting mean buoyancy in balance with eddy-induced diapycnal diffusion. It is not clear how under such apparent arbitrariness that a relation such as (3) can be tested at all, even with incorporation of the neglected eddy eddy terms.

My last concern is that the authors seem to have a definition of potential density[1] which is not conserved if potential temperature and salinity are conserved (see the discussion in section 5). I agree on the non-conservation of density but the whole concept of potential density is in fact its conservation under adiabatic conditions, and I clearly must reject all these discussions.

[1]Potential density is defined as the density evaluated from the equation of state at a temperature taken as the value of potential temperature and the local salinity and at a pressure equal to the constant reference value.

OSD
4, S286–S288, 2007

Further comments:

eq (1): I do not think that the QG approximation is needed to define the eddy-driven part. What is needed in a meaningful definition is only to meet the requirement that the eddy divergence in the mean buoyancy balance splits into an advective and a diapycnal diffusive part. QG might be needed when relating the z-level definition to isopycnal definitions to some order of the eddy amplitude.

Fig. 4, 5 and page 665: the streamwise average still misses a large part of the ACC: the northern boundary. Why does this happen? Also the downwelling domain of the Ekman is absent. Why?

Minor points and corrections:

Almost all *et al.* citations are missing a blank.

Fig. 3 comes before Fig. 2 in the text.

eq(3): bar on σ_y is missing.

p 667, line 17: change Fig. 5 to Fig. 8.

p 670, line 5: change 'transient' to 'eddy-driven'.

p 674, line 7: w[h]ich

p 679, line 9: show[s]

Interactive comment on Ocean Sci. Discuss., 4, 653, 2007.