Ocean Sci. Discuss., 3, S583–S585, 2006
www.ocean-sci-discuss.net/3/S583/2006/

Ocean Science Discussions

OSD

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Interactive Comment

Interactive comment on "The subtropical Deacon cells" *by* J. A. Polton and D. P. Marshall

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Received and published: 16 October 2006

The phrase "Deacon cell" implicitly refers to an adiabatic overturning circulation whereas here we present diagnostics showing overturning circulations that involve both adiabatic and diabatic processes. To avoid this confusion we adopt a new title and make it consistent throughout the text: "Overturning cells in the Southern Ocean and subtropical gyres"

We include a note in the introduction about how our integral constraint is able to accommodate NADW to AABW transformation since it does not require the same quasi-zonal current restrictions that the classical residual mean theory requires.

We agree that the formulation for the PV flux integral constraint was a bit ad hoc so have reformulated the theoretical background section to make it clearer that our goal is to create a diagnostic that is a function of time-mean variables and that exploits the potential vorticity flux impermeability property. In order to further avoid confusion we clearly distinguish our fluxes from those conventionally labeled as PV fluxes, that are computed from instantaneous variables, both in the text and by a slight change in notation.

Following the suggestions we make distinct and clarify the difference between adiabatic and diabatic roles of eddy fluxes in the discussion about limiting regimes (2.4), we also emphasize the directional change in PV fluxes when switching hemispheres and check subsection 4.1 for sign errors. The figures and in particular the contours were clarified in figs 7-8 and 11-13. The contours are parallel to Bernoulli contours but are drawn with every second PV flux on the log colour interval, thus highlighting the path of the Bernoulli contours without overwhelming the colours in regions of intensified flow such as the Drake passage.

We agree that introduction to section 5 was confusing. The differing geometry of the streamlines (being circumpolarly connected or otherwise) does not lead to differing relative roles of diapycnal mixing, as the original manuscript seemed to read. Instead we make clearer that it is a mass conservation constraint on the ageostrophic flow that requires a mean diapycnal mass flux only in the subtropical gyre. In the Southern Ocean this diapycnal mass flux is not required since fluid can slide along isopycnals into and out of the circumpolar region. The diapycnal mass flux can be both adiabatic or diabatic depending to what extent the eddy-induced circulation can cancel the Eulerian-mean circulation. In practice both diabatic and adiabatic processes occur in the Southern Ocean and subtropical gyre, as hypothesized by the reviewer and as revealed in the diagnostics. Our confusing text also led the reviewer also asks about the strength of the spurious diapycnal mixing. Unfortunately this is beyond the scope of the diagnostics and is better addressed using convention spatial plots of diffusion. A strength of the framework is to reduce the complex 3D (in x,y and z) flow into 2D (along and across equi-Bernoulli averaged potentials) flow. This has the advantage of imposing a constraint on the gyre average flow at the expense of losing spatial information.

Finally we have included a brief section about the dynamical differences between sub-

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tropical and southern ocean dynamics to prevent a possible misinterpretation that they are wholly identical.

Interactive comment on Ocean Sci. Discuss., 3, 867, 2006.

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