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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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This note concerned with the description and use of the term "Deacon Cell" in the present paper.

As I understand it the term was first introduced by Kirk Bryan to describe the tight meridional circulation cell found near the latitudes of Drake Passage in the early ocean models and ocean components of climate models. These models were not eddy resolving but similar features were seen in the later high resolution ocean models. The cell was unusual in that it did not correspond to any know feature of the thermohaline circulation, but it implied that surface water was descending to depths of 1500 m in an otherwise well stratified region of ocean.

Analysis of FRAM (Doos et al. 1994, Stevens et al, 1997) and similar models gave more information about the feature. Key results were (a) that no density changes were

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involved, (b) the feature was generated by a large number of shallow meridional cells in which water of a particular density travelled northwards at one depth and southwards at a slightly greater depth and (c) it had the net effect of transferring the surface zonal wind stress to the underlying topography at the latitudes of Drake Passage.

In the low resolution models the cell results primarily from large topographically controlled meanders of the ACC, i.e. zonal fluctuations in the current field. Time dependent fluctuations can also be involved and this is particularly true at high resolution when mesoscale eddies are present. Some studies such as those of Halberg et al. (2001) indicate that their effect could be small. Others such as the present seem to assume that the whole process is dominated by the meso-scale eddies. Both views cannot be correct and for the moment it is probably best to assume that both standing and transient eddies are significant.

Given the above I have a number of problems with the Introduction:

Paragraph 1. This splits the Southern Ocean Circulation into a (real) zonal component and a (primarily imaginary) overturning component. It forgets to mention the important standing eddies/meanders or, more importantly, the fact that most of the apparent overturning is an artefact of the method of analysis, i.e. the zonal averaging used to generate a meridional stream function.

Paragraph 2. First many of the above results were obtained over ten years ago and so are not recent. Secondly, the Eulerian mean overturning at a given longitude does not show a Deacon Cell. It only becomes apparent when a zonal and time average is made. Thirdly, the Eulerian Deacon Cell is cancelled by both transient and standing eddies. Fourthly, if you define the Deacon Cell as has been done above the transient and standing eddies balance the mean Ekman Transport exactly, not just to first order. If you do not then it is not a first order cancellation but depends on the size of the mean Ekman Transport at the latitudes of Drake Passage and the size of the proper thermohaline circulation which passes through the Ekman layer at the same latitudes.

If they were both equal, then there would be no Deacon Cell. (See also Webb and de Cuevas, 2006).

Paragraphs 3 and 5. The fact that the Southern Ocean discussion is dubious does not invalidate the rest of the paper but the introduction and the links between the Southern ocean and the sub-tropical Sverdrup gyre does need to be more rigorous.

In contrast to the properties of the Deacon Cell, the circulation within the sub-tropical Sverdrup gyres does involve density changes and has no connection with the downward transfer of zonal momentum. As far as I know, there is no equivalent with the standing meanders of the ACC, but there is an important zonal difference between the interior flow and the western boundary current.

Where there may be a useful analogy is in the competing and complementary contributions of the isopycnal and diapycnal circulations. In the Southern ocean, the isopycnal (Deacon) cell becomes important when the wind driven Ekman layer is out of balance with the large scale thermohaline circulation. Maybe there is a similar analogy to be found in the sub-tropical gyres.

Paragraph 4. This seems to ignore the thermohaline component driving the ACC. If there was no wind it is likely that there would still be a large ACC transport. A good review of the competing mechanisms is given by Rintoul et al. (2001).

And finally there is the question of terminology. The diabatic circulation of the ocean is usually described as the thermohaline circulation. This is a bit of a mouthful but I still think it is worth keeping the name Deacon Cell to describe the adiabatic cell of the Southern Ocean described above and not as a replacement for thermohaline or meridional overturning cell. In other oceans it may be appropriate to find other names - such as been done with the 'equatorial cells' used to describe the meridional circulation near the equator. For the subtropical gyres, one could be descriptive, i.e. diabatic sub-tropical cell, or use someone's name, as in the diabatic Sverdrup Cell. Alternative one might use another theoretician's name for the adiabatic cells and an experimentalist for the diabatic cells. Stommel, Munk, Worthington, etc. are all possibilities.

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