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Interactive comment on "Flow dynamics around downwelling submarine canyons" *by* J. M. Spurgin and S. E. Allen

J. M. Spurgin and S. E. Allen

jspurgin@eos.ubc.ca

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Dear Jochen,

Thank you for reviewing our manuscript. I will start by addressing a number of particularly interesting issues you raise and then finish by addressing the rest of your comments.

Horizontal Circulation

You note that we identify three types of horizontal circulation: anti-cyclonic, cyclonic and weak (meaning something between the two). Your intuition (and mine) is that the separation between these should be due to the flow strength or Rossby Number. Ah, but no. It is clearly the stratification or Burger Number that choses the type of horizontal

circulation. Weakly stratified flows move around the canyon with little vertical shear and the topography contrains them to follow the topography (cyclonic). Strongly stratified flows have significant shear and while the deeper flow may follow the topography, the shelf-break flow forms an anti-cyclonic eddy.

Oscillatory Flow and Net Upwelling

I have followed this discussion in the literature with interest. There is no real disagreement. Boyer et al, (2004) and Haidvogel (2005) show weak net upwelling (enough to maintain a deep pool on the shelf) of water from $< 50 - 100$ m below the shelf-break. Your study of 2009, showed that there was negligible upwelling of water from > 100 m below shelf-break depth. Obviously "weak" is not a descriptive enough word and we will rework this for the next version of the manuscript to be more precise.

Importance of Downwelling and is the Flux Transitory

Reviewer two suggested enhancing our implications section. Please see Jessica's response to his/her comments.

Details

Page 3: Kampf (2006): Yes we should include this study. With no stratification above the shelf-break depth, it is a clear case of low Burger number flow.

Page 7: Density and nitrate initial conditions will be given (as plots) in the next version of the manuscript.

Page 8: Like the Rossby Number and the Burger Number, the Chi used in this study is calculated at shelf-break depth. Chi is usually negative except near the surface of the ocean, as stratification usually decreases with depth.

Page 17: Yes, the velocity shown is the total vertical velocity.

Page 18: MITgcm is a z-level model and there are thus no sigma coordinate type errors.

Page 20: Not sure what you are getting at here. Upwelling is usually associated with divergence of horizontal flow. The term upwelling is used precisely and more often, less precisely by oceanographers. Here we are simply clearly stating our use of the term.

Page 28/29: As stated in the caption (first phrase), the density anomaly shown in Figure 8 is from shelf-break depth. The cross-section in Figure 9 shows the same phenomenon. This will be made clearer in the new manuscript. The description of pattern 1 versus pattern 2 will be expanded in the caption to Figure 9. The anomalies shown are 4 day averages, as stated in the text. This will also be added to the caption.

The reasons for the positive density/nitrate anomalies are given in the discussion. Starting with paragraph 3 under Section 4.3.2, we discuss that higher densities are required at the outside of the turning flow, both as it turns into the canyon and from the canyon back along the shelf-break. If these required higher densities occur where there is strong downwelling (incoming jet is on the shelf) then no net upwelling is seen, simply a reduction in the downwelling. However is the turning occurs where there is little downwelling, net upwelling is seen (offshore or shelf-break jet).

Table 7: A table of density anomalies will be added to the next version of the manuscript. Please see Jessica's response to reviewer 2's comments.

Sincerely,
Susan Allen

Interactive comment on Ocean Sci. Discuss., 11, 1301, 2014.