Response to reviewers' comments on the manuscript "The influence of a submarine canyon on the wind-driven downwelling circulation over the continental shelf: egusphere-2024-2386"

Pedro A. Figueroa, Gonzalo S. Saldías and Susan E. Allen

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1 Response to Reviewer #2

1.1 General Comments

1. The results section is rather long and the novel results could be emphasized

   Thank you for your recommendation. The results section was shortened a little and some sentences were reformulated for clarity.

1.2 Specific Comments

1. l.74: Do you use sigma coordinates or generalized sigma-coordinates? The latests would be best suited to represent air-sea interactions, hence the wind forcing, and would allow for a better representation of the physical processes at the bottom of the canyon.

   Our simulations used generalized sigma coordinates following Shchepetkin & McWilliams(2009), which are the standard in ROMS models. Specifically, we used $\theta_s = 3$ and $\theta_b = 1$, Vstretching = 4, Vtransform = 2 and hcline = 50 m as input for the distribution of the vertical coordinates to ensure a good resolution in the upper and lower boundary layers. These parameters are now included in the revised version of of manuscript.

2. l.85: The bathymetries (and the following model description) are largely inspired by the work done by Saldias and Allen. Please add "Three types of bathymetric configurations, already described by Saldias and Allen (2020) were used".

   Thank you. We added this information to the text.

3. l.122: please specify why you need to compute the topographic Burger number S.

   The topographic Burger Number is computed to compare with previous and future canyon experiments. Even if it is not analyzed in detail in the text, is a common practice in canyon studies and help to compare with other studies including downwelling flows (e.g. Spurgin and Allen 2014).

4. l.149: "downward velocities occur upstream of the canyon". Please add on Figure 2d the upstream and downstream areas you are referring to. At the upstream corner, the velocity is upward. If your definition of upstream refers to y=-6 km to y=0 km as defined latter in the paper at l.253, one would find upward velocities on Figure 2d at the upstream canyon wall (red color) depending on the depth. This should be clarified as this statement is repeated several times in the manuscript.

   A better description of the upstream areas has been done throughout the entire manuscript. Considering that the upstream wall of the canyon (which is where we are referring in l.149) refers to the coastal area between y = -6 km to y = 0, but the upstream area refers to any place south of the canyon axis, where the flow comes from (For example on the description of Figure 4, Y = -15 km is referred to as upstream). We have added the following statement to clarify this point:

   "The presence of a submarine canyon induces notable changes in its vicinity (Fig. 2d,e,f), where upstream and downstream areas are defined as south and north of the canyon axis (Y = 0 km), respectively."

   In addition, and for clarity, we added two boxes (in Figure 2d) denoting the Upstream and Downstream areas used in the calculations for Figure 9, using matching colors for clarity.

5. l.165: Locating the downwelling front on the plot would help.

   Thank you for the comment. We have clarified the position of the front by indicating the labels of the specific isopycnals reaching the bottom. Labels of the isopycnals are included in the new version of those figures. This is now clarified in the text as well.

6. l.177: "Along the canyon axis (y = 0 km), offshore and onshore velocities occur within the canyon". This seems obvious, do you mean velocity changes?

   Thank you for that comment. The sentence was not clear and the goal was to indicate that, compared to the no-canyon cases, velocities tend to erase the Ekman layer inside the canyon, which enhance the instabilities seen in the no-canyon cases. This has been rewritten as follow:

   "Along the canyon axis (y = 0 km), offshore and onshore velocities within the canyon tend to overcome the typical flow of Ekman Layers (evident in the no-canyon cases in the deep shelf experiments). Moreover, instabilities extend into the canyon in the intermediate and shallow experiments, inducing strong cross-shore exchanges."

7. l.187: "values tend to diminish" and at l.189 "the numbers". Which values? Which numbers? These sentences may be reformulated.

   This sentence was slightly changed considering that, as you mentioned, it was no clear what values we referred to. Now it clearly states the stratification and Burger number values:

   "However, the stratification tends to diminish as the water column gets shallow over the continental shelf. This is evidenced from the Burger Numbers with $Bu = 0$ and $S = 0$ in the shallow shelf experiments..."

8. l.269 and 272 : Please add "not shown" as the figure of dispersion of particles in the case NOCANYON is not in the manuscript. I suggest this part to be shortened.

   "*Not shown*" has been added to the corresponding lines describing the no-canyon cases. The description was slightly shortened considering your general comment. Thank you.

9. l.290: "the vertical velocities induced by the submarine canyon not significantly affecting the vertical particle movements". Can you explain this sentence please? I guess that particles follow the water masses as they are passive tracers. At line l. 292 you mention an aggregation of particles. It should be mentioned if the particles behavior is taken into account with processes such as flocculation, else you should use another word like "accumulate".

   Here we refer to the vertical velocities shown in Figure 2, and how the velocities, which are a direct effect of the canyon on the circulation, do not affect significantly to the vertical movement of particles in the experiments. The word aggregation was changed to accumulate, since these particles are just neutrally buoyant without any extra behavior, as you mentioned. Very good point to clarify. Thank you.

10. l.296: What do you mean by "outside this range"?

    "Outside this range" was referring to particles that were released above or below of the depth ranges indicated in Figure 9. This has been rewritten for clarity:

    "Outside of the depth ranges showed in Figure 9 (i.e. up to the surface and down to 400 m depth)"

11. l.318-322: The improvement in the wind forcing in this experiment compared with previous studies on downwelling canyons is emphasized in different parts of the manuscript, but it is not straightforward. Finally, what are the additional forcing terms in the equation? It is also not very clear to the reader what the novel results are in the study of downwelling canyons. What are the differences between the results of the present study compared to the previous ones?

    The simulations of this work does not add extra forcing terms to the primitive equations solved by ROMS. Moreover, the simulations are driven solely putting a wind stress on the surface of the model, without body forces, as it has been typically done. The emphasis is to reproduce wind-driven downwelling conditions (including a downwelling front and jet, etc) which are typical for mid-latitude eastern boundary margins during winter. This is why we also include no-canyon experiments which do resemble the results of wind-driven downwelling circulations from previous studies (e.g. Austin and Lentz, 2002).

12. The conclusions part draws a clear picture of the downwelling canyon functioning, however it mixes original results emerging from this study with previous results that can be found in the literature. The novel results should be emphasized.

    The conclusions' section was rewritten and separated in two parts. The first one addresses the results that we reproduce and are consistent with previous studies. The second part highlights the novel results related to the modification of instabilities by the canyon, the vertical extension of the cross-shore velocities induced by the canyon and how they modify surface and bottom Ekman layers. Emphasis is given in the particle trapping as a result of the lagrangian trajectories of the flow. Thank you.

13. Figure 2, Figure 6 and Figure 7 (e,f): Please add the number of days after the start of the simulation when the plots were calculated.

    Indication of the days were added to the description of Figures 2 and 6. In the case of Figure 7(e,f), the patterns shown correspond to the integrated transport since day 10 up to day 25, which is now described as well.

14. Figure 3: “Cross-shore sections of velocity field (color) and isopycnes (gray lines) at”. You should add the values of isopycnes on the plots or in the text.

    Isopycnal values were added to Figures 3-4. Thank you.

15. Figure 4: “Cross-shore sections of velocity field (color) and isopycnes (gray lines) at 15 km (a-f) downstream, 0 km (g-l) in the canyon and -15 km (m-r) upstream for the no-canyon simulations at day 25.”. You should add the values of isopycnes on the plots or in the text. For the plots at 0 km, the added canyon bathymetry should be represented using dotted lines and explained in the text.

    Isopycnal values were added also to Figure 4 and the bathymetry of the canyon is now showed on black dashed lines. This is described in the legend of the figure too.

16. Figure 5: Replace “density (gray lines)” with “isopycnes (gray lines)”, and add the associated values. The location of the alongshore sections could be added on Figure 2 to help the reading of the paper. Note that in some of the plots in the manuscript, grey lines appear black rather than grey after printing, which is the case for this figure.

17. Density was changed for isopycnal and values were added to the figure. In Figure 2, green lines were added to show the location of the alongshore sections of Figure 5 and Figure 6.

18. Figure 8: Upstream and downstream areas should be defined, either on Figure 2 as previously suggested, or here.

19. Areas were defined in Figure 2 following previous comments.

20. Figure 9: I guess that the red dotted lines are the isobaths, you should add it to the legend.

    A description has been added to the legend of the figure ”Isobaths of the submarine canyon (from 100 to 400 m) are shown in dashed red lines”. Thank you for this comment.

21. Typos:

    - l.25: Something is missing in the sentence “for downwelling favorable flow (right/left-boundedin the Northern/South- ern Hemisphere) promote an anti-symmetrical circulation”.

      It has been written again as ”In contrast, downwelling favorable flow (right/left-bounded in the Northern/Southern Hemisphere) promotes an anti-symmetrical circulation”.

    - l.37: “focused on upwelling”

      It has been corrected.

    - l.52: ”is to enhance the downwelling” and “These biological characteristics”

      It has been corrected.

    - Figure 2: “with (lower panels) and without”

      It was added to the figure description.

    - l.137: ”extend”

      It has been done.

    - l.147: ”at the location”

      It is corrected now.

- l. 187: "In terms of stratification"
  This sentence was rewritten.
- l.195:" Depending on the location"
  Yes. It is corrected now.
- l.215: "at x=-13"
  changed "in" for "at"
- l.219: "due to"?
  Yes. Corrected now.
- Figure 7: A dot is missing at the end of the legend.
  Thank you, it was included in this revised version.
- Figure 8: "(e-f) at z = -20 m"
  It has been corrected.
- l.271: There is a problem with this sentence, do you mean "Particles released in the presence of a canyon"?
  It has been rewritten as "Particles in simulations with a canyon".
- l.281: "Figure 1"
  Thank you for this one. It was added "Figure 1" for consistency
- l.296: "The percentage of trapped particles appeared to increase"
  It has been corrected.
- l.375: "be trapped by the anticyclonic circulation"
  It has been corrected.
- l.400: "increased cross-shore transport" or "an increase in the cross-shore transport".
  Please check the sentence was rewritten as "Moreover, while the net effect of the canyon is to enhance downwelling, local onshore velocities in the vicinity of the canyon lead to an anticyclonic circulation inside the canyon that can trap particles for the entire simulation period (15 days)".
- l.408: "to be studied"
  Not really sure to which line you referred to (the last line was the 407). Nonetheless, we have re-written the last section of the conclusions to make sure it is clear for the reader.