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Ocean Science Discussions

Interactive comment on "Investigating the relationship between volume transport and sea surface height in a numerical ocean model" *by* Estee Vermeulen et al.

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The manuscript would benefit with a reorder and editing. For example, in the Summary and Conclusion section the authors state (line 534-537) "The HYCOM model provided the means to investigate the validity of the assumptions used to create the proxies, such as the constant relationship between SSH slope and transport per unit distance at each mooring location and the temporal scale of observations needed to build a strong linear relationship between transport and SSH slope." They then follow with a limited discussion explaining some reasons why the proxy does not capture the model transport, referring to figures to justify this reasoning – this is not a summary

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or conclusion. It is suggested that much of the information (lines 534-628) should be incorporated into the relevant parts of Section 3. A reordering of Lines 629-696 would form what may be considered a “Summary and Conclusion” sections.

Authors- Thank you for these suggested changes which were in line with the other reviewer. We have now significantly condensed and clarified the text and flow of the paper.

Section 2.1 should only provide details of the model used in this study. The reader is not interested in the details of the larger regional model that provided the boundary conditions of the higher resolution (1/10o) nested model.

Authors: Noted and changed Changes in manuscript: see section 2.1

The presentation of section 2 was convoluted and thus difficult for the reader to easily understand the approach taken. It is suggested that the authors revise this section to more clearly and concisely explaining the methods and assumptions.

Authors: Noted and revised Changes in manuscript: Section 2

Lines 275-290 “The length scales of the slopes ranged from 24 km at mooring A to 12 km at mooring G and 48 km for the offshore CPIES-pairs, indicating an increase in the spatial scale of offshore flow, possibly due to increased offshore variability. Results from the in situ proxy experiment by Beal and Elipot [2016] also showed an increasing length scale with increasing distance offshore, however the results varied considerably in magnitude: 27 km at mooring B to 102 km at mooring G.” Can you explain the reason for the difference in length scales between the model and observations (in situ and satellite)? Does this indicate the model doesn’t capture the observed variability? What implications does this have for this study?

Authors: The reason why the length scales differ between the model and the observations is because the model does not capture completely and accurately the observed variability. This limitation and its implication is now discussed in this study and clarified

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in the text. Changes in manuscript: See l 440

It is suggested that section 2.4.1 be revised to remove any unnecessary information concerning the larger regional model.

Authors: Noted and changed Changes in manuscript: l193

Line 407-408. “The proxies only capture a portion of the transport estimate from the HYCOM model, suggesting it also only captures a portion of the model variability.” Is this the only problem with the proxy estimate? A more detailed analysis is really required to understand the impact of the assumptions used in developing the proxy.

Authors: The frequently impinging eddies make it difficult for the proxy to accurately estimate the transport of both Tbox and Tjet because the eddies resulted in the correlation of the regression models decreasing offshore. Therefore, the proxy transport estimates (for both Tbox and Tjet) inshore were more accurate than the ones offshore. We have clarified this in the text Changes in manuscript: l 439-470.

Line 418-420 “In summary, the results indicate that the proxy is generally better suited in HYCOM to estimate the box transport rather than the jet transport. Further analysis in this study therefore only focuses on the box transport.” It is not appropriate to simply ignore results that don’t agree. You need to fully explore the reasons why the different proxies fail.

Authors: The difference in the performance of the jet transport algorithm in the models and in the observations suggests that the models are unable to resolve all the dynamics associated with meander events, for which the jet algorithm was specifically developed. The jet transport proxy by Beal and Elipot [2016] was developed to estimate the transport of the Agulhas Current during mesoscale meander events, which generally causes the current to manifest as a full-depth, surface intensified, cyclonic circulation out to 150 km from the coast with anticyclonic circulation farther offshore. The Agulhas meanders in the HYCOM simulation occur in association with large anticyclonic eddies

predominantly located at the offshore edge of the current, with a narrow, southwest stream close to the coast. In some instances anticyclonic eddies span the length of the entire array. Therefore, considering that the model is unable to resolve the dynamics associated with meander events, for which the jet transport algorithm was specifically developed, further analysis only focuses on the box transport proxy In addition, the poorer performance of the Tjet proxy in HYCOM and possibly in the in situ study, may also be because it only represents the southwestward component of the flow, whereas the input sea surface slope reflects the net flow along the array. Therefore, based on these findings further analysis focussed on the Tbox proxy. We have explored this in the text. Changes in manuscript: see l33, l335-344 & l438-461

Lines 485-499 Removing outlier to increase the performance of the proxy is not appropriate. The authors should clearly identify the dynamical reasons for the reduced skill of the proxy. It is only through this in-depth analysis that advantages and disadvantages of the proxy can be fully explored.

Authors- The reason we decided to remove the outliers was because in the case of the offshore linear models, the outliers were often the transport events that violated the linear relationship between SSH slope and transport. Investigation into the current structure of the outlying transport events further showed the baroclinic nature of the eddies that broke down the linear relationship between SSH slope and transport, specifically for the offshore regression models. Thus, removing the transport events that violated the relationship proved to increase the performance of the proxy. Motivating that the offshore variability resulted in the poorer performance of the models offshore. Changes in manuscript: see l390-l395 & l471-474 & Figure 4

The manuscript is lengthy and the prose overly convoluted and repetitive, when reviewing the manuscript the authors should, where possible, simplify the writing and remove repetition. Below are a few examples:

Authors: Thank you for highlighting this, we have thoroughly revised the manuscript to

improve readability.

Line 85-89 “The Agulhas transport proxy of Beal and Elipot [2016] was derived from the physical principle of geostrophy, where along-track sea surface height slope measured by satellite altimeters can ultimately be related to a measure of volume transport across a portion of the current, provided that the surface current represents the flow at depth [Beal and Elipot, 2016]. “ can be deleted as lines 89-93 fully explain the major findings of the Beal and Elipot, 2016 study.

Authors: Noted and corrected

Line 151 change “: : : in doing so: : :” to “.. thus : : :”

Authors: Corrected

Line159-161 remove “ The horizontal resolution of the parent model ranged from 14 km in the northern Indian Ocean to 45 km in the Southern Ocean, with a resolution ranging from 30 to 40 km in the region of the Agulhas Current.” This information is not needed; the reader can refer to George et al., 2010 if they require more information on the model from which the boundary conditions were taken.

Authors: Noted and corrected

Line 154-155 Change “The HYCOM output in this study was made available from a nested 1/10_ model of the greater Agulhas Current System (AGULHAS) [Backeberg et al., 2008; 2009; 2014].” To “This study used output from a nested 1/10_ model of the greater Agulhas Current System (AGULHAS) [Backeberg et al., 2008; 2009; 2014].”

Authors: Noted and corrected

These are a few examples; there are many more instances of repetition and where more concise writing would improve the text. Minor comments:

Line 45 change “As the current continues southwestward the current becomes..” to “As the current continues southwestward it becomes.. “

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Authors: Noted and corrected

Line 60-62 poorly constructed sentence “The unique circulation of the Agulhas Current System, in the context of regional and global climates, makes it an important field of research.”

Authors: The unique circulation of the ACS, in the context of regional and global climate variability, makes it an important field of research Changes to manuscript- l63

Line 67: “However, the close proximity of the current to the coast makes it difficult to monitor using satellite altimetry [Rouault et al., 2010].” Is this statement still true given the development of the AVISO X-track product (https://www.aviso.altimetry.fr/en/data/products/sea-surface-heightproducts/regional/x-track-sla/coastal-along-track-sea-level-anomalies.html)?

Authors: Noted and addressed Changes in manuscript: in l70-73. The close proximity of the Agulhas Current to the coast has made it difficult to monitor using satellite altimetry, however, newer altimetry products dedicated to coastal areas are promising but are yet to be validated within the Agulhas Current region (Birol et al., 2017).

Line 74-84. It can be shown that the total cost of in situ observing, satellite observations and models are all on similar cost. Singling out in situ observations as the only costly tool is not appropriate or accurate.

Authors: Noted, cost aspect removed. Changes in manuscript: l80

Change “ In situ observations may accurately measure the dynamics of the Agulhas Current throughout the water column but are expensive and spatially coarse.” To “In situ mooring observations provide high temporal observations of the Agulhas Current throughout the water column but spatially coarse.”

Authors: Noted and corrected

Line 106 Change [Beal and Elipot, 2016] to Beal and Elipot [2016] Authors: Noted and

corrected

Line 120 Change Zhu et al. [2004] to [Zhu et al., 2004] Authors: Noted and corrected

Line 158-159 Change ".. buffer zone." To ".. sponge layer." Authors: Noted and corrected

Line 166-167 Change "Both models have 30 hybrid layers and targeted densities ranging from 23.6 to 27.6 kg/m3. To "AGULHAS has 30 hybrid layers and targeted densities ranging from 23.6 to 27.6 kg/m3." Authors: Noted and corrected

Line 185 Add " : : : 2010-2013 (Figure 1, Beal et al., 2015) Authors: Noted and corrected

Line 193-195 Change "During the first phase of the ACT experiment, the mooring array was maintained in the Agulhas Current for a period of 34 months, perpendicular to the continental slope at 34_S, south of East London, South Africa (Figure 1)." To " The ACT mooring array was located perpendicular to the continental slope at 34_S, south of East London, South Africa (Figure 1)." Authors: Noted and corrected

Line 200 Change " From the data collected in Beal et al. [2015], two volume transports were estimated:: : : " to "From the data collected, Beal et al. [2015], provided two volume transports estimates: .." Authors: Noted and corrected

Line 202 Change ": : : is a net transport" to ": : : is the net transport .." Authors: noted and corrected

Line 218 Remove "Based on physical principles sea surface slope is proportional to surface geostrophic velocity." Authors: Removed

Line 237 Define Tx and Txsw

Authors: The transport variable in the regression models was defined as transport per unit distance, i.e. the vertically integrated velocity with units in ms2.s-1 where Tx represents the net component of the current flow and Txsw the southwestward

component of the flow. Changes in manuscript: See l187-191

Line 269 “The coordinates of the along-track altimeter data were obtained from the filtered 12km Jason-2 Aviso satellite product, and not the unfiltered 6 km product which was used for the original ACT proxy [Beal and Elipot, 2016], since the 12 km product matched the _10 km model resolution more closely.” Is this difference significant given that the model is interpolated onto the altimetry ground track?

Authors: No, the difference is not significant. However, at the time, we decided to use the 12km resolution as it more closely matches the 10km resolution of HYCOM.

Figure 2 Caption. Change “Figure 2: HYCOM transport per unit distance proxy (m2 sôĂĂĂ1) for Tx (blue) and Txsw (red) transport at 1 km intervals at the first model time step (solid lines, week of 3rd January 1980) and for the mean reference period (dashed lines). The faint grey lines represent the positions of moorings and offshore CPIES pairs.” To Figure 2: HYCOM transport per unit distance proxy (m2 sôĂĂĂ1) for Tx (blue) and Txsw (red) transport at 1 km intervals at the first model time step (solid lines) and for the ACT reference period (2010-2013, dashed lines). The grey dashed-lines represent the positions of moorings and offshore CPIES pairs.” Authors: Noted and corrected

Line 303-306 remove “Tx and Txsw are simply shown at the first model time step (week of the 3rd of January 1980) in HYCOM and for the mean of the reference period (2010-2013) to show the difference between the net and southwest transport components used to calculate Tbox and Tjet (Figure 2).” Authors: Removed

Line 411 Remove “Figure 4 shows the correlation between proxy and model transports for each year.” Authors: Removed

Line 413 Add “: : :.insignificant minimum correlation of 0.00 (2003) (Figure 4).” Authors: Noted

Line 413 Change “: : : correlation of 0.82 (2014) and an insignificant minimum corre-

lation of 0.00 (2003).” To “: : : correlation of 0.82 (2014) and a minimum correlation of 0.00 (2003).” Authors: Noted

Lines 428-431 Remove. “Figure 5 shows the surface variability by displaying the eddy kinetic energy and the mean surface geostrophic flow as represented by the overlaying SSH contours over the 3-year reference period, and over the highest (1988) and lowest (1994) correlated years of the box transport proxy.”

Any important information in this sentence should be included in the figure caption. Authors: Noted and Removed

Line 431-432. Add “During the reference period the current appears to be stable with low levels of EKE inshore whereas offshore the flow is more variable with higher levels of EKE (Figure 5).” Authors: Noted

Line 445 Remove “Figure 6 shows the mean cross-track velocity profiles during the reference period (2010- 2013), the highest correlated year (1988) and the lowest correlated year (1994) for each mooring and the CPIES-pairs.” Any important information in this sentence should be included in the figure caption Authors: Noted and Removed

Please also note the supplement to this comment:
https://www.ocean-sci-discuss.net/os-2018-117/os-2018-117-AC3-supplement.pdf

Interactive comment on Ocean Sci. Discuss., https://doi.org/10.5194/os-2018-117, 2018.

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