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## ***Interactive comment on “An observed 20 yr time-series of Agulhas leakage” by D. Le Bars et al.***

**D. Le Bars et al.**

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Answers to referee #2

"General Comments: In their paper D. Le Bars et al. propose a new method for the estimation of the Agulhas Current leakage based upon calculation of the integrated transport through both the Agulhas Current and Agulhas Return Current. This method is validated using numerical model output and then applied to 20yr of altimetry data to derive a time-series of Agulhas leakage anomalies. The method and results are presented in a clear and coherent manner. The scientific contribution of this work is of benefit to the ocean community at large. This is a solid piece of work which I recommend for publication."

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We thank referee #2 for his/her positive comments and useful suggestions on our manuscript. We address all the specific comments below.

"Specific Comments: More rational could be provided in the introduction as to why the integrated transport through the Agulhas Current and Agulhas Return Current should be a good indicator for Agulhas Current leakage. How are the dynamics of the Retroflexion, and Agulhas Ring shedding events, related to the volume transport in the Agulhas Current and Agulhas Return Currents at the selected altimeters' track? Previous studies have showed a link between Agulhas Current transport and Agulhas Ring shedding events: Pichevin et al. (1999); Goni et al., (1997); Garzoli and Goni, (2000). Also the works of Garzoli et al. (2004) in the North Brazil Current has found a "direct relation between the latitude of penetration, the number of rings shed, and the intensity of the NBC." "

We now include this rational in the last paragraph of the introduction: "This simplified method is used because if we neglect the exchanges between the retroflexion area and the South Atlantic Current extension then, in a steady state, the transport difference between the AC and the ARC should be exactly the Agulhas leakage. This includes anticyclonic eddies and all other forms of leakage. In the real ocean some lag will appear between AC, ARC and leakage in the south Atlantic. Therefore the signal that is observed along the satellite tracks should only be used for the evaluation of interannual variability of the leakage."

"P175, L15: A reference to Rio et al., (2011) seems appropriate here"

We added a reference to Rio et al. 2011 there.

"P177, L12: The "dynamic signal has good quality". That is debatable. Although the altimetric measurements in the Agulhas and Agulhas Return Currents at the selected tracks do not suffer from limitation associated with coastal regions (within 50km from shore), the Mean Dynamic Topography is still poorly resolved in these altimetry products. The initially low spatial resolution of the first-guess MDT (about 300 km) is im-

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proved through the assimilation of in situ observations and climatological data."

We agree with this and already discuss the problems linked with the MDT in sections 5 and 6 of the manuscript. To make clear that what is meant in this sentence is that the signal is better than close to the coast we rewrite it as: "the dynamic topography signal has a relatively good quality"

"P179, L20: The comparisons between the volume transport computed from the model across the 3 tracks prompts for more discussion. The authors state that the results are similar along the 3 tracks. Even though there are similar in the mean leakage and trend, there are marked differences between the tracks even in the yearly averages. Track 122 in particular seems to show large standard deviations. What is happening in the years 1960 and 1970-1972? Are these marked differences in the value of the transport between tracks 122, 198 and 020 associated with longitudinal variations in the position of the Retroflection ? Later is suggested that the lack of correlation between the tracks could be due to a significant downstream variations in the vertical structure of the flow ? Could the low correlations between the 3 tracks be a limitation of the algorithm to appropriately select the AR and ARC regions in that southern track ? Would that explain why the analysis at track 020 (the northernmost track) shows a better agreement with the Lagrangian analysis ? Please expand."

We decided to expand the analysis of these time series with a comparison of the transport in the top 1500m and provided more discussion: "The cross-correlation is small mostly because of the deep ocean. If the top 1500m is considered then the cross-correlation between the transport along these tracks is 0.72 between tracks 20 and 198, and 0.81 between tracks 198 and 122. An explanation for the importance of the deep ocean in decorrelating the time series is that the signal could propagate slower at depth. It would then be necessary to take a lag between the different tracks to improve these correlations. This lag would have to depend on the depth and would probably have to be different for the AC and for the ARC, but this work is outside the scope of this paper."

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"P183, L4: "for the first time an observed time-series of Agulhas leakage has been generated employing satellite ADT". What about the van Sebille et al., (2009a) (Figure 11) which you cite in your references? He also used the ADT from altiemtry."

We removed "for the first time"

"Technical comments: P182, L24: Re-phrase "it was demonstrated to be possible to" to "we demonstrated it was possible to"."

We included this change in the manuscript.

"P182, L25 to 27: Re-phrase. Sentence does not really make sense."

We rewrote this sentence to: "This result allows to make an accurate off-line measure of the leakage with monthly output of the velocity fields instead of the higher frequency needed to advect numerical drifters."

"P183, L5: Replace "employing" by "using""

We implemented this change

"P183, L14: Maybe you could break up that sentence. Replace "make it possible to measure the mean leakage" to "make it possible to estimate the mean leakage with more accuracy"."

We rewrote this sentence as: "The GOCE satellite and follow-up missions will also bring an improvement of the geoid height and Mean Dynamic Topography. It is likely that this will make it possible to measure the mean leakage with more accuracy than the present result using the method described in this paper."

"P183, L29: replace "strongly demanded" by "necessary""

This change was implemented.

"Figure 8: Replace "woth" by "with""

We corrected this typo.

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