Ocean Sci. Discuss., 6, C425–C431, 2009
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Ocean Science Discussions

Interactive comment on "Relating Agulhas leakage to the Agulhas Current retroflection location" *by* E. van Sebille et al.

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Received and published: 2 September 2009

First of all, we would like to thank the anonymous reviewer and Dr. Donners in his role as reviewer for their valuable and constructive comments on the manuscript. In this interactive comment, we will reply to the points that were raised by them.

Reviewer 1:

1) The reviewer states that the results in our study confirm our hypothesis only weakly, but is of the opinion that this study might serve as an example. We want to emphasize that the 90% confidence band is 15 Sv wide, but that the uncertainty is much lower. The one standard deviation error level (so that 76% of the data fall within the estimate), for instance, is only 5.4 Sv.

2) The reviewer asks why the moving averaging window for the proxy is taken to be 95 days. This is because for shorter averaging lengths the correlation between Agulhas leakage and westward extent drops quickly. It is clear from the definition of the two quantities that an instantaneous relation between the two will not exist. Given the chaotic nature of the fluid flow in the retroflection area and the continuous motion of the front, one would expect a time scale related to the shedding frequency of the rings. (what we find for an average of four rings per year) or longer if longer time scales exist in the system. For averaging lengths longer than 95 days the crosscorrelation significance level, which should be lower than the correlation itself, increases. This is because a longer averaging window implies that there will be less points which can be used to compute the correlation on the 37-year model time series. We have clarified this point in the text of our revised version of the manuscript.

3) The reviewer asks whether the difference in confidence levels of ring size versus front retreat between the model and AVISO data affect the confidence level of the estimate. In fact, the uncertainty band has almost the same width in the model ($1.51 \cdot 10^5$ km^2) and the AVISO data ($1.47 \cdot 10^5$ km^2). The band looks wider in the original Fig. 8 (now Fig. 10) than in Fig. 4 because the axes have a different scale. We have addressed this point in the caption of the original Fig. 8 (now Fig. 10) of our revised manuscript. Furthermore, it should be noticed that the relation between ring area and front retreat is only used as a model test. The actual relation between front location and transport cannot be determined from the observations and is not related to error bands in ring area-front retreat plots.

Reviewer 2 (Dr. Donners):

General Comments

1) We agree with Dr. Donners that the correlation alone is no proof of the hypothesis that a more westward extent of the Agulhas Current front is a proxy for more Agulhas leakage. Dr. Donners suggests to separate Agulhas leakage inside rings from Agulhas

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leakage outside rings. The problem with that approach, however, is that rings tend to loose a significant amount of mass very quickly after shedding, so it is a bit arbitrary where to make the distinction in or out of a ring. On top of that, one could argue about what to use as ring boundary. Finally, rings are sometimes split, recaptured, or merged. We have looked into these aspects of the role of rings in a different article on the model data, which has just been resubmitted after revisions to J. Geophys. Res. (Van Sebille et al., On the fast decay of Agulhas rings). In that paper, we show that while more than 80% of Agulhas leakage separates from the Agulhas Current in eddies (rings and cyclones), at the GoodHope line only half of that is still within rings. Most leakage forms large non-rotating patches. Differentiating between floats into the Atlantic and into the Indian Ocean is much easier. We have also done that in the J. Geophys. Res. manuscript, where we show that the ratio between floats ending up in the Atlantic Ocean and floats ending up in the Indian Ocean is roughly $1:3$. That means that a float has an approximately 25% chance of ending in the Atlantic Ocean, which is the same number as found by Richardson (2007, Deep Sea Res.) using real drifters and floats. In this revised version of the manuscript, we have followed Dr. Donners' suggestion to show how the Lagrangian floats overlap with the sea surface height signal. The resulting Fig. 8 (Fig. 2 in this rebuttal) is a snapshot of float density in the Agulhas region with superimposed the sea surface height (blue negative values, red positive values). In this snapshot, the distribution of floats inside the rings appears higher than outside of the rings, although there are still many floats not in Agulhas rings, especially well into the Cape Basin. We have also addressed this point in the text of the revised manuscript.

2) Dr. Donners wonders how the floats are distributed with depth. To address this, we have added a figure (Fig. 5, Fig. 1 in this rebuttal) to the revised manuscript. In that figure, we depict the mean transport per layer for the floats when they are released, and when they cross the GoodHope line and add to the Agulhas leakage time series. We have also added a paragraph to the text, where we discuss the relative shallowness of Agulhas leakage. Because the floats that enter the Atlantic Ocean are predominantly

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in the upper 2000 m (only 0.03 Sv is below 2000 m), excluding the deeper floats will not significantly affect the results presented here.

Specific Comments

3) We have added some remarks on the general properties of the Agulhas leakage, as suggested by Dr. Donners. More specifically, we have added a reference to an article where we show that the model used here seems skillful, in the sense that the statistical properties of the numerical float trajectories can not be considered very different from the statistical properties of the trajectories of real drifting buoys in the Agulhas area.

4) In the original discussion paper we stated that "Agulhas rings are the most notable transport agent". The J. Geophys. Res. manuscript, which has been submitted in revised form, deals extensively with the question of how important the role of Agulhas rings on the Agulhas leakage is (see also point 1 to this review). We have added a reference to this manuscript.

5) Dr. Donners asks how often multiple rings are found. We have added the statistics of that to the text, both for the model data and for the AVISO data. As there are many rings and other eddies in the region, there are multiple closed contours to choose from in most of the occasions (88% in the model data, 86% in the AVISO data). Almost never was there no closed contour found (2% in the model data, 0% in the AVISO data).

6) Dr. Donners correctly points out that the anticorrelation between Agulhas Current strength and Agulhas leakage means that there is a negative trend in the amount of floats being released, but a positive trend in the amount of floats reaching the Atlantic Ocean. We have emphasized this in the revised text.

7) We have added some text to section 4, explaining that the floats are released throughout the entire water column (see also Fig. 5, Fig. 1 in this rebuttal) and every 5 days.

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8) We acknowledge that the error in float trajectories introduced by using velocity fields which are updated only every five days might be reduced with a float integration scheme that linearly interpolates the velocity fields between the five day means. We have cited the article by De Vries and Döös (2001) in the revised manuscript. However, using this integration scheme would require redoing entire the float integration and since we show that the errors are not extremely sensitive to the time resolution used, we anticipate that redoing the entire experiment does not significantly change the results of our study.

Technical comments

9) Dr. Donners rightly states that all instances of 32°E should be 32°S. We have corrected that in the revised manuscript.

10) We have corrected all instances in the text where we discussed snapshots of the model. The model fields are five day averages, the float locations are snapshots.

Interactive comment on Ocean Sci. Discuss., 6, 1193, 2009.

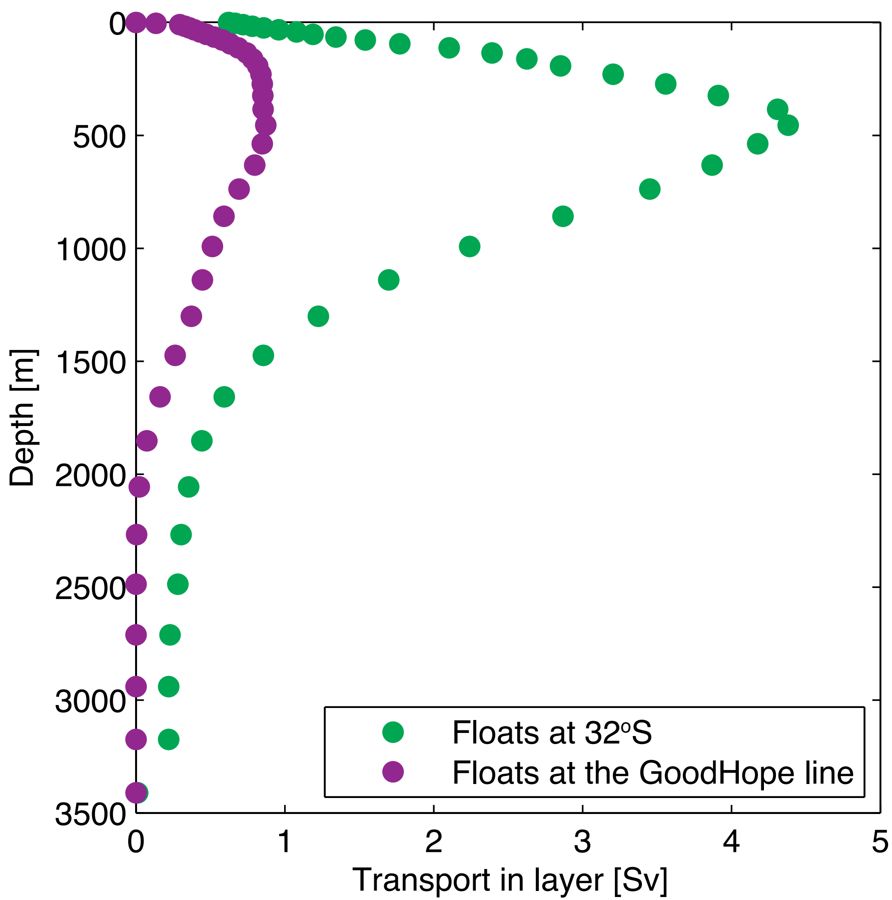

Fig. 1. Mean transport by the Lagrangian floats per model layer at the location where the floats are released (green) and when the floats get into the Altantic Ocean at the GoodHope line (purple).

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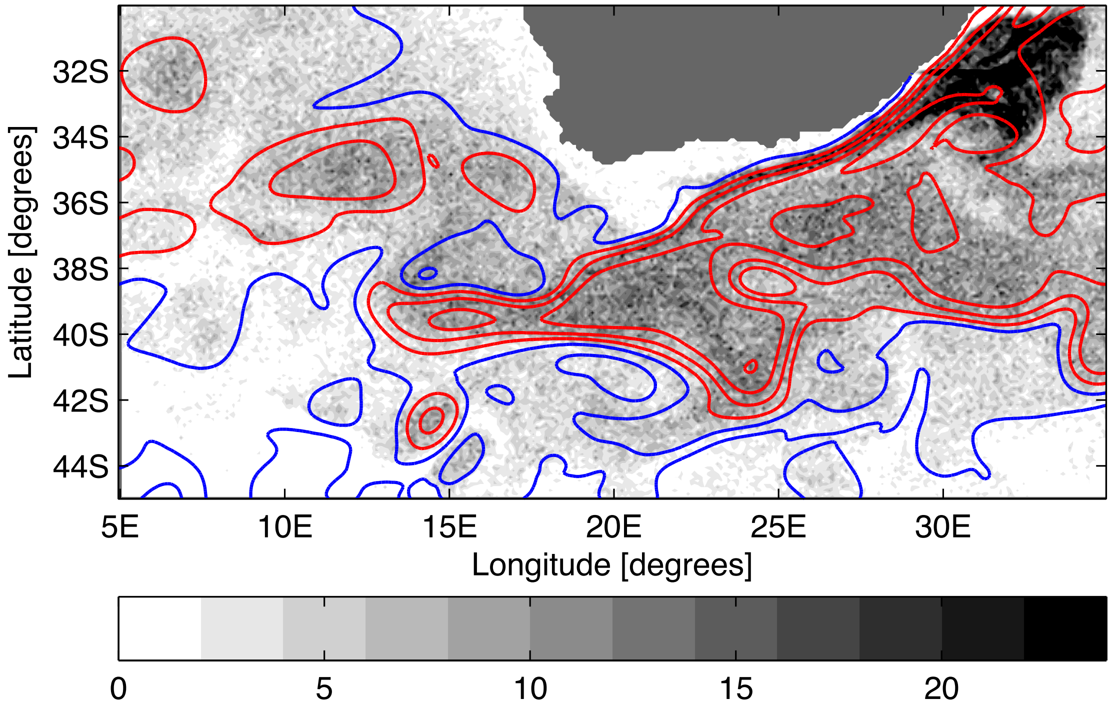

Fig. 2. The number of floats per grid cell in the model run on 20 April 1996. The lines denote the instantaneous sea surface height (at a contour interval of 25 cm), with negative blue and positive red

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