ACT: TOWARDS A MULTI-DECADAL INDEX OF AGULHAS CURRENT TRANSPORT

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1. ABSTRACT

ACT is a US-led, NSF-funded project to build a multi-decadal time series of Agulhas Current volume transport as a contribution to the Global Ocean Observing System. A three-year time series of Agulhas Current transport will be collected from a moored array of instruments across the Agulhas Current and along a TOPEX/Jason altimeter ground track. Subsequently, these measurements will be correlated with patterns of along-track sea surface height variability from satellite altimeter to produce a proxy (or index) for Agulhas Current transport, which can be extended forwards and backwards in time. A proof of concept comes from analysis of a regional, hindcast model of the Agulhas system, which shows high correlations between Agulhas transport and sea surface height difference at the ACT line.

2. MOTIVATION

Why monitor the Agulhas? Because variability of the Agulhas Current and the leakage of its warm and salty waters into the South Atlantic are linked to many climatic processes. For instance, there is evidence to suggest that tropical variability, related to monsoons and Indian Ocean Dipole (IOD) events can cause variability in Agulhas Ring shedding [1]. A southward shift of atmospheric wind patterns since the 1960s, associated with climate change has caused significant warming throughout the Indian Ocean and may have led to an intensification of the Agulhas [2, 3]. The strength of the Agulhas is closely tied to the Indian Ocean heat budget [4] and it can effect extreme rainfall events over South Africa [5]. Paleo-reconstructions show that controls are exhibited on Agulhas variability and its interocean exchange over glacial time scales [6,7]. Ultimately, the warm and salty Indian Ocean waters entering the Atlantic via Agulhas leakage affect the strength of the meridional overturning circulation (MOC) [7,8,10,11] and therefore have a significant impact on global climate.

3. EXPERIMENT DESIGN

Fig. 1a shows a schematic of the entire Agulhas Current System. The main features are a narrow and relatively stable western boundary current along the east African continental slope, the Agulhas Retroflection to the south of the Agulhas Bank, Agulhas Leakage into the South Atlantic mainly via Rings, and the Agulhas Return Current flowing eastward from the Retroflection. The first phase of ACT is to deploy an array of seven full-depth current meter moorings, four C-PIES, and a shallow-water tide gauge across the Agulhas Current to obtain a three year time series of volume and temperature transports.

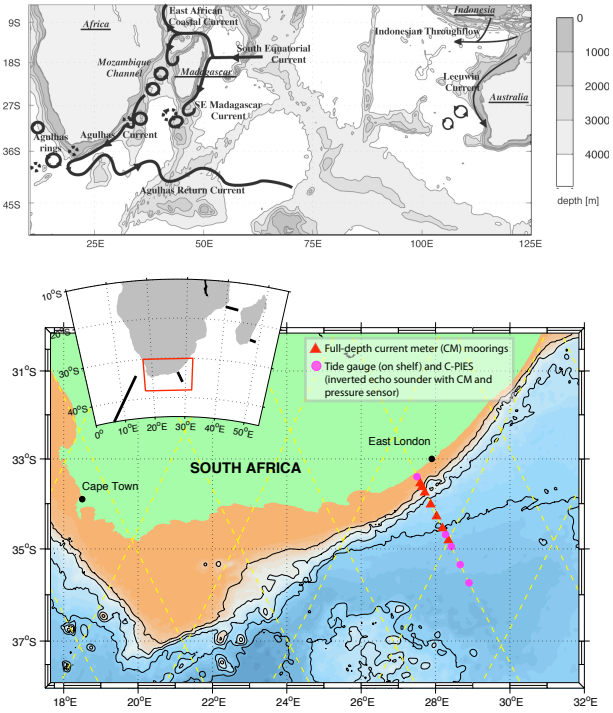

Figure 1(a) Schematic of currents in Southern Indian Ocean. Notice Agulhas Current and its leakage into the Southeast Atlantic via Agulhas Rings [9]. (b) Position of the ACT array across the Agulhas. TOPEX/Jason altimeter ground track is shown in yellow dashed lines. Inset map shows positions of other observing arrays in the region. Bathymetry contours every 1 km.

Fig. 1b shows the chosen site, which coincides with both good satellite coverage (core of the Agulhas typically 40-50 km offshore) and a relatively stable current trajectory (still attached to continental slope, except during solitary meander events). The array will

be deployed in austral autumn 2010, with final recovery in 2013.

The second phase of ACT is to correlate along-track sea surface height (SSH) data from altimeter with these measurements to produce a proxy for Agulhas Current transport, which can be extended forwards and backwards in time, as long as altimeter data is available. New techniques for estimation of wet tropospheric effects in mixed land/ocean footprints, as well as local tide measurements, will be used to recover the best possible coastal altimetry data set to capture the inshore edge of the Current at all times.

4. PROOF OF CONCEPT

Fig. 2a shows the correlation of three measures of Agulhas transport with difference in along-track sea surface height (SSH) at the ACT line, from a hindcast run of the 1/10° two-way nested, Agulhas regional model AG01 [10]. Lagrangian transports are collected

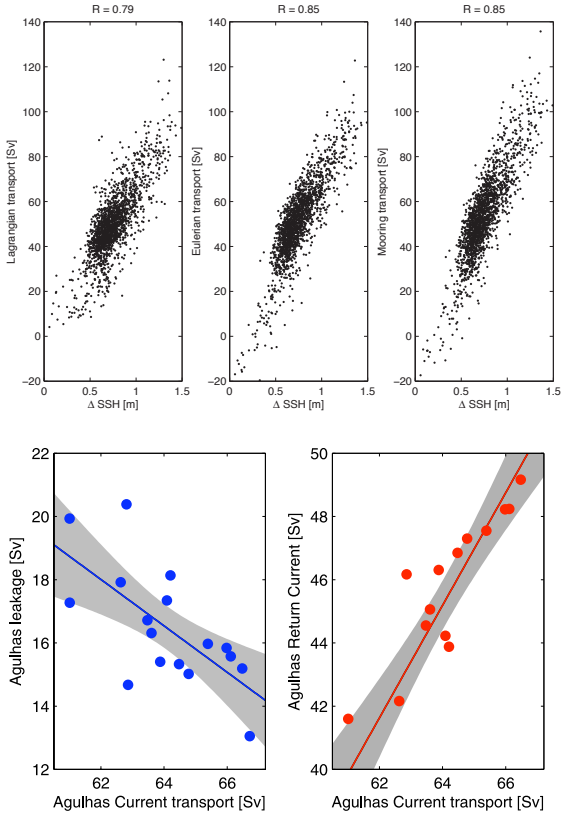

Figure 2(a) Correlation between transport (Lagrangian, Eulerian, subsampled mooring) and SSH difference along the ACT line from 25 yrs of model data (ack. van Sebille). (b) Relationship between two-year averages of simulated Agulhas transport and (left) leakage, (right) Return Current. Gray shading is 95% confidence interval [12].

using virtual floats released in southwestward flow at 32°S. Eulerian transport can be negative, because it may include the Agulhas Undercurrent and any recirculations offshore. For the mooring transport estimate, model data is sub-sampled at the ACT instrument depths and sites. Correlations are high, suggesting we have a good chance of creating a long-term Agulhas proxy from this project.

What about the interocean flux, which is arguably the more important climatic signal, owing to its potential impact on the Atlantic meridional overturning? In ACT we measure the Agulhas Current rather than inter-ocean flux largely because of feasibility. The Agulhas provides a robust signal which can be captured by a small, cost-effective array, while the inter-ocean flux is 5-10 times smaller and highly variable in space and time. However, we may be able to exploit an inverse relationship between the two (Fig. 2b), to estimate Agulhas leakage on biennial time scales [11,12].

5. SUMMARY

Ultimately, a twenty-year proxy of Agulhas Current transport will provide an important climate index for the Indian Ocean, which can be compared to other climate indices, such as the Indian Ocean Dipole and the Atlantic Meridional Overturning, as well as to other western boundary currents, such as the Florida Current and Kuroshio time series. As along as an altimeter flies along the ACT ground track we hope to be able to monitor Agulhas Current transport for the long term using this method, as part of the Global Ocean Observing System.

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