Proposal for a SCOR-WCRP sponsored Working Group on the *Climatic Importance of the Greater Agulhas System*

Abstract

The overarching goal of this SCOR working group is to improve understanding and awareness of the global climate impacts of the greater Agulhas Current system. Although this system is, by nature, regional, our thrust is about understanding changes in the Atlantic Meridional Overturning Circulation (AMOC) and climate that are forced from the southern hemisphere - i.e. by Agulhas leakage - hence the implications are of truly global significance. Moreover, our working group membership is distributed globally. We plan to achieve our goals through the enhancement of collaboration and cooperation within our small, yet global scientific community, and by promoting enlargement of the community. We will hold regular planning meetings to produce a review publication and a steering report that raise the profile of this important region, both in terms of its climatic significance and in terms of the representation it deserves as part of the Global Ocean Observing System. Finally, we will organise a Chapman Conference. WCRP provided comments on this proposal and has agreed to co-fund our group, if approved by SCOR.

Rationale

Mounting evidence from palaeoceanographic and modeling studies suggest that the Agulhas Current and its interocean flux are drivers of global climate change (see Background). For example, through their southern influence on the AMOC, changes in the flux of warm, salty waters from the Indian Ocean may have triggered the end of ice ages, as well as effecting shorter-term climate variability. This puts the importance of the greater Agulhas Current system on a par with Heinrich (land-ice release) Events and deep convection, in terms of northern hemisphere climate. Yet, owing to the relative isolation of the region from the US and Europe, few modern observations and even fewer palaeoceanographic time series exist over the region and it is substantially underrepresented in international monitoring efforts.

It is important that this SCOR working group begin work as soon as possible, to facilitate collaborations to build the best possible research programs in the region and pass on recommendations for future sustained observations as part of IndOOS. The need for such an activity is well identified by our community, as demonstrated by good attendance at a recent unfunded workshop in Kiel, Germany. Ideas and outcomes from this workshop have been used to produce this document. Now is a time of heightened research activity in the region, that will provide unprecedented coverage, new data, and insight into dynamical and climatic mechanisms. There are several Africa-based initiatives (e.g. Agulhas-Somali Current Large Marine Ecosystem project, ASCLME; South African Environmental Observation Network, SAEON), a Dutch program (INdian-ATlantic EXchange in present and past climate, INATEX), a US experiment (Agulhas Current Time-series, ACT), a German program with a hierarchy of models, a recently-funded Japanese climate modeling project (Prediction of Climate Variations and Its Application in the Southern African Region), and two European palaeoclimate programs (Agulhas Warm Water Transports: Climatic Dimension for Southern Africa and Europe, and GATEWAYS - Multi-level assessment of ocean-climate dynamics: a gateway to interdisciplinary training and analysis). There is an urgent need for better linkages between these groups and others in our community, to share resources, data, and even ship-time and to identify collaborations that will maximize the opportunities for data collection in the region while these programs are ongoing. For example, floats, coral coring, coastal altimetry, and air-sea interaction

programs were identified as missing important elements for an observational program. Better collaborations between field scientists and modelers, and between modeling groups are also called for.

Our rationale is aligned with the SCOR call for working group proposals for 2009, which encourages topics related to ocean dynamics and heat transfers, both of which strongly characterize the Agulhas and its inter-ocean exchange. Moreover, SCOR is the best vehicle for our endeavor given that our international community is widespread and that we would seek input from SCOR's Committee on Capacity Building. Many scientists find themselves the sole person or group at their institutions pursuing research in the region and scientists from African countries which abut the Agulhas Current system lack the resources to participate in international meetings and workshops. A truly international and multi-disciplinary approach is needed to strengthen collaborations and identify the questions that will lead to a faster advancement of understanding with respect to the significance of the region as a southern-hemisphere driver of climate change. Our needs fit squarely into the remit of SCOR as a non-governmental organization for the promotion and coordination of international oceanographic activities.

Scientific Background

The greater Agulhas Current system forms a key component of the global thermohaline circulation (Lutjeharms, 2006) and its dynamics are somewhat different from other major western boundary currents, both because of the presence of Madagascar and because the continental boundary ends equatorward of the large-scale wind forcing (Figure 1). Warm, salty waters from the Red Sea, Indonesian Throughflow, and the tropical Indian Ocean are fed into the Agulhas Current from the north and east (Gordon, 1986). Through large air-sea fluxes (Figure 1, left panel)), the Current's variability is strongly linked to patterns of rainfall over eastern Africa (e.g. Reason and Godfred-Spenning, 1998). At the southern tip of the African continent the Agulhas Current retroflects, with most of its water being returned into the South Indian Ocean as the Agulhas Return Current. At the retroflection, large Agulhas Rings are formed by a process of loop occlusion (Lutjeharms and Gordon, 1987). This process leads to a significant portion of Agulhas water, carrying anomalous amounts of heat and salt, being leaked into the South Atlantic Ocean. Palaeoceanographic studies suggest (Peeters et al., 2004) that changes in this leakage are intimately linked to the end of each global glaciation.

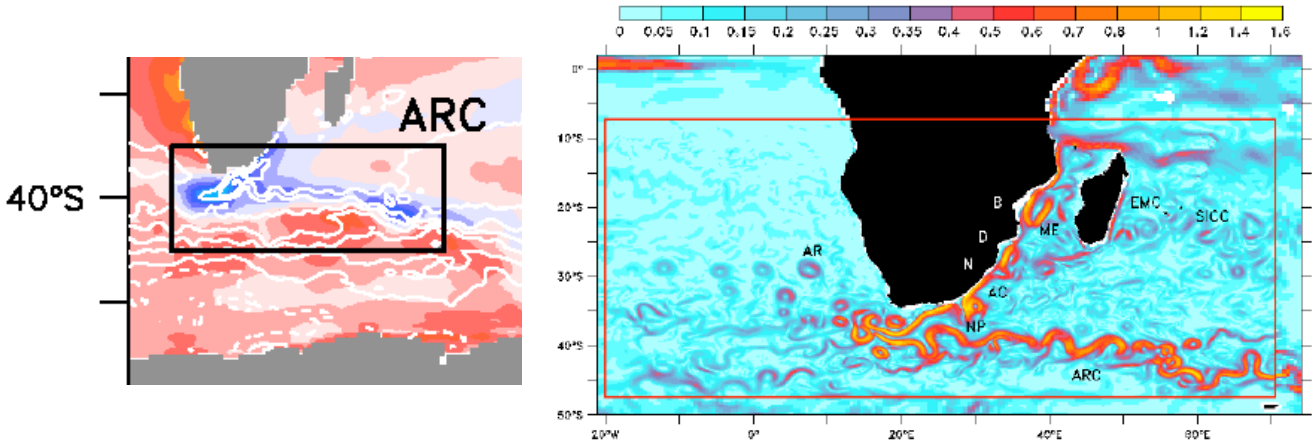

Figure 1: Left panel shows mean air-sea heat flux (Wm^{-2}) over the Agulhas Current, Retroflection, and Return Current region (ARC). This region exhibits the largest surface heat fluxes in the southern hemisphere. Right panel shows 5-day mean speeds (ms^{-1}) at 100 m depth from a nested, high resolution model (from Biastoch et al., 2008b). The features of the greater Agulhas system are clear, as is the exchange of waters with the Atlantic.

In model simulations, variations in the Agulhas leakage are on a par with that of deep water formation in the North Atlantic, in terms of making a comparable contribution to variations in the strength of the Atlantic meridional overturning circulation (Biastoch et al., 2008a), an important element of the global climate system. We fully expect further research to find evidence of links to Southern Ocean overturning also, linked to high eddy heat diffusivity across the meandering Agulhas Return Current (Sallee et al., 2006). Yet, how the Agulhas and its interocean leakage varies is not well understood. There is evidence for control by mesoscale disturbances, such as Mozambique eddies and Rossby waves (Biastoch et al., 2008b; Schouten et al., 2002). These can trigger solitary meanders in the trajectory of the Current which can cause upstream retroflections – preventing inter-ocean leakage – and set the rate of formation of Agulhas Rings. The strength of the Agulhas transport also exerts a control through inertial processes (de Ruijter et al., 1999: van Sebille et al., 2009), whereby a weaker transport appears to lead to a stronger leakage. Shifts and intensity changes of the large-scale wind field also effect the leakage and its properties (Oke and England, 2004), although exactly how is not yet clear.

On a global basis, this region remains one of the poorest understood. Even limited oceanic investigations here have made major and basic discoveries over the past few years. It has, for instance, been shown that no continuous Mozambique Current exists, instead there is a train of eddies (de Ruijter et al., 2002). A new current, the South Indian Ocean Countercurrent, has been discovered to carry water eastward across the subtropical gyre (Siedler, 2006; Palastanga et al., 2007). An undercurrent to the Agulhas has been detected (Beal and Bryden, 1997) substantially modifying the thinking on the volume flux of the Agulhas Current. This is indicative of the pioneering nature of much research in the system. In order to bring an understanding of the key elements of this circulation and its impact on climate to the same cognitive level as other systems, it is highly desirable and urgent that significant resources and well-planned research programs be targeted to the region.

Terms of Reference

The specific goals of our proposed working group are to:

1. Facilitate collaboration between existing and planned (observational and modeling) studies in the greater Agulhas Current system, such that we minimize the gaps in the research, maximize the scientific outcome, and encourage estimates on the robustness of key findings (e.g. multiple model ensembles).

2. Write a review paper (for publication in a peer-reviewed journal) that highlights the importance of the greater Agulhas system in terms of global climate, reviewing the current levels of both understanding and uncertainty as to how changes in the system come about, how they effect climate, and vice versa.

3. Identify key components of the circulation which deserve further study through physical/palaeo observations and/or models, some of which may act as indices/proxies (through sustained observation) that can help describe the state of the Agulhas system on decadal to climate time scales. Communicate these findings to regional and international strategic planning committees, such as CLIVAR, GOOS, GEOSS, GO-SHIP etc.

4. Write a proposal for, and organize, a Chapman Conference on the “Climatic Importance of the Greater Agulhas System”, to be held in 2012.

List of Products

1. Kick-off article in EOS.
2. Review paper in a peer-reviewed journal.
3. Report on recommendations for future research programs and sustained observations, for dissemination to CLIVAR, GOOS, GEOSS, GO-SHIP etc
4. Chapman Conference on the "Climatic Importance of the Greater Agulhas System".

Collaboration and Capacity building

We will enlist the help of the SCOR's Committee on Capacity Building for ways in which our group and its activities can help build scientific capacity in East African nations, such as Mozambique, Tanzania, and Kenya. More resources in these nations would greatly increase the feasibility of sustained observations over the region in the future. We note that two of our members (Juliet Hermes and Johann Lutjeharms) are involved in the Agulhas-Somali Current Large Marine Ecosystem (ASCLME) project, funded by the United Nations Development Program, which shares some of our goals. We will seek a collaboration with ASCLME for a joint planning meeting/workshop and for in-kind support for attendance of these scientists at our SCOR meetings. Communication with International CLIVAR VACS (Variability of the African Climate System) and US CLIVAR WBC (Western Boundary Current ocean-atmosphere interaction) groups will also be sought to identify common ground and establish possible collaborations. We note that committee member Meghan Cronin is on the WBC panel.

Timeline

Once funded, our new SCOR working group will announce itself in an EOS article, in order to reach other scientists conducting related research, encourage their participation, and facilitate their interaction with members of the community.

Our first working group meeting will be held in conjunction with the Ocean Sciences meeting in Portland, Oregon, in February 2010. This meeting will focus on (1) putting together the review article, as described in our terms of reference, (2) encouraging working group members to participate in regional and international strategic panels, and (3) discussing strategies for identifying key components of the Agulhas system for further study / sustained observations.

Our second working group meeting will be in early 2011, possibly in South Africa in conjunction with ASCLME to facilitate capacity building efforts. Here we will focus on (1) a final discussion and submission of review article, (2) initiating a Chapman Conference proposal and identifying a lead convener and (3) outlining a report which will include recommendations on the direction of future research and the requirement for sustained observations in the region. The Conference proposal will be submitted within a few months of this meeting.

Finally, a third working group meeting, potentially also in an African nation, but perhaps at EGU, will aim to (1) have a final discussion about the report on future directions for the region, with dissemination shortly afterwards, and (2) follow up on planning for, and organization of, the Chapman Conference, which should be held within six months of this meeting.

Our final product is to hold a Chapman Conference for the community. (AGU guidelines specify a timeline of 12 to 15 months between proposal acceptance and the actual event.) Such a conference will allow for plenty of scientific discussion, an increase and strengthening of collaborative ties - particularly with African colleagues, and ultimately a more productive outlook for future research, resources, and observation programs, that will accelerate our understanding of the Agulhas and its role in climate.

Chairs and Working Group Members

Our proposed working group has two enthusiastic co-Chairs, representing observations and modeling: Lisa Beal at the Rosenstiel School of Marine and Atmospheric Science at the University of Miami, and Arne Biastoch at the Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR). Plus seven other full members, representing a good balance of expertise, nationality, seniority, and gender (see Table). Each member volunteered their time and ideas at our recent workshop, in which we discussed and initiated this SCOR proposal. The exception is Meghan Cronin whom we recruited after the workshop to fulfill an identified need for expertise in ocean-atmosphere processes.

The group seeks one more member, preferably from the field of fisheries/ecosystems or meteorology/ climate, and from a developing African nation. We have identified David Obura (ecosystems, Kenya) or Alberto Mavume (ocean/atmosphere, Mozambique) as possible members, subject to advice from SCOR.

Name	Seniority	Affiliation	Expertise
Lisa Beal (co-Chair)	jr/mid	University of Miami, USA	physical oceanography
Arne Biastoch (co-Chair)	jr/mid	IFM-Geomar, Germany	ocean modeling
Johann Lutjeharms	sr	University of Cape Town, South Africa	physical oceanography
Rainer Zahn	sr	Univ. Autònoma de Barcelona, Spain	palaeoclimatology
Will de Ruijter	sr	Universiteit Utrecht, The Netherlands	theory / physical oceanography
Juliet Hermes	jr	South African Environmental Observation Network, South Africa	regional ocean modeling / coastal observations
Tomoki Tozuka	jr	University of Tokyo, Japan	coupled climate modeling
Graham Quartly	mid	National Oceanography Centre, UK	bio-physical satellite oceanography
Meghan Cronin	mid	NOAA-PMEL, USA	air-sea interaction

In addition, we have a roster of eleven volunteer Associate members: Herman Ridderinkhof (physical oceanography, NIOZ, The Netherlands), Alan Meyer (satellite oceanography, CSIR, South Africa), Jens Zinke (marine geology, U. Amsterdam, The Netherlands), Frank Peeters (palaeoceanography, U. Amsterdam, The Netherlands), Deirdre Byrne (physical oceanography, U. Maine, USA), Shekeela Baker-Yeboah (dynamical theory, MIT, USA), Paolo Cipollini (coastal altimetry, NOC, UK), Ian Hall (palaeoclimatology, Cardiff U., UK), Veronique Garcon (biophysics, LEGOS, France), Wonsun Park (climate modeling, IFM-Geomar, Germany), and Pierrick Penven (regional ocean modeling, IRD, France). Once again, all these associate members attended the recent workshop, at which they shared ideas for this proposal and asked to be involved.

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