

WG 136 Annual Report 2010/2011

SCOR Working Group 136: On the Climatic Importance of the Greater Agulhas Current System.

Lisa Beal and Arne Biastoch, co-Chairs

1. 2011 WG Meeting

1.1 Organization, Participation, and agenda

SCOR Working Group 136 (WG136) held their second meeting in May 2011. Because of the particular focus on collaborations between existing and planned studies of the region and on capacity building, the meeting was held in combination with the “In-Region Capacity Building Workshop of the WMO/IOC Data Buoy Cooperation Panel (DBCP)” in Mauritius (May 2-6 2011). The website for the meeting can be found at http://www.jcomm.info/index.php?option=com_oe&task=viewEventRecord&eventID=780. Juliet Hermes (SAEON / SCOR) and Augustus Vogel (ONR Global) led organization of the meeting on behalf of SCOR WG 136, including the development of all of the capacity building workshops in which SCOR members participated. Overall organization was coordinated by Sidney Thurston (DBCP / NOAA).

Eight of ten full WG members (Johann Lutjeharms and Francis Marsac were unable to attend) and three associate members were present (for a full list of attendees see end of section 1). In addition, extra travel grants were raised through our Working Group (from various sources) to support the following attendees:

Name	Participation	Country	Funding
Pierrick Penven	workshop leader	France / South Africa	IAPSO
Avelino Langa	trainee	Mozambique	SCOR
Denis Macharia	trainee	Kenya	SCOR
Charles Magori	trainee	Kenya	ONR
Issufu Halo	trainee	Mozambique	ONR
Mohamed Ngwali	trainee	Tanzania	NOAA
Ranjeet Bhagool	trainee	Mauritius	self-funded

Overall, about fifty people attended the meeting, with an approximately even balance between regional trainees and international scientists/trainers. Most trainees obtained travel grants from DBCP/JCOMM (The Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology). Although planning was complex and sometimes challenging because of the partnership with DBCP, we were able to interact with almost an order of magnitude more regional scientists as a result.

The meeting began with two days of talks by international scientists outlining measuring, modelling, forecasting, socio-economic, and outreach activities in the region, among others. A half day of talks was dedicated to AMESD (African Monitoring of the Environment for Sustainable Development) activities, led by local host the Mauritius Oceanography Institute. Proceeding were

two-and-a-half days of capacity building workshops, and finally a half day for assessing the success of the meeting and workshops.

The SCOR agenda was formulated around the WG136 Terms of Reference:

- (1) To facilitate collaborations between existing and planned studies of the region.
- (2) Write a review paper on the climatic importance of the greater Agulhas. This was done (see below).
- (3) Identify key components of the region that deserve further study and/or sustained observations.
- (4) Organize a Chapman Conference with participation of the African science community.

A further goal of the WG is to contribute to capacity building in East African countries which border the Great Agulhas System.

We dedicated a half day to open discussion on regional science and resource planning, a half day to discuss our Chapman Conference proposal, and a closed evening session to consolidate the science and resource planning discussion into explicit goals for sustained observations.

1.2 Reports and Discussions on Current and Future Activities (TORs 1 and 3)

In an open session, Beal summarized current activities known and/or conducted by WG members. These include Mozambique moorings (LOCO/INATEX), East Madagascar Current moorings, Agulhas Current moorings (ACT), a repeat hydrographic line from Cape Town to Antarctica (GoodHope), large marine ecosystem program (ASCLME), African Ceolocanth Program (ACEP), coastal observations maintained by SAEON (South African Environmental Observation Network), seismic/mixing measurements in Agulhas Return Current in early 2012, collection of palaeoclimate data from ocean sediments (GATEWAYS) and corals (CLIMATCH, MASMA), and idealized, regional, high-resolution, and coupled model analyses. The high-density XBT programs across the Agulhas Current off Durban (IX21, ~quarterly), and across the Agulhas leakage off Cape Town (AX25, ~semi-annually) should also have been acknowledged.

Regional scientists gave brief 5-minute reports on their activities. These include: development of a Mozambique Channel model (Halo, Mozambique), a network of tide gauges along the East African coast (Magori, KMFRI, Kenya), deployment of drifting weather buoys (Stander, South African Weather Service), development of real-time satellite products (Arshad, Mauritius Oceanography Institute), the Odinafrica marine atlas (Abdoulkarim, National Oceanographic Data Centre, Comores), establishment of a core region (recognised biodiversity and resilience) for coral reef protection in the northern Mozambique Channel (Obura, CORDIO, Kenya), subsurface mooring off Pemba (Andre, Instituto de Investigacao Pesqueira, Mozambique), and ship measurements in the Mozambique Channel and off Mauritius to investigate the effects of mesoscale variability on marine ecosystems (Ternon, IRD, France). Tafesse Gurma of the National Meteorological Agency, Ethiopia requested help to establish a ship-of-opportunity program on nine commercial ships.

In particular, four significant new activities were described:

- Mike Roberts (DEA Oceans and Coasts, South Africa) reported on a new mooring line across the Agulhas Current (ALEX - Agulhas long-term experiment) at 32S off Port Edward. Originally planned as coastal moorings the array now covers the inshore flank and core of the Agulhas Current. It was discussed whether to approach long-term monitoring of the Agulhas here (by augmenting this array in the future), or at the ACT line (~34 S) taking

advantage of the satellite proxy being developed and needing only a reference mooring or two. A decision is deferred until an assessment of the accuracy of the satellite proxy can be made.

- Meghan Cronin (PMEL, USA) reported on the air-sea flux mooring that got loose in the Agulhas Return Current in January 2011, probably because of high velocities associated with an upstream retroflexion of the Agulhas current. The mooring was successfully recovered and is on its way back to PMEL. Potential new sites were discussed among the members, including farther east or farther north.
- Isabelle Ansoorge (UCT, South Africa) mentioned regular transects down to Marion Island from Cape Town. Usually with XBT lines, this transect may be able to accommodate some measurements across the Agulhas Return Current in the future.
- Gary Brassington (Bureau of Meteorology, Australia) presented Bluelink, operational ocean forecasting around Australia (assimilating altimetry, SST, and *in situ* observations). There is an intention to extend Bluelink into the western Indian Ocean and Agulhas region.

In the course of an open discussion on resources in the region, led by David Vousden (ASCLME), it was identified that sharing of data and resources (e.g. ship time) are essential to achieve our goals for the region, which are based on creating collaborations that facilitate data collection, knowledge transfer, new research, and the building of a minimal network of sustained observations. To this end a memorandum of understanding was signed between NOAA and ASCLME (this was set by Vousden preceding the meeting) and, on an individual PI basis, many opportunities for sharing of ship time and pooling resources were discussed during the meeting. For example, ADCPs could be added to ATLAS moorings in the South Equatorial Current to measure ocean advection in addition to air-sea fluxes. The Seychelles might be able to provide a coastguard escort to protect against pirates during maintenance of the mooring at 8°S. Underway measurements added to the Marion Island cruises could be used to measure the Agulhas Return Current, and a small adjustment to the cruise track could provide measurements for comparison to the ARC buoy, when it is redeployed.

Following productive discussions on the elements that should make up a sustained observation system for the region (TOR 3), the priorities for sustained observations were determined as:

1. Agulhas System air-sea flux buoy
2. Long-term monitoring of Agulhas Current (transport and water masses)
3. Reference mooring in Mozambique Channel (leveraged on existent 10-year time series)

A short science planning document is being prepared (led by Beal, de Ruijter, and Ridderinkhof) that will target international planning committees such as the CLIVAR Indian Ocean Panel (IOP8 is in July and this report will be presented there), OceanObs, and GOOS and can also be used by international and regional African scientists to leverage funding and participation. The southwest Indian Ocean is currently unrepresented in any ocean observing planning document, although it does appear as a priority in several OceanObs09 white papers.

1.3 Capacity Building (TOR 1 and further goal)

Within NOAA's "In-Region Capacity Building Workshop of the WMO/IOC Data Buoy Cooperation Panel (DBCP)" SCOR WG members held training events for the 28 African participants. Organization was led by Juliet Hermes and Augustus Vogel and much preparatory work was done in the weeks leading up to the Workshop by Biastoch, Penven, Quartly, and Tozuka. Individual capacity building workshops included:

- Model Development Team: Introduction to Ocean Modeling (4-hour workshop designed and run by Biastoch and Penven)
- Observation Development Team: Remote Sensing (4-hour workshop designed and run by Quartly)
- Model Development Team: Seasonal Forecasting and SINTEX-F (2-hour workshop designed and run by Tozuka and Sasaki)

Despite some problems (last-minute organization, software issues, only 50% time spent on capacity building, large variety of student backgrounds) the workshops were enthusiastically conducted and well received. Detailed feedback and recommendations for future improvement of capacity building efforts were compiled by Hermes, presented at the meeting, and provided to the DBCP Workshop's reporter Johan Stander (SAWS), and organizer Sidney Thurston (NOAA). It is also available as supplemental information to this report upon request. Here we include two pieces of feedback direct from trainees which carried majority sentiment:

- “The software/programs being used in the modelling is technical, requiring time to learn and exercise these skills which were difficult to master in the limited time! – If the same participants come each year (as planned) this will help. Also if the whole week is dedicated to capacity building this will also help. The trainees have many limitations in using research platforms, such as Linux operative system, and limited scientific software. The trainers found very difficult to deal with such a problem. Time should be invested in well-equipping regionally balanced participants with necessary basics which will then be exercised in later sessions within the same workshop.”
- “Though the trainees learned where to find the data, it seemed obvious that many do not know how to use it.”

Networking lunches were organized to establish relationships and discussions between SCOR WG members and regional participants. These lunches were very successful and the participants were keen for even more social and scientific interaction with international scientists, if there had been more time.

Some feedback from regional scientists about SCOR's capacity-building and networking lunches:

- “SCOR members were keen to share knowledge and new ideas as well as engage us in profiling and networking.”
- “This was probably my first ever most interactive and knowledge intensive. The lunches proved fruitful get-together sessions with specific persons of interest. The great interest by SCOR members to share knowledge and ideas with ‘new’ members was enviable.”
- “It is important to mention that the meeting with some scientists have contributed enough to my scientific work on the eddies in the Mozambique Channel, which is in its final phase.”
- “This workshop provided me with the best platform to know about climate change related research and monitoring programmes that are ongoing in this part of the world. It was also very enriching to learn from experts from all around the globe about their research activities and publications in our region.”

1.4 Chapman Conference (TOR 4)

Will de Ruijter presented the first draft of an AGU Chapman Conference proposal, and led discussions to refine the proposed sessions, identify invited speakers, and establish a location.

Although usually held in the U.S., it makes more sense to hold a Chapman Conference on the Agulhas in Southern Africa where a large number of the scientists conducting research in the region reside. Moreover, AGU expressed great interest in supporting the first Chapman Conference to be held in Africa. It was therefore decided to hold it in South Africa, potentially in Grahamstown away from the distractions of a city like Cape Town, and where David Vousden of ASCLME agreed to act as local organizer.

With sessions focussing on the findings described in the Nature article, plus regional and ecosystem influences, the conference is designed to attract a broad community. Among the anticipated 120 participants we are planning for a good geographical balance between international and regional scientists, students and researchers/lecturers, to maximise the transfer of knowledge and expertise. Additional funding was discussed to support regional and international attendance. Many South African scientists in attendance were confident that they could find some funding from various agencies.

Will de Ruijter prepared a new version of the Chapman proposal taking into account many additional comments and amendments from SCOR members following our meeting. The proposal was submitted in June 2011 and the conference is proposed for September/October 2012.

1.5 Membership and Attendees

Due to his dedication to future activities in the Agulhas Current and significant contributions to discussions at the Mauritius workshop, Mike Roberts (Oceans and Coasts, Department of Environment Affairs, Cape Town) was asked to become an associate member of SCOR WG 136, which he accepted. During the course of the second period David Obura was replaced by Francis Marsac (IRD/UCT) as the tenth full WG member, who has since participated in the production of our Chapman proposal and shall reach out into the ecosystems community.

Participating WG members (Full and Associate)

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2. Review Paper

Following the conclusions of the last meeting we contacted *Science* and *Nature*. Both expressed interest, but *Science* offered only a shorter Perspectives article. After a formal inquiry *Nature* was interested in a review article “On the role of the Agulhas system in ocean circulation and climate” which was submitted on 22 June 2010. The article, summarizing the modern observational and modeling findings as well as the evidence from palaeo measurements, was very well received by four reviewers and finally published on 28 April 2011 (see over page).

Nature allowed only those authors to appear that actively wrote the article (L. Beal, W. de Ruijter, A. Biastoch, R. Zahn). However, since the activity was based on the discussions and iterations among the whole WG, *Nature* agreed to add “SCOR/WCRP/IAPSO Working Group 136” to the authorship, with a list of full and associated members at the end of the article.

The article and the corresponding press releases were picked up in the media and led to several interviews and news articles in the U.S., Great Britain, Spain and Germany. It was displayed on the front page of the US NSF website.

3. Final WG Meeting in 2012

It was decided to hold the final WG meeting in coordination with the Chapman Conference, which is proposed for September/October 2012.

4. SCOR Products

To summarize our activities in terms of SCOR deliverables, four products were outlined in our SCOR proposal:

- (1) Article in EOS
- (2) Review paper [in *Nature*]
- (3) Science Plan Report to CLIVAR, GOOS etc
- (4) Chapman Conference proposal

(1) and (2) are fully completed, (4) has been submitted, and (3) is presently being circulated for comments from the WG and will be finalised in time to be presented at the next CLIVAR Indian Ocean Panel meeting in July.

REVIEW

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On the role of the Agulhas system in ocean circulation and climate

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The Atlantic Ocean receives warm, saline water from the Indo-Pacific Ocean through Agulhas leakage around the southern tip of Africa. Recent findings suggest that Agulhas leakage is a crucial component of the climate system and that ongoing increases in leakage under anthropogenic warming could strengthen the Atlantic overturning circulation at a time when warming and accelerated meltwater input in the North Atlantic is predicted to weaken it. Yet in comparison with processes in the North Atlantic, the overall Agulhas system is largely overlooked as a potential climate trigger or feedback mechanism. Detailed modelling experiments—backed by palaeoceanographic and sustained modern observations—are required to establish firmly the role of the Agulhas system in a warming climate.

The greater Agulhas system around southern Africa forms a key component of the global ocean circulation^{1–3} (Fig. 1). This system feeds the upper arm of the Atlantic meridional overturning circulation (AMOC) through the leakage of warm, saline waters from the Indian Ocean to the Atlantic⁴ (Fig. 2). From year to year, Agulhas leakage is dominated by nonlinear, mesoscale dynamics: it is carried by Agulhas rings (formed by an occlusion of the Agulhas Retroflection; Fig. 2), eddies and filaments^{5–7}. Over longer periods, theory suggests its variability is associated with the large-scale wind field, in particular with the position of the maximum Southern Hemisphere westerly winds^{2,8–10}. These winds are related to the latitude of the oceanic subtropical front (STF), which separates the subtropical gyre from the Antarctic

Circumpolar Current. In essence, if the westerlies shift southwards, as recent data suggest in a warming climate (Fig. 1), then the oceanic ‘gateway’ between the African continent and the STF expands and leakage from the Indian Ocean to the Atlantic increases^{8,9} (Fig. 1 and Box 1). Similarly, a northward shift, as inferred from palaeorecords during glacial periods, would reduce the leakage^{11,12}.

Model simulations suggest that variability in Agulhas leakage can impact the strength of the Atlantic overturning on a number of time-scales^{13–15}. Most significantly, a persistent change in leakage could impact the thermohaline properties of the Atlantic, changing its stratification and its potential for deep convection, and thus altering the AMOC to a new stable state over a period of several hundred years^{13,16}.

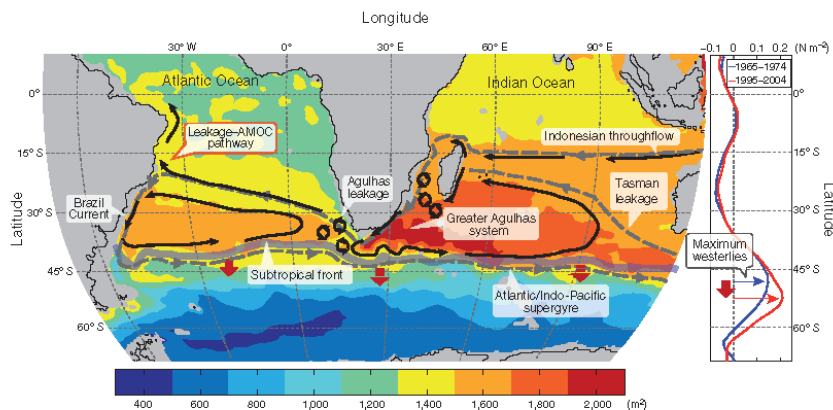


Figure 1 | Agulhas leakage affected by westerly winds and position of subtropical front. Schematic of the greater Agulhas system embedded in the Southern Hemisphere supergyre. Background colours show the mean subtropical gyre circulation, depicted by climatological dynamic height integrated between the surface and 2,000 dbar, from the CARS database²⁸. Black arrows and labels illustrate significant features of the flow. An outline of the Southern Hemisphere supergyre is given by the grey dashed line. The plot on

the right shows the southward expansion of the Southern Hemisphere westerlies over a 30-yr period, from the CORE2 wind stress³² averaged between longitudes 20° E and 110° E (Indian Ocean sector). The expected corresponding southward shift of the subtropical front (STF) is illustrated by red dashed arrows and would affect Agulhas leakage (shown as eddies) and the pathway between leakage and the AMOC, which is highlighted with a red box.

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