SAMOC-SA monitoring the Agulhas Leakage : SAMBA

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So why the interest?

– to start we have to look at the north

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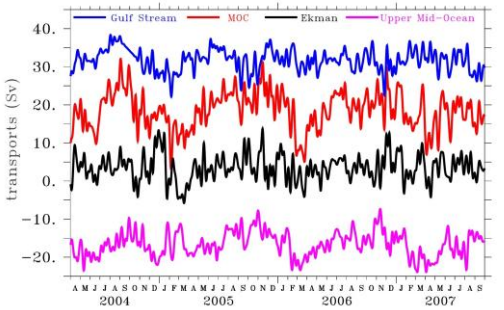
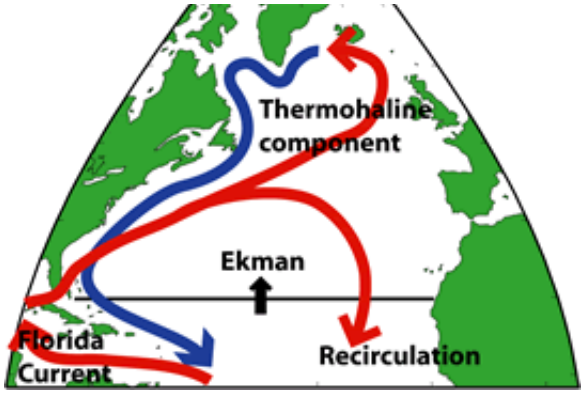
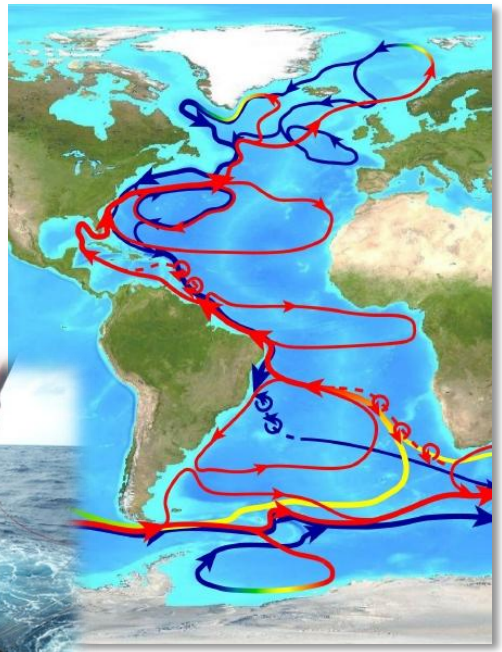
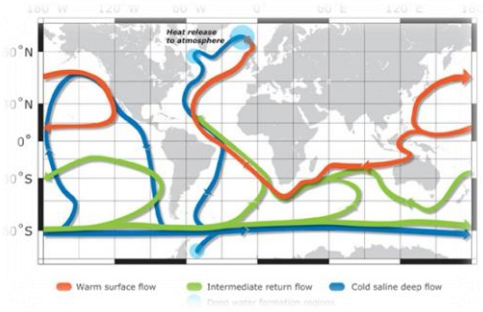
What is Atlantic Meridional Overturning Circulation (AMOC)?

- The AMOC is the dominant north-south ocean circulation feature in the Atlantic.
- The AMOC is the main route for the global ocean heat conveyor belt circulation in the Atlantic.
- About 80% of the heat from global warming over the past 50 years was absorbed by the ocean.
- Large variations of the AMOC impact sea ice, ecosystems, ocean temperatures, and sea level.
- A major change of the AMOC would significantly alter global climate patterns, such as temperature and precipitation patterns over North America and Europe.

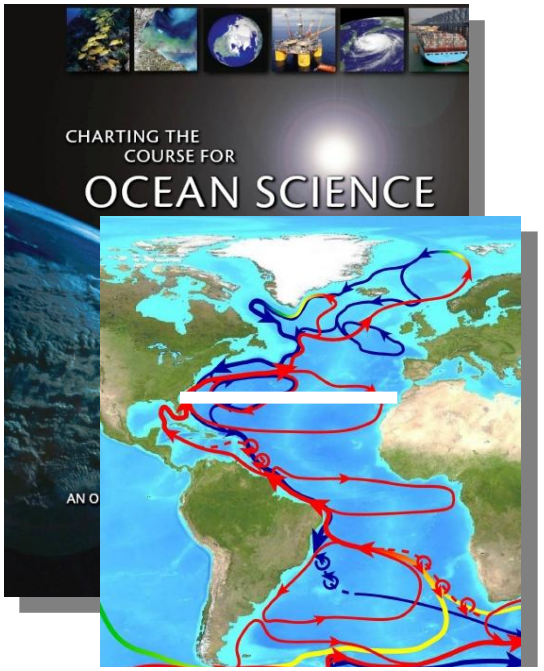






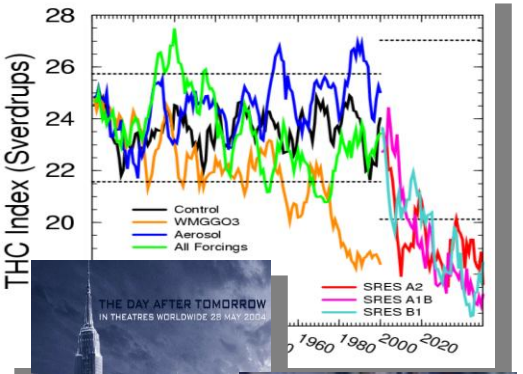


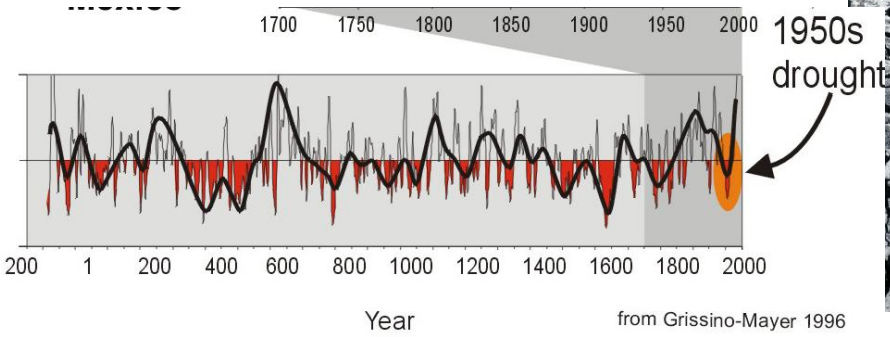
Currently - Atlantic Meridional Overturning Circulation (AMOC – RAPID Array)



Anticipated Outcomes

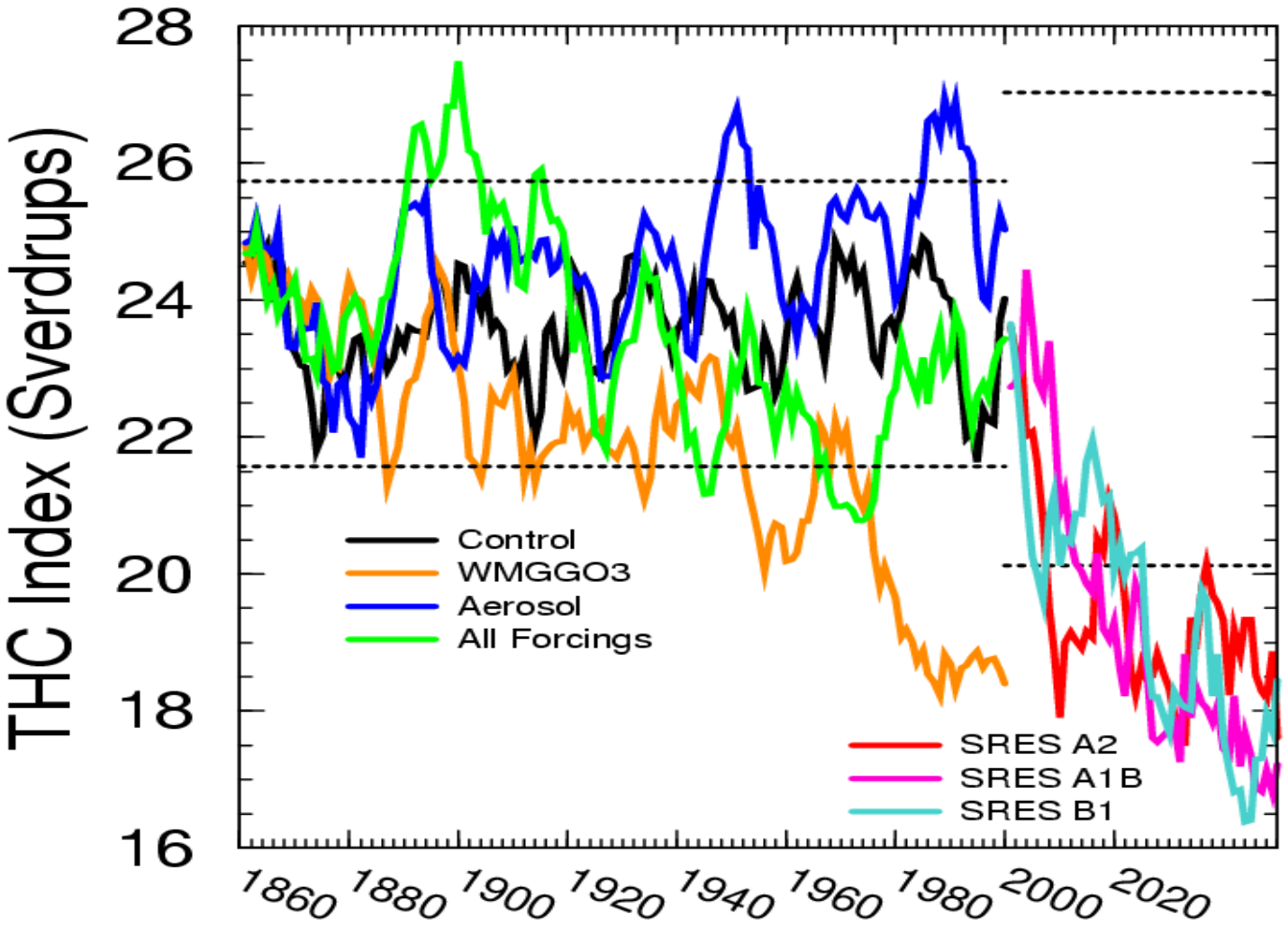
- Enhanced understanding of the MOC system
- Design a comprehensive MOC observation and monitoring program.
- New forecasting capabilities
- Improved ocean models, coupled models, and ocean analyses for their initialization.
- Characterize the impacts and feedbacks of changes in the MOC on ecosystems, carbon budgets, and regional climate.





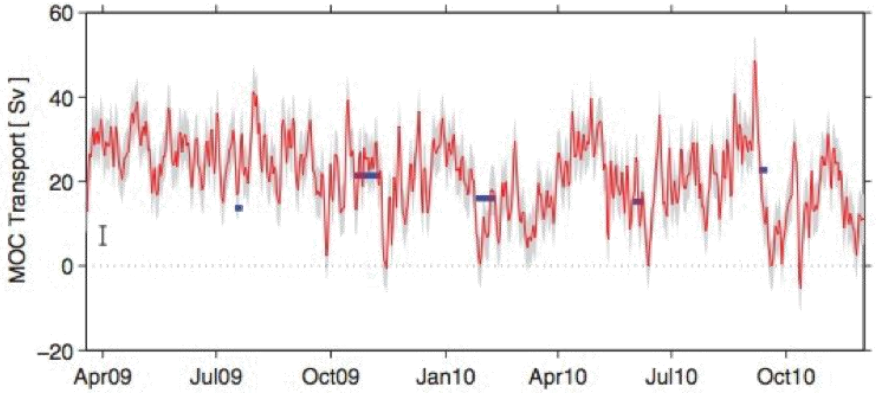
Why the urgency?

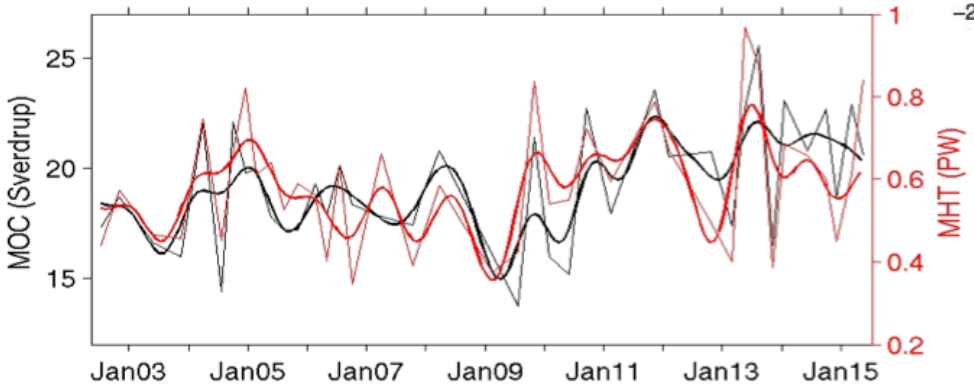
Models indicate that a future slowdown of the MOC in the North Atlantic is possible…we need to improve our cross-basin observations to assess the reliability of these models!



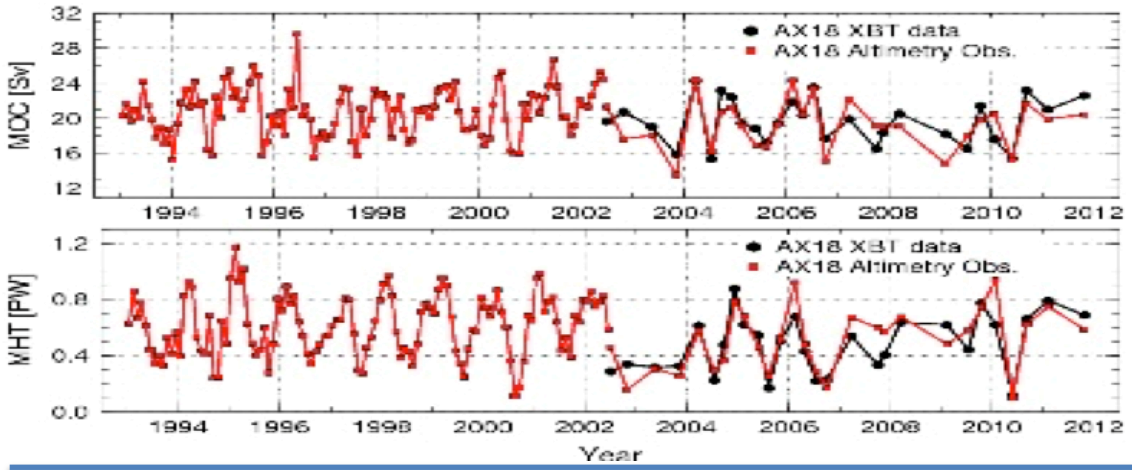
Why the urgency? Observations show a state of flux in transport

Meinen et al., 2013





Garzoli et al, 2013, Dong et al., 2014



Dong et al., 2015

OCEANOGRAPHY

Oceans under surveillance

Three projects seek to track changes in Atlantic overturning circulation currents.

BY QUIRIN SCHIERMEIER

A 'global conveyor belt' stirs the oceans from top to bottom, with surface currents transporting warm water to the poles while cold water in the depths flows back to the tropics. But it operates in fits and starts, with the strength of the currents varying widely. Eager for a better understanding of how the vagaries of the conveyor belt shape weather and climate, oceanographers are planning two new large-scale projects to watch over Atlantic currents.

An array of instruments between Florida and the Canary Islands has been continuously monitoring the strength of the North Atlantic portion of the global conveyor belt since 2004. In December, if all goes well, an international project led by the United States will begin another set of continuous measurements of the Atlantic Meridional Overturning Circulation (AMOC), using an array of sensors strung between South Africa and Argentina. And this month, US and British funding agencies are set to decide whether they will support a new surface-to-bottom monitoring array between Labrador in Canada and Scotland, UK. The United Kingdom will also decide whether to continue operating the existing array.

Expanding such monitoring is crucial if scientists are to improve seasonal weather and climate forecasts, says Harry Bryden, an oceanographer at the University of Southampton, UK. Components of the AMOC, such as the Gulf Stream, ferry vast amounts of heat from the tropics to high latitudes, heating the winds that keep Europe's climate mild. As a result, year-to-year and longer-term changes in the strength of these currents can affect seasonal conditions

In April 2009, the array recorded[2] a 30% drop in average current strength that persisted for a year, reducing the amount of heat transported to the North Atlantic by almost 200 trillion watts — equal to the output of more than 100,000 large power plants.

The anomaly — much bigger than any change that models suggested could happen —

a crucial component of the conveyor belt: the region of the North Atlantic in which surface water heading north from the tropics cools and sinks before it moves back towards the equator. Climate models suggest that the rate of this formation of deep water will decrease by the end of the century[3]. That is problematic not only because deep-water formation drives the ocean circulation, but also because it carries vast amounts of carbon dioxide to the depths, sequestering it from the atmosphere.

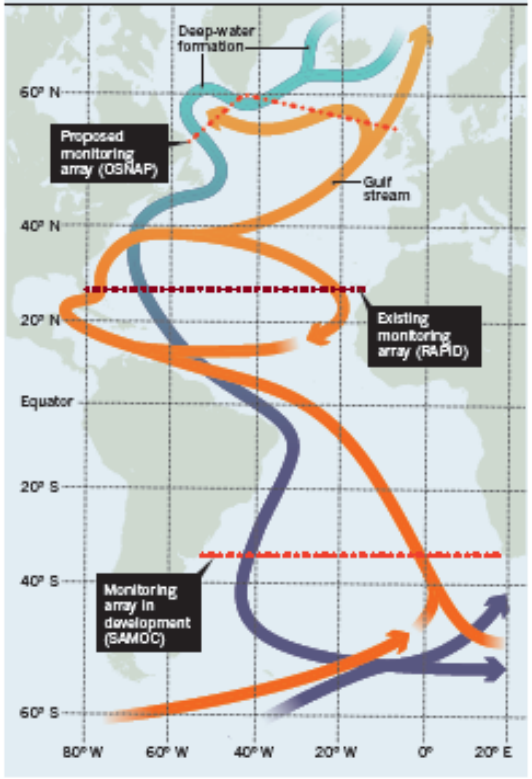
"We need to find out how water masses at high latitudes are tied to the larger Atlantic circulation," says Susan Lozier, a physical oceanographer at Duke University in Durham, North Carolina. "That is not only of interest to oceanographers. The ocean moves such huge amounts of heat and carbon around that most everyone should care."

To understand how deep-water formation works, and why it varies, Lozier and her colleagues have proposed setting up an array of moored instruments and autonomous gliders called the Overturning in the Subpolar North Atlantic Program (OSNAP). This consists of two legs: a western line extending from southern Labrador to the southwest tip of Greenland, and an eastern line from Greenland to Scotland (see 'Ebb and flow'). If the US National Science Foundation and the UK Natural Environment Research Council approve the US$24-million project, measurements of heat and currents in the deep-water-formation region could start in July 2014. They are expected to give their decision later this month. If the array goes ahead, Canada, Germany and the Netherlands have all promised to contribute instruments to it.

Scientists are also trying to trace the cold,

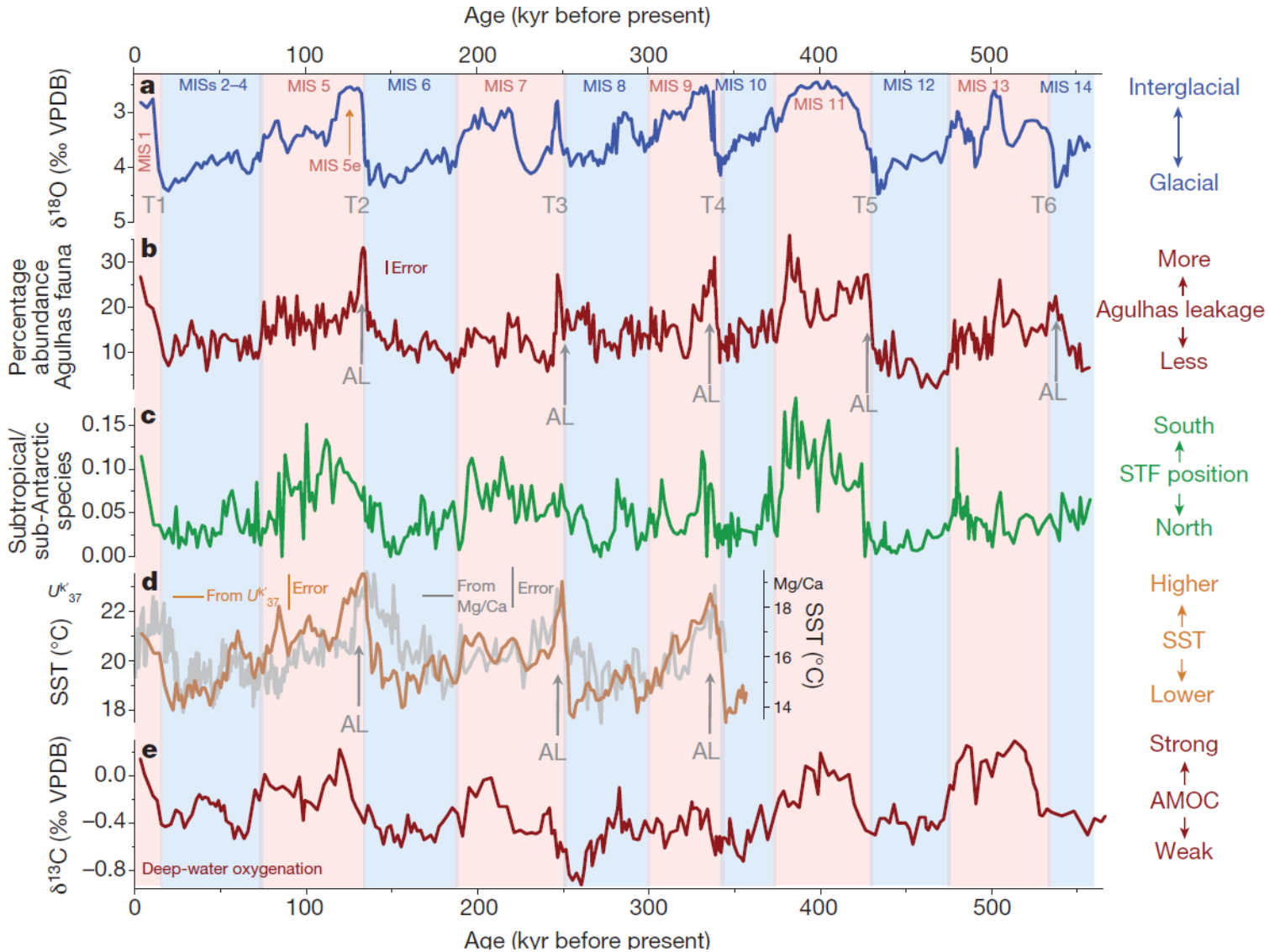
EBB AND FLOW

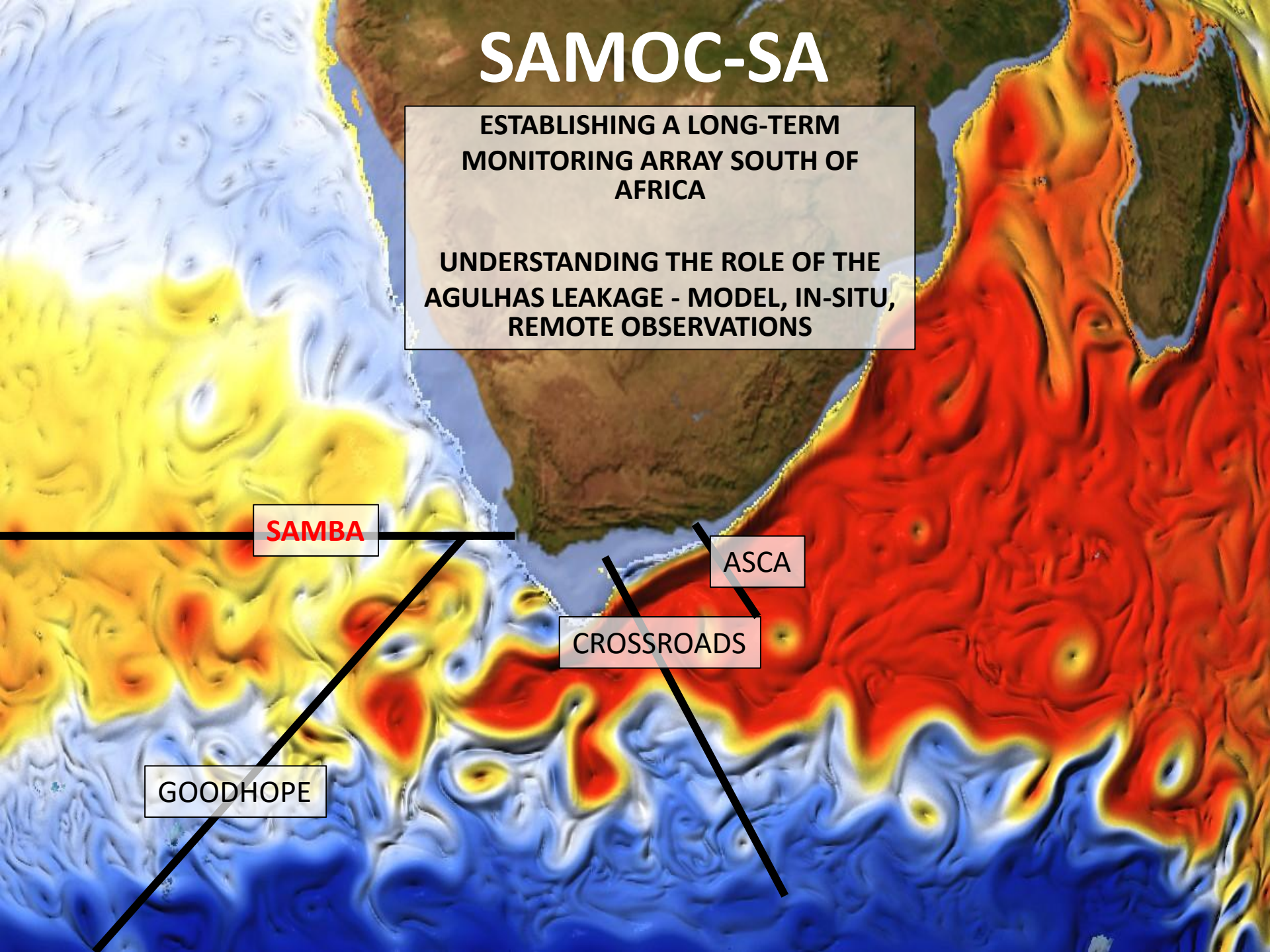
The 'global conveyor belt' transports warm Atlantic Ocean surface water (orange) to the poles and cool deep water (blue) to the tropics.



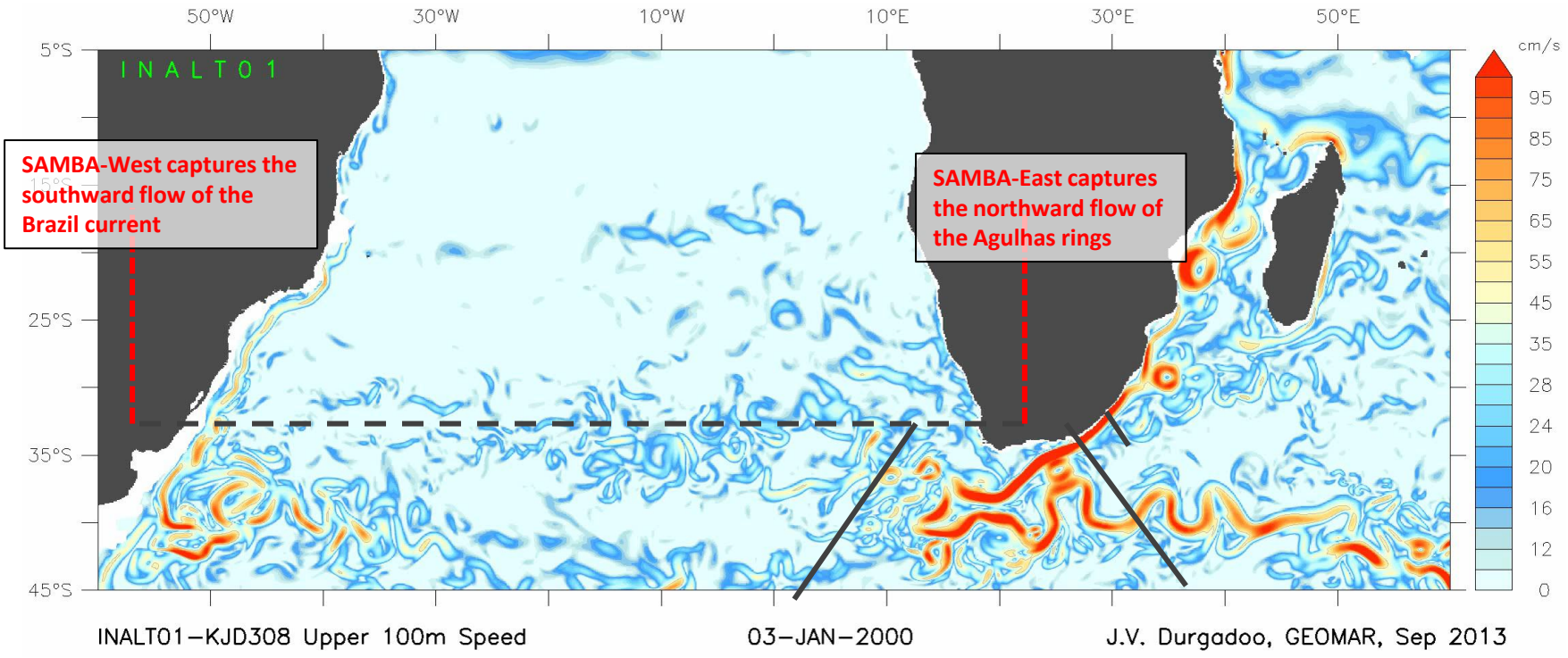
SOURCE: RAPID; NERC; SAMOC; NOAA; OSNAP; S. LOZIER

Beal et al 2011 highlights the impact the Agulhas leakage has on the further afield on the AMOC




SAMOC-SA
ESTABLISHING A LONG-TERM MONITORING ARRAY SOUTH OF AFRICA
UNDERSTANDING THE ROLE OF THE AGULHAS LEAKAGE - MODEL, IN-SITU, REMOTE OBSERVATIONS
SAMBA
ASCA
CROSSROADS
GOODHOPE

The importance of East-West South Atlantic exchange along SAMBA



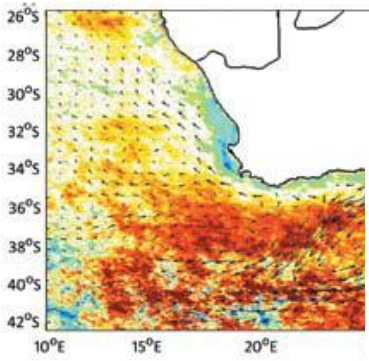
Evidence of climate change south of Africa?

MARINE OFFSHORE ENVIRONMENT

On the recent warming of the Agulhas Current

MATHIEU ROUAULT
PIERRICK PENVEN
BENJAMIN POHL

The Agulhas Current is an energetic current driven by the wind field over the Indian Ocean. It has a profound effect on the climate and the coastal ecosystem of South Africa and plays a key role in the global ocean circulation. The current carries warm and salty water from the tropics polewards and controls the exchange of heat and salt between the Indian and Atlantic Oceans. Since the 1980s, the sea surface temperature of the Agulhas Current system has increased significantly. This is due to an increase of its transport in response to an augmentation in wind stress curl in the South Indian Ocean. This causes an intensification of the Agulhas Current system and leads to an increased flux of salt and heat into the Atlantic Ocean. There is also an augmentation in the transfer of energy from the Agulhas Current to the atmosphere due to increased evaporation. These observed changes could have far-reaching consequences over and above their potential regional impacts on ecosystems and climate.



Vigorous exchange between the Indian and Atlantic oceans at the end of the past five glacial periods

Frank J. C. Peeters[1,2], Ruth Acheson[3], Geert-Jan A. Brummer[2], Wilhelmus P. M. de Ruijter[4], Ralph R. Schneider[5], Gerald M. Ganssen[1], Els Ufkes[1] & Dick Kroon[1]

[1]*Department of Paleoecology and Paleoclimatology, Faculty of Earth and Life Sciences, Vrije Universiteit, de Boelelaan 1085, 1081 HV, Amsterdam, The Netherlands*
[2]*Department of Marine Chemistry and Geology (MCG), Royal Netherlands Institute for Sea Research (NIOZ), PO Box 59, 1790 AB Den Burg, Texel, The Netherlands*
[3]*School of GeoSciences, The University of Edinburgh, Grant Institute, The King's Buildings, Edinburgh EH9 3JW, UK*
[4]*Faculty of Physics and Astronomy, Institute for Marine and Atmospheric Research Utrecht, Utrecht University, Princetonplein 5, 3584 CC Utrecht, The Netherlands*
[5]*Département de Géologie et Océanographie, UMR 5805 EPOC, CNRS/Université de Bordeaux I, 33405 Talence, France*

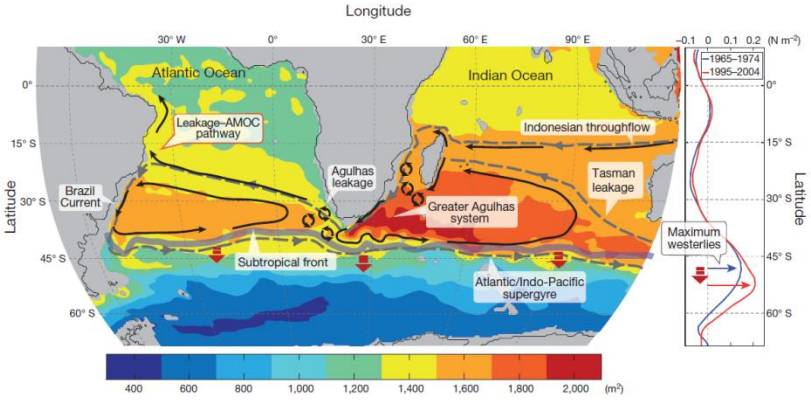
The magnitude of heat and salt transfer between the Indian and Atlantic oceans through 'Agulhas leakage' is considered important for balancing the global thermohaline circulation[1–3]. Increases or reductions of this leakage lead to strengthening or weakening of the Atlantic meridional overturning and associated

REVIEW
doi:10.1038/nature09983

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

Lisa M. Beal[1], Wilhelmus P. M. De Ruijter[2], Arne Biastoch[3], Rainer Zahn[4] & SCOR/WCRP/IAPSO Working Group 136*

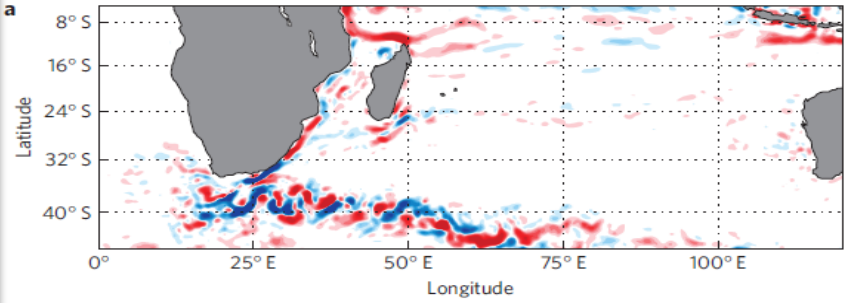
The Atlantic Ocean receives warm, saline water from the Indo–Pacific Ocean through Agulhas leakage around the southern tip of Africa. Recent findings suggest that Agulhas leakage is a crucial component of the climate system and that ongoing increases in leakage under anthropogenic warming could strengthen 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.



nature climate change
LETTERS
PUBLISHED ONLINE: 8 JULY 2012 | DOI: 10.1038/NCLIMATE1587

Impact of intensified Indian Ocean winds on mesoscale variability in the Agulhas system

Björn C. Backeberg[1,2]*, Pierrick Penven[3,2] and Mathieu Rouault[1,2]



So what are we doing in South Africa ?

EOS
BOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

VOLUME 95 NUMBER 6
11 February 2014
PAGES 53–60

Basin-Wide Oceanographic Array Bridges the South Atlantic

PAGES 53–54

The meridional overturning circulation (MOC) is a global system of surface, intermediate, and deep ocean currents. The MOC connects the surface layer of the ocean and the atmosphere with the huge reservoir of the deep sea and is the primary mechanism for transporting heat, freshwater, and carbon between ocean basins. Climate models show that past changes in the strength of the MOC were linked to historical climate variations. Further research suggests that the MOC will continue to modulate climate change scenarios on time scales ranging from decades to centuries [*Latif et al.*, 2006].

At present, the majority of observations of the MOC come from the Rapid Climate Change (RAPID) MOC/Meridional Overturning Circulation and Heat Flux Array (MOCHA). This is a collaborative project between the U.K. National Oceanography Centre (NOC); the Rosenstiel School of Marine and Atmospheric Science, in Miami, Fla.; and the U.S. National Oceanic and Atmospheric Administration (NOAA). Preliminary results from this array of sensors, which extends across the North Atlantic along 26.5°N, have shown that the strength of the overturning circulation varies considerably on time scales as short as weeks to months [*Rayner et al.*, 2011].

Given the complex, multibasin nature of the MOC, achieving a more complete understanding of its behavior requires a more comprehensive observing system, one that extends across neighboring ocean basins. Though Argo floats, gliders, and satellite measurements continue to revolutionize the study of the upper ocean, there is still a clear need to study the full ocean depth with moored instruments. Recognition of this critical importance led to the creation of the South Atlantic MOC (SAMOC) initiative [*Garzoli et al.*, 2010].

The Importance of 34.5°S

The current exchange pathways south of Africa and South America drive water mass interactions between the Indian, Pacific, and Atlantic oceans. Specifically, recent model simulations suggest that the leakage of Agulhas Current water across 34.5°S into the South Atlantic is important to circulation patterns far afield [*Biastoch et al.*, 2008]. The Agulhas Current, which flows westward around the southern coast of South Africa, contributes strongly to the upper limb of the MOC northward flow in the Atlantic Ocean. Additionally, the shedding of Agulhas rings into the eastern South Atlantic is a major source of salinity to the region (Figure 1). Other investigations

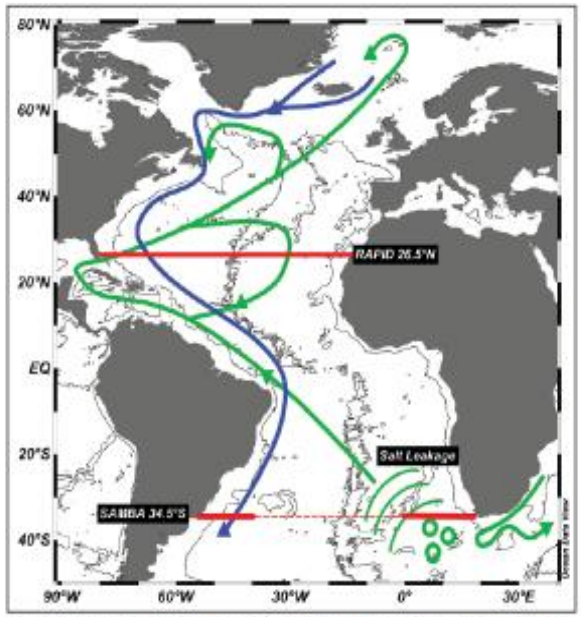
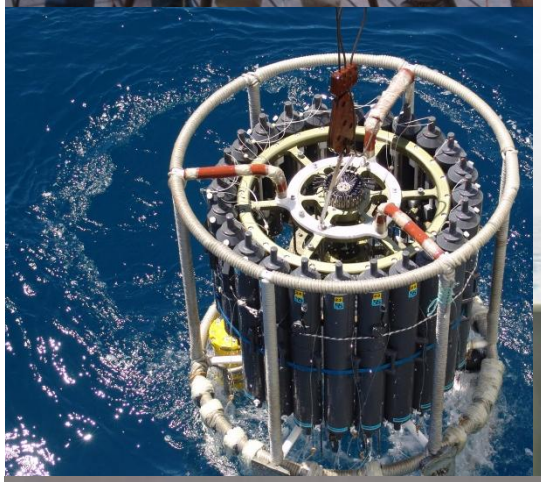


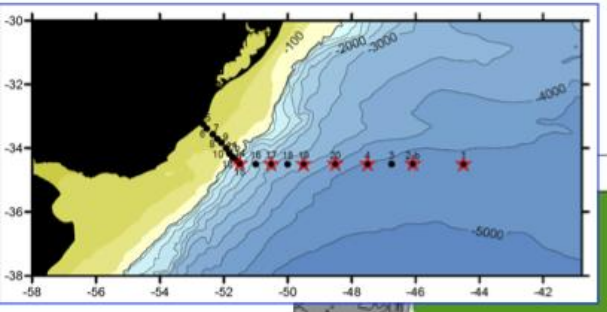
Fig. 1. A simplified schematic highlighting the meridional overturning circulation (MOC)—how currents flow between the southern and northern Atlantic Ocean. Blue lines refer to the pathway of the cold, deep water masses formed in the northern Atlantic; green lines correspond to the northward surface flow (including the Agulhas Current system south of Africa). Agulhas rings (green circles) and their saline influence into the eastern South Atlantic (green arcs) are shown. The existing South Atlantic MOC Basin-wide Array (SAMBA) array along 34.5°S is shown as a solid red line, and the proposed full transect, to be completed in 2014 and 2015, is shown as a dashed line. The Rapid Climate Change (RAPID) MOC/Meridional Overturning Circulation and Heat Flux Array (MOCHA) in the North Atlantic (referred to here as RAPID) is shown also as a solid red line along 26.5°N. Schematic adapted from Zahn [2009].

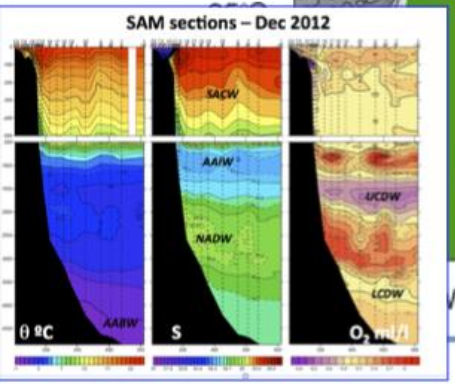
By I. J. Ansorge, M. O. Baringer, E. J. D. Campos, S. Dong, R. A. Fine, S. L. Garzoli, G. Goni, C. S. Meinen, R. C. Perez, A. R. Piola, M. J. Roberts, S. Speich, J. Sprintall, T. Terre, and M. A. Van den Berg



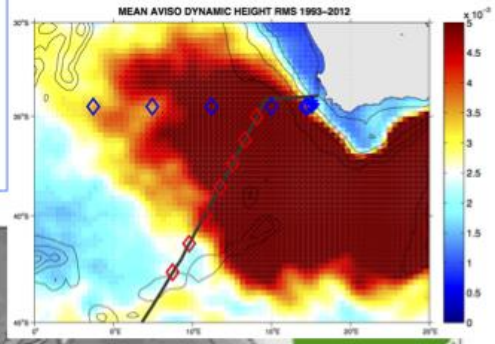
THE PRESENT SAMOC ARRAY: Observations to measure Meridional fluxes and interocean exchanges

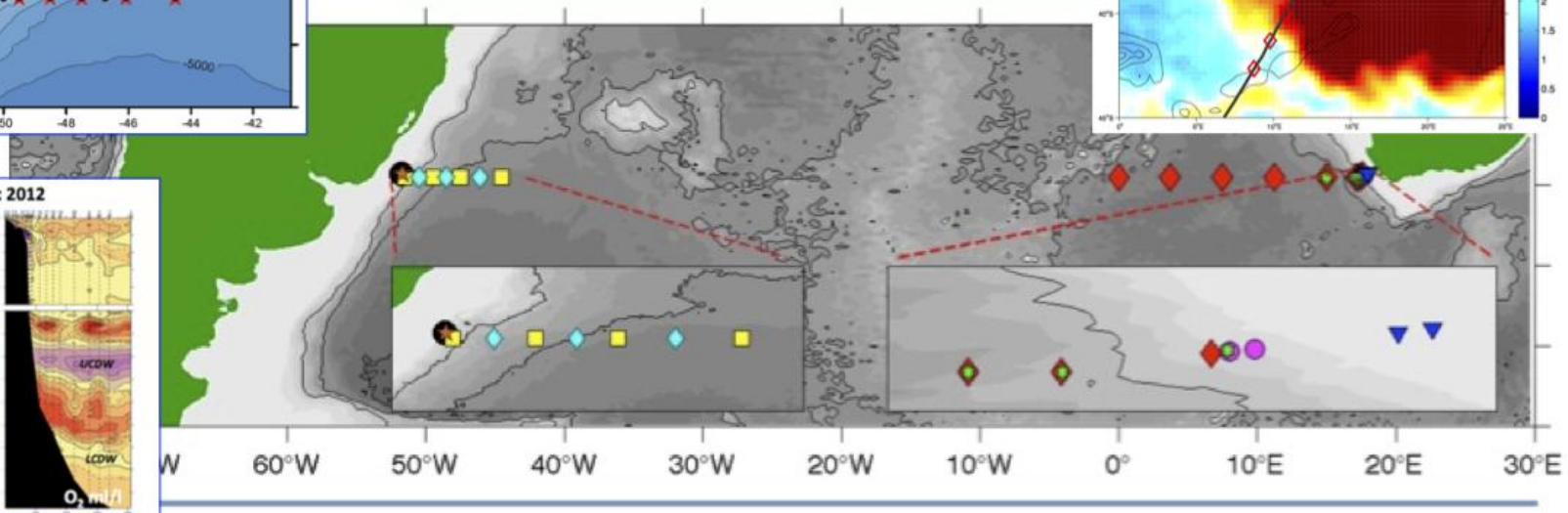
SAM Cruise December 2012





•**7 PIES** were deployed in **Dec 2014** along the **oblique GoodHope transect** (JASON-2 ground track) out to Agulhas Ridge
•Gray line: CLIVAR GoodHope line sampled twice/ year





Temperature, Salinity and Oxygen has been collected during 10 SAM cruises on board of Argentinean and Brazilian research vessels. From Piola, in preparation.

- Refurbishment and redeployment of each CPIES - and first results downloaded
- Hydrographic survey of SAMBA and GoodHope in winter
- Training opportunity for postgraduate students
- First results to be presented at Ocean Sciences New Orleans