SAMOC Implementation Plan

South Atlantic Meridional Overturning Circulation – Future observing system

Background/Introduction

Observations and coupled climate models consistently indicate that variations in the Meridional Overturning Circulation (MOC) are strongly correlated to important climate changes such as variations in precipitation and surface air temperatures over large regions of the globe. To date, most MOC observations have been focused in the North Atlantic, however model studies show that the South Atlantic is not just a passive conduit for the passage of water masses formed in other regions of the world ocean but instead actively participates in their transformation. Water mass transformations occur across the entire basin, but are intensified in regions of high mesoscale variability, particularly at the Brazil/Malvinas Confluence and at the Agulhas Retroflection. Models and observations also show that the South Atlantic plays a significant role in the establishment of oceanic teleconnections. For example, model results indicate that anomalies generated in the Southern Ocean are transmitted through inter-ocean exchanges to the northern basins. The Agulhas leakage influence reaches the northern hemisphere and models suggest that changes occurring in the South Atlantic alter the global MOC. These results highlight the need for sustained observations in the South Atlantic and in the choke points in the Southern Ocean, which, in conjunction with modeling efforts, would improve understanding of the processes necessary to formulate long-term climate predictions. Further information and references can be obtained at

www.aoml.noaa.gov/phod/SAMOC.

The way forward

Based on the community discussion and agreement achieved during four international South Atlantic Meridional Overturning Circulation (SAMOC) workshops during 2007-2011, this implementation plan has been prepared describing a plan for moving forward on measuring the strength of the MOC as well as the meridional heat transport and the meridional fresh-water transport in the South Atlantic, all of which are crucial to improving understanding of climate system variability.

What needs to be measured?

To characterize the time-mean and time-varying components of the MOC in the South Atlantic, as well as the heat and salt carried by the MOC, the international science community has agreed that it will be necessary to measure the full-water-column, full-basin-width, meridional velocity, temperature and salinity along a line of latitude in the South Atlantic. Numerical and analytical modeling indicate that higher latitudes will provide better estimates of the basin-wide MOC, and as such the region from 32-35°S has been identified as the best location for a trans-basin measurement system. Experience gained through the implementation of the North Atlantic MOC observing array at 26.5°N suggests that it is critically necessary to obtain MOC estimates at a very high sampling rate, i.e. daily, to avoid aliasing high-frequency fluctuations into the semi-annual, annual, and longer periods that are of significant interest to climate studies. Tests of prospective array types in a variety of ocean models suggest that 'geostrophic-style' mooring arrays, i.e. those which provide estimates of full-water-column density profiles, are likely to provide very accurate transport estimates for calculating the MOC, although care must be taken not to design an array so zonally sparse as to provide insufficient heat and salt information for calculating meridional transports of those quantities. Moored arrays based on direct velocity measurements would not be cost effective for the trans-basin array, although focused use of direct measurements in the shelf regions and at depth along the continental slope will be crucial. In addition to a moored time-series array, it will also be important to collect trans-basin hydrographic sections for aid in the analysis and attribution of the moored observations.

Where do measurements need to be collected?

Numerical model studies completed in the United States, the United Kingdom, and in Brazil, as well as theoretical studies completed in the Netherlands, indicate that the higher latitudes (32-35°S) are likely to produce more robust estimates of the MOC for several reasons. First and foremost, higher latitudes provide stronger density gradients, leading to improved signal-to-noise characteristics for geostrophic velocity calculations. Secondly, the strongest signals are more tightly confined to the boundaries at higher latitudes, particularly near the eastern boundary, meaning the more intensely sampled array can be done in a smaller region. Thirdly, the measurement of the stability of the MOC, a crucial factor in attribution of observed signals, is more favorable at higher latitudes. Finally, several ocean model studies indicate that at higher latitudes it is possible to utilize less expensive mooring technologies (i.e. pressure-equipped inverted echo sounders) more effectively in some key locations instead of full-depth taut-line moorings, reducing the cost of the overall system. The community recommendation is that a SAMOC monitoring array be located between 32-35°S, and that it involves 10-20 deep ocean moorings, a combination of tall moorings and pressure-equipped inverted echo sounders, coupled with several shorter direct velocity moorings on the shelf on either side of the basin. Furthermore, attribution of the observed signals at 32-35°S will require concurrent observations from Drake Passage and in the passage between Africa and Antarctica. Therefore, maintaining and augmenting the existing arrays in those areas will be crucial for success.

What resources are already in place?

Some observation systems are already in place that can be used as building blocks for a trans-basin array, while other existing global *in situ* and satellite data sets will provide crucial information for analysis and attribution of the data from the recommended program. Pilot boundary current measurement systems are already in place on the western boundary (USA-NOAA, Argentina-SHN, Brazil-USP,Navy) and on the eastern boundary (France_Ifremer, South Africa-UCT) along 34.5°S. Trans-basin expendable bathythermograph sections are collected quarterly (USA-NOAA) along 34.5°S, with trans-basin conductivity-temperature-depth sections collected less frequently in the region of 25°S-34.5°S as well (USA-NOAA/NSF, United Kingdom, Brazil). A group of North and South American countries operating through the Intra-Americas-Institute for Climate Change Research (IAI) have a large shelf-monitoring program planned for the western boundary that would fit together nicely with the western end of the recommended trans-basin array (USA-WHOI, USA-OSU, Argentina-SHN). South

Africa (UCT) recently initiated a shelf array measuring velocity on the eastern shelf that will greatly add to the measurements at that end of the line. Several groups already collect additional hydrographic observations in the region that would be extremely valuable for analysis purposes (Argentina, Brazil, France, Germany, Russia, South Africa, the United Kingdom, the United States). The global observing system, particularly the ARGO float network, the global drifter array, and satellite observations of sea height, sea-surface temperature, sea-surface salinity (SMOS, and upcoming Aquarius), and surface wind will also be crucial for analysis and attribution of signals observed by the moored system.

What plans are being formulated to address these goals?

Based on conversations at the four SAMOC workshops in 2007-2011 (see webpage listed above), a consortium of groups have submitted and/or are submitting proposals to support a trans-basin array along 34.5°S between Uruguay and South Africa. Representatives from several countries also have sought and/or are seeking funding to support ship-time for maintaining the array. The partners seeking funding to date in this endeavor include Argentina (Naval Hydrographic Service), Brazil (Naval Hydrographic Service), Russia (Shirshov Institute of Oceanography), South Africa (Univ. of Cape Town), the United States (NOAA, Scripps, MIT) and possibly the United Kingdom (National Oceanography Centre, British Antarctic Survey).