2013 CLIVAR Country Report: South Africa

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Projects and Publications

Southern Ocean Seasonal Cycle Experiment 2012: Seasonal scale climate and carbon cycle links (CSIR, UCT, SU)

Sebastiaan Swart, Nicolette Chang1 , Nicolas Fauchereau, Warren Joubert, Mike Lucas, Thato Mtshali, Alakendra Roychoudhury, Alessandro Tagliabue, Sandy Thomalla, Howard Waldron, Pedro M.S. Monteiro
News and Views S Afr J Sci 2012; 108(3/4) http://www.sajs.co.za

SOSCEx has four main themes which address the same intraseasonal and submesoscale questions which link the carbon cycle to climate variability: mixed-layer stratification dynamics; CO_2 and O_2 gas exchange with the atmosphere; carbon export from the mixed layer; and the bio-optics linking water column inherent optical properties to outgoing-satellite visible irradiance. In SOSCEx, concurrent in-situ observational and modelling approaches are used to investigate the sampling scales necessary for in-situ observations and testing hypotheses at larger temporal and spatial scales. The modelling experiments will initially be used in two ways. The first is an 'upstream mode' in which the model is a surrogate database that enables us – a priori – to try to determine optimal strategies for positioning gliders by deploying virtual gliders in the model and investigating the effects of different sampling strategies on their recovery in order to anticipate the scales of variability we can expect. By contrast, the second way, a 'downstream mode', will use the model after the experiment in order to test new model parameterisations and to compare modelled and observed scales of variability. The research plan is coordinated to span approaches that encompass in-situ and remotely sensed observations, modelling and laboratory experiments.

The experiment is planned to take place around the three annual logistical trips of the ship, starting with the spring voyage to Gough Island, the mid-summer voyage to the South African National Antarctic Expedition (SANAE) base and the autumn voyage to Marion Island with little (5–10 days) additional time required above the existing schedule. In-situ sampling will begin in September 2012 during the austral spring relief voyage from Cape Town to Gough Island

(located at 40.2°S, 10°E). The four iRobot® SeagliderTM units (Figure 2) will be deployed from the ship (1) south of the Subtropical Front, (2) in the Subantarctic Zone, (3) at the Subantarctic Front and (4) in the northern Polar Frontal Zone. The seagliders will be programmed to profile the water column from the surface to a depth of 1000 m and at a nominal horizontal resolution of every 4 km (4 dives/day). Carbon–explorer floats will be deployed at the same locations as each glider and two Liquid Robotics wave–glider units will be deployed in the Subantarctic Zone and Polar Frontal Zone to sample CO2 and oxygen to derive their fluxes. Each of the units will then be intercepted during the summer SANAE poleward or equatorward legs and finally retrieved in the autumn on the Marion Island trip. Full-depth water column profiles, including clean casts for iron chemistry, will be undertaken at each release and interception location. This sampling will provide us with the biogeochemical and physics boundary conditions of the system, such as CO2 levels, nutrients, iron concentrations, phytoplankton species composition and bio-optics. It will also allow for calibration and quality checks of the data received from the temperature, salinity, oxygen, backscatter, fluorescence and photosynthetically active radiation sensors housed on the gliders. Concurrent on-board bio-assay incubation experiments will examine the limiting factor of phytoplankton growth to be determined (light or iron) and contribute to improving model parameterisation in the Southern Ocean. The water column process stations will be supplemented by six profiles to 1000 m along the meridional axis of the sampling. Continuous remotely sensed data will be collected and used as an independent, large-scale data set before, during and after the period of the experiment. These data include, for example, sea surface height and temperature data to inform on the dynamics of ocean circulation, while ocean colour data will be used as an indicator of primary production and biomass accumulation in the surface waters.
SOSCEx provides a new and unprecedented opportunity to gain a better understanding of the links between climate drivers and ecosystem productivity and climate feedbacks in the Southern Ocean. This combined high-resolution approach to both observations and modelling experiments will permit us, for the first time, to address some key questions relating to the physical nature of the Southern Ocean and its carbon cycle.

This is an activity of the Southern Ocean Carbon – Climate Observatory Programme (SOCCO) which has now been completed and the data analysis is underway.

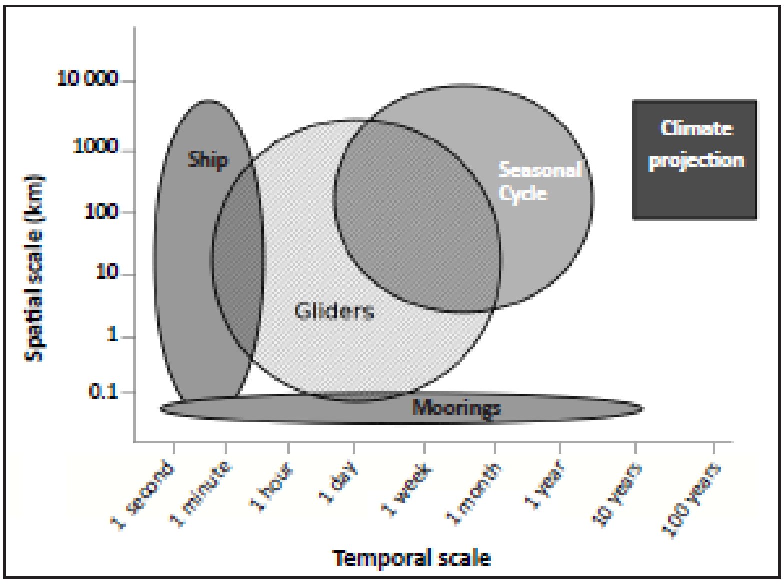

FIGURE 1: A space–time plot showing relative scale magnitudes of a number of platforms (ships, instrumented moorings and gliders), the seasonal cycle and climate projections. This graphical representation emphasises that, even with both ships and moorings observational platforms, it is not possible to address questions on the seasonal cycle sensitivity of climate projections without using autonomous platforms. Ocean gliders are uniquely poised to bridge the spatial and temporal gap between ships and moorings – a bridge which critically covers the seasonal 'window' in the Southern Ocean Seasonal Cycle Experiment.

Modelled Sea-Surface Temperature Scenario Considerations and Southern African Seasonal Rainfall and Temperature Predictability

Asmerom F. Beraki, Willem A. Landman, David G. DeWitt, Cobus Olivier, Kelebogile Mathole, Thando Ndaran (CSIR and SAWS)
Water Research Commission of South Africa: Report

The specific objectives of the project were:
1. To investigate an optimal model configuration that includes the best available description of the surface boundary conditions as reflected in projected global SST, in
Climate predictability and seasonal climate prediction improvement iii order to force AGCMs to produce seasonal rainfall and temperature forecasts over South Africa at lead-times of several months.
2. To develop a global SST forecast product that includes probabilistic forecasts of El Niño and La Niña events.
3. To conduct a comprehensive comparative analysis between a one-tiered and a two-tiered forecasting system.

The project made the following unique contributions to influence the current seasonal operational Multi-Model System (MMS) maintained by the South African Weather Service (SAWS) originally developed locally by the SAWS in collaboration with the Council for Scientific and Industrial Research (CSIR).
1. The emergence of the state-of-the-art Ocean-Atmosphere Coupled Climate Model (OAGCM) locally.

ECHAM4.5-MOM3-SA OAGCM was coupled at the SAWS in collaboration with the International Research Institute for Climate and Society (IRI) and has been configured for operational seasonal forecast production. The model uses ECHAM4.5 atmospheric model, MOM3 ocean model and MPMD (multiple program multiple data) coupler software. This is a major development in local numerical modelling effort following the SAWS being granted the World Meteorological Organization's Global Producing Centre (GPC) for Long-Range Forecasts (LRF). The fact that this coupled model has achieved comparable levels of skill for the Niño-3.4 region with state-of-the-art coupled models administered by international centres is encouraging.
2. The development of high-resolution Multi-Model SST Prediction System.

The system is deemed robust by the IRI and as a result the operational ENSO forecasts are being included as the only contribution from this continent into the IRI ENSO forecast plume. Moreover, global SST hindcasts/forecast are being used by local modelling groups. These novel SST forecasts, including the probabilistic ENSO forecasts, are done in South Africa through the technology developed here. This work has also given direction to the seasonal forecast modelling community in South Africa by providing them with versatile and optimised global SST hindcasts/forecasts for AGCM-based hindcast/forecast production.

3. The optimization of a two-tiered forecasting system.

The two-tiered forecasting system administered by the SAWS has recently been optimized and brought to the standard currently practiced by leading international centres which are still running two-tiered forecasting systems operationally. This optimized forecasting system demonstrates large-scale consistent skill improvements over the old system for a number of variables including, inter alia, surface temperature and rainfall.

The main conclusion from this analysis is that the coupled model is superior to the uncoupled model. Therefore, in South Africa resources should be directed towards coupled model development. However, the optimization of uncoupled models should continue to take place, even if it is to form a strong baseline against which coupled systems can be compared, but also to support the notion of running uncoupled models for the purpose of increasing the ensemble of the multi-model system.

Tropical systems from the southwest Indian Ocean making landfall over the Limpopo River Basin, southern Africa: a historical perspective

J. Malherbe, F.A. Engelbrecht, W.A. Landman and C.J. Engelbrecht (CSIR and SAWS)
Int. J. Climatol. 32: 1018–1032 (2012)

ABSTRACT: The study provides perspective on the contribution of landfalling tropical systems (cyclones, depressions, storms and lows) from the southwest Indian Ocean (SWIO) towards rainfall over the eastern interior of southern Africa, over the period 1948–2008. Although these systems contribute to <10% of the annual rainfall occurring over the region, their relative contribution to local and widespread heavy rainfall events is shown to be highly significant. About 50% of widespread heavy rainfall events over northeastern South Africa are caused by landfalling tropical systems. Fourier analysis performed on the time series of rainfall occurring over northeastern South Africa in association with these systems reveals the existence of a quasi-18-year cycle. The cycle coincides with the well-known quasi-18-year Dyer–Tyson cycle in rainfall over the summer rainfall region of South Africa. These results suggest that atmospheric and surface conditions leading to wet phases of the Dyer–Tyson cycle also favour the landfall and subsequent westward movement of tropical systems from the SWIO over southern Africa – and their eventual contribution to rainfall over northeastern South Africa and southern Zimbabwe.

Multi-model forecast skill for mid-summer rainfall over southern Africa

Willem A. Landman and Asmerom Beraki (CSIR and SAWS)
Int. J. Climatol. 32: 303–314 (2012)

ABSTRACT: Southern African December-January-February (DJF) probabilistic rainfall forecast skill is assessed over a 22-year retroactive test period (1980/1981 to 2001/2002) by considering multi-model ensembles consisting of downscaled

forecasts from three of the DEMETER models, the ECMWF, M´et´eo-France and UKMO coupled ocean-atmosphere general
circulation models. These models are initialized in such a way that DJF forecasts are produced at an approximate 1-month
lead time, i.e. forecasts made in early November. Multi-model forecasts are obtained by: i) downscaling each model's
850 hPa geopotential height field forecast using canonical correlation analysis (CCA) and then simply averaging the rainfall
forecasts; and ii) by combining the three models' 850 hPa forecasts, and then downscaling them using CCA. Downscaling
is performed onto the 0.5° × 0.5° resolution of the CRU rainfall data set south of 10° south over Africa. Forecast verification
is performed using the relative operating characteristic (ROC) and the reliability diagram. The performance of the two
multi-model combinations approaches are compared with the single-model downscaled forecasts and also with each other.
It is shown that the multi-model forecasts outperform the single model forecasts, that the two multi-model schemes produce
about equally skilful forecasts, and that the forecasts perform better during El Ni˜no and La Ni˜na seasons than during neutral
years.

South Atlantic Meridional Overturning Circulation (SAMOC) – South Africa's role

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In the past two decades, discussions on greenhouse warming or the collapse of the global ocean Meridional Overturning Circulation (MOC) and abrupt climate change were largely restricted to academic circles. Nowadays, however, the same topics provide fuel for public debate and mounting pressure for an increase in governmental awareness as substantial indicators suggest that climate is undergoing significant variability and change. The perceived fragility of the climate system has prompted a flurry of new studies whose conclusions are worrisome. Policymakers face the dilemma that, although the changes may be a response of the oceans to global warming, they could just as easily be a natural mode of oceanic change. To separate anthropogenic from natural effects is challenging and to do so we need to substantially improve the existing observational system and foster the development of more realistic but complex models of the climate system.

At present there is only one monitoring system of the MOC in the North Atlantic, namely the RAPID/MOCHA mooring array (Figure 1- yellow line). This not only comprises moored moorings of instruments but also the systematic use of research vessels and self-propelled gliders to monitor the Northern Atlantic Ocean. Given the complexity and the worldwide extent of the MOC it is obvious that a more comprehensive view must take into account changes happening elsewhere and in particular the teleconnection between the South and the North Atlantic Oceans (Figure 1). This connection results in the southward flow of deep cold and salty water masses from the North Atlantic and a compensating northward, warm water pathway in the upper layer of the ocean. Although these pathways are still being defined, recent investigations have shown that intensification and mixing may occur in regions of high mesoscale variability—particularly south of Africa at the Agulhas Retroflection (Figure 2) where warm core eddies are spawned

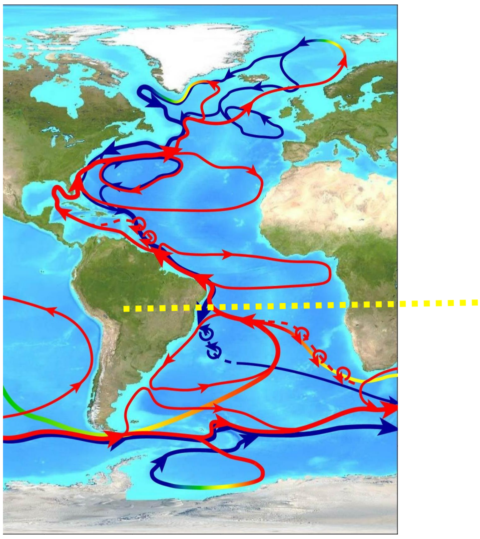

Figure 2: A schematic highlighting the Atlantic Meridional Overturning Circulation and the oceanic teleconnection between the south and north ocean basins. Red arrows represent the complexity of the surface currents (upper 1000 m) with blue corresponding to the deeper (>2000 m) return flows. The current RAPID array in the North Atlantic is represented as a yellow line with a white line highlighting the position of the proposed SAMBA array as part of the SAMOC programme.

In spite of its climatic importance, there is no coherent observational system in place to monitor the South Atlantic's inter-ocean exchanges. Although there are individual efforts to measure the circulation south of Africa (Figure 2), none of these have previously been coordinated, nor have these systems been designed for long-term monitoring purposes. SAMOC aims to address this. It is now essential that our monitoring capabilities of the South Atlantic's inter-ocean exchanges become significantly improved in line with the activities in the North

Atlantic. Modelling and observational studies undertaken at both UCT-Oceanography and DEA-Oceans and Coasts have provided evidence that increased transport of warm Agulhas water south of South Africa into the Atlantic plays a role in strengthening local storms and increasing rainfall over large parts of South Africa. Many of South Africa's flooding disasters have resulted from atmospheric cut-off lows that can intensify further when the southern Agulhas Current is anomalously strong and warm.

Meeting Activity

Mathieu Rouault member of CLIVAR AFRICA and CLIVAR ATLANTIC panels hosted the annual meeting of CLIVAR Africa at University of Cape Town in November 2011. He also participated to the CLIVAR Atlantic meeting in Kiel in September 2012. CLIVAR related activities are somehow coordinated by ACCESS and also take place at the CSIR, University of Cape Town, University of Pretoria, South African Weather Service and WITS, The annual South African Society for Atmospheric Sciences SASAS (http://www.sasas.org.za/) conference attended in general by around 100 persons every years is a good meeting point for clivar activities and publishes extended abstract available online. The next conference will be heal at University of Kwazalu-Natal the last week of September 2013. Otherwise related publications from the dept. of Oceanography on climate and ocean-atmosphere interaction are listed at http://sea.uct.ac.za/department-publications . At last the Nansen Center for Environment Research hosted at University of Cape Town is a new South-Africa Norway venture whose activities that are aligned to CLIVAR.