Argo National Report – South Africa

Report to Argo Steering Team Meeting: March 2015

The South African Argo Program presently is one of deployment opportunities and educational outreach as opposed to procuring of floats and seeding the global Argo array. However, we are striving to develop projects and funding opportunities in that direction. Given South Africa's unique position geographically of bordering three oceans – The Atlantic, Indian and Southern Oceans – we are able to provide numerous deployment opportunities for Argo floats to the global array. We are also working on dynamic research programs and experiments using Argo floats to a) study physical forcing dynamics and b) contribute to the development of biogeochemical floats particularly in the Southern Ocean. The research groups currently involved in the South African Argo program are: The South African Weather Services (SAWS) – who are the National Focal Point, Bayworld Centre for Research and Education (BCRE), University of Cape Town (UCT), the Department of Environmental Affairs (DEA), The Council for Scientific and Industrial Research (CSIR), The South African Environmental Observation Network (SAEON), the Research Schooner *Lady Amber* and the Nansen-Tutu Centre for Marine Environmental Research.

1. **Status of implementation (major achievements and problems in 2014):**

   Floats deployed and their performance

   Southern Ocean and South Atlantic Ocean:

   Gough Island Cruise (RV SA *Agulhas II*) – September 2014

   6 APEX floats: UK Met Office with UCT / DEA

   (serial #'s: 6994, 6995, 6993, 6992, 6991, 6990)

   SANAE Cruise (RV SA *Agulhas II*) – November 2014-February 2015

   14 ARVOR floats: University of Brest with UCT

   4 Bio-Argo floats: Laboratoire d'Océanographie de Villefranche (LOV) with UCT

   (serial #'s: lovbio 019b, lovbio 041c, lovbio 049b, lovbio 081b)

   Indian Ocean:

   Walter Shoal Expedition (RV *Algoa*) – May 2014

   6 APEX floats: UK MetOffice with BCRE

   (WMO#'s: 1901846, 1901847, 1901848, 1901849, 1901850, 1901851)

   Technical issues encountered and solved:

   a) The Department of Environmental Affairs' Nova floats (10) were sent to Lwandle Technologies for float self testing checks as they had been in storage for an extended period of time. Two float were not responding to tests and once sent back to the manufacturers were found to have faulty vacumm switches. These were since replaced and floats retested. No plans exist yet to deploy the remaining eight floats.

b) An application to the South African Cabinet was made to allow Argo floats (and other instruments such as drifters, etc) to be freely deployed in South Africa's EEZ. This has not yet been approved.

Status of contributions to Argo data management (including status of pressure corrections, technical files, etc)

None

Status of delayed mode quality control processes:

Not applicable

2. **Present level of (and future prospects for) national funding for Argo including summary of human resources devoted to Argo:**

Dedicated Argo funding to procure new floats to seed the global array is currently being investigated through the South African Environmental Observation Network (SAEON). Individuals from organisations (listed above) work on different projects involving Argo floats and have come together under the auspices of the South African Argo program to share knowledge, resources, cruise time where applicable and information regarding Argo. We are working towards taking this forward now.

We have one Argo representative for the South African Marine Science community who is also looking to drive the Argo float procurements and data management plans in future endevours.

3. **Summary of deployment plans (level of commitment, areas of float deployment, low or high resolution profiles, extra sensors, Deep Argo) and other commitments to Argo (data management) for the upcoming year and beyond where possible:**

<u>Southern Ocean:</u>

Marion Island Cruise (RV SA *Agulhas II*) – April/May 2015

4 Bio-Argo floats: LOV with UCT

Gough Island Cruise (RV SA *Agulhas II*) – September 2015

available for deployment assistance

SANAE Cruise (RV SA *Agulhas II*) – December 2014 / January 2015

available for deployment assistance

<u>Indian Ocean:</u>

Agulhas System Climate Array (ASCA) deployment cruise – April 2015

available for deployment assistance

East coast mooring cruise (RV *Algoa*) – June-July 2015

available for deployment assistance

East coast mooring cruise (RV *Algoa*) – November-December 2015

available for deployment assistance

International Indian Ocean Expedition (IIOE-2) Expeditions

Cruises are being developed for both the eastern and western Indian Ocean and these can be communicated for interested countries wanting to deploy Argo floats into the Indian Ocean. The Research Schooner *Lady Amber* will also be taking part in these expeditions and her contact details are found below.

Atlantic Ocean:

SAMBA Mooring Array (RV *Algoa*) – October 2015

available for deployment assistance

Pacific Ocean: 2016-2017 (future plans):

The Research Schooner *Lady Amber* will be working with NASA from April 2016 to August 2017 on the Salinity Processes Upper-ocean Regional Study (SPURS-2) Experiment around 10° N and 125° W. There could be opportunities here to deploy Argo floats within the Pacific Ocean but also en route to and from the study region.

Contact: Capt. Peter Flanagan on explorerstrust_uk@yahoo.co.uk

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites:

Three research and two outreach project are noted below:

a) SOBOM:

Isabelle Ansorge

The Centre for Southern Ocean Biogeochemical Observations and Modeling (SOBOM) are a focused group developing a new ocean observing system for carbon, nutrients and oxygen that will complement the already established observing system for heat and freshwater. To this end, 150-200 profiling floats equipped with biogeochemical sensors will be deployed throughout the Southern Ocean and the cruises run by UCT (Dr. Ansorge) in this region (i.e. SANAE and Gough Island) will be used as a platform for deployments. Four bio-Argo floats from LOV were deployed on the 2014/2015 SANAE cruise, with a further four more planned for the Marion 2015 cruise in April.

http://sobom.princeton.edu/content/deployment-opportunities

b) SOSCEx III:

Pedro M.S. Monteiro, Sebastiaan Swart, Sandy Thomalla and Thato Mtshali

SOSCEX III is the focus of a suite of five NRF-SANAP projects funded for the 2015 – 2017 cycle. This forms a central part of the new Climate focused research theme in the Southern Ocean as articulated in both ARESSA as well as the emerging Antarctic and Southern Ocean strategy of the NRF-DST. It is our aim to attract wider collaboration from national, regional and international partners into this unique Climate – Carbon – Ecosystems research platform. To this end we will be publishing the more detailed SOSCEX III White Paper and focusing on linking up with the US based SOCOM initiative (using floats as central platforms) as well as inviting graduate student participation from Mozambique, Namibia and Zimbabwe.

Please refer to Appendix 1 for further information.

www.csir.co.za/nre/coasts_and_oceans/osc.html

c) Validating Hycom-EnOI in the Agulhas using Argo profiling floats - The Nansen-Tutu Centre for Marine Environmental Research (UCT)

Charine Collins, Björn Backeberg, François Counillon and Johnny Johannessen

The greater Agulhas Current system, one of the most energetic systems in the world, plays a key role in the global ocean circulation, regional weather, and the marine environment. A prediction system of the marine environment around southern Africa would not only be beneficial to regional commercial, industrial, and leisure activities, but it would also aid search and rescue activities, and the monitoring of accidental pollutants and harmful algal blooms.

Despite the emergence of various global prediction (operational data assimilation) systems (e.g. MyOcean, Blue-Link), there is hitherto no system for the southern African regional ocean. As a first attempt towards an ocean prediction system for southern Africa, A regional data assimilation system of the greater Agulhas system was developed recently (Backeberg et al., 2014). This system, while not operational yet, assimilates satellite altimeter along-track sea level anomaly (SLA) data into a HYbrid Coordinate Ocean Model (HYCOM) simulation of the Agulhas Current System using the Ensemble Optimal Interpolation (EnOI) data assimilation scheme (hereafter referred to as HYCOM-EnOI). While HYCOM-EnOI improved the meso-scale dynamics in the Agulhas Current system, as well as the water mass characteristics and velocities at ~1000m, there was a slight degradation of the SST distribution.

In this study, we assess the limitations of HYCOM-EnOI in reproducing the water mass properties of the Agulhas Current region through a detailed comparison with Argo profiling floats. A comparison between HYCOM-EnOI and the Argo profiling floats is made in terms of temperature and salinity differences at various depths, differences in water mass characteristics, and mixed layer depth.

The temperature values in the upper 100m simulated in HYCOM-EnOI are, for most of the region, in close agreement (±1°C) with the observations (Figure 3a). On the contrary there is an overestimation of the salinity values in the upper 100m simulated in HYCOM-EnOI by about 0.1psu (Figure3b). In the 500-1000m depth range, HYCOM-EnOI tends to underestimate temperature (Figure 3c) and salinity (Figure 3d) values south of the Agulhas bank, in the vicinity of the Agulhas Retroflection region and the Agulhas Return Current. West of the Agulhas bank, the temperature of HYCOM-EnOI is in good agreement with the observations (±1°C), however, there is again an overestimation of the salinity values by more than 0.1psu. In the deeper layers (1000-2000m, HYCOM-EnOI tends to underestimate the temperature and salinity throughout the region, except east of the Agulhas Bank where there is a good agreement with the observations.

d) Educational Outreach – The Argo Floats Program by SAEON Egagasini:

Thomas Mtontsi and Tamaryn Morris

Five secondary schools have been identified in the Western Cape region to track changes at sea from data collected on floats 1901469 and 1901470 purchased by SAEON/SANAP with support from SAWS and deployed in 2009.

In 2014 school monitoring teams were encouraged to do schools science projects on:

1. The Identification of deep water masses and their direction using temperature
2. Relationships between salinity and depth
3. Relations of temperature, pressure and salinity

The overall focus of the SAEON Egagasini education programme is to:

- primarily encourage awareness of science skills to learners
- to create a platform where Marine Science Research can be integrated into School Sciences curriculum by encouraging interactions between learners, educators and scientists
- to promote an understanding of, create awareness and generate an interest about our oceans

e) Educational Outreach – The Research Schooner *Lady Amber*:

Capt Peter Flanagan

Capt. Flanagan, along with Mrs Carol Young, the Education Consultant for UNESCO, attended hosted the third Argo Outreach Program held in Mauritius by invitation of the Honorable Dr. Bunwaree – Minister for Education. A week long workshop from 07-11 July 2014 was held developing skills on Argo data downloading and interpretation. A total of 98 schools were represented from around Mauritius and each "adopted" an Argo float to continue monitoring in their own capacities.
Continued effort is being made by Capt. Flanagan and his crew from the Research Schooner *Lady Amber* to bring awareness of the Argo program to secondary schools. Most notably in collaboration with the GLOBE project out of Mossel Bay.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

None at this stage.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public:

The following cruises in the Mozambique Channel were loaded onto the CLIVAR + Carbon Hydrographic Data Office (CCHDO) website for Argo data validation:

- Alg 134 – April 2005 data
- Alg 160 – August 2007 data
- Nansen 2008 – November/December 2008 data
- Nansen 2009 – August 2009 data
- Antea_2009 – October / November 2009 data
- Antea_2010 – April 2010 data

7. Keeping the Argo Bibliography up to date:

Ansorge, I.J, Jackson, J.M., Reid, K., Durgadoo, J.V., Swart, S. and Eberenz, S. – 2014. Evidence of a southward eddy corridor in the South-West Indian Ocean. Article in press. Special issue editor Igor Belkin.

Tagliabue, A., J-B Sallée, A. R. Bowie, M. Lévy, S. Swart and P. W. Boyd, Surface water iron supplies in the Southern Ocean sustained by deep winter mixing, Nature Geoscience, doi:10.1038/ngeo2101, 2014.

Domingues, R., G. Goni, S. Swart, and S. Dong. Wind forced variability of the Antarctic Circumpolar Current south of Africa between 1993 and 2010, J. Geophys. Res. Oceans, 119, 1123–1145, doi:10.1002/2013JC008908, 2014.

Thomalla, S. J., N. Fauchereau, S. Swart, and P. M. S. Monteiro. Regional scale characteristics of the seasonal cycle of chlorophyll in the Southern Ocean, Biogeosciences, 8, 2849-2866, doi:10.5194/bg-8-2849-2011. 2011.

Swart, S., S. Speich, I. J. Ansorge, and J. R. E. Lutjeharms. An altimetry-based gravest empirical mode south of Africa: 1. Development and validation, J. Geophys. Res., 115, C03002, doi:10.1029/2009JC005299. 2010.

Swart, S., and S. Speich. An altimetry-based gravest empirical mode south of Africa: 2. Dynamic nature of the Antarctic Circumpolar Current fronts, J. Geophys. Res., 115, C03003, doi:10.1029/2009JC005300. 2010.

Note: Submitted here are all papers that we were made aware of last year, though you may already have them.

8. Thesis citation list:

Swart, S. 2009. Transport and variability of the Antarctic Circumpolar Current south of Africa. PhD, University of Cape Town, South Africa, December 2009.

Note: This thesis may be in your list already, but noted here just in case.

APPENDIX 1:

The 3rd Southern Ocean Seasonal Cycle Experiment (SOSCEx III)

Pedro M.S. Monteiro, Sebastiaan Swart, Sandy Thomalla and Thato Mtshali

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Introduction

Strategic Context

SOSCEX III is the focus of a suite of five NRF-SANAP projects funded for the 2015 – 2017 cycle. This forms a central part of the new Climate focused research theme in the Southern Ocean as articulated in both ARESSA as well as the emerging Antarctic and Southern Ocean strategy of the NRF-DST. It is our aim to attract wider collaboration from national, regional and international partners into this unique Climate – Carbon – Ecosystems research platform. To this end we will be publishing the more detailed SOSCEX III White Paper and focusing on linking up with the US based SOCOM initiative (using floats as central platforms) as well as inviting graduate student participation from Mozambique, Namibia and Zimbabwe.

Science Context

The Southern Ocean is a key component of the earth system, being responsible for 50% of ocean uptake of atmospheric CO_2 and 30% of carbon export flux to the deep ocean (Schlitzer et al., 2002, Majkut et al., 2014). Climate models and decadal data sets predict changes in the Earth's climate that will influence the effectiveness of the Southern Ocean CO_2 sink through adjustments to sea surface temperature, stratification and mixing (Boyd 2002), all of which affect the nutrient and light supply necessary for phytoplankton production (and associated carbon export). The challenge in predicting long term trends in the Southern Ocean carbon cycle lies in our ability to resolve interannual variability and the link between seasonal and intraseasonal dynamics in physical drivers and biogeochemical responses. Despite their importance, surface ocean processes at these scales are poorly understood and quantified due to operational limitations of ships and moorings. This has necessitated the use of autonomous, remotely sensed and modeling platforms that are able to address the temporal and spatial scale gaps in our knowledge of a hitherto under sampled ocean.

Aims

- **Understanding through seasonal scale observations, the role of fine scale upper ocean physical dynamics on CO_2 fluxes and primary production in the Southern Ocean and its impact on large-scale carbon-climate sensitivities.**
- **To make a significant contribution to improving the way global climate models reflect CO_2 and primary productivity climate sensitivities in the Southern Ocean.**

Approach

A novel aspect of SOSCEx III is the integrated multi-platform approach, which aims to explore new questions about the climate sensitivity of carbon and ecosystem dynamics and how these processes are parameterized in models.

1. **Observational**
   The observational approach employs the research ship together with robotics-based continuous year-round, high-resolution observations of the upper ocean. The primary objective is to understand how meso- to sub-mesoscale features (eddies and fronts) interact with seasonal to subseasonal scales (heating & transient storms) to characterize the seasonal cycle of upper ocean mixed layer depth, CO_2 fluxes Fe and light availability, primary production and associated carbon export.
2. **Modelling**
   A hierarchy of medium to ultra-high resolution forced ocean model domains (NEMO-PISCES) will be used to test our understanding of the links between surface boundary layer physical drivers and the biogeochemical response scales, especially in terms of air-sea CO_2 fluxes, ocean productivity and associated carbon export.

Cruise Plan

The observation plans are centered on three seasonal ship-based cruises of the Atlantic Sub-Antarctic Southern Ocean in winter 2015, summer 2015 and autumn 2016 spanned by continuous high resolution robotics-based observations. The primary aims of each cruise and required ship time are summarized below:

1. **Winter**

- Description: Date: July – August 2015; Cape Town to 55^{o}S along GoodHope Line; Ship time: 21 Days; Berth requirements: 20
- Aim 1. Two process stations in the SAZ with twinned glider deployments - surface wave glider and sub-surface buoyancy glider.
- Aim 2. CTD deployments at each process station to provide a) winter Fe profile, b) biogeochemical measurements to characterize the plankton community and rates of production and c) necessary calibrations for the gliders.

2. **Summer**
   Leg 1

- Description: Date: November - December 2015; Cape Town to Antarctica along GoodHope Line on SANAE 55; Ship stopping time: 4 Days; Berth requirements: 10
- Aim 1. Swap out buoyancy gliders and retrieve wave gliders (for overhaul and refurbishment) at both process stations in the SAZ
- Aim 2. CTD deployments at each process station to provide a) early summer Fe profile, b) necessary calibrations for the gliders.

Leg 2

- Description: Date: December 2015 - January 2016; Cape Town to 55^{o}S along GoodHope Line; Ship time: 35 Days; Berth requirements: 25
- Aim 1. Redeployment of wave gliders at two process stations in SAZ to continue twinned sampling above of the buoyancy gliders.
- Aim 2: Ship alternates sampling between two process stations for 21 days (sampling each every alternate day) to measure meso and sub mesoscale evolution of physical, chemical and biological response to sub seasonal storm event.
- Aim 3. Deployment of Lagrangian bio-optics floats at each process station that continue sampling the SAZ till autumn 2016 completing a full seasonal cycle.

- Aim 3. CTD deployments at each process station to provide a) summer Fe profiles, b) time evolution of biogeochemical parameters, c) necessary calibrations for the gliders and floats.

Leg 3

- Description: Date: January - February 2015; Antarctica to Cape Town along GoodHope Line on SANAE 55 return voyage; Ship stopping time: 4 Days; Berth requirements: 10
- Aim 1. CTD deployments at each process station to provide a) late summer Fe profile, b) necessary calibrations for the gliders and floats.
- Aim 2. Retrieval of all buoyancy and wave-gliders at both process stations (floats continue sampling)

3. Autumn

- Description: Date: April – May 2016; Cape Town to Marion Island to 55^{o}S to bio-optics float locations; Ship time: 10 Days; Berth requirements: 10
- Aim 1. CTD deployments at both Lagrangian bio-optics float locations to calibrate float sensors.
- Aim 2. Retrieval of both bio-optics floats.

List of critical requirements

- The redesign of the intake system of the scientific sea water supply to prevent blockage and subsequent pump damage when the pump enters the ice (or kelp beds surrounding subantarctic islands), such that oceanographic research can take place in the marginal ice zone (which dominates the time and spatial coverage of the SA Agulhas II on all SANAE voyages).
- Sufficient band width for efficient internet access particularly during glider and float deployment and retrievals.
- The use of the rubber duck (Zodiac) may be needed for float/glider retrievals, weather permitting.