CLIVAR'S REGIONAL BASIN PANELS AND OCEAN OBSERVATIONS.

Kate Stansfield[(1)], Antonio Caltabiano[(1)]
[(1)]International CLIVAR Project Office, National Oceanography Centre, European Way,
Southampton, SO14 3ZH, UNITED KINGDOM. (ks1@noc.soton.ac.uk; caetano@noc.soton.ac.uk)

This additional contribution outlines the role of CLIVAR's (the Climate Variability and Predictability Project of the World Climate Research Programme - WCRP) ocean basin panels (Atlantic, Indian, Pacific and Southern Ocean) in the regional implementation of ocean observation activities.

1. ATLANTIC PANEL (AIP)

CLIVAR's Atlantic Panel coordinates measurements of the Atlantic Meridional Overturning Circulation (AMOC), initiatives to stimulate the observing system of the South Atlantic and, through the Prediction and Research Moored Array in the Atlantic (PIRATA) and the Tropical Atlantic Climate Experiment (TACE), the observing system of the tropical Atlantic.

1.1 Atlantic Meridional Overturning Circulation (AMOC) studies

The AMOC monitoring system will be significantly enhanced in the next one to five years primarily through two new programmes (EU-THOR - ThermoHaline Overturning at Risk and US-AMOC). These will expand the existing trans-basin and boundary current arrays (e.g. Rapid Climate Change/Meridional Overturning Circulation and Heatflux Array, Line W, Meridional Overturning Variability Experiment, 53°N) with particular focus on the Nordic Seas overflows and on the latitudinal connectivity of AMOC variability in the North Atlantic and to a lesser extent in the South Atlantic. During the ninth meeting of the Panel at Woods Hole, the US-AMOC science team met with AIP to discuss recommendations for implementing programme objectives. A subsequent workshop then laid the groundwork for design and implementation of additional components for the monitoring system.

A major European programme in this area (EU-THOR) was officially launched in January 2009. This programme aims to establish an operational system that will monitor and forecast the development of the North Atlantic thermohaline circulation on decadal time scales. Through the assimilation of systematic oceanic observations at key locations into ocean circulation models it will provide a set of geo-observational products that will be used to forecast the development of the system using global coupled ocean-atmosphere models.

A number of AMOC projects will address decadal predictions (e.g. US-AMOC, EU-ENSEMBLES, EU-THOR, EU-COMBINE). A practical consideration is the development of the Coupled Model Intercomparison Project (Phase Five) protocol which will lead to a large effort to start decadal prediction simulations in 2009/2010.

1.2 Tropical Atlantic studies

The observational network presently includes PIRATA and components of two major field campaigns (TACE and the African Monsoon Multidisciplinary Analysis project) which link tropical Atlantic and West African monsoon research. Seasonal to interannual predictions and improved dynamical characterizations of the African and South American monsoon systems are fundamental elements of these programmes. Significant effort is also directed towards evaluating decadal predictability through the region's contribution to Atlantic multi-decadal variability.

1.3 South Atlantic studies

AIP has long recognized the need to develop the observing system for the South Atlantic. A South Atlantic Meridional Overturning Circulation workshop in 2007 laid groundwork for monitoring heat and mass transports in the South Atlantic. A boundary current array (four pressure inverted echo sounders) has been installed by the National Oceanic and Atmospheric Administration's - Atlantic Oceanographic and Meteorological Laboratory at 34 °S to monitor transports for 2009-2013 in conjunction with an Expendable Bathythermograph (XBT) line. The eastern boundary current transports are being monitored by the Bonus-GoodHope project which includes intensive bio-geochemistry and atmospheric sampling components. It is expected that the US-AMOC science team will likely recommend that a full basin transport array be implemented in the South Atlantic. A south western Atlantic climate variability experiment has been proposed to study ocean-atmosphere-land coupled

phenomena associated with western South Atlantic/ South American climate variability. A white paper was produced by Paulo Nobre in August 2008 and submitted to the Brazil Ministry of Science and Technology and an international alliance including Brazil, Uruguay, and Argentina.

2. CLIVAR/GOOS INDIAN OCEAN PANEL (IOP)

In collaboration with the Global Ocean Observing System (GOOS) of the Intergovernmental Oceanographic Commission, CLIVARs' Indian Ocean Panel oversees the coordination of the implementation of a sustained ocean observing system for the Indian Ocean, including the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) which will complete the distributed moored tropical buoy network around the globe.

2.1 The Indian Ocean Observing System (IndOOS)

IOP has developed and is coordinating the Implementation Plan for IndOOS. It is a multi-platform long-term observing system, which consists of Argo floats, surface drifting buoys, tide gauges, mooring array, Voluntary Observing Ship (VOS) based XBT/XCTD lines and satellite measurements as a backbone observation network for sea surface conditions (see Fig. 1).

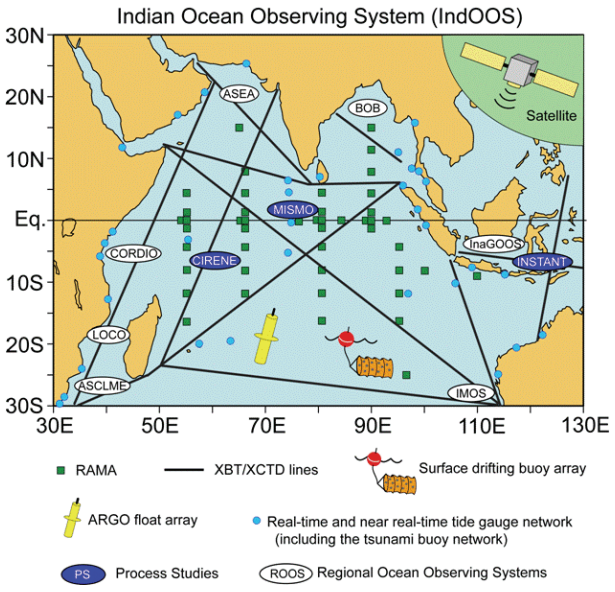

Figure 1. Schematic of the integrated Indian Ocean Observing System (IndOOS). The RAMA is shown by the green surface mooring 'boxes'.

Its critical component, the RAMA, which is the Indian Ocean counterpart to the Tropical Atmosphere and Ocean/TRITON array in the Pacific, has been planned for a target deployment of 46 moorings.

As of March 2009, 22 mooring sites of the 46 planned for RAMA have already been occupied. Equipment and/or ship time contributions have come from the US, Japan, India, China, Indonesia, France as well as from regional activities such as the Agulhas and Somali Current Large Marine Ecosystems Project. An additional ten moorings are expected to be deployed in 2009. Data from the array can be accessed via the IndOOS Data Portal website at http://www.incois.gov.in/Incois/iogoos/home_indoos.jsp.
At the last IO-GOOS meeting in 2008, the establishment of an IndOOS Resources Forum (IRF) was adopted. IRF is an essential activity to secure the ship-time and other resources for IndOOS.

2.2 Applications of IndOOS data to research

IOP seeks to strengthen the cooperation with the Indian Ocean regional observing systems, to promote applications of IndOOS data. With the rapid progress of IndOOS, new data available has helped to improve understanding of various phenomena of climate importance, such as the ocean dynamics associated with Indian Ocean Dipole, El Niño-Southern Oscillation (ENSO) influences on the Indian Ocean, dynamics of the equatorial currents at intra-seasonal, semi-annual and annual time scales, upper ocean response (sea-surface temperature and mixed layer depth) to Madden-Julian Oscillation (MJO) and cyclone forcing and potential feedbacks. The data stream from IndOOS will be vital for monsoon research and prediction, particularly from the viewpoint of monsoon-ocean interaction. The panel has also proposed simple indices to describe Indian Ocean variability to CLIVAR's Global Synthesis and Observations Panel.

2.3 Links to biogeochemical and ecosystem research

IOP has developed strong linkages with the Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER) project, which is a regional programme under the International Geosphere-Biosphere Programme's (IGBP) Integrated Marine Biogeochemistry and Ecosystem Research project. IOP and SIBER will cooperate to implement both the physical and biogeochemical components of the IndOOS infrastructure.

2.4 Indian Ocean field studies

IOP, together with the Asian-Australian Monsoon Panel has endorsed the Thermocline Ridge of the Indian Ocean (TRIO) project, initiated by the French ocean community. TRIO will explore air-sea interactions at synoptic (cyclones and tropical storms), intra-seasonal (MJO) and inter-annual timescales in the 5°S-15°S band of the Indian Ocean. TRIO focuses initially on modelling studies and analysis of existing data, and then will conduct research cruises in late 2010 or early 2011. This will also help the implementation and maintenance of RAMA. In conjunction with TRIO, the Cooperative Indian Ocean Experiment on intraseasonal variability in the year 2011 and the Dynamics of the MJO project are also planned to take place in 2011 by led by scientists in Japan and the US respectively.

3. CLIVAR PACIFIC IMPLEMENTATION PANEL (PP)

As well as advocating continued observations of ENSO, the Pacific Panel coordinates the interactions between key process studies that will leave a legacy of sustained observations and/or improved understanding of climate processes, such as the Northwest Pacific Ocean Circulation Experiment, the Southwest Pacific Ocean Circulation and Climate Experiment and the CLIVAR Variability of the American Monsoon Experiment Ocean-Cloud-Atmosphere-Land Study.

3.1 Seasonal to decadal prediction

Seasonal to decadal prediction lies at the heart of the panel's activities. Thus in 2007, the panel organized a workshop on 'Western Tropical Pacific: Hatchery for ENSO and Global Teleconnections', co-sponsored by WCRP, IGBP - Past Global Changes project and the International Pacific Research Center. It also organized a two-week summer school on 'ENSO: dynamics and predictability' which centred on training students in ENSO theory, numerical modelling and seasonal prediction techniques. A further workshop looked at the issue of ENSO in relation to climate change. An ENSO metrics project, supported by the panel, has compiled an extensive list of useful indices and diagnostics to evaluate seasonal climate prediction models. The panel also maintains a website that allows easy access to recent seasonal predictions and a joint Pacific Panel review paper on ENSO-MJO interactions is in preparation.

3.2 Anthropogenic climate change

Two PP members organized the WCRP/CLIVAR workshop 'ENSO and climate change' in conjunction with the Greenhouse 2009 conference. A joint paper assessing the current status of our understanding of ENSO and climate change is in preparation.

3.3 Southwest Pacific region and the South Pacific Convergence Zone

The panel is currently spearheading new activities to improve understanding of the South Pacific Convergence Zone (SPCZ). The panel is strongly involved in the CLIVAR-endorsed Southwest Pacific Ocean Circulation and Climate Experiment which itself includes an SPCZ component.

4. CLIVAR/CLiC/SCAR SOUTHERN OCEAN REGION IMPLEMENTATION PANEL (SOP)

The Southern Ocean Panel is co-sponsored by the Scientific Committee on Antarctic Research, the Climate and Cryosphere Project (CliC) and CLIVAR.

4.1 The Southern Ocean Observing system (SOOS)

The Southern Ocean Panel is contributing to a regional implementation plan for sustained observations relevant to climate in the Southern Ocean, the SOOS. The success of the activity is reflected in increasing investment in the observing system from several countries.

Only ten years ago the total sum of the observable data from the Southern Ocean was extremely limited. Progress in the last decade means that models can now be realistically tested with observations. However, the eddy saturation limit for the Southern Ocean remains unquantified and fundamental carbon uptake questions for the region remain unanswered. Nonetheless, there is greater confidence in estimates of baroclinic transport rates, ocean overturning and large-scale hydrography.

Advances in technology and understanding mean that it is now feasible to design and implement a Southern Ocean Observing System to meet this need. SOOS will provide the long-term measurements required to improve our understanding of climate change and variability, biogeochemical cycles and the coupling between climate and marine ecosytems.

4.2 Anthropogenic Climate Change

SOP oversees and reviews research programmes addressing the variability of the Southern Ocean at different time scales. For example, the Argo network, coupled with elephant seal data, has dramatically increased the total, and importantly, the seasonal hydrographic coverage in the upper 2000m of the water column and has helped to provide evidence for significant warming and freshening.

The panel has recommended that the community should engage in a synthesis of observations collected during the 20th century in the Southern Ocean, beginning with physical parameters but extending to ecosystems. Surface temperature (ocean and land), deep-water characteristics, carbon content, and sea ice extent are a priority. Innovative methods should be designed to combine observations and model results to be able to better estimate the magnitude and variability of the changes over the 20th century and understand their causes. This will in part be achieved through the Southern Ocean State Estimate project. Atmospheric counterparts or reanalyses with an Antarctic and Southern Ocean focus are needed as well, eventually merging the cryosphere, the atmosphere, and ocean fluxes.

4.3 Atmospheric Chemistry and Climate

The Southern Ocean has been shown to contain large amounts of anthropogenic CO_2 and the future of this carbon sink is being debated. Air-sea CO_2 fluxes may decrease in years to come as the surface ocean warms and if the Southern Annular Mode trends continue, the latter driving enhanced upwelling of the ocean store of natural carbon. This saturation of the carbon sink is a topic of current debate. A related matter is the rising acidity levels and the susceptibility of certain regions to species decline resulting from the dissolution of carbonate skeletal material. Some polar regions, e.g. the Ross Sea, may be the first to suffer ecosystem stress from ocean acidification.

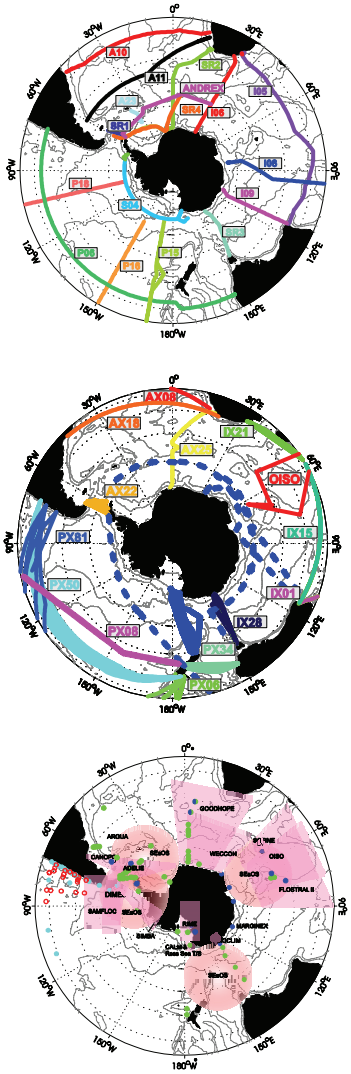

Figure 2. Elements of the SOOS including: top) sustained hydrographic sampling lines; middle) repeat VOS and sustained XBT sampling lines and; bottom) multiyear process studies and in-situ observations (e.g. moorings, bottom pressure gauges and tide gauges)