

## **Indian Ocean Panel Report**

### **1. Panel or Working Group: CLIVAR/GOOS Indian Ocean Panel**

The Panel was established in 2004 and has met on four occasions: February 2004 (Joint with AAMP) in Pune India, March 2005 in Hobart Australia, February 2006 in Honolulu USA and April 2007 in Pretoria South Africa. The Panel prepared a regional implementation plan for sustained observations relevant to climate, which was published and distributed last year (WCRP Informal Report No. 5/2006 and GOOS Report no. 152. Downloadable from <http://eprints.soton.ac.uk/20357/>). The Panel's success is reflected in increasing investment in the observing system from several countries. The Panel's activities (e.g. meetings) are supported jointly by IOC-Perth Office and WCRP, a cost-sharing arrangement that is expected to continue.

### **2. Contributions to WCRP cross cutting topics:**

- The Panel has been coordinating development of the sustained observing system in the Indian Ocean, called IndOOS (Indian Ocean Observing System), which can directly contribute to several WCRP cross cutting topics. IndOOS consists of several observation platforms, including ARGO floats, Volunteer Observing Ship XBT/XCTD sections, surface drifting buoys, tide gauge network, tropical moored buoy array, as well as the satellite observations. As of April 2007, 15 sites in the tropical mooring array have been occupied, representing 32% of the total 47 sites in the proposed array. Number of deployed Argo and surface drifting buoys in the Indian Ocean are closely reaching the planned coverage density, though continuous efforts of deployments to keep the well-covered condition are strongly required.
- JAMSTEC (Japan) will maintain two TRITON moorings and an ADCP near the equator at 90-95°E. NOAA (USA) will maintain eight ATLAS moorings at 1.5°N, 0°, and 1.5°S along 80.5°E, 8°N, 4°N, 1.5°N and 0° along 90°E, 8°S at 67°E, and an ADCP near 0°, 80°E. DoD (India) will maintain three moorings on the equator at 77°, 83° and 93°E. FIO (China) and AMFR (Indonesia) will deploy a new ADCP mooring near 8.5°S, 160.75°E.
- Fishing vandalism continues to be a strong concern for the moored buoy array. Data return for ATLAS and TRITON moorings combined was 68% for the period October 2004 to March 2007, and it is expected that the value will diminish with time because there are several moorings presently not transmitting data.
- Ship time also remains a concern since there is no systematic framework for planning cruises on a regular basis. This issue is not only for the mooring array but also for Argo and surface drifter buoys. The Panel recognizes necessity of a "resource board" for the Indian Ocean to provide resources such as ship time for further development of IndOOS, especially for the mooring array development.
- The Panel has asked the Indian Ocean GOOS Regional Alliance to convene a second high level review of IndOOS at the next annual meeting in December 2007 to assess progress since the first review in 2005. The review panel will be asked to consider formation of the resource board. The draft terms of reference for the review are in Annex A.

- Technical improvements in mooring design by JAMSTEC, NOAA and FIO are in progress to minimize the data loss due to the fishing vandalism and other technical problems.

## **2.1 Monsoons:**

- The Panel confirms that intraseasonal variations are the building blocks of monsoons. The Panel has also identified understanding the heat budget of the upper ocean, particularly the mixed layer, at intraseasonal time scales as a critical area of research. Continuous time series are required for this research and it is one of the key reasons for establishing a basin-scale mooring array with upper ocean temperature, salinity and current measurements.
- The meteorological measurements at the mooring sites will also be extremely valuable for improving estimates of surface fluxes and for heat budget studies. The data also improve data assimilation, ocean state estimation and support weather forecasting and reanalysis efforts. At present there are few such measurements in the Indian Ocean and this lack of information prevents accurate initial condition determination of weather forecasts and limits reanalysis efforts. The flux measurements also provide a good reference data for validation of the satellite flux measurements.
- Two research vessel based process studies on ocean-atmosphere interaction in intraseasonal variability were conducted under the coordination of the Panel. Both studies were successfully finished with a significant amount of in situ observational data, which are now extensively analyzed among the involved scientists.
  - Vasco-Cirene experiment in January/February 2007 was conducted to provide in situ observations of oceanic and atmospheric variability, as well as air-sea fluxes, over the thermocline ridge between 5S and 10S in the western Indian Ocean. Although the strong intraseasonal disturbance was not observed during the experiment, invaluable data on cyclogenesis were obtained by a new observation platform, called Aeroclipper.
  - MISMO experiment during October to December 2006 was taken place in the central/eastern equatorial Indian Ocean to capture the atmospheric and oceanic variations associated with the MJO initiation and passage. The observation captured development of MJO convections and eastward movements of large-scale cloud systems. Ocean variability at the intraseasonal time-scale demonstrated the strong upwelling (> 10m/day) and associated variations in the chlorophyll concentration in the thermocline level.
  - The scientific leaders of Vasco-Cirene and MISMO were invited speakers at the IUGG Symposium on Dynamics of Convectively-Coupled Equatorial Waves and the Madden-Julian Oscillation (ICDM) and 22 talks were presented on the preliminary cruise results
- The Panel reviewed the impacts of the Indian Ocean variability on African climate systems and recognizes strong connections between the precipitation anomaly and the interannual SST variability in the Indian Ocean, such as the IOD and the subtropical dipole mode. ENSO influences tend to show opposite signed rainfall anomaly over the southeastern/eastern Africa. Relative importance among these climate modes, including the influences from the Atlantic Ocean, on the African rainfall variability will be an important issue to be understood, under the strong cooperation with VACS panel.

## **2.2 Decadal Predictability:**

- The Panel has been engaging in researches related to decadal and longer time-scale variability in the Indian Ocean. Such longer time-scale variability remains to be fully documented. In addition, the extent to which it acts to modulate variability on shorter time-scales is an important research question. The understanding of physical processes associated with these variability should be clarified for the studies of decadal predictability in the Indo-Pacific region.
- The Panel also recognizes the importance of predictability and prediction studies of regional climate of the Indian Ocean on decadal time-scales. A white paper on decadal prediction and predictability of African climate and links with the Indian and Atlantic Oceans is in preparation.

### **2.3 Extreme Events and Climate:**

### **2.4 Sea Level Rise:**

### **2.5 Seasonal Prediction:**

- Experimental seasonal predictability/prediction studies are going on at several institutions using coupled GCMs. The Panel recognizes the importance of ENSO-IOD relationship. How these climate modes interact each other and/or how they influence the other phenomenon are key issues to be understood for better seasonal prediction not only within the Indian Ocean but also for the global climate system. This will also provide strong rationale for IndOOS.
- IOP and AAMP are discussing the possibility of a coordinated study and intercomparison of the predictions of the 2006 and 2007 IOD events by the FRCGC (JAMSTEC), GFDL (NOAA) and BMRC (Australia) coupled models. These years are interesting because all models agreed in predicting the strong positive event in 2006 and they disagree markedly in predictions for 2007. We think a case study of the successes and differences can lead to model improvement. Progress has been slow because there is no dedicated funding to coordinate activity between IOP and AAMP meetings. A strong recommendation by the SSG might help find support for coordination.

## **3. Highlights of wider contributions to CLIVAR science**

- Descriptions of several activities coordinated by the Panel are published in October 2006 in a special issue of *CLIVAR Exchanges* on the Indian Ocean.
- IndOOS Data Portal site has been set up at [http://www.incois.gov.in/Incois/iogoos/home\\_indoos.jsp/](http://www.incois.gov.in/Incois/iogoos/home_indoos.jsp/). All the available in situ observation data for IndOOS are listed with the link to data providers. Satellite derived gridded variables are also available through live access server. A white paper regarding IndOOS data management will be prepared jointly by INCOIS and APDR.
- The Panel discussed possible future research directions IOP should take. Considering the rapid growth of IndOOS, quantitative analyses using the observed data will be a key research area. For example, mixed-layer heat budgets, Bay of Bengal variability in association with monsoons, validations of the air-sea fluxes, and predictability/prediction studies of the significant climate modes in the Indian Ocean, such as IOD. Detection and understanding of the decadal and inter-decadal time-scale variability are also important.
- The Panel reviewed a white paper on “monitoring the Agulhas Current” by L.Beal et al. and recognized that the western subtropical region is the weak link of the current IndOOS. The scientific rationale for long term measurement

of the Agulhas is to improve understanding and modelling of its dynamics and its role in inter-ocean exchange (Indian to Atlantic) as it relates to the global overturning circulation. The attractive aspect of the proposal is the staged approach building up the monitoring effort through a series of process studies and coordination of resources across three projects involving international collaboration. At the present time there are not many Argo floats in this region, the repeat hydrographic sections are insufficient, and satellite data do not provide vertical structure directly, leaving the Agulhas Current the least known of all the western boundary currents. The proposed measurements will in the first stage address connectivity of the Agulhas in the region where it is strongest to major currents at lower latitude and the eddy field. Generally, the Agulhas measurements will provide very useful in situ data, which can also be used for model evaluation and improvement. The Panel strongly recommends that the proposed pilot studies should go forward. The SSG is invited to comment on this proposal.

#### **4. Cooperation with IGBP projects**

- The Panel helped to organize the Workshop on Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER), which was held in Goa India in October 2006. A follow-up workshop is planned for the fall of 2007 to develop SIBER science plan.
- The Panel recognizes strong connection between the climate phenomena in the Indian Ocean and coral reef environment, in particular coral bleaching.

#### **5. New activities being planned, including timeline,**

- Intercomparisons among experimental seasonal prediction experiments are planned to identify potential predictability of IOD and reasons for different behavior among the different models. This activity will be done under the cooperation with AAMP during coming one or two years.
- The Panel starts discussing a new process oriented field observation in the tropical Indian Ocean, focusing on the intraseasonal variability. This observational activity can be a multi-national experiment, engaging the interest of AAMP, VACS, and GSOP. Possible year for intensive observation period will be 2012.
- The ACCESS program headed by Prof. George Philander is evolving slowly. There is a possibility to extend observation array into the western and southern Indian Ocean, to do regional ocean modeling and regional climate prediction studies.
- The SAGRADEX program for southern Africa dealing with seasonal to decadal climate prediction for the region will start with a workshop in Cape Town on September 2007.

#### **6. Description of your expected “legacy” at the end of CLIVAR (2013)**

- Fully implemented IndOOS can be a significant contribution to the climate research community, and data from the observing system can be used for seasonal predictability/prediction studies, which are directly connected to socio-economic activities all over the world.
- Basic researches on the variability spanning from intraseasonal to decadal time-scales will compile our understanding and scientific insights into the phenomena, such as the MJO, IOD, and other variability in the Indian Ocean

- With data from IndOOS we should be able to unambiguously answer the question, what is the role if any of ocean circulation dynamics in the MJO.

#### **7. Issues for the SSG**

- The Panel would like to invite Dr. W. de Ruijter to be a new member.
- Endorse the high level review of IndOOS as discussed under 2 above
- Comment on the proposed study of IOD predictions for 2006 and 2007 as discussed in 2.5 above
- Comment on the proposal to monitor the Agulhas Current as discussed under 3 above

## Annex A1

### Proforma for CLIVAR Panel and Working Group requests for SSG approval for meetings

Requests should be made through D/ICPO ([hyc@noc.soton.ac.uk](mailto:hyc@noc.soton.ac.uk)), against the following headings:

1. Panel or Working Group: **CLIVAR/GOOS Indian Ocean Panel**
2. Title of meeting or workshop: **Fifth meeting of the Panel**
3. Proposed venue: **Indonesia**
4. Proposed dates: **April 2008**
5. Proposed attendees, including likely number: **panel members plus 5-7 invited experts. About 25 participants in total.**
6. Rationale, motivation and justification, including: relevance to CLIVAR themes & JSC cross-cutting topics and any panel/working group links and interactions involved: **Continuing implementation of the Indian Ocean observing system. Developing a science plan to address WCRP cross-cutting topics. Planning a multinational process study on the role of the ocean in MJO.**

**Also, IOP serves the needs of the Indian Ocean GOOS Regional Alliance. IOP plays an important role in the annual IOGOOS meeting to link the climate observing system to coastal and societal issues.**

7. Specific objectives and key agenda items:
  - a. review of IndOOS.
  - b. Update on the results of the MISMO and CIRENE process studies of MJO.
  - c. Develop a science plan
  - d. Planning a new multinational process study on MJO.
8. Anticipated outcomes: Meeting report
9. Format: Round table
10. Science Organising Committee (if relevant)
11. Local Organising Committee (if relevant)
12. Proposed funding sources and anticipated funding requested from WCRP: **Half the funding is likely be provided by IOC Perth Office, as in past meetings.** Some IOP members pay travel expenses out of their research budgets. Request to WCRP for 15K USD

## Annex A-2

### **Proforma for CLIVAR Panel and Working Group requests for SSG approval for meetings**

Requests should be made through D/ICPO ([hyc@noc.soton.ac.uk](mailto:hyc@noc.soton.ac.uk)), against the following headings:

1. Panel or Working Group: **CLIVAR/GOOS Indian Ocean Panel**
2. Title of meeting or workshop: **IOP participation at the Fifth Annual Meeting of the Indian Ocean GOOS Regional Alliance**
3. Proposed venue: **Thailand**
4. Proposed dates: **December 2007**
5. Proposed attendees, including likely number: **4 panel members**
6. Rationale, motivation and justification, including: relevance to CLIVAR themes & JSC cross-cutting topics and any panel/working group links and interactions involved: **IOP plays an important role in the annual IOGOOS meeting to link the climate observing system to coastal and societal issues. This year there will be a high level review of the Indian Ocean Observing system (IndOOS) [see terms of reference below].**
7. Specific objectives and key agenda items:
  - a. Inform the regional alliance of progress in developing IndOOS
  - b. Present the case for IndOOS to the review panel
  - c. Form a "Resources Board" for Indian Ocean observations
8. Anticipated outcomes: Meeting report; formation of the Board
9. Format: The annual meeting is usually presentations and workshops. The high level review will involve four presentations by IOP members covering the Terms of Reference and discussion by the Panel.
10. Science Organising Committee (if relevant)
11. Local Organising Committee (if relevant)
12. Proposed funding sources and anticipated funding requested from WCRP: **Perth Regional Office**, some IOP members may self-fund, Request to WCRP for 10K USD

## **CLIVAR/GOOS Indian Ocean Panel Implementation Plan**

### **Second High-Level Review**

#### **Terms of Reference**

Phuket Thailand

3 December, 2007

The need for high-quality ocean observations is shared by research (CLIVAR) and ocean applications and services (GOOS) and there is a shared conviction that, together, the ocean community should endeavour to establish the basis for a comprehensive ocean observation network and oversee the staged implementation of a sustainable ocean observing system for the Indian Ocean. The Indian Ocean Panel (IOP) was established and is supported by CLIVAR and GOOS (through Indian Ocean GOOS Regional Alliance and the Perth Office of the Intergovernmental Oceanographic Commission) with the following Terms of Reference.

1. Provide scientific and technical oversight for implementation of a sustained ocean observing system for the Indian Ocean following the plans in WCRP Informal Report No. 5/2006 and GOOS Report no. 152, in particular with regard to:

- Promotion and implementation of the basin-scale mooring array, working in close collaboration with GEOSS, JCOMM and other bodies.
- Testing, planning and coordination of an integrated, multi-platform approach to the observing system in collaboration with GODAE, GSOP and other bodies.
- Establishing links to coastal applications through the IOGOOS Regional Alliance.
- Encouraging new participants in the observing system by demonstrating usefulness of the implementation already accomplished.
- Identifying and utilizing synergies with the Indian Ocean Tsunami Warning and Mitigation System, in particular with regard to advocating a multi-hazard approach that integrates tsunami warning with other weather related threats.

2. Coordinate and plan research on the role of the Indian Ocean in the climate system in collaboration with other CLIVAR Panels and OOPC with a focus on describing, understanding, modeling and predicting intraseasonal, monsoonal, interannual and decadal oceanic processes and their relationship to climate impacts on all the surrounding continents.

3. Liaise with biogeochemical and ecological research programs and identify opportunities to understand the relationships between climate- and biogeochemical research.

4. In collaboration with IRI and local experts in each region of interest, identify the societal impacts of climate and oceanic variation that require Indian Ocean observations as a foundation for management and amelioration.

5. Rotate up to 30% of the Panel membership each year in order to acquire the skills necessary to address the evolving development of the observing system.

6. Advise the CLIVAR SSG on Indian Ocean climate research and report to GOOS through the IOC Perth Office.

The IOGOOS Workshop and 3rd Annual Meeting (IOGOOS-III) was hosted by the Agency for the Assessment & Application of Technology (BPPT), Indonesia at the Kuta Paradiso Hotel in Bali, Indonesia during August 9 - 12, 2005. IOGOOS III was organized jointly by the IOGOOS Secretariat, IOC Perth Regional Programme Office and BPPT, Indonesia. About 80 participants from 15 countries and IOC participated in the deliberations of IOGOOS III. An important element of IOGOOS III was a High-level meeting held on August 11, 2005 to review the Indian Ocean Panel for Climate (IOP) implementation plan. This meeting was attended by the following nine high-level participants/representatives from eight countries who provided important and constructive comments on the IOP Implementation Plan.

1. Dr. Neville Smith – Australia
2. Dr. Guifei Jing – China;
3. Dr. Radhakrishnan – India;
4. Dr. Sugiarta Wirasantosa – Indonesia;
5. Dr. Jan Sopaheluwakan - Indonesia;
6. Dr. Yoshifumi Kuroda - Japan
7. Mr. Harry Ganoo – Mauritius;
8. Dr. Kamal Tennakkoon – Sri Lanka;
9. Dr. Chester Koblinsky – USA;

IOGOOS Chair Dr. Radhakrishnan, concluded that the IOP Implementation Plan has the broad endorsement of all the participants and the suggestions made by the participants have to be taken onboard by the IOP and IOGOOS. He suggested that a formal communication could be sent by the IOGOOS Secretariat to the IOP sponsors, i.e. IOC-Perth and CLIVAR thanking them for their support and congratulating the excellent progress made by IOP in developing this plan. Since the initial IOP High-Level Review two years ago in Bali there has been much progress in the implementation of the Indian Ocean Observing System (IndOOS) as well as the applications of these new ocean data for societal benefits. There has also been increased political interest in earth observations in general as a result of the Global Earth Observation System of Systems (GEOSS) initiative. With this recent activity it is timely to convene a second High-Level Review (HLR-II) of the IOP Implementation Plan in conjunction with IOGOOS-V in Phuket Thailand.

The Terms of Reference and Responsibilities for HLR-II are as follows:

- The Review Panel (RP) shall be broadly comprised of a high level person(s) from each member of the IOGOOS Regional Alliance, including key sponsors of IOGOOS, representatives from the international GOOS Committees e.g. the JSC, and interested potential new members who are willing to advance GOOS in their Country and actively contribute to its extension in the Indian Ocean Region,
- The RP will be requested to provide input and guidance in response to the IOP briefings as well as an update on their National contributions to IndOOS since the last High-Level Review at IOGOOS-III,
- Provide an overview of IndOOS and its degree of relevance to IOC GOOS objectives, (IOP)

- Provide an update on the implementation progress made for IndOOS including the basin-scale mooring array, Argo program and XBT lines, (IOP)
- Provide an update on IndOOS National Contributions, in particular the recent enhancements by Japan, India, USA, China and Australia, (RP)
- Provide a review of the Scientific rationale of IndOOS for Regional and Global Climate, (IOP)
- Assess the availability of IndOOS data for Ocean products and data assimilation, (IOP)
- Provide an update on emerging Resource Sharing Partnerships towards implementing IndOOS, (IOP)
- Review updated stakeholders' interests for IndOOS data and their social, economic and environmental outputs/outcomes and Benefits, (IOP)
- Assess ongoing and future resources available towards completing the implementation milestones. (RP)