INTERNATIONAL
COUNCIL FOR SCIENCE

INTERGOVERNMENTAL
OCEANOGRAPHIC
COMMISSION

WORLD
METEOROLOGICAL
ORGANIZATION

WORLD CLIMATE RESEARCH PROGRAMME

Report of the Third Meeting of the CLIVAR-GOOS Indian Ocean Panel

February 27 – March 2 2006, Honolulu, U.S.A.

August 2006

ICPO Publication Series No.107

WCRP Informal Report No. 14/2006

GOOS Report No: 155

The work of the CLIVAR-GOOS Indian Ocean Panel is supported by the World Climate Research Programme, Interntional CLIVAR Project Office, the Intergovernmental Oceanographic Commission Perth Regional Office, Indian Ocean GOOS and the CSIRO Wealth from Oceans Flagship Programme.

CLIVAR is a component of the World Climate Research Programme (WCRP). WCRP is sponsored by the World Meteorological Organisation, the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO. The scientific planning and development of CLIVAR is under the guidance of the JSC Scientific Steering Group for CLIVAR assisted by the CLIVAR International Project Office. The Joint Scientific Committee (JSC) is the main body of WMO-ICSU-IOC formulating overall WCRP scientific concepts.

Bibliographic Citation

INTERNATIONAL CLIVAR PROJECT OFFICE, 2006: Report of the Third Meeting of the Indian Ocean Panel. August. International CLIVAR Project Office, CLIVAR Publication Series No. 106. GOOS Report no. (not peer reviewed).

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1) Coordinate the articles for the special CLIVAR Exchanges issue on IO research. Deadline for submission July 2006

(R. Boscolo)

2) Coordinate article for WCRP News on web or Newsletter

(G. Meyers)

3) Keep ICPO and the Perth Office informed with the status and future plans of the IO observing system and ongoing activities

(Panel and R. Boscolo)

4) Find a new acronym for the Indian Ocean Observing System. Submit suggestions to Gary Meyers by end of April 2006

(Panel)

5) Representatives from PMEL, JAMSTEC and NIO will produce a timetable for development of the moored buoy array over the next 5 years, based on assumptions about the availability of ship time and funding. Contingencies for the severity of fishing vandalism will be incorporated into the plan. Submit the timeline to the panel for comments by the end of May 2006

(M. McPhaden, Y. Kuroda and V.N.S. Murty)

6) PMEL will conduct a survey of existing mooring techniques that may provide protection against fishing vandalism while at the same time permitting cost-effective collection and satellite transmission of Eulerian time series data on upper ocean variability.

(M. McPhaden)

7) Establish connections with LOCO and future NL activities in IO

(W. de Ruijter and F. Schott)

8) Identify synergies between the Indian Ocean observing system and IOTWS on mortal hazards. Make presentations at IOTWS future meetings and make the ppts available to the panel

(G. Meyers)

9) Build a webpage with IO Data Information and links to data available by June

(P. Hacker and M. Ravichandran)

10) Complete the white paper on IO Data Information & Management strategy and submit to panel by early June for comments

(P. Hacker and M. Ravichandran)

11) Contact J. Gould and put forward the recommendations of the IOP Implementation Plan for Argo coverage in IO. Establish ways of interactions

(G. Meyers)

12) Contact SOOPIP and put forward the recommendations of the IOP Implementation Plan for XBT coverage in IO. Establish ways of interactions

(G. Meyers)

13) Contact Gustavo Goni at AOML to find a PI to take the responsibility for coverage of IX10

(G. Meyers and R. Boscolo)

14) Send a letter and a hardcopy of the Implementation Plan by the end of April '06 to directors of Oceanographic Institutes/Met Offices of countries in the IO rim

(G. Meyers, W. Erb and R. Boscolo)

15) Compose a list of high level contacts (funding agencies, national reps) and send a letter with hardcopy of the Implementation Plan by end April

(G. Meyers, W. Erband R. Boscolo)

16) Send a letter to NSF and NASA advocating for IO research

(F. Schott and J. McCreary)

17) Prepare a list of IO metrics for GODAE/GSOP synthesis activities

(Panel and T. Lee)

18) Explore the possibility to put carbon sensors on Tsunami moorings

(G. Meyers)

19) Maintain and strengthen links with the biogeochemical community (IMBER, GLOBEC) by inviting reps to IO meetings and identify joint activities

(G. Meyers, R. Boscolo and R. Hood)

20) Write to C. Reason (VACS co-chair) and ask how IOP can provide inputs to the Tanzania workshop scheduled in July 2006 given the limited timeframe

(G. Meyers and C. Reason)

21) Plan a possible joint VACS/IOP meeting within ~15 months from March 2006 to address common issues in southern Africa

(R. Boscolo and G. Meyers)

22) Appoint a co-chair and 3/4 members to rotate

(G. Meyers, W. Erband R. Boscolo)

1. Introduction

Gary Meyers, chair of IOP, welcomed the participants (Appendix A) and thanked all for their prompt response to the change of venue. The 3rd IOP meeting was scheduled for the first week of March 2006 in La Reunion, France, but the dramatic spreading of the Chikungunya fever in the island, forced the IOP chairman to change the venue to Honolulu just a few weeks before the meeting. A special thanks was given to M. McPhaden, who first prompted for an urgent decision on changing venue, and to staff at the International Pacific Research Center who made local arrangements for the new venue.

The agenda (Appendix B) was adopted by the meeting participants.

1.1 Welcome from the Sponsors: GOOS and CLIVAR

W. Erb from the IOC Perth Regional Programme Office welcomed the panel on behalf of GOOS, one of the IOP sponsors. The welcome from CLIVAR, the other IOP sponsor, was given by R. Boscolo, ICPO, who took the opportunity to introduce some of the CLIVAR and WCRP activities relevant to the IOP.

The WCRP strategic framework for the next decade is called COPES, Coordinated Observations & Prediction of the Earth System (http://copes.ipsl.jussieu.fr). The goal of COPES is to provide seamless predictions of the total climate system from weeks through decades. As a first step in COPES, WCRP will synthesize ongoing observational and modelling activities of all relevant WCRP components. This is being done in part by two panels: WCRP Modelling Panel (WMP) and WCRP Observational & Assimilation Panel (WOAP). CLIVAR plays a central role in the delivery of COPES given its science foci:

- The role of the ocean in climate variability and change (ocean observations including sustained observations and process studies)
- Climate prediction and predictability on seasonal to centennial time scales.

The Indian Ocean Panel has a role to play in COPES, in particular with regard to research requiring ocean observations

In 2004, CLIVAR organized a self-assessment, which was structured by the CLIVAR streams. It was decided that on an annual basis CLIVAR progress would be assessed against four phenomenological themes: ENSO, ACC, Monsoon and Decadal/THC and a theme on the ocean's role in climate. Each year a workshop on one of the themes will be held. The Indian Ocean Panel has a role potentially is all of these themes, in particular focussing on oceanic mechanisms and processes, and how they are observed. The new role of the Panel needs to be clearly defined during the course of the coming year, in collaboration with CLIVAR's Asian Australian Monsoon Panel (AAMP) and its Variability of the African Climate System Panel (VACS).

Looking forward to COPES, the CLIVAR SSG has reaffirmed:

- Formation of an Indian Ocean Panel
- Development of a draft proposal for an Indian Ocean Observing System
- Design of OSSEs and data assimilation activities
- Strengthen expertise on surface fluxes in the Indian Ocean.

R. Boscolo suggested that the October 2006 issue of the CLIVAR Exchanges Newsletter be dedicated to the Indian Ocean. Deadline for articles submission is July 2006.

> ACTION ITEM 1. Coordinate the articles for the special Exchange issue on IO research. Deadline for submission July 2006 *(R. Boscolo)*

WCRP is also looking for a science story on the Indian Ocean climate to be published in their web pages or Newsletter.

> ACTION ITEM 2. Coordinate article for WCRP News on web or Newsletter *(G. Meyers)*

Finally R. Boscolo demonstrated the new CLIVAR web pages dedicated to the Indian Ocean Panel (http://www.clivar.org/organization/indian/indian.php), in particular the section on the observing system. These are useful tools for an overview of ongoing activities and progress.

ACTION ITEM 3. Keep ICPO and the IOC Perth Office informed with the status and future plans of the IO observing system *(Panel all)*

M. McPhaden noted that the acronym IOOS generally used by the IOP to indicate the Indian Ocean Observing System should be avoided because the Integrated Ocean Observing System also goes by IOOS and the OceanUS office has filed for a US trademark license on an IOOS logo. He suggested considering coming up with another acronym to avoid confusion.

ACTION ITEM 4. Find a new acronym for the Indian Ocean Observing System. Submit suggestions to Gary Meyers by end of April 2006 *(Panel all)* This action was completed after the meeting. The new acronym is IndOOS

1.2 Intersessional Activity and Future Meetings

G. Meyers listed the relevant meetings/events occurring in the period 2005-2006 as part of the intersessional activity:

- Intergovernmental Global Ocean Observing System Committee (I-GOOS-VII) (4 – 7 April 2005). W. Erb attended.
- GCOS Regional Workshop for South and Southwest Asia (9-11 May 2005). G. Meyers attended.
- Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC) (7-10 June 2005. F. Schott attended.
- AAMP and Pan-WCRP monsoon modeling workshop (15-19 June, 2005). J. McCreary attended
- IOC Intergovernmental Coordination Group for IOTWS (3-5 August 2005 and December 2005). W. Erb and G. Meyers attended
- Indian Ocean GOOS Regional Alliance—Third Annual Meeting (9-12 August 2005). The draft implementation plan for sustained observations was reviewed by a high level panel. W. Erb, G. Meyers, F. Schott, M. McPhaden, Y. Kuroda attended
- Dynamic Planet 2005 IAPSO Joint Assembly convened "CLIVAR THEME I: Interannual Climate Predictability - ENSO/Indian Ocean/SST Impacts On Global & Regional Climate Variability" (22-26 August 2005). G. Meyers convened and several members attended
- IOGOOS/JCOMM Western Indian Ocean XBT Training Workshop (5-7 October 2005). S. Thurston, V.N.S.Murty and G. Meyers attended
- Tropical Moored Buoy Panel and Ocean SITES (17-19 February 2006). M. McPhaden attended
- CLIVAR Pacific Panel (15-17 February 2006). G. Meyers, M. McPhaden and F. Schott attended

Future relevant meetings are:

- WCRP/JSC-27 (6-11 March 2006). G. Meyers and R. Boscolo prepared and submitted a report together with ppt slides for T. Palmer's presentation
- CLIVAR SSG-14 (17-19 April 2006). G. Meyers will submit a report for IOP, M. McPhaden will attend the meeting and make the presentation for IOP.
- Integrated Marine Biogeochemistry and Ecosystem Research—Indian Ocean (SIBER) (3-6 October 2006) G. Meyers and J. McCreary will attend
- OOPC (16-20 May 2006) F. Schott will attend
- AAMP (19-21 February 2007) J. McCreary will attend
- Second Argo Science Workshop (13-18 March 2006)

2. Status of PMEL Moored Buoy *(M. McPhaden)*

With funding provided by NOAA's Office of Climate Observation (OCO), four ATLAS moorings and one ADCP mooring were deployed in October-November 2004, as part of an initial PMEL contribution to the development of the IndOOS basin-scale moored buoy array. Deployments were conducted in collaboration with the National Institute of Oceanography in Goa, India and the Indian Department of Ocean Development on a cruise of the Indian Research Vessel (ORV) *Sagar Kanya*. ATLAS moorings were deployed at 1.5°N, 0°, and 1.5°S along 80.5°E and at 0°, 90°E. The ADCP mooring was deployed close to the 0°, 80.5°E ATLAS mooring, which is a designated Indian Ocean flux reference site.

The real-time ATLAS data stream highlights variability associated with the seasonal cycle, intraseasonal oscillations, and circulation features such as the Wyrtki Jet. However, fishing vandalism has adversely affected data return. As of August 2005, the three moorings along 80.5°E were no longer transmitting via Service Argos, and one mooring (1.5°N) was confirmed lost based on reports from a *Sagar Kanya* cruise to the area in May 2005.

PMEL has developed a web site to display and distribute Indian Ocean data from both PMEL and JAMSTEC moorings. This site is public and can be accessed at http://www.pmel.noaa.gov/tao/disdel/ .

PMEL plans to replace its original Indian Ocean ATLAS and ADCP mooring on a cruise of the ORV *Sagar Kanya* in August - September 2006 (delayed after IOP-3 to August 2006). In addition, PMEL has sufficient equipment to deploy a fifth ATLAS mooring at 1.5°N, 90°E provided adequate ship time is available. PMEL is coordinating with JAMSTEC to optimize the mooring array design for the MISMO experiment, which is a study of ocean-atmosphere interactions on intraseasonal time scales scheduled for October-December 2006, near 0°, 80.5°E. PMEL will participate in the French CIRENE cruise which will carry out ocean-atmosphere interaction studies in the region of the thermocline ridge between 5-10°S in the eastern and central Indian Ocean. The cruise is scheduled for January-February 2007 on the RV *Suroit*, during which an ATLAS flux reference mooring will be deployed at 8°S, 67°E. An unresolved issue at present, which will affect how heavily the mooring is instrumented on deployment, is the availability of ship time for recovery and possible redeployment of the mooring in early 2008. Discussions are underway with Indonesia for ATLAS mooring deployments in the eastern Indian Ocean from the RV *Baruna Jaya* as part of a proposed NOAA/BRKP bilateral. While the time frame for the cruise is not yet determined, it is likely to be in 2007. Discussions are also underway between NOAA and Chinese institutions (SOA and MOST), which may lead to cooperative ocean observing system development activities in the eastern Indian Ocean.

The Panel expressed concern over the degree of fishing vandalism and agreed that this issue and possible alternative ways (not as exposed to vandalism) to monitor the region need to be discussed at the next meeting. The Panel welcomes PMEL's continued investment to maintain and expand the IndOOS basin-scale mooring array.

> ACTION ITEM 5. Representatives from PMEL, JAMSTEC and NIO will produce a timetable for development of the moored buoy array over the next 5 years, based on assumptions about the availability of ship time and funding. Contingencies for the severity of fishing vandalism will be incorporated into the plan. Submit the timeline to the panel for comments by the end of May 2006. *(M. McPhaden, Y. Kuroda and V.N.S. Murty)*
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> ACTION ITEM 6. PMEL will conduct a survey of existing mooring techniques that may provide protection against fishing vandalism while at the same time permitting cost-effective collection and satellite transmission of Eulerian time series data on upper ocean variability. *(M. McPhaden)*

3. Long-term Measurements of Current in the Equatorial Indian Ocean Through Current Meter Mooring Along the Equator ***(V.N.S. Murty)***

The current status of the Indian Ocean Observing System (IndOOS) deep-sea current meter moorings along the equator, future plans and data availability to the user community via intranet from the NIO server (http://www.nio.org/data_info/deep-sea_mooring/oos-deep-sea-currentmeter-moorings.htm) was presented.

The Department of Ocean Development (DOD), Government of India, initiated the Ocean Observing System (OOS) programme in 1997 for long-term current measurements in the equatorial Indian Ocean through the Indian National Centre for Ocean Information System (INCOIS), Hyderabad. Under the IndOOS, 3 locations were selected along the equator for deploying the current meter moorings at 93°E, 83°E and 76°E (Fig 1). The responsibility of executing the project *Long-term measurements of the currents along the equator through current meter moorings* was given to the National Institute of Oceanography (NIO), Goa. This project was implemented at NIO in 2002 after developing a suitable mooring design and procuring the current meters and relevant hardware. The mooring was designed with 6 Recording Current Meters (RCMs) at 100 m, 300 m, 500 m, 1000 m, 2000 m and 4000 m. The first deep-sea current meter mooring was deployed successfully in February 2000 at equator, 93°E onboard ORV *Sagar Kanya*. This mooring was successfully recovered in December 2000 and data were obtained from all the RCMs. The mooring was redeployed and the new second mooring was deployed at equator, 83°E in December 2000. In March 2002, these two moorings were recovered and data were obtained. While redeploying these moorings at the same locations, a new third mooring was deployed at equator, 76°E. In October 2003, all the three moorings were recovered and redeployed for one more year, but the mooring at 76°E was shifted to 77°E (Fig 1). In October 2004, all the three moorings were recovered and re-deployed. One upward-looking ADCP was placed at 100 m on top of each mooring. The three moorings will be serviced again during August - September 2006 onboard ORV Sagar Kanya and redeployed at the same locations. Three 75 kHz uplooking ADCP’s will replacing the present 300 kHz ADCP’s for better range of current profiling of about 400 m.

There is no human-vandalism of the moorings; however; heaps of Tuna-fishing nets are often found around the top current meter, particularly at the 93°E mooring location.

The time-series of current-data were submitted to the INCOIS, Hyderabad and placed on the Websites of NIO and INCOIS.

Preliminary results from the mooring program were presented. The intraseasonal and interannual variability of currents from the moorings at 83°E and 93°E locations were shown. The upper ocean currents measured by the ADCP were compared with simulations from the Frontier Ocean Model For Earth Simulator. A preliminary result on the variability of currents at near-bottom and their comparison with the OFES simulations was highlighted. The measured currents and model-simulated currents compare well. A mechanism for depth penetration of the semi-annual wave associated with Wyrtki Jets was identified from the moorings, Argo floats and TRITON mooring observations. Such phenomenon will be explored using modelling studies.

This project will be continued till March 2007 with funding from DOD. A proposal to extend the deep mooring project at the same locations for possibly another 5 years through 2012 is being prepared. The proposal may also extend the project to more than three locations also with upward looking ADCP’s. The locations of additional moorings have not yet been determined.

The Panel appreciated the contribution from NIO and strongly supports NIO’s proposal to continue the deep equatorial mooring program.

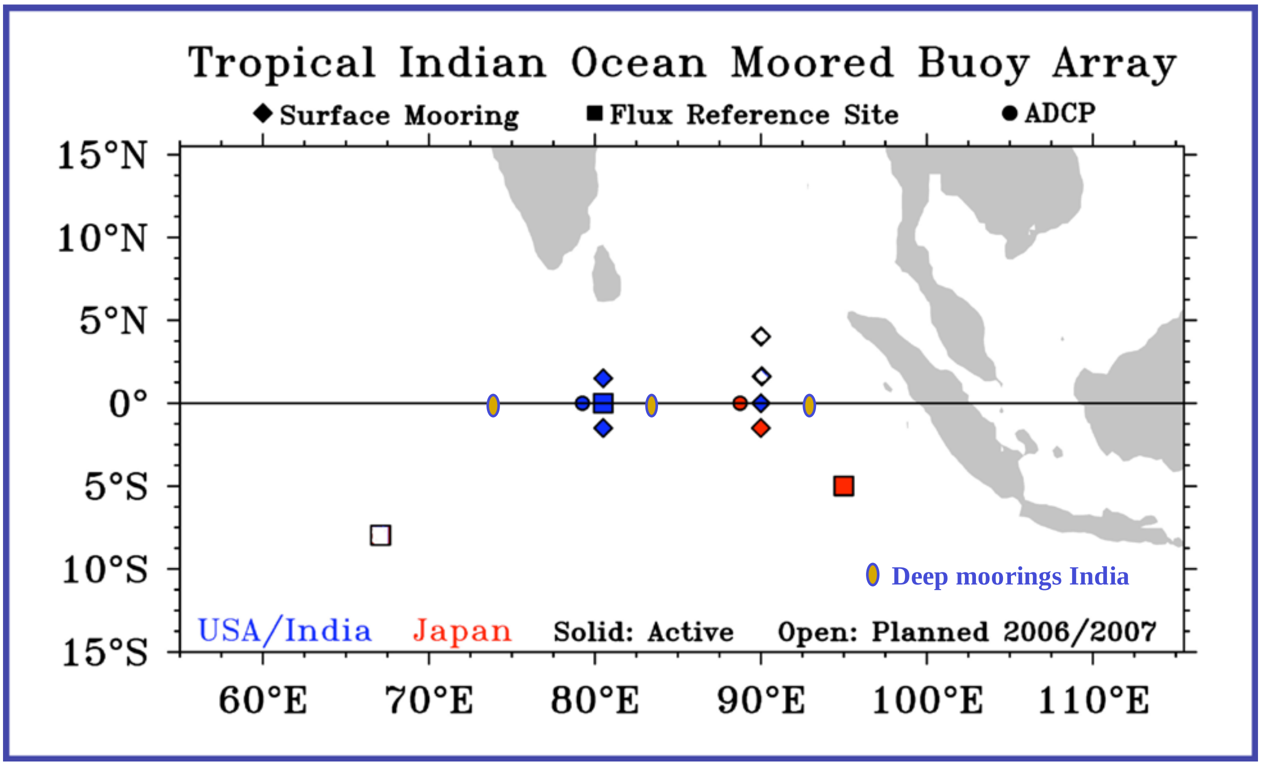

Figure 1. The surface and deep moorings that are already operating or that will be implemented in 2006/7

4. Present Status of the TRITON Project and Future Plans for the Indian Ocean Mooring Array *(Y. Kuroda)*

JAMSTEC's maintaining 15 TRITON sites in the western Pacific and two in the eastern Indian Ocean as of March 2006. Two TRITON buoys were deployed in the eastern tropical Indian Ocean in October 2001. The first is located at 1.5°S, 90°E to determine the upper-layer variations associated with the zonal jets along the equator (Originally it was planned at 0°N,90°E, but technologically it is difficult to design the buoy to survive the Indian Ocean equatorial jets). The second is at 5°S, 95°E, to investigate the contribution of the surface heat flux and the ocean dynamics/thermodynamics to the SST variability in the eastern part of the Indian Ocean Dipole. This location corresponds to the center of the area where the maximum SST anomaly appears during the peak period of the IOD.

TRITON and TAO data have been distributed through the GTS and web pages since January 2001. A new TRITON web page was started in 2005, and hourly real time data are available (http://www.jamstec.go.jp/jamstec/TRITON/real_time/top.html).

The time series of surface heat fluxes derived from the TRITON data at 1.5°S, 90°E were presented. The two year averaged net heat flux indicates that the ocean gains heat at about 14 Wm^{-2}. The data are valuable to validate other flux products derived from satellites and numerical models.

The Japanese Government, through the Ministry of Education, Culture, Sports, Science and Technology **(MEXT)** identified a new fund named "JEPP: Japan EOS (Earth Observation System) Promotion Program" in FY 2005, in order to promote GEOSS related activities. JAMSTEC has been funded for 5-years with JEPP funds for a program named "IOMICS: Indian Ocean Moored Buoy Network Initiative for Climate Studies." The program will enable the development of a new small size TRITON buoy and the continuation of the present TRITON sites in the Indian Ocean.

International coordination is vital to develop the Indian Ocean mooring array particularly for securing enough ship time.

The panel welcomed the launch of a new Indian Ocean mooring program by JAMSTEC under the new Japanese government fund “JEPP” as a fundamental part of the IndOOS basin-scale mooring array.

5. LOCO Long-Term Mooring Array in the Mozambique Channel *(W. de Ruijter)*

The Indian-Atlantic interocean exchange around South Africa is controlled from the Indian Ocean. The structure of the southern Indian Ocean wind field determines largely to what degree the subtropical gyres of the South Atlantic and Indian Oceans are connected to form an interocean ‘supergyre’. It sets the conditions for the non-linear dynamics of the Agulhas retroflection and leakage, largely taking place via ring shedding from the retroflection loop. Upstream control comes from the East Madagascar Current and the Mozambique Channel. The Indonesian Throughflow/South Equatorial Current passes north of Madagascar and part of it flows into the Channel. Here, a connection is established between the tropical and subtropical systems, with part of the global ‘overturning’ circulation passing through the Mozambique Channel. (Deep counter currents have been recently discovered in the Channel bringing Intermediate and North Atlantic Deep Waters equatorward.)

Variations in these flow regimes influence both regional and global climate variability by their impact on heat and freshwater transports. Recent observations have shown that around the narrow section of the Mozambique Channel (around 17º S) the flow breaks up in a series of deep reaching eddies that propagate to the Agulhas Current and act as a control on the frequency of Agulhas ring shedding. Interannual variability of this system appears connected to the anomalous circulation patterns induced by the IOD and ENSO cycles.

Since 2003, the Dutch LOCO mooring array (www.nioz.nl) spans the narrows of the Mozambique Channel. It will stay there for at least 5 years to determine the structure of the currents and T/S fields and the associated transports and (interannual) variability through the Channel. First results indicate periods of up to two years with predominantly tropical upper layer waters entering the Channel alternating with periods of inflow of subtropical origin. It is not clear yet how this variability is controlled nor what its impact is on circulation and climate downstream.

A new Netherlands Indian Ocean Programme is being prepared to address the above and related issues, including a paleoceanographic programme in the region around the LOCO moorings. If granted it will be carried out in the period 2008-2010 (hopefully long enough to catch an IOD/ENSO event). It is open for coordination of plans with other groups. The following recommendations on the design of a sustained Indian Ocean Observing System in the SW IO were put forward and will be revisited at the next IOP meeting:

- To continue and extend the present process-oriented studies in the southwestern Indian Ocean to determine the controls on, and the variability of, the strength of the Agulhas Current and the associated variations in Agulhas leakage and ring formation
- To extend the period of deployment of the LOCO mooring array to measure the effect of (at least) an IOD-cycle on the Mozambique Channel transport and its downstream impact
- Based on these studies and observations: to design an optimal SW IO component of the Indian Ocean Observing System to monitor the tropical-subtropical-interocean connections in this region.

ACTION ITEM 7. Establish connections with LOCO and future NL activities in IO *(W. de Ruijter and F. Schott)*

6. Present Status of Argo Floats in the Indian Ocean *(M. Ravichandran)*

The monthly location of the floats and number of profiles acquired during 2000 to 2005, were presented. The number of active floats and the total number of floats deployed in the Indian Ocean were also highlighted. In July 2006 there were 393 active floats in the Indian Ocean north of 50°S. The density of floats as a percentage of the density upon full implementation is shown below. Data from all the Argo floats deployed in Indian Ocean are available at INCOIS webGIS. The webpage allows the retrieval of data for a specific period, selected location, selected depth, and a particular parameter. Objectively analysed monthly products from Argo data such as mixed layer depth, depth of the 20 and 26 deg isotherm, heat content up to 300 m depth, sea surface temperature and salinity are available from 2002 to present. Maps of active float density and plans for future deployment of Argo floats in the Indian Ocean were presented. All the float data are available after real-time QC. Delayed mode QC of Argo data for the Indian Ocean in general and the northern Indian Ocean in particular was hampered by non convergent TS relationships and lack of good quality salinity measurements in the historical datasets. INCOIS hosts the regional Argo data center and coordinates related activities including future float deployment plans.

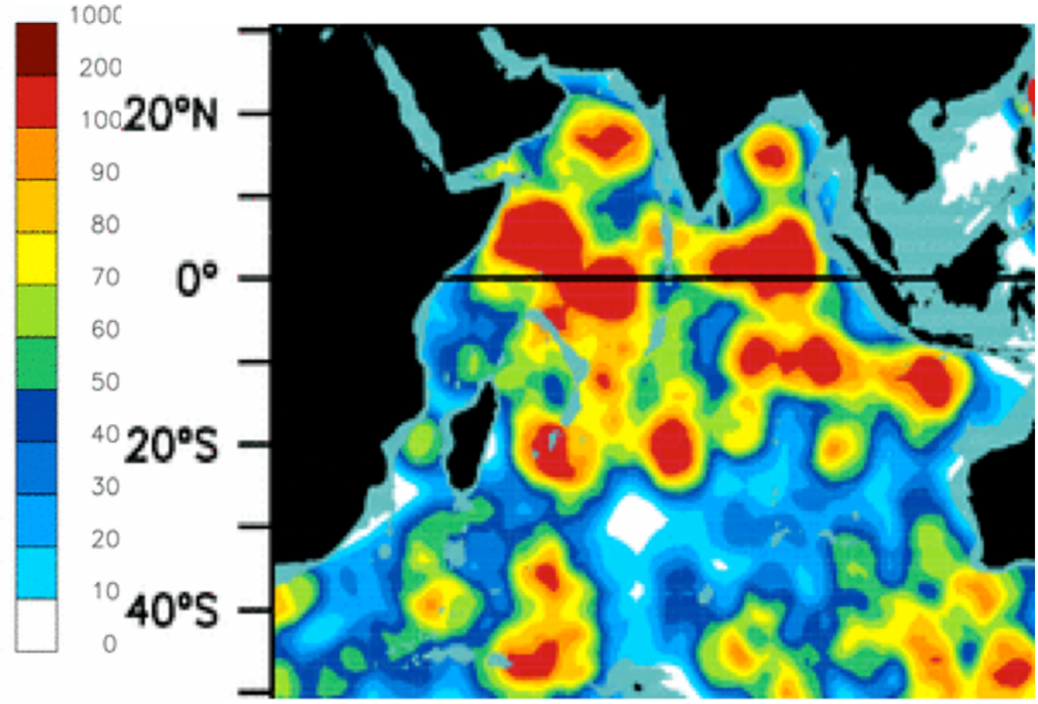

Figure 2. Argo float density in May 2006, from Scripps Institution of Oceanography. Colour scale indicates the percentage of the required density.

7. Establishing A NOAA Partnership for GEOSS with a Focus on the Indian Ocean *(S. Thurston)*

The United States contribution to the Global Earth Observation System of Systems (GEOSS) is the Integrated Earth Observation System (IEOS). IEOS is expected to satisfy US requirements for high-quality, global, sustained information on the state of the Earth for policy decision makers in many sectors of society. In many geographic regions observations are already being collected, while in some areas there remain gaps that need to be filled. NOAA has undertaken an initiative to implement increased global ocean observations for GEOSS and the UNFCCC via the GCOS Implementation Plan (GCOS-92), to include the Indian Ocean. NOAA's Office of Climate Observation (OCO) was established to manage the implementation of NOAA's in-situ, operational ocean observations for climate; however, they are also providing ocean data for many other uses. NOAA OCO manages the tropical array of moorings in the equatorial Pacific (TAO) and Atlantic (PIRATA), global surface drifters array, global sea level networks, ships of opportunity XBT networks, global carbon and hydrographic surveys and ocean reference stations. The mission of OCO is to build and sustain a global climate observing system that responds to the long-term observational requirements of the operational forecast centers, international research programs, and major scientific assessments. The OCO objectives are contributing to instrumentation of the global oceans and are consistent with the objectives of IndOOS as stated in the IOP implementation plan.

While the Indian Ocean is one of the most sparsely sampled basins in the world, as we begin to understand its effects around the globe, it is also becoming one of the most important basins for observations. With the Indian Ocean influencing the monsoons and climate variability in the region as well as potentially playing a role in the western United States precipitation patterns on decadal time scales and influencing El Nino through the Indonesian throughflow, NOAA has been deploying drifting buoys, XBTs, Argo floats and tide gauges into the region for years and just recently expanded its tropical mooring array into the basin.

NOAA plans to continue Indian Ocean mooring and other instrument deployments, ship-time, however, is the principal constraint to this expansion. To achieve NOAA's objectives in this basin, there is the need for long-term regional partnerships that include reliably scheduled ship-time. In addition to NOAA's long and fruitful relationship with JAMSTEC in the western tropical Pacific and now close coordination in the Indian Ocean, NOAA is also developing partnerships with institutes of developing Nations located in the Indian Ocean region under the initiative known as *PArtnerships with Noaa for GEoss Applications*, PANGEA. This capacity building initiative provides training to local decision-makers and scientists on the socio-economic applications of ocean data by US experts in exchange for shiptime to NOAA for instrumentation deployments.

In November 2004 NOAA, in coordination with India's Department of Ocean Development's National Institute of Oceanography (NIO), deployed four ATLAS moorings in the eastern equatorial Indian Ocean aboard NIO's R/V *Sagar Kanya* to measure marine meteorology and subsurface conditions. In exchange, a NOAA organized capacity building workshop was held in Goa India in October 2005 with scientists from twelve Nations in the region as well as representatives from the Shipping Corporation of India (SCI) and Indian Customs Officers. One expectation of this capacity-building workshop was that in-situ XBT observations will be enhanced in the under sampled Western Indian Ocean as contributions to the JCOMM Ship-Of-Opportunity (SOOP) XBT Networks while also filling existing gaps for GEOSS. NOAA provides all of the US support for Argo while also funding global XBT lines since these complementary networks are critical for understanding subsurface temperature and salinity fields. In July 2005, NOAA drifting buoys were aboard the global cruise of the Chinese R/V Ocean-1 and were deployed off the Cape of Good Hope to provide sea surface temperature measurements as well as surface current data. These NOAA drifters deployed by Ocean-1 contributed to a significant milestone since the drifter array reached its design target of 1250 drifters in sustained service during September 2005, thus becoming the first element of GOOS to be fully implemented. NOAA seeks to foster this relationship with China for future collaboration in the Indian Ocean. Another promising NOAA partnership is with Indonesia via InaGOOS. A capacity building workshop similar to that held in Goa will be held in Bali in June 2006 to enhance in-situ ocean observations in the eastern Indian Ocean while also demonstrating the practical socio-economic applications of these ocean data for fisheries, agriculture, and climate and marine hazards risk management. In exchange for this socio-economic applications training by US experts, Indonesia has offered to provide shiptime to NOAA for ATLAS climate and DART Tsunami mooring deployments.

It is hoped that PANGEA will be equally successful with other Partners in the Region to provide additional capacity building enhancements for the Indian Ocean. While 50% of the GCOS-92 global plan has been implemented, almost half of the work remains. Indian Ocean PANGEA partnerships are an efficient way to achieve this since they provide both increased ocean observations while also building regional capacity for the applications of these data for socio-economic benefits. NOAA looks forward to working closely with Institutes and other partners in the Indian Ocean to enhance ocean observations for not only climate but other marine services and applications.

8. ICG/IOTWS Working Group on Sea Level *(B. Kilonsky)*

To help develop a basin wide Indian Ocean Tsunami Warning System (IOTWS), UNESCO/IOC has recommended that the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS) follow the example of the Pacific system and take advantage of existing multi-purpose coastal sea level stations and data communications. Data from the December 2004, and the March 2005, Indian Ocean tsunamis were used to help produce recommendations for the finalization of the technical design of the in situ sea level element of IOTWS. These specifications include a one minute sampling scheme with a 15 minute transmission cycle via a geostationary meteorological satellite. There will be immediate retransmission via the WMO's Global Telecommunications System (GTS) to the Japan Meteorological Agency (JMA), the Pacific Tsunami Warning Center (PTWC), and other appropriate warning centers. Additional station requirements include the following: independent power and communications, fault-tolerant redundant sensors, local logging and readout of data, a warning center event trigger, establishing a system of surveying benchmarks, and locating the gauges in protected areas such as harbours.

We should encourage the installation of eastern Indian Ocean real-time Global Sea Level Observing System (GLOSS) sites in conjunction with the upgrade of the existing central and western Indian Ocean real-time GLOSS sites. The GLOSS stations are designed for long-term sea level monitoring, but with the upgrades are capable of monitoring tsunami and storm surges. This maximizes the potential for long-term maintenance of these sites. The establishment of the eastern Indian Ocean real-time GLOSS sites in conjunction with the upgrade of the existing central and western Indian Ocean real-time GLOSS sites has enabled PTWC and JMA to begin to provide basic basin-wide tsunami advisories and monitoring to the Indian Ocean nations. The process of developing GTS message headers and formats for sea level has been initiated with the co-chair of the CBS Expert Team on Global Telecommunication System and WMO Information System GTS-WIS Operations and Implementation. Current recommendations include creating new sequences for use in reporting tide data in CREX code form. Individual IOTWS centers can then receive these GTS message from their respective national meteorological centers. A GTS sea level display package has been developed by PTWC. Along with the commitment of the IOTWS nations to the free and open exchange of real time sea level data routinely on the GTS and the agreement to provide the historical data and metadata for the designated IOTWS sites in their country, this system will allow other Indian Ocean tsunami warning centers to start increasing the in situ sea level data stream necessary for basin-wide tsunami warning and monitoring. The development of these services is an essential part of the effort that enables the nations affected by the December 2004 tsunami to normalize the lives of their citizens.

The Panel welcomes the plan to upgrade GLOSS stations for IOTWS application. This maximizes the potential for long term records used in climate research with needs of IOTWS. The multiple use of tide gauges for climate issues (e.g. sea level rise) and tsunami warnings is an efficient approach.

> ACTION ITEM 8. Identify additional synergies between the Indian Ocean observing system and IOTWS on natural hazards. Make presentations at IOTWS future meetings and make the ppts available to the panel *(G. Meyers).*

9. Data Management *(P. Hacker and M. Ravichandran)*

Prior to IOP-3, a draft input to a data management plan was prepared and discussed via email. At IOP-3 a break-out session focused on data management for the Indian Ocean observation system. Discussions included:

- Review of OceanSites DM ideas: (2 GDACs, DACs, PIs)
- Summary of pre-IOP-3 ideas and options for DM
- Some INCOIS site capabilities and activities
- Some APDRC capabilities
- Group input and discussion:
    - Data management options (distributed versus centralized)
    - Data priorities (primary, secondary, etc)
    - Product development
    - Website and data search tool
    - Example text for DM document

The present situation is a very distributed collection of data holdings, access, and formats: PIs, DACs, GDACs with no central catalogue. INCOIS (www.incois.gov.in) is the Argo Regional Center for the IO and the national data center for India. APDRC (http://apdrc.soest.hawaii.edu/) serves a variety of data and products via OPeNDAP, LAS and EPIC. It was agreed that a central webpage at one or multiple sites, showing a central catalogue with links to data and products (available at one or more synchronized sites would be very useful at this stage (see APDRC data list as an example).

> ACTION ITEM 9. Build a webpage with IO data information and links to data, available by June *(P. Hacker and M. Ravichandran)*

Initially the model of "one-stop shop" (virtual) with a distributed access to data via the central webpage and central catalogue is proposed. Eventually it could evolve into an integrated Indian Ocean data center (similar to the Argo GDAC) focusing on specific data parameters (i.e., T and S, velocity, etc), or data types (i.e., XBT (QC is an issue), drifters, etc). The rationale is to assist with product generation (maps, input to assimilation models, etc.), and to handle data types where Indian Ocean data are not easily aggregated from original data sites. The focus is on the ocean and atmospheric boundary layers. The primary data are: Argo, drifters, moorings, XBT, sea level, ADCP, CTD and bottle). The secondary data are: atmosphere, satellite, model, land, river, other… The data products are research and application product development and serving: surface current, T/S(z). Other data to include are those from process experiments and biogeochemical data. Free and open access to primary and ancillary data consistent with CLIVAR and GOOS data policies will be the norm.

> ACTION ITEM 9. Complete the white paper on IO Data Information & Management strategy and submit to panel by early June for comments *(P. Hacker and M. Ravichandran)*

The written DM plan should be a living document with annual updates. Its content should include an overview of the plan, role of data center partners: DACs and PIs, CLIVAR requirements and details for each data type (primary and secondary). An example of the text for the DM document is as follows:

Mooring (meteorological and ocean time series data)
The Indian Ocean is known as a data sparse region among the tropical oceans. At the same time, the Indian Ocean is believed to play a significant role in climate variability in the Asian-Australian Monsoon region. In order to better understand the role of the Indian Ocean, more in situ measurements for analyses of ocean conditions, and for validation of the satellite data, are required. A mooring program for the Indian Ocean has been initiated and is now providing real-time and delayed-mode data for atmospheric and upper ocean parameters. Real-time and delayed-mode quality control are conducted by the PIs at their DACs.
NOAA/PMEL data are available at the TAO/TRITON web site:
http://www.pmel.noaa.gov/tao/disdel/.
JAMSTEC data are available at their website:
http://www.jamstec.go.jp/jamstec/TRITON/real_time/index.html.
The NIO equatorial mooring data are available at:
http://www.nio.org/data_info/deep-sea_mooring/oos-deep-sea-currentmeter-moorings.htm.
The APDRC serves WOCE mooring data via an EPIC server at:
http://apdrc.soest.hawaii.edu/.
The OceanSites project is developing a virtual data network for distribution of their data.

10. Future of the Panel *(G. Meyers)*

During the break-out session one group focused on the future of the Panel. The discussion was driven by the following questions: how to promote and implement the IO Plan? What should IOP do to acquire support from science/GOOS infrastructure (CLIVAR, GOOS, others) and from governments in order to implement the plan? What sponsors need to do to help? How do we transmit proposals and information to sponsors, i.e. events, showcase?

The breakout also discussed the Panel's role in CLIVAR and strongly favoured submitting a proposal to SSG-14 to make the panel an independent basin-panel. An outline of the proposal included review of the panel's history and accomplishments during 2004-2006, plans for future leadership, rotation of members and new terms of reference. The proposal was also to be sent to the co-sponsors, IOC Perth Regional Office and IOGOOS.

11 Review of the Implementation Plan recommendations

The group also reviewed the recommendations put forward within the implementation plan and proposed the following action items:

> ACTION ITEM 11. Contact J. Gould and put forward the recommendations of the IOP Implementation Plan for Argo coverage in the IO. Establish mechanisms for interactions *(G. Meyers)*

> ACTION ITEM 12. Contact SOOPIP and put forward the recommendations of the IOP Implementation Plan for XBT coverage in the IO. Establish mechanisms for interactions *(G. Meyers)*

ACTION ITEM 13. Contact Gustavo Goni at AOML to identify a PI to take the responsibility for coverage of IX10 *(G. Meyers and R. Boscolo)*

ACTION ITEM 14. Send a letter and a hardcopy of the Implementation Plan by the end of April 2006 to directors of oceanographic institutes/met offices of countries in the IO *(G. Meyers, W. Erband R. Boscolo)*

ACTION ITEM 15. Compose a list of high level contacts (funding agencies, national reps) and send a letter with hardcopy of the Implementation Plan by end April 2006*(G. Meyers, W. Erband R. Boscolo)*

ACTION ITEM 16. Send a letter to NSF and NASA advocating for IO research *(F. Schott and J. McCreary)*

12 CLIVAR/GODAE Global Ocean Reanalysis Framework

T. Lee introduced the CLIVAR/GODAE Global Ocean Reanalysis Evaluation Framework. GODAE has developed regional metrics and intercomparison focusing on meso-scale analysis products for short-term ocean nowcast/forecast (e.g., MERSEA – an EU Project for N. Alt. & Med. Sea). An effort was initiated within GODAE to evaluate global reanalysis products for climate application purposes. The initiative is in coordination with the CLIVAR-GSOP effort to develop metrics and define reference data sets with inputs from CLIVAR Pacific, Atlantic, & Southern Ocean Panels, WGOMD, and ETCCD. Recommendations from IOP are also sought. The objectives of the framework are:

- To evaluate the quality and consistency of existing global reanalysis products so as to facilitate user applications and to define some level of uncertainty (comparison with data – quality; intercomparison – consistency).
- To identify the common strength and weaknesses so as to find ways of improvement.
- To determine what assimilation method is most suitable for what application (dynamical mapping, budget analysis, initialization of climate forecast, drive biogeochemical models offline, etc.).
- To define climate-indices and diagnostic quantities that should be produced on a regular basis by each reanalysis effort to support regional and global CLIVAR research.
- To provide a guideline for future ocean reanalysis.

The diagnostics related to the Indian Ocean in the current draft of the metrics are:

- Meridional overturning stream function north of 10S.
- Meridional heat transport north of 10S.
- Upper-ocean heat content.
- Indonesian Throughflow volume transport.

What other quantities/indices should be included? What reference data sets in the Indian Ocean are recommended?

ACTION ITEM 17. Prepare a list of IO metrics for GODAE/GSOP synthesis activities *(Panel and T. Lee)*

13. Surface Drifters OSSE's *(G. Vecchi)*

The ability of a 5°x5° network of drifting buoys (drogued at 15m depth) to be maintained in the Indian Ocean given the divergent current systems existent in that region was explored using observing system simulation experiments (OSSEs). In the observed evolution of the drifting buoys, prominent areas from which drifting buoys diverge have been identified, including most of the western Indian Ocean, the Java upwelling zone and the thermocline ridge region. OSSEs indicate that this divergence should be expected in the surface currents in the Indian Ocean. Various deployment strategies were explored, none yielding satisfactory sampling.

- Further studies are needed to develop an adequate deployment strategy that samples these regions (regions that have been identified in the Indian Ocean Observing System Implementation Plan as being of scientific interest.)

Backtracking experiments were performed to identify seeding locations that would lead to future sampling of a target region. It was found that the seeding locations varied from year to year, suggesting that prediction of the surface currents many months in advance would be necessary to implement this strategy. Further, even with targeted deployment, certain regions remained opaque to drifters: there is no place in which to deploy surface drifters so that they appear in the upwelling regions off Somalia and Java during the Southwest monsoon a few months later.

- Mechanisms for *in situ* temperature observations in the cores of these upwelling regions should be explored, in order to constrain satellite estimates.

The ability of the 5°x5° network to monitor the time-evolution of surface currents of the model was also explored. It was found that the divergence of drifters and the oceanic eddies substantially impact the ability to reconstruct surface currents solely from drifter tracks.

- Different methods to recover the surface currents using drifter track information should be explored.

14. Evaluation of Sampling Strategies for XBT/Argo and Drifters Measurements *(T. Lee)*

Model sensitivities of heat content and heat transport to temperature fields: what can they tell us about XBT/Argo sampling?

- Annual-mean, top-400m, 10°S-10°N heat content and cross-equatorial heat transport are most sensitive to middle-lower thermocline temperature in the southern tropical-subtropical region associated with large-scale semi-annual waves (relevant to interannual to decadal variability).
- Existing frequently repeated XBT lines can monitor these waves north of 20°S. Intervals of 2-3 weeks seem adequate for this purpose.
- Argo floats are needed to monitor the region south of 20°S.

Model current and local temperature advection at 15 m (center drogue depth for drifters): what can they tell us about drifter sampling?

- Variability of 15 m current: The 5ºx5º sampling of drifters cannot resolve most variability. Even near the equator where zonal scale is large, this sampling has trouble resolving the narrow meridional scale.
- Variability of 15 m horizontal advection of temperature: Dominated by eddy contribution; impractical to be resolved by drifters (even with 1ºx1º sampling).
- Time-mean 15 m horizontal advection of temperature: Again dominated by eddy contribution except for large-scale meridional advection in the South Indian Ocean. The latter is resolved by 5ºx5º sampling of drifters, but enhancement by eddies is missed.

15. IOD - ENSO Forecast Experiments *(Y. Masumoto and G. Vecchi)*

Results of the Indian Ocean Dipole and El Nino Southern Oscillation (IOD-ENSO) forecast experiments using GFDL coupled model and SINTEX-F model were presented. The forecast experiments for the past IOD events in both models demonstrate a possible predictability with a lead-time of about six months, although there is a significant influence of the predictability barrier during the winter and spring seasons. The forecast experiments with SINTEX-F for the summer and fall of 2006, starting from 1 November 2006, show that positive IOD may occur in the Indian Ocean, with the Pacific condition changing from weak La Nina to normal. The forecast experiments using the GFDL coupled climate model do not indicate a clear forecast for an IOD event, for forecasts initialized in December 2005; ensemble forecasts give only a 10% probability of positive IOD. The GFDL forecast experiments indicate that there are predictability regimes for the IOD, with certain years being more constrained by oceanic initial conditions in December than other years when the occurrence of IOD is chaotic. The observed structure of the Indian Ocean in March 2006 suggests the overall situation of the surface and subsurface variables in the Indian Ocean looks similar to that in 1994 and 1997, the similarity being stronger in 1994.

Despite progress on IOD predictability experiments, there are still many issues to be solved, such as;

- The predictability barriers,
- Preconditioning for IOD,
- Deterministic mode/Stochastic mode,
- Relation between IOD and ENSO,

- Influences of ISOs.

The panel agreed to encourage in-depth analyses of the outputs from the prediction experiments with different models.

16. INSTANT Update and Preliminary Results *(R. Molcard)*

The international program—INSTANT (International Nusantara STratification ANd Transport) is now underway. The countries involved in the program are: Indonesia (BRKP, BPPT and LIPI), United States (LDEO; SIO), Australia (CSIRO), France (LOCEAN) and the Netherlands (NIOZ). The first phase of INSTANT is now complete and the 11 current meters and T/C sensors arrays have been recovered and redeployed in the main passages of the Indonesian Through Flow (ITF) during June/July 2005. Pressure gauges in Roti Island, in Bali/ Lombok and in Alor/Timor were also recovered and redeployed. CTD profiles and hull mounted ADCPs were conducted during the recovery cruises. Many Indonesian scientists joined the cruises and actively participated in the measurements. Several had been invited for training courses as well as for PhD degrees in the various laboratories of the participating countries.

For the first time 18 month-long time series of currents, temperature and conductivity are available over the entire depth of the main entrances and exits of the ITF. The data are presently being analyzed. They reveal much variability in a wide range of temporal and spatial scales with a significant difference between in- and out-flows. On the Indian Ocean side several coastally trapped Kelvin waves passed across Lombok Strait and propagated along the Flores Island coast to the Ombai Strait. They are believed to play a significant role in the intra seasonal variability of the ITF. Flow in the Timor Passage is steadier with few reversals and it is confined on the northern side. The most intense flow occurs above the sill, where there is a remarkable deep in- and out-flow between the Timor Sea and the Indian Ocean. Mean values along these passages are of the same order of magnitude as those deduced from previous measurements with standard deviations, which could exceed the means. The ITF in Ombai Strait is concentrated on the southern side, and there is an eastward flow below the ITF, at a depth between 300m and 500 m. In Lombok Strait there is an intensification of the flow on the western side. Volume and temperature transports and their variability over all straits and passages will be soon delivered to numerical modelling groups for intercomparison.

The final recovery of INSTANT moorings will occur by the end of 2006, giving another 18 months of data and a total data set of 3 years.

17. The Indo-Pacific Warm Pool: Ocean-Atmosphere Interaction Observation and its Climate Impacts Study (*W. Yu*)

A review of Chinese observation activities starting with the year 2003 was presented. After the TOGA-COARE project in the western Pacific, this recent work represents China's new devotion to tropical ocean-atmosphere interaction observing. China has deployed six of its total of 30 Argo floats and has maintained one HD XBT line in the Indian Ocean. China is planning to strengthen its observation activities in the next five-year cycle by setting up a process study project, which will be a valuable contribution to the implementation of ocean observation system in Indian Ocean. It is expected that two summer cruises with total ship time of 60 days will be conducted. These cruises could also help IOP in developing its Indian Ocean mooring array, especially in the eastern part. Dr. Yu will advise IOP of the project's progress and assist in coordinating relevant observation activities.

18. Biological and Ecological Challenges *(R. Hood)*

From a biogeochemical and ecological perspective the Indian Ocean is, arguably, the most poorly understood and under sampled ocean basin in the world. The Indian Ocean acts as a substantial net source of carbon to the atmosphere, but it also has significant carbon sink regions in the southern part of the basin. But these time-space patterns are poorly characterized at present, especially in upwelling regions like the Arabian Sea where CO_2 "point sources" to the atmosphere may exist. Our understanding of the forcing underlying these fluxes is also rudimentary, i.e., more research is needed to understand the relative importance of wind, temperature, upwelling and biological productivity in dictating ΔpCO_2. The IO has warmed rapidly in the 20^{th} century relative to most other oceanic regions. This warming will likely cause the IO to become an even larger source of CO_2 to the atmosphere because increased surface water temperatures reduce the solubility of CO_2.

The biogeochemical and ecological variability in the IO is very different from the Atlantic and Pacific. The IO is bounded to the north at relatively low latitude, which prevents significant thermocline ventilation. The IO also experiences dramatic seasonal changes in wind forcing and precipitation associated with the monsoon cycle, which gives rise to equally dramatic seasonal changes in the surface current patterns. The monsoon cycle also drives strong seasonal changes in coastal upwelling and primary production, e.g., in the Arabian Sea. Another unique aspect of the IO is the absence of equatorial upwelling and biogeochemical response.

Although the Arabian Sea and the Bay of Bengal span approximately the same latitude range, they are dramatically different biogeochemically. The Arabian Sea has:

- intense upwelling and mesoscale variability
- high productivity that is strongly seasonal
- net evaporation with high salinity sources
- strongly seasonal Fe and dust deposition
- a deep ocean oxygen minimum zone and high rates of open ocean denitrification
- significant open ocean N_2-fixaiton; and strong net efflux of CO_2 to the atmosphere.

In contrast, the Bay of Bengal has:

- weaker upwelling, modest productivity and less seasonality
- significant freshwater and nutrient sources
- a deep OMZ but no significant open ocean denitrification
- broad shelves and high rates of shelf denitrification
- significant open ocean N_2-fixation
- weak influx/efflux of CO_2 to the atmosphere.

The Bay of Bengal does, however, respond biogeochemically to perturbations associated with tropical storms and cyclones that can give rise to substantial chlorophyll and production anomalies. The Indian Ocean and the Arabian Sea in particular have traditionally been considered to be Fe replete due to the large dust transport and deposition associated with the SW Monsoon. However, recent modelling and observational studies have suggested that upwelling of low Fe:N ratio water during the SWM may give rise to Fe limitation in freshly upwelled waters. In situ Fe enrichment studies in the Southern Ocean sector of the Indian Ocean have shown that this region is Fe limited and/or Fe and light co-limited, but it is not known how far north this limitation extends. Models suggest that large areas of the southern tropical and subtropical waters of the Indian Ocean may be subject to Fe stress and limitation. Studies have suggested that dust and Fe transport from southern Africa stimulates carbon fixation and creates carbon sink regions in a broad swath across the southern Indian Ocean. This begs the question as to whether or not similar phenomena occur further north, for example, in the Arabian Sea.
Finally, a variety of climatic perturbations influence biogeochemical cycles and variability in the Indian Ocean, but these influences are poorly described and understood at present. Such perturbations include the MJO, ENSO (via atmospheric teleconnections to the Pacific) and the IOD to name just a few. The IOD, for example, appears to induce significant equatorial and coastal upwelling on the eastern side of the IO basin which gives rise to a strong productivity response that can be clearly seen in satellite ocean color data. This impact also appears to extend northward into the Bay of Bengal and the Arabian Sea, and modelling studies suggest that these perturbations significantly impact carbon export from surface waters.

In an effort to address these (and many other) issues, an international, interdisciplinary group of scientists will meet at the National Institute of Oceanography in Goa, India in October 3-6, 2006 to:

- Review the state of our understanding of the biogeochemical and ecological dynamics of the Indian Ocean in relation to physical oceanographic variability
- Identify prominent gaps in our knowledge, especially as they pertain to the role of physical and ecological processes that regulate biogeochemical cycles and the carbon cycle in particular

- Formulate a plan for the implementation of a biogeochemical and ecological observational and modelling research program that leverages and substantially enhances the planned CLIVAR/GOOS Indian Ocean observing system.

The topics covered will include physical variability and forcing, phytoplankton productivity response, microbial processes and DOM cycling, nutrient and trace metal cycling and limitation, and carbon cycling and CO_2 exchange. This workshop will adopt a basin-wide perspective, but coastal processes will also be considered, especially those that significantly influence basin-wide nutrient and carbon fluxes. Breakout sessions will be focused on three primary tasks identified above. For more information see the SIBER website at http://www.ian.umces.edu/siber.

The CO_2 survey group (Chris Sabine, Dick Feely and Bronte Tilbrook) relayed the following updates on the 2007-2009 CO_2 survey cruise:

1) NSF is unable to fund a ship in 2007, for the S4P/P16S Cruise
2) Jim Swift will send a letter to Eric Itsweire to support IO I8Sº/I9ºN line instead
3) Cruise is likely to occur in Jan. - Mar. 2007, on R/V Roger Revelle, starting from New Zealand
4) Survey line I8ºS/I6ºN is planned for a non-ice strengthened ship during IPY 2008
5) Plans are to return the IO in the 2009 time frame.

SIBER is aware that DART moorings are to be deployed in the IO and would like to know if CO_2 sensors can be installed on these buoys.

> ACTION ITEM 18. Explore the possibility of installing carbon sensors on DART moorings *(G. Meyers)*

> ACTION ITEM 19. Maintain and strengthen links with the biogeochemical community (IMBER, GLOBEC) by inviting reps to IO meetings and identify joint activities *(G. Meyers, R. Boscolo and R. Hood)*

19. Decadal Variability of Indian Ocean Cross-Equatorial Cell (*F. Schott*)

The Indian Ocean exports heat southward across the equator, but large uncertainties exist among different air-sea flux climatologies and models, even regarding the mean of this heat transport. An interesting discrepancy has been detected in the decadal developments of heat storage of the north and south Indian Ocean. While the upper few 100m of the southern IO shows a significant heat storage increase over recent decades, the northern IO does not (Lee et al., 2004. *Geophys. Res. Lett.*, **31**, L18305, doi:10.1029/2004GL020884). The mechanism mainly responsible for the heat exchange between both basins is the Cross-equatorial Cell (CEC; Schott et al., 2002. *Progr. Oceanogr.*, **52**, 57 – 1003). As part of the CEC, the Somali Current transports thermocline waters northward, where they upwell and are then exported back southward across the equator by the Sverdrup transport, to be subducted in the southeastern subtropics. Inflow from the Indonesian Throughflow (ITF) also participates in the CEC. In an analysis of output fields from the SODA assimilation model it is shown that all branches, Somali Current, Somali upwelling, interior cross-equatorial flow, and upper-layer ITF that participate in the CEC, significantly decreased during the decades 1950-90 in that model. As the main driver of this CEC "slowdown" a decrease of the southward cross-equatorial Sverdrup transport, based on COADs wind stresses used in SODA, was diagnosed (Schoenefeldt and Schott, 2006. *Geophys. Res. Let*. in press). A similar, if weaker decadal slowdown of the CEC was determined in the recently available output from the higher-resolution SODA-POP assimilation, which is driven by ERA-40 stresses, and again, the cause of the slowdown was a decrease of the cross-equatorial Sverdrup transport. A cautionary note here is that the NCEP-NCAR wind stresses do not yield such decadal Sverdrup transport decrease, and attempts are underway to analyze the CEC in the JAMSTEC Earth Simulator model output, since this model is driven by NCEP-NCAR stresses.

20. The SST Warming Trend in the Indian Ocean and Surface Fluxes (*L. Yu*)

The satellite observations of SST that became available since early 1980s show that the sea surface of the tropical Indian Ocean has been warming up steadily, and the warming trend averaged over the basin is of about 0.1°C per decade over the past 25 years. Since SST is an important driver for climate change and variability, finding the mechanism that causes the SST warming trend has important implication for projecting regional long-term climate change and for understanding the role of the Indian Ocean region as a primary heat source for the global circulation.

On the annual mean basis the Indian Ocean north of 15°S is a heat gain region. One intuitive view of the SST warming is that the Indian Ocean has been gaining more heat from the atmosphere so that the upper ocean is being heated up. However, our study, which uses a newly developed surface heat flux dataset by the Objective Analyzed air-sea Fluxes (OAFlux) project (http://oaflux.whoi.edu/) and the ISCCP surface radiations (http://isccp.giss.nasa.gov/), found that surface heat fluxes alone cannot explain the warming trend. The amount of the net heat gain received by the tropical Indian Ocean has been reducing due to the large increase of oceanic latent heat loss. The downward trend in net surface heat flux is also suggested by independent SOC flux analysis, but the two flux analyses give different estimates on the amount of the reduction. SOC shows a change of about 30Wm^{-2} for the decades 1980s through 1990s, while our OAFlux estimate is less than half of the SOC estimate. SOC analysis is based solely on the COADS ship reports, and the limited ship routes in the Indian Ocean may be a cause of bias.

It is generally believed that higher SST would increase the vapour pressure difference between the sea surface and the ambient atmosphere, and this would increase the latent heat loss from the ocean. Our study shows, however, that the increase of latent heat loss is induced primarily by the increased wind speed. More than 70% of the yearly variances of latent heat flux can be explained by the fluctuations of wind speed.

There are several implications of the study. First, that the net surface heat flux has a trend opposite to that of the SST suggests that the thermal forcing alone cannot be responsible for the SST warming, and this calls for the consideration of oceanic dynamic processes in analyzing the cause of the SST changes. Second, latent evaporation at the air-sea interface results in the transport of water vapour into the atmosphere. Water vapour is a key element of the hydrological cycle. The movement of water vapour in the hydrological cycle is coupled to precipitation and soil moisture. It is yet to be known how much the monsoonal precipitation has been impacted by the increased evaporation over the Indian Ocean. Third, water vapour is an important greenhouse gas. As the temperature increases, the atmosphere is able to hold more water vapour. The additional water vapour, acting as a greenhouse gas, absorbs energy that would otherwise escape to space and so causes further warming in the region. Lastly, the salinity in the ocean mixed layer would increase due to the loss of water vapour to the atmosphere, and the change would affect the mixed layer structure of the upper ocean, which influences and modifies the way that the ocean and the atmosphere interact.

21. Indian Ocean Warming over 1960-1999 (*G. Meyers*)

The Indian Ocean Thermal Archive (IOTA) is a new compilation of historical temperature profiles from 1900 through 2005, carefully quality controlled using the standards set during WOCE. The XBT data set through 1999 was updated with profiles from the Argo Program through 2005. For a comparison to simulations of 20th century climate by the IPCC 4th Assessment models, linear trends in observed subsurface temperature from1960 to 1999 were estimated. The linear trends show a general warming of the surface and seasonal thermocline in agreement with other SST datasets.

This warming is particularly large in the subtropics and sub-Antarctic, and extends down to 800 m around the subtropical front (40°S). Most of the IPCC models also show the deep subtropical warming. Analysis of the models' barotropic stream function showed that a 0.5° southward shift of the subtropical gyre modulated by the meridional temperature gradient can account for the deep subtropical warming. Earlier studies have related the southward shift of the gyre to a change in wind stress curl associated with stronger westerly winds.

In the tropics (south of the equator), the IOTA observations show surface warming accompanied by a robust subsurface cooling, which corresponds to a shoaling of the thermocline. Not all of the IPCC models show this cooling, and the majority in fact show subsurface warming. However, the trend in subsurface temperature in this region in all of the models is strongly associated with the strength of the equatorial Pacific trade winds. Its expression in the Indian Ocean apparently is transmitted through the Indonesian region by mechanisms identified in Wijffels and Meyers (2004, JPO 34 1232-1253). Usually a shallow thermocline is associated with cooler SST. However this analysis indicates that the SST warmed in the tropics while the thermocline shoaled. Combined with Lisan Yu's result in section 20, a simple interpretation of both surface fluxes and depth of the thermocline indicate a cooling process on SST. Is it possible that the shoaling thermocline and increasing stratification at the bottom of the mixed layer traps surface heat flux in a thinner layer? The next steps in this study will try to identify the dynamical role of the ocean in SST warming by analysing the IPCC models that produced something like the observed vertical structure.

22. Interaction Between the Indonesian Throughflow and Circulations in the Indian and Pacific Oceans (*J. McCreary*)

Circulations associated with the Indonesian Throughflow (IT) are studied using a suite of models: a linear, continuously stratified (LCS) model and a nonlinear, 4.5-layer model (LOM), both confined to the Indo-Pacific basin; and a global, ocean general circulation model (COCO). Solutions are wind forced, and obtained with both opened and closed Indonesian passages. Layers 1-4 of LOM correspond to near-surface, thermocline, subthermocline (thermostad), and upper-intermediate (AAIW) water, respectively, and analogous layers can be defined for the other two models as well.

The three models share a common dynamics. When the Indonesian passages are opened, barotropic and baroclinic waves radiate into the interiors of both oceans. The steady-state, barotropic flow field associated with the IT is an anticlockwise circulation around the perimeter of the southern Indian Ocean, with its meridional branches confined to the western boundaries of both oceans. In contrast, steady-state baroclinic flows extend into the interiors of both basins, a consequence of damping of baroclinic waves by diapycnal processes (internal diffusion, upwelling and subduction, and convective overturning).

At the exit to the Indonesian Seas, the IT is highly surface trapped with a secondary, deep core in all the models. The separation into two cores is caused by eastward-flowing currents in the interior Pacific (Equatorial Undercurrent, TJs, etc.), which drain layer-2 and layer-3 waters from the western ocean to supply water for the upwelling regions in the eastern ocean; indeed, depending on the strength and parameterization of vertical diffusion in the Pacific interior, the draining can be strong enough that layer-3 water flows from the Indian to Pacific Ocean. Consistent with observations, water in the near-surface (deep) core come mostly from the northern (southern) hemisphere, a consequence of the wind-driven circulation in the tropical North Pacific being confined to the upper ocean.

In the southern Indian Ocean, the IT-associated flow around the perimeter of the basin deepens away from the Indonesian passages, a result of eastward surface and westward subsurface currents generated by the radiation and damped, baroclinic Rossby waves from the Australian coast. In the LCS model, these currents are spread rather uniformly throughout the interior ocean. In LOM and COCO, they are concentrated into much narrower flows, the surface current forming a South Indian Subtropical Countercurrent.

23. El Nino and IOD Signals over Tropical Indian Ocean (*W. Yu*)

Due to the non-orthogonal essence between IOD and El Niño, they impose entangled impacts in the tropical Indian Ocean. With the aid of partial correlation analysis, the individual atmospheric/oceanic patterns associated with IOD and El Niño are identified. It is revealed that the atmospheric anomalous pattern during IOD is represented by the strong equatorial zonal wind anomaly accompanied by a pair of anti-cyclonic circulation cells on either side of the equator. The El Niño influence in the tropical Indian Ocean is characterized by the strong along-shore wind anomaly along Java-Sumatra in contrast to the weak equatorial zonal wind anomaly. El Niño also sees a pair of anti-cyclonic circulation cells. However, the northern component shrinks significantly while its southern counterpart dominates and exhibits a much larger meridional structure then that of IOD. Such different atmospheric patterns further lead to distinguished oceanic variations. It is shown that oceanic subsurface variations associated with IOD mainly locate north of 10ºS while El Niño causes the variations south of 10ºS. These different spatial patterns in the wind field characteristic of IOD and ENSO help to understand the different responses in the ocean and broader scale response in the climate system.

24. Intraseasonal Variability in the South Indian Ocean (*G. Vecchi*)

A suite of model experiments with the GFDL modelling system indicate that large-scale atmospheric intraseasonal variability in the southern Indian Ocean thermocline ridge (10°S-3°S) involves significant ocean-atmosphere coupling, and may influence large-scale intraseasonal variability beyond the Indian Ocean.

The Indian Ocean ocean-atmosphere exhibits energetic intraseasonal SST variability; in particular, there is substantial sub-seasonal SST variability - O(1-2°C) - in the southern Indian Ocean thermocline ridge, a region between 10°S and 3°S in which the strong wind-stress curl raises the thermocline close to the surface (Harrison and Vecchi 2001, Duvel et al 2004, Duvel and Vialard 2006, Saji et al 2006). The full character and climate significance of the sub-seasonal oceanic variability is not yet fully understood.

Observed data and a suite of model experiments indicate that 3-D oceanic processes are fundamental to the intraseasonal SST swings. The SST swings are driven by atmospheric variations on intraseasonal timescales. Recent oceanic observations indicate that some state-of-the-art ocean models are unable to reproduce the full character of the variability.

In atmospheric general circulation models and coupled climate model experiments these SST swings strongly feed back into intraseasonal atmospheric variations, of the same magnitude as the very variations that drive the changes – this suggests active ocean-atmosphere coupling. In the coupled climate model, the SST variations play an important role in the evolution of the Madden-Julian Oscillation (MJO). Further, because of the active role of the ocean in the models there is a large-scale preconditioning of the intraseasonal variability.

- Observations of oceanic and atmospheric variations in the Indian Ocean on intraseasonal timescales are essential.
- These modelling experiments underscore the potential of the upcoming MISMO and CIRENE process studies, and the utility of the developing mooring array.
- Given the well-established connection between the MJO and weather over land, and the model-suggested connection between intraseasonal changes in the Indian Ocean and the MJO, the usefulness of knowledge of intraseasonal Indian Ocean conditions to forecasts of intraseasonal weather variations over the global continents should be explored.

25. ISO: Models' Performance and Science Questions. Hints for Observational Needs *(B. Wang)*

Interannual variations of the Asian Australian Monsoon (AAM) are determined not only by remote ENSO forcing; the local monsoon-warm pool ocean interaction (rather than warm ocean SSTA) plays a critical role. This monsoon-warm pool ocean interaction has been described by Saji et al. (1999) and Webster et al. (1999) as a positive feedback between equatorial winds and anomalous zonal SST gradients similar to Bjerkness positive feedback. One potential weakness is that the IOD is short-lived and there must be a negative feedback to make it decay from fall to winter. Wang et al. (2003, J. Climate) proposed a new mechanism that characterizes the monsoon-warm pool ocean interaction as an off-equatorial atmospheric Rossby wave (a Southern Indian Ocean (SIO) anticyclonic anomaly) and the east-west contrasting SST anomalies. The equatorial interaction is a part of this basin-scale interaction. This interaction can provide either a positive or a negative feedback depending on the monsoon basic state: from boreal summer to fall the monsoon basic flow makes this interaction a positive feedback thus amplifying both the SIO anticyclonic and "dipole-like" SST anomalies, whereas from fall to winter the reversed monsoon flow north of the SIO convergence zone makes this interaction a negative feedback, thus damping the dipole (but the subtropical SWIO warming continues because it remains located in the trade wind regime). The argument here implies that the annual reversal of monsoon circulation is another hidden factor that contributes to interannual variability of the AAM.

26. MISMO: Mirai IO Cruise for the Study of the MJO Convection Onset (*K. Yoneyama and Y. Masumoto*)

MISMO is a process study, which will be conducted in October - December 2006, focusing on the atmospheric evolutions in association with the intraseasonal disturbances known as the MJO (Madden-Julian Oscillation) and the ocean responses to the MJO events. During the MISMO cruise, stationary observations at (0°N, 80.5°E) will be conducted about one month from late October. Since the atmospheric vertical structure and the air-sea interaction are the major targets for atmospheric observation, atmospheric sounding by radiosonde and Doppler radar observation as well as surface meteorological measurement, including skin sea surface temperature measurement, are the key components to be conducted. In addition, observations using wind profiler, cloud radar, lidar, videosonde, ozone sonde with precise hygrometer and so on will also be done. Furthermore, in accord with the Mirai cruise, intensive meteorological observation at the Maldives Islands will be carried out.

The ocean observations consist mainly of three parts; Argo floats, near surface temperature observation, and intensive moored buoy array. About 10 Argo floats will be deployed during MISMO using the R/V Mirai to observe the mixed-layer variability during the passage of the intraseasonal disturbances. Two JEPP (Japanese EOS promotion program) buoys (0°N, 79°E and 82°E) and four ADCP moorings (0°N, 79°E and 82°E; 1.5°N and 1.5°S, 80.5°E) will be deployed to make an intensive mooring array, together with the existing TAO/ATLAS buoys at 1.5°N/S and 0°N along 80.5°E, for the calculation of temporal variability of heat and mass balances. In addition, to understand the variability in the near surface temperature profile in detail, a thermistor chain including the skin temperature sensor will be added on one of the JEPP buoys. Data obtained during MISMO will deepen our understanding of various aspects of the intraseasonal variability in the central equatorial Indian Ocean. Further information on MISMO can be found at http://www.jamstec.go.jp/iorgc/mismo/.

27. VASCO - CIRENE (*R. Molcard*)

Recent studies based on Tropical Rainfall Measuring Mission's (TRMM) Microwave Imager (TMI) data show that tropical intraseasonal perturbations may be associated with sea surface temperature (SST) variations of several degrees, especially south of the equator in the western Indian Ocean (55°E-80°E, Eq-15°S) during the southern summer. While this variability is partly reproduced by forced or coupled ocean models, the relative role of different physical processes (warm layer formation, Ekman pumping, sub-surface cooling due to vertical mixing, surface fluxes) in these intraseasonal SST perturbations still has to be established. Since there are very few in situ observations in this region, an experimental campaign is needed to confirm the hypotheses that can be built using numerical modelling. The objective of the VASCO-Cirene campaign is to measure the impact of the different physical processes listed above on SST perturbations from diurnal (warm layer) to intraseasonal time-scales. This aims to better explain (i) the mechanisms of the intraseasonal variability of the SST and (ii) the feedback of these SST variations on the atmosphere.

The VASCO-Cirene experiment will take place from the beginning of January until mid-February 2007. The VASCO (PI, Jean-Philippe Duvel jpduvel@lmd.ens.fr) observing system will be based on balloons launched from the Seychelles. Two kinds of balloon will be used in VASCO. The pressurized balloons, measuring temperature, humidity and pressure and used during INDOEX, will fly at about 850hPa along a quasi-Lagrangian trajectory. The Aeroclipper is a new system developed jointly by CNRS and CNES, where the balloon pulls a guide rope that connects it to the surface of the ocean. It moves on quasi-Lagrangian trajectories depending on the surface wind. The combination of oceanic and atmospheric measurements allows one to derive turbulent fluxes of moisture, heat and momentum. The temporal resolution of 15mn will harvest information on the perturbation of these parameters at mesoscale. Simulated trajectories and real trajectories during tests in 2005, and 2006, suggest that both balloons will visit the region of large intraseasonal perturbation.

The Cirene (PI, Jérôme Vialard jv@lodyc.jussieu.fr) ship campaign, within the western Indian Ocean will be synchronized with the VASCO observing system. In collaboration with PMEL, one ATLAS mooring will be deployed at the beginning of Cirene at the flux reference site at 67°E, 8°S as planned by the IOP. The ship will then proceed to perform a ~25 day on station cruise in this region of strong intraseasonal perturbation

with intensive physical oceanography, air-sea fluxes and atmospheric measurements. The oceanic measurements will include continuous CTD casts (temperature, salinity, currents, oxygen) of the upper ocean, microstructure measurements with an autonomous profiler. Special care will be taken in measuring the diurnal cycle in the surface layer since it is believed to play an important role in intraseasonal SST variability (ASIP instrument developed by B. Ward). Biogeochemical measurements (nutrients, pigments) will also be collected because they can provide useful information on the physical processes at the origin of the SST perturbation. Drifting floats (slowed down by a drogue at 500 m) will be deployed (collaboration with WHOI) to evaluate the mesoscale variability of the oceanic thermal structure in the mixed layer. Flux at the interface will be monitored continuously. Atmospheric measurements will include radiosondes (at least twice a day), but also a complete set of instruments from RSMAS that will allow in particular to derivation of 3km-high temperature and humidity continuous profiles, as well as cloud pictures, etc…
These measurements will be combined with those from VASCO, from PROVOR/Argo floats and from satellites and re-analyses to provide a picture of the intraseasonal perturbations in early 2007.

28. South Indian Ocean Variability (*S.-P. Xie*)

The southwest tropical Indian Ocean is emerging as an important region for climate variability with potential predictability because of a unique thermocline dome. The dome is centered around 10ºS in response to the Ekman pumping between the steady southeast trades to the south and weak equatorial westerlies to the north. The collocation of this thermocline dome with the Indian Ocean intertropical convergence zone (ITCZ) suggests strong ocean-atmosphere interactions involving changes in atmospheric convection.

Large ocean Rossby waves are observed in the tropical southern Indian Ocean in response to the El Nino/Southern Oscillation (ENSO) and/or the Indian Ocean dipole (IOD). Propagating into the thermocline dome in the western half of the basin, these subsurface waves induce co-propagating signals in sea surface temperature (SST) with a clear response in precipitation and tropical cyclone activity (Xie et al. 2002, *J. Climate*, **15**, 864-878.). The transit time for these ocean waves across the basin is about one year, a delay that gives rise to enhanced predictability in the region (Luo et al. 2005, *J. Climate*, **18**, 4474–4497).

Large intraseasonal SST variability is found over the tropical southern Indian Ocean using satellite microwave observations that see through dense clouds (Harrison and Vecchi 2001, *Geophys. Res. Lett*., **28**, 3717-3720). These intraseasonal anomalies of SST are large in austral summer when the ITCZ is overhead. The SST anomalies are nearly zonally uniform, associated with large-scale, organized variations in atmospheric convection and surface wind. There is some evidence that the SST variability slows the timescales of atmospheric intraseasonal variability in the tropical southern Indian Ocean compared to the equatorial region (N.H. Saji, personal communication).

Few observations exist in the tropical southern Indian Ocean. The planned CIRENE field experiment is very timely for observing intraseasonal variability in the ocean and atmosphere as well as the processes by which subsurface anomalies influence SST over the thermocline dome. The formation of the barrier layer under the ITCZ and surface heat flux, in particular, are likely important processes that influence the intraseasonal variations.

29. Active Role of Southwest Indian Ocean *(H. Annamalai)*
Model solutions demonstrate that warm SST in the SWIO determines local increase in precipitation, which in turn weakens the Indian Ocean Walker Circulation. The weakened Walker Circulation with its anomalous descent over the tropical west Pacific - Maritime Continent suppresses the precipitation there, contributing to the development of a low-level anticyclone over the Philippines and the South China Sea. A set of ensemble solutions was carried out to assess the combined and individual effects of tropical Pacific and Indian Ocean SST anomalies on the Asian monsoon and extratropical circulation, particularly over the Pacific-North American (PNA) region.

Model solutions demonstrate that precipitation variations over the SWIO are tied to local SST anomalies and are highly reproducible. Changes in the Indian Ocean Walker Circulation suppress precipitation over the tropical west Pacific – Maritime Continent, contributing to the development of a low-level anticyclone over the Philippine and South China Sea. Our model results indicate that more than 50% of the total precipitation anomalies over the tropical west Pacific – Maritime Continent is forced by remote Indian Ocean SST anomalies, offering an additional mechanism for the Philippine Sea anticyclone apart from Pacific SST. This anticyclone increases precipitation along the East Asian winter monsoon front from December to May. The anomalous subsidence over the Maritime Continent in conjunction with persistent anomalies of SST and precipitation over the Indian Ocean in spring prevent the north-westward migration of the ITCZ and the associated deep moist layer, causing a significant delay in the Indian summer monsoon onset in June by 6-7 days (Annamalai et al. 2005, *J. Climate*, **18,** 4150-4167).

Analysis of the circulation response shows that over the PNA region, the 500hPa height anomalies, forced by Indian Ocean SST anomalies, *"oppose"* and *"destructively interfere"* with those forced by tropical Pacific SST anomalies. The model results validated with reanalysis show that compared to the runs where only the tropical Pacific SST anomalies are specified, the root-mean-square-error of the height anomalies over the PNA region is significantly reduced in runs in which the SST anomalies in the Indian Ocean are prescribed in addition to those in the tropical Pacific. Among the ensemble members, both precipitation anomalies over SWIO and the 500hPa height over the PNA region show high potential predictability. The model results indicate that the Northern Hemisphere extratropical response to Indian Ocean SST anomalies is significant and the effect of this response needs to be considered in understanding the PNA pattern during El Niño years. Our results suggest that the tropical Indian Ocean plays an active role in climate variability and accurate observation of SST in this region is urgently needed. (Annamalai et al. 2006, *J. Climate*, in press).

30. Panel Business

C. Reason, co-chair of the VACS panel, was unable to attend the IOP meeting, nevertheless, he submitted issues for discussion:

- CLIVAR VACS will organize a workshop on predictability and prediction of East and southern African climate on intraseasonal to interannual scales and oceanic influences (July 2006, Dar es Salaam, Tanzania). The workshop will specifically address IO impacts on both East and southern Africa. IOP inputs are sought and it was requested that the potential of funding support from the IOC Perth office be explored
- It is proposed to have a joint VACS/IOP meeting sometime in 07 or 08 (next VACS panel meeting is scheduled in July 2006, after the workshop)
- VACS is interacting more with both AIP and WGSIP, the latter is particularly interested in the SAGRADEX project that Richard Washington and Chris Reason tabled for southern Africa (i.e., mini AMMA)
- GEF has approved funding for an Agulhas and Somali Current Large Marine Ecosystem experiment (LME) – ratification by some of the 8 countries involved along the western Indian Ocean rim of Africa is still to be completed. This could help with funding the observational programme in the western Indian Ocean and potentially be a vehicle for the African countries bordering the IO to get involved.

ACTION ITEM 20. Write to C. Reason (VACS co-chair) and ask how IOP can provide inputs to the Tanzania workshop scheduled in July 2006 given the short notice of the workshop *(G. Meyers and C. Reason)*

ACTION ITEM 21. Plan a possible joint VACS/IOP meeting in 15 months from March 2006 to address common issues in southern Africa *(R. Boscolo and G. Meyers)*

Finally, the panel discussed the mechanism to rotate members and the benefits of having a co-chair

ACTION ITEM 22. Appoint a co-chair and 3/4 members to rotate *(G. Meyers, W. Erband R. Boscolo)*

APPENDIX A. List of Participants

Panel Members

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APPENDIX B. Agenda

Day 1 Monday 27 February

9:00-9:10 Welcome and local arrangements *(G. Meyers and J. McCreary)*
9:10-9:20 Welcome by GOOS and introduction to meeting *(B. Erb)*
9:20-9:50 Welcome by CLIVAR and CLIVAR activities related to IOP *(R. Boscolo)*
9:50-10:30 Inter-sessional activities and confirmation of agenda *(G. Meyers)*

10:30-11:00 Coffee Break

SUSTAINED OBSERVATIONS: IMPLEMENTATION, COORDINATION AND SCIENCE UPDATE

11:00-11:45 Status of the tropical mooring array *(M. McPhaden)*
11:45-12:10 Long-term measurements of current in the equatorial IO through current meter mooring along the equator *(V.N.S. Murty)*
12:10-12:30 Present status of TRITON project and future plans for the IO mooring array *(Y. Kuroda)*

12:30-13:30 Lunch

13:30-14:00 LOCO long-term mooring array in the Mozambique Channel *(W. de Ruijter)*
14:00-14;30 Present status of ARGO floats in IO *(M. Ravichandran)*
14:30-15:00 Establishing partnership for GEOSS with a focus on the IO *(S. Thurston)*
15:00-15:30 ICG/IOTWS working group on Sea Level *(B. Kilonsky)*

15:30-16:00 Coffee Break

16:00- 17:30 Breakout Session: two groups on:

- Data Management (*chairs: M. Ravichandran and P. Hacker)*
- Future of the Panel: how to promote and implement IO Plan? What IOP should do to acquire support from science/GOOS infrastructure (CLIVAR, GOOS, others) and from governments in order to implement plan? What sponsors need to do to help? How do we present to sponsors, i.e. events, showcase? Report to SSG-14 (*chairs: G. Meyer and B. Erb*)

Day 2: Tuesday 28 February

REPORTING ON THE GROUPS DISCUSSION
9:00-9:30 Data Management *(P. Hacker)*
9:30-10:00 Future of the Panel *(G. Meyers)*
10:00-10:30 Discussion on the Observing System

10:30-11:00 Coffee Break

11:00-12:00 Review the recommendations put forward by the Implementation Plan *(G. Meyers)*

OBSERVING SYSTEM SIMULATION EXPERIMENTS
12:00-12:30 Surface Drifters OSSE's *(G. Vecchi)*

12:30-13:30 Lunch

13:30-14:30 Evaluation of sampling strategies for XBT/ARGO and drifters measurements *(T. Lee)*
14:30-15:00 Seasonal IOD and ENSO predictions for 2006 (*Y. Masumoto)*
15:00-15:20 IOD-ENSO forecasts using NOAA/GFDL experimental forecast system *(G. Vecchi*)

15:20-15:45 Coffee Break

15:45-16:30 INSTANT update/preliminary results *(R. Molcard*)
16:30-17:00 The Indo-Pacific Warm pool: Ocean-atmosphere interaction observation and its climate impacts study (*Weidong Yu*)
17:00-17:30 Biological and ecological challenges *(R. Hood)*

18:00-20:00 Reception at University of Hawaii campus offered by IO-GOOS office

Day 3: Wednesday 1 March

SCIENCE TALKS

9:00-9:30 Decadal variability of Indian Ocean cross-equatorial cell (*F. Schott*)
9:30-10:00 The SST warming trend in the Indian Ocean and surface fluxes (*Lisan Yu*)
10:00-10:30 Indian Ocean warming over 1960-1999 (*G. Meyers*)

10:30-11:00 Coffee Break

11:00-11:30 Interaction between the Indonesian Throughflow and circulations in the Indian and Pacific Oceans (*J. McCreary*)
11:30-12:00 El Nino and IOD signals over Tropical Indian Ocean (*Weidong Yu*)
12:00-12:30 Intraseasonal variability in the South Indian Ocean (*G. Vecchi*)

12:30-13:30 Lunch

13:30-14:00 ISO: Models' performance and science questions. Hints for observational needs *(B. Wang)*

MISMO-CIRENE WORKSHOP (*Chairs: Y. Masumoto and R. Molcard*)

14:00-14:30 MISMO: Mirai IO cruise for the study of the MJO convection onset (*K. Yoneyama*)
14:30-15:00 MISMO Ocean observations (*Y. Masumoto)*
15:00-15:40 Introduction of CIRENE (*R. Molcard*)

15:40-16:00 Coffee Break

16:00-16:30 South Indian Ocean: a region of active air-sea interaction (*S.-P. Xie*)
16:30-17:00 Active role of Southwest Indian Ocean *(H. Annamalai)*

17:00-17:30 Discussion on possible interaction between MISMO and CIRENE

Day 4. Thursday 2 March

9:00-10:15 Discussion on Action Items for the Observing System and Data Management

10:15-10:45 Coffee Break

10:45-12:00 Panel Business:
- Membership
- SSG report
- VACS requested input on Tanzania workshop
- Next meeting
- Outreach activities

12:00 END OF MEETING

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