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CONTENTS

1. Introduction

The 5th IOP meeting took place at the Ramada Bintang Bali Resort Hotel thanks to the local organizing committee composed of Fadli Syamsudin, IOP member, Reni Sulistyowati and Damayanti Sarodja. Fadli Syamsudin welcomed the participants (see Appendix A) and reminded them of the charges to the meeting (see agenda Appendix B). Apologies were received for being unable to attend from Lisan Yu and Chris Reason. Both circulated information and material in advance of the meeting. A minute of silence was held for Fritz Schott, an active IOP member who had died the week before the meeting. Prof. Jana T. Anggadiredja (Deputy Chairman of BPPT) opened the meeting by introducing a series of talks by Indonesian scientists on national activities related to the Indian Ocean climate studies.

2. Science Talks on Indonesian Indian Ocean Activities

Recent Oceanographic Activities in Indonesia (Prof. Indroyono Soesilo, BRKP)
One of the Indonesian oceanographic activities has included focus on the monitoring of the Throughflow, with Indonesia involved in both SITE (South China Sea – Indonesian Transport Exchange) and INSTANT (International Nusantara Stratification and Transport) international projects.

The marine areas surrounding Indonesia are particularly rich and are part of the so-called Coral Triangle (CT), which span Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor-Leste. This region is sometimes referred as the “Amazon of the Seas” because it exhibits the highest marine life abundance and diversity on the planet. CT serves as the spawning and juvenile growth areas for what is the largest tuna fishery in the world. Coral bleaching, ocean acidification and sea level rise are long-term threats to Indonesia’s marine biological resources.

Indonesia is the world’s largest archipelagic nation and according to climate projections, will loose 2000 islands by 2030. Severe floods will kill some mangrove communities, destroying critical shrimp nurseries that provide an important source of income to the nation. In September 2007 the Coral Triangle Initiative was launched within the Asia-Pacific Economic Cooperation aiming at enhancing the conservation of marine biological resources. Financial support comes from the GEF (Global Environmental Fund - World Bank), USA, Australia, France, China and New Zealand for:

- Protected Areas
- Adaptation to climate change
- Managing fisheries
- Census on threatened species

Indonesia will host the World Ocean Conference (WOC) in May 2009 focusing on climate change impacts on the oceans and the role of oceans in climate change (http://www.woc2009.org/home.php)

Indonesian Tsunami Early Warning System (InaTEWS) (Dr. Ridwan Djamaluddin, BPPT)
The development of InaTEWS consists of 3 integral components, namely: a) Operational or Technical works: responsible for the monitoring, processing, warning issuance and dissemination; b) Capacity Building: responsible for the development of the system, modelling, human resources development, preparation of modules for training material, and education; c) Emergency Response, Rehabilitation, Reconstruction: responsible for the public education, enhancement of public awareness and preparedness, logistic, search and rescue, rehabilitation and reconstruction.

The corresponding monitoring systems consist of seismic networks, tide gauge networks, buoys, and a GPS and satellite observation network. The processing center is distributed: at each network is operated by different institutions; these institutions together are the operators of InaTEWS.

Education and training of the warning centre staff, as well as consultation with agencies, authorities and ministries in the Indian Ocean region, are the main focus of Capacity Building. Furthermore, measures for the secure dissemination of warnings are developed and evacuation and escape plans generated. Training courses last three weeks and focus on the new Tsunami Early Warning System installed in Indonesia. They offer the possibility for young scientists/engineers to learn the necessary background knowledge to work with the individual technical components, and how to use the system to find the information needed to start or to stop a Tsunami Early warning. The final goal of this training course is to broaden the experience and expertise of Indonesian scientists, which is of vital importance when establishing the InaTEWS.

***Indonesian Global Ocean Observing System (InaGOOS)* (*Dr. Aryo Hanggono, BRKP*)**

The Indonesian monitoring system is important for various activities and applications, such as navigation, sea transportation, fishery, marine disaster mitigation, environment monitoring, and marine resource production. Marine data are beneficial in predicting marine climate/weather and environmental conditions, protecting marine life, mitigating marine environment changes due to human activities, and for promoting advancement of marine science. The overall INAGOOS science plan goals are:

- To explore, model and quantify the potential predictability of the marine ecosystem from the overall basin to the coastal areas
- To initiate the operational observational/modeling system in the Indonesian archipelago at regional level (IOGOOS)

INAGOOS will implement technologies for automatic real time monitoring system for the collection of physical and biological data to be assimilated in ocean forecast models. It will provide circulation and ecosystem forecast models at regional, basin and local scale for decision-making.

The INAGOOS plan is structured in seven areas of actions:

- Ocean Hydrodynamics
- Integrated water cycle
- Biochemical fluxes and cycles
- Open ocean and coastal marine pollution
- Sedimentary fluxes and coastal erosion
- Operational fisheries
- Multi-hazard observing systems and early warning

Data and information management (DIM) lies at the heart of GOOS, so the development of a Marine Data and Information Center is a high priority for the immediate future. DIM will address the issue of how the marine data flow to services and products. The DIM system is likely to be based on a distributed computer-linked network of data-processing centers or nodes, and to include a Data and Information Management Service that provide coordination as well as advice to users on the practical aspects and to create products of local interest.

Indonesian Region and Indian Observations (Dr. Berny A. Subki, SEACORM, BRKP)

SEACORM (Southeast Asia Centre for Ocean Research and Monitoring) is currently developing a national system for Indonesian Operational Oceanography in selected areas. The sustainable development of Indonesian coastal areas, the management of water (the integrated atmosphere–ocean water cycle), marine resources (off-shore activities and fisheries) and the overall management of open sea and land-derived pollution is a serious concern. Millions of people’s lives depend upon the continuous assessment of the state of the system so that prevention actions against pollution, overexploitation of fish stocks, loss of water resources and marine ecosystem habitat loss can be organized in a timely fashion, together with adaptation and mitigation measures.

A marine environmental prediction system is composed of four methodological blocks observing, modelling, data assimilation and an information management system containing the Decision Support Systems that provide software interfaces for policy makers. The synergy between the first three building blocks produces an optimal estimate of the present and near future state of the system that is considered to be the basic information before any decision about prevention or mitigation actions should be taken. The data management system makes this information available in real time to policy makers and environmental agencies responsible for the protection of the marine resources and habitats.

> **ACTION 1.** Recognize the progress made by the Indonesian Oceanographic community in enhancing observations and developing activities aiming at understanding the dynamics of the surrounding oceans and their impact on regional and global climate. Encourage interactions with the international community (F. Syamsudin, G. Meyers and Y. Masumoto)

3. Status of UNESCO IOC Perth regional project office and future support of IOP (Nick D'Adamo)

The IOC Perth Regional Project Office is supported by the Western Australian State Government, the Australian Bureau of Meteorology and the UNESCO IOC. Western Australia has important requirements for ocean data and information from the offshore and coastal environment including vessel port entry, Indian Ocean commerce, rock-lobster fisheries, offshore oil and gas operations, gauging load levels for ore carriers and oil rig design (engineering in general). The foci are:

- Regional development of GOOS around Australia (IO, SEA, Pacific)
- Create a regional UNESCO IOC focal point in Perth
- Identify IOC related user needs
- Establish regional opportunities for capacity building
- Encourage investment in GOOS, as a focus
- Promote, facilitate, and sponsor programs relevant to all IOC themes.

Since 1998 the IOC has created four regional "Alliances" for the Southern Hemisphere: IOGOOS, WAGOOS, SEAGOOS and PIGOOS. The CLIVAR/GOOS Indian Ocean Panel was established within these alliances.

The Perth Office was reviewed in 2007 and the positive assessment endorsed the Office and its programmes for 5 more years (till 2013).

4. CLIVAR and WCRP activities relevant to IOP (*Y. Masumoto, R. Boscolo)*

The outcomes of the CLIVAR SSG-15 meeting (Geneva September 2007) were reviewed where the severe cut in WCRP funding for years 2008-2009 and hence in CLIVAR support for activities was highlighted. However the SSG agreed not to restructure CLIVAR in response to the announced reduction of WCRP funds for 2008 feeling that that a major organizational change would disrupt progress. They decided to leave the structure as it is, out to at least the 2010 timeframe at which time it was suggested that the project be reorganized to accommodate a final analysis and assessment phase. The SSG recognized that WCRP support for meetings would be minimal. Panels and Working Groups will be required to seek other support for meetings and to seek to reduce costs by arranging meeting in the margins of Workshops/Conferences with the SSG will providing guidance on allotment of WCRP funds for meetings.

Two major events are planned for 2009:

- The World Climate Conference-3 (http://www.wmo.int/pages/world_climate_conference/)
- OceanObs09 (http://www.oceanobs09.net/)

The following SSG-15 action items are strongly relevant to IOP activities:

- Ensure CLIVAR coverage of Indonesian Throughflow and clarify relative roles of Pacific and Indian Ocean Panels in this area.
- SSG encourages the IOP proposal for a resource board for the region and recommends they develop an implementation plan for ship time to maintain the long term observing system of IndOOS.
- SSG endorses coordinated study and intercomparison of the predictions of the 2006 and 2007 IOD events, started between IOP and AAMP.

R. Boscolo reported on the preliminary outcomes of the WCRP/JSC-29 meeting (Arcachon March 2008). She reviewed the progress with the WCRP strategic plan (COPES), which focuses in the following Cross Cutting topics:

- Anthropogenic Climate Change
- Atmospheric Chemistry and Climate
- Monsoons/YOTC (Year of Tropical Convection)
- Extreme Climate Events
- Seasonal Prediction
- Decadal Prediction
- Sea Level Rise (SLR)
- Regional Climate modelling and downscaling

The following JSC action items are relevant to the CLIVAR community:

- Form a CLIVAR-led group to prepare WCRP's input to OceanObs09, ensuring adequate participation of CliC, GEWEX (e.g. SeaFlux), SOLAS, WGSF, and the SLR crosscut
- Recommendation that JSC of WCRP should have direct input to and influence on the WCC3 programme and outcome(s). Chair JSC to send letter to WIOC and Conference chair, offering JSC help in developing the WCC-3 programme, outlining what WCRP might see as a single major outcome, suggesting consolidation of current list of anticipated outcomes, using WCC3 to promote excitement and opportunities of career in climate science for young persons. To seek for and include IGBP's input into this process. Reconfirm Ramaswamy as WCRP representative to WIOC.
- Crosscuts should be fully integrated in the projects' work. All aspects of WCRP work should be measured against the COPES goals.
- Develop an implementation plan for the intermediate term based on the COPES Strategic Framework by the WCRP Projects' leadership and with active involvement of JSC members. All the core projects, to assess and identify what activities need to be further emphasised and which can be de-emphasised in the intermediate term. Projects will be requested to summarise their assessment and plans in form of a WCRP a legacy document. JSC Chair and members will provide the leadership to develop a long-term vision for WCRP in consultation with the Projects, Sponsors, supporters and the scientific community at large.

5. Updates on IndOOS and recent science-results from the data streams

Upper ocean signature of the Madden-Julian Oscillation (MJO) (Jérôme Vialard)

A lot of modelling studies (even in hindcast mode, e.g. Woolnough et al, 2007) suggest that including coupling with the upper ocean improves the simulated Madden Julian Oscillation. In this respect, there is a need to better understand the processes of the upper ocean response to the MJO. Recent studies making use of microwave data (that sees "through' clouds and allows a better estimate of the surface cooling below convection) highlight two regions of strong SST signal associated with the MJO. The first one is along the 5°S-10°S thermocline ridge in the Indian Ocean, and the second between Australia and the Maritime Continent. Comparatively, the SST response is smaller in the western Pacific.

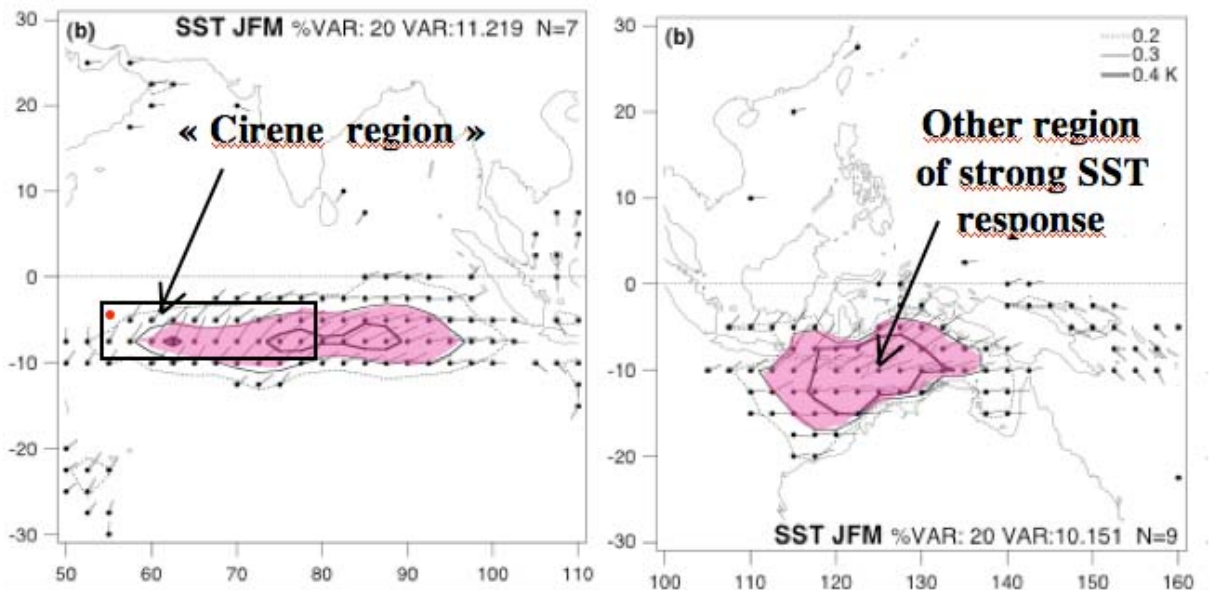

Figure 1. Amplitude of the SST signal associated with the Madden-Julian Oscillation diagnosed from 8 years of satellite SST data (TMI), from (Duvel and Vialard, 2007). There are 2 regions of strong amplitude SST signal associated with the MJO: the 5°S-10°S band in the Indian Ocean, above the thermocline ridge, and the region between Australia and Indonesia. Comparatively, the amplitude of the SST signal in the western Pacific is much smaller.

In this talk, Dr Vialard showed how data from the recently deployed RAMA mooring allowed exploration of further details of the upper ocean SST response in the thermocline ridge region. The SST signal seems to be largely driven by air-sea fluxes, although lateral advection and vertical processes are not negligible. There is no mooring data available in the second region to explore the oceanic processes and it was suggested that data be collected there, at least in the framework of a process study. Another point of the talk (also highlighted by Woolnough et al. 2007) is that the diurnal cycle of the upper ocean might contribute significantly to the intraseasonal variability in these two regions.

> **ACTION 2.** Contact Australian oil companies to explore the possibility of obtaining meteorological and oceanographic data from offshore platforms in northern Australian waters (N. D'Adamo and G. Meyers)

> **ACTION 3.** Gather a short list of satellite data essential for Indian Ocean research (J. Vialard)

The Research Moored Array for the African-Asian-Australian Monsoon Analysis and Prediction (RAMA) (M. McPhaden and Y. Masumoto)

The ***R***esearch Moored ***A***rray for African-Asian-Australian ***M***onsoon ***A***nalysis and Prediction (RAMA) is a new moored buoy array in the Indian Ocean designed for advancing monsoon research and forecasting. Recurrence of monsoon rains is critical to agricultural production that supports a third of the world's population. The Indian Ocean also remotely influences the evolution of El Niño and the Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), North American weather, and Atlantic hurricane activity. Despite its importance in the regional and global climate system though, the Indian Ocean is the most poorly observed and least well understood of the three tropical oceans.

RAMA is a contribution to Global Ocean Observing System (GOOS), the Global Climate Observing System (GCOS), and the Global Earth Observing System of Systems (GEOSS). Nations that have provided mooring equipment, ship time, personnel, and/or logistic support so far include Japan, India, the United States, Indonesia, China, and France. In addition, the Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project, a consortium of eight African countries, will also provide ship time and logistic support in the near future. A report describing RAMA in detail has been accepted in the *Bulletin of the American Meteorological Society* and publications using RAMA data are beginning to appear in the referred scientific literature.

The present status of and some results from the TRITON and ADCP moorings under JEPP-IOMICS project were reviewed. Two TRITON buoys deployed by JAMSTEC at 1.5°S, 90°E and 5°S, 95°E are continuously observing and sending meteorological and surface/subsurface ocean data, although there are some gaps in the meteorological data due probably to fishing vandalism. In February 2008 the two TRITON buoys were replaced by new, small and light weighted m-TRITON buoys developed under the JEPP-IOMICS project. The m-TRITON buoys can provide the high quality data, which has basically the same accuracy with that from the standard TRITON buoys.

TRITON data at two locations in the eastern Indian Ocean clearly demonstrate that, for both 2006 and 2007 positive IOD events, a large amplitude subsurface negative temperature anomaly appeared a few months prior to the air-sea coupled IOD evolution. Such subsurface temperature evolution can only be observed in detail by a mooring buoy, and the negative anomalies can be considered as preconditions for the positive IOD events.

There are five upward-looking ADCP moorings along the equator covering the region from 77°E to 93°E as a part of RAMA/IndOOS. To obtain basic characteristics of current variability associated with the equatorial waves in the Indian Ocean, preliminary analyses on coherences among the data are performed. The results suggest large amplitude Kelvin wave in zonal current variability and mixed Rossby-gravity wave in meridional current variability at the intraseasonal time-scales. The analyses also indicate that the moorings located at 80.5°E and 83°E provide basically the same variability in terms of the short-term variations, suggesting a possible redundancy of the resources.

Upwelling velocity was estimated from three ADCPs deployed at 79°E and 82°E on the equator and at 1.5°S, 80.5°S during the MISMO campaign from Oct. to Nov. 2006. The average value over the one-month MISMO period shows about 3m/day upward motion below the thermocline. However, temporal variation of the vertical velocity is significantly affected by the intraseasonal variability in the currents, resulting in larger than 15m/day upward motion associated with a passage of the mixed Rossby-gravity wave.

> **ACTION 4.** Make sure that the committed ship-time for RAMA in 2008/2009 is well coordinated among the involved nations (M. McPhaden, M. Ravichandran, K. Yoneyama, W. Yu and F. Syamsudin)

Mike McPhaden suggested eliminating one of the 39 surface moorings of the initial plan, namely the mooring at 5N, 80E. This site was proposed in the first place by Fritz Schott who had an ADCP mooring there in 1993-94 to measure currents south of Sri Lanka. The rationale is as follows:

1) The mooring is only 1 deg north of an identical mooring located at 4N, 80E. There are no other surface moorings so closely spaced in the array. We expect that surface moorings this close together will provide largely redundant information on surface meteorological and upper ocean variations, based on our understanding of spatial coherence scales in the tropics which are generally > 1 deg meridionally.
2) The mooring is located in the Sri Lankan EEZ and only 100 km from land. Historically, moorings closest to land are the most heavily vandalized. This site will most likely be very expensive to maintain because of anticipated equipment losses. At the same time, it is likely to return relatively little data compared to other sites.
3) A secondary but nonetheless practical issue is that clearances are required to routinely service the mooring because it is located in the Sri Lankan EEZ. Clearances are sometimes difficult to obtain, which may complicate maintenance and compromise our ability to ensure uninterrupted data streams at this site.

ACTION 5. Write a justification for eliminating the mooring site at 5N-8E from the RAMA plan (M. McPhaden)

Long term measurements of current in the equatorial Indian Ocean using deep-sea current meters moorings (VSN Murty and W. Yu)

The long-term measurement of currents in the Equatorial Indian Ocean using deep-sea current meter moorings is an observational program funded by the Ministry of Earth Sciences (MoES), Government of India. At present there are three OOS deep-sea current meter moorings at 77E, 83E and 93E along the equator in the Indian Ocean, and the possibility of additional ADCP moorings at both 77E and 93E. At these locations, a total of four additional ADCP moorings are planned at 1N and 1S on either side of the equator during 2008-12. The status of the OOS currents data was mentioned, highlighting the generation of 5 years of data at 93E, 4 years of data at 83E and 2 years of data at 77E. At 77E upward-looking ADCP (300 kHz, RDI) data were available (at the time of IOP-5) during October 2003-October 2004 and also during November 2004 – June 2006. At the 83E and 93E locations the ADCP (300 kHz, RDI) data were available during November 2004 – June 2006. Important findings from the ADCP data analysis for the period from November 2004 to June 2006 were presented. The zonal velocity variability in the upper 150 m from 77E to 93E was pointed out and the interesting feature of decrease in the duration of equatorial jets (vertical bands of eastward zonal velocity) from 3-4 months at 77E to 1 month duration at 93E was highlighted. Upward phase propagation is seen at all three locations. The zonal velocity structure also suggests the presence of equatorial undercurrents during southwest monsoon months. The low frequency (>90 day period) variability in zonal currents is large at 77E and 83E throughout the observational period (from November 2004 to June 2006), and less at 93E particularly from September 2005 to May 2006. Intraseasonal variability (20-90 day) in zonal currents at 77E, 83E and 93E showed larger amplitude at 83E during August -October 2005 corresponding to the Madden-Julian Oscillation (MJO). Further work is going on.

The zonal velocity structures obtained from OOS ADCP at 77E, PMEL ADCP at 80.5E, OOS ADCP at 83E, TRITON ADCP at 90E and OOS ADCP at 93E are found to be coherent and consistent. This is the first time observation of ADCP currents over the stretch of 16° of longitude (77E to 93E) had been achieved, due to international efforts under the IndOOS. Comparison of ADCP zonal currents with various model simulated zonal currents during October 2003 – October 2004 was presented and it was shown that the model zonal currents follow the pattern of the observed currents, highlighting the semi-annual variation of zonal currents; however the model simulated spring jets were found to be overestimated.

China, like other Asian countries, is significantly influenced by the monsoon climate. The interannual variations of the Chinese summer rainfall anomalies are closely linked to the monsoon strength. China gives strong support to the IndOOS, especially its mooring component RAMA. China will contribute to RAMA/IndOOS by deploying moorings and by linking IndOOS to national programs so as to demonstrate its social importance.

In Nov. 2007, one innovative subsurface mooring was deployed off coast of Java by FIO/SOA, which could transmit the data periodically through releasing a mini satellite buoy from the subsurface float to the surface. Unfortunately the mooring was failed to work due to its technical problem. FIO/SOA will deploy another set of subsurface ADCP moorings in Oct. 2008. For this deployment, the conventional subsurface mooring will be adopted, while the innovative one will be fully tested before any further deployment.

FIO/SOA will deploy surface buoys at the location (8S, 100E); this is scheduled for during Apr. 2009.

To link the IndOOS to the national requirements, China will work together with Thailand to deploy a surface buoy in the Andaman Sea. The purpose is to monitor the summer monsoon onset over the Bay of Bengal and Andaman Sea region and its propagation into the South China Sea.

Mike McPhaden suggested creating an IndOOS bibliography to focus initially on the in situ component only: RAMA, Argo, drifters, tide gauges, XBT.

ACTION ITEM 6. Initiate and maintain an IndOOS bibliography on the CLIVAR webpage to track the use of the observing system in scientific studies. Draft criteria for including papers and reach consensus among the IOP members (M. McPhaden, G. Meyers and R. Boscolo)

The Indian Ocean XBT Network (G. Meyers)

The status of the Indian Ocean XBT network was reviewed following input from NOAA (G. Goni), BoM-Australia (L. Cowan), NIO (Gopalakrishna) and information on the JCOMM-Ops website.

As reported in the OceanObs'99 book (Observing the Oceans in the 21st Century), The Upper Ocean Thermal (UOT) Expert Panel reviewed XBT sampling in 1999, with a view to the time when the Argo program will be fully implemented [now]. The recommendation was a switch from "broadcast sampling" (which is achieved now with Argo floats) to line sampling. The Indian Ocean lends itself to line sampling because there are relatively few major trading ports and shipping routes. The IOP reviewed the ocean-climate phenomena that can be monitored in preparing the Indian Ocean implementation plan and recommended high priority on the following lines:

Line	Phenomena
IX1 (Australia to Indonesia)	Indonesian throughflow, IOD (eastern pole)
IX8 (Indian to Mauritius)	Inflow to western boundary, IOD (western pole), Chagos-Seychelles dome
IX12 (Australia to Red Sea)	Long time series, SEC, C-S dome
IX15/21 (Australia to South Africa)	Eddy resolving transect across the south Indian Ocean (incl. Agulhas Current)
IX14 (India to Andaman Is)	Bay of Bengal heat content
IX22 & PX2 (Indonesian Seas)	Indonesian throughflow and regional heat content

The sampling on the Indian Ocean XBT lines in 2007 is summarized below:

Line	# of transects*	# of drops
IX1	23/52 t'cts	504
IX8	02/18	53
IX12	13/18	810
IX15	3/4	516
IX21	5/4	369
IX14	25/24	288
IX9N/10E	16/18	466
IX22	8/12	351
PX2	7/12	117

* relative to the number recommended in the implementation plan

Recommendation: write to JCOMM Ops and the SOOP Implementation Panel to express appreciation for efforts in implementing the IOP recommendations and to re-emphasize the importance of maintaining long time series. Note the need to bring the sampling rates up to recommended levels, particularly on IX1 and IX8. [Note added after the meeting: IX1 is likely to come up to the required rate in 2008. IX8 may not be feasible for logistic reasons so an alternative plan is needed.]

Meyers reviewed a number of recent scientific papers based on the XBT data.

ACTION 7. Ask the SIBER group to check the IOP XBTs priorities and provide feedback on the requirements of the biogeochemistry community (J. Wiggert)

ACTION 8. Write to the operators of JCOMM to thank them for their effort with XBT deployment and data archiving. Make a recommendation to maintain the IX8 as high priority in XBT deployment, or find an alternative line that monitors the same target-phenomena (G. Meyers)

The Indian Contribution to IndOOS (M. Ravichandran)

The current status of Indian Ocean measurement by India was presented. There are about 7 moored buoys active in both Arabian Sea and Bay of Bengal. These buoys provide mostly marine meteorological parameters such as air temperature, air pressure, wind vector, sea surface temperature, and humidity in real-time. Also, data acquired from the year 1997 to till present are archived and QCed: they will be soon available to all users. Also, three additional current meter moorings will be deployed within two years. India has committed to deploy at least 25 drifters per year in the north Indian Ocean. Also mentioned were the long term measurements of vertical structure of currents on the shelf and at the break and simultaneous measurements of sea level and winds in the vicinity around 5 locations in the coastlines of India. Dr Ravichandran also outlined the proposed Bay of Bengal observatory to be established by India.

Regarding the IndOOS Portal, Dr. M. Ravichandran has circulated a draft white paper and he requested to the buoy deploying countries to provide the QC procedures adopted by them, so that this can be kept in the IndOOS portal for ready reference for users.

The Status of the Argo floats array in the Indian Ocean (M. Ravichandran)

There are about 418 active floats in the Indian Ocean including 16 Oxygen floats (north of 40 deg S). More than 200 floats are less than 2 years old and about 131 floats are more than 3 years old. There is a gap in the region between 0 to 20 S and 40 to 60 E, which needs to be filled soon. More than 65,000 profiles have been archived so far from the Indian Ocean region. Data available from all Indian Ocean floats are gridded using objective analysis and made available from the INCOIS live access server. Also, there are several monthly products (spatial and temporal) generated and made available for the whole Indian Ocean region.

J. Vialard pointed out that the NEMO line goes through some of the areas that are not well covered by Argo at the present time, particularly on IX3 (Mauritius-Red Sea) north of Madagascar. The NEMO ships could be asked to fill the gaps.

> **ACTION 9.** Explore whether some Indian ARGO floats con be deployed from French SOOP (J. Vialard and M. Ravichandran)

6. Planning New Multinational Process Studies

MISMO: Current and Future (Kunio Yoneyama)

First, the current situation on MISMO (Mirai Indian Ocean cruise for the Study of the MJO-convection Onset) project was presented. The field experiment MISMO took place in the central Indian Ocean during October - December 2006. One year on since the experiment, quality-controlled data taken at R/V Mirai, a mooring array, and Maldives land-based sites have been released from MISMO web site at http://www.jamstec.go.jp/mismo/. Analyses of those data sets are progressing. The MISMO atmospheric sounding array clearly captured the gradual growth of convective activity from early to late November. By comparing with satellite data analysis, it was found that while meso-scale convective systems developed and moved eastward, high precipitable water vapour moved westward with phase speed similar to the equatorial Rossby-wave, and large-scale cloud systems drastically developed when both (eastward and westward) disturbances met over the central Indian Ocean. In addition some results of simulation on MJO event in MISMO using the global cloud-resolving model called NICAM (Nonhydrostatic ICosahedral Atmospheric Model) were shown.

The second half of this talk was devoted to introducing the next field campaign as the MISMO follow-on using the R/V Mirai. Initial thoughts on this are to conduct the stationary observations around 0, 67E, where one of RAMA buoys will be deployed, and where most of cumulus convection associated with the MJO occurs. Since the MJO-convection is spatially large (several 1,000 km in zonal) and timescale long (30-60 days), multi-national effort should be a key component. Discussion on this effort has just been started between relevant scientists.

Cirene: results and plans for a follow-up (J. Vialard)

Some results using the data collected during Cirene were presented during this talk. The Cirene data provides insights on a wide range of phenomena including tropical cyclones, the Madden-Julian oscillation and the consequences of the Indian Ocean Dipole in the thermocline ridge region. On this last aspect, the data show spectacular anomalies in early 2007, with subsurface temperature anomalies of up to 7°C, a freshening of 0.2 psu or more over 200m, and significant current anomalies down to 800m.

The plans for a follow-up to Cirene were also mentioned. One focus of the cruise could be the seas north of Australia, where there is a strong SST intraseasonal response to the MJO, which has not been extensively studied. The cruise would probably start in this region, hopefully deploy a mooring there, and then perform one zonal section along 8°S, towards the Seychelles, deploying RAMA moorings on the way. The cruise would be organised simultaneously to the French-lead SWICE project (South West Indian ocean Cyclone Experiment), probably in early 2011.

In addition to the Cirene objectives (upper ocean signature of the MJO), the follow-up cruise would have enlarged scientific objectives, including:

- one new regional focus (intraseasonal SST variability north of Australia)
- influence of the Indonesian throughflow on the Indian ocean
- intraseasonal Rossby waves at 8°S and their upper ocean signature
- tropical convection (the cruise would run through the ITCZ; with a ground-validation program of the Indo-French satellite Megha-Tropiques, that aims at studying tropical convection and water cycle)
- ocean surface salinity (SMOS will be launched in 2009 and there is apparently one clear salinity front at that latitude that moves zonally under the effect of zonal advection)
- tropical cyclones

***Progress of the HARIMAU Programme in Indonesia* (*F. Syamsudin*)**

The Hydrometerorological Array for ISV-Monsoon Automonitoring is a 5-year project (FY2005-2009) sponsored by JEPP (Japan Earth observation system Promotion Program) in collaboration with an Indonesian Research/Technology Grant (http://www.jamstec.go.jp/iorgc/harimau/). HARIMAU is a radar-profiler network over the Indonesian Maritime Continent (IMC) with the main objectives to:

- Improve understanding of intraseasonal variability (ISV; period of 60-90 days) in terms of convective and rainfall events over the maritime continent. These phenomena might have a great effect on global climate modes, such El-Nino Southern Oscillation (ENSO) and the Indian Ocean Dipole mode (IOD), through tropical ocean-atmosphere interaction.
- Contribute to prediction of and preparation for natural disasters such as flash flood, landslip, drought, and air pollution, caused by extraordinary weather in relation to the ISVs, by monitoring the atmosphere continuously and distributing real time data to governmental institutions.
- To provide data for climate variability and change studies. Provide information to socio-economic sectors such as agriculture, water resources management, aviation, and air pollution control. Improve capacity building for younger scientists.

After a Memorandum Of Understanding (MOU) stating collaborations for HARIMAU between JAMSTEC and BPPT (Indonesian Agency for Assessment and Application of Technology) had been signed in July 2006, the first HARIMAU observation station equipped with two meteorological Doppler radars were installed in Sumatera Island in October 2006. In March 2007 two wind profilers were installed in Kalimantan and Biak (near Papua), and in September 2007 another meteorological radar was installed near Jakarta in Jawa.

An effort to establish an Ocean Climate Monitoring System Under Nusantara Earth Observation NETwork (NEONET) is underway with the aim to provide information on climate variability and change to policymakers.

***Overview of YOTC, AMS, IMS activities. What is the role of IOP?* (*J.McCreary*)**
Given the current intensified monsoon research in programs like AMY (Asian, Monsoon Years, http://www.wcrp-amy.org/), the panel felt the need to enhance coordination between the IOP and AAMP. J. McCreary proposed informing AAMP about ongoing and planned observations in the recently designed Indian Ocean Observing System (IndOOS) that are most relevant to monsoon research.

> **ACTION 10.** Draft a letter to YOTC/AMS/IMS PIs to ask in which way IOP can contribute to these projects/activities. Flag to AAMP the lack of a reliable dataset for cyclone analysis in Indian Ocean (J. McCreary)

7. Linking IndOOS to regional and Coastal Observations

LOCO observations around Madagascar (Will P.M. de Ruijter)
The Dutch LOCO mooring array is situated in the narrow section of the Mozambique Channel (MC) near 17S. Since early 2003 it has been continuously monitoring the current and hydrographic fields over the full cross section of the Channel. It will stay in the water till at least early 2010. A proposal has been submitted to the Dutch national funding agency to extend its operation till 2012 and add an array in the southern branch of the East Madagascar Current (EMC). Together these arrays will monitor the subtropical and tropical source waters of the Agulhas Current. A companion proposal has been submitted to NSF in the USA by Dr. Lisa Beal (RSMAS) to place an array of current meter moorings across the Agulhas Current for a few years. These arrays would yield an unprecedented synchronous view of the variability of the Agulhas and its sources.

The poleward volume transport through the Mozambique Channel appears highly variable and is largely related to southward propagating eddies that form at a frequency of about 5 per year. Between November 2003 and February 2006 the mean poleward transport amounted 8.6 ± 14.1 Sv. In May 2006 it suddenly almost doubled and has fluctuated around that larger value until the next servicing of the moorings in February 2008. Those involved are presently trying to explain that dramatic increase and also analyse the 3D current and water mass structure. The earlier-discovered Mozambique Undercurrent appears to be also continuously present at the mooring site as a deep countercurrent carrying Antarctic Intermediate water and NADW equator-ward. Its volume transport was 1.5 ± 3.2 Sv. Based on a series of hydrographic sections and the continuous moored observations a positive salinity anomaly of 0.2 psu was observed in the upper layer with a maximum around 250m. It has persisted over 2000 and 2001. A similar anomaly was also observed in the southern branch of the Eastern MC. Output from a global run with the OCCAM model forced by NCEP reanalysis data suggests that both anomalies have their origin in the subduction zone in the southeastern part of the subtropical gyre. However, the MC anomaly might also have resulted from a weakening of the South Equatorial Current that reduces the westward transport of relatively fresh Indonesian Throughflow waters. A detailed analysis of these variations is ongoing.

***ALI: an index for the internal variability in Agulhas Leakages* (*W. de Ruijter*)**
An index is proposed for the interannual variability in Agulhas leakages. The index is based on the variation of the location of the Agulhas Current Retroflection. From sea surface height, the Agulhas Current path is defined as the contour of equal sea surface height that starts at the point along 32E where the western boundary current has its largest geostrophic velocity. The variation of the westward extent of this contour is a proxy for the Agulhas leakage. The actual relation between westward extent and leakage is determined using three different models (1/8 deg Global NCOM, 1/10 deg two-way nested NEMO, and ½ deg Global ORCA) by daily seeding numerical drifters according to volume flux. A 75-day lagged correlation between the location of the most western extension of the contour and the drifter-based inter-ocean flux is used to quantify the Agulhas Leakage Index (ALI). Using the AVISO altimetry data, a time series of Agulhas leakage in the period 1992-2007 is computed. The mean Agulhas leakage during this period is 11.9 Sv, with a 95% confidence interval of 3.2 Sv. The variability is 3.3 Sv, and the early retroflection of December

2000 is captured. This demonstrates the usefulness of the ALI as a tool for both monitoring the Agulhas leakage variability and for skill assessment of ocean GCMs.

***PACSWIN Project* (*Y. Masumoto for J. You*)**

Indonesian Throughflow in the Indonesian archipelago provides an important boundary condition for the Indian Ocean and is believed to play significant role in the global ocean circulation. Despite its significant impacts on both the Pacific and Indian Oceans, in situ observations of the throughflow are quite limited due mainly to the geographical complexity in this particular region. The INSTANT program from 2004 to 2006 was the most recent observational program conducted under international collaboration, and successfully observed mean magnitude and variability of the throughflow within several key passages in the Indonesian Seas. PACSWIN (Indonesian Throughflow: PACific Source Water INvestigation) is a new international ocean climate program to monitor the variability of the Indonesian Throughflow. PACSWIN tries to compensate the gap in the Indonesian Seas by the current ARGO program and to resolve various water masses and their pathways as well as the magnitude of the throughflow. Three priority observation components, submarine cable network, moorings and floats, are planed to provide in situ data set for better understanding of broad scientific research themes. PACSWIN is still in the planning stage, but a workshop on the submarine cable network will be held in April 2009 at Pusan, Korea.

IOP encourages this ambitious observational effort and is expecting large contributions from PACSWIN to IndOOS.

> **ACTION 11.** Write to PACSWIN chair (J. You) to encourage the group to develop a science plan and submit it to IOP for feedback. Propose to involve Indonesian scientists in the steering group and to establish contacts with regional programs (SEAGOOS, IOGOOS etc…) (G. Meyers and Y. Masumoto)

***Australian Integrated Marine Observing System: IMOS* (*G. Meyers*)**

The Integrated Marine Observing System, (IMOS), is a nation-wide collaborative program designed to observe the oceans around Australia, including the coastal oceans and the ‘bluewater’ open oceans. IMOS will provide data to support research on many of the critical marine issues facing Australia, including climate change, human impacts on the marine environment and sustainability of ecosystems. IMOS is a $92M project established with $50M from the National Collaborative Research Infrastructure Strategy (NCRIS) [a program of the Australian Government] and co-investments from 10 operators including Universities and government research laboratories. The program has strong links with similar international programs and agencies.

IMOS is made up of nine national facilities that collect data, using different components of infrastructure and instruments, and two facilities that manage and provide access to data and enhanced data products, one for in situ data and a second for remotely sensed satellite data. The observing facilities include three for the open (bluewater) ocean (Argo Australia, Enhanced Ships of Opportunity and Southern Ocean Time Series), three facilities for coastal currents and water properties (Moorings, Ocean Gliders and HF Radar) and three for coastal ecosystems (Acoustic Tagging and Tracking, Autonomous Underwater Vehicle and a biophysical sensor network on the Great Barrier Reef). The value from this infrastructure investment lies in the coordinated deployment of a wide range of equipment aimed at deriving critical data sets that serve multiple applications. IMOS is driven by the needs of the marine community, to deliver free, open and timely access to key data-streams to support climate- and marine-research, public services, industry and management activities.
Additional information about IMOS is available at the website http://www.imos.org.au

***Linking Indian-Ocean research with ocean data assimilation (ODA) efforts* (*Tony Lee*)**

IOP’s research activities are linked to ODA efforts through the following aspects:

(1) Providing IndOOS in-situ observations to validate and constrain ODA systems, including global systems such as ECCO (US) and MERCATOR (France), regional systems such as BlueLink (Australia), and coastal systems from INA-GOOS and SEACORM (Indonesia).

(2) IOP members are actively involved in the intercomparison of ODA products and comparison of ODA products with observations in order to examine the consistency and fidelity of ODA products. An example is the CLIVAR/GODAE Global Reanalysis Evaluation effort coordinated by D. Stammer of CLIVAR GSOP and T. Lee of IOP and GODAE (1st workshop in ECMWF Sept. 2006, 2nd workshop at MIT Sept. 2007; 3rd workshop Oct. 2007 in JAMESTEC, Tokyo Office). During and after IOP-5 meeting, IOP members discussed and compiled 6 categories of Indian-Ocean indices and diagnostic quantities. These indices have been distributed to various ODA groups. IOP members will engage in the analysis of these indices once the ODA groups provide their estimates. As another example, IOP is involved in an intercomparison of Indonesian Throughflow related quantities. This is effort coordinated by the INSTANT group broad participations from various modelling and ODA groups. IOP members Y. Masumoto, T. Lee, and G. Vecchi participated the 1st workshop in Lamont-Doherty Earth Observatory in May 2008.

(3) Applications of ODA products for Indian Ocean research: an example was presented in which IndOOS mooring data are used to validate an ECCO ODA product; the latter is used to study seasonal-interannual heat budget in the tropical Indian Ocean (Lee and Halkides, 2008). The study highlights the important difference in the physics that control mixed-layer temperature in the southeastern tropical Indian Ocean, especially between the equatorial region and the coastal upwelling region off Sumatra and Java. This would help understand local heat balance derived from in-situ observations in different locations of that region.

ACTION 12. Prepare a paper on the definition of and indices for IOD, to be discussed at the next meeting. Collect info from published papers and involve AAMP and PP in the discussion. (M. McPhaden and G. Meyers)

8. *NOAA Bilateral programs in the region (S. Thurston*)

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. 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 international objectives are:

- Optimize Cost-effective resources sharing for ship time, instrumentation, etc…
- Enhance regional capacity and training for socio-economic benefit
- Eliminate gaps and overlap redundancy
- Coordinate joint implementation
- Ensure free, open and timely access to data

In collaboration with Indonesia’s Ministry of Marine Affairs and Fisheries (DKP) and the Agency for assessment and application of Technology (BPPT), NOAA has been deploying drifting buoys, XBTs, Argo floats and tide gauges into the region. In August 2007 an education and RANET capacity building workshop was organized in Bali with the title “Use of Ocean Observations to enhance sustainable development”. The DKP-NOAA MoU includes:

- Joint work on ocean-climate research, ocean observations and their socio-economic applications, IOGOOS, InaGOOS
- Mitigation of marine and coastal hazards, including continued support to sustain the Indian Ocean Tsunami warning System (IOTWS) efforts in Indonesia and regionally
- Research, management, development and conservation of living resources for inland water and marine resources

The NOAA-DKP-BPPT joint objectives are:

- Establish a multi-year collaboration in which the proposed (and possibly other) mooring sites could be serviced at least once per year and in which long term scientific and technical relationships could be developed between our organizations,

- Contribute to the broader Indian Ocean observing system development plan by BPPT Baruna Jaya serving as a platform for underway deployment of drifters, floats, and other oceanographic instruments,
    - Support, by the end of the 3-year period, 10 of the 47 moorings in RAMA though the combined contributions of equipment, personnel and ship time,
    - Promote the development of the Indian Ocean Observing System with other potential international partners,

The Ministry of Earth Sciences (MoES) of India and NOAA are currently establishing a Partnership program in climate research and measurements. The scope of the MoES-NOAA Partnership is:

- Activities that support the improvement of numerical modelling and data assimilation in the field of meteorology, hydrology, and oceanography with specific focus for tropics and monsoon region including the reanalysis of historical observations and re-forecasting methodologies for improved extended range monsoon predictions;
- Activities that support the use of satellite data in the field of modelling and assimilation related to meteorology, hydrology, and ocean with a focus on the tropics and monsoon region;
- Activities that enhance the understanding of the role of the regional meteorology and the Indian Ocean on hemispheric and global weather and climate variability/change and impacts;

MoES and NOAA jointly agree to:

- Support, by the end of the 5-year period, 20 of the 47 moorings in RAMA though the combined contributions of equipment, personnel and ship time,
- Promote the development of the Indian Ocean Observing System with other potential international partners,
- Promote the use of the data for improved weather, ocean, and climate forecasting, with special emphasis on prediction of Asian monsoon rainfall
- Share results of data analysis and jointly publish papers in the referred literature,
- Encourage interaction and coordination with other collaborative efforts under the MoES-NOAA Partnership where synergies exist,

NOAA agrees to:

- Provide all mooring instrumentation and hardware for the deployment of NOAA subsurface ADCP and surface ATLAS moorings,
- Provide training of MoES personnel in mooring deployment and recovery onboard MoES Research Vessel,
- Provide data processing and quality control,
- Display and disseminate data telemetered in real-time data from surface moorings on a public web site. The data will be made available to INCOIS in near real time
- Provide delayed-mode data to research partners within 6 months of mooring recovery

MoES agrees to:

- Provide 60 Days at Sea per year on a research vessel equipped to deploy, recover and repair deep ocean (up to 6000 m) surface and subsurface moorings.
- Conduct detailed bathymetric surveys at mooring sites before deployments,
- Provide ship personnel for technical and deck support during mooring operations,
- Provide high quality meteorological (wind speed and direction, air temperature, relative humidity, rainfall, short and long wave radiation, and barometric pressure) and oceanographic (CTD to 1000 m) measurements from the research vessel when near the mooring sites,

Discussions are currently underway with South African Weather Service on establishing a contribution for the Western Indian Ocean.

9. Societal Issues

Links to Indian Ocean Tsunami Warning System on boundary monitoring plus regional Western Australian and South East Asian initiatives (Nick D'Adamo)

The Secretariat of the Intergovernmental Coordinating Group for the Indian Ocean Tsunami Warning System (IOTWS) is co-located with the UNESCO IOC Perth Office in Perth, Western Australia. The IOTWS has a rapidly developing network of coastal and deep-water sea level stations. Sea level data measured by the core IOTWS network is available over the Global Telecommunications System (GTS) and can be monitored using TideTool (developed by PTWC, the Pacific Tsunami Warning Centre) and through the ODINAFRICA network (http://www.vliz.be/vmdcdata/iode/). The overall sea level network includes deep ocean DART buoys (DART = **D**eep Ocean **A**ssessment and **R**eporting of **T**sunamis), being variously deployed and managed by member nations of the IOTWS. Information from the ICG of IOTWS indicates that: the coastal sea level network comprises over 120 stations, with 45 currently transmitting real time data on GTS, and 20 more installations planned throughout 2008; 17 DART buoys are currently deployed, with the number to increase to 21 by end of 2008, however most are yet to be delivering real time data; in respect to data exchange standards, CREX standards for sea level data transmission have been promulgated, but are not yet widely adopted; and CREX standards for deep ocean stations are in development, with the 2nd half of 2008 set as the target for 'pre-operational' use and trial exchanges. The south Sumatra earthquake of 12 September 2007, which threatened but did not produce a serious tsunami, led to a post assessment of IOTWS performance in relation that event. The associated report was highlighted and provided to the Secretariat of IOP5: *(IOC (2008) Indian Ocean Tsunami Event – Post-Event Assessment of IOTWS Performance. IOTWS, 12 September 2007. IOC Information Series No. 77. UNESCO 2008 (English).*

Delegates were then referred to the detailed presentation on IOTWS given at this meeting by Dr Ridwan Djamaluddin.

Opportunities for integration and synergies between IOP monitoring operations and some local monitoring programs (existing and planned) in the coastal waters off Western Australia were then highlighted. The context was that opportunities exist for IOP to work with the relevant Western Australian entities in joint monitoring, maintenance of stations, infrastructure sharing etc. UNESCO IOC Perth could help broker and coordinate relationships for integration. These opportunities included the Statewide Western Australian marine protected area monitoring network (www.dec.wa.gov.au), noting that some MPAs situated up to 250 km offshore (e.g. Rowley Shoals Marine Park) and all State-based MPAs have long time frames in respect to their management, which includes sustained long term monitoring of biological and physical parameters. The same point was highlighted in respect to the oil and gas industry's exploration and production activities in the waters between northwest Australia and Indonesia, with UNESCO IOC Perth and WAGOOS (Western Australian Global Ocean Observing System) providing potential vehicles for IOP to integrate with companies in established collaborative monitoring. In the same context, mention was also made of the Western Australia Marine Science Institution (www.wamsi.org.au), which is a virtual research institute leading bio-physical marine research and which may also have the potential to link with IOP's coastal imperatives. Australia's new ocean forecasting system *Bluelink* (www.bom.org.au/bluelink) was also highlighted in respect to it being a key user of data from IOP for the system's data assimilation needs. Bluelink provides forecasts, out to 7 days, of salinity, temperature, currents and sea level anomaly, for Australia's waters and beyond (over 1000kms offshore at this stage) and relies heavily on available data to assimilate into its modeling.
South East Asia GOOS is currently developing its first strategic plan and this initiative was mentioned as a means to encourage IOP to contribute to the development of key observational objectives in the plan relevant to the IOP's implementation plan and also relevant to ensuring that connecting scientific themes (i.e. between SEA and IO) are adequately represented in the plan. UNESCO IOC Perth Office is jointly sponsoring and assisting in the plan's development and can provide a convenient link between IOP and SEAGOOS.

Members were then encouraged to provide Nick D'Adamo with any ideas for integration in respect to the above-mentioned programs.

***Technical/knowledge transfer to IO-rim countries* (*W. Yu*)**

IndOOS, as an international initiative to promote the oceanic observing level in the Indian Ocean and to understand its role in global climate system, represents the collaborative efforts in this challenging and frontier area. The smooth progress of IndOOS still faces some obstacles, among which are the lack of the ship time and the relatively lagged S&T status in the nearby countries. Under these circumstances, the success of the IndOOS relies much on the active participation of the IO-rim countries into IndOOS activities and their immediate progress in oceanic science and technology.

Not like the TAO/TRITON story, where NOAA and JAMSTEC took much of the responsibility in its establishment and operation, IndOOS requires more contribution from the IO-rim countries. The science and technology transfer to the IO-rim countries could help them to establish their own observing capabilities and gain social benefits through participation of IndOOS. Social benefits are the vital driving force of the IndOOS. Hence the science and technology transfer to IO-rim countries should be given special consideration and taken as one of the priorities. The suggested actions include technical cooperation on the mooring systems and its availability to the IO-rim countries, and PostDoc/Visiting Scholar programs within the frame of IndOOS.

***What is m-TRITON buoy?* (*M. Yamaguchi*)**

m-TRITON is the last development in mooring system buoys. M-TRITON development started in early 2005, after several tests the buoys were implemented for MISMO observations. Now, 2 m-TRITON buoys are officially operating in the East Indian Ocean.

The motivations for the development of a new TRITON buoy are:

- Adopt new technology: enhance capability of operational sensor extension and reliability of the data processing and transmission units
- Reduce weight and size: cuts in construction and operation costs

The float body is divided into 2 blocks and it is made of polyethylene foam with a urethane coating. This body is the heaviest part and it is about 80 kg, so the surface float can be assembled by hand without any power machine such as a crane.

Several parts are secured to main pole and put together on the platform. An ARGOS position transmitter is mounted on the upper part of the float body covered with FRP board. The mooring line is a 500m-long wire rope; ballast inline, nylon ropes, floatable polyolefin ropes, glass balls, acoustic releasers and the anchor are also deployed. The wire rope is specially manufactured so to decrease the vibration of the rope in the flow.

A small and low-power consumption ARGOS transmitter, data logger and AD converter unit were developed for the sensors. For data processing and data transmission units: enhancement of optional sensor extension, light weight and less power consumption, improved interface capability, and the make enable to use the next generation high speed data transmission ARGOS system.

10. Air-Sea heat, freshwater and momentum fluxes in the Indian Ocean (*M. McPhaden*)

M. McPhaden presented a report that Lisan Yu prepared for the meeting on:

- What can be learned from buoy measurements?
- What can be learned from integrating buoy measurements with satellite observations and NWP products?

Two cases were considered: Seasonal Variability and Cyclone Nargis.

First it was shown how much the six flux products (NCEP1, NCEP2, ERA40, ECMWF, NOC, OAFlux+ISCCP) taken in consideration differ on an annual mean basis. In the Bay of Bengal, the noise/signal ratio is greater than one. NWP model fluxes show the Bay loses heat to the atmosphere, which is opposite to the NOC and OAFlux+ISCCP analyses. A near-real time flux product is available from NCEP1. Its comparison with buoy measurements at [15N-90E] suggests a cooling bias in NCEP1 net downward heat. Seasonal SST variability at [15N-90E] correlates well with changes in net downward heat, suggesting the primarily role of the mixed-layer processes in SST variability. Warming of the sea surface was associated with a shallowing of the surface mixed layer that traps the heat in a shallower layer. The shallowing of the mixed-layer depth coincided with the surface layer freshening, indicative of the salinity impact.

The cold wake left by cyclone Nargis is clearly seen from satellite microwave observations and is consistent with buoy SST measurements. Near the storm center, latent heat flux (LHF) is largest while sensible heat flux (SHF) can be negative (i.e. heat is transferred from air to the ocean). Buoy measurements at 8N and 12N along 90E show clearly that during the cyclone Nargis the near surface air is warmer than the sea surface. This supports a sensible heat transfer from the atmosphere to the ocean indicated by OAFlux estimated SHF.

11. Multimodel comparison of IOD predictions for 2006-07 with AAMP (*Y. Masumoto*)

Intercomparison of the coupled forecast/hindcast models available for the IOD prediction studies have been conducted under the collaboration with AAMP since the last IOP meeting in Pretoria. The comparison started from investigation of the predicted conditions in various variables in SINTEX-F and POAMA models. For the 2006 positive IOD event, SINTEX-F consistently predicts the IOD evolution, for cases initialized at November 2005 and afterwards, but the predicted IOD tends to start a few months earlier than it should do for long-lead experiments. POAMA also predicts the IOD event reasonably well, but always shows earlier evolutions and prolonged events. A possible reason for the differences between the two models is that different subsurface conditions appeared in each model. For example, heat content in the tropical Pacific Ocean in August 2006 predicted from 2006 April condition demonstrates the weak El Nino condition in SINTEX-F, while the La Nina conditions appeared in POAMA. Such differences in the subsurface conditions in the Indo-Pacific sector may affect the evolution of the IOD event in each model. Initial shock due to mismatch between the oceanic and atmospheric conditions seems to be an important factor controlling the subsurface evolution.

Further investigation on the causes of the differences, critical data for improvements of the IOD predictability, and the comparison with other model outputs are necessary. The panel encourages continuation of such multi-model comparison studies under the collaboration with AAMP.

12. Exploring potential predictability of IOD (*G. Vecchi*)

In order to explore the predictability of a phenomenon, one must explore its sensitivity to various factors. In general, a phenomenon has a certain inherent predictability, but its actual predictability is also impacted by the prediction system used, the observations available, and the model initialization scheme, among other factors. In order to assess the potential predictability of the Indian Ocean Dipole (IOD), we explore idealized predictions in a “perfect model/perfect observation” framework, which focuses on the inherent predictability of phenomenon within the model used. These type of experiments complement and should exist within the context of “real” prediction experiments (imperfect model/obs) - cf. the proposal to look at recent IODs across various model systems. Perfect model/obs experiments are built off a free running simulation from the GFDL CM2.1 coupled climate model, which generates it’s own IOD variability of reasonable quality. We then start “forecasts” of a set of IODs by perturbing atmospheric initial conditions (keeping ocean initial conditions (IC’s) unchanged - so “perfect observation/assimilation”) and have the model forecast itself (so “perfect model”) – initialized at January 1 for an August IOD forecast. The perfect model/perfect observation experiments indicate that some IOD events are predictable up to three seasons in advance, while others have limited predictability. It also appears that the predictability arises from a synergistic background in the Indian and Pacific basins since forecasts initialized with each basin's initial conditions exhibit more limited predictability.

Questions remain following these experiments, which may be partly answered through a coordinated - multi-model/multi-institution - analysis of potential predictability in the Indian Ocean. These results described above are from only one model system: how general are they? What is the sensitivity of predictions to errors in initial conditions - such as those we may expect from an imperfect observing network/initialization scheme? Are "predictable" initial conditions transferable to other model systems? (i.e., can I use GFDL "predictable" IC's to drive the IOD in SINTEX-F or the CSIRO model etc?) What about the predictability of the climate impacts of the IOD, or the predictability of other phenomena? An experimental framework like this may be particularly useful as the larger climate community moves to decadal predictions, where verification is quite difficult given the shortness of the observational record.

13. Research on decadal and longer time-scale variability involving the Indian Ocean (*T.Lee*)

T. Lee highlighted examples of recent research on decadal and longer variability involving the Indian Ocean conducted by IOP members and colleagues (the past 1-2 years):

- Modelling study of the multi-decadal weakening of the Walker Circulation and its impact on the Indo-Pacific Ocean (Vecchi and Soden 2007).
- Observation of temperature trends in the Indian Ocean in the past four decades and analysis of IPCC coupled models and ocean models to investigate the mechanisms (Alory et al. 2007, Alory and Meyers 2008, Trenary and Han 2008).
- Observational study of decadal variability in the Indo-Pacific region and its implications for atmospheric and oceanic linkages of the meridional mass and heat transports in the Pacific and Indian Ocean (Lee and McPhaden 2008).
- Observational study of the change of the Indonesian throughflow associated with the 1976/77 climate shift (Wainwright and Meyers 2008).

IndOOS, the Indian Ocean observing system, was designed in order to capture a broad spectrum of variations and changes - including decadal and climate change. IndOOS will contribute to dynamically based decadal predictions by:

- Improving state estimation to develop initial conditions
- Developing our understanding of decadal variations in the Indian Ocean and their controlling mechanisms
- Improving the representation of Indian Ocean climate processes in global climate models.
- Providing surface flux data to force and validate models.
- Providing observational description of modes of variability.

T. Lee and G. Vecchi led a discussion to gather feedback on WCRP's decadal white paper. F. Vecchi will lead the write-up of the formal feedback.

> **ACTION 13.** Contact the Decadal Prediction WG and provide info on Indian Ocean decadal variability. All members to provide inputs on IO decadal signals (G. Vecchi and T. Lee)

14. Research Projects

INSTANT and SITE: South China Sea – Indonesian Transport/ Exchange (Dwi Susanto)

Over the last three decades, Indonesian throughflow (ITF) transport estimates have varied from near zero to 25 Sv. Before INSTANT (International Nusantara Stratification and Transport Program), the Indonesian throughflow (ITF) had been measured at locations over different passages which make it difficult to get the best estimate of the total ITF from the Pacific to Indian Ocean. INSTANT is an international collaborative program of researchers from Indonesia, United States, Australia, France and the Netherlands with fieldwork over the period December 2003 to December 2006. Over these three years El Nino was mostly weak with an interruption to La Nina conditions in early 2006 followed by an El Nino during the mid-end of 2006 and which coincided with a positive Indian Ocean Dipole event, which peaked in October-November 2006. INSTANT data reveal wide ranges of frequencies from tidal, intraseasonal, seasonal, to interannual variability. Preliminary results indicate an ITF mean of 13-14 Sv.

Although ITF measurements have been conducted for more than two decades, the ITF branch through the South China Sea-Karimata Strait-Sunda Strait has always been ignored and has received little observational attention. International collaborative research has been carried out among scientists Dr. Dwi Susanto (LDEO-USA), Dr. Indroyono Soesilo and Dr. Sugiarta

Wirasantosa (BRKP-Indonesia) and Prof. Guohong Fang (FIO-China) to measure the South China Indonesian Seas Transport/Exchange (SITE, South China Indonesian Seas Transport/Exchange) in the Karimata Strait using series of trawl resistance bottom mount (TRBM) ADCPs. These were deployed in December 2007 and are planned to be finally recovered in December 2009. An expansion of this program has been signed to include Sunda Strait. The objectives are: (1) To measure the magnitude and variability of SITE flow in Karimata and Sunda Straits. (2). To determine the role of SITE flow on the main ITF and Indian Ocean Dipole (3) To investigate the impacts of SITE flow on seasonal fish migration.

Links to SIBER (Jerry Wiggert)

The SIBER (Sustained Indian Ocean Biogeochemistry and Ecosystem Research) initiative has emerged with an underlying motivation to develop a new, parallel program in the IO focused on biogeochemical and ecological research that could capitalize on the implementation of the CLIVAR/GOOS Indian Ocean mooring array, and associated cruises, currently underway. In summary, the idea is to make use of this mooring program, and other developing/existing infrastructure, as a physical observational foundation that promotes opportunities for interdisciplinary, international collaboration and research in the Indian Ocean. Given that the last major international, interdisciplinary effort in the Indian Ocean (i.e., the JGOFS program) took place in the early to mid-1990s, and was in fact focused exclusively on the Arabian Sea, it is high time for a coordinated basin wide effort to take place.

Two SIBER workshops have been held at NIO over that past couple years. The first was a gathering of over 200 scientists from 20+ countries that came together to review the state of our knowledge of the biogeochemical and ecological dynamics of the IO, identify prominent gaps in our understanding and generate a roadmap for developing a science plan. This roadmap was then pursued in the follow-up meeting of ~30 scientists held 27-30 November 2007 and the initial draft of the SIBER implementation plan was created. This plan will be released for comment by the Indian Ocean scientific community in early August and finalized soon thereafter. Along the way, the SIBER leadership has published reports in CLIVAR Exchanges and IMBER Update and 2 articles have appeared in EOS. In addition, an AGU Monograph that will feature contributions from the plenary speakers who attended the first SIBER workshop is currently in the works.

During the 2nd workshop, six major themes were identified in the process of formulating the science plan. These are: 1) Boundary current dynamics, interactions and impacts on biogeochemistry and ecology; 2) Equatorial circulation and Indonesian throughflow impacts on biogeochemistry and ecology; 3) Controls and fate of primary production in the Indian Ocean including marginal seas; 4) Biogeochemical differences between the Arabian Sea and the Bay of Bengal; 5) Global change and anthropogenic impacts; and 6) Role of higher trophic levels in ecological processes and biogeochemical cycles. Some of the highlight topics that have emerged from this thematic structure are: 1) the need to characterize how the Indian Ocean Dipole, the Madden-Julian Oscillation and the equatorial Wyrtki Jets act to define intraseasonal to interannual basin wide ecological and biogeochemical variability; 2) identification of the role and spatio-temporal influence of iron limitation on primary production that has recently been identified in modelling, in situ and remote sensing efforts; 3) revealing the processes that lead to the maintenance of contrasting Oxygen Minimum Zone characteristics in the Arabian Sea and Bay of Bengal; and 4) quantifying how ecological and biogeochemical processes and cycling pathways will be altered by natural and anthropogenic climate change, where human influences will include the impact of land use changes on the distribution and magnitude of dust source regions and nutrient loading within riverine inputs.

15. Links with GSOP (*M. McPhaden*)

The panel decided to draft a proposal to GSOP for simple indices to describe Indian Ocean variability, with emphasis on the Indian Ocean Dipole (IOD). The purpose of this proposal is to provide a regional evaluation of currently available ocean analysis products to see how consistent they are among themselves and how well they compare with observations. This proposal is motivated in part by GSOP's request for involvement of the basin panels in providing feedback on the veracity of ocean analysis products and their utility for addressing questions related to regional dynamics.

The initial proposal consisted of time series for the full record length of each ocean analysis up to the present, or at least though December 2006, to capture the large 2006 Indian Ocean Dipole event and to facilitate comparison with moored ADCP time series observations. To keep the effort manageable and focussed, the following time series were requested from each analysis product as described below:

1) Monthly SST in the IOD index regions: a) 50°E - 70°E, 10°S - 10°N b) 90°E - 110°E, 10°S - 0°. Anomalies of these two time series will define variability associated with the IOD in each ocean analysis product. Presumably, these indices should be very similar for the different analysis products to the extent that they assimilate SST. We understand that several groups have made IOD index region SST time series available already; this is request to update those time series.
2) Monthly sea level (in meters) in the same two regions as in (1). These will give us a measure of the time varying upper ocean mass distribution associated with IOD variability. Anomalies of these two indices can be readily validated against satellite altimetry beginning in 1992.
3) Surface zonal wind stress (in N/m2) averaged 2.5N-2.5S, 70-100E. This quantity is the principal dynamical forcing for IOD variability.
4) Zonal volume transport integrated 2.5N-2.5S in the upper 200 m along 80E (in Sv). This quantity should be related to zonal wind stress forcing, zonal sea level differences and SST differences across the basin. The latitudinal range should capture most of the variability associated with the biennial Wyrtki Jets. An ADCP transport array between 2.5N and 2.5S along 80E, to be deployed this August for 3 years, could be used validation for this index in the future.
5) Zonal transport per unit width (i.e. depth integrated zonal velocity) at 0°, 80°E over the upper 200 m (in Sv/m). This quantity should be reasonably well correlated with zonal transport along 80°E and is more readily verified using moored velocity measurements from 1993-94 and 2004-present.

ACTION 14. Make a list of IO indices for GSOP to produce reanalysis products. All members to provide inputs (T. Lee and M. McPhaden)

16. HLR list of recommendations (G. Meyers)

The recommendations elaborated by the High-Level Panel at their meeting held in Thailand in December 2007 (see Appendix C) were reviewed.

ACTION 15. Write a formal response to HLR Panel on the list of recommendations on IndOOS listed in the HLR meeting report, February 2008 (G. Meyers, Y. Masumoto and R. Boscolo)

ACTION 16. Organize a workshop that will explore the common interests of regional GOOS activities such as LOCO, Indian monitoring of the Arabian Sea and Bay of Bengal, InaGOOS, IMOS and other activities particularly on the East coast of Africa. Explore venue and possible dates (N. D'Adamo and G. Meyers)

Panel Business

ACTION 17. Find a replacement for those members rotating off (G. Meyers, Ravi and C. Reason). Propose Weidong Yu as co-chair and L. Yu and M. McPhaden to remain on the panel for another 2 years (G. Meyers and Y. Masumoto)

ACTION 18. Contact EGU to explore ways to honour Fritz Schott work in Oceanography (J. MCreary)

ACTION 19. Promote visibility of IOP science and activities at international/relevant conferences and workshop (all)

ACTION 20. Prepare a glossy brochure on IOP activities (N. D'Adamo, G. Meyers and R. Boscolo)

ACTION 21. Explore the possibility to hold next IOP meeting in La Reunion (R. Boscolo and J. Vialard)

Appendix A.

List of Participants

Panel Members

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APPENDIX B.

AGENDA

Day 1: Monday 12 May

9:00 Welcoming by LOC: Dr. Fadli Syamsudin
9:10 Opening speech by Prof. Jana T. Anggadiredja (Deputy Chairman of BPPT)
9:20 Keynote talk: Prof. Indroyono Soesilo (Agency for Marine and Fisheries Research)

SCIENCE TALKS:
10:00 Indian Ocean Tsunami Warning System (IOTWS) of BPPT (*Dr. Ridwan Djamaluddin*)
10:30 **Coffee/Tea Break**
10:50 SEACORM Program on Indian Ocean Monitoring (*Ir. Berny A. Subki, Dipl.Oc*)
11:20 INA GOOS Concept and Planning (*Dr. Aryo Hanggono*)

12:00 Welcoming by patrons and IOP chairs:
- IOC-Perth & WCRP/CLIVAR (*N. D'Adamo, R.Boscolo*)
- Reports on SSG-15 and HLR *(Y. Masumoto, R. Boscolo and G. Meyers)*
- Review of the agenda and Action Items *(G. Meyers, Y. Masumoto)*

13:00 – 14:00 **Lunch**

UPDATES ON INDOOS AND RECENT SCIENCE-RESULTS FROM THE DATA STREAMS:
14:00 Large SST intraseasonal variability in the Maritime Continent and near Australia *(J. Vialard)*
14:30 RAMA *(M. McPhaden and Y. Masumoto)*

15: 15 **Coffee/Tea Break**

15:45 Long term measurements of current in the equatorial Indian Ocean using deep-sea current meters moorings (*VSN Murty*)

PLANNING NEW MULTINATIONAL PROCESS STUDIES:
16:30 MISMO—results and plans (*K. Yoneyama*)

17:30 Adjourn

19:00 Gala Dinner with the traditional dance of Bali

Day 2: Tuesday 13 May

8:30 The Indian Ocean XBT Network (*G. Meyers*)
9:00 Overview of the Indian Contribution to IndOOS (*M. Ravichandran*)
9:30 Status of the Argo floats in IO (*M. Ravichandran)*

PLANNING NEW MULTINATIONAL PROCESS STUDIES (Continued):
10:00 CIRENE—results and plans (*J. Vialard*)

10:30 **Coffee/Tea Break**

11:00 HARIMAU project (*F. Syamsudin*)
11:20 YOTC, AMS, IMS What is the role of IOP? (*J.McCreary, assistance from Bin Wang*)

REGIONAL ISSUES (LINKING INDOOS TO REGIONAL AND COASTAL OBSERVATIONS; STATUS OF REGIONAL OBS. WHAT ARE THE REGIONAL OBJECTIVES AND HOW ARE THEY ENHANCED BY INDOOS AND RAMA?)

11:30 LOCO and US proposal for extension and continuation (*W. de Ruijter*)
11:45 Agulhas Leakage Index (*W. de Ruijter*)
12:00 Present status of Indian moorings in Bay of Bengal and Arabian Sea (*M. Ravichandran)*
12:20 PACSWIN (*J. You*)
12:40 IMOS (*G. Meyers*)

13:10 **Lunch**

14:10 Link to ocean state estimation (*Tony Lee*)
14:30 NOAA bilateral programs in the region (*Sid Thurston*)

SOCIETAL ISSUES:
15:00 Links to IOTWS on boundary monitoring (*Nick d'Adamo*)

15:30 **Coffee/Tea Break**

16:00 Technical/knowledge transfer to IO-rim countries (*W. Yu*)
16:30 M-TRITON technology (*M. Yamaguchi*)

17:00 Adjourn

Day 3: Wednesday 14 May
8:30 Air-Sea heat, freshwater and momentum fluxes in the Indian Ocean (M. McPhaden)
9:00 Multimodel comparison of IOD predictions for 2006-07 with AAMP (*Y. Masumoto*)
9:30 Potential project on Intraseasonal to Seasonal predictability (*G. Vecchi*)
10:00 Research on decadal variability and changes involving the Indian Ocean (*T.Lee*)
- White paper on short-term climate prediction (*R. Boscolo*)

10:30 **Coffee/Tea Break**

RESEARCH PROJECTS:
11:00 INSTANT (*Dwi Susanto*)
11:20 SITE: South China Sea – Indonesian Transport/ Exchange (*Dwi Susanto*)
11:40 Links to SIBER (*Jerry Wiggert)*

12:30 Report from GSOP meeting (*M. McPhaden*)
- IOP input to OceanObs09

13:00 **Lunch**

14:00 Discussion on HLR report

14:30 Panel Business:
- Membership
- Outreach
- Next meeting

15:30 **Coffee/Tea Break and End of meeting**

Excursion proposal: sunset watching & "Kecak" Bali dance at Tanah Lot

APPENDIX C.

High-Level Panel for the IndOOS

Terms of Reference

(1) Assessment of implementation progress: gaps, redundancies, opportunities
(2) The use of IndOOS data for ocean state estimation and socio-economic applications
(3) The importance of IndOOS for climate research, including SIBER
(4) Providing for free, open and timely exchange of data
(5) The merits of establishing a Resource Board to coordinate implementation requirements and resources for IndOOS
(6) Identify near Term Priorities

Panel Members

- Dr PS Goel, Secretary Ministry of Earth Sciences, India
- Dr Chet Koblinsky, Director Climate Program, NOAA
- Dr Neville Smith, Deputy Director (Research and Systems), Bureau of Meteorology, Australia [Rapporteur]
- Dr Kiyoshi Suchiro, Executive Director, International Development, JAMSTEC
- Mark Majodina, Director of International Activities, South African Weather Service (not in attendance)

Report against Terms of Reference

1. Assessment of implementation progress: gaps, redundancies, opportunities

- The progress since 2002, and since the last review is unambiguously positive. We see:
    - The target Argo and drifter deployments have been reached
    - RAMA is now 1/3 complete
    - There are a number of recent enhancements from India, Australia, and others that provide significant supplementation in a number of areas, particularly for the boundary regions.
    - The increased participation is also to be applauded: e.g., > 10 participants in Argo (incl. Deployment assistance); ~ 6 nations contributing to moorings
    - The IOP itself has been a positive force for participation in IndOOS
- Articulation of the benefits are in early stages, but some indications of benefits for prediction, and significant advances in terms of knowledge are evident.
- Within the remit of the IOP, the HLRP cannot see any major gaps that have not already been identified by the Panel. The emergence of boundary monitoring as strength among the activities fills a gap that was evident in early planning. Western Indian Ocean sampling is less than desired, particularly wrt boundary regions.
- There was a significant gap in the presentations around remote sensing, particularly with respect to an integrated approach to observing the Indian Ocean. It was difficult for the HLRP to see how consideration of the existing and planned satellite missions has impacted thinking on the in situ array design.
    - It would have been nice to see greater emphasis on sea surface fields, even SST, since this remains a critical element in prediction on daily to intraseasonal time scales
    - The HLRP noted a seeming decrease in importance attached to surface fluxes emerging from the FAR. This might encourage a re-examination of the role of surface observation platforms for the region.
- There is redundancy, but it would seem that which exists now has scientific benefits in excess of any budget advantages that might accrue from lessening this redundancy. The HLRP suggests that the intersections of, say RAMA and Argo be studied more closely, in terms of the strength it adds, and opportunities for bridging temporal and spatial gaps.
- Conclusions:

Recommendation/Finding 1. The HLRP should welcome the tremendous progress that has been achieved, in terms of the IndOOS, and in terms of leadership for ocean and climate science in the region through the work of the Panel. The engagement of Indian Ocean agencies in the work is to be welcomed and should always be seen as a measure of success.

Recommendation/Finding 2. The HLRP does believe increased emphasis and attention should be given to the remote sensing aspects of the IndOOS. It is clear that remotely sensed data has already played a critical role in developing knowledge, but the degree to which it has shaped the thinking surrounding the development of the IndOOS was absent from the presentations.

Recommendation/Finding 3. The HRLP welcomes the attention given to socioeconomic issues and the data and information aspects of the system. Both were seen as challenges at the time of the last Review and we welcome the significant response facilitated by the IOP.

Recommendation/Finding 4. With respect to redundancies, the HLRP is of the view that there is an appropriate level of redundancy within networks, and between networks. However, the Panel also believes the IOP should begin to understand this redundancy more directly, particularly between and other elements of the OS, with particular attention on quality control.

2. The use of IndOOS data for ocean state estimation and socio-economic applications

- The socio-economic presentations were interesting and instructive. It is clear that the socio-economic development of the Indian Ocean region is sensitive to climate variability and climate change. We have seen a number of ways climate information can be used to both mitigate the negative impacts for vulnerable sectors, and to improve efficiency and productivity where the sensitivity provides opportunities.
- It is less clear there can be a direct line drawn from the OS to socio-economic impacts, but this is a challenge that is not unique to IndOOS. It suffices at this time to be well informed about the potential benefits and to be aware that unique attribution of effect is rare.
- There was less emphasis on ocean state estimation within the presentations. Indeed, this aspect might be seen as a weakness were it not for the fact that the HLRP is ware the climate and ocean state estimation efforts are well linked to the IOP.
- In other regions, particularly in the North Atlantic there have been a number of studies that tease out the relevance of elements of the OS to particular phenomena and mechanisms. Such studies for the Indian Ocean would be beneficial, particularly with a view toward decadal prediction. E.g., are there adequate deep observations?

Recommendation/Finding 5. The HLRP recommends strengthening of the links to ocean state estimation science, with perhaps a future meeting of the panel getting perspectives from specialists, including from the satellite community. Particular emphasis should be given to satellite data and developing a qualitative sense of impact of various elements for decadal predictability.

3. The importance of IndOOS for climate research, including SIBER

- As discussed under 1, the importance of the IndOOS for research is unambiguous. There remains a belief that the Indian Ocean has climate modes that operate independent of other climate modes.
- The emergence of decadal variability as a more prominent aspect of research does in our view add greater weight to relevant data than before. Understanding the level of predictability will be important for the future.
- The emergence of process studies for boundary currents and air-sea processes and intra-seasonal variability is a +ve aspect.
- The emergence of SIBER is to be welcomed. The use of data for management and associated research should only be strengthened by this emerging partnership.
- SIBER is an outstanding opportunity for the future. The scientific rationale is strong with both socio-economic and knowledge benefits evident.
    - The strength of the IMBER endorsement provides great confidence for the potential involvement of IOGOOS. Irrespective of the latter, there are clear benefits from the work of the IOP.

Recommendation/Finding 6. The HLRP welcomes the strong links between the development of IndOOS and research, from climate to ocean prediction, and extending into biogeochemical and ecological domains. The IOP should consider appointment of a Rappporteur or Member from SIBER.

Recommendation/Finding 7. The HLRP believes we should recommend that IOGOOS immediately consider SIBER as an initiative in its work program, and undertake to bring nations of the Indian Ocean into the program, as part of IndOOS extended. This would be subject to the review of the Science Plan.

4. Providing for free, open and timely exchange of data

- The HLRP welcomed the presentations on data and data exchange. It agrees that exchange of data is critical for advancing climate and related research.

Recommendation/Finding 8. The HLRP believes there are opportunities for strengthening the sharing of data between IOP activities and coastal projects and would encourage both the IOP and IOGOOS to examine opportunities.

Recommendation/Finding 9. The HLRP emphasised the importance of quality control, integration and assembling of data sets and encouraged even greater emphasis in the future.

5. The merits of establishing a Resource Board to coordinate implementation requirements and resources for IndOOS

Recommendation/Finding 10. A Sub-Committee for IndGOOS Resources.

- The rapid development of IndOOS is based on scientific understanding and this is mandatory. IndOOS development thereafter is inextricably linked to the investment and broad multi-national institutional support. Bilateral agreements are valuable but not sufficient to guarantee successful and efficient coordination implementation.
- The HLRP takes the view that a “club” like CEOS is the most appropriate model, with the common interest being the ocean observing system of the Indian Ocean (general, but with initial focus on climate).
- The Indian Ocean GOOS provides the broad framework for participation, though we note it is for IO agencies primarily
- The “club” would be a sub-Committee with the specific charge of coordinating the deployment of resources for the IndOOS.
    - o The sub-Committee for IndOOS Resources would …
        - To consider the resource requirements for the implementation of IndOOS and develop forward estimates of the committed, in principle commitments and highest priority unmet needs;
        - To the extent possible, harmonise and coordinate the deployment of resources dedicated to the program;
        - To report on the deployed resources to the Heads of the Institutions, through IOGOOS.
    - o Scientific guidance is provided by the IOP initially, but we may anticipate an expanded remit over time.
    - o The Committee would be open. Secretariat support would be provided through the IOGOOS and IOC Perth Regional Office Secretariats;
    - o The Sub-Committee would need to be supported by regular scientific reviews of the IndOOS, order 2-3 years;

6. Identify (other) near Term Priorities

Recommendation/Finding 11. IOGOOS should consider the convening a technical Working Group, ideally working with the IOP, SIBER and the IOTWS-ICG to examine and exploit the use of IndOOS platforms as “platforms of opportunity” for expanded instrumentation. This WG might also consider measurements of opportunity on vessels working in the region.

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