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(14) Finish analysis of Indian-ocean indices derived from ocean reanalysis products for GSOP by IOP before OceanObs'09 and for input to the next GSOP meeting (Tony Lee to remind analysts)

(15) A letter from IOP and curriculum vitae for Dr. Magori needs to be submitted through the ICPO in support of this nomination for approval by the SGG members.
(Panel co-chairs and ICPO)

Summary and thanks:

The sixth meeting of the World Climate Research Project - Climate Variability and Predictability Programme (WCRP-CLIVAR) Indian Ocean panel (IOP) took place from 3rd to 5th June, 2009. The meeting was graciously hosted by Météo-France at the Laboratoire de l'Atmosphère et des cyclones (LACy) in Saint Denis, La Réunion. Our deepest thanks are due to Mr. Gerard Therry the director of LACy for hosting our panel meeting and to our local organisers Dr. Matthieu Plu (Head of the Météo-France LACy research team on tropical cyclones) and Mr. Thierry Mercier who did their utmost to ensure a successful meeting. Panel members Dr. V. S. N. Murthy (National Institute of Oceanography, Goa, India) and Dr. Fadli Syamsudin (Indonesia's Agency for the Assessment and Application of Technology (BPPT), Jakarta, Indonesia) were unable to attend and sent their apologies. The panel acknowledges the financial support of the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) through the IOC's Perth Regional Programme Office, Western Australia, and WCRP-CLIVAR. Many thanks to all involved.

Meeting report:

1. Opening:
Participants (see Appendix A) were welcomed by Mr. Gerard Therry, the Director of LACy, Dr. Nick D'Adamo from IOC Perth and Dr. Kate Stansfield from the International CLIVAR Project Office. The Panel co-chairs, Dr. Yukio Masumoto and Dr. Weidong Yu then gave a brief overview of the agenda (see Appendix B), changes to the agenda and the logistics for the meeting. Next the panel considered the action items from the last meeting in May 2008 (see Appendix C) and reviewed the actions arising from the CLIVAR Scientific Steering Group meeting in May 2009 (see Appendix D). A list of acronyms is given in Appendix E.

2. Science Talks 1: Research activities in La Réunion
2.1 Operational activities on tropical cyclones at the Regional Specialised Meteorological Centre (RSMC) La Réunion (Philippe Caroff)
Tropical cyclones (TCs) are a major natural hazard representing a main contributor to the environmental and structural damage and fatalities generated by all the natural disasters worldwide (around 30% and 20% respectively according to the United Nations for the period between 1963 and1992). Like most of the tropical oceans the South-West Indian Ocean (SWIO) is prone to this threat responsible for some 2000 fatalities in the last decade in the region.

To monitor and provide warnings on these still deadly and devastating phenomena a dedicated organization has been implemented under the World Meteorological Organization (WMO) umbrella. Tropical Cyclones / Regional Specialised Meteorological Centres (RSMCs) have been established in the different cyclone basins. The Météo-France regional centre based at La Réunion Island is one of these and officially started operating as the RSMC for the South-West Indian Ocean in June 1993. The 3 main missions of RSMC La Réunion are 1) to act as the operational tropical cyclone warning centre for the Southwest Indian ocean providing the first-level information (analyses, forecasts, guidance and warnings) on all the tropical disturbances forming or evolving within its area of responsibility, 2) through research, contribute to better knowledge on tropical cyclones and more specifically to improve the handling of tropical cyclones by numerical models and develop new tools tailored for tropical cyclone forecasting and 3) contribute to developing the forecasters of the region through training courses or attachment of forecasters.

La Réunion's Area of Responsibility covers the area from 30°E to 90°E and from 0°S to 40°S. On average about 11% of the global TC activity (corresponding to an average of 9 tropical storms – among which almost half reach tropical cyclone stage) occurs in this area annually.
The main operational mission of the RSMC is to provide first-level information and forecasts to the National Meteorological and Hydrological Services (NMHS) of the 15 members of the SWIO Tropical Cyclone Committee. This international responsibility is exerted in order to support tropical cyclone disaster mitigation (reducing losses of lives, human suffering and tropical cyclone induced damage to property).

The operational work consists of two phases, analysis and forecast. During the analysis phase the tropical cyclone specialist determines the location of the TC's center and its current motion, estimates the intensity of the TC, and assesses the size of the atmospheric circulation associated with the TC. In the forecast stage the future track of the storm is predicted, along with changes in intensity and size.

The analysis process relies mostly on satellite imagery, fusing all the data coming from different sources (analysis of the conventional satellite imagery through the Dvorak Technique, microwave imagery, scatterometer data, Advanced Microwave Sounding Unit data, etc.). However conventional observations are still highly needed to validate or adjust the analysis techniques based on remote sensing. They are also extremely useful to improve the analysis fields of sea-level pressure or sea surface temperature within the numerical models. For tropical cyclones which develop in oceanic areas with sparse observations any effort to improve the marine observing network is much welcome. The International Buoy Program for the Indian Ocean (IBPIO) with dozens of drifting buoys now covering the basin has been highly beneficial for instance while the Research Moored Array for African-Asian-Australian Monsoon (RAMA) network is considered a great way to ensure a permanent coverage of cyclogenesis areas crucial for TC monitoring.

The track forecasts are mostly based on the guidance provided by Numerical Weather Prediction products through the different numerical models outputs received at the Centre.

All the information and expertise is then disseminated through a number of bulletins and advisories tailored for the different users. These first-level guidance and forecasts are then used by the NMHSs for elaborating predictions of the local influence and consequences of the TC for their country (e.g. winds, rainfall, waves, storm surge) and issuing appropriate national warnings to the populations.

The RSMC La Réunion verifies its forecasts after each cyclone season. While track forecasts errors have been drastically reduced in the recent years (by 40% in four years for the 48 hour and 72 hour forecasts) intensity forecasts remain challenging with little progress.

2.2 Research activities about tropical cyclones (Matthieu Plu)

This presentation concerned the research activities on tropical cyclones that are conducted at LACy (La Réunion), a joint lab between the Centre National de la Recherche Scientifique, Météo-France and La Réunion University. The main approach is numerical modelling, that relies on the operational model Aladin-Réunion and the non-hydrostatic, high-resolution, mesoscale research model, Meso-NH. Using both models, four major topics about tropical cyclones are addressed: data assimilation, interaction with orography, structure and intensity change and ocean-atmosphere interactions. The first results on the interaction of tropical cyclone Ivan (2008) and a sharp Sea Surface Temperature (SST) gradient demonstrated the last topic, through comparison of an ocean-atmosphere coupled simulation with a SST-forced simulation.

2.3 South West Indian Ocean (SWIO) tropical Cyclone Experiment (SWICE) experiment (Frank Roux)

Tropical Cyclones (TC) in the SWIO, Regional Specialised Meteorological Centre (RSMC), La Réunion area of responsibility (0-40 °S and west of 90 °E) typically average 8-15 Tropical Storms (wind speed >17 m/s), 1-9 Tropical Cyclones (wind speed >33 m/s) and 0-3 Severe TCs (wind speed >65 m/s) per annum. The TC track forecasts have consistently improved in the past decade and the 48-hour forecasts are now as good as the 24-hour ones were 10 years ago.

However, the errors that remain are still too large even in the short term on scales of order 100 km (roughly the diameter of the TC core or the size of La Réunion) or on time periods of 24-hours to provide enough accuracy and guidance for emergency response management. Unlike track prediction, the forecast of intensity (i.e. wind & rainfall) has shown little improvement.

The intensity forecast has lagged behind the track improvements because a much wider range of processes must be accurately modelled to accurately predict intensity. The storm inner core dynamics, microphysical processes, air-sea fluxes, the ocean thermal structure and its response to the surface winds, the interaction with land and the large scale environment can impact intensity changes.

The proposed SWICE field experiment will take place between January and February 2011, from La Réunion. The scientific objectives of SWICE are to:

- To validate the empirical Dovrak laws (which predict a tropical cyclone's maximum sustained winds) over the SWIO
- To participate with the Calibration-Validation of Megha-Tropiques satellite products
- To quantify the impact of “targeted observations” on cyclogenesis, track and intensity forecasts
- To analyze the influence of synoptic perturbations (e.g. tropical waves, the Madden Julian Oscillation, upper-level perturbations, subtropical anomalies) on cyclogenesis, storm intensity and track.
- To characterize the microphysical properties of iced hydrometeors in the upper tropical troposphere

The proposed observational network will consist of the following elements:

- Existing and additional radiosounding stations will lead to more a better description of the synoptic environment and perturbations; these data will also help to diagnose large scale budgets and to quantify the impact of TCs on their environment.

- Operational and non-operational surface observations in this region (SE Africa, Madagascar, Mauritius, and Seychelles) must be activated and data must be transmitted on the Global Telecommunication System (GTS), store.
- Weather surveillance radars (one in La Réunion, three in Madagascar).
- A Falcon-20 aircraft will conduct missions dedicated to synoptic surveillance in the vicinity of active systems; the maximum range of the aircraft, the available airports and the climatological distribution of TCs determine the region of interest.
- AEROCLIPPER balloons will be launched to probe the surface wind (and estimate the surface turbulent fluxes) during the cyclone penetration phase. The AEROCLIPPERs will then probe in near real time the location of the eye, the surface pressure, dynamic and other surface parameters in the eye.
- Calibration and validation of satellite data will have a high priority, with flights to be planned in coordination with satellites overpasses.
- There will be coordination, at least for a limited period of time, with the CIRENE-2/ Thermocline Ridge of the Indian Ocean (TRIO) oceanographic campaign planned for the first months of 2011 in the SWIO. At this stage, the TRIO cruise is not programmed and remains uncertain, depending on the availability of R/V l'Atalante in the Indian Ocean in 2011.
- High-resolution numerical modelling will be conducted during the field campaign for both operational and research purposes.

ACTION: Encourage use of RAMA data for cyclone studies conducted by scientists in La Reunion and elsewhere. Encourage coordination of SWICE with TRIO/CINDY/DYNAMO. (J. Vialard)

2.4 Cyclone modelling and observations (M. Lengaigne)
Northern hemisphere cyclones have been extensively studied during the last decades however there have been fewer studies of southern hemisphere cyclones. An ongoing project using satellite observations, reanalysis and atmospheric regional models has allowed study of the main drivers of tropical cyclone interannual variability in the south-western Pacific. Using observed cyclone data and cyclogenesis indexes, we have shown that the position of the South Pacific Convergence Zone (SPCZ) locates the dynamic fields favourable to cyclogenesis. During strong El Niño events, the SPCZ becomes zonal and leads to cyclones forming in the Central Pacific region (French Polynesia) while this is not the case during moderate events. A few Intergovernmental Panel on Climate Change (IPCC) General Circulation Models reproduce the SPCZ climatology and interannual variability reasonably well. These models indicate a tendency for a more frequent 'zonalisation' of the SPCZ and therefore potentially an increased number of Tropical Cylcones (TCs) forming in the central Pacific. Experiments using a forced atmospheric regional model indicate that about half of the interannual variability of the cyclonic activity simulated by the model is stochastic.

Based on the methodology developed for the South Pacific, we aim at extending this work in the Southwest Indian Ocean using similar tools (regional modeling, observations, and reanalysis). We especially wish to investigate:

- To what extent do large-scale oceanic and atmospheric conditions influence cyclone characteristics in the southern Indian Ocean, and by which mechanisms (relationship of the Seychelles–Chagos thermocline ridge with the interannual variability of the convergence zone,).
- The influence of ocean-atmosphere coupling on TC characteristics.
- The influence of global warming on TC activity in this region.

2.5 Atmospheric Research lab of the University of La Reunion - OPAR (Robert Delmas)
OPAR is a permanent station for long term atmospheric observations (e.g. temperature, ozone, UV radiation, H_2O, greenhouse gases, aerosols) targeted at the dynamics and chemistry of the troposphere and the stratosphere in the context of climate change in the southern hemisphere. OPAR provides data for international research/monitoring networks for scientific research (e.g. LACy and partners) and for satellite validation: (e.g. ENVISAT, METOP (IASI, GOME2), MEGHATROPIQUES, and ADM-AEOLUS). OPAR's operational instrumentation includes spectrometers, radiosondes, a solar photometer an Infrared radiometer and two Lidars.

OPAR presently provides data for three international atmospheric observation networks (NDACC, SHADOZ, AERONET). The location of Reunion in the southern hemisphere in the Indian Ocean makes OPAR a unique site for both stratospheric and tropospheric observations. After the installation of the Maïdo Observatory (2011) OPAR aims at becoming a global station of the GAW Network (Global Atmospheric Watch, WMO).

Scientific work carried out with OPAR data mainly concern research activities of LACy.

OPAR specific research activities mainly deal with validation of satellite instrumentation and studies of small scale atmospheric dynamics for the Maïdo Observatory.

OPAR has collaborations with five laboratories in France two in Belgium one in Australia and one in South Africa. The number of OPAR measurements per year has increased steadily over the past 16 years and the photometer AERONET has functioned continuously since 2005.

OPAR is anticipating a suite of new instruments including a UHF radar wind profiler, a mobile aerosol lidar, a Doppler wind lidar (wind profile 5-50 km) and the new OPAR altitude station at Maïdo peak is expected to open in 2011.

The OPAR website can be found at: http://opar.univ-reunion.fr. It has French/English versions and contains descriptions of the OPAR instrumentation. Access to the OPAR database is via login/password.

3. Updates on the Indian Ocean Observing System (IndOOS) and recent science results from the data streams

3.1 The Research Moored Array for African-Asian-Australian Monsoon - RAMA (Mike McPhaden, M. Ravichandran, Yukio Matsumoto)

3.1.1 Status and Plans for the Pacific Marine Environmental Laboratory's (PMEL) participation in RAMA (M. J. McPhaden)

This presentation reviewed progress in the past year (since IOP-5 in May 2007) and plans for the coming year for PMEL's participation in the implementation of RAMA. Highlights in the past year include expansion of the array from 18 to 22 occupied mooring sites, as the result of two new ATLAS moorings deployed along 80 °E and two along 55 °E. Seven cruises on five ships from four different nations were involved in maintaining the array between May 2007 and May 2008; a similar level of effort is planned for the next year. The need for regular cruises at yearly intervals to maintain the array was emphasized given that the design lifetime of ATLAS moorings is one year. Also, new implementing arrangements (IAs) in support of RAMA were signed in September 2008 between NOAA and the Indian Ministry of Earth Science (MoES) and in May 2009 between NOAA and Indonesia's Ministry of Marine Affairs and Fisheries (DKP) and the Agency for the Assessment and Application of Technology (BPPT). These IAs are formal 5-year agreements that provide for ship time to implement RAMA, technical exchanges between participating agencies, data sharing, and capacity building. A new partnership was established with the Agulhas and Somali Current Large Marine Ecosystem (ASCLME) program, which supported deployment of the two ATLAS moorings along 55 °E in November 2008. Fishing vandalism, its effects on data return and engineering efforts to mitigate data loss from vandalism were reviewed. Several new publications based on RAMA data appeared in the refereed literature, including an article in Eos, Transactions of the American Geophysical Union on a study of cyclone Nargis (McPhaden *et al.*, 2009a) and the cover story in the April 2009 issue of the Bulletin of the American Meteorological Society on the history, status, and plans for RAMA (McPhaden *et al.*, 2009b).

3.1.2 Long term measurements of currents in the equatorial Indian Ocean through deep-sea current meter moorings – a contribution to RAMA (M. Ravichandran)

Dr. M. Ravichandran presented on behalf of Dr. V. S. N. Murty, National Institute of Oceanography (NIO), India. He showed the present status of 3 existing deep sea moorings at 77 °E, 83 °E and 93 °E along the equator. The Ocean Observing System (OOS) deep-sea moorings at 77 °E, 83 °E and 93 °E along the equator in the eastern equatorial Indian Ocean are part of IndOOS. As part of the OOS program, the time series observations across the equator at were extended to understand the meridional extent in the intraseasonal variability in the zonal and meridional currents and to check the spatial variability (e.g. meandering nature) in the equatorial jets. For this purpose, 4 additional moorings were successfully deployed in October 2009 (at 1 °N, 77 °E; 1 °S, 77 °E, 1 °N, 93 °E and 1 °S, 93 °E) increasing the contribution by NIO/MoES to the RAMA by 4. All the moorings have 5 to 6 Recording Current Meters (RCMs) at 6 levels and 1 up-looking Acoustic Doppler Current Profiler (ADCP) at 400m. The nominal depths of RCMs are 100, 300, 500, 1000, 2000 and 4000 m. Dr. M. Ravichandran showed the zonal and meridional currents along the equator measured from the ADCPs along with the data from 3 current meter moorings. During March-Sept 2005, all 5 ADCPs recorded similar velocity variations with slightly weaker currents at 90 °E and 93 °E on the equator. The observation showed that the fall Wyrtki jet in 2005 and spring jet in 2006, were also weaker at 90°E and 93 °E on the equator. The magnitude of spring jet in 2006 dropped abruptly in May 2006 at all the 5 locations, which may be in response to the development of the Indian Ocean Dipole (IOD) in 2006. Preliminary observations from the 93°E, equatorial mooring over the last 3 years, show a fall jet up to 150 m deep in Oct-Nov 2006, early development of a spring jet in 2007 and the appearance of an Equatorial under current in July 2007. The observed variability in the thermocline is thought to be a response to the development of the IOD in 2008. Some of the features observed from the moorings are (i) the identification of biweekly variability in the meridional currents at 93°E, (ii) a dominant semi-annual variability at 77 & 83 °E, (iii) intraseasonal variability with periods of between 20 and 90 days at all three locations, (iv) Equatorial undercurrents during the southwest monsoon months in the eastern equatorial Indian ocean, (v) weakening of equatorial jets towards the far eastern basin, and (vi) a decrease in the amplitude of the semi-annual wave from 77 to 93°E.

3.1.3 *The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) contribution to RAMA (Yukio Masumoto)*
The present status of JAMSTEC mooring observations in the Indian Ocean, under the Japan EOS Promotion Program/Indian Ocean Buoy Network Initiative for Climate Studies (JEPP-IOMICS), and some recent results from the mooring buoys were reviewed. JAMSTEC are maintaining two m-TRITON buoys at 1.5 °S, 90 °E and 5 °S, 95 °E, and one subsurface ADCP mooring at 90 °E on the equator. Both m-TRITON buoys suffered from vandalism causing a gap in real-time data for about seven months starting at the end of July 2008. Fortunately, these m-TRITON buoys were recovered and replaced with new buoys in March 2009, and are collecting data again.

TRITON and m-TRITON data demonstrate interannual variability in the subsurface condition in the eastern equatorial Indian Ocean. During April/May 2009, there was a positive temperature anomaly at the thermocline depth, which is similar to the condition in the previous few years. Continuous time series from the mooring buoys are necessary to monitor when the positive temperature anomaly is replaced by a negative one to identify when an episode of positive IOD starts.

Subsurface zonal current, observed by the ADCP buoy, indicates significant semiannual variation with clear upward phase shift. Dynamical balance of the zonal current is investigated by checking its relation with the zonal pressure gradient term calculated using Argo data. It turns out that rate of time change of the zonal current is mainly dominated by the zonal pressure gradient force in the subsurface layer between 90m and 170m depths, which also shows clear semiannual signal. Time series of satellite observed sea surface height and zonal wind anomalies in the equatorial region suggest that the equatorial Kelvin and Rossby waves excited by the zonal winds along the equator play crucial roles in generating the semiannual zonal pressure gradient force

JAMSTEC will deploy an additional m-TRITON buoy in December 2009, at 8°S, 95°E. This new location may contribute to capture the southern boundary of the negative temperature anomaly during positive IOD events and also to monitor the strong intraseasonal variability along 8°S in the southern tropical Indian Ocean.

3.2 XBT Network (Gary Meyers)
A "Ship of Opportunity Program" Community White Paper has been submitted to OceanObs'09 (Goni *et al.*, 2009). The lead author is Gustavo Goni with contributions from D. Roemmich, G. Meyers, R. Molinari, G. Vissa, C. Sun, M. Baringer, S. Garzoli, S. Swart and T. Boyer. The paper covers the present status of the global network of Low Density (LDX), High Density (HDX) and Frequently Repeated (FRX) lines and it provides examples of the scientific results derived from the different modes of sampling. It was noted in the paper that FRX Lines have not generally been taken up by the international community, except in the Indian Ocean, and some Indian Ocean scientific results are highlighted. The paper questioned if more than 12 sections per year is still a valid recommendation for FRX lines. At a past panel meeting IOP had recommended weekly sampling on line IX1 to observe the Indonesian throughflow which raises the question do we have a case for weekly sampling on IX1? Gary Meyers reported that he thinks we do, but the case has to be substantiated. The paper proposes that JCOMM should sponsor an analysis to assess the value of the global FRX network, in particular to determine the optimal sampling frequency and how much spread can be allowed in the repeated lines. A particular task is to compare the IX1 transports to those measured by INSTANT (the International Array to Measure the Indonesian Throughflow).
Finally note that Gary Meyers has collated ~20 references for XBT data usage in published articles which should be submitted to ICPO.

ACTION: Ask JCOMM for to sponsor analysis of the value of HRX XBT lines (G. Meyers) G. Meyers to forward the list of XBT publications to ICPO (G. Meyers)

3.3 Argo float status in the Indian Ocean (M. Ravichandran)
Dr. M. Ravichandran presented the present status of Argo floats in Indian Ocean. He mentioned that there are 412 active floats (north of 40 °S) and presented the total number of deployed floats and profiles acquired from 2002 to present. He mentioned that though the required number of active floats meets the Argo design criteria for the Indian Ocean as a whole (i.e. one float per 3x3 degree box), the floats are not evenly

distributed and there are gaps where no floats exist (see Figure 1). He also mentioned that Argo float information is available through several sources: Google earth, the IndOOS data-portal at Indian National Centre for Ocean Information Services (INCOIS), the Coriolis data centre or the US-Global Ocean Data Assimilation Experiment (GODAE) data centre. He also demonstrated the new Live Access Server, where users can access Indian Ocean, gridded, Argo data sets. He briefly reported on the Indian Argo User's workshop (July 20-22, 2008, INCOIS, Hyderabad) and presented the outcome of that workshop. The users strongly recommended 5 days repeat sampling in the Bay of Bengal and higher vertical sampling resolution with Iridium communication. This action has been taken up at the national level in India. All the floats deployed in Bay of Bengal have a 5 day repeat sampling cycle and the most recent floats deployed by India in the Bay will have high resolution sampling in the top 20 m of the water column. This item was also discussed at the Argo steering team meeting (Hangzhou, China, March 22-23, 2009). The team recommended that to achieve a higher sampling rate more floats should be deployed instead of changing the sampling strategy (i.e., if a 5 day sampling cycle is needed, instead of deploying one float deploy two floats).

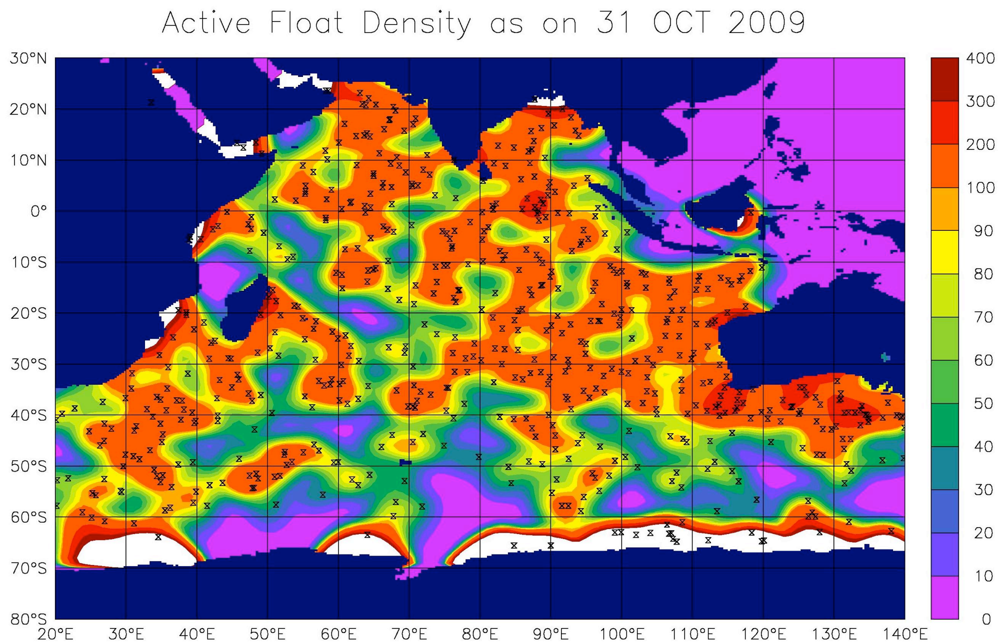

Figure 1: Active Argo float density map for the Indian Ocean, current as of October 31st 2009, Regions with shading other than orange/red (i.e. above 90% density) are considered to be "gaps". In general, the gaps occur more in the western Indian Ocean than the eastern Indian Ocean however, the gaps are dynamic and change from season to season. (Figure courtesy of M. Ravichandran, INCOIS).

3.4 The Indian Ocean Observing System (IndOOS) Data Portal (M. Ravichandran)

Dr. M. Ravichandran presented the status of the IndOOS portal. This portal is built on a distributed network of data archives and provides both direct access to binary data via Open-source Project for a Network Data Access Protocol (OpeNDAP) and via File Transfer Protocol (FTP). It has web based browsing, live access server (LAS) and data discovery. Data archives are maintained by the individual groups in IndOOS at their institutes. However, satellite data (wind, sea surface height anomalies, seas surface temperature and chlorophyll) are available via the LAS for the Indian Ocean region. The primary data consist of observations from the in-situ systems and the secondary data consist of value-added products and satellite data. Dr. M. Ravichandran demonstrated the different in-situ system's data available from the IndOOS portal and the organizations involved in maintaining the system. He also mentioned that INCOIS is building a centralized data system where users can access data at one place with single or multiple formats by parameter or by platform. He also showed the proposed generic data flow of in-situ data from all the IndOOS platforms; however this effort will take at least a few years to build.

ACTION: Distribute Data portal paper during OceanObs'09 (M. Ravichandran, Y. Masumoto)

4. IndOOS Resources Forum (IRF)

4.1 Report on IOGOOS's endorsement (ref: IOGOOS-VI, Dec 2008) regarding the development of an Indian Ocean Resources Forum - IRF (Nick D'Adamo and Yukio Masumoto)
The Sixth Annual Meeting of the Indian Ocean Global Ocean Observing System (IOGOOS-VI) was held in Hyderabad, India from 3-5 December, 2008. A summary report of the proceedings is pending finalisation by the IOGOOS Secretariat; however Nick D'Adamo believed that issues relating to the IOP were unlikely to change in substance from the draft version. Assuming for now that those issues do not change in substance, then the following applies (from IOGOOS-VI) for the purposes of the present IOP6 discussion:
IOGOOS-VI considered the request from IOP for the development of an Indian Ocean Observing System (IndOOS) Resources Forum (IRF). With respect to the actual working function of the IRF, IOGOOS members were comfortable for the IOP to decide on its own modus operandi. The chair requested that IOP finalise the terms of reference (ToR) for the IRF to be those as submitted to the IOGOSS-VI meeting, but with Section 5.4 of the draft ToR changed to: "5.4 IOGOOS will seek Secretariat support for the Forum from the UNESCO IOC Perth Regional Programme Office". IOP co-chair Dr. Masumoto has distributed the draft ToR to the IOP via email.

IRF Secretariat issues for consideration:

- Budget - IOP needs to estimate the IRF resource requirements
- Leadership - it is suggested that we have an IRF 'Director' or equivalent
- Governance - IOGOOS sees the IRF as an organ of IOGOOS, established to facilitate IOP
- Funding - IOC Perth will be requested to provide funding (amount to be determined) for the IRF Secretariat support
- Economies – it would seem desirable to harmonise meetings of the IOP and the IRF (and the High Level Review Panel) to rationalise costs associated with delegates' travel and local meeting costs

Development of the IRF Business Plan:
The IOGOOS chair requested, through the IOP Co-Chair, Dr. Masumoto, that the IOP have the Business Plan for the IRF ready for consideration by IOGOOS, at the next IOGOOS meeting. To achieve a finalized IRF Business plan by IOGOOS-VII, the Chair indicated that IOGOOS is keen to have the IRF Business Plan developed and finalised in a timely manner, out of session, in the intervening period between IOP-6 and IOGOOS-VII (i.e. over the next 2-3 months).

If feasible, IOGOOS would like to see a combined meeting of IOGOOS-VII, IOP-7, IRF-1, and IOP High Level Review Panel-3 in view of the likely cross-attendance of individuals at these meetings, hence helping to reduce overall travel costs. A possible timeframe for a meeting could be March/April 2010 as this would give equal displacement of IOGOOS-VII and IOP-7 timelines based on the dates of the past meetings. Iran and IOC Perth have both offered to host IOGOOS-VII but IOC Perth could host all 4 meetings together. As yet dates and a venue for IOGOOS-VII are to be announced.

A specific recommended action for IOP arising out of IOGOOS-VI was to undertake an internal review and prioritization of the needs of the respective ocean observing components of IndOOS, with a view to having the priorities and associated needs for enhancement of those components submitted to the 1st meeting of the proposed IRF.

4.2 Development of the IRF in response to IOGOOS-VI: ToR, membership, Secretariat support (Gary Meyers, Mike McPhaden, Nick D'Adamo, Yukio Masumoto)
As mentioned in the previous section IOGOOS-VI reviewed the proposed terms of reference for the IRF and made only one change. However they did recommend that IOP be tasked (at IOP-6) with developing an IRF business plan, including membership for IRF, and emphasised that the IRF business plan should include SIBER and that the plan should be approved by the IOGOOS Chair. IOGOOS-VI also proposed that the first IRF meeting should take place at IOGOOS-VII and in conjunction with the third IOP High Level Review.

Gary Meyers has provided a draft framework for the business plan, which follows:

IRF draft Business Plan

- Background—Development of IndOOS: progress and problems
    - Multinational success
    - Ship time
    - Resources
    - Sustainability
- Objective of IRF

    - Multinational coordination to maximise/optimise ship time and resources
    - Promote IndOOS at home (i.e. in IOP members' home countries)
    - Promote IndOOS in international bodies e.g. Global Environment Fund, World Bank, if appropriate
- Structure and governance
  - Members invited by IOGOOS
    - Following recommendations by IOP and SIBER (Sustained Indian Ocean Biogeochemistry and Ecosystem Research)
    - Elect Chair for 2-3 year term
  - IOC Perth provides Secretariat support and resources for meeting
  - IRF Secretary appointed by IOC Perth
    - Nominations
  - Secretary convenes regular (perhaps annual) meetings normally back-to-back with IOGOOS, with duties and responsibilities still needing to be defined
  - Secretary reports outcomes to IOGOOS, SEAGOOS and other stakeholders
- Modus operandi
  - First meeting—IRF develops a "sustainability strategy"
  - Annually, IOP & SIBER identify needs (meetings ~June; in collaboration out of session)
  - IRF preferably meets in conjunction with IOGOOS, which for 2009 would be in Nov-Dec, however in view of the amount of work needed to be done to develop the IRF, it is suggested the first IRF meeting be in March/April 2010 (with IOGOOS-VII therefore also asked to meet with IRF-1, back-to-back, at that same time)
  - IRF members report progress toward national contributions to the IRF Secretary before IOP meetings
- The goal is incremental growth of IndOOS toward the IOP and SIBER Implementation Plans
- A measure of success is the percentage of RAMA running. There will be other measures of success, as yet to be defined.
- Membership-
  - Should be people who are in a position to either commit or have a high level capacity to facilitate the commitment of resources for the development of IndOOS, and the overall number of members on the IRF should be a maximum of 10 to12
  - Members could be selected from some of the following organisations or bodies:
    - Ministry of Earth Sciences, India (MoES)
    - National Oceanic and Atmospheric Administration, USA (NOAA)
    - Agency for Marine-Earth Science and Technology, Japan (JAMSTEC)
    - State Oceanic Administration, China (SOA)
    - National and International Research Alliances Program, Australia (NIRC)
    - Agency for the Assessment and Application of Technology, Indonesia (BPPT)
    - Department Maritime and Fisheries Affairs, Indonesia (DKP)
    - L'Institut polaire français Paul- Émile Victor, France (IPEV)
    - L'Institut national des sciences de l'Univers France (INSU)
    - Agulhas and Somali Current Large Marine Ecosystems Project (ASCLME)
    - UNESCO/IOC
- Make business plan for IRF, including the finalized ToR, an initial membership list, and secretariat candidate, and submit it to IO-GOOS. (G. Meyers, N. D'Adamo, M. McPhaden, Y. Masumoto)

ACTION: Respond to IOGOOS recommendation on the link between IOP and SIBER (Y. Matsumoto, W. Yu, R. Hood)

5. Enhancement of IndOOS

5.1 National Oceanic and Atmospheric Administration (NOAA) bilateral programs in the region (Sid Thurston)
The establishment of a US National Climate Service is underway and observations for socio-economic applications are critical to driving this process. NOAA is a leading provider of reliable weather, water and climate information to the nation and the globe. NOAA's products are the result of a vigorous research program and a growing operational capability. The International community has responded to the need for in-situ global ocean observations for climate research and operational oceanography and the GCOS-92 implementation plan is approximately two-thirds implemented.

For the Indian Ocean, there is a wide range of emerging Science and progress on the implementation of the Indian Ocean Observing System (IndOOS) for the Research moored Array for African-Asian-Australian Monsoon Analysis and prediction (RAMA), and other in-situ IndOOS networks. Resource sharing, bilateral partnerships, are contributing towards a successful outcome of this initiative and the newly established IndOOS Resource Forum (IRF) is expected to further coordinate towards advancing full implementation.

NOAA has entered into mutually beneficial and fruitful partnerships with India, Indonesia, and the Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project for the central, eastern and western Indian Ocean, respectively. NOAA and India's Ministry of Earth Sciences (MoES) signed a memorandum of understanding (MOU) in April 2008, NOAA and Japan's Agency for Marine-Earth Science and Technology (JAMSTEC) renewed their long-term MOU in 2008, NOAA and Indonesia's Ministry of Marine Affairs and Fisheries (DKP) and Agency for the Assessment and Application of Technology (BPPT) signed two major new agreements at the recent *World Ocean Conference* (WOC) in Manado Indonesia in May and China's State Oceanic Administration (SOA) and Indonesia (DKP) signed an MOU in 2007.The University of Paris and the University of Cape Town are committing ship time to expand RAMA into the southwest Indian Ocean with MOU's under discussion.

The partnership between MoES and NOAA is based on both science drivers as well as the societal applications of enhanced ocean-climate observations. Under the NOAA-MoES MOU there are several implementing arrangements broadly across NOAA for: RAMA implementation and Indian Ocean scientific collaboration, Climate Model and Ocean Assimilation Analyses for the Indian Ocean Region, Climate Monitoring and Prediction System for the South Asian Region, and South Asian Regional Reanalysis (SARR). Other joint collaborative projects are being considered for Carbon Cycle Greenhouse Gas Measurements and Research, Tropical Cyclone Research, and Tsunami monitoring collaboration. A NOAA-MoES Science Colloquium was held at MoES in New Delhi in September 2008, and the First NOAA-MoES Joint Executive Committee Meeting will take place in New Delhi in early October 2009 to review ongoing projects and invite new areas of collaboration. A MoES-NOAA Seminar for Climate collaboration is being planned for Spring 2010.

The 5th Indonesia Ministry of Marine Affairs and Fisheries (DKP), Agency for the Assessment and Application of Technology (BPPT) and NOAA Capacity Building Workshop will be held in Bali Indonesia in October 2009, with the Theme *Planning For Climate Change in the Coastal and Marine Environment,* and BPPT's *Baruna Jaya III* will re-service the four NOAA RAMA Moorings off NW Sumatra in July 2009. The ASCLME survey aboard the R/V *Fridtjof Nansen* gave NOAA's Pacific Marine Environmental Laboratory (PMEL) in Seattle, Washington the opportunity to deploy two ATLAS moorings in the western Indian Ocean at 8/12 South along 55 East in late November 2008. The IOC/WMO Data Buoy Cooperation Panel Capacity Building Task Team is planning a Training Workshop for the Western Indian Ocean in early 2010 for a) Data access/collection/management and b) Regional modelling/products. Finally, synergies and potential options going forward are being explored between the new Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER) project and India's MoES INDOFLUX ocean component.

5.2 Repeat Hydrographic observations and the Global Ocean Ship-based Hydrographic Investigations Project (GO-SHIP) proposal (Yukio Masumoto)

Yukio Masumoto raised an issue about the inclusion of repeat hydrographic observations as one component of IndOOS. So far, IndOOS does not explicitly show the repeat hydrographic observations in its figure and explanations, but they are implicitly included with other ship based hydrographic observations. Since GO-SHIP coordinates the repeat hydrographic observations in the global oceans and the repeated deep ocean observations in the Indian Ocean are necessary for detecting long-term variations in the deeper layer, it is suggested to include them explicitly in IndOOS and start coordinating with GO-SHIP community. The members of IOP agreed to this suggestion.

ACTION: Contact GO-SHIP to initiate coordination between IOP and GO-SHIP on hydrographic sections as a part of IndOOS (Y. Masumoto)

5.3 Indian Ocean Tsunami Warning System (IOTWS) "ocean": current status and future plans (Nick D'Adamo, with input from Tony Elliott, who is the Head of the Secretariat for the Intergovernmental Coordination Group of the Indian Ocean Tsunami Warning System)

In December 2004 UNESCO (through IOC) was tasked by the United Nations to lead the establishment of a Tsunami Early Warning System for the Indian Ocean. 28 member countries contribute to the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning System (ICG/IOTWS). The planned system is "end-to-end" from Regional through National down to local, and addressing hazard detection and forecast, threat evaluation and alert formulation, alert dissemination/public safety message and preparedness and response. It is intended that the System be fully owned by Indian Ocean countries, based on international and multilateral cooperation, open and free data exchange, and that it will protect all countries in the Indian Ocean and be transparent and accountable to all countries. The Secretariat for the IOTWS Intergovernmental Coordination Group is co-located in Perth with the UNESCO IOC Perth Office. The Secretariat's resources derive from sponsorship through the Australian Bureau of Meteorology. There were 73 operational seismic stations by the end of 2008 and 80 seismic stations are planned by the end of 2010. There are currently over 60 coastal sea level stations reporting continuously and a further five are planned to be installed in 2009/10. In addition 44 deep ocean stations are planned. Of the nine currently in operation, two transmit in real time on the Global Telecommunication System (GTS).

Thursday June 4th:

6. Planning new multinational process studies

6.1 MISMO results and CINDY plans (Kunio Yoneyama)
As a follow-up project of MISMO (Mirai Indian Ocean cruise for the Study of the Madden-Julian Oscillation (MJO) -convection Onset) in 2006, a new field experiment, CINDY2011 (Cooperative Indian Ocean experiment on intraseasonal variability in the Year 2011) will be conducted from October 2011 to January 2012. The aim of the experiment is to collect in-situ atmospheric and oceanic observation data to study the intraseasonal variability in the central equatorial Indian Ocean, with focus on the initiation process of the MJO-convection. Based on the analyses of MISMO data as well as recent results from MJO studies, major objectives which should be addressed by the experiment are: (1) evolution of heating profile associated with the MJO, (2) relationship between convective systems and large-scale equatorial waves, and (3) relationship between MJO convective activity and sea surface/upper ocean conditions. For these objectives, an observational network with ships and land-based sites as well as a moored buoy array will be constructed through a multi-national effort. Theoretical simulations suggest that rectangular configuration seems to be best to capture the influence of equatorial waves for accurate budget analysis. Exact configuration of the observational network will be determined upon the results of available ship-time and land-based sites. So far, researchers from Japan, U.S., India, Australia, and Seychelles have expressed their interest in participation in the campaign. In particular, U.S. researchers will intend to join as part of their own project DYNAMO (Dynamics of the MJO) which consists of a field campaign component and numerical modelling studies by various groups. We also expect participation from countries such as Indonesia, France, China, and others. At present, only JAMSTEC has committed to participation on the R/V Mirai in CINDY2011; other institutes are still requesting or will request funds for participating. The latest information can be found at the CINDY2011 web pages at http://www.jamstec.go.jp/iorgc/cindy/.

ACTION: Confirm the process of CLIVAR endorsement for CINDY/DYNAMO (K. Stansfield K. Yoneyama, M. McPhaden)

6.2 US contribution to CINDY: DYNAMO (Mike McPhaden)
There is considerable evidence for the importance of the Madden-Julian Oscillation (MJO) in weather and climate (e.g., hurricane activity, U.S. West Coast flooding events, and El Niño-Southern Oscillation - ENSO), and in their seamless prediction. But our ability to simulate and predict the MJO is severely limited due to model misrepresentation of processes key to the MJO. Development, improvement and validation of parameterizations for weather and climate models critically rely on in situ observations. A lack of in situ observations in the region of the tropical Indian Ocean has impeded the progress on the study of MJO, especially its initiation. All these point to an urgent need for a field observation campaign in the tropical Indian Ocean region with a focus on the MJO and tropical intraseasonal variability in general.

The US research, operations and applications communities are poised to join CINDY2011, an international field program that will take place in the central equatorial Indian Ocean in late 2011 - early 2012 to collect in situ observations to advance our understanding of MJO initiation processes and to improve MJO prediction. DYNAMO is the program that organizes the US interest of partaking in CINDY2011. The DYNAMO campaign will be augmented by other field programs (AMIE, HARIMAU, PAC3E-SA, ONR air-sea interaction) also taking place in late 2011 - early 2012. The integrated observation data set from these programs will cover MJO events at different stages of their life cycle with complimentary observational emphases. The opportunity to be an integrated part of these coordinated programs to maximize the value of observational products makes the timing of late 2011 - early 2012 critical for DYNAMO.

The field campaign of DYNAMO/CINDY2011 consists mainly of a sounding-radar array formed by research vessels and island sites and enhanced moorings inside and near the array. The design of the field campaign and the selection of observational objectives (e.g., vertical profiles of moistening and heating, structure and evolution of cloud and precipitation processes, surface fluxes, atmospheric boundary-layer and upper-ocean turbulence and mixing) have been and will continue to be guided by the DYNAMO modelling activities, which provide hypotheses on potentially crucial processes of MJO initiation. DYNAMO field observations will serve as constraints and validation for models to quantitatively test these hypotheses. This integrated modelling-observational approach will be pursued by a proposed climate process team (CPT) and will lead to targeted information to assist model improvement.

The expected outcome of DYNAMO will be (i) a unique in situ data set available to the broader research and operations communities, (ii) advancement in understanding of the MJO dynamics and initiation processes necessary for improving MJO simulation and prediction, (iii) identification of misrepresentations of processes key to MJO initiation that are common in models and must be corrected to improve MJO simulations and predictions, (iv) provision of baseline information to develop new physical parameterizations and quantify MJO prediction model improvements, and (v) enhanced MJO monitoring and prediction capacities that deliver climate prediction and assessment products on intraseasonal timescales for risk management and decision making.

6.3 New science results and Thermocline Ridge of the Indian Ocean (TRIO) project plans (Jerome Vialard)
The first item of this talk was a study of the intraseasonal variability of the coastal waveguide of the Northern Indian Ocean. It was shown that the baroclinic wave response of the equatorial waveguide to intraseasonal variability of the wind due to the MJO propagates northward into the coastal waveguide of the North Indian Ocean. As the result, there are systematic variations of the sea level of a few cm in the Bay of Bengal and western coast of India, lagging the equatorial signal. While the amplitude of this signal is smaller than the seasonal cycle, it was shown that this variability dominates the alongshore current record along the west coast of India. This is the result of the intraseasonal signal being trapped at the coast under the form of poleward propagating coastal Kelvin waves, while lower frequency signals propagate westward as planetary waves, and are thus associated to weaker offshore pressure gradients.

The second part of this talk showed that the main mode of variability of the Indian Ocean (the Indian Ocean Dipole) is an efficient trigger of El Niño. This is demonstrated by clear improvement of El Niño simple statistical hindcasts at 11-15 month range when including an Indian Ocean Dipole (IOD) Index (with scores higher than any over available statistical or dynamical model). A mechanism has been proposed explaining how the IOD-induced wind anomalies over the tropical Pacific can help to trigger El Niño. Usual El Niño theories
mostly consider dynamics internal to the tropical Pacific (e.g. the “recharge oscillator” paradigm). While recent studies suggested that Indian Ocean variability could influence the development of a synchronous El Niño, the present study is the first to show how the Indian
Ocean influence can combine with the Pacific preconditioning to trigger an El Niño the following year. The Indian Ocean is still the least observed of the three tropical oceans. These results (if confirmed) suggest that an improvement of observations and modelling of the Indian Ocean would benefit our knowledge of tropical interannual variability and improve seasonal forecasting on a global scale.

Finally, an update on the TRIO cruise was presented. A French R/V will not be available in the Indian Ocean at the proposed time of TRIO (late 2010 / early 2011). The TRIO science plan has however been positively evaluated, and a re-submission of TRIO at a later date was encouraged. The TRIO effort will now join the CINDY initiative (Japanese, Australian, and potentially US ships). In the course of next year, TRIO will be redesigned to join CINDY. There would also be a strong incentive to move the South-West Indian ocean tropical Cyclone Experiment (SWICE) initiative by one year to join CINDY/TRIO in late 2011/early 2012. SWICE is still planned in early 2011. TRIO plans are as yet uncertain, but in any case, the proposal will be re-submitted for consideration for funding (in January, 2010).

ACTION: Coordination of TRIO/CINDY/DYNAMO for the basin-scale process study of MJO, with consideration to include SWICE (J. Vialard, K. Yoneyama. , M. McPhaden)

6.4 Year of Tropical Convection (YOTC), AMS, International Monsoon Study (IMS) (Jay McCreary) -
Indian Ocean variability is strongly connected to Asian, Australian, and African monsoons. Among these monsoonal systems, observational activities and researches of the Asian monsoon are rapidly expanding under YOTC, AMS, and IMS. To build up and enhance connection with the Asian monsoon research community, the IOP relationship to the Asian - Australian Monsoon Panel (AAMP) should be critically considered. As a first step forward, we have sent a letter describing the IOP activities and proposing more collaboration between AAMP and IOP. Although we have not received any response to it from AAMP so far, the discussion should be started to seek ways for cooperation.

ACTION: Ask AAMP co-chairs for the response to the letter sent from IOP about a year ago (Y. Masumoto, J. McCreary)

7. Harmonisation of development of Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) and the IOP framework

7.1 Report on IOGOOS's recommendations regarding the development of SIBER as a project complementary to IOP (ref: IOGOOS-VI, Dec 2008) (Raleigh Hood, Nick D'Adamo and Yukio Masumoto)
IOGOOS-VI (held at Hyderabad, India, December 2008) re-affirmed its intention to adopt SIBER. SIBER will be sponsored jointly under Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) and IOGOOS. IOC Perth (for IOGOOS) and IMBER will sponsor SIBER in a similar way to the joint sponsorship of IOP by GOOS and CLIVAR.

The following extracts are taken from the IOGOOS-VI report:

- "... IRF Business Plan should be developed with due reference to and inclusion of SIBER, in respect to potential synergies in science pursuits and harmonizing the respective sustained observing system developments across the IOP and SIBER."
- "To that end, it is recommended that SIBER participate in the development of the IRF at IOP6 to assist in developing the IRF Business Plan and also in order to ensure appropriate recommendations for representation of bio-geochemical needs in the IRF."
- IOGOOS also encouraged SIBER, through Dr. W. Naqvi, NIO, India, to:
  > "... make a presentation to the Secretary, Ministry of Earth Sciences, India, requesting the Ministry's institutional support for resources to progress the SIBER objective of improving the network of measurements of ocean carbon through the Underway PCO2 system."

7.2 IOP representation, through membership, on SIBER (Yukio Masumoto and Weidong Yu)
IOP representation on SIBER was discussed, as requested by one of the recommendations from IOGOOS-VI (held at Hyderabad, India, December 2008). Because Prof. Hood, who is one of the co-chairs of SIBER, is now an official member of IOP he can also represent IOP on SIBER and directly convey the IOP's ideas and opinions to the SIBER community. The panel concluded that there is no need for an additional liaison member from IOP.

7.3 Developing the SIBER science plan in coherence with IOP's framework (Raleigh Hood) The deployment of coastal and open-ocean observing systems in the Indian Ocean has created new opportunities for carrying out biogeochemical and ecological research there. International research efforts need to be motivated to exploit these opportunities to advance our understanding. Sustained Biogeochemistry and Ecosystem Research (SIBER) is a decade-long, multidisciplinary international science plan and implementation strategy that is designed to leverage these observing systems and other international programs in order to advance our understanding of biogeochemical cycles and ecosystem dynamics of the Indian Ocean in the context of climate and human-driven changes.

The long-term goal of SIBER is to understand the role of the Indian Ocean in global biogeochemical cycles and the interaction between these cycles and marine ecosystem dynamics. This understanding will be required in order to predict the impacts of climate change, eutrophication and harvesting on the global oceans and the Earth System and is fundamental to policy makers in the development of management strategies for the Indian Ocean. To address this goal, emphasis will be given to the analysis required to predict and evaluate the impacts of physical and anthropogenic forcing on biogeochemical cycles and ecosystem dynamics in the Indian Ocean. SIBER will leverage the sampling and monitoring activities of several coastal and open-ocean observing systems that are being planned and deployed in the Indian Ocean and will provide the basin-wide scientific coordination and communication required to predict Indian Ocean biogeochemical cycles and ecosystem dynamics in the context of climate change and other anthropogenic influences.

To address its long-term goal SIBER has structured its research around six major scientific themes. Each of these focus on a specific set of scientific questions that need to be addressed in order to improve our understanding of the biogeochemical and ecological dynamics of the Indian Ocean and develop a predictive capability. These themes can be broadly separated into three that are regionally focused and three that address general scientific questions.

Regional Scientific Themes:

- Theme 1: Boundary current dynamics, interactions and impacts (How are marine biogeochemical cycles and ecosystem processes in the Indian Ocean influenced by boundary current dynamics?)
- Theme 2: Dynamic variability of the equatorial zone, southern tropics and Indonesian Throughflow and their impacts on ecological processes and biogeochemical cycling (How do unique physical dynamics of the equatorial zone of the Indian Ocean impact ecological processes and biogeochemical cycling?)
- Theme 3: Physical, biogeochemical and ecological contrasts between the Arabian Sea and the Bay of Bengal (How do differences in natural and anthropogenic forcing impact the biogeochemical cycles and ecosystem dynamics of the Arabian Sea and the Bay of Bengal?)

General Scientific Themes:

- Theme 4: Controls and fates of phytoplankton and benthic production in the Indian Ocean (What are the relative roles of light, nutrient and grazing limitation in controlling phytoplankton production in the Indian Ocean and how do these vary in space and time? What is the fate of this production after it sinks out of the euphotic zone?)
- Theme 5: Climate and anthropogenic impacts on the Indian Ocean and its marginal seas (How will human-induced changes in climate and nutrient loading impact the marine ecosystem and biogeochemical cycles?)
- Theme 6: The role of higher trophic levels in ecological processes and biogeochemical cycles (To what extent do higher trophic level species influence lower trophic levels and biogeochemical cycles in the Indian Ocean and how might this be influenced by human impacts, e.g., commercial fishing?)

The SIBER Science Plan is ambitious and very broad. It encompasses biogeochemical research from the continental margins to the deep sea and trophic levels ranging from phytoplankton to top predators including fish and humans. It should be emphasized that this plan is intended to provide a set of options (i.e., these scientific themes) for different countries to consider as potential research foci in the Indian Ocean. This approach is necessary in order to accommodate the broad (and often regional) interests of many countries that are interested in pursuing research in the Indian Ocean.

Programmatic Linkages
SIBER has been developed in conjunction with the International Geosphere-Biosphere Program (IGBP), through support from the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) program, and IOC through support from the IOGOOS program.

SIBER will coordinate with international research efforts such as the Global Ocean Ecosystem Dynamics (GLOBEC) sponsored Climate Impacts on Oceanic Top Predators (CLIOTOP) program and the GLOBEC/IMBER sponsored Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) program. SIBER will also leverage several coastal and open ocean monitoring programs in the Indian Ocean. These include the CLIVAR and GOOS sponsored Indian Ocean Observing System (IndOOS), Australia's integrated Marine Observing System (IMOS) and several regional GOOS programs. To develop a broader understanding of the Indian Ocean ecosystem SIBER will coordinate its efforts with those of the Indian Ocean Census of Marine Life (IOCOML), the Western Indian Ocean Marine Science Association (WIOMSA), the South African Network for Coastal and Oceanic Research (SANCOR) and the Agulhas-Somali Large Marine Ecosystem program. As the SIBER program develops it is envisaged that the number of participants, institutes and programs involved will increase. SIBER will provide the innovation, direction and coordination required to build a critical mass of multidisciplinary science and scientists to deliver this ambitious, achievable and globally important program.

ACTION: IOP members to provide comments to SIBER on the SIBER science plan (All members)

ACTION: Ask SIBER group to prepare specific implementation plan of the observations, considering the existing observing system IndOOS (R. Hood, Y. Masumoto, W. Yu, M. McPhaden)

7.4 Proposal to deploy Indoflux CO_2 sensors on some RAMA buoys (P.V. Sundareshwar Palloor)
In 2006 an Indo-US bilateral workshop brought together scientists from 17 US institutions and their counterparts in Indian institutions to develop the objectives and blueprint for the INDOFLUX (summarized in Sundareshwar *et al.*, 2007). This network, dubbed INDOFLUX will be a unique undertaking that will link terrestrial, coastal and oceanic environments in an integrated monitoring program. The network will gather data (collected automatically and manually), relay them to a central data warehousing center from where the information will be shared with domestic and global partners in near real-time. The Government of India has earmarked approximately US $50 Million for the next five years to implement INDOFLUX. Dr. Sundareshwar

is currently helping develop the science and implementation plan for this multi-agency network by bringing together a multidisciplinary team of scientists and administrators from India, the USA and Europe. These efforts will significantly enhance institutional and bilateral collaborations for the study of global change.

8. SCIENCE TALKS 2: Research activities of new members and new research activities of other members

8.1 Modelling the Oxygen Minimum Zone in the Arabian Sea (Raleigh Hood)

Oxygen minimum zones (OMZs) typically occur below regions of high surface productivity where ventilation is restricted. OMZs are present in both the Bay of Bengal (BBOMZ) and the Arabian Sea (ASOMZ) in the northern Indian Ocean with near-total depletion of oxygen at depths from 100-1000 m. Interestingly, oxygen concentrations are slightly lower in the Arabian Sea, which leads to profound biogeochemical differences between the two basins. However, it is not clear why these differences exist and in some models the BBOMZ is stronger than the ASOMZ. A striking feature of the ASOMZ is its location, which is not in the western part of the basin where biological production and presumably export is the highest.

In this presentation, results from a coupled biophysical model with an oxygen compartment to investigate the ASOMZ and the BBOMZ were presented. The model consists of 6 active layers, which represent the mixed layer and its diurnal variability (layers 1 and 2), the seasonal thermocline (layer 3), the main thermocline (layer 4), the oxygen minimum region (layer 5), and a deep layer with higher oxygen (layer 6). The biological model is the same NPZD model used by Hood et al. (2003), except with two size classes representing small and large detritus and an additional oxygen compartment.

Solutions were presented that show how the ecosystem, and in particular the subthermocline, oxygen distribution, responds to both biological and physical parameters. Our model results suggest that two detritus size classes are needed in order for the biological model to be able to develop simultaneously both realistic concentrations of surface phytoplankton as well as sufficiently low subsurface oxygen levels. They also suggest that differences in the physical processes which control vertical nutrient exchange give rise to the observed differences between the BBOMZ and the ASOMZ and that physical processes (that control horizontal ventilation) and biological processes (that control the sinking rate of detritus) are responsible for the northeastward intensified location of the ASOMZ.

8.2 Two-year oscillations of the monsoon and global climate in the present decade (Debasis Sengputa)

The South Asian summer monsoon is known to have significant biennial variability. We find that seasonal mean (June-July-August-September) rainfall over Central India and North Bay of Bengal (CI-BoB) has a pure two-year oscillation in the period 1999-2005 arising from modulation of the seasonal cycle. The odd years (1999, 2001, 2003 and 2005) are relatively wet, while the even years (2000, 2002 and 2004) are dry. This period includes the severe Indian drought of 2002, when the All India Monsoon Rainfall was about 20% below normal. Using global satellite and in situ observations of rainfall, SST, surface winds and air temperature, we find that the biennial fluctuation of monsoon rain is related to biennial oscillation of several features of global surface climate. We document the nature of this biennial oscillation (BO).

BO of the summer monsoon rain over CI-BoB and the west Pacific in 1999-2005 is not related to east Pacific SST; it is, however, associated with the BO in the tropical west Pacific summer SST and the spring SST in the southwest Indian Ocean (SWIO). It is also associated with the BO of the tropical north Atlantic SST from summer through the following winter. SST in the deep tropical north Atlantic is warm following years of wet summer monsoon in the CI-BoB-west Pacific. The pattern of SST BO has similarities with the Atlantic meridional mode. The SST warming appears to be due to reduced evaporation. It is accompanied by warm surface air temperature over north Eurasia and eastern North America. The pattern of land warming is similar to the surface air temperature signal of the Arctic Oscillation (AO), and is due
to increased westerly surface winds at about 50 degrees of latitude in the north Atlantic. The winter AO index shows a biennial oscillation in 1999-2004. In odd years, when the northern hemisphere is warm, the winter ITCZ has a northward shift/intensification in the Atlantic and central Pacific, consistent with previous findings on ENSO to paleo time scales. The biennial oscillation of the monsoon in the present decade is therefore connected to the BO of global surface climate.

8.3 The Leeuwin Current in the southeast Indian Ocean (Ming Feng)

The Leeuwin Current is an anomalous, poleward flowing eastern boundary current in the southeast Indian Ocean, driven by large-scale pressure gradient. The strength of the Leeuwin Current and its eddy field are closely correlated with ENSO, due to the existence of coastal waveguides. The Leeuwin Current also exhibits decadal variability, as well as a long term trend. A climate downscaling model will be used to project the future changes of the Leeuwin Current under climate change, but deriving a suitable forcing for the downscaling proves to be challenging. It is hoped that the situation will be helped as Australia's Integrated Marine Observing System (IMOS) starts to implement a northern Australian monitoring project.

8.4 Modelling the oceanic response of cyclone Nargis (Tony Lee)
Cyclone Nargis emerged in the Bay of Bengal in late April 2008 and made landfall in Myanmar on early May, causing huge loss of life and substantial destruction. Understanding the oceanic and atmospheric processes that govern the genesis, intensification, and the path of such tropical storms can help improve forecast systems for the protection of life and property. The in-situ measurements from the developing Indian-Ocean Observing System (IndOOS) and satellite observations, the backbone of IndOOS, have provided complementary observations to help address these issues. Several IOP members and their colleagues are engaging in the study of the atmospheric and oceanic aspects associated with Cyclone Nargis using IndOOS observations in conjunction with an eddy-resolving ocean model. RAMA buoy measurements, Argo observations, and various satellite-derived products are being used to examine the evolution of Cyclone Nargis and the performance of ocean model and atmospheric analysis/reanalysis products.

8.5 Near-surface eastward flows in the Southern Indian Ocean (Jay McCreary)
Near-surface (z >= -200 m) eastward flow overlies westward flow across the South Indian Ocean (SIO; the region south of about 10–15ºS). Such flows also occur in the Pacific Ocean. In both oceans, they flow against both Sverdrup circulation AND Ekman flow, and hence are referred to as Subtropical Countercurrents (SCCs). Interestingly, the SCCs in the SIO are stronger and more extensive than they are in the Pacific. Furthermore, they appear to be part of larger and more complex circulations, as they are linked to the subsurface westward flows, Indonesian Throughflow (ITF), Leeuwin Current, and subduction/convection regions south of the Indian Ocean.

Several forcing mechanisms have been proposed to account for the SIO SCCs: i) the ITF, ii) the poleward density gradient across the basin; iii) basin-wide subduction across the southern portion of the SIO, and iv) localized subduction/convection in the southeast IO and south of Australia. As yet, there is no consensus whether one of these processes is the primary cause, and it is possible that all play a role. Thus, the SIO SCCs represent a fundamental gap in our first-order understanding of the large-scale mean circulation in the SIO.

8.6 Air-Sea heat, freshwater and momentum fluxes in the Indian Ocean (Lisan Yu)
Lisan Yu reported on a study that had conducted a data analysis to gain understanding of the cause of the association of a high SST front with warm anticyclonic features in the central Bay of Bengal before Cyclone Nargis (2008). The pre-existing warm-core ring appeared to have played a role of preconditioning in modulating the track and intensity of the cyclone. Using observations acquired from a recently implemented RAMA buoy, together with basin-scale Argo profiling floats and a constellation of earth observing satellites, the study investigated the generation mechanism of the warm-core ring and the mechanism governing the usual coupling between high SSTs and high SSHs.

9. Regional Issues – 1

9.1 Long term Ocean Climate Observations (LOCO) and Agulhas Current monitoring (Will de Ruijter)
Previous studies on the connection between the Indian and Atlantic Oceans show that the Atlantic Meridional Overturning Circulation may strengthen and stabilize with increased Agulhas leakage. This Agulhas Leakage has varied significantly and may have even been shut off in the (paleo) past. This has important consequences for climate variability at regional to global scales.

Its variation seems to be controlled from the varying flows in the Indian Ocean (IO) which converge in the southwest IO. Sustained observations in the southwest IO are thus a necessity. The Dutch NWO-funded LOCO/INATEX (Indian-Atlantic exchange in present and past climate program - project leaders De Ruijter and Ridderinkhof) and the US National Science Foundation-funded Agulhas Current Time-series (ACT) program (project leader Beal) fill in this need.

Initial conclusions from the sustained LOCO moored observations are that the volume transport in the Mozambique Channel has a strong inter-annual variation around a mean of ± 15 Sv. Over 2003-2008 this variation seems related to the Indian Ocean Dipole cycle. Dominant variability appears at the ± 5/yr frequency at which Mozambique Channel eddies form. There is a seasonal cycle with an amplitude of ± 5 Sv but the eddies overwhelm the seasonal signal.

State of the art numerical models appear to reasonably simulate the mean volume transport and its annual cycle but fail to reproduce the dominant variability in the Mozambique Channel.

Funds are available for continuation till 2011-2012 in the narrow section of the Channel and to deploy a similar (about half in size) array of moorings in the eastern Mozambique Channel in the 2010-2012 period. A partnership with the ASCLME program will be established to combine and strengthen both programs.

One goal of the ACT is to also build a multi-decadal time-series of Agulhas Current transport. First a mooring array will be deployed across the Agulhas along an altimeter ground track to obtain accurate 3-year long time series of transport from in situ measurements. These will then be calibrated with the altimetry data to produce a proxy time series of Agulhas transport from 1992 and into the future. The initial deployment cruise for ACT is set for the 4th-24th April, 2010, aboard the R.V. Knorr, Cape Town to Cape Town.

9.2 Report on the South West Indian Ocean workshop (Will de Ruijter)
A workshop on the South West Indian Ocean was held on the 2nd/3rd March 2009, Kiel, Germany. The main intention of the workshop was to establish and foster collaboration
between the individual groups working in the area, and to discuss an initiative for the establishment of a Scientific Committee on Oceanic Research (SCOR) working group. 24 participants attended the workshop.

The separate basin observation systems (such as IndOOS) lack the inter-basin connections which connect the global circulation This motivates the proposal for a SCOR working group on the Climatic Importance of the Greater Agulhas system

Specific goals of the working group are to:
1. Facilitate collaboration between individual groups working in the area
2. Write a review of the climatic importance of the Greater Agulhas system
3. Identify key research issues, indices & proxies, sustained observations; communicate with CLIVAR, GOOS etc.
4. Propose and organize a Chapman conference in 2012

Proposed membership of the working group is:
Co-chairs: Lisa Beal (Miami, United States of America) & Arne Biastoch (Kiel, Germany)
Johann Lutjeharms (University of Cape Town, South Africa),
Rainer Zahn (Barcelona,Spain),
Will de Ruijter (Utrecht, Netherlands),
Juliet Hermes (South African Environmental Observation Network, South Africa),
Tomoki Tozuka (Tokyo, Japan),
Graham Quartly (National Oceanography Centre, Southampton, United Kingdom),
Meghan Cronin (NOAA/PMEL, United States of America)

The proposal for a working group on the climatic importance of the greater Agulhas system has been accepted by SCOR and the working group has been established. It is co-chaired by Lisa Beal (Miami) and Arne Biastoch (Kiel). The working group is co-sponsored by WCRP.

9.3 Agulhas and Somali Current Large Marine Ecosystems - ASCLME (Tommy Bornman)
The five-year Agulhas and Somali Current Large Marine Ecosystems (ASCLME) project is centred on the two large marine ecosystems (LMEs) of the western Indian Ocean region. These are the Somali Current LME – which extends from the Comoros Islands and the northern tip of Madagascar up to the horn of Africa – and the Agulhas Current LME which stretches from the northern end of the Mozambique Channel to Cape Agulhas.
Over the next five years, the nine countries of the western Indian Ocean region, including Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa and Tanzania, will work together through the ASCLME project.

The ASCLME project is funded by the Global Environment Facility (GEF) and implemented by the United Nations Development Programme (UNDP).
The goal of the ASCLME project is to ensure the long-term sustainability of the living resources of the ASCLME region by introducing an ecosystem-based approach to management.

The overall project objectives are:
- To acquire sufficient baseline data to support an ecosystem-based approach to the management of the Agulhas and Somali Current LMEs.

- To produce a Transboundary Diagnostic Analysis (TDA) and Strategic Action Plan (SAP) for both the Agulhas Current and Somali Current LMEs.

The project aims to address the Agulhas and Somali Current LMEs under one initial assessment process because (i) this is a more cost-effective approach for the GEF and (ii) the two systems are closely interlinked. In fact, the project also intends to extend the assessment to include the Mascarene Plateau. There is existing data and strong evidence that this plateau to the east of Madagascar exerts a considerable influence on both LMEs through its effects on the South Equatorial Current, a primary driver of both the Agulhas and Somali current systems. The information from this assessment and data collection phase will, be used to develop discrete TDAs and eventually SAPs for the ACLME and SCLME, and possibly help to confirm the presence of a Mascarene Plateau LME so as to allow consideration to be given for initiating a TDA and SAP process for this area at a later date.

ACTION: Encourage the building of a strong link among ASCLME, IOP and SIBER (M. McPhaden, R. Hood)

9.4 Integrated Marine Observing System (IMOS)- the status of IMOS Blue Water and Climate Node and Western Australia Coastal Node (WAIMOS). (Gary Meyers)
IMOS is a distributed set of equipment and data-information services which collectively contribute to meeting the needs of marine climate research in Australia such as the effects of climate change on boundary currents and the impacts on marine ecosystems. The observing system provides data in the open oceans around Australia out to a few thousand kilometres as well as the coastal oceans.

Examples of Bluewater and Climate Drivers are Sea Surface Temperature impact on rainfall and uptake of CO_2 in the Southern Ocean. Bluewater and Climate observations currently include 211 active Argo floats, a flux and biogeochemistry mooring at 47°S, and ship of opportunity XBT surveys and underway sampling of surface temperature, salinity, pCO_2, and fluorescence.

The main study region for WAIMOS is defined as the continental shelf and slope waters between Fremantle and Shark Bay with a focus on the region offshore of Two Rocks and the Perth Canyon. WAIMOS drivers are mainly centered around marine resources and ecosystems such as Marine Natural Heritage in the Kimberley, Ningaloo, Shark Bay and Perth Canyon Whale Sanctuary regions, oil and gas reserves off the northwest shelf and the impact of the Leeuwin current on fisheries. WAIMOS measures coastal currents and water properties using Moorings, Ocean Gliders and HF Coastal Radar. The installation of WAIMOS started in February 2008 and will be completed by the end of 2009.

The 2009/10 Australian federal budget announced a new Marine and Climate Super Science Initiative with a \$387.7 million AUD funding allowance. Of this \$120.0 million AUD will be spent on building a new state-of-the-art deep water research vessel, however \$52.0 million AUD has been allocated to an extension of the IMOS network, including increased monitoring of the Southern Ocean and waters off northern Australia. The IMOS extension will focus initially during 2009/10 on the Southern Ocean Argo array (which is critical to better understanding climate change) and the Kimberley coast (which may provide an opportunity to extend RAMA eastward for MJO monitoring and/or continue the INSTANT array in the Timor Passage.)

9.5 Present status of Indian moorings in Bay of Bengal and Arabian Sea (M. Ravichandran)
Dr. M. Ravichandran has presented the observational system established by India, especially in the coastal regions of seas around India. Currently 35 tide gauges have been established and 18 locations are operational. Real time data are being received at INCOIS using Very Small Aperture Terminal (VSAT) communications. There are 9 drifting buoys operational in the North Indian Ocean deployed by India. There are 4 XBT lines (Chennai-Singapore, Chennai-Port Blair, Kolkatta-Port Blair and Mumbai – Mauritius (IX8)) currently operating by India. Apart from this, the Kochi-Kavaretti XBT/XCTD high density line has been operational for the last 4 years. These data are transmitted to GTS through the Atlantic Oceanographic and Meteorological Laboratory (AOML), USA. During his presentation he mentioned that operating IX8 line is difficult since ships availability is critical, but he has shown the planned XBT transects in the IX8 line using research vessels. Currently 8 moored buoys are operation both in Bay of Bengal and Arabian Sea to measure met-ocean parameters around Indian seas in real time. He has shown the proposed location of new moored buoy which carry sub-surface parameters and wave spectrum in few buoys. He also mentioned the Coastal Ocean Dynamics Applications Radar (CODAR) locations to measure surface currents and wave deployed on the Indian coast. Some of the other coastal observations along the Indian coast for the specific study contain current meter moorings, waves, tides, beach profiles, etc were also presented. India has also established long term moorings to understand the seasonal, intra-seasonal and inter annual variability on the shelf and at the shelf break using ADCPs (3 in the east coast and 3 in the west coast). The preliminary

observations show large intraseasonal variability along the coastline of India. He briefly mentioned the proposed Bay of Bengal Observatory and its instrumentation for long term measurements of upper ocean temperature, salinity and currents.

10. Regional Issues – 2

10.1 African Monitoring of Environment for a Sustainable Development (Rezah Badal)
Dr. Bedal gave an overview of the African Monitoring of Environment for a Sustainable Development (AMESD) program with a focus on AMESD activities in the South West Indian Ocean (SWIO). The overall objectives of AMESD are i) to facilitate access to environmental information derived from earth observation technologies and ii) to increase the information management capacity of African regional and national institutions. Specific AMESD objectives are:

- To improve access by African users to existing basic Earth Observation data
- To establish operational information services in the fields of environmental management
- To strengthen political and policy development frameworks for ensuring an active participation of African governments in the global environmental surveillance Initiatives.
- To ensure an adequate technical level of AMESD African stakeholders

AMESD is the follow up to the PUMA project during which 55 satellite ground receiving stations were installed in 46 African Countries. The AMESD Program aims to deploy about 50 AMESD stations and will include the development of data delivery services ("THEMAs") and will include a capacity building component. The project is funded through the European Development Fund with a timeframe for implementation of 2007-2011 and an overall budget of 21 M€. AMESD's main earth observation partner is EUMETSAT with a memorandum of understanding that allows free access to EUMETCAST satellite data and products for AMESD partners.
In the SWIO region the main activity for the AMESD THEMA will be devoted to "coastal and marine management" applications. The THEMA will particularly focus on developing an operational service using ocean observation data (Sea Surface Temperature, Ocean Colour, Altimetry, etc.) for a better management of fishery resources.

The SWIO THEMA is partly supported by the Indian Ocean Commission (IOC) which is an intergovernmental organization founded in 1984. IOC includes five Member States: Comoros, France (Reunion), Madagascar, Mauritius and Seychelles. Partner countries on the East African coast are Kenya, Mozambique and Tanzania. The Regional Implementation Centre for the SWIO THEMA is the Mauritius Oceanography Institute.

10.2 Observation and research activities in Kenya (Charles Magori)
Kenya Marine and Fisheries Research Institute (KMFRI) is a State Corporation in the Ministry of Fisheries Development of the Government of Kenya. It is mandated to conduct aquatic research covering all the Kenyan waters and the corresponding riparian areas including the Kenyan's EEZ in the Indian Ocean waters. The Institute was established by an Act of Parliament (Science and Technology Act, Cap 250 of the Laws of Kenya) in 1979 and run by a Board of Management. KMFRI's vision is to be a centre of excellence in aquatic research and promotion of sustainable utilization of marine and freshwater resources. The Institute's Mission is to contribute to the management and sustainable exploitation of aquatic resources and thus alleviate poverty, enhance employment creation and food security through multidisciplinary and collaborative research in both marine and fresh-water aquatic systems.

There are 2 research divisions: (i) Marine and Coastal Division and (ii) Inland Waters Division. Each division comprises of 6 research programmes namely: Fisheries, Aquaculture, Environment and Ecology, Natural Products, Socio Economics, Information and Data Management.
KMFRI has participated in the following past and present research programmes.

- GEF-SWIOFP : South West Indian Ocean Fisheries Project (2008-2012)
- ASCLME: Agulhas and Somali Current Large Marine Ecosystem (2008-2012)
- Kenya/Belgium Project on Marine ecology (1985-1997)
- IOC/UNESCO Regional Cooperation in Scientific Information Exchange in the Western Indian Ocean region (1989-1999)
- GLOSS: Global Sea Level Observing System (1986–ongoing)
- EU-STD 2: Assessment of mangrove dynamics (1990-1992)
- Kenya/Netherlands Ocean on Marine Programme (1992-1995)
- Kenya/Belgium Project in Freshwater Sciences (1992-1997)
- Sida/SAREC Regional Training programme for physical Oceanography (1992-2000)
- EU-STD 3 : Interlinkages of coastal ecosystems (1993-1995)

- UNEP: Integrated Coastal Zone Management Project for Eastern Africa (UNEP EAF/5) (1994-1999)
- UNEP: Eastern African Marine and Coastal Environment and Resources Database and Atlas (UNEP EA/14) (1995-1998)
- EU-LVFRP: Lake Victoria Fisheries Research Project (1995-ongoing)
- IOC/UNESCO/SAREC: Ocean Data and Information Network in Eastern Africa (1997-2000)
- EU-INCO : Groundwater/Anthropogenic input in coastal ecosystems (1997-1999)
- EU-INCO: Macrobenthos project (1997-1999)
- GEF-LVEMP: Lake Victoria Environment Management Programme (1997-ongoing)
- EU-KMFRI Project: Fish added value project on by catch (2001-ongoing)
- EU-KMFRI Project: Seaweed project (2001-ongoing)
- ODINAFRICA III Project - The goal of the current phase of the project is to improve the management of coastal and marine resources and the environment in participating countries.

11. Contribution to WCRP cross cut themes

11.1 Potential project on Intra-Seasonal to Seasonal predictability (Gabe Vecchi)
The proposed intraseasonal variability (ISV) prediction experiment (with a monsoon focus), aims to gain the involvement of a broad community of modelling and prediction centres in an activity to compare numerical model retrospective forecasts of the Intraseasonal Oscillation (ISO), which includes both the Madden-Julian Oscillation (MJO) and the Monsoon Intraseasonal Oscillation (MISO).

Objectives
1) Understanding of the physical basis for intraseasonal prediction. Determine potential and practical predictability of ISO in a multi-model frame work.
2) Developing optimal strategies for a multi-model ensemble (MME) ISO prediction system, including effective initialization schemes and quantification of the MME's ISO prediction skills with forecast metrics under operational conditions.
3) Revealing new physical mechanisms associated with intraseasonal variability that cannot be obtained from analyses of a single model.
4) Identifying model deficiencies in predicting ISO and finding ways to improve models' convective and other physical parameterizations relevant to the ISO through development of model process diagnostics.
5) Help to determine ISO's modulation of extreme hydrological events and its interannual variability and contribution to interannual climate variation.

11.2 New JAMSTEC work on down-scaling basin-wide predictions for regional climate (Yukio Masumoto)
JAMSTEC has just started two new 5-year projects under funding from the Japan International Cooperation Agency (JICA) and the Japan Science and Technology Agency (JST). The projects aim to conduct cooperative research with developing countries, with capacity building efforts as one of the main parts. One of the two projects by JAMSTEC is a collaboration with South Africa, which is led by Prof. Yamagata (JAMSTEC) and Prof. Philander (ACCESS, South Africa), entitled "Prediction of Climate Variations and its Application in the Southern African Region". The project focuses on downscale predictions and predictability studies of the climate variations around the southern part of the African continent, including development of a coupled climate model and mutual exchange of researchers. Another project, cooperating with Indonesia, is entitled "Climate Variability Study and Societal Application through Indonesia-Japan "Maritime Continent" COE - Indonesian Contribution to GEOSS", which is led by Prof. Yamanaka (JAMSTEC) and Dr. Syamsudin (BPPT, Indonesia). This project supports Indonesia to improve prediction and adaptation for climate variations shorter than a few years, including transfer of atmospheric radar and oceanic mooring buoy observations. Both projects are highly relevant to the IOP activity through improving understanding of the climate variability on both sides of the Indian Ocean and through enhancement of observational network around the Indian Ocean.

12. Related Activities:

12.1 Indian Ocean indices estimated by ocean reanalysis products (Tony Lee and other IOP analysts)
Tony Lee briefly recapped the six categories of Indian-Ocean indices recommended by IOP to the Global Synthesis and Observations Panel (GSOP) after IOP5, with analysts for each category identified as follows:

1) Indian-Ocean Dipole and Wyrtki Jet (McPhaden & Lee)
2) Indonesian throughflow (Wijffels & Meyers)
3) Arabian Sea (Vecchi & Wiggert)
4) Seychelles/Chagos Thermocline Ridge (Vialard)
5) Leeuwin Current (Feng & Patiaratchi)
6) Agulhas Current region (de Ruijter *et al.*)

Tony Lee has contacted various ocean data assimilation groups to obtain their estimates of indices. Several such groups have provided their estimates for some of these indices. The files are placed in a repository in the Asian Pacific Data Research Center of International Pacific Research Center (IPRC), University of Hawaii (Peter Hacker's group), awaiting analysis. Some analyses are ongoing. Mike McPhaden presented an analysis for category (1). Tony Lee prompted the rest of the analysts to start and continue the analysis before the OceanObs'09 meeting in Venice, Italy.

ACTION: Send to the WGOMD Repository for the Evaluation of Ocean Simulations the list of indices that IOP made for GSOP (Gabe Vecchi)

ACTION: Finish analysis of Indian-ocean indices derived from ocean reanalysis products for GSOP by IOP before OceanObs'09 and for input to the next GSOP meeting (Tony Lee to remind analysts)

12.2 Working Group on Ocean Model Development (WGOMD) Repository for the Evaluation of Ocean Simulations (Gabe Vecchi)
Dr. Vecchi reminded the panel of the WGOMD Repository for the Evaluation of Ocean Simulations (REOS) webpage which can be found at:
http://www.clivar.org/organization/wgomd/reos/reos.php

Metrics for the Indian Ocean are listed at:
http://www.clivar.org/organization/wgomd/reos/indian.php

Dr. Vecchi drew attention to the actions on panel members listed on the Indices of Climate Variations and Climate Change that had been suggested by IOP as follows:

Indices of Climate Variations
- ENSO foremost, since there is still debate as to how many IOD's are really independent of ENSO
- Dipole mode index plus IOD east and IOD west; plus related rainfall impacts (Indonesia, Kenya, South Eastern Australia) (Gary Meyers for additional information)
- Thermocline ridge near 5-12S and related cyclone activity. This is partly an aspect of IOD/ENSO but possibly somewhat independent (Jerome Vialard, Tony Lee and Chris reason to work out details)
- Southern subtropical dipoles and relation to impacts on southern and eastern Africa (Chris Reason to work out details)

Climate Change Indices
- Basin-mean SST anomaly (say north of 20S), as the Indian Ocean has one of the most pronounced upward trends. There are references to impacts on global climate, but there is still scientific debate
- Indonesian Throughflow, An index based on altimeter is available using a method that has been published. The IX1 index based on XBT data is probably the best but may be difficult in near real time. We can provide a delayed mode update about once per year (Gary Meyers to work out details)
- Index of the Agulhas retroflection. Related to inter-basin exchange, an aspect of meridional overturning cell (Will DeRuijter to work out details)

12.3 OceanObs'09 (Yukio Masumoto)
Community white papers have been submitted by the following panel members:
Masumoto, Y. *et al.*, (2009): Observing Systems in the Indian Ocean.
McPhaden, M. *et al.,* (2009c): The Global Tropical Moored Buoy Array.

12.4 Joint IOGOOS/SEAGOOS pilot project titled: Ocean Forecast Demonstration projects in IOGOOS and Southeast Asian Regional Global Ocean Observing System (SEAGOOS) (Nick D'Adamo)

The BLUElink Ocean Forecasting Australia initiative aims to be an important oceanographic forecasting, as well as research tool, for Australia. The project is based on multi-scale hydrodynamic models, including those providing global output as boundary conditions for BLUElink's 10km resolution simulations. BLUElink assimilates data from the Global Ocean Observing System (GOOS).

A high resolution mesh covering Australia and adjacent seas is nested into a global model to give finer resolution answers near Australia (and potentially beyond) and to obtain boundary conditions for finer scale regional modelling. BLUElink ocean forecasts for Australia can be found at: http://www.bom.gov.au/oceanography/forecasts.

Currently for Australia the project produces 7-day forecasts of temperature, salinity, sea-surface currents and sea level anomaly. The model is 3-dimensional and has a resolution of 10 km.

BLUElink aims in the near future to extend its 10km resolving capability to cover the Indian Ocean, South East Asia and the West/Southwest Pacific. In light of this eventuality, a project to facilitate BLUElink's applicability and utility for the Indian Ocean has been initiated under IOGOOS. Recent discussion of the project concept has been extended to include SEAGOOS.

The aims of the project are to provide re-analysis and insight for process studies to provide boundary conditions for finer scale nested models and to enable improved forecasting for Natural Resource Management in the Indian Ocean/South East Asia regions.

BLUElink was introduced to IOGOOS by Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) at IOGOOS-5, in Phuket, 2007. IOGOOS members expressed interest in developing an IOGOOS project focused on the application of ocean forecasting systems for IOGOOS member states. SEAGOOS members then advised that they wanted the same or similar project for SEAGOOS. An ocean forecasting workshop was held in conjunction with the GOOS Scientific Steering Committee meeting Perth, Feb 2009 with representatives from IOGOOS and SEAGOOS, including modellers and users. It was further re-affirmed at that workshop to proceed with project development for such a project with both IOGOOS and SEAGOOS involved.

Currently a project group is being established which includes members of IOGOOS, SEAGOOS and BLUElink. IOC Perth is acting as a co-sponsor and facilitator for this purpose.

An initial project planning workshop will take place (hopefully in late 2009 or alternatively in early 2010) to set specific objectives, consider budgets, select geographic areas to apply and demonstrate the utility of ocean forecasting systems and to build a constituency for the project overall (in general, to develop a business plan for the proposed project). Malaysia and Indonesia have expressed early interest in being initial project demonstration sites.

13. Panel Business:

13.1 Membership:

The panel proposed that Dr. Charles Magori of the Kenya Marine and Fisheries Research Institute, Mombasa, Kenya be invited to join the IOP panel.

Action: A letter from IOP and curriculum vitae for Dr. Magori needs to be submitted through the ICPO in support of this nomination for approval by the SGG members.
(Panel co-chairs and ICPO)

13.2 Next meeting:

It was proposed that the IOP contact the chair of IOGOOS to see if a joint meeting of IOGOOS/SIBER/IRF and IOP could be arranged for March/April 2010. Dr. Nick d'Adamo offered to host the meeting in Perth through the IOC Perth office.

Since the panel meeting a letter has been drafted by panel members and the ICPO and sent to Dr. Shailesh Nayak, Secretary of the Ministry of Earth Sciences, Government of India and Chairman of IOGOOS.

13.3 Outcomes of SSG-16 - issues for the Indian Ocean panel:

See Appendix D.

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APPENDIX A.

PARTICIPANTS:

PANEL MEMBERS:

Weidong Yu (co-chair)	First Institute of Oceanography, Qingdao, CHINA
Yukio Masumoto (co-chair)	FORSGC, JAMSTEC, Tokyo, JAPAN
Ming Feng	CSIRO, Floreat, Western AUSTRALIA
Raleigh Hood	Horn Point Lab. Uni. Meryland USA
Tony Lee	NASA Jet Propulsion Laboratory, Pasadena USA
Jay McCreary (AAMP)	University of Hawaii, Honolulu, USA
Michael McPhaden	NOAA, PMEL, Seattle, USA
Gary Meyers	CSIRO, Hobart, AUSTRALIA
W. de Ruijter	University of Utrecht, NL
Debasis Sengupta	Indian Institute of Science, Bangalore INDIA
Gabriel Vecchi	NOAA-GFDL, Princeton USA
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Lisan Yu	WHOI, Woods Hole, USA
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M. Ravichandran	INCOIS
Charles Magori	Kenya Marine and Fisheries Research Institute
Sid Thurston	NOAA/USA
Mr Tommy Bornman	ASCLME
Matthieu Plu	LACy
Philippe Caroff	LACy
Frank Roux	LACy
R. Delmas	LACy
P.V. Sundareshwar Palloor	South Dakota School of Mines and technology
Gerard Therry	La Reunion/Meteo Fr director
Thierry Mercier	Local support
Victoria Coles	Horn Point Laboratory, University of Maryland

APPENDIX B.

AGENDA

IOP-6 MEETING
3-5 June 2009, La Reunion

Final Agenda (May 29th, 2009)

Wednesday June 3rd:
OPENING:
08:45 Delegates arrive - tea and coffee available
09:00 Welcome by LOC (G. Therry)
09:10 Welcome by ICPO (K. Stansfield)
09:20 Review of the agenda and Action Items (Y. Masumoto and W. Yu)
09:40 Report on SSG-16: CLIVAR legacy and future of WCRP (Y. Masumoto and W. Yu)

SCIENCE TALKS 1: Research activities in La Reunion
10:00 Operational activities on tropical cyclones at RSMC La Reunion
(P. Caroff)
10:20 Research activities about tropical cyclones (M. Plu)

11:10 SWICE experiment (F. Roux)
11:30 Cyclone modelling and observations (M. Lengaigne)
11:50 OPAR: Atmospheric Research lab of the University of La Reunion (R. Delmas)

UPDATES ON INDOOS AND RECENT SCIENCE-RESULTS FROM THE DATA STREAMS
13:20 RAMA (M. McPhaden (15 -20 mins), M. Ravichandran (10-15 mins), Y. Matsumoto (15 mins)
14:10 XBT Network (G. Meyers)
14:40 Argo float status in the IO (M. Ravichandran)
15:00 The IndOOS Data Portal (M. Ravichandran)

INDOOS RESOURCES FORUM (IRF)
15:10 Report on IOGOOS's endorsement (ref: IOGOOS-VI, Dec 2008) regarding the development of an IRF (N. D'Adamo and Y. Masumoto)
16:00 Development of the IRF in response to IOGOOS-VI: ToR, membership, Secretariat support (G. Meyers, M. McPhaden, N. D'Adamo, Y. Masumoto)

ENHANCEMENT OF INDOOS
16:30 NOAA bilateral programs in the region (S. Thurston)
16:45 Air-Sea heat, freshwater and momentum fluxes in the Indian Ocean (L. Yu)
17:00 Repeat Hydrographic observations and the GO-SHIP proposal (Y. Masumoto) - no slides
17:15 IOTWS "ocean": current status and future plans (N. D'Adamo with input from T. Elliott)
17:30 Close

Thursday June 4th:
PLANNING NEW MULTINATIONAL PROCESS STUDIES
09:00 MISMO results and CINDY plans (K. Yoneyama)
09:30 US contribution to CINDY: DYNAMO (M. McPhaden) - **no slides**
09:40 New science results and TRIO project plans (J. Vialard)
10:00 YOTC, AMS, IMS (J. McCreary) - **no slides**

HARMONISATION OF THE DEVELOPMENT OF SIBER AND THE IOP FRAMEWORK
11:00 Report on IOGOOS's recommendations regarding the development of SIBER as a project complementary to IOP (ref: IOGOOS-VI, Dec 2008) (R. Hood, N. D'Adamo and Y. Masumoto)
11:20 IOP representation, through membership, on SIBER (Y. Masumoto and W. Yu) - no slides
11:40 Developing the SIBER science plan in coherence with IOP's framework (R. Hood) - see 11:00 am presentation
12:10 Proposal to deploy Indoflux CO2 sensors on some RAMA buoys (P.V. Sundareshwar Palloor)

SCIENCE TALKS 2: Research activities of new members and new research activities by old members
14:00 Modeling the Oxygen Minimum Zone in the Arabian Sea (R. Hood)

14:20 Two-year oscillations of the monsoon and global climate in the present decade (D. Sengputa)
14:40 The Leeuwin Current in the southeast Indian Ocean (M. Feng)
15:00 Modeling the oceanic response of cyclone Nargis (T. Lee)
15:20 Near-surface eastward flows in the Southern Indian Ocean (J. McCreary)

REGIONAL ISSUES - 1
16:10 LOCO and Agulhas Current monitoring (W. de Ruijter) (30 min)
16:40 Report on SW IO workshop (W. de Ruijter) (10 min) - **see talk at 16:10**
16:50 ASCLME (T. Bornman)
17:10 IMOS (G. Meyers)

17:30 Present status of Indian moorings in Bay of Bengal and Arabian Sea (M. Ravichandran)

Friday June 5th
REGIONAL ISSUES - 2

08:50 African Monitoring of Environment for a Sustainable Developement (R. Badal)
09:00 Observation and research activities in Kenya (C. Magori)
09:20 Discussion on establishing link between IndOOS and regional and coastal observing systems (general discussion)

CONTRIBUTION TO WCRP CROSS CUT THEMES
09:40 Potential project on Intra-Seasonal to Seasonal predictability (G. Vecchi)
10:00 Australian droughts to Indian Ocean - extreme events (G. Meyers) - Not Discussed
10:20 New JAMSTEC work on down-scaling basin-wide predictions for regional climate (Y. Masumoto)

RELATED ACTIVITIES:
11:00 Indian Ocean indices estimated by ocean reanalysis products (T. Lee and other IOP analysts)
11:20 WGOMD repository for the Evaluation of Ocean Simulations (G. Vecchi)
11:40 OceanObs09 (Y. Masumoto) - **Not Discussed**
12:00 Joint IOGOOS/SEAGOOS pilot project titled: Ocean Forecast Demonstration projects in IOGOOS and SEAGOOS (N. D'Adamo)

Panel Business:
12:20 Wrap-up discussion (all panel)
12:40 Membership and Next meeting (all panel)
12:50 Closing remarks (Sponsors and co-chairs)

14:30 Co-chairs, local host and Secretariat wash-up discussion

APPENDIX C:

ACTIONS ARISING FROM IOP-5 IOP-5 Meeting, 12-14 May 2008 Bali Indonesia (Status 05/05/2009)

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 its impact on regional and global climate. Encourage interactions with the international community (F. Syamsudin, G. Meyers and Y. Matsumoto)

2) Contact Australian oil companies for exploring the possibility to obtain meteorological and oceanographic data from offshore platforms in north Australia (N. D'Adamo and G. Meyers)

3) Gather a short list of satellite data, which is found to be essential for Indian Ocean research (J. Vialard)

Sent a draft list to the panel members (7/11/08)

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

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

DONE

6) Initiate and maintain an IndOOS bibliography in 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)

DONE

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

Discussion initiated

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)

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

DONE.

Jerome contacted Gael Alory on the possibility to have one observer onboard both for XBT transects along the portions which are not yet covered (only the La Réunion-Melbourne transect is done with XBTs) and for Argo deployments on the NEMO lines. Ravi is arranging floats deployment in October, Australia (Susan) will have some additional floats too.

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)

DONE

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. Matsumoto)

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)

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

DONE

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. Matsumoto and R. Boscolo)

DONE: a draft response as been submitted to he IOGOOS-VI meeting

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)

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. Matsumoto)

DONE.

Mike, Chris and Lisan will stay till end 2010 Gary and Ravi will be replaced by Ming and Debasis, respectively, at the end of 2008 Weidong will become co-chair.

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

DONE

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

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

No longer needed

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

DONE.

The 6th IOP meeting will be held in the facilities of LACy-MeteoFrance in La Reunion on 3-5 June 2009.

APPENDIX D.

ACTIONS RELEVANT TO IOP ARISING FROM SSG-16 Meeting, 19-22 May 2009, Madrid, SPAIN

•Reports from CLIVAR panels and working groups
- More cooperation with WGCM and WGSIP are needed.
- Enhance cooperation with PP (e.g. ITF) and AIP (e.g. Agulhas Current)
- Strengthen cooperation with AAMP and VACS

• Building consensus on the near term imperatives
- Seven imperatives are proposed, for which ~ 20-page report will be written.

• FYI –
- Tim Palmer steps-down from co-chair, current co-chairs are Jim Hurrell and Martin Visbeck
- CLIVAR Exchanges: 2009 Oct. issue will be "Ocean Observation" following OceanObs'09 – contributions please.
- Next SSG at NCAR, around May/June 2010

Imperative VI – Ocean observing system (Harrison, Curry, Masumoto)
• Advocacy for sustained observations
• Development, implementation and system design
• (Building links IGBP – carbon, biogeochemistry, ecosystems)

Input from IOP to Yukio please

- 2.4 Formulate CLIVAR response to request for MJO Task Force (SSG Exec in discussion with D/WCRP and D Waliser)
- 2.5 Strengthen advocacy for sustained ocean observing system
- 5.6 Further develop Earth System Science connections. In particular strengthen links with IGBP wider than marine from Earth System Model development perspective
- CLIVAR basin panel's requested to consider involvement in OceanObs'09 parallel community fora from perspective of physical oceanography (Basin Panel co-chairs, D Stammer)
- Work on interbasin issues encouraged either through GSOP or OceanObs'09 meeting of opportunity of basin panel chairs.
- 6.3 Identify WCRP representation to SCOR WG on Agulhas Working Group and pass to D/WCRP (Panels, D/ICPO)

- Encourage cross WCRP activity in model validation and improvement; identify the process by which this is to be done.
- Though the implementation path is not clear yet, there is an identified need for climate-oriented reanalysis. Seek to develop concept with the reanalysis and wider modelling community.
- Set up a data portal for CLIVAR-endorsed campaigns (ICPO)
- 5.6 Review and strengthen process by which CLIVAR- endorsed activities report outcomes to CLIVAR
- Promote pan WCRP Conference rather than proposed 2nd CLIVAR Science Conference to celebrate successes of projects and way forward for WCRP (co-chairs, D/WCRP, ICPO for CLIVAR)
- Take advantage of available pathways to promote needs for modelling, process studies and observations at WCC-3
- Build WGSIP links to other panels as for VAMOS (WGSIP co-chair, panel chairs)

- IOP are encouraged to entrain new members to explore science issues and build science case for continuing input of resources into IndOOS. Collaboration with AAMP is also encouraged. Consider back to back IOP and AAMP meeting in near future (IOP co-chairs, AAMP co-chairs)

- 6.4 Check on CINDY/DYNAMO endorsement status (D/ICPO)

- 6.1 Request panels and Working Groups and other WCRP projects to distill information on experience with analyses of CMIP-3 output. Email to be circulated requesting this, with rational (WGCM co-chairs, Anna Pirani)
- 6.2 Basin Panels are requested to provide feed in on science questions to be addressed using ocean synthesis products (GSOP co-chairs, ICPO, basin panels)

APPENDIX E:

List of Acronyms:

AAMP	Asian-Australian Monsoon Panel
ACT	Agulhas Current Time-series
ADCP	Acoustic Doppler Current Profiler
AMESD	African Monitoring of Environment for a Sustainable Development
AO	Arctic Oscillation
AOML	Atlantic Oceanographic and Meteorological Laboratory
AR4	IPCC Fourth Assessment Report
ASCLME	Agulhas and Somali Current Large Marine Ecosystem program
ASOMZ	Arabian Sea OMZ
BIRA-IASB	Institut d'Aéronomie Spatiale de Belgique
BPPT	Indonesia's Agency for the Assessment and Application of Technology
BBOMZ	Bay of Bengal OMZ
BO	Biennial oscillation
CI-BoB	Central India and North Bay of Bengal
CINDY2011	Cooperative Indian Ocean experiment on intraseasonal variability in the year 2011
CLIOTOP	Climate Impacts on Oceanic Top Predators
CPT	Climate process team
CSIRO	Australia's Commonwealth Scientific and Industrial Research Organisation
CODAR	Coastal Ocean Dynamics Applications Radar
DKP	Indonesia's Ministry of Marine Affairs and Fisheries
DYNAMO	Dynamics of the MJO
EEZ	Economic Exclusion Zone
ENSO	El Niño-Southern Oscillation
FRX	Frequently Repeated
FTP	File Transfer Protocol
GCOS	Global Observing System for Climate
GEF	Global Environment Facility
GEOSS	Global Earth Observation System of Systems
GLOBEC	Global Ocean Ecosystem Dynamics
GLOSS	Global Sea Level Observing System
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System
GO-SHIP	Global Ocean Ship-based Hydrographic Investigations Project
GSOP	Global Synthesis and Observations Panel
GTS	Global Telecommunication System
HDX	High Density
IBPIO	International Buoy Program for the Indian Ocean
ICED	Integrating Climate and Ecosystem Dynamics in the Southern Ocean
ICPO	International CLIVAR project office
IGBP	International Geosphere-Biosphere Program
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research
IMOS	Australia's integrated Marine Observing System
IMS	International Monsoon Study
INCOIS	Indian National Centre for Ocean Information Services
IndOOS	Indian Ocean Observing System
INSTANT	A new International Array to Measure the Indonesian Throughflow
INSU	L'Institut national des sciences de l'Univers France
IOC	Intergovernmental Oceanographic Commission of UNESCO
IOCOML	Indian Ocean Census of Marine Life
IOD	Indian Ocean Dipole
IOP	CLIVAR/GOOS Indian Ocean Panel
IOGOOS	Indian Ocean Global Ocean Observing System
IOTWS	Indian Ocean Tsunami Warning System
IPEV	L'Institut polaire français Paul- Émile Victor, France
IPCC	Intergovernmental Panel on Climate Change
IPRC	International Pacific Research Center
IRF	IndOOS Resources Forum
ISO	Intraseasonal Oscillation
ITF	Indonesian Throughflow

JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JCOMM	Joint WMO-IOC Technical Commission on Oceanography and Marine Meteorology
JEPP-IOMICS	Japan EOS Promotion Program/Indian Ocean Buoy Network Initiative for Climate Studies
JICA	Japan International Cooperation Agency
JST	and the Japan Science and Technology Agency
KMFRI	Kenya Marine and Fisheries Research Institute
LACy	Laboratoire de l'Atmosphère et des cyclones
LAS	Live access server
LDX	Low Density
LME	Large marine ecosystem
LOCO	Long term Ocean Climate Observations
LOCO/INATEX	Indian-Atlantic exchange in present and past climate program
MISO	Monsoon Intraseasonal Oscillation
MISMO	Mirai Indian Ocean cruise for the Study of the MJO-convection Onset
MME	Multi-model ensemble
MJO	Madden-Julian oscillation
MoES	Indian Ministry of Earth Science
MOU	Memorandum of understanding
NASA	National Aeronautics and Space Administration
NDACC	Network for the Detection of Atmospheric Composition Change
NIO	National Institute of Oceanography
NIRC	National and International Research Alliances Program, Australia
NMHS	National Meteorological and Hydrological Service(s)
NOAA	National Oceanic and Atmospheric Administration
OMZ	Oxygen minimum zone
OPAR	Reunion Island Atmospheric Physics Observatory
OpeNDAP	Open-source Project for a Network Data Access Protocol
RAMA	Research Moored Array for African-Asian-Australian Monsoon
RCM	Recording Current Meter
REOS	Repository for the Evaluation of Ocean Simulations
RSMC	Regional Specialised Meteorological Centre
SARR	South Asian Regional Reanalysis
SANCOR	South African Network for Coastal and Oceanic Research
SAP	Strategic Action Plan
SCC	Subtropical Countercurrent
SCOR	Scientific Committee on Oceanic Research
SEAGOOS	Southeast Asian Regional Global Ocean Observing System
SIBER	Sustained Indian Ocean Biogeochemistry and Ecosystem Research
SIO	Southern Indian Ocean
SOA	State Oceanic Administration, China
SPCZ	South Pacific Convergence Zone
SSG	Scientific Steering Group
SSH	Sea-surface height
SST	Sea-surface temperature
SWICE	South-West Indian Ocean tropical Cyclone Experiment
SWIO	South-West Indian Ocean
SWIOFP	South West Indian Ocean Fisheries Project
TC	Tropical cyclone
TDA	Transboundary Diagnostic Analysis
ToR	Terms of reference
TRIO	Thermocline Ridge of the Indian Ocean
ULB	Université Libre de Bruxelles
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UV	Ultraviolet
VACS	Variability of the African Climate System
VSAT	Very Small Aperture Terminal
WAIMOS	Western Australia Coastal Node
WCRP	World Climate Research Programme
WGOMD	Working Group on Ocean Model Development

WIOMSA	Western Indian Ocean Marine Science Association
WMO	World Meteorological Organization
WOC	World Ocean Conference
XBT	Expendable Bathythermograph
XCTD	Expendable Conductivity-Temperature-Depth profiler
YoTC	Year of Tropical Convection

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