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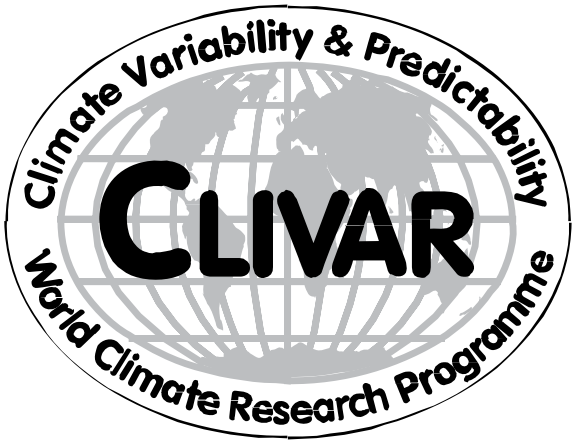

REPORT OF THE 4TH CLIVAR ASIAN-AUSTRALIAN MONSOON PANEL MEETING

Dept. Meteorology, Reading University, United Kingdom
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Report of the 4th meeting of the CLIVAR Asian Australian Monsoon Panel

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Terms of reference of the CLIVAR AAMP

The CLIVAR Asian-Australian Monsoon Panel is a part of the CLIVAR organisation. It will play a primary role in the development of CLIVAR's research programme for monsoons in the Asian-Australian sector extending from the western Pacific Ocean to Africa. The programme will include investigations of the annual monsoon cycle, and intraseasonal through interannual to longer-term variability of the entire monsoon system. More specifically its terms of reference are:

1. Evolve a strategy to assess climate variability and predictability of the coupled ocean-atmosphere-land system in the Asian-Australia-Africa monsoon region;

2. Design and implement a programme to investigate the mechanisms of ENSO-monsoon interactions;

3. Determine a monitoring strategy for the Indian Ocean, Western Pacific and surrounding marginal seas and land regions necessary for investigating the structure and variability of the monsoon;

4. Co-ordinate and promote interactions among meteorologists, oceanographers and hydrologists from interested nations;

5. Develop an implementation plan for monsoon research in the region, that recognises the need for a well co-ordinated and optimised set of process studies; and

6. Work in co-operation with other existing and planned regional and multinational programs directed at improving our understanding of the monsoon system, which include investigations on regional weather forecasting, seasonal climate prediction and impacts on human activities.

The history of the panel and its activities are recorded in previous meeting reports. This 4th meeting report is the first one after recent reformation. The new panel currently comprises:

J. Slingo	Co-Chair, University of Reading, Reading, UK
P. Webster	Co-Chair, University of Colorado, Fort Collins, USA
I.-S. Kang	Seoul National University, Seoul, Korea
R. Kawamura	Toyama Univ., Toyama, Japan
R. Kumar Kolli	Indian Institute of Tropical Meteorology, Pune, India
W. K.-M. Lau	NASA/GSFC, Greenbelt, USA
J. McCreary	IPRC, Honolulu, USA
G. Meyers	CSIRO, Hobart, Australia
N. Nicholls	BMRC, Melbourne, Australia
D. Sengupta	Indian Institute of Science, Bangalore, India
J. Shuttleworth	University of Arizona, Tuscon, USA
H. Wang	LASG, Beijing, China

The ICPO contact for the CLIVAR Asian-Australian Monsoon Panel is Zhongwei Yan.

Meeting objectives

- To review the level of understanding of processes related to the climatology of Asian-Australian monsoon and its variability

- To provide a statement on current level of skill in monsoon seasonal prediction

- To develop a strategy for cross-CLIVAR monsoon modelling (in cooperation with VACS, VAMOS, WGSIP and GEWEX)

- To propose mechanisms for integration of process studies and pull-through to modelling issues: Interaction between GEWEX and CLIVAR

- To develop a strategy for Indian Ocean observations in cooperation with VACS, building on SOCIO meeting outcomes and taking into consideration plans in other climate research communities.

Major recommendations

1. The AAMP noted that there were strong reasons for the building of a long-term observational array for the climate system of the Indian Ocean. They also noted that within the next three years there are a number of intensive process studies planned for the Indian Ocean. Given that the establishment of observational arrays and the undertaking of process studies will be, by necessity and by desire, a multinational effort, a mechanism to entrain substantial resources will be required. Noting the success of the TOGA Intergovernmental Panel in acquiring support for both TOGA and TOGA COARE, the AAMP recommends the establishment of a CLIVAR Intergovernmental Panel for the Asian-Australian monsoon region.

2. The Panel noted the formation of Panels for the Atlantic, Pacific and Southern Oceans and considered the formation of a counterpart for the Indian Ocean. It was decided that AAMP will for the time being coordinate development of an ocean observing array relevant to monsoon prediction. AAMP will also coordinate oceanographic research on basin scale circulation dynamics, boundary currents and mixed layer dynamics. To accomplish this, the Panel recommended the creation of short-lived, ad hoc panels and task forces to consider specific projects such as the international coordination of process studies and the definition of mooring arrays. This will bring a larger number of oceanographers into the Panel's deliberations. Such groups would have limited tenure and communicate principally electronically where possible.

3. The Panel noted with considerable concern that model systematic error remains a major barrier to progress in seasonal and climate change prediction and has recommended experimentation that focuses on specific processes and phenomena. It was agreed that a new approach was needed to address model systematic errors that differs from the traditional method of inter-comparing model climates. It was proposed that a cross-CLIVAR modelling workshop, which would focus on specific phenomena, should help us to highlight deficiencies in the representation of particular physical processes. The importance of involving the observational community, particularly GEWEX, in this exercise was stressed.

1. Introduction and panel business

Dr. Ian James (Head of Department) welcomed the Panel to Reading.

The incoming chairs welcomed the new panel and thanked the members for agreeing to serve on the reconstituted AAMP. The new membership of the Panel reflects the need to have a balanced coverage of atmospheric and oceanic research, with good representation from those countries directly influenced by the AA monsoon. It is also intended to strengthen the links with the GEWEX communities, particularly those involved in land surface and cloud processes. The importance of achieving a better incorporation of findings from process-based, field experiments into model development was also a factor in the setting up of the new Panel.

The AAMP acknowledged the efforts of the outgoing panel and, in particular, the leadership of Drs. K-M. Lau and J. S. Godfrey, in forming a solid foundation upon which a viable international monsoon programme has developed.

The agenda for the meeting (see Annex 1) was discussed and approved. The invited experts were welcomed to the Panel meeting.

John Gould outlined the scope and present status of CLIVAR, noting the publication of the wide-ranging CLIVAR Initial implementation Plan in 1998. He commented that an International CLIVAR Science Conference was planned for 2003 and that this would be a unique opportunity to demonstrate the importance of CLIVAR research. He stressed that although the main focus of the AAMP is on seasonal to interannual timescales, the Panel should also consider modulation on decadal and longer timescales and the potential signatures and impacts of anthropogenic climate change. Past records of monsoon variability are crucial here.

John Gould also discussed the remit of the Panel, noting that in some senses it could be considered as African-Asian-Australian (AAAMP). However, CLIVAR had established a separate Variability of African Climate System (VACS) panel. In light of this, the AAMP should continue with an emphasis on the Asian and Australian monsoon system. However, it noted that in view of the strong relationships between the African and the Asian-Australian monsoon especially in the East African sector, the AAMP and VACS would need to work closely together.

Bill Lau reviewed the past activities of the AAMP and noted that an Ocean Model Intercomparison Project (OMIP) proposed by Stuart Godfrey had yet to be established. (Note this concept, specific to the ocean role in monsoons systems, has a more narrow focus than the OMIP activities being carried out under the auspices of the WOCE/CLIVAR/WGCM Working Group on Ocean Model Development -

http://www.ifremer.fr/lpo/OMDWG/). Difficulties in the experimental design and in defining the forcing fields were discussed. Copies of the US CLIVAR A-A Monsoon Plan were made available to the Panel.

Bill Lau introduced the draft Asian-Australian Implementation Plan developed by earlier panels and the status of the document was discussed. The desirability of keeping the plan as a fluid document, which could be updated, was agreed. However, the current draft should be finalised for publication prior to the next CLIVAR SSG meeting.

The remit of the AAMP was considered in the context of the increasing evidence that the biosphere (both land and ocean) is important for the climate system. Traditionally the emphases encouraged by the Panel were essentially atmospheric and oceanic, but it was generally agreed that attention should also be given to interactions with the biosphere. The Panel also considered ongoing research into the agricultural, hydrological and health aspects of monsoon variability and change.

The Panel was briefed by ICPO on the difficulties faced by CLIVAR in overseeing the management of wide range of ocean, atmosphere and paleo data sets and products needed by CLIVAR researchers. A CLIVAR Data Task Team had been established but had failed to get to grips with these difficult issues. The DTT had been disbanded and a new group consisting largely of nominated representatives of each of CLIVAR's science panels and WGs is in the process of formation. Discussion of specific data issues ensued, particularly with respect to extended, high frequency records of precipitation. The desirability of climate data (both observational and model) being openly and freely available was strongly endorsed by the Panel. ERA-40 data and AMIP-II model simulations were mentioned as specific examples where progress may be inhibited due to lack of access.

Short reports on national activities were presented by the Panel members. These are available on the CLIVAR AAMP website.

Recommendations:

1.1 The Panel noted that there were a number of atmospheric circulations that were common to both the Asia-Australian monsoon and African regions. Similarly, Indian Ocean SST anomalies influence climate variations over Africa. To initiate interactions, and to take advantage of the efforts of the two panels, it was suggested that one member of each panel becomes an ex-officio member of the other. Furthermore, from time to time, the two panels should hold their regular meetings in the same location with interlocking agendas.

1.2 The Panel recommended that the AA Monsoon Implementation Plan should be amended and brought up-to-date on an annual basis, taking into account new scientific findings and plans as discussed at that year's Panel meeting. The review and

amendment of the document will not require an extra meeting but will be accommodated remotely.

1.3 Consideration of interactions with the biosphere (both terrestrial and marine) was recommended. The Panel further recommended that applications of monsoon research to agriculture, hydrology and disease should be included in the Panel's remit since they provide important links to other programmes such as IGBP and IHDP.

1.4 The Panel noted the importance of data issues and will recommend a member of the AAMP to represent the panel's concerns.

1.5 High-resolution gridded daily precipitation data exist over the Indian subcontinent from 1900 to 1970. The Panel recommends efforts to complete the data set from 1970 to present.

1.6 Panel members should bring pressure to bear on national agencies to encourage the open and free dissemination of climate data (both observational and model) for research purposes.

Actions:

A1.1 Finalise and publish the Implementation Plan. Schedule, based on existing draft:
Early January 2002: Panel members to be requested to update specific sections of the plan and to supply text and figures in electronic form.
Mid-February 2002: Deadline for submission of text/figures by panel members
Mid-March 2002: Updating of draft implementation plan by co-chairs completed and sent out to Panel and CLIVAR SSG for final comments.
Mid-April 2002: Implementation Plan finalised and prepared for publication
May 2002: Implementation Plan published and presented at CLIVAR SSG meeting.
Action: Co-Chairs, Panel Members, ICPO

A1.2 Open and free access to climate data, including high frequency observations and model data, should be actively pursued by bringing pressure to bear on national agencies.
Action: Panel Members

A1.3 Investigate possibility of joint meeting with VACS in 2002.
Action: Chairs of AAMP and VACS, ICPO

2. Status of understanding of AA monsoon

Presentations on various aspects of the phenomenology of monsoons were given by members of the Panel. These included the following topics:

- The monsoon as a coupled ocean-atmosphere phenomena
- The Indian Ocean Zonal (Dipole) Mode
- Interannual variability of the Indonesian Throughflow
- Interannual and decadal variability of the Asian monsoon
- Variability of the Australian monsoon
- Processes governing the onset of the AA monsoons
- Intraseasonal variability of the AA monsoons

The Panel noted that intraseasonal oscillations of the monsoon (ISOs) were critical components of the annual cycle of the monsoon and its interannual variability. The Panel agreed with the conclusion that the ISO was probably the building block of monsoon variability and impacted the agriculture and water resource sectors at least equally as interannual variability of the monsoon.

Recommendations:

2.1 Statements on our current level of understanding and on outstanding issues in monsoon phenomenology should be prepared by panel members for inclusion in the Implementation Plan (see *Action Item A1.1*).

3. Predictability and prediction of AA monsoon

Presentations on statistical/empirical and dynamical methods of seasonal prediction were given. Current statistical methods for predicting monsoon rainfall include:

- Empirical regression
- Dynamic stochastic transfer models
- Power transfer models
- PC regression
- Neural networks

It is clear that dynamical methods still fall behind empirical methods in terms of skill and that this is attributable, at least in part, to model systematic error. However, the use of multi-model ensembles appears to provide useful information. It was also demonstrated that risk analysis tools might be a good way to quantify the usefulness of a prediction, even from imperfect models. Examples of extremes and return times of extremes were given.

Generally, the assessment of the probability of the occurrence of an event has come from numerical prediction schemes. Empirical prediction, on the other hand, has generally provided one assessment of the occurrence of an event. The Panel noted with considerable interest new research using a technique Canonical Ensemble Correlations (CECs), which can produce a probability distribution to accompany the empirical prediction.

The Panel was briefed by Duane Waliser on model experimentation in the US to quantify the potential extended predictability of the ISO depending on its phase. Despite the general modelling problems with the ISO, the Panel noted with some excitement that there appeared to be short-term skill in some models (i.e., 10--15 days) and also in empirical prediction.

Results from the intercomparison of seasonal forecast models (SMIP) sponsored by the WGSIP were presented. It is clear that quantitative predictability is beyond the scope of present models. A link between the bias in the time-mean state and errors in the simulation of subseasonal variability was evident with the over-emphasis on the dominant pattern of subseasonal variability being a key aspect of model error.

The Panel was briefed on activities related to the application of seasonal forecasts for agriculture and water resources.

Recommendations:

3.1 The Panel considered the CEC technique to be a fruitful avenue of research as such empirical forecasts allow the assessment of risk.

3.2 The Panel recommended the use of statistical methods to confront the dynamical models as a means for identifying model error and improving model performance.

3.3 The Panel recommended that the improvement of simulation and prediction of monsoonal ISOs, within the context of understanding the underlying physics of the phenomena, be given the highest priority in research (see *Action Item A4.2*).

3.4 The Panel endorsed the proposal to develop and implement an experimental prediction programme to investigate the inherent predictability of the ISO depending on its phase, season, and ENSO.

4. Modelling issues

Following the extreme 1997-99 ENSO cycle, the AAMP commissioned a model intercomparison study of this event. This has now been completed with 10 models being used. Details of the results can be found on: http://climate.snu.ac.kr/clivar/index.htm. The Panel was briefed on the main outcomes of the intercomparison, which included the following conclusions:

- All models displayed a poor simulation of the precipitation over the Maritime Continent. In an independent study this has been demonstrated to have serious effects on global systematic errors and is not corrected by increasing horizontal resolution.
- The Indian Monsoon tends to be too strong and too variable with the suggestion that land surface parametrizations may be inadequate. Conversely, the West Pacific/East Asian monsoon is too weak and lacking in variability. The lack of atmosphere-ocean coupling was suggested as a possible cause.
- Analysis of the ISO showed that this phenomenon was still poorly simulated in models. Again the importance of ocean-atmosphere interaction was stressed. Results from additional integrations in which high frequency SST fields were imposed, showed no significant improvement, mainly because the simulated ISO may not be correctly timed with the SST field.
- The model ensembles tended to show quite high levels of reproducibility even though the skill tended to be low.

The Panel thanked Dr. In-Sik Kang for his thorough work in driving this study forward. A number of papers have already been submitted based on the results of this study. The Panel noted, however, that only a fraction of the modelling groups were represented in this intercomparison and looked forward to seeing the results from a broader range of models within the AMIP-II Diagnostic Subprojects. The importance of taking full advantage of existing Model Intercomparison Projects was noted.

Modelling problems, relevant to African and American monsoons, were presented by Chris Thorncroft (co-chair of VACS) and Roberto Mechoso (Chair of VAMOS). The importance of the diurnal and seasonal cycles, often poorly simulated in models, was stressed. For seasonally arid climates, the onset of the rainy season presents particular challenges to models. The VAMOS presentation also emphasized the special challenges posed by the need to model phenomena in a wide variety of space and time scales, such as convective precipitation, low-level jets, synoptic disturbances and continental or even planetary scales structures. The need to evaluate specific processes and phenomena in climate models was discussed. This means confronting models with observational data, including those from field experiments, at a higher level than is currently done. It was noted that WGNE is preparing a set of standard diagnostics for model evaluation, which includes specific assessments of processes and phenomena many of which are relevant to the priorities of the AAMP.

The Panel was briefed by Jan Polcher on the GEWEX Global Land/Atmosphere System Study (GLASS; http://www.gewex.com/glass.html). There is currently little evaluation of

land surface schemes for monsoon environments, mainly due to the lack of verification data. However the importance of understanding the performance of these schemes in seasonally arid environments was emphasised.

The Panel discussed the role of land surface anomalies in the seasonal to interannual monsoon variability and predictability. Although it was recognised that more research needs to be done in this area, it was generally concluded that the influence of land surface anomalies is likely to be secondary to that of El Nino. On intraseasonal timescales, however, it was agreed that there might be more sensitivity to land-atmosphere interactions. It was noted that progressive improvements to land surface schemes are likely to arise from better representation of vegetation and soil water processes. The importance of modelling land surface heterogeneity was stressed.

The proposed cross-CLIVAR Workshop on modelling for monsoon environments was introduced with input from VACS and VAMOS. This proposal arose from discussions at the CLIVAR SSG where it was noted that many model systematic errors were of common interest to the various Panels (VACS, VAMOS, AAMP) and Working Groups (WGSIP). WGSIP has already noted that model systematic error is a major barrier to progress and has recommended experimentation that focuses on specific processes and phenomena (e.g. ISO). It was agreed that a new approach was needed to address model systematic errors that differs from the traditional method of intercomparing model climates. It was proposed that a workshop, which focused on specific phenomena, should help us to highlight deficiencies in the representation of particular physical processes. The importance of involving the observational community, particularly GEWEX, in this exercise was stressed. Examples of potential candidates for study include the diurnal cycle, the ISO, the seasonal cycle, subseasonal coupling with the upper ocean.

Recommendations:

4.1 The Panel called for enhanced research to improve the capability of models, especially coupled models, to simulate the ISO. The Panel endorsed the proposed studies of the ISO being carried out within AMIP-II and CMIP diagnostic subprojects and requested further briefings on progress.

4.2 The Panel recommended that the Maritime Continent, a key heat source for the global circulation, should be a focus of special study in order to improve widespread model systematic error.

4.3 Greater collaboration with the GEWEX land surface activities was recommended. This should lead to better understanding of the influence of the land surface on monsoon variability and predictability.

4.4 The Panel agreed with the need for a CLIVAR-wide plan for the formulation of an overall modelling strategy. It endorsed the proposal for a focused workshop on specific processes and phenomena, known to be poorly simulated across a wide range of models. The Panel recommended that, where possible, results from process studies be

used as "points of comparison" for model evaluation and model intercomparison. The Panel recommended the formation of an ad hoc working group to develop an outline proposal for the Workshop. The working group should include representatives from CLIVAR and GEWEX and should report to the CLIVAR SSG in May 2002.

Actions:

A4.1 To liase with the WGNE to ensure that appropriate standard diagnostics are proposed for model evaluation which address the specific processes and phenomena (e.g. diurnal and seasonal cycles; ISO) of interest to the modelling issues identified by the AAMP.

Action: Slingo

A4.2 Report on the representation of ISOs in atmosphere-only and coupled models to be given at the next Panel meeting, based on AMIP-II and CMIP results.

Action: Slingo, Sperber.

A4.3 To liase with the GEWEX land surface modelling communities, particularly GLASS, on issues relating to the role of land-atmosphere interactions in the mean climate and variability of the AA monsoons.

Action: Slingo, Shuttleworth

A4.4 To establish an ad hoc working group to develop a Workshop proposal with representatives from AAMP, VACS, VAMOS, WGSIP and GEWEX. Proposed schedule:
January 2002: Establish working group
May 2002: Workshop proposal to CLIVAR SSG
June 2002: Formation of Workshop Organising Committee
Spring/Summer 2003: Modelling Workshop

Action: Slingo, Mechoso, Thorncroft, Sperber

5. Process studies and field experiments

The panel was briefed on existing and planned process studies and field experiments of relevance to the AA monsoon. These include:

- South China Sea Monsoon Experiment (SCSMEX): See http://climate.gsfc.nasa.gov/~kim/relacs/campaign/index.html). The second phase of SCSMEX is planned for 2003 with the involvement of China and Japan. The Panel noted that it was impossible for the US to participate due to the short lead-time in planning the experiment.

- GEWEX Coordinated Enhanced Observing Period (CEOP): See http://www.msc-smc.ec.gc.ca/GEWEX/GHP/ceop.html. CEOP is an effort to address some of the critical aspects of the climate system involving land areas. It will focus on two overall issues - water and energy fluxes and reservoirs over land areas, monsoonal circulations. CEOP will involve the simultaneous or near-simultaneous collection of observations from several regions around the world. In particular, it will include extensive field measurements for addressing monsoonal systems. A CEOP Subproject, the CEOP Asian-Australian Monsoon Project (CAMP: http://monsoon.t.u-tokyo.ac.jp/draft-camp/en/index.htm) will provide an important integration of ocean observing programmes (e.g. SCSMEX-2) with the land components of CEOP.

- The Joint Air-Sea Monsoon Interaction Experiment (JASMINE): See http://paos.colorado.edu/~jasmine/index.html. JASMINE-I held during 1999 provided compelling evidence of the role of air-sea interaction in monsoon intraseasonal variability. It also gave striking results on the pronounced diurnal cycle over the Bay of Bengal. The Panel noted the success of JASMINE-I and endorsed the plan for a second phase, JASMINE-II, during the summer of 2004.

- The Bay of Bengal Monsoon Experiment (BOBMEX): See http://caos.iisc.ernet.in/faculty/dsen/bobmex.pdf. The Panel was briefed on the results from the first phase of BOBMEX during July/August 1999 when detailed oceanographic and meteorological measurements by two research ships and two buoys placed in the north and south of the Bay were made. Recognition of the limited scope and time frame of JASMINE I and BOBMEX has led to the need for a follow-up experiment, which is planned as a multi national experiment during the summer of 2004. This would be coordinated with CEOP. The Panel endorsed the need for such a multi-national experiment.

- OASUS: OASUS is a focused experiment led by the US to study coastal upwelling at 18N, 58E in the Arabian Sea during May, June 2003. Studies of the biological and chemical aspects of the upwelling are the prime aims of the experiment. The Panel endorsed OASUS but suggested that atmospheric soundings be included in the experiment.

- Arabian Sea Monsoon Experiment (ARMEX): See http://caos.iisc.ernet.in/hpg/armscience.html. An experiment to study the evolution of the upper ocean in the south-eastern Arabian sea, and its interaction with the atmosphere is planned by India for the summers of 2002 and spring of 2003. ARMEX will involve extensive surface, upper ocean and atmospheric measurements from ships, buoys and coastal stations.

The Panel was pleased to see the wide range of field experiments already being planned for the AA monsoon region and offered their endorsement for all the proposed studies. However, it is clear that considerable added value could be gained by closer collaboration and possible sharing of resources. The Panel also noted the importance of continued study of the Indonesian Throughflow.

Whereas the majority of tropical experiments during recent years have occurred in the Pacific Ocean (e.g., TOGA COARE), a growing number of process studies have occurred in the Indian. The Panel noted that the opportunity now exists for careful comparison of a number of quantities between various tropical regions. In particular, the Panel was curious about the degree of agreement between flux characteristics between the ocean basins and in the regional seas.

Recommendations:

5.1 The Panel noted the synergy between BOBMEX and JASMINE-II, and between OASUS and ARMEX, and recommended that the experiments be closely coordinated.

5.2 The Panel were pleased to see the extensive CEOP activities for the land regions of the AA monsoons and fully endorsed the activities of CAMP to bring in the ocean experiments.

5.3 The Panel recommends that the intercomparison of process study results be given high priority as a research focus.

5.4 The Panel recognised the importance of the community being updated regularly on plans for process studies and field experiments. This is needed to avoid lost opportunities for collaboration and joined-up funding, as well as ensuring that the modelling community is aware of the observations available against which to test the models.

Actions:

A5.1 Investigate mechanisms to combine the plans for BOBMEX and JASMINE-II to provide a coherent plan for the Eastern Indian Ocean.

Action: Webster, Sengupta

A5.2 Investigate mechanisms to combine the plans for OASUS and ARMEX to provide a coherent plan for the Arabian Sea. Give serious consideration to including atmospheric soundings as part of OASUS.

Action: Halpern, Sengupta

A5.3 To maintain an up-to-date list of current and planned field experiments with hyperlinks to relevant websites.

Action: ICPO, Panel members

6. Long term monitoring of the Indian Ocean

The Panel were briefed on existing data provision for both the atmosphere and ocean, from both satellite and in situ measurements. The following table provides a summary of existing continuous, long-term time series of variables available from remote sensing and in situ measurements. These are in addition to the standard meteorological measurements that are transmitted over the GTS on an operational basis. Most of these data are available through the Physical Oceanography Distributed Active Archive Center (PODAAC: http://podaac-www.jpl.nasa.gov/index/).

Variable	**Δx**	**Δy**	**Δz**	**Δt**	**Start in**	**Platform**
SST	1^0	1^0		7 days	1985	AVHRR
SST	0.25^0	0.25^0		1 day	1997	TMI
Subsurface Temperature	5 ship tracks		10m	30 days	1985	XBT
Surface wind speed	0.25^0	0.25^0		1 day	1988	SSM/I
Ocean vector wind	1^0	1^0		10 days	1992	ERS
Ocean vector wind	0.5^0	0.5^0		1 day	1999	Seawinds
Sea surface height	1^0	1^0		10 days	1992	ERS and T/P
Significant wave height						
Chlorophyll-a	1^0	1^0		7 days	1997	Seawifs
Wind profile	3 ocean sites		0-10km	1 day	?	?
Current profile	3 sites		0-300m	1 day	?	?
Rainfall (land)	1^0	1^0		1 day	1900	Stations
Rainfall (ocean)	1^0	1^0		1 day	1997	GPCP

Sub-surface temperature records from XBT lines as part of WOCE in the Indian Ocean are available at: http://www.marine.csiro.au/~pigot/REPORT/. The Panel noted the substantial commitments by a number of countries to deploy Argo floats in the Indian Ocean during the next few years (see http://www.argo.ucsd.edu/) with good coverage of the northern Indian Ocean by 2003. Argo activity in the Indonesian Throughflow region is documented at: http://www.marine.csiro.au/~waring/cooe/. The Panel appreciated the international efforts that have lead to the possibility of a full deployment of Argo floats in the Indian Ocean by 2003. The panel reviewed the Argo proposal for the Indian Ocean and offered its endorsement.

The Panel was briefed on current ocean monitoring activities by India. These include:

- 5 deep sea moored buoys and 5 coastal moored buoys, all measuring surface pressure, air temperature, winds, SST, SSS, waves and surface ocean currents.
- 4 XBT lines done monthly to 3-monthly: Chennai - Port Blair, Kolkata - Port Blair, Chennai - Singapore and Mumbai - Mauritius.
- Surface drifters measuring surface pressure and SST.
- 2 equatorial current meter moorings at 83^0E and 93^0E. The mooring at 83^0E has an upward looking ADCP at 100m.
- Indian satellite P4/Oceansat with MSMR, Ocean Colour Monitor.

Plans for 2002-2007 include the implementation of 25 moored buoys in the northern Indian Ocean as well as 150 Argo floats, depending on the availability of a new ship to deploy and maintain the buoys. An additional XBT line from Mumbai or Cochin to Mombasa is planned. Humidity and radiation sensors will be installed on most buoys, and rain sensors on some buoys. The coastal radar network of the IMD is likely to be upgraded to Doppler radar and the tide gauge network is also likely to be upgraded. There are plans for an Indo-French tropical climate satellite 'Megha-Tropiques'. The Panel was pleased to hear of the significant efforts from India to monitor the northern Indian Ocean and its meteorology. The Panel queried whether the Indian buoy data, currently archived at Delhi, were making their way on to the GTS. The Panel also expressed the desirability of Indian satellite data being internationally available. Past difficulties with INSAT data were noted.

The panel was briefed by Yukio Masumoto on the operation of the TRITON buoys in the eastern Indian Ocean by JAMSTEC (see: http://www.jamstec.go.jp/jamstec/TRITON/) and the Observational Activities on Study for the Indian Ocean Climate System (OASIS) conducted by Frontier Research System for Global Change (FORSGC). FORSGC is maintaining two VOS XBT/XCTD lines (Malacca Strait - Persian Gulf and Malacca Strait - Mauritius), one ADCP mooring at 90E on the equator and Argo float deployments. FORSGC is also conducting surface drifter measurements and hydrographical measurements by R/V Mirai. OASIS consists of the activities of FORSGC and the TRITON buoys in the Indian Ocean by JAMSTEC. It focuses on the upper ocean variability in the eastern Indian Ocean on the intraseasonal to interannual time-scale. There was a strong recommendation that the TRITON buoys need to be maintained at least until 2003/4 so that they can be used within the process studies identified above. Their importance for the long term monitoring of the Indian Ocean, particularly the Indian Ocean Zonal (Dipole) Mode, was stressed.

The case for pilot-monitoring of the Indian Ocean was presented based on the Workshop on Sustained Observations of Climate in the Indian Ocean (SOCIO: http://www.marine.csiro.au/conf/socio/socio.html). This was considered in the context of both the societal and science drivers. The societal drivers include factors such as storm surges, fisheries, environmental management, drought mitigation and the clustering towards short timescales (days - season) were noted. The science drivers include topics such as diurnal to intraseasonal SST variability, biogeochemical coupling, Indian Ocean Zonal (Dipole) mode, sea level trends; here the clustering tends to longer timescales (seasons - decades). The ISO time-scale was recognized as the key building block of seasonal and interannual variability in the oceans. SOCIO concluded that a sustained observing system for the Indian Ocean was viable. The Panel endorsed the general concepts of the SOCIO plan. However, the Panel noted that the placement of buoys should be governed by the need to establish well-founded empirical relationships between subsurface circulation dynamics and SST where a buoy is placed, as well as links to climatic responses elsewhere. The Panel emphasized the need for a monitoring system that can help us understand the intraseasonal oscillation. It was noted with some concern that the current design of Argo floats does not permit subseasonal sampling. Options for a better, integrated observing system include Argo floats that sample more frequently and/or a well designed combination of floats and moorings.

The Panel considered the proposal for monitoring the western Indian Ocean (WIOMAP/I-MAP) prepared by Mark Jury and others. East African climate variability is the main driver of this proposal, which was communicated to the AAMP by VACS. The main elements of the I-MAP proposal address the need for monitoring the ocean Rossby waves in the south-western Indian Ocean. The associated SST anomalies have been predicated as responsible for extreme weather events over Mozambique and other parts of S.E. Africa. While recognising the importance of being able to predict climate variability for East Africa, the Panel expressed the concern that any proposed monitoring system requires sound scientific justification that has to be stronger than associations suggested by correlations. The Panel recommended that modelling studies be carried to provide the underpinning for the proposal. In general, the Panel felt that more modelling studies, providing evidence of the impact of Indian Ocean SST variability on climate, were needed.

The Panel was briefed by Jay McCreary on the current level of understanding of the ocean circulations in the Indian Ocean, and of our ability to simulate them with ocean models. The dynamics of the mean and annual cycle are now reasonably well understood, but our knowledge of the thermodynamics and mixed layer physics is less complete. The influence of salinity is understood least of all, yet clearly identified as an important modelling issue; for example, freshwater input (through rainfall or river outflow) can lead to a shoaling of the mixed layer, and hence to a concentration of surface jets, as observed in the West Pacific. In this regard, a particular weakness of existing models lies in their representaion of the oceanic mixed layer (and likewise the PBL for atmospheric models), where errors in coupling occur and can amplify. The importance of understanding and modelling intraseasonal variability was emphasised. Much more work needs to be done to determine the nature and causes of interannual-to-decadal variability in the Indian Ocean. Finally, the relative skills of different ocean (and coupled) models in simulating the Indian-Ocean mean circulation and its variability have not been systematically assessed. It is important that systematic errors in model simulations are known, as these errors will help to focus the process studies and the placement of monitoring sites.

Recommendations:

6.1 The panel recommended that checks should be made ensure that the Indian buoy data are being placed on the GTS and being disseminated globally. The Panel also expressed the desirability of Indian satellite data being internationally available, bearing in mind past difficulties with INSAT data.

6.2 There was a strong recommendation that the TRITON buoys in the eastern Indian Ocean need to be maintained at least until 2003/4 so that they can be used within the process studies identified above.

6.3 The Panel recommended that consideration be given to modifying the design of Argo floats to permit subseasonal sampling.

6.4 In collaboration with VACS, the Panel recommended the formation of an ad hoc review committee (Webster, Thorncroft, Meyers, McCreary) to consider the WIOMAP and I-MAP proposals. The committee was asked to complete their review by October 31 and to seek external expertise if necessary.

6.5 The Panel recommended that any proposed Indian Ocean monitoring system requires sound scientific justification and proposed that detailed observational and modelling studies be undertaken. Observations are needed to identify the role of ocean dynamics in the generation and maintenance of SST anomalies. Beyond purely oceanographic issues, the Panel felt that more modelling studies providing evidence of the impact of Indian Ocean SST variability on climate were needed.

Actions:

A6.1 Ensure that the observations from the Indian deep sea buoys are available over the GTS from Delhi.

Action: Sengupta

A6.2 Ensure that the TRITON buoys in the eastern Indian Ocean remain active until at least 2003/4.

Action: Kawamura/Masumoto

A6.3 Liase with the Argo Float Implementation Team to investigate possibility of higher frequency sampling.

Action: Meyers

A6.4 Establish an ad hoc review committee with VACS to consider the WIOMAP and I-MAP proposals and to report back to the CLIVAR SSG.

Action: Webster

A6.5 Liase with WGCM (re CMIP) and WGOMD (re OMIP) on initiating studies of the Indian Ocean circulation and assessment of model systematic errors.

Action: Slingo, McCreary

A6.6 Liase with WGSIP and VACS on experimentation to investigate the importance of Indian Ocean SST variability for seasonal predictability.

Action: Slingo, Sperber, Thorncroft

7. Any Other Business

The action items listed above were reviewed and agreed in principle by the Panel, pending formal documentation by this report. It was noted that this Panel meeting had focused largely on the Indian Ocean and the Indian monsoon. It was agreed that the next meeting should focus on the role of land-atmosphere interactions (including the biosphere), and on the East Asian monsoon (including the winter monsoon). It was also noted that the TBO needed consideration at the next meeting.

The Panel was informed that the WCRP had requested CLIVAR representation on the Task Team on Climate research for Arid and Desert Regions. Slingo has been nominated by the CLIVAR SSG to serve on the team.

It was recommended that the Panel and ICPO establish a list of contacts in the monsoon regions, especially in those nations not included in panel membership. Such a group could be kept appraised of scientific activities and opportunities that may arise in the monsoon regions to which they may facilitate co-operative efforts or from which they may take advantage.

Next meeting was planned for August 2002 in New Mexico, hosted by Peter Webster.

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List of web-sites with supporting materials for the AAMP meeting report

Monsoon observations

http://www.met.rdg.ac.uk/cag/MOL/ - Monsoon on Line monitoring real time monsoon rainfall over Indian sub-continent …

http://podaac-www.jpl.nasa.gov/index/ - Global satellite data including daily sea surface temperature, rainfall and wind speed, sub-surface temperature, sea surface height and significant wave height …

http://www.dwd.de/research/gpcc/e23.html - Global monthly precipitation data and image …

http://www.argo.ucsd.edu/ - A global array of 3,000 free-drifting profiling floats measuring the temperature and salinity of the upper 2000m of the ocean …

http://www.meteo.shom.fr/ibpio/index.html - International Buoy Programme for the Indian Ocean to provide meteorological and oceanographic data …

http://www.marine.csiro.au/~pigot/REPORT/ - Sub-surface temperature records from XBT lines as part of WOCE in the Indian Ocean …

http://www.jamstec.go.jp/jamstec/TRITON/ - TRITON buoys to measure temperature from air to 750m under sea surface, salinity, current and precipitation …

Monsoon modelling

http://climate.snu.ac.kr/clivar/index.htm - A CLIVAR/AAMP-commissioned model intercomparison study … simulating precipitation over monsoon regions …

http://climate.gsfc.nasa.gov/~kmkim/aamip/ - More about the CLIVAR/AAMP AGCM intercomparison project …

http://www.enm.meteo.fr/ufr/umt/shiva/main.html - Simulating Indian monsoons …

http://www-pcmdi.llnl.gov/cmip/ - Coupled model intercomparison …not much monsoon yet …

http://www.gewex.com/glass.html - A GEWEX-project, where a new generation of land surface schemes for climate modelling is emerging …

Process explorations

http://paos.colorado.edu/~jasmine/index.html - Joint Air-Sea Monsoon Interaction Experiment (JASMINE) ... JASMINE-I during 1999 over the Bay of Bengal ... JASMINE-II is planned …

http://caos.iisc.ernet.in/faculty/dsen/bobmex.pdf - The Bay of Bengal Monsoon Experiment … BOBMEX-I during July/August 1999 with two buoys ... BOBMEX-II is being planned …

- OASUS - to study coastal upwelling at 18N, 58E in the Arabian Sea during May, June 2003, aiming at the biological and chemical aspects of the upwelling … no web info yet

http://caos.iisc.ernet.in/hpg/armscience.html - Arabian Sea Monsoon Experiment to study the evolution of the upper ocean off the southern tip of India planned for the summers of 2002 and 2003 ...

http://ncc.cma.gov.cn/scsmex/html/scsmex_e.htm - South China Sea Monsoon Experiment (SCSMEX) homepage

http://climate.gsfc.nasa.gov/~kim/relacs/campaign/index.html - SCSMEX link in USA

http://www.clivar.org/organization/pacific/activities/workshop_2001/papers/SCSMEX.htm - Scientific details of SCSMEX -I and -II
http://www.ihas.nagoya-u.ac.jp/game/index.html - GAME has deployed a few field experiments in Asian monsoon regions, e.g., Tibet and Huai river basin …
http://www.msc-smc.ec.gc.ca/GEWEX/GHP/ceop.html - Coordinated Enhanced Observing Period (CEOP) … to include extensive field measurements for monsoon with a sub-project CAMP …
http://monsoon.t.u-tokyo.ac.jp/draft-camp/en/index.htm) - more info of CAMP

General studies

National reports of AA monsoon studies – to be set in CLIVAR web
http://climate.gsfc.nasa.gov/~kmkim/clivar/ - Draft CLIVAR / AA Monsoon Implementation Plan
http://ugamp.nerc.ac.uk/promise/ - Predictability and variability of monsoons, and the agricultural and hydrological impacts of climate change …
http://www.ihas.nagoya-u.ac.jp/game/ - GEWEX Asian Monsoon Experiment
http://rossby.metr.ou.edu/~spark/AMON/ - Asian Meteorology Online Newsletter …
http://www.met.reading.ac.uk/cag/Monsoon/Groups.html - Monsoon research groups on the Internet …

Within the monsoon regions

Australia

http://www.bom.gov.au/bmrc/csr/apn/index.html - APN network for climate extremes …
http://www.marine.csiro.au/conf/socio/socio.html - Ideas for Sustained Observations of Climate in the Indian Ocean (SOCIO) …

China

http://www.lasg.ac.cn - State Key Lab of numerical simulations for Atmospheric Sciences and Geophysical fluid dynamics, developing and applying AGCM, OGCM and coupled GCM …
http://www.tea.ac.cn - IGBP/START Regional Centre of Temperate East Asia, developing regional model, focusing on monsoon–ecosystem interaction …
http://www.ncc.gov.cn - National Climate Centre, host of SCSMEX …APN project on ENSO and Warm Pool …
http://www.nmc.gov.cn/indexnmc.html - National Meteorology Centre … numerical forecasting, weather data …
http://202.106.103.181/ - National Satellite Meteorological Centre … Chinese FY-series satellite data and images …

India

http://www.imd.ernet.in - India Meteorological Department, providing real-time weather reports, forecasts, satellite images, synoptic charts …
http://www.tropmet.res.in - Indian Institute of Tropical Meteorology … a mirror site of 'Monsoon On Line', providing regional monthly rainfall and temperature data …
http://www.ncmrwf.gov.in - National Centre for Medium Range Weather Forecasting of India ...

Japan

http://www.jamstec.go.jp/jamstec-e/index-e.html - Japan Marine Science and Technology … host of Japan Argo and TRITON …
http://www.apn.gr.jp/ - Intergovernmental Asian Pacific Network linking global change sciences to policy making …

Korea

http://climate.snu.ac.kr/ - Atmospheric science at Seoul National University … host of the AA monsoon inter-model comparison project …

More project-related web pages are available at www.clivar.org (search through SPRINT)