Prospectus for CLIVAR Asian-Australian Monsoon Panel

The Asian-Australian monsoons affect more than half of the world population. Monsoon prediction remains a major challenge for the scientific community for the 21st century.

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What is AAMP?

The Asian-Australian Monsoon Panel (AAMP) is a part of the CLIVAR (Climate Variability and Predictability) project under the World Climate Research Programme (WCRP). It plays a primary role in developing CLIVAR's research programme for the monsoon. In particular, it has been established to

- Evolve a strategy to assess climate variability and predictability of the coupled ocean-atmosphere-land system in the monsoon region;
- Design and implement a program to investigate the mechanisms of ENSO-monsoon interactions;
- Determine a monitoring strategy for the Indian Ocean, Western Pacific and surrounding marginal seas and land regions necessary for investigating the monsoon structure and variability;
- Co-ordinate and promote interactions among meteorologists, oceanographers and hydrologists from interested nations;
- Develop an implementation plan for monsoon research in the region, which recognizes the need for a well coordinated and optimized set of process studies; and
- Cooperate with other existing and planned regional and multinational programs including investigations on regional weather forecasting, seasonal climate prediction and impacts on human activities.

Typical questions AAMP's program helps to answer:

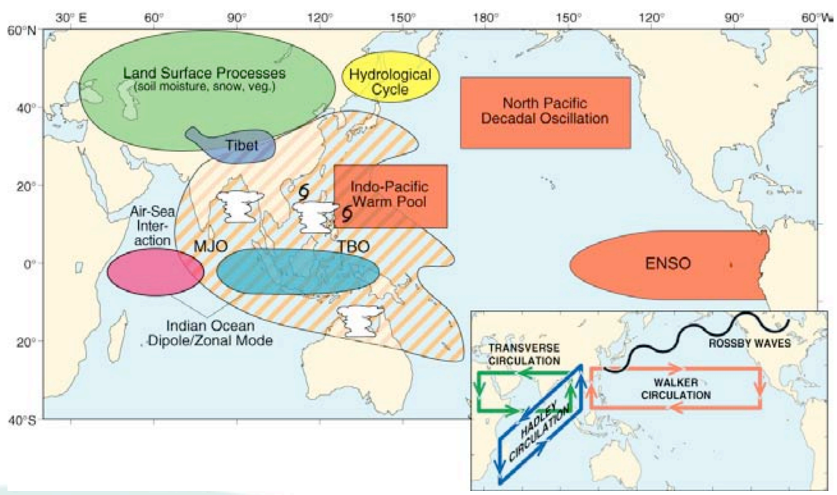
- Will there be floods / droughts during this and next monsoon season?
- How are the monsoons related with El Nino?
- Will extreme floods / droughts be more frequent with global warming?
- How does the monsoon variability influence farmers and industries?

Describing the AA monsoon

The AA monsoon encompasses the Indian-Asian monsoon during northern summer and the Indonesian-Australian monsoon during southern summer. A variety of processes, both local to the monsoon and remotely driven, act to regulate and vary the strength and duration of the monsoons. Those identified by the AAMP deserving special attention for research in the near future include:

ISV - Active and break episodes of the monsoons are dominated by intraseasonal variations (timescales 2 weeks to 2 months). In particular the Intraseasonal Oscillation or Madden-Julian Oscillation is viewed as being a elementary component of the monsoon. Hence, monsoon simulation and prediction hinges on the ability to simulate the ISO.

ENSO - El Nino Southern Oscillation (ENSO), though rooted in the equatorial Pacific, affects the AA monsoon through perturbations to the Walker circulation, the lateral overturning circulation in the east-west plane. The complicated relationships between the monsoon and ENSO vary decadally and are a showcase for the complexity of global climate system. variability.



Conceptual monsoon system (courtesy of H Annamalai)

Ocean-Atmosphere Coupling in the Indian Ocean is recognized as playing a primary role in governing year-to-year variations of rainfall in the transitional monsoons and in promoting the effects of ENSO. A variety of coupled phenomena have been identified, including the Indian Ocean Dipole (or zonal mode) and south Indian Ocean Rossby waves, that involve seasonally-varying feedbacks between winds, rainfall, ocean circulation and surface temperature. Unraveling these mechanisms and their impacts on the monsoon and determining their role in promoting predictability of the monsoons remain a challenge to researchers.

ITF - Indonesian Through Flow is a critical choke point in the global climate system directly affecting the oceanic transport of heat and freshwater from the Pacific into the Indian Ocean and ultimately affecting the global thermohaline circulation. Interannual varitions of the ITF associated with ENSO affect the climate of the eastern Indian Ocean, while decadal variations of the ITF determine ENSO's influence on the monsoons.

Observing the AA monsoon

Lack of sufficient observations is an obstacle for advancing studies of the atmosphere-ocean-land coupled monsoon system. Satellite and in-situ observations continue to play a fundamental role in climate studies, however, special field programs for measuring air-sea and air-land interactions as well as high-resolution proxy data for exploring monsoon history are still needed. The AAMP is actively involved in international observational programs such as Argo and CEOP.

Satellite observations
global coverage
hourly resolution
various variables for ocean, land and atmosphere →

Field Programs
air-sea/air-land fluxes at typical places, e.g., Bay of Bengal, South China Sea, Tibetan Plateau and the CEOP continental sites →

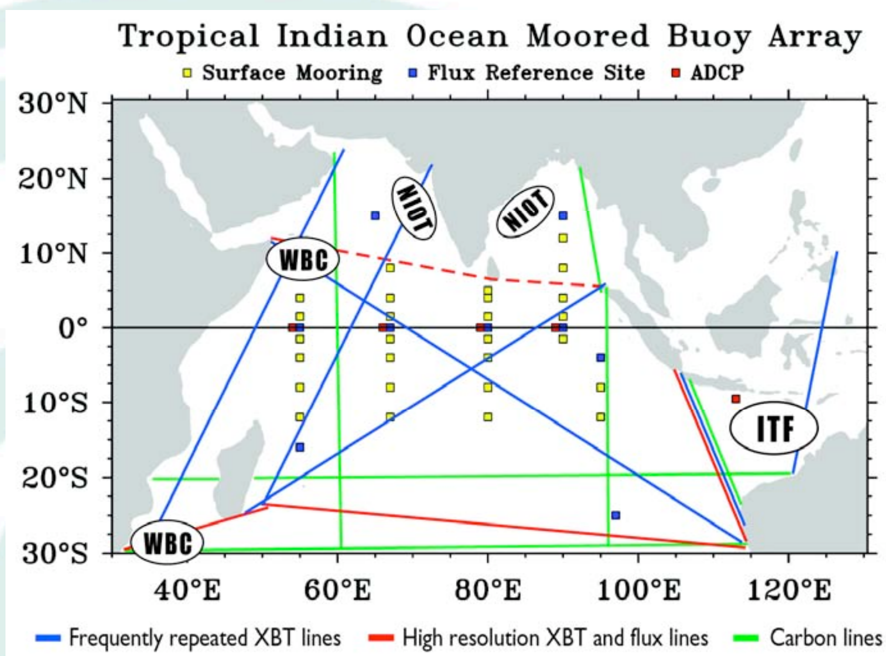
International / regional

coordinating organizations and data / information systems for monsoon Studies e.g., CLIVAR DIS

← **In-situ** monitoring on both land and ocean, e.g., weather stations, moorings, Argo drifters

← **Proxy data** with a resolution suitable for recognizing seasonal / interannual variability, e.g., tree rings, coral sediments

The Indian Ocean remains the least observed basin over the world. The AAMP and the newly established Indian Ocean Panel will play a role in developing a sustained **Indian Ocean Observing System**, which has recently been initiated.



The evolving design of a sustained observing system for the Indian Ocean. The system includes 3°x3° Argo profiling float array, 5°x5° surface drifting bouy array and a real-time tide gauge network. NIOT will establish arrays of meteorological and deep sea moorings.

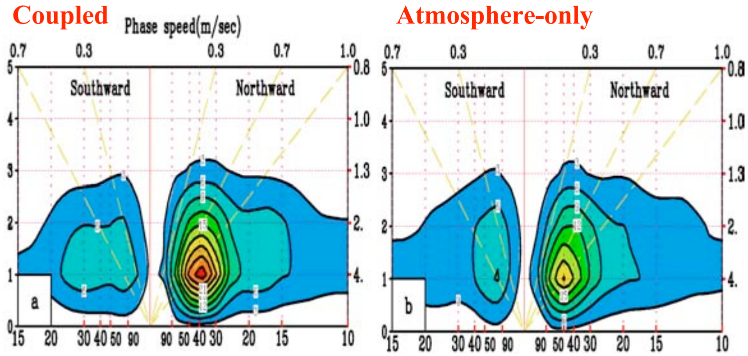
Simulating the AA monsoon

Simulating monsoon variability with numerical atmosphere-ocean-land coupled climate models is an efficient way of achieving better understanding of the mechanisms of the monsoon and monsoon prediction. However, current models are still unable to correctly reproduce some basic phenomena, including aspects of the inter-tropical convergence zone (ITCZ), the ISO, the abrupt monsoon onset/breaks and diurnal cycles. They are thus unlikely to explain well the complicated relationships the monsoons have with ENSO, extratropical circulation and the slowly varying components such as the Eurasian snow cover and IOD. The AAMP recognises that evaluation and improvement of global and regional coupled models, with emphasis on key physical processes such as the ISO, will remain as an important topic in next 5-10 years.

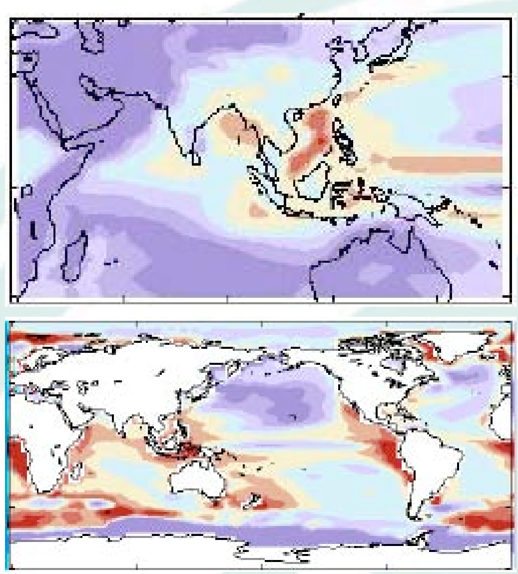
Coupled modeling is essential

Comparative analyses of the ISO between observation and simulation by 24 AMIP II models suggested that while all models produced less organized propagation of the convection than observed, the coupled models exhibited improved propagating features compared with their atmosphere-only counterparts.

Monsoon rainfall and other related phenomenon such as the tropical biennial oscillation are also better simulated in coupled models (Sperber 2003).



Atmosphere-ocean coupling enhances the northward-propagating ISO, which helps to predict active and break periods of Indian monsoon (Fu et al. 2004)



Aspects of atmosphere and ocean modeling remain problematic

Modeling Indian Ocean circulation and its variability remains a challenge. There is a long way to go before clear explanations of some typical phenomena such as IOD.

There are still systematic errors in the SST field in the coupled models, relating to the erroneous split ITCZ and influencing simulation of the other variable field such as monsoon rainfall.

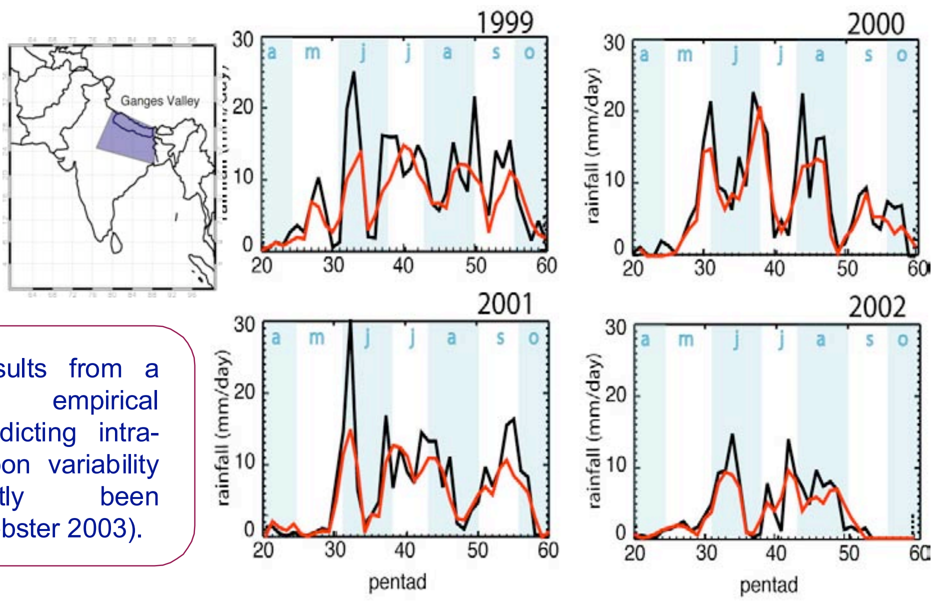
Left: upper - summer precipitation pattern simulated by a coupled model; lower - error pattern in the simulated global sea surface temperature field (Martin 2004)

AAMP will help advance the progress by organizing workshops with collaboration with other relevant organizations (e.g., the AAMP/IOP-endorsed Indian Ocean Modeling workshop, 2004, Hawaii).

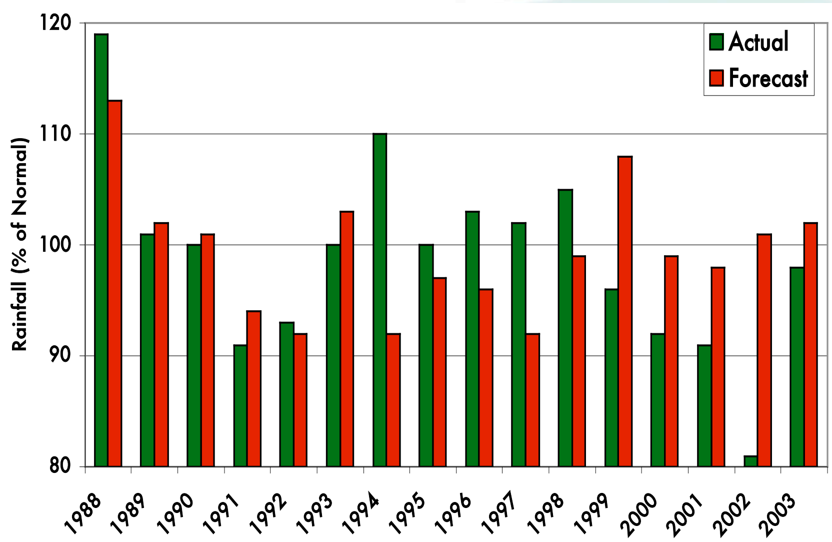
Predicting the AA monsoon

There is long way to go before dynamical models can provide reliable prediction of monsoon variations. Empirical methods based on observation statistics and physical diagnosis are still extensively applied. The AAMP view is that a near-term target for dynamical prediction is best focused on intraseasonal-interannual timescales. The AAMP also encourages the development of empirical methods based on diagnosis of physical relationships within the system.

20-day forecast of 5-day rainfall at Ganges Plain



Encouraging results from a physics-based empirical method for predicting intra-seasonal monsoon variability have recently been documented (Webster 2003).

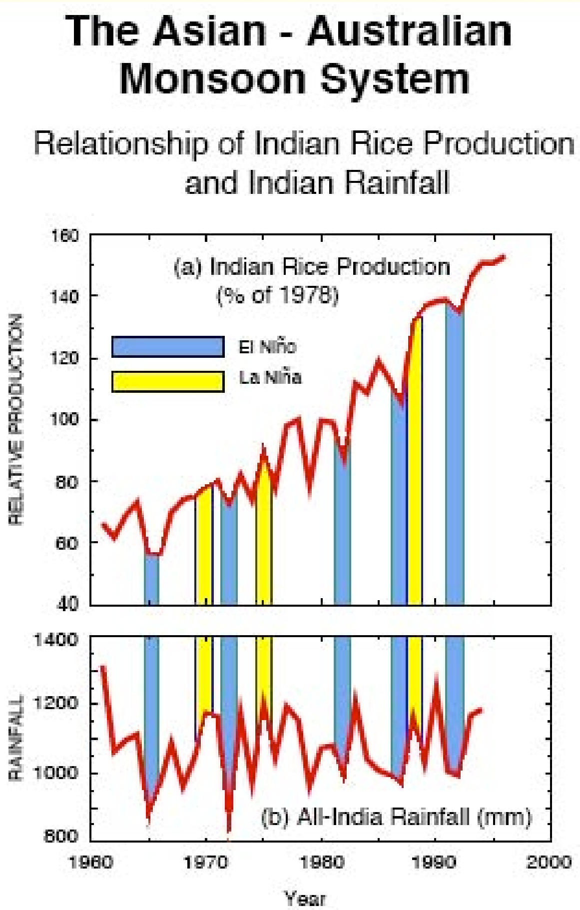


Performance of the operational forecasts of all-India summer monsoon rainfall, using an empirical approach. The forecasts, initially quite successful, have had reduced skill in recent years (e.g., 1994, 1997 and 1999). The system was revised following its gross failure in 2002 and the forecast for 2003 used the new approach (Kelkar 2003: The challenges of monsoon forecasting. Indian Met. Soc.). This experience accentuates the need for concerted efforts in developing and updating suitable strategies for monsoon prediction.

The association of the monsoon with global circulation features in 2002 is beyond the range of past associations used to train the empirical models (Kolli 2003)

Application of monsoon prediction

The AAMP sees applications to society as a crucial aspect of climate study and is making effort to guide the community towards linking research and application. There is great potential in application of monsoon prediction to food, water availability and health issues in the monsoon region. Regard also has to be taken of the impact of global warming on monsoon variability.



Crop production vs. Indian monsoon rainfall. Notwithstanding the overall growth in rice production in India due to better farming practices and technological development, year-to-year fluctuations in production are determined largely by the success or failure of the summer monsoon which is in turn affected by the particular phase of the El Niño/Southern Oscillation phenomenon (from Webster et al. (1998, J. Geophys. Res., 103, 14451-14510), adapted from Gadgil, 1995, Current Science, 69, 649-659).

Example - CFAB - Climate Forecasting Applications in Bangladesh (CFAB) aims to make forecasts available to agricultural and other government officials in Bangladesh. Another version of the forecast, for flood prediction, is being planned. AAMP endorsed CFAB as an example project to show how to make prediction of monsoons and how the forecasts can be well applied in the society.

Example - Climate variations could cause 20% increase/decrease in annual agricultural productivity in Australia (McIntosh et al., 2004). A recent study at CSIRO showed that the key to seasonal climate prediction related to farming application would be ocean temperature. A newly developed forecasting system demonstrated considerable benefits for farmers (e.g., an increase of USD 25 000 in annual cash flow for a simulated grazing enterprise).

Many national and international organizations are involved in monsoon studies. Coordination is essential for international activities, including regional and multi-national monsoon experiments. The AAMP welcomes collaboration with other international organizations in order to optimize the use of the scientific resources and the approach towards better understanding and predicting the monsoons and applications.

WCRP

AAMP

Collaborates closely with other WCRP and CLIVAR organizations, including:
GEWEX
CLIVAR/VACS
CLIVAR/VAMOS
CLIVAR/WGCM
CLIVAR/WGSIP
WGNE

Has direct links to the scientific community of relevant countries including:
Australia
Bangladesh
China
India
Indonesia
Japan
Korea
UK
USA

Has wide relationships with international and regional organizations such as:
APN
APCN
IGBP
START

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