MEETING REPORT

Atmosphere–ocean interactions in the Indo-Pacific basin and their impact on Asian climate

The regular and extreme weather and climate events in the Indo-Pacific basin, namely the southwest and northeast monsoons, the El-Nino Southern Oscillation (ENSO), and the cyclones/typhoons, often evolve together and profoundly influence Asian as well as global climate. There are many aspects of these events that are still neither well understood over seasonal time scales nor over the longer period of global climate change. In practical terms, they are often not well forecast.

The workshop covering these aspects of Asian climate, meteorology and oceanography brought together scientists from India, Japan, Malaysia, Sri Lanka, Vietnam, UK and USA. New results were presented based on the extensive data that are now available over the Indian Ocean. Improved computational models developed at the large international research and forecasting centres explain the systematic features of the seasonal and multi-year climatic oscillations; notably the South and East Asian monsoons, and the influences of ENSO extending from the Pacific to the eastern side of the Indian Ocean. However other perturbations, such as the Equatorial Indian Ocean Oscillation (EQUINOO), also need to be analyzed in order to explain the variations of the monsoon rains over South Asia. Trends in sea surface temperature also affect seasons in South East Asia.

The technical sessions consisted of 19 invited talks, poster session and a panel discussion. In the first session on Indian Ocean Dipole (IOD), ENSO and EQUINOO, Sulochana Gadgil (India) said that EQUINOO and ENSO together explain all major Indian drought years. She suggested that understanding the physics of EQUINOO and improving its prediction be one of the foci of research of the Asian Network on Climate Science and Technology (ANCST) as it has important implications for prediction of the interannual variation of the Asian monsoon. Kentaro Ando (Japan) reviewed recent and planned international observational programmes in the Indian Ocean and on-going studies of IOD and air–sea interaction in the Eastern Indian Ocean. The data in the eastern and southern Indian Ocean are comprehensive, but there are gaps in the northwestern Indian Ocean owing to activities of pirates. N. Saji (Japan) discussed the observed and modelled teleconnections along the Equatorial Waveguide during IOD–ENSO interactions, focusing on the 2006 El-Nino event which models failed to predict. He suggested that IOD dynamics plays a significant role in the evolution of these events. Lareef Zubair (Sri Lanka/USA) showed how ENSO, IOD, EQUINOO and Madden-Julian Oscillation (MJO) influence the climate of islands in equatorial Indian Ocean. Kunio Yoneyama (Japan) presented new results from a recent field campaign on MJO in Indian Ocean named CINDY/DYNAMO. The inter tropical convergence zone (ITCZ) in the southern hemisphere may initiate convection during MJO. C. Gnanaseelan (India) discussed a tropical Indian Ocean (TIO) mode of subsurface temperature variability in observations and climate models. Coupled air–sea models qualitatively represent this mode of variability and their seasonal evolution, but not their duration.

Jun Matsumoto (Japan) in introducing the theme of extreme weather and climate, described the influence of ENSO and MJO on heavy rainfalls in Central Vietnam. Heavy rainfalls in Central Vietnam are observed more frequently when MJO activity is pronounced in the equatorial eastern Maritime Continent, and in La Niña years. M. Rajeevan (India) noted that extreme precipitation events over India show an increasing trend in recent years but there is a multi-decadal variation that needs to be accounted for. The frequency and extent of severe heat waves have increased over India. Recent modelling initiatives suggest a possibility of useful forewarnings of severe weather events with adequate lead time. S. Kumarenthiran (Malaysia) said that cold air surges from the Siberian high pressure system cause abundant rainfall over the northeastern states of Peninsula Malaysia and the western part of Sarawak. Therefore understanding and advance prediction of cold surges are vital in providing early warnings for disaster preparedness. Dato Samah (Malaysia) noted that changes in the Antarctic can have large influence on ocean circulation system and global climate as Southern Ocean connects all the global oceans.

In the next session on atmospheric boundary layer (ABL), land and ocean processes, G. S. Bhat (India) showed that monsoonal atmospheric boundary layer over the Bay of Bengal and the Arabian Sea differs from that over other tropical oceans. Evidence for turbulent entrainment at ABL top was shown analysing radiosondes data collected from ships. Julian Hunt (UK with co-authors Moustaoui and Mahalov) described recent research on the interactions between the surface and deeper layers of the ocean, which may be quite weak, or over a certain range of Richardson number (when internal waves form) can be strong enough that the deeper layers are strongly affected – an aspect of ocean dynamics that is incorrectly incorporated in current models in equatorial regions. Similar dynamics is also relevant to explain how the ABL evolves in stable conditions. Monsoon dynamics also depend critically on land–sea interactions, and boundary layer processes, both of which have distinct features in Asia. Lixiao Li's (China) work using new measurements on 60 m meteorological towers on the south coast of China presented a new overall structure for the mean flow and turbulence in tropical cyclones, where wind speeds regularly exceed 30 m s^{-1}. Around the quiet central core within 20 km radius there is a sharply defined 'eye wall', where the

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wind speed increases from near zero to its maximum in less than 100 m, and encircling horizontally orientated vortex roll structures. Data also showed how the anomalous amplification of small scale turbulence above the sea surface where spray droplets evaporate, create intense heat transfer and buoyant convection, and contribute to the lightning.

P. A. Francis (India) discussed the cooling of the Arabian Sea and the Bay of Bengal in response to cyclones. He showed that more than the intensity of the cyclone (or maximum surface wind speed), it is the salinity structure (i.e. upper ocean stratification) that controls the extent of cooling. Debasis Sengupta (India) discussed the on-going study of air–sea interaction in the Bay of Bengal and showed the presence of frequent submesoscale (1–30 km) salinity-dominated fronts in the North Bay of Bengal. The surface boundary layer is generally shallow under the fronts, suggesting that fronts actively stratify the near-surface ocean. P. N. Vinayachandran (India) proposed a mechanism for cold pool formation in the Bay of Bengal off Sri Lanka combining recent ship observations and model results. Summer Monsoon Current (SMC) carries cooler upwelled water from the coasts of India and Sri Lanka, and he suggested that cooling events taking place within the summer monsoon are controlled by ocean dynamics dominated by SMC. He also proposed a salt pump by which the saltier Arabian Sea water located at subsurface layers is intermittently pushed up to the surface of the Bay of Bengal.

Opening the session on regional weather and climate, John McBride (Singapore) said that monsoons dominate the weather of Singapore where El Niño years tend to be drier and warmer. Sushil K. Dash (India) presented the trends in seasonal mean summer monsoon over India based on the regional model RegCM CORDEX simulations over the South Asia domain. Projected seasonal (June–September) mean rainfall shows a gradual increase in the intensity over some of the regions. Model results also indicate significant increase in the maximum and minimum temperatures and a decrease in the occurrence of cold nights. Hiep Van Nguyen (Vietnam) presented the effects of ENSO on autumn rainfall in the Extended Central Vietnam (ECV) region. Autumn rainfall in ECV reduces by 10-30% under El Niño conditions (mainly due to a weakening of the North East monsoon circulation) and increases by 9–19% during La Niña years. La Niña conditions not only cause an increase in rainfall, but also change the temporal distribution of the monthly rainfall over the region, with more rainfall in the latter months of the year.

The conclusion of the workshop was that, with the growing collaboration within the framework of ANCST, a specialist research group should focus on Asian climatic phenomena related to the oceans of south and south eastern Asia, together with the science of the basic atmospheric–ocean interactions. Such a group could also explain the reasons for expanding measurement facilities, and help provide scientific information about changing climate and extreme conditions to communities and Governments.

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