summer monsoon (ISM) variability from the southeastern Arabian Sea. Feba Francis (University of Hyderabad) highlighted returning to the weakening teleconnections of Tropical Pacific and ISM/Rainfall. Syed Azharuddin (Birbal Sahni Institute of Palaeobotany, Lucknow) presented the high-resolution palaeoceanographic record off Saurashtra, NE Arabian Sea.

The workshop concluded with the overview of CMIP6 Pace Maker experiments by Christophe Cassou (CERFACS, France).

The workshop was followed by four days of training activity to run certain simulation experiments on the CMIP5 model. The results obtained using ICTP-SPEEDY model showed that ENSO impacts are relatively stronger over the Inter Tropical Convergence Zone region compared to extra-tropics and high-latitude regions. Positive phase of ENSO causes weakening of rainfall over Africa and East Asia, whereas La Nina phase produces more rain over these regions, particularly in the winter season. Model results further reveal that ENSO has stronger impact over South Asia, particularly over the Indian region because of its strong impact over the Indian Ocean and Bay of Bengal through Walker circulation. Results of geopotential height changes and wind vector at 850, 500 and 250 hPa further reveal that ENSO significantly impacts Hadley circulation. Positive phase of ENSO (El Nino) weakens the Hadley cell, whereas negative phase of ENSO (La Nina) causes strengthening of the Hadley cell. This ENSO-induced strengthening and weakening of the Hadley cell causes significant impact over Indian monsoon in summer.

The workshop provided an opportunity to the scientists, especially young researchers and students to interact with a galaxy of experts in climate change science from all over the world. Exchange of opinions/suggestions helped the participants, especially the students and young researchers to have a broad idea of the recent developments in present-day science of climate change as well as their correlation with the global climatic events, which could be of help in decoding and verifying the climatic models for prediction of future climate change, relevant to the society.

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MEETING REPORT

Asian urban environment and climate change*

A conference was held to review recent research on the changing environment and atmospheric conditions in growing Asian cities, especially in relation to global climate change, and how these cities may in turn affect regional and global climate, and how changing technologies, transportation systems and planning may mitigate these effects. The following summarizes the presentations made at this conference, with over 40 participants, to highlight the important issues that need to be addressed.

Using over 140 years of observations, Matsumoto (Tokyo Metropolitan University, Japan) found a rise in annual mean temperature of 3°C since 1900 in the Tokyo metropolitan area, compared with ~1.3°C in the rural areas. Extremes of hourly rainfall have also risen. Chen *et al.* (Sun Yat Sen University, China) suggested the use of high-resolution satellite observations to detect extreme local temperatures that could occur at locations with significant features of land use and anthropogenic emissions but that are often missed from standard weather-station data. In another study, Chen *et al.* (Sun Yat Sen University, Chinese Academy of Sciences and NOAA Climate Division, USA) also showed the emissivity of the surface material in urban areas using data from Landsat.

Lagmay (University of the Philippines) described a science-based disaster warning system that provides hazard maps for floods, landslides and storm surges from tropical cyclones. This system works through the participation of local people who transmit on-line data about flood levels to a centre where computer models predict the evolving hazard and impact in the affected areas; the warning is then sent back to the local communities.

Hunt *et al.* (University College London, UK) pointed out that with very high temperatures, weak winds driven by deep turbulent convection can vary markedly across the urban area due to surface conditions and density of high buildings, with the maximum towards the downwind part of the city. Li and Fan (University of Hong Kong, Hong Kong, China) found that in Hong Kong, temperatures within the central business district increase rapidly than those outside. The annual average wind speed also decreased until 1995, but has remained relatively steady since then. Using a laboratory model, they found buoyant

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plumes forming and circulating the air within an urban dome up to a height of about 500 m, where it is capped by a stable inversion.

To study the effect of urbanization in the megacity cluster in the Pearl River Delta (PRD), Chan and Cheng (City University of Hong Kong, Hong Kong, China) simulated the climate in that region over a period of 25 years using the Weather and Forecasting (WRF) model with a 20-km grid. The albedo and diurnal heating cycle have been changed substantially by urbanization such that the mean surface temperature has risen rapidly compared to global warming by about 1.4°C over the large conurbation. The pattern of precipitation has also changed. Just like other mesoscale disturbances in boundary layer flows, the large changes in surface conditions over the conurbation affect precipitation and temperature in areas more than 100 km downwind.

The critical question of whether the steady rise in the peak precipitation over cities is driven more by the size and physical nature of these urban areas or by global climate change was addressed by Holst *et al.* (City University of Hong Kong and Chinese University of Hong Kong, Hong Kong, China). They studied a pre-monsoon rainfall episode over the PRD region by running the 1-km resolution WRF model, focusing on how rainfall rates varied with anthropogenic heating and overall size of the urban area. The results confirmed that the highest precipitation rates above 100 mm/h are several times more likely to occur in large and dense urban areas than in rural areas, where the main cause of increase in precipitation is global warming.

Wang *et al.* (University of Hong Kong, Hong Kong, China) have reported a 50% decrease in the average wind speeds in Asian urban areas over the past 50 years. When the approaching winds are at their lowest values, the atmosphere is generally unstable with deep convection. Despite similar mean surface temperatures within and outside the urban areas, the vertical temperature profiles and turbulence structures differ, which leads to vertical upward currents near the urban areas, subsequently enhancing mixing of heat and pollutants, a process demonstrated from experiments in a large water tank.

To plan for housing for the high population density (~13,000 km^{-2}) in an overcrowded settlement of Bandung, Indonesia, Paramita and Fukuda (Indonesia and Japan) assessed the high temperatures, humidity and wind speed using the local scale of computationally-based environmental modelling and GIS. Koerniawan and Gao (University of Kitakyushu, Japan) proposed a new approach to urban design through the construction of 'super-blocks' of high-activity local buildings with varied uses to reduce net transportation in Jakarta, Indonesia.

The inaugural speech by Shi (Tsinghua University, China) focused on the challenge of minimizing high temperature and air pollution caused by the rapid growth of ground transportation in China, associated with transcontinental travel. These issues were taken up by Wu (Tsinghua University, China) for developing policies for low-carbon and sustainable transport systems based on advanced systems for measuring and controlling road transport, as well as new technologies such as electric vehicles and real-time information systems on the roadside and in vehicles. Studying the interacting roles of the individual driver and the central control system, in relation to the patterns of traffic and variable pollution across the urban areas, will lead to optimal solutions.

Yan (Royal Institute of Technology, Sweden) found that communities want to make their own choices in determining the amount of environmental risk they are willing to take, rather than accepting 'optimal solution' by planners, government and environmentalists.

Brimblecombe (City University of Hong Kong, Hong Kong, China) found that in street canyons, because of the weak dispersion and reduced chemical transformation in the air between the vehicle sources and the location of pedestrians in street canyons, toxicological impacts differ. This is important for developing policies relating street-level traffic to the environment, and also for the interpretation of data taken at these locations.

Using aerosol data from measurements taken at 12 levels on the 300-m meteorological tower in Beijing, Han (Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China) showed how aerosols can reduce the surface temperature significantly, although the deposition of black carbon may lead to a slight increase. Ning (City University of Hong Kong, Hong Kong, China) pointed out that to provide a much better depiction of pollution distribution, the next generation of air-sensing for urban air quality needs to include personalized and community-based air quality monitoring, in addition to the existing regulatory and stationary monitoring network. A real-time mapping of the population exposure to PM2.5 in Beijing was presented by Zhao (Tsinghua University, China) using medical data for lung cancer and heart diseases.

Using GIS methods, Guo *et al.* (Peking University, China and University of Illinois, Champaign-Urbana, USA) found exposure to PM2.5 and carbon monoxide to be maximum for people who moved outside of the buildings, and less for those who travel by vehicles, and even less for sedentary and elderly people. Jin *et al.* (Nanjing University, China) performed a similar study for Nanjing, China through simulations. Fung and Yao (Hong Kong University of Science and Technology, Hong Kong, China) described a forecast system for Hong Kong and the PRD that has been used for daily forecasts and policy studies.

Dey (Indian Institute of Technology, Delhi, India) reviewed how fog and pollutant aerosols interact in the Gangetic Plain in India, where agricultural practices have a larger overall effect than urban pollution exacerbated by a decline in the monsoon rainfall and high temperature in the region. Liu (Univ Kebangsam, Malaysia) analysed daily variations of PM10 over the Klang Valley, Malaysia, in relation to local and synoptic weather conditions, including forest fires. Based on local real-time measurements, Saini (Ambedkar University, Agra, India) analysed the chemical interaction among pollutants in the city of Agra, India under high temperatures.

Jadoon (Fatima Jinnah Women's University, Rawalpindi, Pakistan) studied the use of coal burning for the manufacture of bricks and cement in Pakistan, and suggested a transition of energy supply from coal to renewable energy sources to reduce the high levels of air pollution, especially in mountainous areas.

Patwardhan (Indian Institute of Technology, Mumbai, India) reviewed how the costs for greenhouse gas reduction should include the expected benefits, especially for reducing the increasing frequency of occurrence of natural hazards. Insurance could also play a greater role.

Jiang *et al.* (Tsinghua University, China) investigated how spatial planning of buildings and roads could lead to lesser use of vehicles. Although self-contained 'super-blocks' may not be effective in reducing the use of vehicles and emissions, they may be suitable for high-tech, low-emission transport such as electric vehicles and mass transit.

The major conclusion of this conference was that local levels of pollution in large urban areas are highly variable, and may be related to the increasing frequency of occurrence of natural hazards. Detailed studies of the urban structure, types of buildings and open space, and transport systems, together with detailed measurements and modelling of the atmospheric environment are beginning to provide forecasts and tools to find policies that minimize the impacts of pollution and natural hazards. However, such approaches must take into consideration the different topography, regional environment and climatology for the different areas and geographical latitudes of Asia. The influence on global climate and severe natural hazards resulting from growing emissions from Asian megacities are dominant factors that local and national policy makers will have to consider.

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