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NEWS

Monsoons: Past, present and future*

During the past three decades, there has been a remarkable progress in the understanding of the variability of the monsoon. Monsoon variability occurs on many time scales. They span the range of a few weeks to a few thousand years. In the last three decades, observations and computer models have identified the mechanisms that govern the variability of the monsoons on different time scales. These

developments were discussed in a discussion meeting on 'Monsoon: Past, present and future' held in Orange County (Coorg) in November 1997.

In his opening remarks, R. Narasimha (Indian Institute of Science and JNCASR) stressed the need to consolidate the knowledge we have gained during the past three decades about the variability of the monsoon; D. R. Sikka (former director, Indian Institute of Tropical Meteorology, Pune) provided a historical perspective of monsoon research in India over the last 120 years. He suggested that the monsoon research in India had three different epochs. These epochs were 1875-1947, 1948-1980 and 1980-1997. During the first epoch (i.e. 1875-1947)

the meteorological observational network was established. During this period it was apparent that the prosperity of India was inexorably linked to the summer monsoon rainfall all over India. The long-range forecasting of the monsoon began more than 100 years ago when H. F. Blandford discovered an association between snowfall in Eurasia and the Indian summer monsoon rainfall. Gilbert Walker, who was the Director General of Observatories in the early part of this century, discovered the association between all India monsoon rainfall and the large-scale oscillation in surface pressure in the southern hemisphere. He termed the see-saw in surface pressure between the West Pacific Ocean and East Pacific Ocean in

*A report of the discussion meeting on 'Monsoons: Past, Present and Future' held from November 20 to November 22, 1997 in Orange County (Coorg). This meeting was co-sponsored by Indian Academy of Sciences and Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR).

the southern hemisphere as the southern oscillation. The southern oscillation is linked to the variations in the east-west circulation in the tropics. The east-west circulation in the tropics is called the Walker circulation in honour of the pioneering contribution made by Gilbert Walker. During the period 1947–1980, several international observational programmes were launched to understand the monsoon. Some of these were the International Indian Ocean Experiment (IIOE) in 1964, Indo-Soviet Monsoon Experiment (ISMEX) in 1973, and Monsoon Experiment (MONEX) in 1979. These experiments and routine observations provided the first detailed picture of the vertical structure of the thermodynamical variables during the monsoon season. The launching of the Indian remote sensing satellite (INSAT) in early 1980s provided, for first time, an opportunity to monitor continuously the progress of the monsoon over the continent as well as the oceans. In the early 1990s the first indigenous observational experiment called MONTBLEX (Monsoon trough Boundary Layer Experiment) was launched. This experiment provided the first detailed measurement of the fluxes near the surface during the monsoon. Sikka concluded his talk by pointing out that monsoon research in India has entered a new phase with the launching of the Indian Climate Research Programme (ICRP) in 1997.

Sulochana Gadgil (Indian Institute of Science, Bangalore) made a brief presentation on the ICRP. She indicated that this programme was launched to harness the expertise available in India in atmospheric, oceanic and space sciences and utilize the facilities available for observation and modelling in the Department of Ocean Development (DOD), CSIR and the universities. The major objectives of the ICRP are: (i) to document the spatial and temporal variability of the monsoon climate, (ii) to understand the physical processes that lead to climate variability, and (iii) to understand the impact of climate change on natural and managed ecosystem.

In order to attain the objectives enumerated above, it is proposed to undertake analysis of existing data, gather new data from satellites and buoys, and organize special observational experiments in the Bay of Bengal. Sulochana Gadgil pointed out that there is considerable overlap

between the objectives of ICRP and the international programmes such as the World Climate Research Programme (WCRP) and the International Geosphere Biosphere Programme (IGBP), Gadgil remarked that the emphasis in ICRP will be on the monsoon climate that is a special feature of our region.

Murari Lal (Indian Institute of Technology, New Delhi) provided an overview of the simulations by coupled ocean-atmosphere models. He highlighted the variations in the Indian monsoon rainfall predicted by these models with an emphasis on future climate. In these models it is assumed that the amount of carbon dioxide in the atmosphere will continue to increase at the rate of 1.5 to 4.5 ppm per year over that next hundred years. These models also assume that the amount of sulphate aerosols in the atmosphere will also increase exponentially due to the increasing use of coal in China, Europe, America, Australia and India. Specifically, these models assume that the maximum sulphate aerosol loading in India will increase from the present value of 8 mg/m^2 to 40 mg/m^2 in fifty years. If the increase in CO_2 alone is incorporated in these models, they indicate that the all India summer monsoon rainfall will increase from the present value of 87 cm to around 112 cm by the year 2050. This would imply an increase in the all India monsoon rainfall by more than 25% in the next 50 years. This increase is well above the inherent inter-annual variability in the model. When the effect of increase in sulphate aerosol is incorporated in these models, they indicate a *decrease* in all India monsoon rainfall! This is due to the cooling of the continental surface on account of the reflection of solar radiation by the sulphate aerosols. Murari Lal cautioned, however, that the results obtained from these models cannot be used for making policy decisions since some of the parameters (such as sulphate aerosol loading) used in the model are not known accurately. In addition, most of the models show large variations in the Indian monsoon rainfall depending upon the numerical techniques used and the manner in which clouds and mountains are incorporated in the model. Many of these models do not reproduce correctly the spatial pattern of the present-day monsoon rainfall. He advocated the use of high-resolution regional climate model embed-

ded in a general circulation model. He claimed that such models provide a more accurate prediction of the spatial structure of all India monsoon rainfall. This lecture was followed by a spirited discussion about the reliability of climate models. Some of the participants argued that the spatial and temporal variability of Indian monsoon rainfall predicted by these models differs substantially from the observations and hence one cannot rely upon the predictions by these models regarding the monsoon in the next century. Some other participants argued, however, that some of the climate models have shown systematic and steady improvement in their ability to simulate the spatial and temporal variability of the Indian monsoon rainfall. All the participants agreed, however, that there is a need to characterize more precisely the sulphate aerosol loading over India based on the sulphur content of the Indian coal and the projections regarding increase in coal consumption in India over the next hundred years.

G. B. Pant (Director, Indian Institute of Tropical Meteorology, Pune) discussed the climate change in the Himalayas over the past thousand years as revealed by data from tree rings. The analysis of climate variation was based on 600 coniferous tree samples in Kashmir, Himachal Pradesh and Uttar Pradesh. The tree ring data does not indicate any temperature trend over the past two hundred years in the Himalayas. This is in contrast to the increase in surface temperature seen over the past hundred years in the data from the plains of India.

Chaya Sharma (Birbal Sahni Institute of Palaeobotany, Lucknow) provided an overview of the reconstruction of past climate using pollen data. The pollen analysis covered the regions from Kashmir in the Western Himalayas, Katmandu in the Central Himalayas to Sikkim in the Eastern Himalayas. In the Kashmir valley, pollen analysis suggests a cooler period around 10,000 years before present, followed by a gradual warming between 7000 and 4000 years before present. Pollen studies in Ladakh indicate that during the last 30,000 years the climate there was cold and dry. There were, however, brief periods when warm climate lasting about 2000 to 3000 years existed. About 1000 years ago there was a transition from moist to relatively dry conditions in the western Himalayas.

R. Ramesh (Physical Research Laboratory, Ahmedabad) reviewed the data available on past monsoons and the ability of climate models to simulate past monsoon. He showed that during the last glacial maximum (which occurred around 18,000 years ago), there was an increase in the salinity of the surface waters in the Bay of Bengal. There is evidence that the surface winds in the Arabian sea were 50% below the present values. This indicates a reduction in monsoon rainfall during the last glacial maximum. Around 9000 years ago the solar radiation incident in the tropics was about 7% more than present and the proxy data indicate that the monsoon rainfall was more than the present. The simulations of past monsoon using general circulation models show a linear relationship between the solar radiation incident at the top of the atmosphere in the tropics and the monsoon rainfall. Some models show that a 1% change in solar radiation causes a 2.5% change in monsoon rainfall.

R. Sukumar (Indian Institute of Science, Bangalore) presented results based on the use of stable carbon isotope ratio as indicators of past climate based on the different ecological requirements of different plant types. He discussed the classification of plants into C₃ and C₄ types on the basis of their photosynthetic pathways of carbon fixation. He showed

that C₄ plants (mainly tropical grasses) thrive under arid conditions while C₃ plants dominate when wetter conditions prevail. The ratios of ¹³C to ¹²C in the C₃ and C₄ plants are different because of the differences in the photosynthetic pathways of carbon fixation. He showed the variations in the ¹³C to ¹²C ratio in peat samples collected from a pit dug in the Nilgiris. He used this data to show that this region had arid climate during the last glacial maximum (about 18,000 years ago) and a wet period around 9000 years ago.

S. W. A. Naqvi (National Institute of Oceanography, Goa) discussed the regulation of the amount of CO₂ in the atmosphere by the oceans. The amount of carbon stored in the ocean is more than 50 times the amount of carbon stored in the atmosphere. Hence the exchange of CO₂ between the ocean and the atmosphere has a profound influence on the concentration of CO₂ in the atmosphere. At the present time around 7 billion tons of CO₂ is pumped into the atmosphere by the burning of fossil fuels and deforestation. Out of the 7 billion tons, 2 billion tons is absorbed by the oceans and 3 billion tons accumulates in the atmosphere and causes an increase of CO₂ in the atmosphere at the rate of around 1.5 ppm per year. Any change in the rate of absorption of CO₂ by the

ocean can cause a dramatic change in the CO₂ of the atmosphere. During the last glacial maximum (around 18,000 years ago), the CO₂ of the atmosphere was around 200 ppm which was lower than the pre-industrial value of 280 ppm and the present value of 360 ppm. The equatorial ocean is a source of CO₂ for the atmosphere while the ocean in the southern hemisphere acts as a sink. Naqvi highlighted the effect of deep-ocean circulation and nitrogen cycle on the CO₂ content of the atmosphere.

In the discussions that followed the presentation on palaeoclimate, many participants underscored the need to extend the observations to other regions of India so that the large-scale signal of climate variations can be deduced. Many participants highlighted that corals in the Indian seas may provide high-resolution data on past climate changes in the Indian region. The simulation of past climate using climate models was considered necessary in order to gain confidence in our ability to predict future climate.

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National Centre for Ultrafast Processes

During the last decade there has been enormous interest to study processes occurring in the solid state and condensed phase in real time by using techniques particularly in the picosecond (10^{-12} s) and femtosecond (10^{-15} s) domains. Many biological, chemical and other transport phenomena are known to occur from millisecond to a few hundred femtoseconds. In order to understand the fundamental dynamic processes for the development of new materials, study of the fast processes in various areas of physics, chemistry and biology has become important. Towards this, new lasers and techniques have been developed during the last two decades for investigating the dynamics of the ultrafast processes and physical properties occurring in clusters of atoms and molecules in real time in condensed phase and in solid state. Time resolved laser Spectroscopic

techniques are used in these studies for understanding transient phenomena.

Study of ultrafast processes paves the way to control the product of chemical reactions, angular distribution of photoelectrons and the evolution of vibrational wave packets of diatomic molecules. During the last two decades, lasers with ultrashort light pulses have been developed which are now available with pulses shorter than 100 femtoseconds. Using these lasers impressive pulse shaping and tailoring techniques have emerged that make it possible to control molecular dynamics. Investigations on ultrafast phenomena are aimed at developing technologies in the cutting edge of materials research: new catalysts for chemical transformation, nanophase materials, biotechnological process materials and molecular electronic and photonic systems.

The Department of Science and Technology (DST), Government of India has established a National Centre for Ultrafast Processes at Madras University. A separate building with laboratories, hostel and other infrastructure will be exclusively established for NCUFP in the Taramani Campus of the University with the support of the Government of Tamil Nadu. The Centre will have major facilities for (i) lifetime measurements by time correlated single photon counting, (ii) nanosecond pulsed laser systems for absorption and emission studies, and (iii) flash photolysis equipment using flash lamps.

Facilities also being established include (i) picosecond emission spectrometer and (ii) picosecond pump probe laser system.

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