

## Frontiers in earth and climate science\*

In the three-day Young Scientists' Conclave organized last year, about 150 participants from India, Bangladesh, Pakistan, Kazakhstan, Sri Lanka, South Africa, Maldives, and other countries of central and South Asia participated and presented their research findings as oral and poster presentations. The event was inaugurated by R. Narasimha (JNCASR, Bengaluru). The inaugural function was followed by invited thematic lectures by eminent scientists and presentations by young scientists with poster sessions, wherein different aspects of earth and climate sciences were discussed.

J. Srinivasan (JNCASR, Bengaluru) spoke on 'monsoon and climate change'. He was of the opinion that the land-sea contrast theory of monsoons is inadequate to explain changes in the monsoon in the 20th century, and hence is unsuitable for predicting the changes that will occur in the 21st century. He further elaborated that an alternative theory based on moist static energy budget is useful to understand how variability of the monsoon is influenced by carbon dioxide, aerosols and the sun. He also discussed the challenges faced by coupled ocean-atmosphere models in simulating the impact of climate change on the monsoon. Satish C. Shenoi (INCOIS, Hyderabad) talked about the understanding of the Indian Ocean warming. He discussed that the Indian Ocean is warming faster than the other oceans at the rate of  $2.1 \times 10^{22}$  J/decade and accounts for 93% heat. The warm Indian Ocean causes reduced rainfall over India. He further suspected the role of cross-equatorial cell in the perceived warming.

R. Ramesh (PRL, Ahmedabad) spoke on the 'Paleomonsoon studies from various monsoon proxies including tree rings, speleothems, etc.'. He reconstructed the monsoon over the past 10,000 years and

beyond through analysis of speleothems from various parts of India. He further discussed that there are several proxy records from East Asia and Oman reconstructing Indian Summer Monsoon (ISM) during the Pleistocene. However, a few records exist from the core monsoon zone of India covering this time-span. The importance of this period is recurring glacial-interglacial cycles. In tropical climates the glacial-interglacial periods are interpreted in terms of weakening or strengthening of the monsoon respectively. Response of ISM during these cycles is documented in studies carried out over the Indian Ocean and using various terrestrial proxies.

However, most of the terrestrial proxies which are direct recorders of monsoon focus on the last glacial maximum; hence, there is a lack of understanding regarding the effect of glacial millennial climate variability on ISM. With the absolutely dated (U-Th mass spectrometry) speleothems (direct recorders of ISM) in combination with the high-resolution stable isotope ( $\delta^{18}\text{O}$ ) or trace element (Mg/Ca/Sr/Ca and Ba/Ca) analyses, glacial-interglacial cycles can be studied in great detail. He also talked about the relationship between  $\delta^{18}\text{O}$  against salinity as a part of calibration.

Ravi S. Nanjundiah (CAOS, IISc) discussed the impact of climate change on intraseasonal variability of ISM. According to him, ISM has a rich intraseasonal structure. One of the ubiquitous signatures of this is the poleward propagation of rain bands from the equatorial Indian Ocean to the monsoon trough over the Indian land mass. Using TRMM rainfall data, he delineated different modes of intraseasonal variability. He divided the variability into two components – a high frequency intraseasonal oscillation (HF\_ISO) with a quasi-periodicity of about 10–20 days, and a low frequency intraseasonal oscillation (LF\_ISO) with a quasiperiodicity of 20–60 days. While the LF\_ISO is essentially a poleward propagating mode, the HF\_ISO has a richer structure consisting of northward propagations originating from the Sumatran coast and embedded with mid-latitude interactions. He further found

that there is an increase in extreme rainfall events during break phases of ISO which can reduce the LF\_ISO variability and increase synoptic variability. The recent decreasing trend in the mean ISM could be related to these changes.

S. Suresh Babu (VSSC, Thiruvananthapuram) spoke on aerosol and South Asian regional climate. Aerosols in solid or liquid form suspended in the atmosphere, are produced by both natural and anthropogenic activities and exert a variety of impacts on the environment. They can affect radiation, monsoon rainfall, stimulate tropical cyclones, cause droughts and floods, and affect regional climate through radiative forcing and microphysical effects. Aerosols directly affect the radiation balance of the earth-atmosphere system through scattering and absorption. They scatter radiation back to space, thus enhancing planetary albedo and exerting a cooling in the atmosphere, whereas the absorption radiation by aerosols such as black carbon causes warming in the atmosphere. He further discussed that aerosols also influence the radiation balance indirectly by altering the cloud optical properties, cloud water content and lifetime. Solar heating by absorbing aerosols can evaporate low-level clouds, resulting in a reduction in cloud cover and albedo leading to a net warming in the atmosphere. He also discussed the challenges in studying the impacts of aerosols on climate with reference to their immense diversity, size, composition and origin as well as spatial and temporal distribution. He further mentioned that the impact of aerosols on climate must be understood and quantified on a regional level rather than just a global average basis, despite the heterogeneity.

R. Srinivasan (IISc, Bengaluru) spoke on the geological characteristics of pre-Pleistocene glacial deposits of India. He apprised that global warming and cooling cycles have occurred several times in the history of the earth. We are at present recovering from the Pleistocene glaciation event that began 1.8 Ma. In India, geological evidence for pre-Pleistocene glaciations/cold climate has been ca. 2700 Ma, 2100–1900 Ma, 550 Ma and

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300 Ma. He further discussed that the striated and faceted boulders, dropstone–diamictite association, and pebble nests suggest that the 2700 Ma glacial deposits in the Dharwar Supergroup of Karnataka are ice-rafted glaciomarine deposits. The 2100–1900 Ma cold climate is evidenced by the occurrence of  $\delta^{13}\text{C}$ -enriched carbonate rocks in association with phosphorites of Rajasthan. The 1000 Ma cold climate is evidenced by the occurrence of dropstone bearing carbonate rocks in the Sausar Group of central India. The ~550 Ma glaciation event is recorded by Blaini Boulder bed in the Himalaya, which has diamictites rarely showing dropstones. They could be fluvioglacial to glaciomarine, capped by pink dolomites. The 300 Ma glaciation event is recorded by Talchir Boulder bed, which is diamictite with dropstones, indicating a fluvioglacial to glaciomarine environment.

Anil V. Kulkarni (DCCC, IISc) talked about the ‘Recent advances in Himalayan glaciology and future challenges’. He discussed the state of the Himalayan glaciers and possible changes in extent due to climate change. Glacier distribution is generally influenced by the mass budget, estimates of which are available for relatively few glaciers and for short duration. Kulkarni, on the basis of his research findings, suggested that there is a negative mass budget over past decades. The glaciers in the Himalayan region are losing area and mass approximately at  $12.6 \pm 7.5\%$  in 40 years from 1960 and  $-6.6 \pm 1$  Gt/year respectively. However, the loss in mass for many small glaciers located in the low-altitude range could be as high as  $1000 \text{ kg m}^{-2} \text{ year}^{-1}$ , which is an important source of water for many mountain communities. In addition, glacial retreat and mass loss will also be influenced by numerous local factors like formation of glacier lakes, deposition of black carbon, debris cover and topography, which provide a unique challenge in understanding future changes in the Himalayan glaciers having profound impact on water availability in micro, mini and major river basins of the Himalaya. Besides, retreating glaciers can also increase the possibility of glacier lake outburst flood and landslide, creating additional new hazards for the mountain community.

R. Chandrajith (University of Peradeniya, Sri Lanka) gave a talk on ‘Medical geology: a geoscience for the future’. He discussed about the chemistry of the lo-

cal geological environment which has a marked impact on the living organisms. The strong geochemical fractionation of chemical elements caused by periodic heavy rainfall and droughts can be observed in tropical regions where elements are either severely depleted or accumulated to toxic levels in the geological environment. The relationship between human health and the geoenvironment is clearly exemplified by several established cases of dental fluorosis, iodide deficiency disorders, arsenic poisoning, kidney disease with uncertain etiology and selenium-based diseases.

Rajiv Sinha (IIT, Kanpur) talked about ‘paleo-channels in northwestern India: the geoarchaeological context and groundwater prospects’. He discussed that the large perennial river systems are considered a pre-requisite to urbanization in Old Bronze-age civilizations, numerous Indus Civilization (~4.8 to ~3.9 ka). Urban-scale sites in northwest India are not located adjacent to extant Himalayan rivers. Palaeochannel traces observed in satellite imagery led to suggestions that such centres sustained by Himalayan river flow, termination of which contributed to Indus urban decline. Sinha, on the basis of his research findings, suggested a large buried fluvial system adjacent to the Indus urban settlements at Kalibangan (Rajasthan) and Banawali (Haryana). Isotopic fingerprinting of the buried channel sediments demonstrates that this palaeochannel was a former course of the Sutlej River, but optically stimulated luminescence (OSL) dating of sand grains indicates that river flow terminated by ~15 Ka, significantly earlier than Indus occupation. He also presented the groundwater-depleted areas in and around this palaeochannel based on various borehole datasets.

V. M. Tiwari (NGRI, Hyderabad) inferred water storage variability from Gravity Recovery and Climate Experiment (GRACE) satellite measurements over India. He appraised that uneven distribution of monitoring and utilization poses a greater challenge to quantify the variability and availability of water resources in different parts of the country. Satellite-based observations can provide a possibility to infer water storage variability on basin scale.

Anil Bhardwaj (VSSC, Thiruvananthapuram) spoke on ‘India to Mars: The Mars Orbiter Mission (MOM)’. He talked

about the Indian MOM, its challenges for the project, mission and launch vehicle, new technological requirements, mission constraints, strict timeline, and technological and scientific objectives and interesting science results. He also discussed about the future planetary exploration missions of India.

K. Rajendran (IISc, Bengaluru) spoke about the role of plate tectonics in the evolution of the earth as a habitable planet. J. N. Goswami (PRL, Ahmedabad) discussed about Chandrayaan-I and the future plans of ISRO towards basic understanding of the solar system. He enthusiastically talked about the technological possibility of sending satellites to planetary bodies. R. R. Yadav (WIHG, Dehradun) presented an interesting topic on the cultural implications of climate change, where he presented a case study on the Moghul invasion and the worst climate in Kabul.

The TWAS Regional Office Prize was conferred on Eric H. Karunanayake (University of Colombo, Sri Lanka) for his contributions in nurturing science in Sri Lanka despite the hurdles. He also delivered a lecture on ‘Building the Institute of Biochemistry, Molecular Biology and Biotechnology (IBMBB): hurdles and challenges’.

In the concluding session of the Conclave, eight young students from Central and South Asia were selected for oral presentations. Conclave provided an opportunity to young scientists from these regions to discuss the outstanding grand challenges in earth and climate science, and also discuss some of their recent research findings. Simultaneously, the conclave also provided a platform for the young scientists to promote networking and offered a unique opportunity for collaborative research by sharing their recent research findings, future plans and research interests.

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