

PERSPECTIVE

A Report of the Workshop on ‘Advances in Earth System Science’ Organized by the Department of Geology, Banaras Hindu University (BHU) and Indian Academy of Sciences (31st October – 1st November, 2018 at Varanasi)

N. V. CHALAPATHI RAO

Convener of the workshop & Editor-in-Chief, *Journal of Earth System Science*
Department of Geology, Institute of Science, Banaras Hindu University, Varanasi
221005. E-mail: nvcrao@bhu.ac.in



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Science, Scientists, and Society

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N. V. CHALAPATHI RAO

Convener of the workshop & Editor-in-Chief, *Journal of Earth System Science*

Department of Geology, Institute of Science, Banaras Hindu University, Varanasi 221005. E-mail: nvcrao@bhu.ac.in

A workshop on ‘Advances in Earth system science’ under the aegis of the Indian Academy of Sciences, Bangalore, convened by N.V. Chalapathi Rao (BHU) was held from 31st October – 1st November, 2018 at the Banaras Hindu University, Varanasi. The workshop was a part of the 84th Annual meeting of the Indian Academy of Sciences. An editorial board meeting of the *Journal of Earth System Science* (*JESS*; published by the Indian Academy of Sciences) also was held during that time. About 50 delegates (Fellows of the Indian Academy of Sciences and the editorial board members of the *JESS*) belonging to the various domains of earth system science viz., earth, planetary, atmosphere and oceans, gathered on a common platform to deliberate on various contemporary topics. Five technical sessions were convened and twenty one talks were held.

The inaugural lecture was delivered by Vinod Gaur (CSIR - 4th Paradigm) who emphasised the importance of the First principles approaches to address fundamental problems in Planetary Sciences Research and Education. New views of the origin of the solar system were updated by J.N. Goswami (PRL). The Himalaya is one of the places on the earth where seismicity is a grave concern. V.C. Thakur and B.R. Arora (WIHG) provided an overview of Seismotectonics of the domain and stressed on the role of Plate boundary and wedge thrust earthquakes. The evolution of various branches of earth sciences and their culmination into earth system science was traced by R.N. Singh (IIT-G). Crustal architecture and Moho topography beneath

the eastern Indian and Bangladesh margins from latest marine data sets were presented by K.S. Krishna (UoH). Based on the diffusion chronometry of garnet grains S.K. Bhowmick (IIT-KGP) brought out pulsed tectonic patterns in the evolution of early earth hot orogens. Based on the presence of Martian rare mineral jarosite, Saibal Gupta (IIT-KGP) postulated that analogous environment can be found in the Rann of Kutch and documented the presence of jarosite. R. Bhutani (Pondicherry Univ) summarised the various radiogenic isotopic clocks used to under the evolution of the earth and summarised their pros and cons. The importance of self potential method in subsurface exploration of mineral deposits was demonstrated by A. Biswas (BHU).

Biomass burning is a major hazard especially in the Northern India. Chemical characterisation of the carbonaceous aerosols and their implications to atmospheric radiative forcing and climate was elucidated by M.M. Sarin (PRL). Glacial melting due to enhanced temperature is a global problem. S.K. Bhattacharya (IIT-KGP) demonstrated, from oxygen isotopes, a decrease in snow/glacier melt contribution during 2002-2004. Prediction of monsoon and climate is a challenging problem. A.K. Sahai (IMD) enumerated the challenges involved in subseasonal predictions. The atmosphere and oceans are coupled systems and this aspect is further explored by V.V.V.S. Sarma (CSIR-NIO) who provided evidence of modification of coastal waters by atmospheric deposition pollutants. Depleting groundwater is a major concern of the Northern Indian plains and A. Mukherjee (IIT-KGP) delineated the measures for groundwater security of India. The role of tropical Indian ocean warming and its impact on regional climate is highlighted by C. Gnanaseelan (IITM, Pune). By using a time varying model temporal evolution of hydroclimatic teleconnection and long-lead prediction of Indian summer monsoon rainfall was demonstrated by R. Maity (IIT-KGP).

An exclusive session was devoted to the Young Associates of the Indian Academy of Sciences. Various ways to estimate spatio-temporal variations of surface water availability at regional scales and their challenges and opportunities were provided by Riddhi Singh (IIT-B). Dating of lunar surface morphology by various remote sensing techniques was provided by K. Yhosu (Nagaland Univ). Evidence for high rates of nitrogen fixation in the Arabian sea was presented by Arvind Singh (PRL). A numerical method for flood risk assessment was given by N. Hazarika (Nagaland Univ).

The valedictory session was addressed by Ram Ramaswamy (President of the IASc) and Rakesh Bhatanagar (VC, BHU) and several delegates (A.K. Singhvi, M.M. Sarin, V.C. Thakur, P.C. Pandey, Riddhi Singh, Arvind Singh and R. Navalgund) expressed their views regarding future courses of action which are summarised below:

- Atmospheric deposition of iron dust, via dry-fallout and wet-scavenging, is a dominant external source of iron to the open ocean. Further studies are needed to consider these issues and impact on ocean surface biogeochemistry by utilising a wide range of approaches from fundamental chemistry, through modelling and field work.
- Although no quantitative estimates are yet available for rapidly changing GHG (greenhouse gases) budget of Asia, the direct/indirect evidence of ocean acidification (OA) due to CO₂ and other anthropogenic gases are catching-up the attention of the scientific community. A systematic study comprising of modeling combined with regional air-to-sea fluxes of the relevant species is most

- essential to assess relative impacts of CO₂ versus the other anthropogenic gases to coastal waters.
- Workshops like this one should be organized routinely to allow free interaction between various disciplines of Earth System Science. In the future, such workshops may also be thematically oriented to include scientists from at least one different discipline than Earth Sciences to foster inter-disciplinary work. For example, a workshop on ‘Societal contributions of Earth Science: past, present and future’ can also include some social scientists and economists, who will help move forward the discussion on policy implications of Earth Science research.
- An understanding of the way humans are altering natural hydrologic cycles via various interventions should be looked into. We need to understand how these alterations can be managed to sustain the coupled human-natural systems. This effort requires a combination of data collection as well as modeling exercises.
- In view of the likely known impacts of climate change, understanding hydrology of the river basins of north India is very crucial. Impacts on agriculture, availability of drinking water for the large masses are socially relevant. While there have been many investigations, they either confine to smaller regions or look at a specific science issue. What is required is to look at the problem holistically and on the basin scale. This requires a networked, coordinated large project with expertise of many individuals and organisations. It also requires strong scientific leadership.
- India has had launches to the moon and Mars and in future Chandrayaan 2, Mars 2, Venus, etc. The group of Earth System Science should proactively participate in generating ideas, formulating science objectives of the missions and also in building instruments.
- The need to establish a theoretical physical mineralogy branch in India is felt which required strong integration of thermodynamics and computational chemistry.
- Increase interactive ocean-atmosphere studies to unravel how oceanic and atmospheric processes influence the biogeochemistry. Understanding the role of the thickness and intensified oxygen minimum zone influence the pelagic and benthic community. Development of coupled biogeochemical-physical for Indian Ocean as most models fail to capture the processes in this region.
- Integration of Geology and Geophysics departments of the country under one umbrella "Department of Geosciences" or "Department of Earth Sciences".
- Inclusion of programmes like Hydrology in Geosciences. although many civil and agriculture Departments have already included it in their courses and research.
- Some introductory courses on fluid dynamics as related to mantle convection should be included. Emphasis should be more on quantitative research rather the subjective like palaeo research.

The main takeaway from the workshop is the utmost need felt for integration of various disciplines of the Earth system science to address scientific problems of contemporary importance. The role of modelling and addressal of global scientific problems by Pan Indian large working groups was also highlighted. The sessions were well attended by ~ 300 students, research scholars and faculty of Banaras Hindu University.