Preface

Regional aerosol warming experiment – Ganges Valley aerosol experiment (RAWEX–GVAX)

Climate change has great significance in Asia in general, and India in particular due to its diverse geographical features and high population density. It is now well known that atmospheric aerosols have a decisive role in perturbing regional and global climate. Ground-based and satellite-borne measurements have shown that the Indo-Gangetic Plains (IGP), which extends from western desert, across the plains and over to the Bay of Bengal and one of the densely populated and rapidly developing regions of the subcontinent, has some of the highest and persistent aerosol optical depths (AOD)/loading, especially during the dry winter and pre-monsoon seasons. This is also one of the regions across the globe that shows a persistent steady increasing trend in AOD; increasing surface dimming; and enhanced mid-tropospheric warming. The regional climate implications, resulting from the perturbations to regional radiative balance through direct, indirect, and semi-direct effects of this high and increasing aerosol loading, are shown to significantly impact the monsoon rainfall, hydrological cycle, and the snow-cover over the Himalayas, (which feeds the major rivers flowing through this region with fresh water and act as the lifeline for its millions of population), though the exact nature and extent of this impact are not unequivocally understood or quantified. As such, this topic has been a central theme of research in aerosol–climate interactions, not only in India, but over the globe as well. Several scientific programmes as well as concerted field experiments have been conceived and executed over to better understand the above issues. The Indo-US field experiment, RAWEX–GVAX (Regional Aerosol Warming Experiment–Ganges Valley Aerosol Experiment), conducted during 2011–12 jointly by the US Department of Energy, Indian Institute of Science, Indian Space Research Organisation (ISRO) and Department of Science and Technology has been another major effort in this direction. This utilized the ARM Mobile Facility (AMF) of the Department of Energy of the USA, deployed at the ARIES (Aryabhatta Research Institute for Observational Sciences), Nainital for the period from June 2011 to March 2012. Several aerosol and atmospheric parameters were measured using the AMF, concurrently with those from a number of aerosol observatories established under the Indian initiatives. The other major component, RAWEX, aimed at quantifying the climate implication of the atmospheric warming produced by the absorbing aerosols.

Over the years, the Ganges valley has undergone rapid industrialization. Coal still remains the primary energy source. The region is dotted with a number of large and super thermal power stations, cement factories, and steel mills; all extensively using coal as fuel. Climatologically, a high-pressure ridge over the wintertime IGP confines the pollution within the shallow atmospheric boundary layer (ABL), leading to enhanced concentrations, especially near the surface. The synoptic regional wind is dominated by westerly flow, conducive for advection of significant quantity of mineral dust from the western Thar Desert and the vast arid regions of the Middle-East and Africa. The period during late December and early January marks the traditional planting of the year's second crop in much of the Ganges valley. This is preceded by large-scale burning of the agricultural residues of the previous harvest, adding significant aerosols to the regional aerosol mix. The northwesterly winds at the 850 hPa level favour long-range transport of biomass burning plumes. Aerosols during this period would better represent the anthropogenic component of the composite aerosols in this region and aid in evaluating their impacts at regional and global scales.

These issues have been in the centre stage of aerosol-climate research in India. Several focused programmes and field experiments have been conceived and executed to address these. A major outcome has been the establishment of a network of aerosol observatories under the ARFI (Aerosol Radiative Forcing over India) project and air-borne measurements of crucial aerosol parameters under RAWEX; both being executed under the ISRO-Geosphere Biosphere Programme (I-GBP). Realizing the overlapping scientific objectives of these two experiments, the domain of interest, the infrastructure needs and expertise involved, and the other complementary experiments existing in this region, a joint experiment RAWEX–GVAX has been formulated. The rationale of conducting such a major experiment included the fact that the monsoon systems occupy and impact about 30% for the world's land mass and impact a large fraction of the world population and the aerosols have a decisive impact on monsoons. The monsoons represent a collective thermodynamic response of the atmospheric–oceanic coupled system, modelling of which demands coupled Earth system models and excellent validation. In addition, South Asia exhibits extensive cloud cover from early spring to summer, modulating the regional energy budget, the intrinsic dynamics of the system, and a potential for the local pollution to affect the sequence of events that lead to monsoon by changing regional and local energy budgets. As such, this field campaign has its focus on measurements of clouds, precipitation, and complex aerosols to study their mutual interactions. The comprehensive dataset thus generated could be used to constrain convection, cloud properties and aerosols.

These data have been analysed as well as synthesized with model simulations and a number of publications providing deeper insights into aerosol–radiation–cloud interactions have emerged. RAWEX and GVAX together have brought out a number of significant results. Besides, there are results, which have strong relevance to RAWEX–GVAX, but have emerged from longer-term databases and experiments (under RAWEX), falling beyond the period of the field experiment, and also from experiments and campaigns carried out subsequent to RAWEX–GVAX. The highlights, especially focusing on the vertical distribution, trends and gradients, are detailed in the succeeding articles. This special section provides an overview of this experimental programme in the backdrop of the evolution of aerosol research in India, and its main findings through a series of papers.

K. Krishna Moorthy
S. K. Satheesh
V. R. Kotamarthi
–Guest Editors