Preface

Characterizing the optical, physical, and chemical properties of atmospheric aerosols, and the spatio-temporal heterogeneities in these caused by the distributed nature of the sources and sinks, the meso-scale and synoptic scale dynamics of the atmosphere, and long-range 'transboundary' transport at different altitude levels, with specific focus on the Indian mainland and the surrounding oceans is of great importance in assessing the radiative impacts and the consequent regional climate implications. Such efforts call for a comprehensive approach, such as making campaign mode observations using a variety of instruments over multiple platforms over the land, the ocean and in the atmosphere (including space). To accomplish these objectives, an exhaustive field experiment, **Integrated Campaign for Aerosols, gases and Radiation Budget (ICARB)**, was conceived and successfully accomplished by the Indian Space Research Organization under its Geosphere Biosphere Programme (ISRO-GBP), during March – May 2006. This unique and most exhaustive national endeavour had the participation of more than 120 atmospheric scientists from various institutions in India, and deployed a variety of instruments. A network of 14 aerosol observatories over the Indian mainland and two islands (one each in the Arabian Sea and the Bay of Bengal (BoB)), a fully dedicated, carefully instrumented cruise of the research vessel *Sagar Kanya* for a period of 64 days, and an instrumented aircraft making 26 sorties from 5 bases, were all executed in tandem to collect exhaustive scientific information of aerosols and the state of the atmosphere around the Indian region and adjoining oceans. An experiment of this magnitude was conducted for the first time, not only in Asia but perhaps, over the entire globe as well.

After the completion of the experimental phase of ICARB in May 2006, the voluminous data have been examined by scientists to understand the various aspects of aerosols and gases, in line with the project objective. This special issue of the *Journal of Earth System Science* is a compendium of 18 scientific papers from various groups describing and discussing their findings. Each of these papers has been accepted after peer review in keeping with the journal's policy. It is my pleasure to thank Dr. D Shankar, Associate Editor, *Journal of Earth System Science* who handled several of these papers. It is also my pleasure to acknowledge all the reviewers who have evaluated the papers in depth and critically and made several suggestions to improve the quality of the papers.

The lead article of this issue by **Moorthy *et al*** provides an overview of ICARB, the objectives, rationale, methodology, various segments, the details of experiments carried out in tandem on different platforms, and a flavour of some of the important results obtained. The vertical distribution of aerosol properties and concentration of absorbing aerosols in the lower atmosphere is strongly influenced by the boundary layer dynamics, prevailing circulations, size distribution of aerosols near the surface, and the concentration of precursors. The information of vertical distribution of aerosols and clouds is extremely important in aerosol radiative forcing and aerosol cloud interactions. It also helps to identify elevated layers of aerosols that are amenable for long-range transport. The ICARB has therefore focused on this aspect through the dedicated air segment, in which the altitude distribution of aerosols was measured using instruments mounted onboard the NRSA aircraft. The papers by **Babu *et al*** and **Gopalakrishnan *et al*** present some of the significant findings from these measurements. Interestingly both papers show an increase in the mass concentration of BC and number concentration of nucleation mode aerosols at higher levels, above the well-mixed region. Long-range transport and new particle formation are suggested. The role of the marine atmospheric boundary layer in the vertical transport of sensible and latent heat fluxes, and their contrasting spatial patterns are discussed by **Alappattu *et al*** based on balloon-borne GPS sonde measurements from the research vessel and

this information was supplementary to the aircraft data. During the same period the altitude profiles of extinction coefficients of aerosols over the central mainland was measured continuously using a lidar at Pune, by **Raj *et al*** who observed strong elevated aerosol layers at 2 to 3 km altitude level.

While these measurements were progressing over the ocean and in the atmosphere, the network of 14 aerosol observatories, spread over the Indian mainland and islands in the Arabian Sea and BoB, measured the temporal evolution of aerosol properties over distinct environments. A synthesis of the spectral aerosol optical depths (AOD) and the derived Ångström parameters is presented by **Beegum *et al*** who also delineate the role of long-range transport of mineral aerosols from west Asia in modulating the aerosol characteristics, with a characteristic regional distinction. During the same period, examining the oceans around India, **Moorthy *et al*** and **Nair *et al*** conclude that the Bay of Bengal has a higher concentration of aerosols at all sizes, both within the boundary layer as well as in the vertical column, compared to the Arabian Sea. They also show that the BoB has a higher abundance of accumulation mode aerosols than the Arabian Sea. **Nair *et al*** also show regions of extremely low aerosol concentration in the Arabian Sea associated with large-scale subsidence. Chemical speciation of aerosols in the Marine Atmospheric Boundary Layer leads to source identification and apportionment. It also helps to delineate the relative dominance of natural and anthropogenic aerosols in different regions of the oceans. The papers by **Kumar *et al***, **Nair *et al*** and **Reddy *et al*** present details which indicate that the BoB is more anthropogenically impacted than the Arabian Sea and the coastal regions adjoining the peninsula have more abundance of non-sea-salt species. They also point out that the southern Arabian Sea had more of a relative abundance of mineral dust than the northern Arabian Sea, almost contrary to the normally expected pattern for this season, and attributed it to the prevailing lower tropospheric circulations. Modelling the large-scale atmospheric dynamics in terms of the wind convergence and vorticity, **Aloysius *et al*** brought out the role of wind convergence and vorticity in causing the spatial heterogeneity in AODs over the Bay of Bengal. Besides these studies, satellite data have also been used to infer on the large-scale spatial pattern of aerosols. The papers by **Misra *et al*** and **Ramachandran and Kedia** describe the results from the data derived from OCM and MODIS satellites.

The paper by **Vinoj *et al*** based on multi-instrumented aerosol characterization from the Minicoy Island in the Arabian Sea, brought out the impact of long-range transport from west Asia on the one hand, and the pristine nature of the island environment in the absence of transport on the other. Region specific results are also reported from Patiala (**Singh *et al***) and the high-altitude station Nainital (**Dumka *et al***) which show contrasting patterns and demonstrate the spatial heterogeneity on the mainland, indicating the need for more spatially resolved measurements of accurate characterization of the aerosols and gases. Using ground-based and satellite data, **Badrinath *et al*** examined the environment around the urban center, Hyderabad, and showed the significant impact of forest fires on the species concentrations. The paper by **Niranjan *et al*** examines the spatial gradients over the BoB using simultaneous ship-borne, satellite and land-based data from Visakhapatnam.

The ICARB was a national endeavour. More than 100 scientists from 26 institutions including national laboratories, academic institutions, and universities, contributed to its success. Though it would be difficult to list them by name, the research outputs from these investigators appear as scientific papers in this issue. Nevertheless, it is essential to put on record the immense help and total co-operation extended by the Director, NRSA; its aircraft team headed by Dr. K Kalyanaraman, and Mr. V Raghu Venkataraman and the technical team, who were ready to flex schedules of the aircraft to suit the experiment requirements. Excellent support and facilities were provided by the National Centre for Antarctic and Ocean studies, which provided the research vessel for a period of two months dedicated for this campaign. The support received from Dr. Rasik Ravindra, Director NCAOR, and Dr. M Sudhakar, Mr. M M Subramaniam and his team is gratefully acknowledged. The support provided by the India Meteorological Department in making the regular meteorological measurements as well as balloon ascents from the ship was creditable. I also sincerely acknowledge the full co-operation and timely help rendered by Mr. Rolan Profugo of Springer and Ms. Hema Wesley of Indian Academy of Sciences, in all aspects related to this special issue.

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