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**Editor**

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Cover Photo: Contrast between a clean and discoloured surface of the marble Mosque dome at the Taj Mahal (Courtesy: Bergin et al., Environ. Sci. Tech., 2014)

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# IASTA-2014 CONFERENCE: A BRIEF REPORT

IASTA-2014, the biennial aerosol science and technology conference of Indian Aerosol Science and Technology Association was organized in Varanasi, India in the green campus of Banaras Hindu University. The conference brought together researchers, students and technologists in one platform to discuss recent advances in various fields of aerosol science and technology over three days (November 11-13, 2014). The theme of the conference was "*Changing aerosols in changing climate: Impacts on monsoon and* glaciers". 193 extended abstracts, 11.5% higher than the previous IASTA Meeting, were accepted after peer-review by the technical program committee. The aims of the IASTA-2014 were as follows:

- To discuss the development of Indian Aerosol Science and Technology on a common platform
- To encourage exchange of data and views in the field of aerosol science and technology
- To contribute to the development of aerosol science in India
- To discuss the possible collaborations and networked efforts within the Indian subcontinent

Prof. S. K. Dash (IIT Delhi) gave the key-note address. Besides the contributed papers, six invited talks summarized the recent advances and highlighted the future needs in four important sub-disciplines of aerosol research. Prof. Y. S. Mayya (IIT Bombay) presented an overview of nucleation modelling of nano-particle formation. Prof. P. C. S. Devara (Amity University, Haryana) discussed about aerosol-rain-climate interaction in India. Prof. S. N. Tripathi (IIT Kanpur) summarized the observational studies that are being carried out at IIT Kanpur to understand the role of carbonaceous aerosols on the regional climate. Dr. Sachchidanand Singh (NPL Delhi) highlighted the issues regarding aerosol direct radiative forcing estimates over India. Dr. S. Suresh Babu (SPL, VSSC) talked about the potential impact of aerosols on Himalayan glaciers. Prof. R. Baskaran (IGCAR) presented the studies on atmospheric dispersion of aerosols for impact assessment.

The conference attracted large participation from the industry, where several state-of-the-art instruments were exhibited. The list includes - *Alfatech Services* representing *Grimm Aerosol Tecnik, GmbH, TSI Instruments India Pvt. ltd.* representing *TSI Incorporated, USA* , *Tesscorn Systems India Pvt. Ltd.* representing several companies (e.g. *Cambustion Ltd., UK; Digitel Elektronik GmbH*; *Droplet Measurement Technologies, USA*; *Ecotech Pty Ltd., Australia*; *MSP Corporation, USA*; *Palas GmbH*; *Sunset Laboratory Inc., USA*), *Mars Bioanalytical Pvt. Ltd.* representing *Aerodyne Research, USA, M&G Analyzer Systems* representing *BGI and Magee Scientific, USA,* and *AMSH Product Line Pvt. Ltd., India*.

One of the highlights of the conference was award distribution ceremony to encourage participation of young students. In the "Platform presentation" category, Ms. Lakshmi, N.B. (SPL, VSSC) and Ms. Hema P. Aswathy (IIT Madras) bagged 1st and 2nd prize, respectively. The 3rd prize went to Mr. Sourangsu Chowdhury (IIT Delhi). In the "Poster presentation" category, 1st prize went to Ms. K. Satinder (NEERI), while the 2nd and 3rd prizes went to Mr. Sushant Das (IIT Delhi) and Mr. Anand Kumar (IIT Kanpur).

# Remote Sensing of Aerosols: Research Gaps and Needs in India

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## RATIONALE

Atmospheric aerosols exhibit large temporal and spatial variability due to a variety of production, removal and transport processes. The diversified sources (both natural and anthropogenic) and short life time result in the aerosol characterization a real challenge. The interesting phenomenon such as “Atmospheric Brown Cloud (ABC)”, occurring during the winter period and its impacts on health, agriculture and climate on both regional and global scales, has led to considerable concern and further intense research. Besides the paucity of sufficient experimental data in the region, study of the variability in natural aerosols is noticed to be one of the critical issues that aids for better understanding and analysis of this complex problem. Aerosol radiative forcing is recognized to be one of the largest sources of uncertainties in assessing future climate change. The direct radiative forcing of anthropogenic aerosols from sulphates, fossil fuel soot, and organic aerosols range from –0.25 to –1.0 $Wm^{-2}$ while the indirect radiative forcing estimates range from 0 to –1.5 $Wm^{-2}$. The radiative forcing of greenhouse gases on the other hand ranges from +2.1 to + 2.8 $Wm^{-2}$. These estimates show that the magnitude of aerosol radiative forcing is almost equal to that of greenhouse gases but opposite in sign. Thus the issue underlying potential aerosol-climate interactions needs thorough understanding of the presence of aerosols and their associated radiative effects, both in the context of the present-day climate and climate change scenarios. Long-term measurement of aerosol properties is an essential requisite for such exercises including seamless prediction and verification of the presence of aerosols in climate modification.

The aerosol optical depth, which may be derived from measurements of attenuated direct solar radiation, is a measure of aerosol radiative forcing at all the temporal and spatial scales. To better understand the direct and indirect aerosol effects, it is necessary to know not only the aerosol optical depth, but also the aerosol scattering and absorption properties separately, and their vertical profiles. The radiative effects of aerosols on regional climate forcing can be better understood by isolating the local influences. Moreover, there is a lack of knowledge about the distributions of aerosols in the free troposphere, particularly in the tropical zone ─ one of the less-studied regions of the Planet. The aerosols in the boundary layer are directly produced from the natural and anthropogenic processes while those in the troposphere and aloft are largely due to gas-to-particle conversion processes. Thus the boundary layer aerosol system is different from that of the troposphere. As a result, removal of boundary layer aerosol component from that of the columnar (in quiescent conditions), grossly represents free tropospheric aerosol component. In the last few years, the interest in the local/regional/continental/hemi-spherical/global distributions and associated large-scale effects of free tropospheric aerosols has increased. Most such observations are sporadic, for short periods of time and for only a few places on Earth.

Currently, aerosol forcing estimates are obtained primarily from models. In order to obtain information on wider scale and global level, the satellite-based remote sensing data need to be used. For better characterization of aerosol properties, multi-angle and polarization remote sensing data are also required. For this purpose, suitable methods for retrieving aerosol parameters over large areas need to be developed by way of both the experimental and modeling approaches. Besides more campaign-mode experiments that are needed to establish the results, there is also a necessity to establish statistical significance of the results by making model runs for several decades and using ensemble technique to isolate the model variability in the retrieval of aerosol parameters.

While the retrieval of the spatial and temporal distributions of aerosols on a global scale is a task for satellite measurements, the increased emphasis on satellite aerosol retrievals has created the need for accurate ground-based, ground-truth aerosol measurements with which to validate satellite aerosol retrievals over land. In addition, measurements from ground-based lidars and sun photometers can be used to produce land-based aerosol climatology and that is complementary to the satellite retrievals.

**BACKGROUND**

Aerosols affect the climate in several ways. They can influence the radiation budget and hence dynamics directly by interacting with solar and terrestrial radiation, and indirectly by their effect on cloud microphysics, precipitation and albedo. In addition, the aerosol residence time and transport mechanisms are different in different regions of the atmosphere. While a great deal of attention has been directed towards the influence of stratospheric aerosols on climate, the treatment of tropospheric aerosols, particularly in the boundary-layer where the natural and anthropogenic contributions are significant, has become a difficult task mainly because of their shorter residence time.

Albeit the parameters such as columnar aerosol optical depth (AOD) and corresponding size distribution are useful for the study of seasonal and long-term trends. Apart from the regular measurements of aerosols using lidars and solar radiometers at different research and academic institutions, several field programs mainly aimed at "characterization of aerosols" have been carried out in India; most of them have been conducted in campaign-mode. With the initiation of the MONsoon EXperiment (MONEX-79); Indian Middle Atmosphere Program (IMAP); Geosphere Biosphere Program (GBP); INDian Ocean Experiment (INDOEX); Indian Climate Research Program (ICRP, and now ICRB, Indian Climate Research Board) and with the establishment of scientific bodies such as Indian Aerosol Science and Technology Association (IASTA), scientists are able to coordinate their research work more effectively in advancing the knowledge in the field of Aerosol Science and Technology.

**FUTURE SCOPE AND NEEDS**

Considering the continuation of aerosol observations from the ongoing research programs, and more new proposal for making detailed aerosol measurements, using portable systems, at several places in the country are coming up, with spatiotemporal variations and long-term trends in aerosol burden over India can be better understood. Such observations, both at single location by individual organizations and also at multiple-sites/multi- parameter/multi-institutional collaborative programs through campaign-mode experiments/modeling efforts will help to reduce the existing uncertainties due to aerosol and pre-cursor gas emissions. Such aerosol climatology will also help to reduce the existing uncertainties due to aerosol emissions.

Albeit the complete list is very exhaustive, some of the high-prioritized areas in which the aerosol studies are of immediate need are indicated in the paragraphs to follow:

i) Land and Marine Aerosol Climatology

In India, studies on the characteristics of aerosols up to stratospheric altitudes, using the data over longer period, have been carried out, so far, at Pune, Trivandrum, Visakhapatnam, Bangalore and at Background Air Pollution MoNitoring (BAPMoN) stations of India Meteorological Department (IMD). These data sets have been archived using ground-based lidar and solar radiometric methods and they have been utilized for studying recent long-term changes and trends in the boundary-layer aerosol loading, air quality and turbidity. The results show significant inter-annual and intra-seasonal variability and increasing trend in aerosol loading, but the year-to-year variability shows a strong dependency on local influences like monsoon precipitation etc.

As most part of India is surrounded by oceans, development of marine aerosol climatology, particularly over the Bay of Bengal, Arabian Sea and Indian Ocean needs to be strengthened, particularly to understand their impact on Indian monsoons. Albeit some data have been or being collected during the major research programs in India such as MONSOON- 77, MONEX-79, INDOEX-India, BOBMEX, ARMEX, ARFI, ICARB, more data covering different aspects of aerosols, are to be acquired by utilizing the cruises available for future research programs.

ii) Aerosol-Precipitation Relationship

The correspondence between atmospheric aerosol distributions and precipitation on different spatiotemporal scales needs further examination, understanding and development. These studies primarily require database for longer period, and more details about the aerosol (particularly hydrophilic or hydrophobic in nature) physico-chemical properties, dynamical and aerosol-cloud coupled processes. Studies undertaken using long-term data sets of boundary layer aerosol archived at Pune and Trivandrum suggest a fair agreement between aerosol loading and monsoon precipitation. Such information over other places in the country will play a vital role in understanding the role of aerosols in the Indian monsoon, and the ways to forecast its behavior.

iii) Effect of Absorbing and Non- or Less-Absorbing Aerosols

Information on absorbing and non-absorbing aerosols is essential for evaluating their impact on Earth-atmosphere radiation balance. Most of the observational data sets available, so far, in India limited to non-absorbing or less-absorbing aerosols. Hence, suitable experimental methods need to be developed for the measurement of absorbing aerosols such as carbon (elemental or black, organic, brown and yellow) and biomass aerosols. In this context, the black and organic carbon aerosol observations initiated at SPL, Trivandrum; PRL, Ahmedabad and IITM, Pune followed by some more institutes would supplement this information to some extent, but regular measurements at other key carbon-rich locations in India, in a network mode, are highly essential to understand the regional effects of absorbing aerosols in regional/global climate change.

iv) Establishment of Network with Existing Lidars and Setting-up of Aerosol Monitoring Facilities in the North-Eastern (NE) Region

There is an immediate need for the establishment of a network with active remote sensing facilities such as lidars available in the country for better understanding of the site-time-height variations in aerosol characteristics, on regular basis, and eventually for obtaining aerosol climatology for the study of aerosol properties under different environments and meteorological conditions, and related large-scale aerosol dynamics and wave activity. In this context, the programs such as I-LINK (Indian LIdar NetworK), proposed by PRL should be promoted. There is also a need for setting-up of aerosol measurement facilities including lidar in the north-eastern region where such observations are very sparse. The proposed, well planned, observational program at Mayapuri, Darjeeling would be a good beginning and it is expected that this program would also cover a few more stations in the NE region in the near future.

v) Effects of Aerosol Shape

It is realized in the recent investigations that non-sphericity of aerosols, particularly dust aerosols over oceans would contribute an uncertainty of about 10 per cent in the aerosol radiative forcing on climate. These effects were more noticed in the retrieval of climate forcing parameters due to aerosols from satellite observations as compared to land observations of aerosol extinction. Hence, retrieval algorithms involving better computer code that can correct the Mie scattering properties for non-sphericity of aerosol particles need to be developed in order to minimize this error among many other unknowns. Polarization properties or phase of aerosol particles at different altitudes using “polarization diversified lidars” would help such estimations.

vi) Development of Aerosol Multiple Scattering and Fluorescence Techniques

The aerosol lidar and radiometric data archival and retrieval techniques are more straight forward when the sky is clear or cloud-free. In the presence of turbid atmosphere (like cloud, fog, haze, snow etc.) and vegetation cover, the received signals suffer from multiple and fluorescence scattering processes. These effects have been realized recently even with moderate to high pollution episodes. Therefore, these scattering techniques need to be improved for the development of realistic parameterization schemes for the local/regional/global weather and climate forecast/prediction models and their validation.

vii) Aerosol Indirect Effects

The indirect effects of aerosols on cloud microphysics and associated radiative forcing and climate change are very complex. Recent studies suggest that introduction of anthropogenic aerosols due to biomass-burning, fossil-fuel etc. would enhance cloud life time and drop size spectrum significantly but reduces precipitation. Studies in this direction are very scanty in the country. Therefore, experimental and data analysis techniques aiming at aerosol- cloud-climate interactions require further improvements. In this context, the on-going cloud observations using the ground-based dual-pol lidars at IITM, Pune, NARL, Gadanki and SPL, Trivandrum play a vital role. The polarization properties of lidar scattered signals would be very valuable in identifying the cloud phase and associated precipitation/radiative characteristics of cloud condensation nuclei/ice nuclei.

viii) Multi-dimensional Mapping of day-night aerosol characteristics over complex terrains

One of the most important future directions to the Indian aerosol research should be multi-dimensional mapping of aerosol characteristics and other related atmospheric parameters over different environments (associated with complex terrain and meteorological conditions) using a mobile (truck-mounted or trailer-based) lidar. This will serve as a very valuable input

information to the climate models, particularly to account for the radiative forcing due to aerosols on different time scales.
The on-going experiments at Hanle, Kullu and neighboring regions, and on- going/proposed multi-organizational, multi-location and multi-field campaign programs will help filling such gaps. Moreover, aerosol studies over inaccessible regions like forests, lakes, mountain valleys, glaciers etc. are very sparse. Mapping of aerosol parameters over such regions is possible with satellite data. However, the satellite data retrieval algorithms require validation (atmospheric correction for aerosol effects) with aerosol vertical distributions and height-integrated aerosol extinction (optical depth) from ground-based lidars and radiometers. The ongoing data validation schemes of Indian satellite missions would play a great role in obtaining information on aerosol index over different parts of the country.

ix) Interface between Aerosol, Water vapor, Ozone and Nitrogen Dioxide

Mechanisms involved in the generation and development of secondary aerosols and relationships between aerosol, ozone and water vapor need further understanding. In this context, studies relating to the stratosphere-troposphere exchange/coupling and feedback processes using lidars, radiometers and in-situ instruments are needed. The results of such studies will also help in understanding the radiation-induced thermal field variations due to aerosols. Such studies will form a potential base for understanding aerosol growth processes, heterogeneous chemistry involving $O_3$ and $NO_2$ with aerosol as catalyst.
Another important problem associated with aerosols is aerosol-aerosol interactions and interaction between aerosol and background. In detail, this implies that the interactions between primary and secondary aerosols (new particle formations due to gas-to-particle conversion processes) and their integrated influence on composite aerosol behavior are not known. Our knowledge on modulation of such interactions on back-ground aerosol levels in the formulations of local/regional aerosol radiative forcing is very poor.

x) Aerosol Studies during Natural / Anthropogenic Episodes

Besides regular aerosol measurements, by following careful calibration-validation techniques, for understanding the long-term effects, event-oriented studies such as air pollution episodes, volcanic eruptions using both lidars and radiometers also should be more concentrated in order to understand the local/regional/continental/hemispherical/global physico-chemical, radiative and dynamical properties of aerosols. Systematic monitoring of aerosol characteristics during volcanic eruptions employing lidar in combination with in-situ techniques will yield certain large scale dynamical parameters using aerosol-cloud-clusters as tracers, and possibility to assess the influence of volcanic aerosols on global climate variability.

xi) Polar Aerosols

The aerosols, and pre-cursor gases over the polar regions play great role not only in the Earth’s radiation budget but provide reference levels for all the environmental and pollution studies due to their remoteness and restricted human activities. Moreover, the atmosphere over poles is very sensitive to human-induced changes in any part of the globe and dynamics of the atmosphere over poles itself seems to modify global weather and climate. Thus, the attenuation of solar irradiance and the processes of scattering and absorption by the aerosol particles may cause appreciable effects on the weather and climate of the Polar Regions. Albeit, some piece- meal observations on aerosols and associated parameters have been carried out by some Institutions in the country in coordination with National Centre for

Antarctic and Ocean Research (NCAOR), Goa, we need to quantitatively attribute aerosol forcing to aerosol type (natural and anthropogenic) for highly diverse conditions and episodic situations.

xii) Dust Pollution over Indo Gangetic Basin (IGB)

Dust storms in IGB act aerosol-extreme-laden events and they are often (during dust- loading seasons in the northern and north-western parts of Indian sub-continent) responsible for complicated mixing of natural and anthropogenic aerosols. This is further complicated due to the fact that the IGB region is very diverse in topography, population distribution, meteorology and emission sources. These unique features will induce large uncertainty in satellite retrievals and thereby the Earth's global radiation budget. Recognizing this phenomenon, ground-based aerosol networks involving initially with sun-sky photometers and later combined with multi-wavelength radiometers have also been established in the region in order to quantify aerosol loads and resultant effects of pollution mostly from the combustion of biomass, bio-fuel/fossil fuel emissions and the transported mineral dust outbreaks not only on Earth-atmosphere radiation balance and air quality but also on hydrological cycle. Thus the IGB region is one of the hotspots for Indian aerosol research. Numerous attempts have been on by several Institutions, but more need to be done to enhance our scientific understanding of the aerosol extremes due to dust episodes, their origin, evolution and effects.

xiii) High-Altitude/Mountain and Glacier Aerosols

Measurements over high-altitude/mountain stations represent background levels of aerosol concentration. So, it would be possible to examine and assess the extent to which the „clean" remote areas have been affected by growing urbanization/industrialization. Moreover, background sites with presumably cleaner environments and clear-sky conditions offer an excellent opportunity to calibrate the performance of the optical monitoring sensors/equipment. Added, these stations lie in the boundary-layer during daytime and in the free troposphere during the nighttime, thus provide good opportunity to investigate the transport/mixing of aerosols and gases from/between the boundary-layer to/and the free troposphere. Under seasonally varying wind patterns, these stations being in the free troposphere during night, becomes very important for regional study of transport of pollutants, particularly during early morning/night transition period. Scenarios of climate change in the mountainous regions of the world are highly uncertain mainly because of lack of sufficient data. At high elevations in the Himalayas, for instance, an increase in temperature could result in faster recession of glaciers and a reduction in snowmelt water will put the dry season flow of the snow-fed rivers under greater stress. The above-mentioned measurements over tropics are sparse and more so in India. Hence we need to gather more aerosol data to address the above issue including albedo.

xiv) Type-Segregated Aerosol Optical and Radiative Properties

By now, many groups in India have made extensive measurements of aerosol characterization, especially the columnar aerosol optical depth (a gross indicator of aerosol extinction) under different environments. All these measurements represent bulk effect. What is needed in the present-day understanding of the aerosol physico-chemical property is the type-segregated effects. Besides the complexity of internal and external mixing of aerosols, optical depth and associated radiative forcing due to different types (maritime, biomass, urban, industrial, desert dust etc.) of aerosols separately would provide clearer regional scenarios as compared to global means. Therefore, it is worthwhile to look into this issue by making fresh observations in this direction as well as re-analyze the large volumes of data already archived at some locations in India.

xv) Stratosphere-Troposphere Coupling / Exchange Processes

Campaign / co-experiment measurements involving the MST, X-band and Ka-Band radars, Mie-Rayleigh Lidar, Lower Atmospheric Wind Profiler (LAWP), Dual-Pol Micro Pulse, Doppler Wind and Raman Lidars in conjunction with GPS Radiosonde and Solar Radiometer facilities need to be organized to investigate the influence of temperature, vertical wind velocity (particularly during jet stream situations) on the height-integrated aerosol optical depth and size distribution, ozone and precipitable water content. Also, the role of structure and stratification of tropical tropopause in the variations of aerosol optical depth (as well as size distribution), which provide an insight into the stratosphere-troposphere coupling mechanisms, would form an interesting study.

xvi) Aerosol Modeling Activities

The complex interactions between meteorological elements including radiation, aerosols, cloud microphysics and dynamics make it difficult to assess the effect on precipitation change and climate. Due to uncertainty of these interactions and effects from local to global scale, a coordinated multi-disciplinary approach involving experiments and models is highly essential. The modeling efforts in these directions are very much limited and they need to be established and verified with long-term data sets. One potential way to resolve the current situation could be through new satellites and the associated products and sophisticated statistical methods. We need to concentrate on developing aerosol models (preferably coupled models) such as WRF-ARW, WRF-Chem., GCMs in order to delineate aerosol and pre-cursor gas influence on weather and climate through their modulating effects on radiation changes. For this purpose, we need good parameterization (super) schemes and data assimilation techniques. Sensitivity studies should also go on for continuous model improvements. Boundary-layer processes (e.g., entrainment), phase (external versus internal mixing, water versus ice etc.), composition (hydrophilic versus hydrophobic), latent heat release by clouds and complete chemistry (including nitrogen) need to be incorporated in the models.

Acknowledgements

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# Sistan Basin in eastern Iran: A major dust source for south Asia

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## Characteristics of the Sistan Basin

The Sistan Basin in south-eastern Iran has been widely recognized as one of the most intense and active dust-storm regions in southwest Asia. Despite of this, it remains nearly unknown to the broad dust-aerosol community in India and the meteorological aspects that favour the dust outbreaks, the dust-plume pathways, the affected areas and the specific role of the Hamoun ephemeral lakes and the position and movement of the Inter-Tropical Convergence Zone (ITCZ) in dust activity need to be better examined and clarified. Sistan is a topographic low basin, located in south-eastern Iran along the borders with Pakistan and Afghanistan (Fig. 1). The northern part of the basin is covered by shallow (< 4m in depth) ephemeral lakes that are fed from the discharge of the Helmand river. During the hot dry summer season, the lakes get dried forming a saline surface and leaving an alluvial silt material that is very easily eroded by the strong northerly Levar winds (Rashki et al., 2013). The combination of the saline dried soil with the intense surface winds favours massive dust storms over the region, where $PM_{10}$ concentrations of above 1000 $\mu gm^{-3}$ have been recorded in Zabol (Rashki et al., 2012).

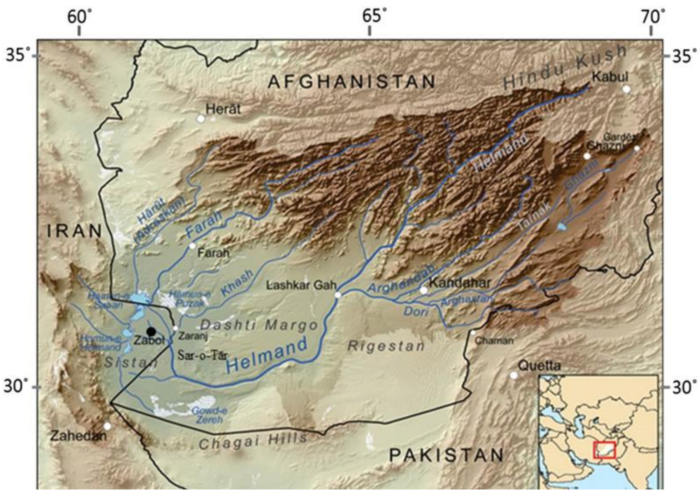


**Figure 1:** Topographic map of Hamoun Basin and Sistan region. The location of Zabol is indicated by the black circle (30° 57′N, 61° 34′E). The bold color in the map defines the Helmand drainage basin that fed Hamoun lakes complex. *[Source: http://en.wikipedia.org/wiki/Sistan_Basin; Reproduction by Rashki et al. 2013]*.

## The levar wind: Synoptic and dynamic meteorological aspects

Every year during the summer season (June-September), Sistan is under the influence of the intense Levar or "120-days" wind, which blows from northern directions with high velocity (~20 $ms^{-1}$) in certain circumstances resulting in massive sand and dust storms. Regional Climate Model (RegCM4) simulations showed that the mountainous topography around

Sistan creates a canal strengthening the northern winds, since sheltering and channelling are known to enhance the wind flow (Fig. 2). The wind profile shifts also to larger vertical gradient, with much higher values near the surface (950-900 hPa) and lower above 750 hPa (Fig. 3). The simulations also revealed a diurnal variation in the wind speed for levels below 800 hPa with maximum values during night time and early morning (18:00 and 00:00 GMT), when the nocturnal low-level jet is stronger.

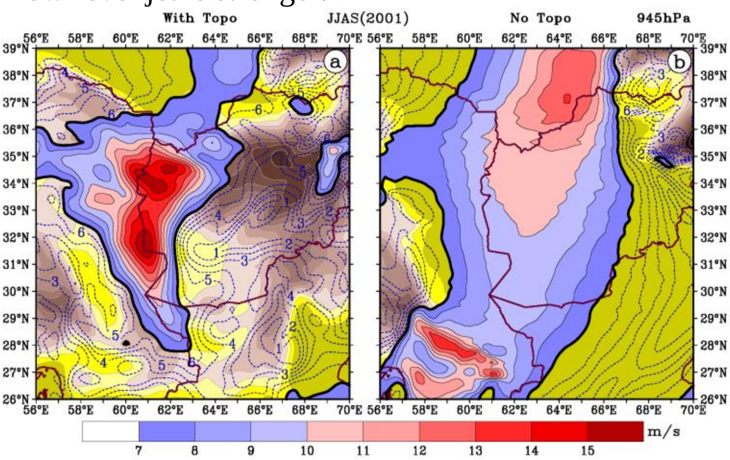


**Figure 2:** Seasonal (JJAS, 2001) mean wind velocity (ms$^{-1}$) over Sistan and surroundings via RegCM4 simulations at 00:00 GMT (LST=GMT+3:30) with (a) and without (b) the underlying topography. The contours are in 1 ms$^{-1}$ and values greater than 7 ms$^{-1}$ are drawn *[Reproduction by Kaskaoutis et al., 2014a]*.

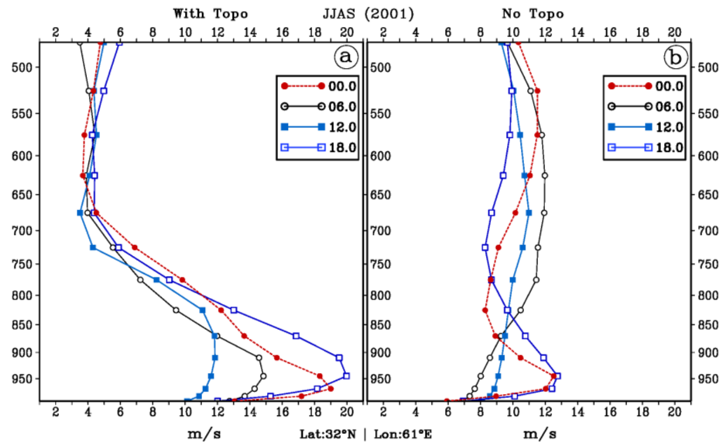


**Figure 3:** Seasonal (JJAS, 2001) mean vertical profiles of wind velocity (m s$^{-1}$) over Sistan basin (32$^{o}$N, 61$^{o}$E, where the wind velocity is maximum) via RegCM4 simulations with (a) and without (b) underlying topography at 00:00, 06:00, 12:00 and 18:00 GMT (LST=GMT+3:30) *[Reproduction by Kaskaoutis et al., 2014a]*.

A recent work by Kaskaoutis et al. (2014a) shed light on the synoptic and dynamic meteorological conditions associated with intense dust storms in Sistan. The intense dust storms correspond to daily-mean visibility records at Zabol of vis <1 km following the World Meteorological Organization (WMO) and were found to be 356 during the summer months (June-September) of the period 2001-2012 with higher frequency in June (93) and July (111).

Figure 4 shows the composite-mean maps for the Mean Sea Level Pressure (MSPL) and geopotential height at 700 hPa (Z700) obtained from the NCEP/NCAR database during the dust-storm days. At surface level, the cyclonic circulation over central Pakistan and north-western India along with the high pressure gradient between the Pakistan low-pressure center and the high-pressure regime over west-central Asia induce the strong northerly Levar wind, which is responsible for dust storms in the Sistan region. As the monsoon season progresses, the low pressure system weakens significantly and so does the dust activity over Sistan (Rashki et al. 2012). At 700 hPa, the ridge over Africa and Middle East combined with the trough over the Indian sub-continent induce a strong northerly flow (associated with the flow of the low-level jet) over Iran-Afghanistan-Pakistan borders.

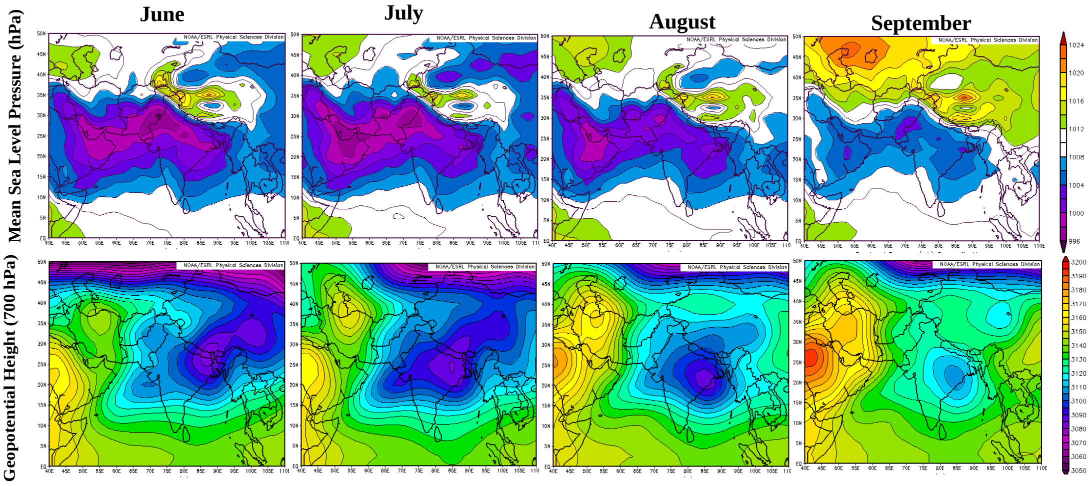


**Figure 4:** Composite-mean MSLP maps (upper panels) and Geopotential Height at 700 hPa (lower panels) of the dust-storm days over Sistan during the period 2001-2012 for the summer (JJAS) season *[Reproduction by Kaskaoutis et al., 2014a]*.

Furthermore, the anomalies of the meteorological fields during the dusty days from the mean 30-year (1981-2010) NCEP/NCAR monthly climatology were studied aiming to reveal the meteorological patterns that favour the dust outflows from Sistan. Figure 5 provides the synoptic maps of the MSLP (above) and Z700 (below) anomalies of the dust-storm days during 2001-2012 from the climatology 1981-2010. The anomaly patterns are characterized by positive anomalies (enhancement) in the high-pressure system centered over Caspian Sea and central Asia and negative ones over Hindu Kush. Similar pattern was observed for the 700 hPa pressure level. This suggests that during the dust-storm days the west-to-east pressure gradient, which is the inaugural force for the Levar wind and the low-level jet, is further enhanced. Actually, wind-speed records at Zabol revealed much stronger northerlies during the dust-storm days compared to the monthly climatology. This meteorological dipole in anomalies was also active during specific case studies, like the frequent Sistan dust storms during June 2008 (Kaskaoutis et al., 2014b) and during the recent case 1-3 July 2014 (unpublished data).

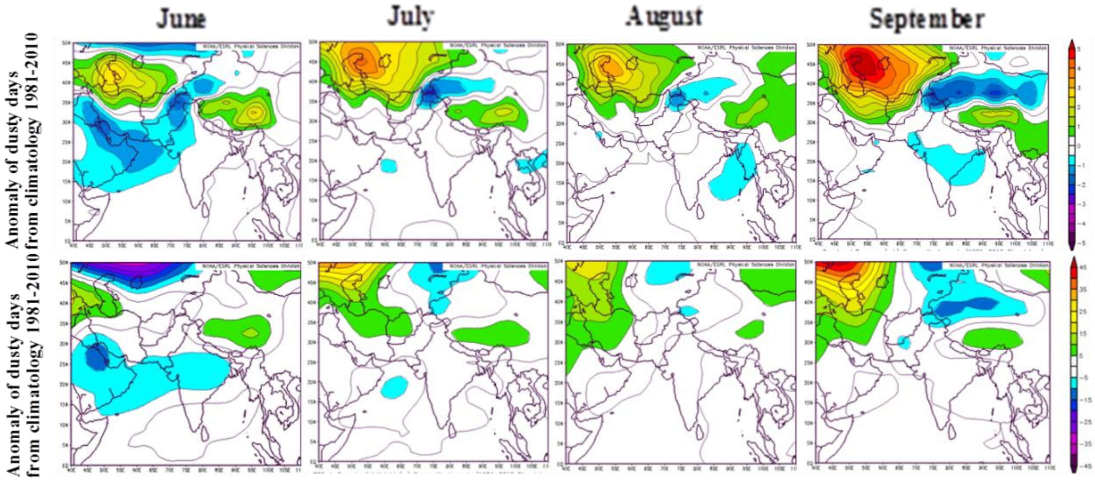


**Figure 5:** Anomalies of MSLP (above) and Z700 (below) from the mean climatological situation (1981-2010) for dust storms over Sistan during the period 2001-2012 *[Reproduction by Kaskaoutis et al. 2014a]*.

**Sistan dust storms and influence over northern Arabian Sea**

Recent studies by Kaskaoutis et al. (2014b) and Rashki et al. (2015) examined the dust transport pathways and the role of Sistan in dust loading over north Arabian Sea. Figure 6 shows the 5-days HYSPLIT forward trajectories during dust storms originated from the Sistan Basin in June and July. The results reveal that the most affected areas from the Sistan dust storms are the southeast Iran, southwest Afghanistan and south-central Pakistan. The air masses are initially having a southward direction due to Levar wind and when they reach the northernmost Arabian Sea they are progressively shifting to east-northeast, mostly affected the Indus basin. The northern Arabian Sea is also strongly affected, while the north-western India and the central Arabian Sea are affected in certain circumstances. The synoptic atmospheric circulation over south Asia during the summer monsoon (Rashki et al., 2014) is the control factor for the pathway and the “shift” of the Sistan-originated dust storms. The south-western monsoon air flow interacts with the northerly Levar flow along the Oman Sea and coastal north Arabian Sea, where the ITCZ lies during this season. The convergence zone seems to play a crucial role for the north-eastwards shift of the Iranian dusty air masses, while the steep increase (up to 3-4 km) in their altitude pathway towards Arabian Sea is attributed to the uplift along the convergence zone. Thus, the position and the movement of the ITCZ seems to play a crucial role concerning the influence of the Sistan dust storms over Arabian Sea. The ITCZ seems to differentiate the dusty air masses coming from Iran and Arabia over the northern Arabian Sea by uplifting the Iranian air masses to higher altitudes and usually above the dusty air masses coming from the Arabian Peninsula.

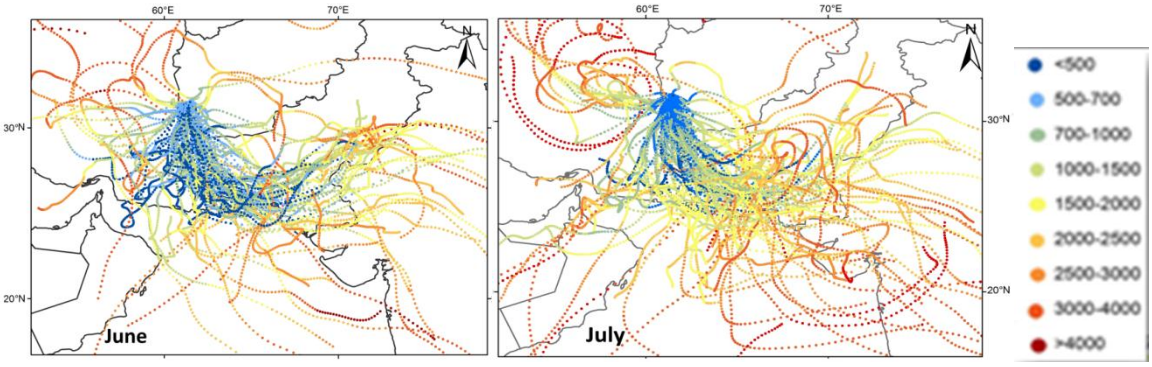


**Figure 6:** 5-day forward air-mass trajectories originated from Sistan Basin at 500 m agl on the dust-storm days for the June-July months during the period 2001-2012. The trajectory pathways are colour-scaled according to the altitude *[Reproduction by Rashki et al. 2015]*.

The severe dust aerosol loading over Arabian Sea in June 2008 examined in detail by Prjith et al. (2013) was then verified that it was mostly attributed to enhanced dust activity and several (18) dust outbreaks from Sistan over the marine environment as well as to favourable meteorological conditions that allowed the influence of the Sistan dust storms over central part of the Arabian Sea (Kaskaoutis et al., 2014b).

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## RESEARCH NEWS

## 1. Particles responsible for discolouration of the iconic Taj Mahal identified

Bergin, M. H., S. N. Tripathi, J. Jai Devi, T. Gupta, M. Mckenzie, K. S. Rana, M. M. Shafer, A. M. Villalobos and J. J. Schauer (2014): *The discoloration of the Taj Mahal due to particulate carbon and dust deposition,* Environmental Science and Technology (in press)

The discoloration of the white marble domes of the iconic Taj Mahal in Agra has been a major environmental concern for quite some time. Works in the last decade have established the entire Indo-Gangetic Plain as aerosol hotspot. Air quality data from Agra, an urban site in the central Indo-Gangetic Plain, also suggest poor air quality in the region. However, the source attribution of the discoloration from aerosols depositing on the white marble was not known. This study analyzes ambient particulate matter as well as the particles deposited on the marble domes. Using the chemical composition derived from the collected samples, the authors further estimated the relative contributions of dust, brown carbon and black carbon to the aerosol optical depth at 400 nm. The reflectance spectrum of the clean marble was compared with that of the three aerosol species. In combination, the surface reflectance spectrum is significantly altered by the dust, brown carbon and black carbon with enhanced absorption at shorter wavelength. 59% of the discoloration is estimated to be the contribution of dust, followed by 38% by brown carbon and 3% by black carbon. The results will help formulating appropriate mitigation measures to restore the aesthetics of the iconic Taj Mahal and counter air pollution problems in the region.

## 2. Global burden of household air pollution

Reference: Smith, K. R., N. Bruce, K. Balakrishnan, H. A-Rohini, J. Blames, Z. Chafe, M. Dherani, H. D. Hosgood, S. Mehta, D. Pope, E. Rehfuess and others in the HAP CRA Risk Expert Group (2014): *Millions dead: How do we know and what does it mean? Methods used in the comparative assessment of household air pollution,* Annual review of Public Health, 35: 185-206.

The household air pollution has been identified as one of the leading causes of mortality in the recently concluded global burden of disease study. In this article, the authors have estimated that in 2010, household air pollution was responsible for 3.9 million premature mortality and ~4.8% of lost healthy life years globally. The article reports an Indian model of household air pollution and personal exposure. A large fraction of the combustion-derived outdoor $PM_{2.5}$ in South Asia is attributed to household cooking with the contribution increased from 15% in the year 1990 to 30% in the year 2005. The risk of acute lower respiratory infection from child exposure to household air pollution representative of India (285 µg $m^{-3}$) was calculated in the range 2.0 to 3.8. In India in 2010 all but 24% of ischemic heart disease in men and 42% in women and 33% of acute lower respiratory disease in children could have been eliminated had there been no exposure to ambient and household air pollution, and passive and active smoking. The study highlights the seriousness of the air quality issue in India in view of high $PM_{2.5}$ concentration (both ambient and household).

## 3. CMIP5 models seriously underestimate aerosol load over India

Reference: Sanap, S. D., D. C. Ayantika, G. Pandithurai and K. Niranjan (2014): *Assessment of the aerosol distribution over Indian subcontinent in CMIP5 models*, Atmospheric Environment, 87: 123-137.

CMIP5 models were used for climate projection in IPCC AR5. Aerosols play a major role in modulating the climate both directly and indirectly; hence misrepresentation of aerosol burden (and absorption property) would lead to large error in climate forcing. The article examines the model fidelity and biases in simulating aerosol distribution over India in 21 CMIP5 models. Majority of the models show large negative bias in AOD over the Indo-Gangetic Basin with a few overestimating AOD. Underestimation of AOD by most of the models is attributed to underestimation of BC and dust (two major aerosol species in India). The study pointed out the deficiencies and calls for improved representation of aerosols in the current state-of-the-art climate models.

## 4. Agricultural yield loss in India by short-lived climate pollutants

Reference: Burney, J. and V. Ramanathan (2014): *Recent climate and air pollution impacts on Indian agriculture,* Proceeding of National Academy of Science, 111: 16319-16324.
Recent studies have shown that India has already been negatively affected by climate change in the agricultural sector. This study presents the impacts of short-lived climate pollutants (SLCP) - black carbon and ozone, on wheat and rice yields in India using statistical models. The authors noticed larger impact of SLCP on wheat yield relative to rice, because wheat's growing season coincides with the large build-up of SLCP in India. The relative impacts of SLCP on the yield loss varied across the states, with Uttar Pradesh showing 50% lower yield (than they otherwise would have been without the SLCP trends) of wheat. The four major wheat producing states suffering most are Uttar Pradesh, Rajasthan, Madhya Pradesh and Chhattisgarh, while the two other states - Punjab and Haryana show insignificant impact. For rice, Tamil Nadu and Andhra Pradesh show relatively higher impacts than other major rice producing states. Overall, the yield loss for wheat attributable to SLCP in the year 2010 alone stands out to be over 24 million tons, which translates to ~5 billion USD. The results imply a growing concern about food security in the future and highlight the importance of implementation of appropriate mitigation measures with co-benefits for climate, health and agricultural yield under warming climate.

## FORTHCOMING EVENTS

1. **2015 European Aerosol Conference in Milan (Italy); September 6-11, 2015 -**

   The 2015 European Aerosol Conference (EAC 2015) will be held in Milan, Italy during September 6-11, 2015. Abstract submission deadline is February 27, 2015. More detailed information about this workshop can be found out in the conference website: **http://www.eac2015.it/**.

2. **SOLAS Open science Conference 2015 -**

   SOLAS open science conference will be held in Kiehl, Germany during September 7-11, 2015. More detailed information about this workshop can be found out in the conference website: **https://www.confmanager.com/main.cfm?cid=2778**

3. **9th Asian Aerosol Conference 2015 -**

   9th Asian Aerosol Conference will be held in Japan during Jun 24 - 27, 2015. More detailed information about the conference in the website: **http://aac2015.w3.kanazawa-u.ac.jp/**

4. **10th Annual International Symposium on Environment 2015 -**

   The symposium will be held in Athens, Greece during May 25-28, 2015. More detailed information can be obtained from the symposium webpage: **http://www.atiner.gr/environment.htm**

5. **International Conference on Carbonaceous Particles in the Atmosphere -**

   The international conference on carbonaceous particles in the atmosphere will be held in Berkeley, California, USA during August 10-13, 2015. More detailed information can be obtained from the symposium webpage: **http://iccpa.lbl.gov/**

## 2015 AARA Fellows
## Call for Nominations

2015 AARA Fellows are to be appointed by the Chair of the AARA Fellows Committee at the Ninth Asian Aerosol Conference in Japan, June, 2015, Kanazawa, Japan. The nomination material must be submitted to the AARA President by 31 Dec. 2014 in the form of an electronic version. All aerosol scientists are encouraged to nominate candidates for AARA Fellows.

**About AARA Fellows:**
The Asian Aerosol Research Assembly (AARA) has established AARA Fellows to recognize individuals with outstanding service to the AARA and significant contributions to the field aerosol science and technology and in Asian regions for more than 10 years. Nominations of candidates for AARA Fellows are invited. AARA Fellows are appointed once every two years to up to five individuals except that inaugural AARA Fellows in 2015 can have more than five individuals. AARA Fellows are appointed by the Chair of the AARA Fellows Committee or his/her representative at the Asian Aerosol Conference or other relevant aerosol conferences.

**Details of the nomination and selection procedure:**
1. NOMINATION
   (i) Nomination is made by a full letter of justification, including a curriculum vitae and a bibliography. The letter should highlight the major contributions of the nominee to the field of Aerosol Science and Technology, and ways in which the nominee has served the AARA.
   (ii) A maximum of three supporting letters will be considered.
   (iii) Only living nominees will be considered.

2. SELECTION
   (i) The AARA President selects a senior person to Chair the Fellows Committee. The Chair will form the Committee which consists of (a) members recommended by the Presidents of Member Societies or AARA board members (one member per society), or (b) existing fellows. The committee reviews all nominations to make the selection based on a simple majority vote of all members at least 4 months before the date AARA Fellows are appointed.
   (ii) The Chair of the AARA Fellows Committee presents AARA Fellows with a Certificate at the Asian Aerosol Conference or other relevant Aerosol Conferences. All members of AARA Member Societies are encouraged to nominate candidates for the forthcoming AARA Fellows. Questions concerning AARA Fellows can be addressed to the current President of the AARA:

Chair, AARA Fellows Committee
Dr. Panuganti CS Devara
E-mail: devara7@gmail.com

# Call for Nominations: *Asian Young Aerosol Scientist Award*

The Asian Young Aerosol Scientist Award recognizes outstanding contributions to aerosol science and technology by young aerosol scientists in Asian Countries. The purpose of the award is to promote aerosol research by young scientists in Asia. All aerosol scientists in Asia are encouraged to submit nominations for this award.

The award is jointly sponsored by TSI Inc., members of the Asian Aerosol Research Assembly (AARA), and contributions from the organizer of the Asian Aerosol Conference (AAC), aerosol organizations, aerosol related companies or individuals. The award, which consists of a cash prize and plaque, will be presented at the Asian Aerosol Conference (AAC) to one to two recipients. Any Asian aerosol scientist who satisfies the following conditions is eligible to be nominated, except members of the Award Committee:

(i) Nominee must not be over age of 40 (*i.e.* must be before his or her 41st birthday) at the time of nomination.

(ii) The nominee must have been working in Asian countries for at least the last 5 years since the date he (she) obtained his Ph. D. Candidates without a formal Ph. D. but who have provided significant contributions to aerosol science and technology will also be considered.

*Submission of Nominations:*

Nomination of the award must be made by an Asian aerosol scientist and include at least three letters of recommendation highlighting the candidate’s contributions to aerosol science and technology. Nominations, reference letters, and supporting documents including nominee's curriculum vita and 3 best published papers must be received electronically no later than 3 months (April 24, 2015) before the Asian Aerosol Conference (June 24-26 2015, Kanazawa Tokyo Hotel, Japan) by the award committee. Please send nominations to:

**A/Prof Howard Bridgman, President AARA**
**Chair of the Award Committee, Asian Young Aerosol Scientist Award**
**School of Environmental and Life Sciences, University of Newcastle**
**NSW 2308, Australia**
**Telephone: 61249215093, Mobile: 612425281387**
**Email: howard.bridgman@newcastle.edu.au**

If there are any questions, please contact the Committee Chair.

## OBITUARY

Prof. Asit Ray, Aerosol Scientist, passed away Tuesday, November 11, 2014, after a battle with lung cancer. He was the William Bryan Professor of Chemical and Materials Engineering at the University of Kentucky. Prof. Ray received a B.Tech. degree from the Indian Institute of Technology, Kharagpur, followed by a Ph.D. from Clarkson University in Potsdam, N.Y. in 1980. He spent his career at the University of Kentucky, during which he made significant contributions to the study of mass ejection during charged droplet breakup and to the use of particle levitation techniques for the study of aerosol behaviour. He effectively measured resonances of light scattered from levitated droplets to get fundamental information on evaporating droplets, such as activity coefficients of multi-component mixtures.

Prof. Ray had spent a sabbatical at the Indian Institute of Technology Bombay. He also participated in the 2005 Workshop on Nanoparticle Aerosol Science and Technology and IV Asian Aerosol Conference, held in Mumbai. Prof. Ray was a highly creative and rigorous researcher and has inspired generations of undergraduate and graduate students, through his commitment to scientific and engineering excellence. He is survived by his wife, Sharmishta, son, Rohit and daughter, Neha.