Climate "Forcing" by Aerosols

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Originating from the Greek word *Klima* ("inclination of the sun's rays over a latitude"), *climate* has been understood to mean the total experience of weather and atmospheric behaviour that prevails on a given region over a number of years. Climate is a multidimensional concept involving a host of elements/variables such as temperature, atmospheric pressure, precipitation, wind speed and direction, sunshine, and cloud cover. Definitive climatic change involves changes in mean values and variances of these variables (measured over a typical averaging time of about 30 years), that result in new and apparently lasting conditions. Any such change that is *imposed* upon the planetary energy balance is called *climate forcing*. Changes of this nature may be brought about by natural phenomena like solar variability (changes in the intensity of solar radiation), volcanic activity, or by human disturbances of the atmospheric composition, for example, through emissions of air pollutants.

About Aerosols

Atmospheric aerosols are multi-phase particles (liquid or solid particles in a gaseous medium) that tend to remain dispersed in air rather than to settle. Their interaction with solar (and other) radiation depends on the particle size (which typically varies from a few nanometers to tens of microns) and refractive index, which in turn depend upon the aerosol composition.

Aerosols include natural dust, sea-salt and also substances (such as fly-ash, mineral particles, soot, organic carbon and ionic constituents like sulphates) emitted by the burning of fossil fuels. Unlike greenhouse gases, *climate forcing* by aerosols varies with time and location because of their short atmospheric lives and scavenging by precipitation. In addition, aerosols like soot may *cool* the earth's surface by absorbing incoming radiation, but cause a warming of the atmospheric layers in which they reside. Aerosols also seed clouds and modify cloud structure, resulting in brighter clouds which can backscatter radiation to a greater extent. This brings on further *cooling*. However, there is also a potential for *warming* as aerosols tend to shorten cloud lifetime, thereby increasing the time that the earth's surface is exposed to solar radiation.

On Global Warming

Headquartered at Geneva, the *Intergovernmental Panel for Climate Change* periodically reviews the state of the climate science and identifies science policies for research on human-induced climate-change, potential impacts of climate change and options for mitigation and adaptation. Based on data from an entire body of studies, it is currently accepted that the earth has warmed by about 0.8°C since 1750, a third of which can be attributed to solar variability. Greenhouse gases like carbon dioxide, methane, nitrous oxide and the halocarbons which trap outgoing long-wave infrared radiation also have contributed to the warming of the earth's surface. It has been estimated that an increase in the concentration of these gases (between 1750 and now) would cause a warming by about +1.5°C i.e. about 0.7°C higher than actually observed. One probable explanation for this mismatch is that, the models employed for prediction did not accurately account for a number of complex interactions between several atmospheric processes that affect the concentrations of greenhouse gases. Nevertheless, the consistent over-prediction of warming owing to the emissions of greenhouse gases has led to the search for other agents affecting global warming/cooling. It was in the early 1990s, that a likely *global cooling* effect by atmospheric aerosols was identified.

The Indian Ocean Experiment and Other Studies

In the past decade, an interesting science has evolved for studying the multitude effects of aerosol on radiation and climate. Our group at IIT Bombay has been focusing on some of these effects through a set of parallel studies which include:

- Participation in aerosol-climate field campaigns, like the Indian Ocean Experiment.
- Measurements of aerosol chemical composition from sources indigenous to the Indian region.
- Development of detailed inventories of emissions from biomass and fossil-fuel combustion for India.
- Modeling regional transport and climate effects of aerosols (through an Indo-French project)
- Integrating multi-year atmospheric observations with emission maps and model predictions (in collaboration with Physical Research Laboratory, Ahmedabad, and Institute for Tropospheric Research, Germany, among others).

The Indian Ocean experiment was conducted during 1998-1999 with international participation. Land-, ship-, satellite-, aircraft- and balloon-based sensors were deployed to simultaneously measure atmospheric aerosol, trace gas composition and radiation. The studies showed the presence of high levels of continental aerosols, especially black carbon, over the Arabian Sea and tropical Indian Ocean. Indeed, multiple elevated particle layers were observed originating over India, south-east Asia, and west-Asia. These aerosols were shown to strongly *cool* the lower layers of the atmosphere, but *warm* the upper layers, a fact which has a bearing on the Indian monsoons. Measurements of enhanced radiation absorption using laser-based sensors (see Figure) raised questions about how the regional climate may be affected by biomass burning (dominant in our region) as compared with fossil-fuel burning.

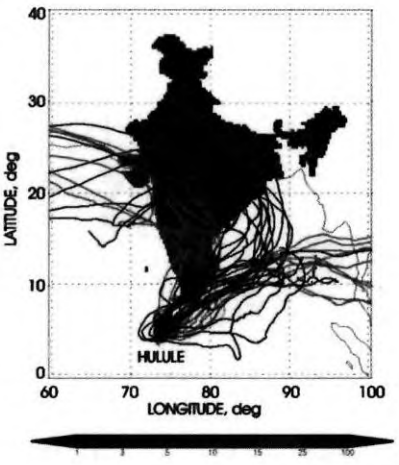

Figure: Red trajectories corresponding to high Lidar (laser-based sensors) ratios indicating radiation absorption passed over regions of high biomass to fossil-fuel emissions (in blue in underlying emissions map).

Interestingly, many issues of relevance to science and policy-making were also highlighted. These included (a) locating the *sources* of aerosols over India and the Indian Ocean and assessing their inter-annual variations (b) linking the chemical composition and optical properties of such aerosols, and (c) studying the effects of aerosols on radiation balance, and on monsoons. Our current and future work in this area will address these aspects of aerosol-impact on the climate ■

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Techfest 2003

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The sixth Techfest (2003), IIT Bombay's annual technological extravaganza this year (31st Jan to 2nd Feb), brought an entire posse of attractive events chosen from a wide spectrum of technology areas.

Unprecedented in its scale of organization, Techfest 2003, attracted the largest ever participation from the country's student community, which took part in a varied range of technology competitions. In addition, the presence of a large number of corporate personnel, researchers, academicians, industrialists and IITB's alumni took the event beyond participation by novitiates. The "festival" was covered by the National Geographic Channel, The Week, Digit, and was also webcast live on the internet.

The highlight of Techfest 2003 was a strong line up of competitions. In all there were nineteen of them encompassing various aspects of design, innovation, ingenuity and skill. The regular competitions like *Open Hardware, Open Software, Contraption, Yantriki, LaSTraw, Chem-E-Car* and others saw very innovative entries which were appreciated by the judges, and the audience alike. Perhaps the most consummate among these was Yantriki, which featured a "robo-sports" competition.

Robos (flown in from Germany) playing "Robo Cup"

Another special feature of the Techfest was the *Industry Defined Problems.* It provided the student community an opportunity to try their hands on practical problems posed by the industry. Companies like Mastek and Tata Power offered mentorship to the winners of this event, to whom an impressive sum of Rupees Five lakhs was given away as cash prizes. Such an array of competitions and prizes now make Techfest the biggest event of its kind in Asia.

The contribution of the institute alumni came in the form of a *Techpreneurs Meet,* which aimed at acquainting the students with the essence of entrepreneurship. The focus lay on manufacturing industries. The students were provided with an insight of the critical inputs needed for setting up a manufacturing facility, and some of the strategies for achieving success in the Indian industrial scenario. Groups were formed which comprised alumni and students who belonged to the same geographical locations of the country – to enable enthusiastic students to receive sustained mentorship for their ideas.

Another event which caught the attention of the students strongly was *Tech-e-Tete*, the Lecture Series featuring a group of persons eminent in their own fields. The speakers included Prof. M G K Menon (Chairman, Board of Governors, IIT Bombay), Dr. R Chidambaram (Principal Scientific Adviser to Govt. of India), Dr. Bernhard Schoelkopf, (Director, Max Planck Institute of Biological Cybernetics, Germany) and Mr. Ajit Balakrishnan (CEO, Rediff). There was also a lecture on Prime Numbers by Prof. Manindra Agarwal, IIT Kanpur, acclaimed internationally for his recent work on an algorithm for deciphering prime numbers. Another lecture on "Computer Networking and Securities," which proved to be one of the most popular ones was from the 17 year old Ankit Fadia – who is already an independent Computer Security and Digital Intelligence Consultant, and has also authored several internationally best selling books on the subject of Network Security. Dr. Richard M. Stallman, President, Free Software Foundation and founder of GNU project spoke through a Video Conference from Boston USA.

Satellite model displayed by ISRO at the R&D exhibition

For the first time, Techfest also staged a Panel Discussion comprising people at the helm of industry and the academia. The panel focussed on the theme of "competitive advantage" that a technology based education can offer in relation to the options and opportunities in business. The speakers included Mr. Nanadan Maluste (VP, Kotak Mahindra), Dr. Pratap Sirur (Head, Finance and Dean NMIMS, Mumbai), Dr. A K Sengupta (Director, SIESCOMS) and Dr. Gautam Sardar, (Head, Technology Development, TCS).

Workshops on astronomy, cryptography, wireless networking, archaeology, robotics, MEMS and Computer Aided Process Engineering-which had closed room participation-focused on recent developments and applications. The participants were also offered hands-on-sessions in solving problems. As part of this event, there was a live telecast from Mount Wilson Observatory, USA. Also, open workshops on the applications of Geographic Positioning Systems (GPS) and Geographic Information Systems (GIS) were conducted.

The event *Hub* featured "On the Spot Contests and Documentaries" from the National Geographic Channel. In parallel, some of the best technologies from the country's premier R&D organizations were on display. The participating institutions included ISRO, BARC, TIFR, ADA, DRDL and IITB, amongst others. Private R&D institutions like Philips and GE's JF Welch Technology Centre also were participants to the exhibition.

"Techfest at Dark" offered an enthralling mix of entertainment and competitions. As the slogan promised there indeed was 'Something for everyone!' The most successful displays in this section were the 3D Laser show, 'Aibo' Robo Cup show and the Air show. The laser show provided a rare spectacle, while the Aibo League Robo Cup, where robots played a game of soccer provides a perfect mimicry of human skills! As part of the event *Air Borne,* scaled down models of World War II airplanes, with their high-flying acrobatics, enabled a fanciful re-creation of history.

As this brief recount may indicate, the programs of Techfest 2003 were a mix that brought together both beginners and the experienced technologists. In its own way, Techfest 2003 achieved significant success in fulfilling its ultimate aim: to augment academia, industry and student interactions ■

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