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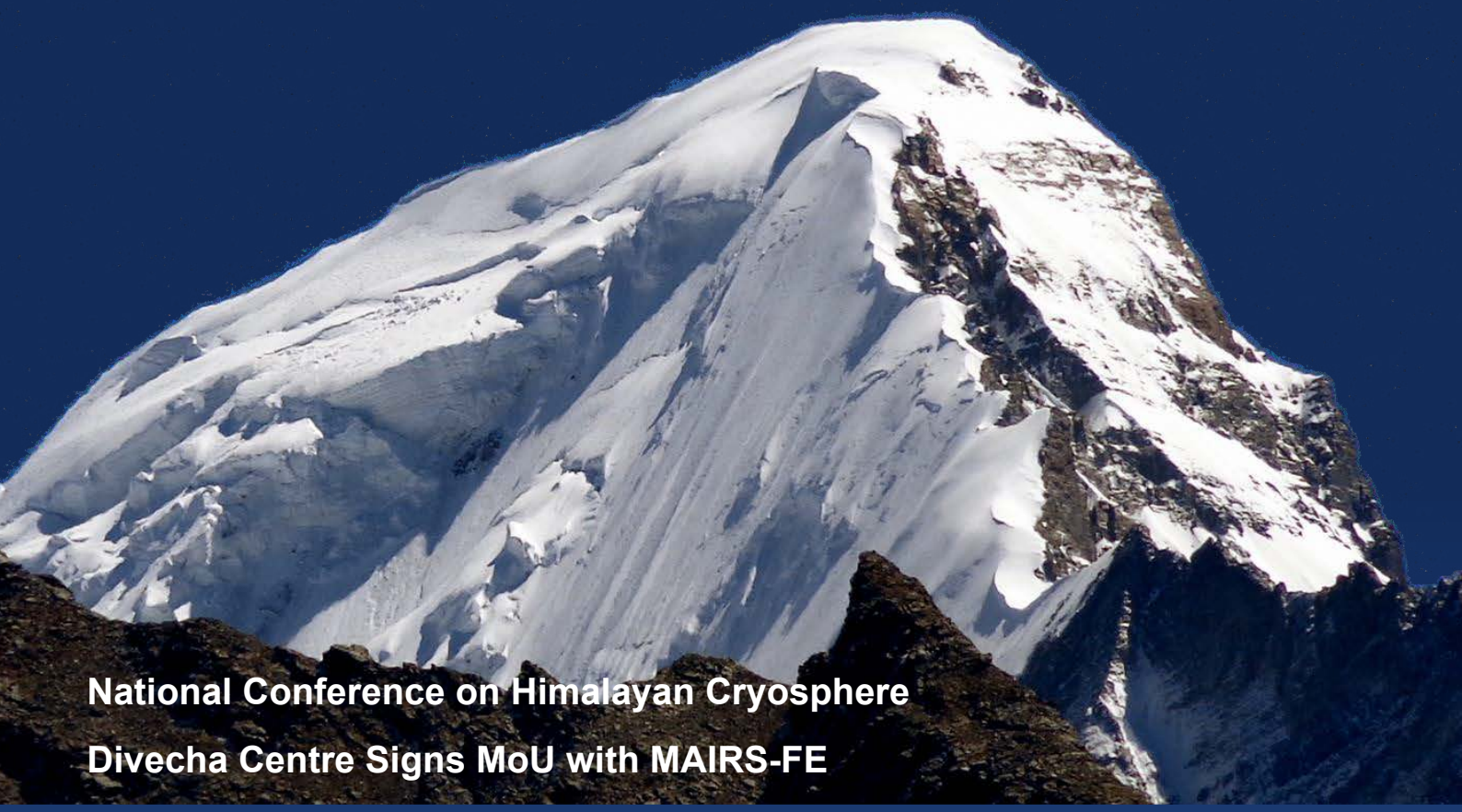
DIVECHA CENTRE FOR CLIMATE CHANGE

Newsletter of the

DIVECHA CENTRE FOR CLIMATE CHANGE



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FROM THE CHAIR

Greetings!

The Divecha Centre for Climate Change was established at the Indian Institute of Science in January 2009 with a generous financial contribution from Arjun and Diana Divecha and the Grantham Foundation for Protection of the Environment, aiming at understanding and quantifying climate variability and climate change, and assessing the consequences on environment sustainability. The Centre is also supported by Department of Science and Technology, New Delhi as a "Centre for Excellence". The Centre also aims to provide an important link between science and policy.

Towards achieving these objectives, the Centre designs and executes experimental programs and modeling studies. Pursuing the above, the Centre has been successful in identifying a few technologies to mitigate/reduce the severity of climate change, in collaboration with entrepreneurs and different engineering departments in the Indian Institute of Science. The Centre has collaborative programmes with the Grantham Institute for Climate Change at the Imperial College London, on the impact of aerosols on climate and the impact of climate change on water. In addition to applied research, the Centre also has several outreach activities to create awareness among students, general public and policy makers about climate change and its consequences; carried out through workshops, lectures and quiz contests. An annual invited public lecture, called the 'Jeremy Grantham Lecture on Climate Change', has been held for the past seven years. We organize lectures and training courses aiming at capacity building to address issues related to climate variability, climate change, adaptation and sustainability. The Centre also provides advice to ministries and departments of the Government of India in forming national and international policies related to climate change.

In line with one of the major objectives, the Divecha Centre is making a foray in water security by becoming a part of 'Water Solutions Laboratory' network of Sustainable Water Future Programme, which is a core activity of 'Future Earth'. Water Solutions Lab would aim at influencing policymaking at a regional scale by initiating active dialogue between scientists, policy-makers and the general public. Part of this will be to provide advanced training to students and young water professionals to build their capacities for successful science-policy interactions. Despite that water occupies a major fraction of Earth, the availability of clean and usable water (for the living beings) is becoming increasingly stressed, and this stress is likely to intensify in the coming years, as global warming interacts with growing populations and increasingly developed societies demand more water for agriculture, manufacturing, and personal use. An estimated third of the world's population currently lives in water-stressed countries. This will likely increase to two-thirds by 2030. Asia is already hard-hit by water stress as increasing populations will create more pressure in the coming decades. The 'Water Solutions Laboratory' will address the water-related science, policy and societal questions in the light of the global environmental change. A regional workshop being planned will provide us an understanding of various research topics relevant to the domain.

S. K. Satheesh

NATIONAL CONFERENCE ON HIMALAYAN CRYOSPHERE

Prof. Kulkarni delivering a talk on Himalayan Cryosphere

Dr. Anil Kulkarni, Divecha Centre for Climate Change, organised a National Conference on Himalayan Cryosphere on January 23rd and 24th, 2017 at Bengaluru. The main goal of this conference was to bring together, the community working on the Himalayan Cryosphere, generate new ideas and create new collaborations. In this conference, 70 scientists and engineers from 20 institutions participated and presented 65 papers. The conference was grouped into five technical sessions. These were Observations, Modelling, Climate Change, Hydrology and Disasters. The conference was supported by Science and Engineering Research Board (SERB) and Divecha Centre for Climate Change (DCCC). The conference was inaugurated by Dr. Sanjeeva Rao, SERB, Dr. Akhilesh Gupta, DST and Prof. J. Srinivasan, CAOS. The inaugural talk was given by Prof. J. Srinivasan. He highlighted the need for better understanding of the role of glacier melt in total river discharge, importance of mapping potential glacier lake outbursts and the need for improvement in disaster management strategies.

The first technical session on the observation of Himalayan Cryosphere was chaired by Mr. A. Ganjoo, Director, Snow and Avalanche Study Establishment (SASE), Manali. The main highlight of the session was a presentation by Mr. Shashank Bhushan, a young graduate student from Indian Institute of Technology, Dhanbad. He showed that the mean elevation of the Gangotri glacier decreased by 9.5 meters during the past 15 years. He developed a unique procedure to use geodetic method to estimate mass balance of large glaciers like Gangotri, where mass balance cannot be estimated by conventional methods. Ms. S. Pratibha, Indian Institute of Science, discussed the changes in Supraglacial Debris cover. She argued that there has been a steady increase in debris cover during the past 17 years. The observations presented in this session on changes in debris cover, velocity and mass loss are important to understand current state of Himalayan glaciers.

Dr. Argha Banarjee from IISER, Pune, discussed the retreat of glaciers in the second technical session on modeling of Himalayan glaciers. The numerical

result from a simplified glacier model was used to explain the temporal pattern of glacier ice thinning on retreat. Dr. M. R. Bhutiyani, Director, Defence Terrain Research Laboratory, Defence Research & Development Organization (DRDO), talked about the impacts of Climate Change in the Karakoram Himalaya, with reference to permafrost degradation related mass movements. The session also included a presentation on model that is based upon surface velocity, slope and laminar flow of ice, to estimate spatial distribution of glacier depth at basin scale and subsequent development of an area scaling method for Western Himalayan glaciers.

Dr. H. S. Negi, SASE, delivered a talk on "winter time climatic variations over north-west Himalayan Cryosphere" in the technical session on "Himalayan Cryosphere and climate change". He discussed temperature and precipitation trends in the last 25 years (1991-2015) in Northwest Himalaya, based on high altitude field observations. He showed a warming trend in temperature, decreasing trend in snowfall but increasing trend in total precipitation (rainfall and snowfall). This is an important observation, which can have profound effect on glacier distribution. In addition, winter snow albedo observations were discussed.

In the last technical session on Disaster, Director, SASE, delivered a talk on "Different cryospheric hazards and mitigation techniques in Himalaya". He showed the impact of various major hazards that occurred in the Himalayan region and work done so far in hazards in Cryosphere. He discussed snow avalanches and Glacier Lake Outburst Flood (GLOF) in particular and other hazards in general. He explained how snow pack conditions, weather and some time seismic activity, can influence avalanche occurrences.

The concluding session was organised by Dr. Anil Kulkarni and all participants were given opportunities to discuss their dream projects. Participants gave suggestions to improve our understanding of Himalayan Cryosphere. These include a better estimate of glacier stored water and annual mass loss on basin scales. The prediction of future changes in glacier extent and its influence on water availability was highlighted. In addition, many delegates also discussed the need to develop better tools to understand future disasters due to changing Cryosphere. The conference provided ample opportunities to young researchers to interact with experienced scientists and generate new ideas.

Delegates attending presentations

DIVECHA CENTRE FOR CLIMATE CHANGE SIGNS MEMORANDUM OF UNDERSTANDING WITH MAIRS-FE

Monsoon Asia Integrated Research for Sustainability (MAIRS) is a regional consortium for the integrated study of earth system processes in the Asian Monsoon Region; the vast region covering South, Southeast and East Asia. It is a region where the major features of landscape, such as vegetation, soil and water system are developed in a monsoon climate. Monsoon rainfall is the main water resource of the region. However, the high variability of monsoon climate causes a high frequency of climate related disasters, such as floods, drought and heat waves which often bring about great damage to the region. At the same time, 'Monsoon Asia' (the

The signing of the memorandum of understanding between Future Earth and MAIRS-FE. From left to right: Fumiko Kasuga, S.K. Satheesh, Michael Manton (Chair, MAIRS-FE SSC), Tong Zhu and Hein Mallee. *Photo Source: FE Asia Regional Centre*

region influenced by the Asian monsoon) is a region with very active development and the highest population density in the world. In the above backdrop, MAIRS envisages significantly advancing the understanding of the interactions between the human-natural components of the overall environment in the monsoon Asian region and implication of global earth system, in order to support the strategies for sustainable development. In the previous issue of the newsletter, I have indicated that the Scientific Steering Committee (SSC) of MAIRS has accepted our proposal to host the MAIRS Regional Project Office (RPO) at the Divecha Centre.

Future Earth and Monsoon Asia Integrated Research for Sustainability - Future Earth (MAIRS-FE) have now signed a memorandum of understanding (MoU) to complete the transition of the MAIRS project to Future Earth. This transition of MAIRS, (the Monsoon Asia Integrated Regional Study), to Future Earth commenced about two years ago. The Future Earth Regional Centre for Asia hosted a meeting of the Scientific Steering Committee (SSC) in November 2016, which provided the turning point for the project. At that meeting, offers of support to host the International Project Office (IPO) for MAIRS-FE at Peking University

S.K. Satheesh, Chair, Divecha Centre for Climate Change, signs the memorandum of understanding. Also seen are Michael Manton, Tong Zhu. Photo source: FE Asia Regional Centre

in Beijing and to host the Regional Project Office (RPO) at the Divecha Centre for Climate Change, Indian Institute for Science in Bengaluru, India, were accepted. Recently, representatives from FE and MAIRS signed the agreement at the Fifth Workshop on Future Earth in Asia held at the Research Institute for Humanity and Nature (RIHN) in Kyoto on 24th January 2017 which formalized the hosting of Regional Project Office (RPO) of MAIRS-FE at Bengaluru, India. The Scientific Steering Committee (SSC) of MAIRS recently appointed Prof. J. Srinivasan as the Director of the RPO of MAIRS-FE.

The Initial Strategic Research Plan for Future Earth in Asia prepared by the SSC identified three priority research areas. These areas, which will be important for researchers in Asia and to align with the goals of Future Earth's Knowledge-Action Networks, are:

- Resilience to climate-related natural disasters
- Human health in monsoon Asia
- Water, energy and food nexus.

MAIRS-FE will continue to address cross-cutting global change issues related to the unique Asian monsoon climate and topography, and develop links across the diverse cultures and societies of Asia. It will also closely work with other Future Earth global research projects, relevant Knowledge-Action Networks and the Regional Advisory Committee for Future Earth in Asia. The MAIRS RPO would start functioning in the near future.

VISIT OF PROF. FUMIKO KASUGA, DIRECTOR, FUTURE EARTH GLOBAL HUB, JAPAN

Prof. Fumiko Kasuga, Director, Future Earth Global Hub, Japan, visited the Divecha Centre for Climate Change on 2nd Feb 2017. Prof. Kasuga's visit was to facilitate collaboration between Future Earth Global Hub, Japan and the regional hub Centre. Prof. Kasuga discussed the progress of ongoing activities and plans related to Future Earth at both the hubs. The meeting was attended by about 30 members including students and faculty from other departments as well.

The vision of the Future Earth is for people to thrive in a sustainable and equitable world. This requires contributions from a new type of science that links disciplines, knowledge systems and societal needs. Prof. Kasuga presented an agenda to address some major ongoing societal challenges of the Future Earth programs.

Prof. Kasuga delivering a talk on the Vision of Future Earth

She weighed on two key aims of Future Earth, one being the interdisciplinary approach across disciplines, and transdisciplinary approach between research and stakeholders from the public and private sectors to improve the contribution of science to the solution of societal issues. By doing so the major

goals of future earth is to facilitate the creation of collaborative networks among future earth family and society. Many ongoing programs and activities are implemented by broadening these activities with through state-of-the-art communications, dialogues and work not only with policy interfaces, but also to learn and extract values by knowledge generation. She gave a brief structural overview of globally distributed secretariat of the Future Earth. She also spoke about the roles of regional and national structures and how they can contribute to fulfil the goals of the Future Earth.

Prof. Kasuga outlined some ongoing projects such as global carbon project (global carbon budget) and global land program (land use and deforestation). She emphasized the need of schemes in order to interpolate between ongoing projects and achieve goals of future earth, called as Knowledge Action Networks (KANs). These are the elementary channels or essential links to key focal challenges for delivering research strategy. Knowledge Action Networks are collaborative frameworks of Future Earth that facilitate highly integrative sustainability research with the aim to generate the multifaceted knowledge, required to inform solutions for complex societal issues.

Prof, Kasuga discussed some of the main objectives of KANs such as, identification and response to society's needs, knowledge generation, inter-disciplinary and trans-disciplinary research and adding value to research. She deliberated on Future Earth plans to launch an initial series called Knowledge-Action Networks (KAN). She also talked about the Sustainable Development Goals (SDG KAN). She laid stress on the aim of the SDGs Knowledge-Action Network to use science as both a tool and an approach to achieve the SDGs. She elaborated on Health KAN since she is in charge of this domain and also her area of research. She spoke about some of the major goals of SDGs while including new areas such as climate change among other priorities. In order to achieve these goals the need to set up indicators within each goal and the need of science to support and study the progress is essential. She also debated on some of the pressing

Discussion with the students and staff of Divecha Centre

challenges involved in achieving these goals and how SDGs can help tackle these challenges by implementing a common plan. Prof. Kasuga urged the students to get involved in Knowledge Action Networks by joining the Future Earth Open Network. The Open Network will serve as an important portal for professionals from around the world to gather and do the crucial work of building transformations to a more sustainable world. It can keep track of Future Earth activities around the world and help adapt and advance the programme's research agenda moving forward.

This was followed by a question and answer session. One of the questions asked by a senior project associate was whether Future Earth brings different stake holders and other policy makers together, or do they fund them as well for this initiative. Prof. Kasuga replied that they are supporting the process of gathering stake holders but these groups are not being funded yet. Another question was about how to interface with the political establishments to achieve the SDG. To this she replied that they are looking at implementing an interface where scientists are one of the stake holders at national level. She also said that these SDGs are taken care by high level forums and she believes that the governments in different countries have different procedures to implement the SDGs. Another question was how the future earth program would look like in ten years time. She replied that the future would actually depend on each country whether they will be able to achieve these goals or not. Finally Prof. Kasuga asked a question on how Divecha Centre is planning to interact with its neighbouring countries (SAARC countries). Prof. Satheesh answered that Nepal has committed to implement these goals; support and funding from their government are yet to be given. Currently Sri Lanka is involved in Future Earth program.

This visit has opened doors towards further development of a new platform promoting science for society thereby providing the knowledge and support to accelerate existing and future programmes on global environmental change.

Interactive question and answer session

OPEN DAY EVENT 2017 AT THE DIVECHA CENTRE

The Indian Institute of Science has an open day in the first week of March every year to celebrate the birthday of its founder Jamsetji Nusserwanji Tata. The day-long science and technology carnival was held on a Saturday 4th March this year.

The general public visiting the Indian Institute of Science campus

Open Day is an event when the Institute opens its doors to the general public to visit, observe and learn, question and understand various scientific and technological innovations going on at the Institute. On this day, thousands of visitors flock to see the scientific demonstrations, experiments and exhibitions to interact with researchers at the Institute. The staff of Divecha Centre for Climate Change conducted experiments, quiz and posters to explain issues related to climate change for the public.

Visitors seeing the posters and demonstrations

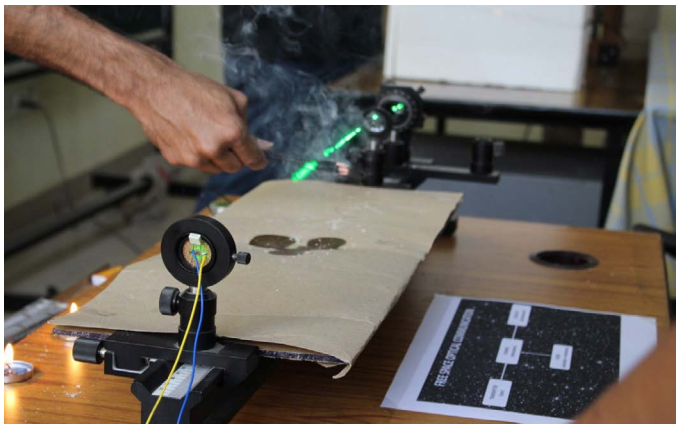
Thousands of people made a beeline to see these projects and posters while research assistants and students explained the science behind them and kept them motivated with enthusiasm. The Centre was also visited by school students and college going students in large numbers who came from different parts of Bengaluru.

Some of the experiments done by the Centre were demonstration of greenhouse effect due to infra red absorption by carbon dioxide. There

was a simple demonstration of extinction and thermal turbulence on a light beam propagating through the atmosphere. The measurement of soot using a micro-athelometer was demonstrated.

The working of a Solar Panel explained

Posters related to aerosols, climate change, global warming and aerosol monitoring instruments were presented to the visitors. The public were informed about the unprecedented rise in concentrations of greenhouse gases. An interactive presentation with satellite



An experiment showing the effect of light scattering and turbulence on a light based communication system

images of various events like crop burning, cyclones, and northern lights was presented to highlight the immense potential of satellite technology.

On the whole the public showed a lot of enthusiasm and for many it was a new learning experience. The school and college students were very enthusiastic and the visit motivated many of them to pursue careers in areas related to climate change.

The demonstration of the role of rotation in a tornado

BERLIN ENERGY TRANSITION DIALOGUE 2017
19TH – 23RD MARCH, BERLIN, GERMANY

Every spring the Berlin Energy Transition Dialogue brings together key international decision makers in energy policy, industry, science and civil society as well as foremost energy experts from all over the world. They discuss the latest energy developments, innovative political instruments, new investment opportunities and future business propositions deriving from the on-going transformation of the global energy sector. This conference is hosted by the German Federal Government in cooperation with the Renewable Energy Federation (BEE), the German Solar Association (BSW-Solar), and the German Energy Agency (DENA).

This year's Berlin Energy Transition Dialogue attracted more than 2,000 high-level participants from 93 countries, including 30 ministers, vice-ministers and state secretaries, to discuss how we can accelerate global *Energiewende* (Energy Transition) towards renewable energy and energy efficiency. The interactive discussions on Twitter reached 7.5 million people, with almost 6,000 posts from over 1,900 users. Mr. Mitavachan Hiremath, who is a part of the policy and translation team at Divecha Centre for Climate Change, was invited to this meeting by the German government.

This year's conference focused on the following two themes:
1. How to successfully align the energy system with the targets of the Paris Climate Agreement and the UN development goals of Agenda 2030 in a cost efficient way?
2. How to set the right framework to trigger the necessary investments into energy efficiency and renewable energy in a reasonable time frame?

The first event as part of this 5 day program was a guided tour on "energy self-sufficiency and prosumers" on 19th March. This event was organised by the German Energy Agency (Dena). The first stop was Mockernkiez, a sustainable residential housing project in the heart of Berlin which is being built to showcase innovative and decentralized energy supply concept in the context of residential complex. The second stop was Feldheim, a self-sufficient village with renewable energies meeting the entire energy demand of the villagers. Through this guided tour, the participants learnt how an entire community can secure its energy supply on a self-sufficient basis and how citizens can become "prosumers" (that is both producers and consumers).

On the second day, the program highlighted the investment and market prospects in major countries, carbon pricing mechanisms and necessity for effective leadership and innovations. The day ended with an award ceremony supporting the innovative startup ideas from across the world. The third day focused mainly on policy mechanisms and how to attract investments to speed-up the energy transition. Different parallel side events were planned on investor prospects, energy efficiency in industry, grid infrastructure, energy-efficient buildings, decarbonising transport. The day ended with a panel discussion on the need for integrated energy transition.

Panel discussion on Carbon Pricing – Leadership & Innovation

On the fourth day, there was a guided tour on “Digitalisation and the energy transition”. e*Message Europe, a leading company in European continental paging market offers smart grid solutions for secure and reliable control of distributed small load and production facilities in the low voltage grid level. E.O.N’s: agile accelerator, a hub that nurtures new business ideas and brings them to life with expertise from the energy sector was launched in 2013 to promote innovation in energy sector. On the fifth day, a guided tour provided a glimpse of the sustainable mobility concepts, alternative fuels and infrastructure systems of the future.

Panel discussion on Integrated Energy Transition

LONG-TERM MEASUREMENTS OF ATMOSPHERIC BLACK CARBON: CAMPAIGN FOR CALIBRATION, STANDARDIZATION OF PROTOCOLS AND INTER-COMPARISON

BC or Black Carbon aerosols are produced as by products of all low-temperature and incomplete combustion processes involving hydrocarbons; due to either natural or anthropogenic processes. The chief sources are combustion of fossil fuels for transport, industry, and energy sectors; fossil fuel and biomass fuels for domestic applications; large scale crop residue burning as well shifting cultivation in the agricultural sector; and large-scale forest fires. Of the various atmospheric aerosol species, BC is the strongest absorber of radiation over a wide wavelength range from visible through Infrared and contributor to atmospheric warming. The global climate forcing potential of BC through its strong absorption is well recognized in climate science. It is now recognized that BC contributes next to CO_2 to global warming, though BC is a short-term climate forcing agent with mean life time of a week to 10 days compared to about 100 years of CO_2. Despite this global effect, BC forcing could be significantly high over regions where its abundance is high (like the Asian region), during periods when BC is confined close to the surface by low-level inversions (such as winter) and during large-scale forest fires, and over surfaces with high reflectance (such as snow and glaciers over land and clouds in the atmosphere). In addition, BC has strong implications for health and being in the fine size range; these particles are easily inhaled and could reach deeper into the respiratory system. As on today, there are no space-based techniques for global measurement of BC. Thus, accurate and long-term measurements through ground-based network are to be resorted to for generating primary data of BC for (1) climate or health impact assessments, (2) for international negotiations (such as UNFCCC, IPCC etc), (3) working out mitigation plans and monitoring the efficacy.

Systematic and long-term measurements of BC have been initiated in India by the Indian Space Research Organization (ISRO) under its Geosphere Biosphere programme, and have set up a network (ARFINET) containing about 40 observatories spread across the region (Fig.1).

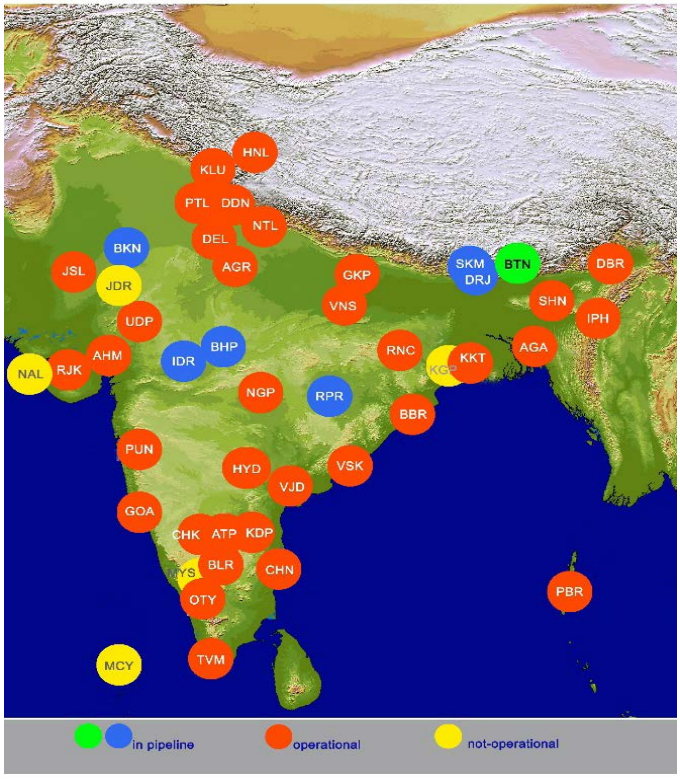


Fig. 1. The spatial distribution of aerosol observatories, measuring BC, under ARFINET

The measurements, made use of optical attenuation measurements of samples collected on filter tape substrates, using an instrument, Aethalometer, which is used globally, in view of its simplicity and field-rugged nature, even for harsh environment. Due to operational constraints and entwining research with data, the network has been established in a phased manner, by adding stations over the years. Consequently, the network used different models of Aethalometers, with the later version having several improved features compared to the earlier legacy instruments (because of improved understanding of the uncertainties with filter based BC measurement techniques). This calls for periodic calibration and inter-comparison for the instruments, for establishing consistency between measurements and to refine the sampling protocols and analysis procedures. This has been done in campaign modes, periodically and also as part of major field campaigns. However, regular such exercises are needed, in view of the expansion of the network, change in the instrument models and analysis software and also the need for long-term quality controlled data for scientific and policy applications.

The biggest, and most extensive of such campaigns has been conducted very recently at the Divecha Centre for Climate Change, IISc, Bengaluru, jointly with Space Physics Laboratory, VSSC, ISRO (the nodal agency for ARFINET) along with the scientists from Aerosols d.o.o., Slovania, the manufacturers of the instrument. The campaign spanned for nearly two weeks, from 3rd to 13th April 2017. It involved 41 instruments from the network stations (covering three different models), operated under the same ambience, aspirating air (containing BC) through a common manifold inlet to ensure identical sampling conditions.

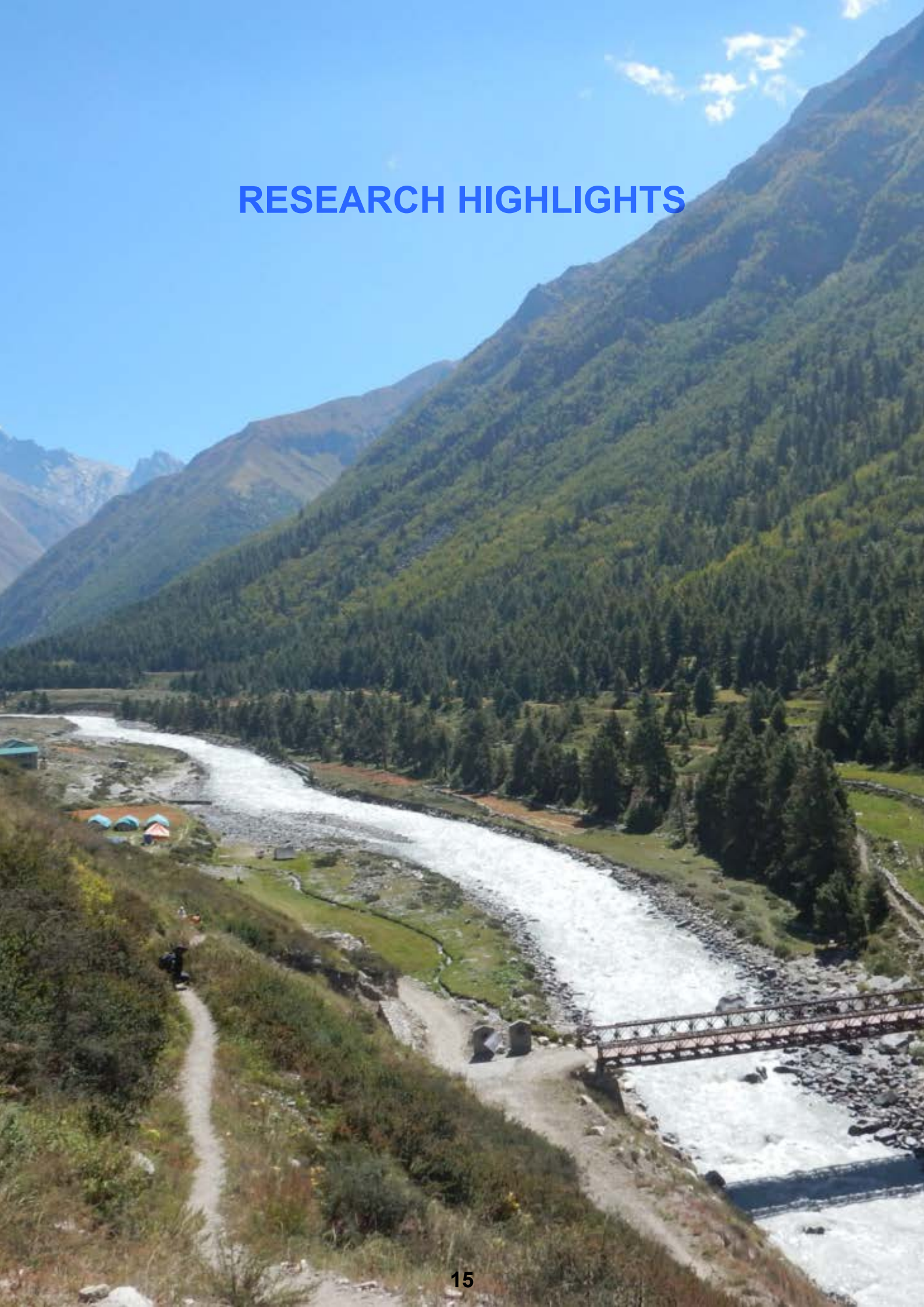
Figure 2: Photograph of the Aethalometers undergoing calibration and inter-comparison tests as part of the campaign. The instruments are seen in the left panel, while the right panel shows the aspiration of air through the manifold

The campaign included a two-day workshop, which was attended by domain experts and the network scientists, hand-on training to participants on various essential house-keeping and preventive maintenance as well as essential quality checks of the data, and also servicing and calibrating of instruments as found essential. During the workshop, which was attended by more than 50 participants, the scientists from the manufacturing company explained different aspects of instruments, the sampling protocols, and the theory behind the data deduction, the improvements / changes brought about in different models and the essential precautions to be followed. The effect of particle loading on the filter tape on the estimated value of BC concentration and the methods to correct this were discussed in detail. The workshop was inaugurated by Prof. S. K. Satheesh, Chair, Divecha Centre for Climate Change, following which Prof. J. Srinivasan highlighted the climate perspectives of atmospheric BC, their role in the environment and health.

Dr. K. Krishna Moorthy highlighted the need for long-term and continuous BC measurements over a region, the necessity to maintain accuracy and consistency between measurements and instruments and the chief objective of this campaign. Prof. Grisa Mocnik, Director of Research and Development, Aerosol d.o.o., Slovenia, presented the evolution of aethalometer and its various applications, advantages and limitations. A summary of the proceedings was given by Dr. S. Suresh Babu, from SPL, ISRO. Following the workshop, the experts from Aerosol d.o.o., Slovenia, provided hands-on training to the participants on the operation and maintenance of aethalometer. Detailed outcome of this campaign would be brought out in the form of a technical document shortly.

Photograph of the participants of the workshop

RESEARCH HIGHLIGHTS



MITIGATION OF FLOODS DUE TO GLACIAL LAKE OUTBURST

Most of the glaciers in the Himalayas have been receding during the past 50 years. This has led to the creation of many glacial lakes in the Himalayas. The moraine dammed glacial lakes can lead to sudden glacial lake outburst floods (GLOF). The south Lhonak glacier in Sikkim, had a lake with a large volume and hence posed a serious threat to the villagers living downstream of the lake.

Glacial lake in Sikkim

The risk of GLOF can be modelled if information of lake area, volume, nature of moraines, topography and geography of the region is known. Therefore investigation using remote sensing and field data was carried out by multi agency team to assess potential hazard. Satellite images were used to map changes in lake extent from year 1976 to 2015. Then, field and model investigations were used to map glacier depth and extent of ice at the core of terminal moraines. Investigations have shown continuous growth in the aerial extent of the lake from 21 to 126 Hectare between years 1976 and 2015. The volume of lake water was estimated to be 53 million m^3 in the year 2014 and this was expected to increase to 90 million m^3 in the future due to further expansion. Resistivity survey has also shown the presence of ice at the core of terminal moraine. Therefore, GLOF simulation was carried out using flood models. This has provided information on flood level and flood arrival time at different locations in the valley, indicating vulnerability of human life and property in the region.

The Department of Science and Technology requested Prof. Anil Kulkarni to call a one-day meeting of the experts at Divecha Centre for Climate Change to discuss various ways to mitigate the threat of GLOF. This meeting was held on 21st February 2015 at Divecha Centre for Climate Change. After a detailed discussion the experts concluded that a siphon system should be installed to decant the water slowly from the lake behind the moraine dam. This decision was communicated to the Sikkim government which has installed the siphon system. The photographs provide a glimpse of the events that led to the installation of the siphon.

Contributed by: Anil Kulkarni

Installation of siphon system

Siphon System after installation

Decantation of water from the lake

POTENTIAL CLIMATE IMPLICATIONS OF ELEVATED LAYERS OF SOOT FROM HIGH-ALTITUDE AIRCRAFT EMISSIONS

Soot is one of the primary air pollutants which absorbs the sunlight and consequently warms the atmosphere. In most parts of India we find a high concentration of soot near the ground on account firewood used for cooking and emissions from vehicles and coal power plants. Measurements of the altitude profiles of BC over Central Indian location, Hyderabad, using high-altitude balloon ascents, have shown occurrence

Figure 1: High altitude balloon facility used for the measurement of soot

of elevated layers of soot between 4 to 8 km above the ground (figure 2a) within which, the concentration of soot was very high, at times even surpassing the near surface values. Such a high concentration of soot well above the ground could not be attributed to sources near the ground. As a part of his doctoral work, Mr. Gaurav Govardhan, Grantham fellow, at Divecha Centre for Climate Change examined the hypothesis that this elevated soot layer may be on account aircraft emissions.

He used a chemistry transport model WRF-Chem to simulate the observed elevated layers of soot. The model simulated vertical variation of soot is shown in figure 2b. The red curve shows the model the variation of soot with height in the simulation that did not include aircraft emissions but included emissions near the ground. Note that there is no elevated layer of soot in this simulation. He then carried out one more set of model simulations, in which realistic emissions of soot from aircrafts were also included. The corresponding vertical profiles of soot from these simulations are shown by a black curve in figure 2b. The elevated sharp and confined layers of soot were simulated by the model upon prescription of such soot emissions from aircrafts flying over the study domain. The new simulations show an elevated soot layer although the maximum value is smaller than the observations. This provides a strong evidence for the emissions from aircrafts might be contributing significantly to the elevated soot layers in India. The discrepancy between model simulation and observation maybe on account of errors in the assumptions about emissions of the soot from aircraft.

The model simulations showed, further, that such elevated sharp and confined

layers of soot emitted by aircrafts can interact with strong convection occurring over the Indian region and can get lifted up. The model simulations and space based LIDAR observations showed that such lifted soot layers intrude into the stratosphere. Based on the previous reports, he further hypothesized that, such aircraft emitted soot can intrude into the stratosphere and can play a role in depletion of stratospheric ozone. Thus the study suggests that, the aircraft emissions of soot, apart from being responsible for the observed sharp and elevated layers of soot could also influence the ozone layer in the stratosphere.

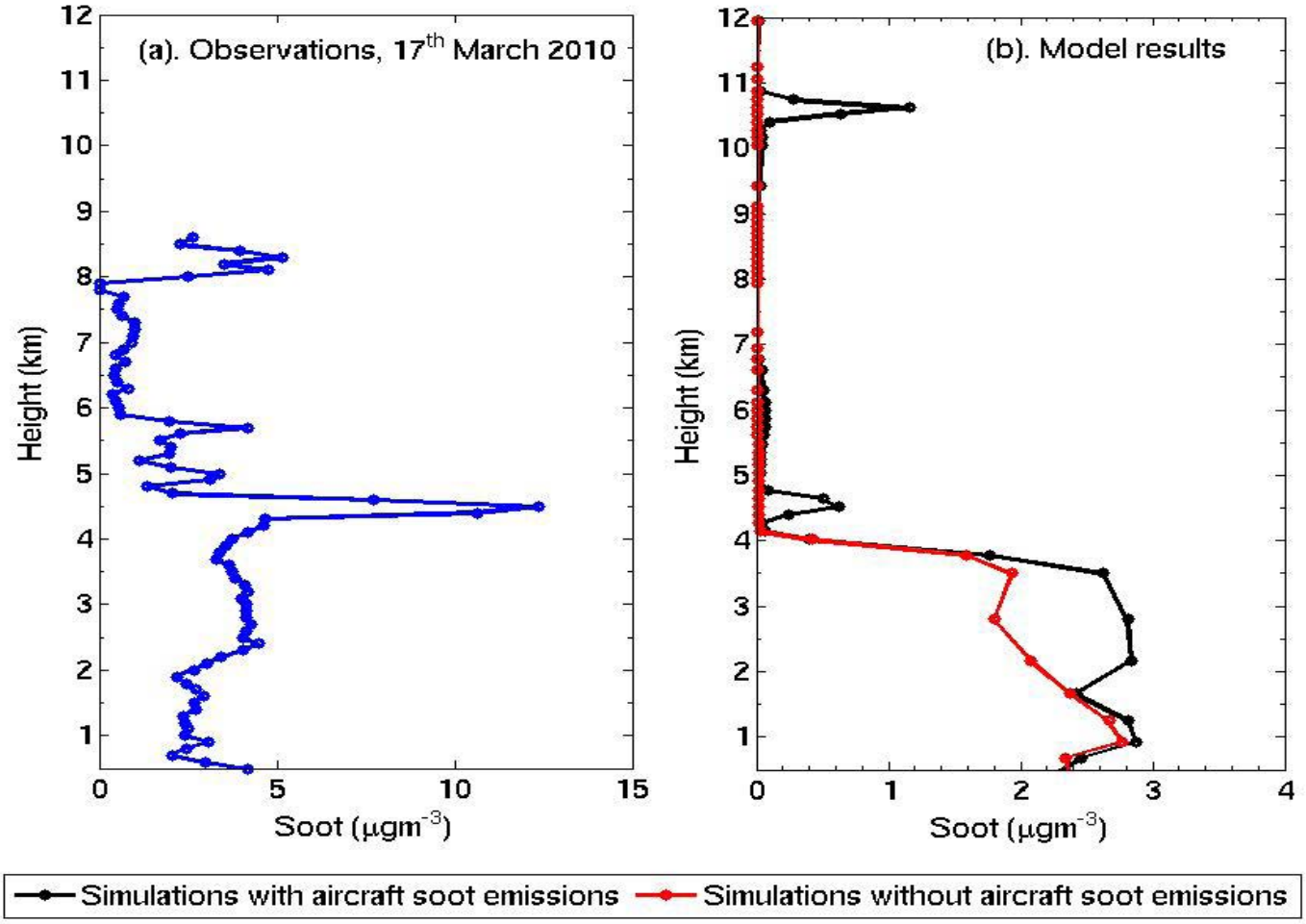


Figure 2: (a). Observed vertical profile of soot over Hyderabad, India obtained from balloon measurements during 17th March, 2010 (b). Model simulated vertical profile of soot for; the simulations without aircraft soot emissions (red line) and the simulations with inclusion of soot emissions from aircrafts (black line).

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WHY IS INCREASED ABSORPTION OF SOLAR RADIATION NOT AS EFFECTIVE AS INCREASING CARBON-DIOXIDE IN CONTROLING EARTH'S CLIMATE?

The climate system responds to radiative imbalances caused by greenhouse gases or aerosols and this change is quantified as a change in the global mean surface temperature. For example, since the pre-industrial period, the changes in various "anthropogenic" agents such as CO_2, CH_4 and aerosols have caused a net radiative imbalance of about 2 Watts/m^2 and the global mean surface temperature has increased by about 1^0C as a response to this imbalance. Earlier, it was assumed that all climate change agents are equal i.e., they cause the same climate change as that of CO_2 if the amount of radiative imbalance introduced by them is the same. However, climate modeling studies in the last two decades have shown that this is not always the case. To measure the effectiveness of various forcing agents in causing climate change, relative to CO_2, the concept of efficacy was introduced. Efficacy is defined as the ratio of global temperature change due to a particular forcing agent to the temperature change caused by CO_2 for the same imposed radiative imbalance. Previous climate modeling studies have made estimates for some forcing agents such as solar radiation, CH_4 and black carbon aerosols. These studies have found that the efficacy of solar radiation is less than one which means solar radiation is less effective in causing climate change when compared to CO_2. However, a mechanistic explanation for the lower efficacy of solar forcing was lacking.

In a recent study, we set out to identify the reasons for the lower efficacy of solar radiation. In this study, using climate model simulations, we estimate the efficacy of solar radiation relative to CO_2 and provide a comprehensive analysis of the differing adjustments in the climate system which explains the lower efficacy of the solar radiation changes. In one of our simulations, the atmospheric CO_2 was doubled abruptly from its pre-industrial value of 285 to 570 ppm. In this simulation, the imposed radiative imbalance was about 4 Watts/m^2 and the simulated global mean warming is about 4^0C. In another experiment, we increased the solar radiation abruptly to produce the same global mean warming of 4^0C. In this second experiment, however, the required radiative imbalance was found to be 5 Watts/m^2. Hence, while a 1 Watts/m^2 imbalance due to CO_2 causes a 1^0C warming, a similar imbalance due to solar radiation causes only 0.8^0C warming. Hence, we find that the solar radiation is less effective (80 %) than CO_2 in causing climate change.

For the case of solar radiation increase, the climate system is able to lose heat relatively efficiently to space and hence an increase in solar radiation is less effective in causing climate change than an equivalent increase in CO_2.

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