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Newsletter of the

DIVECHA CENTRE FOR CLIMATE CHANGE

South Asia Regional Office of Future Earth
Local and Remote Rainfall Influences (LORRI) Workshop
Training Program on Glaciers, Climate Change and Remote Sensing
Eureka: Interview in Rajya Sabha TV
NERC-MoES Joint Program for Monsoon Studies



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FROM THE CHAIRMAN

Greetings!

The Divecha Centre for Climate Change was established at Indian Institute of Science in January 2009 with a generous financial contribution from Arjun and Diana Divecha and the Grantham Foundation for the Protection of the Environment.

The primary goal of this centre is to understand climate variability and climate change, and their impacts on the environment. The Centre continues to pursue experimental and modelling studies in this direction. It has identified 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 is also working 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, the Centre has also undertaken outreach activities to create awareness among people and policy makers about climate change and its consequences. This has been done 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 in order to build capacity to address issues related to climate variability and climate change. The centre provides advice to ministries and departments of the Government of India to develop national and international policies related to climate change.

Plans are also underway to expand its activities to South and Central Asia regions. Recently, South Asia Regional Office of global science-sum policy initiative, 'Future Earth' has been established at the Divecha Centre for Climate Change. Future Earth is, actually, the confluence of major international programmes; the International Geosphere Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP), DIVERSITAS-an international programme of biodiversity science, besides a few others. 'Future Earth', has five global hubs, or secretariats, that are located in Canada, France, Japan, Sweden and the United States. The vision of "Future Earth" is 'Science for the People' and requires solutions-oriented research that responds to the challenges faced by the society due to global environmental change in collaboration with various research partners, decision-makers in government, the private sector and civil society. The centre would involve scientists from Social Sciences, thus would take a leadership role and formulate strategies to drive the society along a sustainable pathway. In this context, the centre would encourage involvement of social scientists in its activities. Since the degree of climate change and the extent of its effects on people will differ from one part of the world to another and between rural and urban areas, it is important to have region-specific strategies to tackle the effects of climate change. The centre will identify outstanding grand challenges specific to this region on issues related to climate change.

The installed capacity of wind energy power plants has increased rapidly in India. The COP-21 has identified development of renewable energy as one of the key enabling technologies for achieving the GHG mitigation targets. The total installed capacity of wind power plants in India is around 23 GW at present. The total potential for wind energy at a hub height of 100 m has been estimated to be more than 300 GW by the Centre for Wind Energy Technology. This implies that less than 10% of the total available wind energy resource has been tapped. To meet the ever growing energy demand within the country it is estimated that India will require an additional 400 GW by 2030. Engagement of the centre with the academic and national institutes in India as well as industry would definitely be mutually beneficial.

S.K. Satheesh

INAUGURATION OF THE ANNEX

In the first phase, the Divecha Centre for Climate Change was housed in the third floor of the building for Centre for Atmospheric and Oceanic Sciences in the lush green environs of the Indian Institute of Science campus. The building incorporated elements of green technology while providing research facilities to faculty, project staff and students. The building was inaugurated by Mr. Arjun Divecha on 24th January 2011.

The building features a 125 seat auditorium with modern facilities, a board room with teleconferencing capability, two rooms for researchers and students faculty and project staff. The auditorium has been in frequent use since its completion with periodic hosting of workshops, seminars and lectures. An innovative feature of the auditorium is the solar power enabled lighting system. The terrace has been designed so that the visitors and students can exchange ideas during and after conferences and enjoy refreshments. In

view of the rapid expansion of the Centre, it was decided to build an annex to the existing building to provide more space for post-doctoral fellows, workshops and meetings. The construction of this annex was inaugurated by Mr. Arjun Divecha on 26th May 2016. This annex is expected to be ready for occupation by January 2017.



Mr. Arjun Divecha addressing the gathering during his visit at the Divecha Centre for Climate Change (DCCC) on 26th May 2016



Mr. Arjun Divecha inaugurating construction of the annex of the Divecha Centre for Climate Change (DCCC) on 26th May 2016. Also seen in the photo are (from left) Prof. J. Srinivasan, the then Chairman, Divecha Centre, Prof. Anurag Kumar, Director, Indian Institute of Science, Prof. S.K. Satheesh, Divecha Centre and Prof. Vikram Jayaram, Chairman of the Division of Mechanical Sciences.

SOUTH ASIA REGIONAL OFFICE OF “FUTURE EARTH” INAUGURATED

Future Earth is an international research initiative supported by ICSU, UNESCO, UNEP, and the Belmont Forum among many others. The vision of the Future Earth program is 'Science for the People'. The main goal of Future Earth is to develop the knowledge required for societies worldwide to face challenges posed by global environmental change and to identify and implement solutions and opportunities for a transition to global sustainability. Future Earth will develop the strategic knowledge for responding effectively to the risks of global environmental change. Future Earth is, actually, the confluence of major international programmes; the International Geosphere Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP), DIVERSITAS-an international programme of biodiversity science, besides a few others.

Future Earth Secretariat has a unique and innovative structure, comprising of five global hubs, which will function as a single entity, and are located in Canada (Montreal), France (Paris), Japan (Tokyo), Sweden (Stockholm) and the United States (Colorado). These are further complemented by Regional Offices spread across the globe. A regional office is an autonomous research platform that promotes scientific co-operation between countries of a particular geographical region in Future Earth related activities.

The South Asia regional office of 'Future Earth' was inaugurated at the Divecha Centre for Climate Change (DCCC), Indian Institute for Science (IISc), Bengaluru on 09th July 2016. Regional Office for the South Asia has its domain spanning over the SAARC countries, Myanmar and a few Indian Ocean Island countries. This regional office is located at the Divecha Centre for Climate Change (DCCC), IISc, Bengaluru. Along with this, a national brainstorming meeting on Future Earth was conducted. This was attended by nearly 70 invited experts across multiple disciplines (including weather, climate, monsoon,

aerosols and anthropogenic emissions, polar and cryosphere research, modelling, hydrology, agriculture, remote sensing, oceanography and so on) in line with the basic framework of the programme. The purpose of this meeting was to take stock of the activities being pursued under different science departments and academia on topics relevant to Future Earth, chalk out the way ahead considering the overall guiding principles of the international programme and the topics of regional relevance and suggest ways to synthesis the information emanating from these efforts and generate knowledge needed for societies (regional and global) to address the grand challenges posed by climate change for sustenance and to adapt to the changes.



Shri. A.S. Kiran Kumar, Secretary, Department of Space (DoS) and Chairman, ISRO, Prof. Anurag Kumar, Director IISc and Dr.M. Rajeevan, Secretary, Ministry of Earth Sciences (MoES) during the inaugural session of Future Earth South Asia regional office at DCCC

The opening session was chaired by Prof. Anurag Kumar, Director IISc while Dr.M. Rajeevan, Secretary, Ministry of Earth Sciences (MoES), and Shri. A.S. Kiran Kumar, Secretary, Department of Space(DoS) addressed the gathering. Prof. S.K. Satheesh, Chairman, DCCC, welcomed the gathering. In his opening remarks, Prof. Anurag Kumar briefly touched upon the rationale of this new international initiative. He announced the formal establishment of the Future Earth South Asia regional office at the Divecha Centre for Climate Change.



Prof. Anurag Kumar announcing the formal establishment of the Future Earth South Asia regional office at the Divecha Centre for Climate Change.

Shri. A.S.Kiran Kumar, Secretary DOS, enumerated the various space based services

ISRO provides to the nation and the region, which imparts information of natural resources, productivity, glacier dynamics, water resources, winds over ocean, flood assessment, information on essential climate variables and aerosols and greenhouse gases through dedicated satellites, ground based observational network and integrated information dissemination.

Shri. Kiran Kumar went on to talk about the various satellites and tools developed by ISRO and how they help in getting the data on climate and other parameters. He also spoke about the new generation satellites that are going to be launched by ISRO in future and how it can help with this initiative.



Shri. A.S. Kiran Kumar, Secretary, Department of Space (DoS) and Chairman, ISRO addressing the gathering.

In his address, Dr.Rajeevan, Secretary, MoES, emphasized the role of MoES in providing information on weather and climate to the common men of India; the farmers, fishermen and pilgrims to the urban residents, highway users and the government agencies with an aim to impart societal benefits. He also elucidated the plan of the ministry to expand the services so as to reach deeper into the society and information on impacts of changing climate such as extreme weather extended droughts and heat waves.

Dr.Rajeevan noted that the main goal of Future Earth is to develop the knowledge required for societies worldwide to face challenges posed by global environmental change and to identify and implement solutions and opportunities for a transition to global sustainability. He further stated that by establishing the Future Earth South Asian Hub in India at IISc, would provide the country with opportunity to take leadership role and expertise on the science behind rapid global change and formulate strategies to drive the society along a pathway for sustainability.



Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences (MoES), New Delhi addressing the gathering.

This was followed by a comprehensive presentation by Prof. S.K. Satheesh, Chairman of Divecha Centre and Executive Director of Future Earth South Asia regional office, on the general objectives, and structure of Future Earth initiative and the functions of the regional office.

“The South Asia regional office,” Prof. Satheesh said, “is an autonomous research platform that promotes scientific cooperation between India and neighbouring countries in Future Earth related activities. The regional hub will ensure that regional priorities are made part of the strategic development of Future Earth activities.”

“The vision of ‘Future Earth’ is ‘Science for the People’ and requires solutions-oriented research that responds to the challenges faced by the society due to global environmental change in collaboration with various research partners, decision-makers in government, the private sector and civil society,” he added. The regional hub will soon organize its first workshop to take this forward. “Thematic working groups, or task teams, will be established soon after this workshop,” said Prof. Satheesh.

“The mandate of this hub/office is to integrate the available information and develop strategic knowledge and region-specific strategies to tackle and face consequences of climate change,” he added.



Prof. S.K. Satheesh, Chairman, Divecha Centre for Climate Change (DCCC) and Executive Director of the newly-formed office talking about the Future Earth.

The next session, chaired by Dr M. Rajeevan, Secretary MoES, and Prof. J. Srinivasan, DCCC, sought inputs from different domain experts attending the meeting. The brainstorming session witnessed discussions on selected topics, which are relevant to the South Asian region. Keeping in view the broad mandate of Future Earth, some tentative topics relevant to the domain are discussed to initiate activities. The topics include: Impacts of climate change on (a) Monsoons (b) Extreme weather (c) Glaciers (d) Ecology (including biodiversity) (e) Aerosols and Clouds (including air quality) (f) Remote sensing (including LU/LC changes) (g) Agriculture and Food security (h) Oceanography (Sea-level rise) (i) Hydrology and (j) Renewable Energy.



Prof. V.K. Gaur, Former Secretary, Department of Ocean Development (currently Ministry of Earth Sciences) expressing his views. Prof. J. Srinivasan, Divecha Centre for Climate Change and Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences chairing the forenoon session of brainstorming session.



Dr. Harsh Gupta, Former Secretary, Department of Ocean Development (currently Ministry of Earth Sciences) expressing views



Prof. R. Sumkumar, Centre for Ecological Sciences and Associate Faculty of DCCC, IISc

During the afternoon, Dr. K. Krishnamoorthy, Chairman, Future Earth national committee for India and Prof. Ravi Nanjundiah, Chairman, Centre for Atmospheric and

Oceanic Sciences (CAOS) summarized the proceeding, with interactive deliberations from the participants. .



Prof. R.S. Nanjundiah, Chairman, Centre for Atmospheric and Oceanic Sciences, IISc and Dr. K. Krishnamoorthy, Chairman, Future Earth National Committee for India chairing the brainstorming session.

Prof. Satheesh concluded the session by talking about the vision of Future Earth and its proposed activities. He stated that the vision of Future Earth is for people to thrive in a sustainable and equitable world. In order to achieve this, it is extremely important for the scientific community to engage with diverse decision-makers in government, the private sector and civil society to collate all the knowledge that is available. The regional office will promote scientific co-operation between India and its neighbouring countries in Future Earth related activities. He mentioned that:

- (a) Activities of the office should be inter-disciplinary in nature.
- (b) Mandate of the office is to integrate available information from national

laboratories in India as well as in SAARC countries, ministries and departments and academic institutions and develop specific strategies to tackle and face consequences of climate change.

(c) Promote the implementation of specific activities of Future Earth over this region.

(d) Ensure that regional priorities are made part of the strategic development of Future Earth.

(e) Operate as primary point of contact between interested researchers, research institutions, funding agencies and other interested parties, and Future Earth.

(f) Provide up-to-date and timely information about the objectives and organization of Future Earth, actively reaching out to researchers and stakeholders over this region.

SHORT COURSE BY PROF. LAKSHMI VARAHAN, UNIVERSITY OF OKLAHOMA

The Divecha centre for Climate Change organized a short course on “Forecast Error Correction Using Data Assimilation” conducted by Prof. S. Lakshmi Varahan, Department of Computer Science, University of Oklahoma from 4th to 15th July 2016. Data assimilation is the problem of optimally combining models and data.

Data assimilation research is primarily driven by the need to make weather forecasts using models, requiring that the present state of the atmosphere be estimated optimally. The instructor, Prof. S. Lakshmi Varahan, has co-authored the book “Dynamic Data Assimilation: A Least Squares Approach”, by Cambridge University Press. He has offered many short courses on the subject for agencies making operational forecasts around the world, and the present course reflects his interest in building capacity in data assimilation within the research community in India.

The course began with the fundamental principles and mathematical tools behind data assimilation. These are linear algebra and vector spaces, matrix theory, multivariate calculus, least squares estimation, and optimization. Least squares methods underpin prevalent data assimilation techniques, and the geometric and algebraic foundations of least-squares estimation were discussed. Following the treatment of the linear problem, where the model is linear in parameters to be estimated, the nonlinear problem was considered.

This requires approximating the nonlinear function by a Taylor series. Matrix methods for solving least squares problems were developed. Computational complexity theory was introduced and computational costs of alternative approaches described.

Iterative methods for solving the least squares problem were discussed (e.g. steepest

descent, conjugate gradient). The first week focused on static data assimilation problems and the aforementioned mathematical techniques. The second week concentrated on dynamic data assimilation, which is more relevant to weather forecasting.

A number of well-established and newly developed methods for assimilating data into both deterministic and stochastic dynamic models were introduced.

The course ended with a discussion of methods for assimilation in nonlinear problems. There were 4 lectures each day, and with 10 days of lectures, these 40 lectures comprised a brief introduction to a wide range of material that is normally spread over two full courses when it is taught by the instructor at Oklahoma.

Fifteen students completed the course, with about half from IISc. Many of the students work on research problems involving data assimilation, but some attended out of interest in learning mathematical methods and estimation techniques. The students who completed the course were engaged, and the lectures were interactive.

From the beginning to the end of the course there was a perceptible progression from the students taking an instrumental view of the subject matter to wanting to understand the fundamentals. The course also seemed to make a difference to their attitude towards mathematics, and how they approached learning new techniques. They seemed to develop some mathematical maturity, willing to see an argument through to its end before either making a judgement or asking why something couldn't be done differently. One lesson to perhaps be learned is that, while such short courses are no substitute for a regular curriculum, with the right instructor they can make a significant difference to students' mind set and approach.



Prof. S. Lakshmi Varahan with some of the students and faculty who attended the course.

LOCAL AND REMOTE RAINFALL INFLUENCES (LORRI) WORKSHOP

As part of the joint UGC-UKIERI project a second workshop on Local and Remote influences on Rainfall over India (LORRI) was held on 19th and 20th July at Divecha Centre for Climate Change.

The two-day workshop began with a welcome by Prof. J. Srinivasan who briefed the audience about the history of this project and its scientific goals. The first scientific talk was by Prof. Apostolos Voulgakis from Imperial College, London. He presented current understanding of the local and remote impacts of aerosols on general circulation and monsoon.

Dr. K. Krishnamoorthy from the Indian Institute of Science illustrated the history of aerosol

observations in India. He showed how observation of aerosols was felt important in India and a thrust was initiated couple of decades ago. Dr. Sagnik Dey of the Indian Institute of Technology, Delhi presented his research on the indirect effect of aerosols. He showed how aerosols can modulate clouds and the radiation budget of the atmosphere. Dr. V. Vinoj of the Indian Institute of Technology, Bhubaneswar showed, through modelling experiments, how carbonaceous aerosols, like dust, can impact Indian summer monsoon through changes in low-level circulation. Dr. K. Rajendran highlighted the results from CMIP5 model simulations. He showed how sensitive the ENSO-Monsoon relationship was in different models.



Prof. Apostolos Voulgakis from Imperial College, London with participants of LORRI workshop

Mr. Dilshad Shawki from Imperial College detailed the influences of remote sulphate aerosols on Indian summer monsoon. He showed, through 150 year-long simulations of a coupled general circulation model, that removal of sulphate aerosols from mid latitude, including east Asia, America and Europe, will shift the inter-tropical convergence zone northward during northern summer. As a result, Indian summer monsoon precipitation intensified. This was shown to be because of an enhanced flux of energy across the equator from southern to northern hemisphere.

Dr. Dilip Ganguly of Indian Institute of Technology, Delhi outlined the current understanding of the impact of anthropogenic aerosols on monsoon, and climate in general. Dr. L. Kiranmayi of Indian Institute of Technology, Bhubaneswar illustrated the observed changes in equatorial waves in the past three decades.

Dr. S. Suresh Babu from Space Physics Laboratory, Thiruvananthapuram showed recent advances in observation of aerosols in India and their role in modulating radiation.

Mr. Gaurav Govardhan from Indian Institute of Science showed the skill of HadGM model in the simulation of aerosol properties over the Indian region with prescribed emissions. He showed that error in meteorological parameters like winds and rainfall results in error in the simulated bias in aerosol concentrations in the model.

Ms. Anwesa Bhattacharya from Indian Institute of Science showed the impact of aerosols in modulating the active-break cycle of the Indian summer monsoon. She showed how an interactive aerosol module in the model can realistically simulate the observed asymmetry in cloud properties between transition phases of low frequency intraseasonal oscillation of Indian summer monsoon.

Mr. Farhan Jamil from Indian Institute of Science illustrated observed changes in the

diurnal cycle of the Asian summer monsoon on continental time scale. He showed how a higher loading of aerosols in the atmosphere can explain this observed changes in diurnal properties of rainfall and circulation during past six decades.

Dr R Krishnan from Indian Institute of Tropical Meteorology, Pune showed the relative importance of aerosols and greenhouse gases in simulating the observed variability and trend of Indian summer monsoon. He showed that the inclusion of aerosols in a numerical model can explain the observed decreasing trend in the moderate rainfall events over Indian monsoon region.

Dr. Massimo Bollasina from University of Edinburgh, UK presented his several important studies on impact of aerosols on monsoon. He showed, how aerosols over East Asia can have impact on the subtropical high and thus can change Asian monsoon.

In the last talk of the workshop Dr Apostolos Voulgakis summarized the current understanding of the local and remote impacts of aerosols on the Indian monsoon. The final session of the workshop was a discussion among all participants on the future directions in the area of aerosol-monsoon interaction.

The need for a model inter-comparison project to understand the impact of aerosols was highlighted.



Prof. Apostolos Voulgakis from Imperial College, London with Dr. K. Krishnamoorthy and Prof. S.K. Satheesh during LORRI workshop

BOOK BY AMITAV GHOSH AND PANEL DISCUSSION ON CLIMATE CHANGE

There was a panel discussion on climate change after the launch of the book “The Great Derangement: Climate Change and the Unthinkable”, by Amitav Ghosh, at Indian Institute of Science, Bengaluru on 27 July 2016. The panel members were Amitav Ghosh(author), Rohini Nilekani (Arghyam Foundation), K Shanker (ATREE), R.Sukumar (Ecological Sciences and Associate Faculty of Divecha Centre for Climate Change, IISc) and J. Srinivasan (Divecha Centre for Climate Change, IISc).



R. Sukumar, Amitav Ghosh and Rohini Nilekani during a panel discussion on climate change after the launch of the book “The Great Derangement: Climate Change and the Unthinkable”, by Amitav Ghosh

Karthik Shanker introduced the author, Amitav Ghosh, and highlighted some salient features of the book.

In the book, the author has argued that collective action is poorly treated in modern literature, which is largely about individual moral adventure. Therefore, literature has been doubly limited in imagining possibilities for collective action to confront challenges such as climate change.

There are challenges particular to addressing various aspects of climate change, the overarching difficulty being that it poses

challenges to human freedom and that powerful countries have an interest in maintaining the status quo, which stems from the present balance of emissions.

Amitav Ghosh reiterated his main message in the book, of art in its modern form having abandoned reality, and therefore being unable to come to grips with the large scale effects of climate change, its effects, and the challenges posed to human action.

Ghosh pointed out that many effects of global warming (e.g. coastal inundation) are predictable, and the challenges lie with developing the imagination to deal with these problems.

R. Sukumar argued that there is large uncertainty in many scientific predictions of impacts, especially at the local level. Therefore while scientists had a role to play, the science isn't always at the stage where it can offer useful information.

R. Sukumar raised the issue of lack of awareness of climate change before the middle of the last decade. J. Srinivasan pointed out that rural people who are on the frontlines of experiencing climate change have known about it for a long time but urban people have been ignorant about it till recently.

J. Srinivasan raised the issue of population growth and its role in climate change. However most of the panel members exhibited discomfort with the topic, illustrating the difficulties of addressing the role of population explosion on climate change squarely.

Rohini Nilekani was concerned with lack of response from weak governmental institutions, and seemed to agree with the book's argument about the role of non-governmental institutions.

TRAINING ON GLACIERS, CLIMATE CHANGE AND REMOTE SENSING

In the Indian Himalayas, large quantity of water is stored in the form of seasonal snow, ice and glaciers. Melt water from these glaciers and snowfields provide important inputs in the form of run-off to the North Indian Rivers, especially during critical summer months.

This makes these rivers perennial and has helped to sustain and flourish the Indian civilization along the banks of the rivers Ganga and Indus. However, runoff from the Himalayan glaciers is not assured because geological history of the Earth indicates that glacial dimensions are constantly changing, as glaciers are highly sensitive to minor variations in climate. Therefore, monitoring of Himalayan glaciers is important to assess future changes in the runoff of the North Indian Rivers. However, Himalayas have very rugged terrain and conventional field based methods are difficult to be employed. Therefore, remote sensing has emerged as an alternative method for collecting information on glaciers. In India due to lack of trained manpower, it is difficult to generate reliable information. Therefore, proper training in extracting glaciological information from remote sensing data is to be imparted to scientists working in the field of glaciology for full utilisation of this advanced technology. A training program was organized by Dr. Anil Kulkarni and faculty members of Divecha Centre for Climate Change and Centre for Atmospheric and Oceanic Sciences at Indian Institute of Science during July 18 - 29, 2016. In addition to Divecha Centre for Climate Change, this training was sponsored by Department of Science and Technology, Government of India, New Delhi. In addition, experts working in the field of cryosphere and remote sensing such as Dr. R.R. Navalgund (former Director, Space Applications Centre, ISRO), Dr. M. Ravichandran, Director, Indian National Centre for Oceanic Information Services (INCOIS), Dr. P.G. Diwakar, Scientific Secretary, ISRO, were also invited as guest faculty.



Dr. Anil Kulkarni of Divecha Centre for Climate Change during inaugural session



Shri. A.S. Kiran Kumar, Secretary, Department of Space (DoS) and Chairman, ISRO and Prof. S.K. Satheesh, Chairman, Divecha Centre for Climate Change during inaugural session of the training program on glaciers, climate change and remote sensing.

The curriculum included (a) Distribution of Glaciers and snow cover (b) Climate (c) Morphology of glaciers (d) Transformation of snow to ice (e) Paleoglaciation (f) Distribution of temperature in glaciers (g) Flow and sliding of glaciers (h) Glacier Mass Balance (i) Ice and Snow ablation (j) Fundamentals of remote sensing (k) Optical properties of snow and ice and (l) Response of glaciers to climate change. In addition to lectures, practical sessions were also conducted on runoff estimates in Himalayan rivers, depth estimate using different techniques, climate change and mass balance, topographic corrections of reflectance and simple estimates of glacier flow.

More than 50 young scientists from various institutions across India have attended this training program.



Shri. A.S. Kiran Kumar, Secretary, Department of Space (DoS) and Chairman, ISRO addressing the students in his speech during inaugural session of the training program on glaciers, climate change and remote sensing.

FIRST MEETING OF THE FUTURE EARTH NATIONAL COMMITTEE

Recognizing the global initiation of a long-term science-cum-policy programme, Future Earth (FE), and subsequent to the establishment of South Asia Regional Office of Future Earth at the Divecha Centre for Climate Change, IISc, Bengaluru, the first meeting of the newly constituted 'Future Earth National Committee' under the International Council Scientific Unions of INSA, was held at INSA on 25th July 2016. Prof. S.K. Satheesh, Chairman, Divecha Centre and Executive Director of FE South Asia regional office was special invitee to this meeting. This meeting took cognizance of following, discussed on the Future Earth related issues relevant to India and South Asia: The Future Earth is a confluence of several international programmes, viz the International Geosphere Biosphere Programme (IGBP), the international programme of Bio-Diversity (DIVERSITAS), International Human Development Programme (IHDP), besides several others. It is a science-cum-policy programme, aimed at generating and imparting knowledge required for societies (global and regional) to address the grand challenges, posed by climate change, for sustenance and to adapt to the changes.

A national brainstorming meeting was conducted on 9th July at DCCC, to take stock of the activities being pursued under different science departments and academia on topics relevant to FE, chalk out the way ahead. This

meeting was attended by nearly 70 invited domain experts across multiple disciplines (including weather, climate, monsoon, aerosols and anthropogenic emissions, polar and cryosphere research, modelling, hydrology, health and nutrition) in-line with the basic framework of the programme. Extensive discussions were carried out on the ongoing research activities in the country on (a) Climate and Health implications of the regional emissions Aerosols and Trace gas emissions (b) Climate impacts on Himalayan Cryosphere and Polar Ice cover and implications for the society in terms of water budget and sea level rise (3) Societal impacts of sea-level rise and sinking deltas in terms of sustenance and food security and (4) Climate change impact on bio-diversity including migration of non-local species, especially at high-altitude regions. The trans-boundary nature of the processes and impacts as well the need for science data across political boundaries was stressed upon and resolved that the multi-disciplinary nature of FE programme provides the ideal umbrella for such activities. The committee also suggested expanding the FE national committee including domain experts from health, agriculture and food security, bio-diversity, health, economics and social sciences, adaptation and social sciences, in view of the highly multi-disciplinary nature of Future Earth programme.

THE 9TH ANNUAL JEREMY GRANTHAM LECTURE ON CLIMATE CHANGE



Prof. William Boos, Department of Geology and Geophysics, Yale University

The 9th Annual Jeremy Grantham Lecture on climate change was delivered by Prof. William Boos, Department of Geology and Geophysics, Yale University on 25th July 2016 at the Divecha auditorium in the Indian Institute of Science. In this lecture titled “Will Climate Change lead to abrupt cessation of the monsoon?”, he discussed whether climate

change will cause an abrupt shutdown of Indian monsoon.

In the recent past some scientists have predicted that global warming and air pollution can cause the abrupt cessation of the Indian monsoon. Prof. William reviewed the evidence from the past, present and future monsoon climates and presented an overview of the physical mechanisms that might cause abrupt changes in monsoons. He talked on how these physical mechanisms will be apparent in the near future.

Monsoons are expected to respond to changes in aerosols, land use and anthropogenic greenhouse emissions. Since there is an abrupt onset of the monsoon in many years in June. Some scientists have speculated that a similar abrupt transition may occur on longer time scales. Monsoon intensity has changed abruptly on geological time scales. Some scientists have argued that there may be a tipping point beyond which abrupt transition may take place.



Prof. William Boos delivering 9th Jeremy Grantham Lecture on climate change

Prof. Boos argued that these mechanisms have flaws, as some important mechanisms were not included. He used results from complex

global climate models to show that the South Asian monsoons responds in a more linear and continuous manner to a broad range of

forcing. He showed that large increase in soot had no impact on the Indian monsoon but a large increase in sulphate aerosol decreased the monsoon rainfall. The impact of increase

in sulphate aerosol was gradual and not abrupt. He demonstrated that there is no "Tipping Point" that can lead to an abrupt shut down of the Indian monsoon.



Prof. William Boos interacting with the students

INTERACTION WITH THE SECRETARY, MINISTRY OF ENVIRONMENT, FORESTS AND CLIMATE CHANGE

Hydrofluorocarbon (HFCs) have been widely used as a replacement for CFCs and HCFCs worldwide. In fact, the use of HFCs has been rising in various sectors due to industrial development and urbanization. The global warming potential of HFCs varies from 140 to 11,700. Due to the adverse climate impacts of increasing HFCs, control and regulation of the use of HFCs has become necessary. Consequently, amendment proposals have been proposed by the parties to the Montreal protocol. India is a signatory to Vienna Convention for Protection of Ozone Layer and its Montreal protocol on substances that deplete the Ozone layer. It has become necessary to pursue research and

development by the country on alternatives of HFCs as most alternative technologies presently available are protected by patents.

As suggested by the Hon'ble Minister of Environment, Forests and Climate Change (MoEF & CC), a discussion meeting was conducted under the Chairmanship of Secretary, MoEF & CC on 10 August 2016. Prof. S.K. Satheesh, Chairman, Divecha Centre for Climate Change participated in this meeting as invitee. Divecha Centre for Climate Change is expected to make assessment of climate co-benefits of new substances being developed as alternate to HFCs.

TALK BY PROF. J. SRINIVASAN DURING THE FOUNDATION DAY OF THE MINISTRY OF EARTH SCIENCES, NEW DELHI

The Ministry of Earth Sciences celebrated its foundation day on 27 July 2016 at Vigyan Bhawan in New Delhi. In this event many eminent scientists were invited to talk about the scientific developments in India during the last decade. Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences welcomed the participants.

The Hon'ble Union Minister for Science & Technology and Earth Sciences, Dr. Harsh Vardhan released the Vision and Strategy Document for next 15 years (up to 2030). The Hon'ble Minister of State for Science & Technology and Earth Sciences, Shri Y.S.Chowdary also addressed the gathering.

The Foundation Day lecture was given by Shri A.S. Kiran Kumar, Secretary, Department of Space and Chairman, ISRO.

Prof. J. Srinivasan, Divecha Centre for Climate Change talked about work done in India on climate change during the past decade. He highlighted the recent work that indicated that the decrease in rainfall over India during the past fifty years may be caused by the higher sulphate aerosols in mid-latitude regions rather than higher soot emissions over India.



The Hon'ble Union Minister for Science & Technology and Earth Sciences,
Dr. Harsh Vardhan



The Hon'ble Minister of State for Science & Technology and Earth Sciences,
Shri Y.S.Chowdary



Prof. J. Srinivasan, Divecha Centre
for Climate Change

EUREKA WITH PROF. J. SRINIVASAN: INTERVIEW IN RAJYA SABHA TV

Rajya Sabha TV is a part of the public broadcasting network of the Government of India. They have a weekly program called Eureka in which they interview an eminent Scientist in order to highlight new developments in Science and Technology. Prof.J.Srinivasan, Divecha Centre for Climate

Change appeared in this program on 6th August 2016 in Rajya Sabha TV. This program is now available in YouTube (Web link: <https://www.youtube.com/watch?v=nlsj-ykO3bY>). In this interview, Prof. Srinivasan discussed various issues related to climate change.



FUTURE EARTH SESSION AT THE 16TH ANNUAL CONFERENCE OF SCIENCE COUNCIL OF ASIA (SCA)

A session on "Future Earth" was held in Colombo, Sri Lanka, from 30 May to 1 June 2016, as part of the 16th Annual Conference of the Science Council of Asia (SCA). The theme of the Conference was "Science for the People: Mobilizing Modern Technologies for Sustainable Development in Asia" with a focus on all areas of emerging technologies, success in their use in national development and the challenges faced by developing Asian countries in mobilizing new technologies for sustainable development. The Conference was graced by the presence of Hon'ble Prime Minister of Sri Lanka, Ranil Wickramasinghe. The Conference included 10 plenary

presentations and more than 100 oral presentations on subjects ranging from nanotechnology, urban planning, climate change, health and science communication in a total of 14 separate parallel sessions. Prof. S.K. Satheesh, Chairman, Divecha Centre for Climate Change participated in this conference and discussions as invitee. The session on "Future Earth", where the Future Earth Secretariat introduced the initiative's recent topics on the global and regional levels, and discuss challenges and perspectives in Asia. The session also presented the role of "Future Earth" in Asia as a knowledge and engagement hub.

THE NATURAL ENVIRONMENTAL RESEARCH COUNCIL (NERC) – MINISTRY OF EARTH SCIENCES (MOES) RESEARCH PROGRAM ON ASIAN MONSOONS

Accurate prediction of Indian Summer Monsoon and its spatio-temporal distribution remains an enigma, though these have important implications for the Indian economy, agricultural productivity, water management, and forecasting, besides being vital to the livelihood of millions of people in the monsoon region, especially in the Indo-Gangetic Plains. Ministry of Earth Sciences (MoES) launched the “National Monsoon Mission” program in 2012, aiming at improving monsoon prediction at all temporal and spatial scales through joint efforts of national and international scientific communities. Although this has resulted in considerable improvement in the scientific understanding and prediction processes, accurate representation of small-scale processes continue to pose a major challenge towards improving prediction. This basically arises from the paucity of data at smaller space and timescales. Improved understanding of the smaller scale physical processes will help in improving the computer simulation models, parameterization of physical process, which in turn will produce improved monsoon prediction. One of the major uncertainties in this context arises from atmospheric aerosols, the tiny suspended particles in the atmosphere.

To address the issue of better understanding of processes that drive the variability, and predictability of the South Asian/ Indian Monsoon, India (MoES) and the United Kingdom (NERC - The Natural Environmental Research Council) have embarked on an ambitious long-term plan to carry out extensive joint observational campaign under a joint umbrella. Nick-named SWAAMI (Acronym for ‘South West Asian Aerosol Monsoon Interactions’), this campaign involves deployment of UK’s atmospheric research aircraft, “Facility for Airborne Atmospheric Measurements (FAAM)” equipped with sophisticated scientific instruments and

India’s Sagar Nidhi and Sindhu Sadhna research ships during the pre-monsoon and active monsoon periods. Faculty and students of Divecha Centre for Climate Change played active role in these campaigns.

The first phase of this campaign was carried out by the joint Indo-UK scientists’ team during early June 2016 (before the monsoon got established over Central and northern parts of India) aboard the FAAM. This aircraft is a full-fledged mobile laboratory, equipped with several state-of-the-art instruments for measuring physical, chemical and optical properties of aerosol and clouds, along with meteorological parameters over different altitude regions of the atmosphere over Indian main land. During the second phase, the measurements were mostly over the oceanic regions of the Arabian Sea and investigated the properties of rain-bearing monsoon clouds and aerosols and their interactions.

Complementing this effort, the ISRO (Indian Space Research Organization) also carried out extensive airborne measurements of optical and microphysical properties of aerosols, and on cloud condensation nuclei over the Indo-Gangetic basin, using its aircraft equipped with a suite of advanced scientific instruments. These sorties, primarily focused on the vertical distribution of cloud condensation nuclei and dust and formed a part of the Regional Aerosol Warming Experiment (RAWEX) under ISRO’s Geosphere Biosphere Programme, aiming at understanding the role of elevated absorbing aerosol layers on clouds and monsoon was led by the Space Physics Laboratory of ISRO and provided vital supplementary information for SWAAMI.

Both these aircraft measurements surveyed the atmosphere in the altitude range 60 m to 7600 m and included both profiling sorties and gradient sorties examining respectively the

vertical and spatial variations. They have revealed the presence of elevated aerosol layers above clouds and also aerosol layers trapped between clouds at various levels both during the pre-monsoon as well as the monsoon period with distinct condensation properties. It was also observed that the boundary layer is highly distinct in the eastern part while it is very indistinct in the western parts of India. These measurements are unique since such observations are not

possible using the conventional ground based measurements and satellite observations. These observations are also unique since they have been made during one of the hottest years India has witnessed so far. Hon'ble Minister for Science and Technology and Earth Sciences, Dr. Harsh Vardhan was on board and participated in one of the experimental flights and witnessed the capabilities of the various instruments on board the aircraft.



Hon'ble Minister for Science and Technology and Earth Sciences, Dr. Harsh Vardhan (third from left) on board the FAAM aircraft. Also see in the photo are Dr. K.J. Ramesh, Director General of Meteorology, India Meteorological Department, Dr. Monica Sharma from Research Council of UK, New Delhi, Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences, Prof. G.S. Bhat, Associate faculty, Divecha Centre for Climate Change and Prof. S.K. Satheesh, Chairman, Divecha Centre for Climate Change.

The project “Interaction of Convective Organization and Monsoon Precipitation, Atmosphere, Surface and Sea (INCOMPASS), another project under the Indo-UK joint efforts, aimed at capturing the key surface-atmosphere feedback processes in models. The would improve the skill of rainfall prediction in operational weather and climate models by way of better understanding and representation of interactions between the land surface, boundary layer, convection, the large-scale environment and monsoon variability over a range of scales.

The campaign “BoBBLE: Bay of Bengal

Boundary Layer Experiment” aimed at determining, quantifying and modelling ocean-atmosphere interactions that drive variability in the South Asian monsoon. Under this project, an observational campaign has been undertaken in the Bay of Bengal during June-July 2016 along with the analysis of wider observational and reanalysis-based data sets, and a set of hierarchical modelling experiments. The study will improve the understanding about the role of thermodynamic surface and mixed layer processes in the monsoon as well as the role of large-scale ocean structure, ocean dynamics and ocean biogeochemistry in the monsoon.



(From left) Dr. K.J. Ramesh, Director General of Meteorology, India Meteorological Department, Prof. G.S. Bhat, Associate faculty, Divecha Centre for Climate Change and Prof. S.K. Satheesh, Chairman, Divecha Centre for Climate Change, Hon'ble Minister for Science and Technology and Earth Sciences, Dr. Harsh Vardhan and Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences.

PROF. SATHEESH ASSUMES CHARGE AS CO-EDITOR OF THE INTERDISCIPLINARY SCIENCE JOURNAL, CURRENT SCIENCE

Current Science, published every fortnight by the Current Science Association, in collaboration with the Indian Academy of Sciences, is the leading interdisciplinary science journal from India.

It was started in 1932 by the then stalwarts of Indian science such as CV Raman, Birbal Sahni, Meghnad Saha, Martin Foster and S.S. Bhatnagar. In 2011, the journal completed one hundred volumes.

The journal is intended as a medium for communication and discussion of important issues that concern science in India. Besides full length research articles and shorter research communications, the journal publishes review articles, scientific correspondence and commentaries, news and

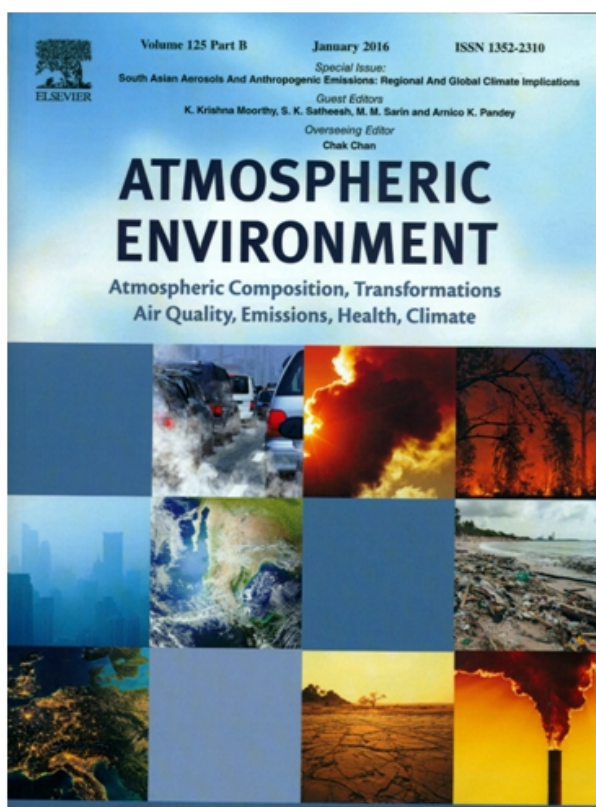
views, comments on recently published research papers, opinions on scientific activity, articles on universities, Indian laboratories and institutions, interviews with scientists, personal information, and book reviews.

It is also a forum to discuss issues and problems faced by science and scientists and an effective medium of interaction among scientists in the country and abroad. Current Science is read by a large community of scientists and the circulation has been continuously going up.

Prof. S.K. Satheesh, Chairman, Divecha Centre for Climate Change assumed charge as Co-Editor of CURRENT SCIENCE with effect from 01 June 2016.

SPECIAL ISSUE ON "SOUTH ASIAN AEROSOLS & ANTHROPOGENIC EMISSIONS: REGIONAL & GLOBAL CLIMATE IMPLICATIONS" IN ATMOSPHERIC ENVIRONMENT

A reputed peer reviewed journal, "Atmospheric Environment", published by Elsevier recently published a special issue on "South Asian Aerosols and Anthropogenic Emissions: Regional and Global Climate Implications" with a Divecha Centre faculty member as one of the guest editors (Vol. 125, Part B, Pages 307-524, January 2016; Edited by K. Krishna Moorthy, S.K. Satheesh, M.M. Sarin and Arnico K. Pandey). This special issue also contain research work carried out by faculty and students of Divecha Centre for Climate Change.



The south Asian region is one the world's most populous and fast-developing regions. The more than 1.7 billion population (~24% of the world population) with highly diverse living habits, fast growing industrial and transport sectors, large and increasing demand for power, diverse fuel use for domestic and industrial purposes, and equally diverse geographical features make this region a large

cauldron of emissions and atmospheric processes.

It is being increasingly recognized to be among the global hotspots of aerosols and anthropogenic trace gases.

The complex geography of this region adds considerable amount of natural aerosols (sea spray, windblown desert dust, pollen, etc) into the atmosphere, which mix with the man-made ones, making the aerosol environment one of the most complex in the world.

The large spatial diversity of the sources coupled with the varying atmospheric dynamics, driven by the contrasting monsoons and the topography, make South Asia's aerosol and pollution very difficult to characterize, to model and to plan effective mitigation measures, despite the fairly good knowledge on their implications to radiative and climate forcing, health effects and environmental degradation.

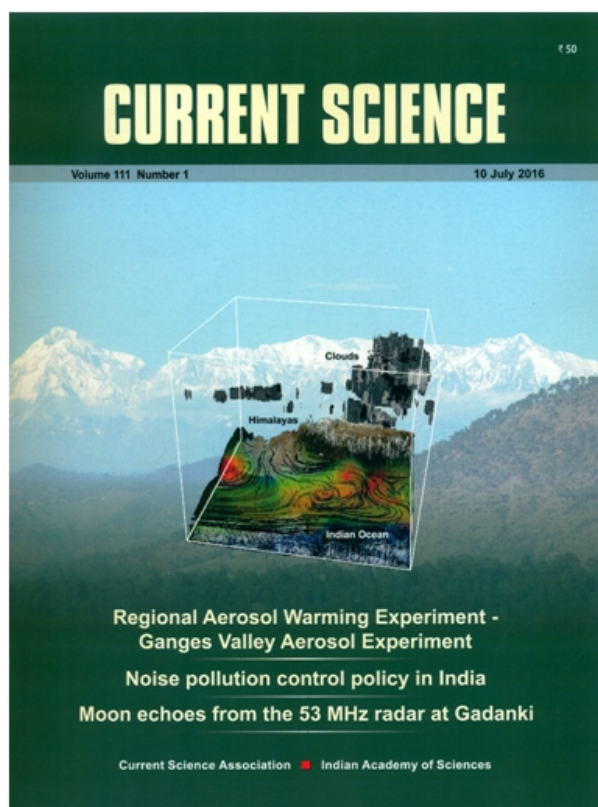
In the recent years, there have been several reports on the impact of aerosols (more importantly black carbon - BC) on the regional and global climate system including Asian monsoon, with the caveats of long-term impacts on the livelihoods of tens of millions of people in this region; though specifics of these are not yet unequivocally established.

While tropospheric perturbations would produce strong regional signatures, their global impacts still remain marginally above the uncertainty levels.

This special issue, a compendium of research papers on south Asian aerosols, would provide the readers considerable insight into the different aspects of south Asian aerosols and anthropogenic trace species and their implications.

SPECIAL SECTION ON "REGIONAL AEROSOL WARMING EXPERIMENT – GANGES VALLEY AEROSOL EXPERIMENT (RAWEX–GVAX)" IN CURRENT SCIENCE

A reputed peer reviewed interdisciplinary science journal, "Current Science", recently published a special issue on "Regional aerosol warming experiment - Ganges Valley aerosol experiment (RAWEX-GVAX)" with a Divecha Centre faculty member as one of the guest editors (Vol. 111, Pages 52-132, July 2016; Edited by K. Krishna Moorthy, S.K. Satheesh, and V.R. Kotamarthi). This special issue also contain research work carried out by faculty and students of Divecha Centre for Climate Change.



Climate change has great significance in Asia in general, and India in particular due to its diverse geographical features and high population density. It is now well known that atmospheric aerosols have a decisive role in perturbing regional and global climate. Ground-based and satellite-borne measurements have shown that the Indo-Gangetic Plains (IGP), which extends from western desert, across the plains and over to the Bay of Bengal and one of the densely populated and rapidly developing regions of

the subcontinent, has some of the highest and persistent aerosol loading, especially during the dry winter and pre-monsoon seasons. This is also one of the regions across the globe that shows a persistent steady increasing trend in aerosols; increasing surface dimming; and enhanced mid-tropospheric warming. The regional climate implications, resulting from the perturbations to regional radiative balance through direct, indirect, and semi-direct effects of this high and increasing aerosol loading, are shown to significantly impact the monsoon rainfall, hydrological cycle, and the snow-cover over the Himalayas, (which feeds the major rivers flowing through this region with fresh water and act as the lifeline for its millions of population), though the exact nature and extent of this impact are not unequivocally understood or quantified.

The Indo-US field experiment, RAWEX-GVAX conducted during 2011-12 jointly by the US Department of Energy, Indian Institute of Science, ISRO and DST has been another major effort in this direction. Faculty and students of Divecha Centre had central role in implementing this major field experiment as well as in data analysis. This utilized the ARM Mobile Facility (AMF) of the Department of Energy of the USA, deployed for the period from June 2011 to March 2012. Several aerosol and atmospheric parameters were measured using the AMF, concurrently with those from a number of aerosol observatories established under the Indian initiatives. The other major component, RAWEX, aimed at quantifying the climate implication of the atmospheric warming produced by the absorbing aerosols.

This special section provides an overview of this experimental programme in the backdrop of the evolution of aerosol research in India, and its main findings through a series of papers.

