ELEVENTH POST GRADUATE COURSE IN SATELLITE METEOROLOGY AND GLOBAL CLIMATE [SATMET – 11]

August 1, 2018 to April 30, 2019

MEMOIRS

Organized By
CENTRE FOR SPACE SCIENCE AND
TECHNOLOGY EDUCATION IN ASIA AND THE PACIFIC (CSSTEAP)
(AFFILIATED TO THE UNITED NATIONS)

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SPACE APPLICATIONS CENTRE AHMEDABAD

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CENTRE FOR SPACE SCIENCE AND
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MESSAGES

Centre for Space Science and Technology Education in Asia and the Pacific
(Affiliated to the United Nations)

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MESSAGE

It gives me immense pleasure to note that the 11th Post Graduate Course on 'Satellite Meteorology and Global Climate' conducted by Space Applications Centre (SAC), at the behest of Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) is successfully concluding on April 30, 2019. I am also happy to note that 13 participants from 8 countries of the Asia Pacific region will be receiving their diploma certificate. On this important occasion, I congratulate all the participants for successfully completing the course.

The advent of satellite-based observations, over the past few decades has added a new dimension to the study of atmosphere and weather systems. The INSAT system, with capability of sounding of the atmosphere, especially temperature & humidity profile provides an important input to numerical weather prediction models. The combination of INSAT-3D and 3DR has resulted in improved temporal and spatial resolution of the derived geophysical products which are vital for weather monitoring, now-casting, short range forecast, cyclone monitoring and disaster management. The Mega Tropiques, SCATSAT and SARAL Altika Satellite Sensors covering the microwave regions, with enhanced radiometry and temporal resolutions, especially over tropical cloudy regions, has made the space data an indispensable component in weather monitoring and forecasting.

I am sure, the exposure of Indian Space meteorological data products and services will enable all the participants to pursue in similar lines to meet their country's needs. I congratulate all the participants of the 11th SATMET course and wish the very best in their future endevours. I also compliment the faculty and staff members of CSSTEAP and SAC for their sincere efforts for successful conduct of the course.

4/4/2019

(कै. शिवन / K. Sivan)

Dated: April 04th, 2019

UNITED NATIONS
Office for Outer Space Affairs

15 April 2019

I wish to congratulate all students on the successful completion of the course and on obtaining the Post-Graduate diploma certificates. The United Nations Office for Outer Space Affairs (UNOOSA) values the efforts of the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) as a capacity developer in the Asia Pacific Region and as a facilitator in 'bringing the benefits of space to humankind'.

Using space can unleash a range of benefits in virtually every aspect of the functioning of modern society, especially considering the challenges the world is facing due to climate change. Space-based technologies and space-derived information play a key role in climate knowledge, science, monitoring and early warning. Space-based information can contribute to assessing the vulnerability of communities to climate change and can help monitor the effectiveness of adaptation strategies. Moreover, space technology can help us mitigate and better manage natural disasters caused by climate change.

I am certain that this 9-month training programme has greatly increased the skills of its beneficiaries, who will now be able to use this knowledge to contribute to sustainable development efforts in their countries through space.

I extend my sincere thanks to the Director of the CSSTEAP and to the course coordinator and faculties for making this programme successful. I also want to thank the Chairman of the Indian Space Research Organisation for his precious support to the CSSTEAP.

Let me close this message by wishing the students success in their future achievements and expressing my confidence that they will greatly contribute to reaching new frontiers in leveraging space for sustainable development.

Yours sincerely,

Simonetta Di Pippo
Director
Office for Outer Space Affairs

Bringing the benefits of space to humanity

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CSSTEAP Centres & The Course - A Report

Centre for Space Science and Technology Education in Asia and the Pacific

Dr. A. Senthil Kumar
Director, CSSTEAP

Introduction

Geospatial information technologies have contributed significantly to the socio-economic development planning in most developed and developing countries. The Sustainable Development Goals (SDGs) that comprise the 2030 Agenda for Sustainable Development combined with the targets of the Sendai Framework for Disaster Risk Reduction and the commitments of the Paris Agreement for Climate Change contribute collectively to the overall global development goals, which are expected to be realized on national, regional and global scales. Space-based data and geospatial information are essential for implementation, monitoring and realization of these goals.

Focusing attention on Asia and the Pacific (AP) region of the globe, this region has become a hub of innovation which is transforming the way in which people live, work, and relate to one another. Recent advancement in digital innovation such as artificial intelligence, big data analytics, the internet of things and cloud computing show promise to bring new and innovative solutions to pressing regional problems. Faster and more versatile digital connectivity, satellite-derived data, geographic information systems and spatial analysis have become increasingly accessible and available, generating more evidence-based data to support real-time decision-making. Geospatial information has also increasingly been incorporated in development planning, which has led to more accurate monitoring and evaluation of development interventions. As a result, geospatial information applications have come to play a more prominent role in the implementation and realization of the 2030 Sustainable Development Agenda (SDGs).

Despite advances in the availability and quality of space-derived information, several gaps and challenges remain for their effective use at the AP regional and national level. A lack of capacity and resources in terms of finance, space-derived data, knowledge and expertise, specific tools and well

trained human resources is a common problem. Many developing countries in the AP region still do not have the capacity to utilize, analyze and interpret space-derived data. Other challenges include issues related to policies, procedures, guidelines and standards for acquiring, sharing and utilizing space-derived products and services, and the lack of procedural harmony between agencies and countries. A comprehensive training and education in Remote Sensing & Geographic Information System (RS & GIS) would enable developing countries to build a capability in the field, and to educate and stimulate participants in other disciplines as well.

Considering the importance and use of space science, technology and applications in promoting social and economic development, the United Nations, through its Office for Outer Space Affairs (UN-OOSA), facilitated the establishment and operation of the Regional Centres for Space Science and Technology Education. In its resolution 45/72 of 11 December, 1990, the United Nations General Assembly (UN-GA) endorsed the recommendation of the Committee on the Peaceful Uses of Outer Space (COPUOS) to establish Regional Centres for Space Science and Technology in developing countries. Under the auspices of the United Nations, through its Office for Outer Space Affairs (UN-OOSA), six Regional Centres for Space Science and Technology Education have been established in the regions that correspond to the United Nations Economic Commissions for Asia and the Pacific (India and China), Africa (Morocco, Nigeria) and Latin America and the Caribbean (with offices in Brazil and Mexico) and Jordan for the West Asia region. The Centres are affiliated to the United Nations through UN-OOSA. Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) is the first Centre and was established on November 1, 1995 in India and has been Centre for Space Science and Technology Education in Asia and the Pacific imparting education/training in the areas of RS & GIS, Satellite Communications, Satellite Meteorology and Global Climate, Space and Atmospheric Science, Navigation and Satellite Positioning System and Small Satellite Missions using modern infrastructure, technology and training tools and practices. The Centre has announced a new Post Graduate course on Global Navigation Satellite Systems (GNSS) from 2015 and is hosted by Space Applications Centre, ISRO Ahmedabad.

The Centre's headquarter is located in Dehradun, India, and its programs are executed by faculty of the Department of Space (DOS) at campuses in Dehradun, Ahmedabad and Bengaluru. The Centre has arrangements with Indian Institute of Remote Sensing (IIRS), Dehradun for RS & GIS course; with Space Applications Centre (SAC), Ahmedabad for Satellite Communication (SATCOM), Satellite Meteorology and Global Climate (SATMET) and Global Navigation Satellite System (GNSS) and Navigation and Satellite Positioning Systems (NAVSAT) short courses; with Physical Research Laboratory (PRL), Ahmedabad for Space & Atmospheric Science course and UR Rao Satellite Centre (URSC), Bengaluru for short course on Small Satellite Missions. The Centre also has agreement with the Government of India by which it has been accorded specific privileges and international status to the Centre, similar to the privileges enjoyed by UN specialized agencies. Under the agreement the Centre also has access to facilities, infrastructure and expertise of DOS/ISRO institutions, including IIRS, SAC, PRL, NRSC and URSC. The Centre has a Governing Board consisting of signatories from

17 countries from Asia-Pacific region and two observers, (UN-OOSA & ITC, The Netherlands). The Centre has formal UN affiliation with UN-OOSA for developing the CSSTEAP model and extending support in terms of expert advice, technical assistance, relevant documentation and future directions. The countries have agreed to the goals and objectives of the Centre by endorsing a cooperation agreement through which the Centre was established. The technical activities of the Centre are guided by an International Advisory Committee (AC) consisting of subject experts that critically reviews the curricula, technical facilities, expertise in terms of faculty, etc.

Group Photograph of CSSTEAP 13th International Advisory Committee Meeting held on 30th November, 2018 at IIRS, Dehradun.

The course curricula developed by the Centre and endorsed by the United Nations are adapted for the educational programs. The educational programs of the Centre are oriented towards the dissemination of knowledge in relevant aspects of space science and technology. The Centre offers Post Graduate level courses in these five areas. The model of the PG courses is designed as to emphasize university educators, researchers and application scientists on the development and enhancement of knowledge and skills coupled with an application project with a small component (3 months) in India and major one (one year) in their home country with a view to transfer the technology in their home organization. This gives an opportunity to the scholar to apply their knowledge and training received to deal with a 'real life' problem, where inputs from space technology can be used. Besides the Post Graduate level courses, the Centre also conducts short courses, workshops, awareness programs on specific themes in the four areas, highlighting how space-based information can be used for national development. These educational programs have benefited many scientists/engineers who will be the future policy & decision makers in several countries.

CSSTEAP conducts all of its educational programs in close collaboration with one of the DOS institutions and thus has direct access to their physical facilities and intellectual capabilities. In addition to providing facilities, infrastructure

Dr. K Sivan, Chairman, ISRO / Secretary Department of Space and Present Chairman CSSTEAP Governing Board during the 23 GB Meeting at Delhi.

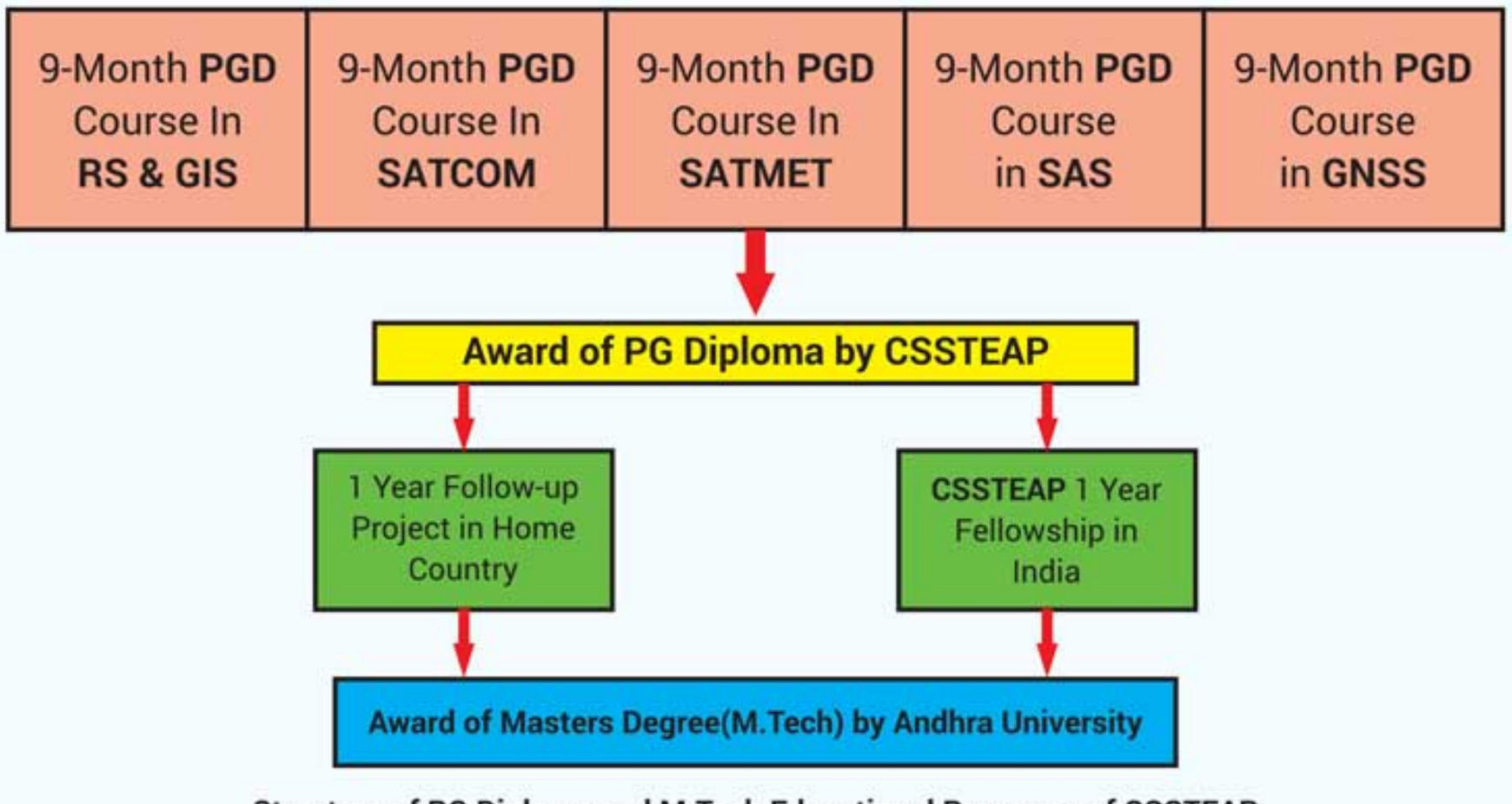
and skilled manpower, the Government of India, through the Department of Space provides most of the funding. Funding grants for international travel of participants, subject experts, tuition fees and scholarships of participants and the management of the Centre are mainly provided by Department of Space on behalf of Host country. UN-OOSA also provides funding for travel of the participants. Other agencies financially contribute include are UN Agencies like UNSPIDER, Beijing, China; UN-ESCAP in Bangkok, Thailand, UNESCO and UNDP.

Educational Programs

The Centre offers post-graduate (PG) level training in five areas of specialization namely:

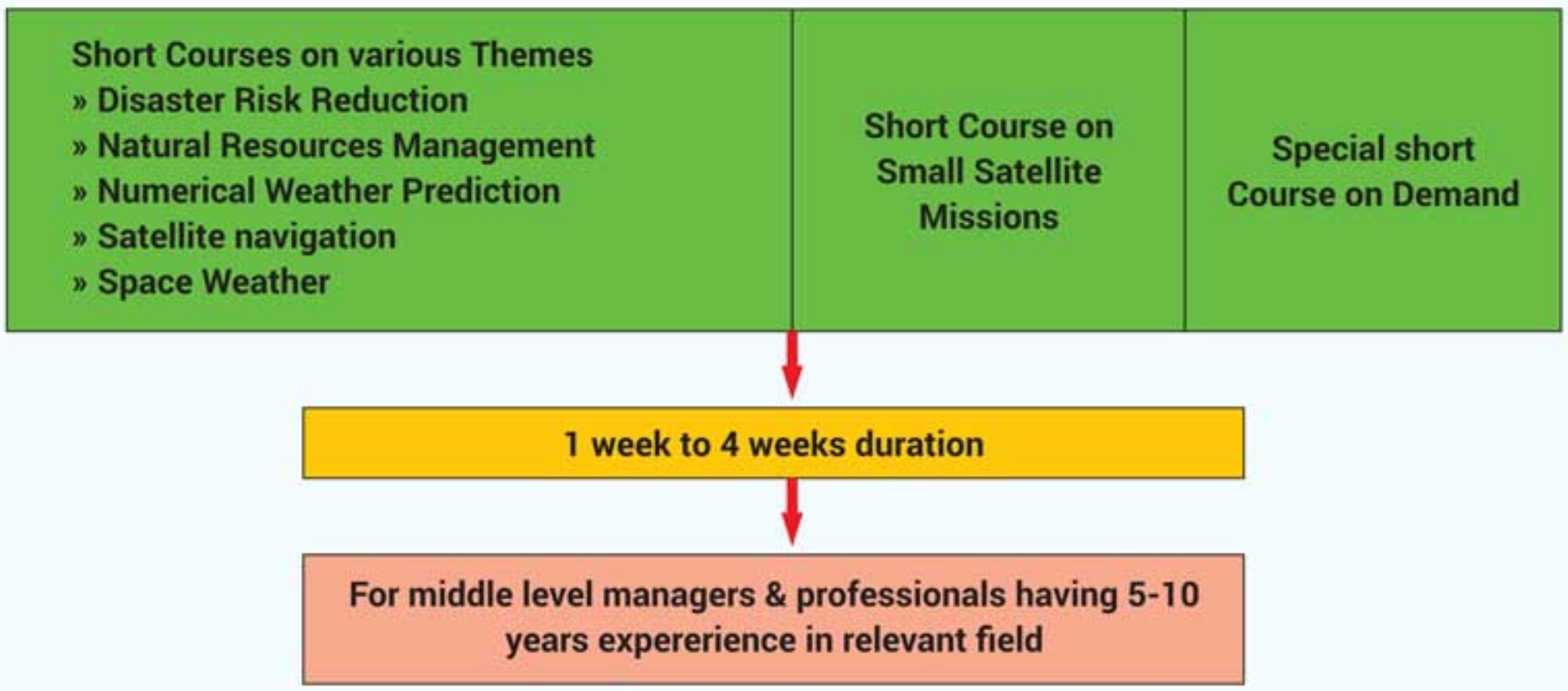
a) Remote Sensing and Geographic Information Systems (RS & GIS),
b) Satellite Communication (SATCOM),
c) Satellite Meteorology and Global Climate (SATMET)
d) Space and Atmospheric Science (SAS), and
e) Global Navigation Satellite Systems (GNSS).

Apart from these, Centre conducts short courses on different themes of Remote Sensing and GIS, Small Satellite Missions and Navigation and Satellite Positioning system on regular basis. The structure of PG Diploma and the short term programs is given in (Fig. 1 & 2). The Centre also organizes workshops & awareness programs from time to time.



Structure of PG Diploma and M.Tech Educational Programs of CSSTEAP

Fig. 1: Structure of PG Diploma Educational Programs at CSSTEAP



Short term training programs of CSSTEAP

Fig. 2 Short term training programs at CSSTEAP

The educational programs are conducted in English and for participants who need help to improve their English language skills, facilities are made available upon their arrival in campus. The courses are taught in smart classroom environments with the use of modern teaching methods and tools, and also include multimedia tutorials for self-study. Practical are given in the laboratories and skill development environments of the DOS institutions. In each of the host institutions, most of the

faculty are drawn from the host institutions (about 80% of the teaching time). Whenever desirable or needed, faculty is drawn from other DOS/ISRO institutions, or professional, scientific or academic institutions in India (~10%) or from institutions or organizations outside India, from the Asia-Pacific Region as well as globally (~ 5%). In order to provide wider exposure to the participants in their respective fields, the Centre provides opportunities for technical visits to scientific institutions, laboratories and national symposia in India. The successful completion of the 9-month PG-Phase of the programme leads to the award of a Post Graduate diploma by the Centre. For the participants who successfully finish their PG course and are interested in continuing for a Master of Technology (M.Tech.) degree, the Centre offers the opportunity to do so, in collaboration with Andhra University (AU) in Visakhapatnam, India. To this end, the student has to complete a 1-year research project in an application of space science or technology. This project has to be approved by CSSTEAP and AU, and the research is supervised by designated academic staff of CSSTEAP, AU and the institution where the research is carried out. In most cases the 1-year project is carried out at the home institution of the student concerned. Since 2004 onwards every year selected meritorious PG participants in RS & GIS are being given fellowships to complete their M.Tech. thesis work at CSSTEAP.

Till date 158 PG participants (76 in RS & GIS; 41 in SATCOM; 20 in SATMET and 21 in SAS) from 16 different countries have been awarded M.Tech. degree. (Fig. 3)

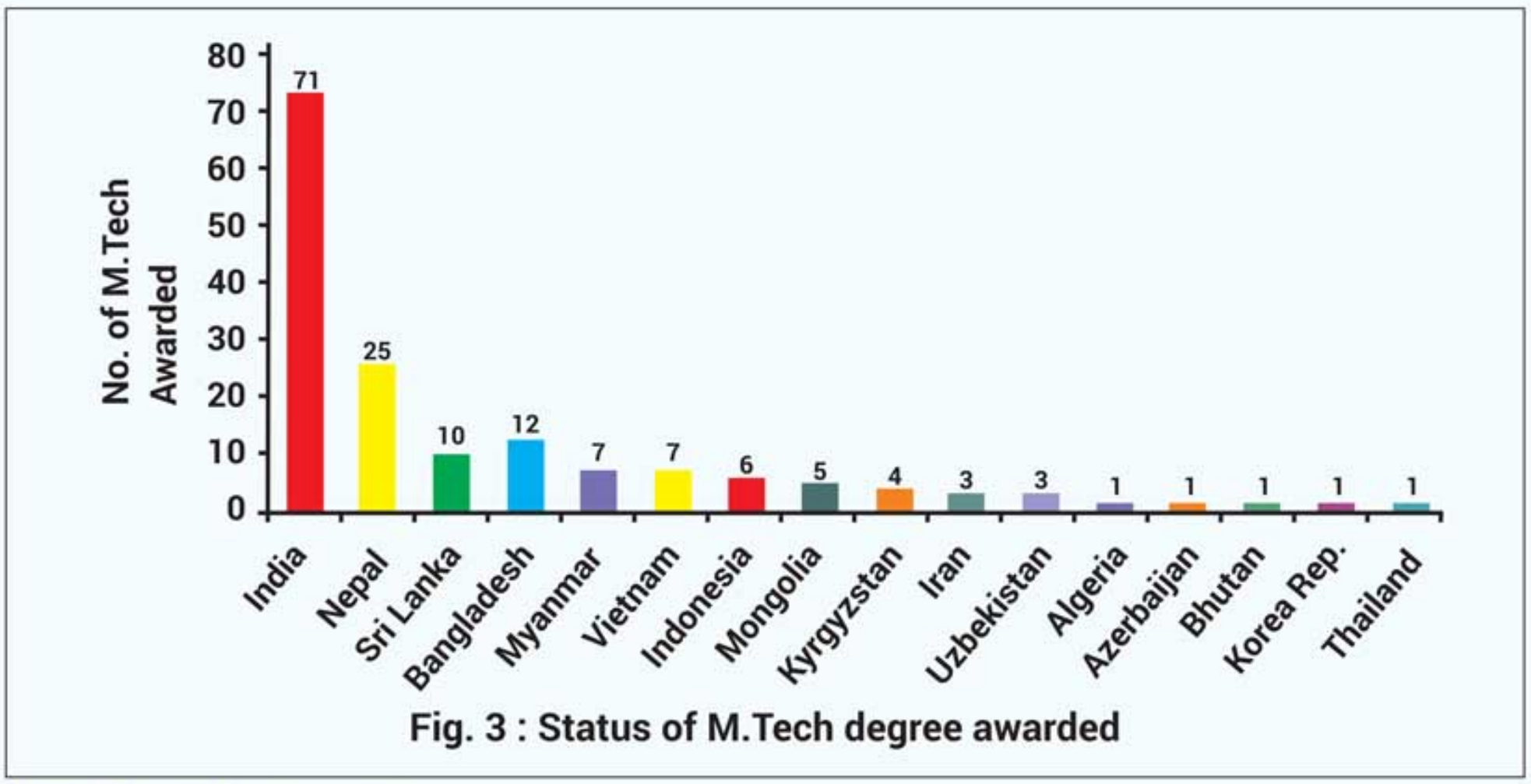


Fig. 3 : Status of M.Tech degree awarded

Satellite Meteorology course

Anthropogenic intervention has led to large scale changes in our planet. With ever-growing population, compounded with increased industrialization, deforestation and pollution, the climate change impact is increasingly evident in our present day's world. The world encounters a severe shortage of essential resources (such as water, food, energy). In addition, the climate change and deforestation led to increased incidents of human-animal conflicts. It is inevitable to accept that the

present human impacted world has brought in considerable stress on life on earth, life above the earth surface and life below in deep oceans.

Meteorological information is very crucial in sustainability of essential resources and disasters resilience. Meteorological information and their timely and real-time distribution, are of utmost concern to the region of Asia Pacific in particular. This region covers countries many of which experience the typical tropical weather systems-especially Tropical cyclones and monsoons (both summer and winter) – and a few other the mid-latitude weather phenomenon. Global environment is also of great relevance for many countries of this region, particularly issues related to climate change, global warming, sea level rise, ozone depletion, etc. The understanding of meteorological information has been historically connected to our aspiration and ability to predict the quantitative aspects of the weather, so that it is possible for us to judiciously plan and manage resources. At present we realize better than ever that such an ability is obtainable only with the use of synoptic and real-time information, which is crux of satellite meteorology.

CSSTEAP conducts a comprehensive post graduate training programme of nine months duration on the subject with a complete treatment of principles, applications and prospects of using the technology to solve grass-root problems of nature concerning state, dynamics of atmospheric processes in the region and develop & manage of satellite meteorology and its applications in the countries of Asia-Pacific region. The PG course of 9 months is divided into two semesters including the pilot project in the second semester. The first semester covers basics in meteorology/ climatology, remote sensing, numerical techniques, satellite orbits, instrumentation, etc. In the second semester topics related to advanced concepts in satellite meteorology, geophysical parameter retrieval and applications, dynamical weather and climate models, assimilation techniques, climate issues, etc., are covered. This is followed by a pilot project. The topics of pilot project are decided based on the relevance to the participant's region.

The operational meteorological satellite data available in the AP region namely, INSAT, METEOSAT, GMS & NOAA are used extensively during the training course. The recent advances in non-optical remote sensing for meteorology is emphasized by using the data from Oceansat-1, ERS, DMSP, SSM/ I, etc. The computing facility is extensively updated and is being used for weather and climate model simulation. Facilities also include state of art GCM, mesoscale models (MM5, WRF), ocean circulation model, ocean wave model and image processing, graphic and visualization software, 4-D GIS etc. The course is conducted at Space Applications Centre (SAC) which is a nodal ISRO Centre for development of state-of-art meteorological space-borne sensors and also in numerical weather modelling. SAC is well equipped with the earth station to receive the satellite data (INSAT, NOAA) besides a strong laboratory support for experimental studies and an automatic weather station. An operational meteorological satellite data archival Centre exists at SAC. Support from India Meteorological Department and many other meteorological institutions spread over the country with their modern facilities, as well as the overseas experts is also available.

Achievements

Till date the Centre has conducted 58 PG Courses: 23 in RS&GIS, 11 in SATCOM, 11 each SATMET and SAS and 02 in Global Navigation Satellite System. Currently 11th SATMET course at SAC, Ahmedabad and 11th SAS course at PRL, Ahmedabad are in progress. In addition, the Centre has conducted 54 short courses and workshops in the past 23 years. These programs have benefited some 2090 participants from a total of 36 countries in the Asia-Pacific region and 29 participants from 19 countries outside Asia Pacific region have also benefited from these educational programs. The Centre has played a major role in the development of curricula of four courses which are currently being followed by all the UN-Regional Centres. All course materials are published by the Centre in the form of hard-copy lecture volumes and CDs. The Centre further publishes conference proceedings and other outreach documents, such as general information brochures, course announcement brochures, newsletters and memoirs- marking the end of every PG course. A half yearly newsletter is published regularly and sent to all alumni and to persons and institutions associated with the Centre. CSSTEAP has scientific and research collaborations with University of Illinois, USA; TWAS-UNESCO; ICIMOD, Nepal for cooperation and mutual assistance in the areas of education and research.

In order to obtain first hand feedback, understand the alumni role in promoting space technology in their countries and to develop a network & establish meaningful linkages between CSSTEAP & its alumni, CSSTEAP has taken initiative to hold alumni meets in different countries of the region. In this direction, five alumni meets have been successfully conducted: in Kathmandu (Nepal); Dhaka (Bangladesh); Colombo (Sri Lanka); Thimpu (Bhutan) and Yangon (Myanmar).

Pilot research case studies in the form of student project work showing the potential application of space science and technology in natural resources management, improved meteorological, communications studies etc., in Asia-Pacific region is being done by the Centre. The Centre initiated research activities in the form of Phase-II of PG course i.e., M.Tech research work by eligible PG participants. The Centre has taken initiative to facilitate its alumni to do higher studies leading to Ph. D. degree and M. Sc. and Centre provides support in terms of expert faculty to guide the student for analyses and logistics (accommodation, research lab, library access, etc.). During the 2018-19, total six participants have been supported with CSSTEAP M.Tech fellowship namely three participants from India, Two from Bangladesh and one from Sri Lanka. To generate awareness among users, researchers, engineers, professionals, decision makers and academicians, in year 2018, the Centre organized 2 short courses on specialized areas of Remote Sensing & its applications:

1) Geospatial Modelling in Forestry and Ecology for Climate Change Response Studies during April 16 to April 27, 2018)
2) Disaster Risk Reduction (DRR) with Special Emphasis on Floods and Earthquakes during May 28 to June 22, 2018

The Centre has established international linkages with various organizations viz., UN-OOSA, UN-SPIDER, SAARC, UN-ESCAP, UNESCO, UNDP, COSTED, WMO, START-SASCOM, NAM S& T, TWAS towards few fellowships / travel support/ sponsor short courses. There are also linkages with other Universities / Institutes (Institute of Space and Astronautical Science (ISAS), Japan; University of Illinois; Frieburg University, Germany; SSNEOG, Australia; EUMETSAT, U.K, Onera, France; University of Colorado, University of Reading, U.K; NOAA-USA, University of Wisconsin, USA; University college of London, U.K; University of Hannover, Germany, etc.) for Guest Faculty and scientific exchange programs. In India, apart from DOS/ISRO Centers CSSTEAP has linkages with many universities and academic institutions for imparting education/training.

As mentioned in the introduction about the 2030 Agenda for Sustainable Development that includes 17 Sustainable Development Goals (SDGs). Building on the principle of "leaving no one behind", the new Agenda emphasizes a holistic approach to achieving sustainable development for all. CSSTEAP is also committed to achieve the SDGS and has plans to include SDGs in CSSTEAP core courses. In the year 2018, CSSTEAP have arranged lectures on

1) "Overview of Sustainable Development Goals (SDGs)" by Dr. Shirish Ravan, UNOOSA through Skype on October 8, 2018.
2) "Building Space Application Capacity for Disaster Risk Reduction" by Dr. Sanjay Srivastav, UNESCAP through Skype on June 14, 2018.

In addition, during 2019 CSSTEAP is also planning to conduct Global Webinar series (CEOS/GEO/UN) with RCs on SDGs.

CSSTEAP has also introduced Space Law concepts and arranged a guest lecture on

1) "Space Law: Intl. Treaties & Regulations" by Mr. Gopala Krishnan, ISRO HQ. on October 27, 2018.

CSSTEAP has supported SAARC with Resource Person on EO data for rapid response & open source data portals for DM for SFDRR during 2018 on a workshop on Utilization of Space based & Geospatial information for achieving the targets of the Sendai Framework for DRR".

Besides above, CSSTEAP has supported offshore training programs jointly organized by UNOOSA/UN Habitat one at China and Two at Myanmar on Disaster Risk Reduction and Damage Assessment.

The Centre plans to encourage research programme to the interested scholars. The Centre has been serving tirelessly towards the capacity building in the Asia-Pacifc region and has significant achievements since its inception. I am sure given the rapid pace of space technology advancements there are challenging tasks ahead for us to accomplish in the future.

Space Applications Centre
Ahmedabad

Harnessing Space Technology for Societal benefits

Shri. D. K. Das
Director, Space Applications Centre

Space Applications Centre (SAC), Ahmedabad, is a major research and development Centre of the Indian Space Research Organisation (ISRO). The core competence of the Centre lies in the development of space borne and air borne instruments/payloads and their applications for national development and societal benefits. These applications are in diverse areas and primarily meet the communication, navigation and remote sensing needs of the country. Besides these, the centre also contributes significantly in scientific and planetary missions of ISRO like Chandrayaan, MOM etc and in the human space flight programme, Gaganyaan. SAC has developed the payloads for major navigation satellites of the country including Navigation with Indian Constellation (NavIC) and GPS Aided Geo Augmented Navigation (GAGAN). SAC designs and develops the optical and microware sensors for the satellites, signal and image processing software, GIS software and range of applications for Earth Observation (EO) programme in diverse areas of Geosciences, Agriculture, Environment and Climate Change, Physical Oceanography, Biological Oceanography, Atmosphere, Cryosphere, Hydrosphere, Early Warning and Disaster Management Support etc. SAC has developed web based real time data archival portals like VEDAS and MOSDAC. The facilities at SAC includes highly sophisticated payload integration laboratories, electronic and mechanical fabrication facilities, environmental test facilities, systems reliability/assurance group, image processing and analysis facilities, project management support group and a well-stocked library. SAC has active collaborations with industry, academia, national and international institutes for research and development. SAC also has a state-of-the-art, Planetary Simulation and Immersive Visualisation (PLASIV) lab for display of digital elevation models of satellite data.

The Organisation

SAC is currently organized into the following major Areas, Groups and Divisions:

- SATCOM & Navigation Payload Area (SNPA)
- SATCOM & SATNAV Applications Area (SSAA)
- Sensors Development Area (SEDA)
- Microwave Remote Sensors Area (MRSA)
- Earth, Ocean, Atmosphere, Planetary Sciences & Applications Area (EPSA)
- Electronic Support Services Area (ESSA)
- Mechanical Engineering Systems Area (MESA)
- Systems Reliability Area (SRA)
- Signal & Image Processing Group (SIPG)
- Antenna Systems Group (ASG)
- Human Spaceflight Technology Group (HSTG)
- Planning & Projects Group (PPG)
- Construction & Maintenance Group (CMG)
- Library & Documentation Division

The Administrative areas comprises of Personnel & General Administration, Purchase & Stores, Accounts & Finance, etc. SAC fraternity of 2068 personnel includes 1778 scientific & technical and 290 administrative personnel.

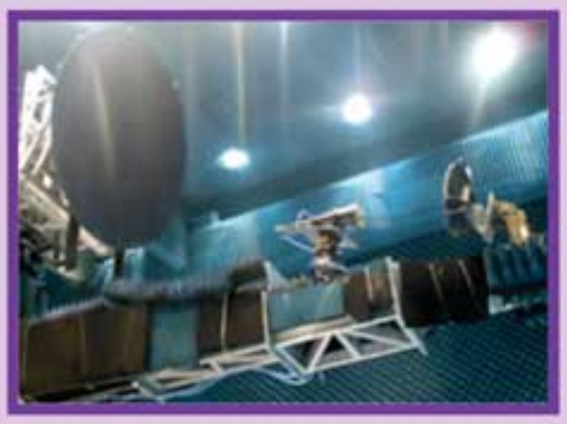
SATCOM & SATNAV Technology and Applications

The communication transponders developed at this centre for Indian National Satellite (INSAT) and Geo Synchronous Satellite (GSAT) series of satellites are used by government and private sector for VSAT, DTH, internet, broadcasting, telephony etc. These satellites are instrumental in reaching remote parts of the country. In 2018-19, SAC has delivered 6 communication payloads, which includes GSAT-29, GSAT-7A, GSAT-31 & AIS. GSAT-29 is the India's first high throughput and optical communication satellite, which provide communication services in Ku, Ka, Q/V and optical band with optical high-resolution camera to users over specific Indian region. GSAT-7A payloads consists of Ku band transponders and provides on demand coverage for special Users. GSAT-31 providing DTH & VSAT services in the frequency bands of both INSAT-4A and INSAT-4CR. AIS is a ship-to- ship and ship-to-shore data broadcast system operating in the VHF maritime band.

Payload development of GSAT-30 and GSAT-20 is in advanced stage. In addition to this, various payload development works are going on for GSAT-22/23/24, GSAT-12R, GSAT-32, IDRSS, GISAT-1&2 & INSAT-3DS.

GSAT-29: Integrated payload

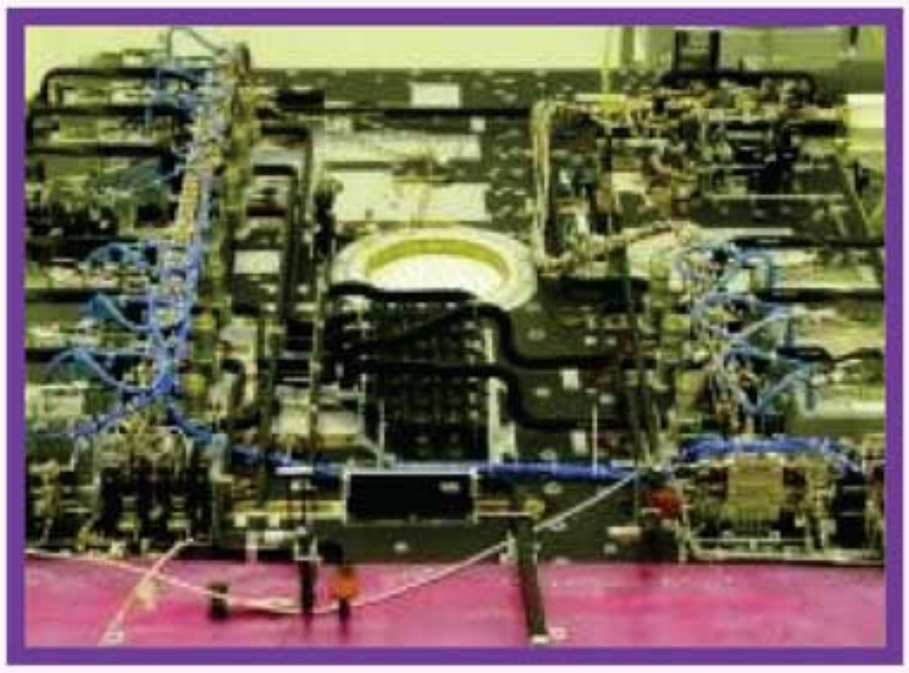
AIS payload



GSAT-7A: Gregorian Antenna

ISRO has been working on design and deployment of satellite based navigation systems for India, enabling navigation and guidance using our own signals. The two types of systems have been made operational; NavIC: based on constellation of seven IRNSS satellites and GAGAN: Space based GPS augmentation system using three GEO satellites. SAC has developed all the technologies required for IRNSS and GAGAN.

In order to meet the high demand of navigation and positioning services, NavIC will provide highly accurate real time positioning for land/sea/air based users. Subsystem development of IRNSS-1J is in advanced stage of development. For the first time, indigenous atomic clocks will be used in this mission.



GSAT-31

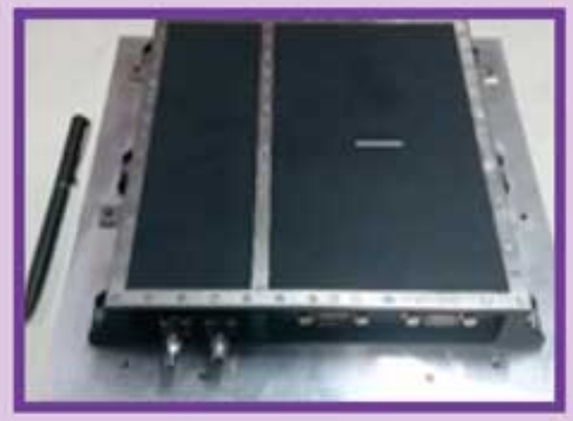
SATCOM & SATNAV applications form the backbone of societal applications, which demonstrates the usage of different space segment satellites. In SATCOM Applications, the core areas are satellite based Tele-education, Tele-medicine, Village Resource Centres (VRCs), disaster management; satellite based Broadband Services & Mobile Satellite Service (MSS). SAC is providing support in the design & development of pilot project execution for special user groups, which is of national importance. SAC has developed many navigation applications like NavIC Messaging Receiver, NavIC Vehicle Tracking System, NavIC based timing receiver, NavIC receiver for Pisharoty Sonde, Mobile app in tracking NavIC signals in Xiaomi MI8 smartphone etc.

MSS Terminals for Tracking of Sub-20m from four different industries

SAC is actively involved in the design & development of ground segments for communication satellites, MSS ground terminals, NavIC user receivers, simulator, encryption scheme, code analysis activities and development of advanced SATCOM, SATNAV applications. SAC has developed ground segments for GSAT-9, and provided services to the SAARC countries. SAC has developed ground systems for GSAT-11 & GSAT-19. Ground infrastructure activities for GSAT-29 is completed

and the work for GSAT-20 and AIS ground receiver is progressing well.

SAC has successfully demonstrated Live visualization and Tracking of Crew Escape system (CES) for the safe recovery of the crew module for any exigency at the launch pad.



Inhouse NavIC Rx

7.5m Ka band Antenna at SAC

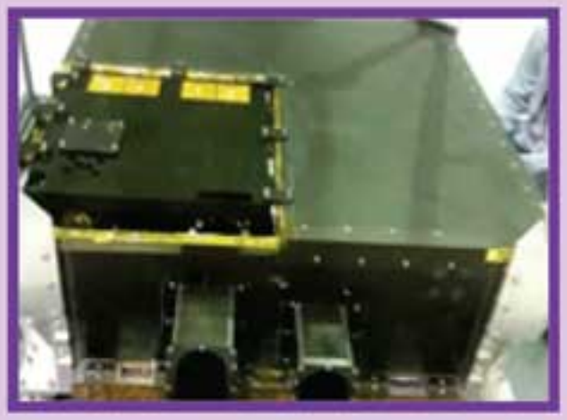
Remote Sensing Technology

In the quest to connect the benefits of space based observation to the advantage of a common man, SAC has conceived and launched a spectrum of optical and microwave sensors covering a plethora of applications like Agriculture, Weather Monitoring, Fishery, Forestation, Urban mapping, Surveillance and so on. SAC has developed instruments operating in optical as well microwave wavelengths providing capability of high-resolution imaging.

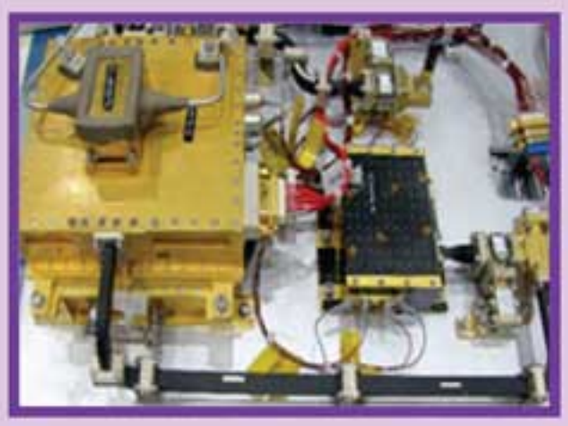
RISAT-2B payload

SAC has delivered all the payloads for Chandrayaan-2, which consists of Terrain Mapping Camera (TMC-2), Imaging Infrared Spectrometer, Orbiter High Resolution Camera, Synthetic Aperture Radar, Lander Position Detection Camera (LPDC), Lander Hazard Detection Avoidance Camera (LHDAC), Lander & Rover Imagers and Ka-Radar Altimeter. Recently

launched HySIS payloads consists of first ISRO's hyperspectral imager covering VNIR & SWIR region. SAC has delivered X-band SAR payload for RISAT-2B, which will provide continuity of RISAT-2 services.



HySIS: VNIR & SWIR



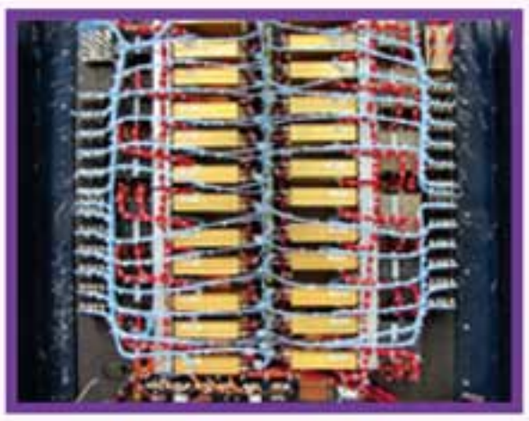
Chandrayaan-2: Ka band Radar Altimeter

Payload development activities for Cartosat-3 series, Resourcesat-3 series, Oceansat-3 series, GISAT, Microsat-2A &2B, Aditya-L1, RISAT-2B repeat missions, RISAT-1A, RISAT-2A, INSAT-3DS, HRSAT, NISAR is in progress.

Cartosat-3 is the next generation of cartographic application satellite envisaged to meet the increasing user demands for very high-resolution Panchromatic and Multispectral imagery for cartographic applications. INSAT-3DS, consists of an Imager and a Sounder, is planned as a ground spare for INSAT-3D & INSAT-3DR, which is already operational in orbit. Geo Imaging Satellite (GISAT) is envisaged to provide high resolution imaging capability from geostationary orbit, which comprise of high-resolution multispectral imaging in VNIR aided by LWIR multispectral. The Oceansat-3 series satellite will provide the essential data continuity services to the Oceansat-2 data users with improved accuracy and in more number of bands. The main objective of Resourcesat-3/-3A is to provide continuity of data services to the user community on an operational basis in the area of Land and water resources management with improved spatial resolution, spectral resolution, spectral coverage and better revisit frequency compared to Resorcesat-2/2A. Resourcesat-3S/3SA provides wider swath with stereographic imaging capability with enhanced spatial resolution. HRSAT series consists of multiple high resolution satellites and is planned to provide one-meter resolution data for applications like mapping, agriculture, disaster monitoring etc.

SAC is significantly contributing to the development of microwave sensors/radars, which are capable of operating in all weather conditions like both day & night, through clouds, rains, haze, dust, fog and smoke. RISAT-1A is a repeat of RISAT-1 mission with almost similar configuration and improved technologies. It will provide critical information for agriculture and disaster management support. RISAT-2A will provide the continuity of operational services beyond the mission life of the RISAT-2. NASA-ISRO Synthetic Aperture Radar (NISAR) is a joint venture between ISRO & NASA.

RISAT-2BR1: Frequency Generator



RISAT-1A: DVM Tile electronics

SAC is also contributing to ISRO's Human Space Programme (HSP)-Gaganyaan, in which SAC is responsible for the development of Crew communication system and Cabin system including EMS, Fire Detection & Suppression system, Display & Camera system etc.

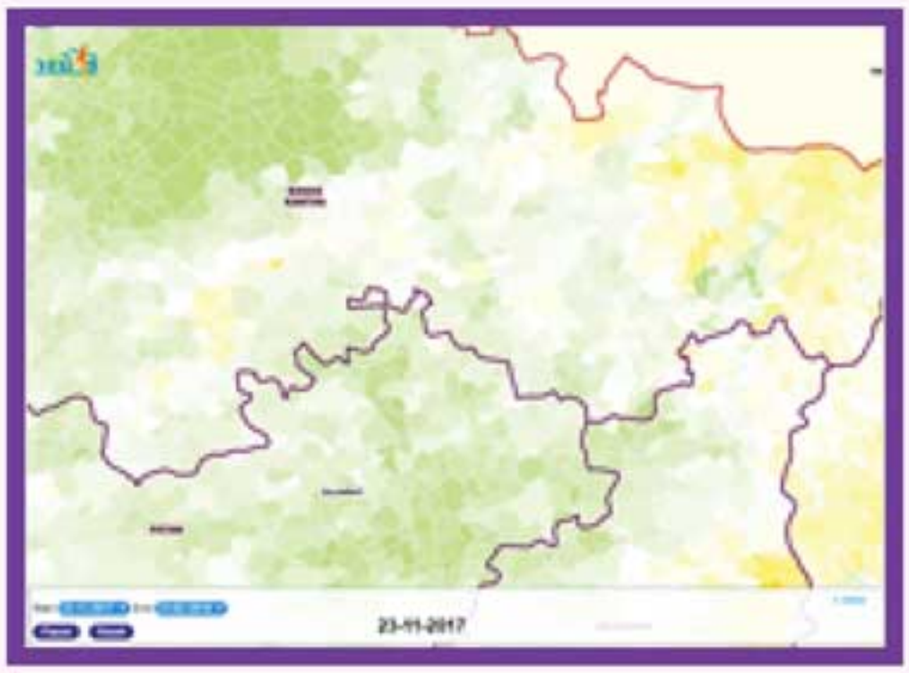
Remote Sensing – Image Processing & Applications

SAC has been developing the algorithms, the software required for processing, and product generation of data acquired from IRS satellites. It involves the design, development, operationalization and maintenance of software for remote sensing data processing related to earth, planetary and astronomical observations for Indian as well as International user community. SAC has developed DPGS and QLP Software for Chandrayaan-2 and DPGS software for Cartosat-2E. Software for ASTROSAT is developed and ported at ISSDC and released for public use. Software development for Cartosat-3, HRSAT, NISAR, Oceansat-3, RISAT-2B and RISAT-2A is in progress

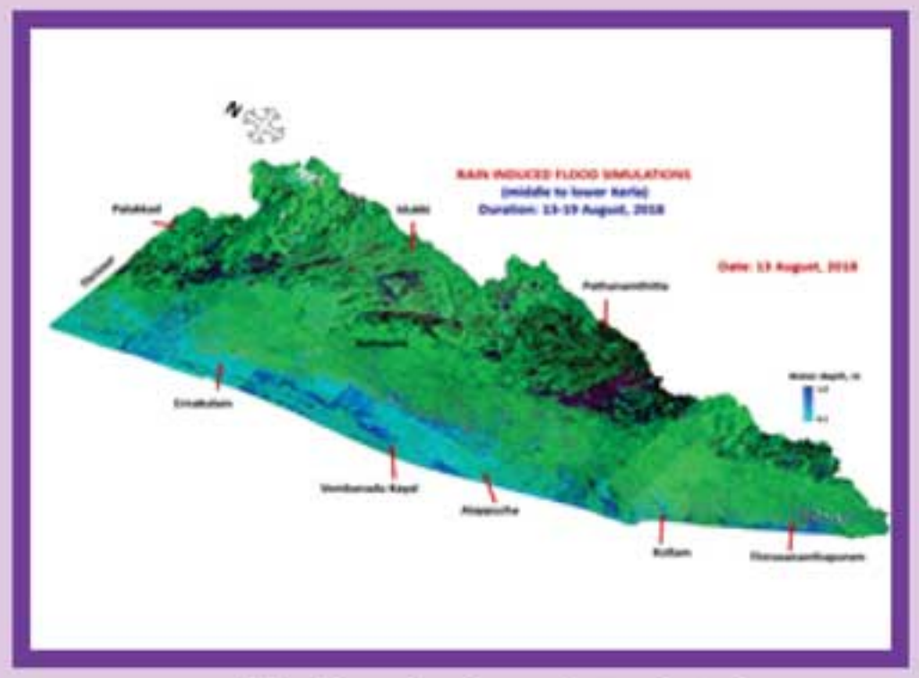
GHRC MCC Mosaic over India
(Imaged on 9th December 2018)

SAC has made very distinctive contribution in the field of agriculture, forestry, coastal zone management, fisheries, urban planning, watershed development, ground water prospecting, oceanography and atmospheric studies through its remote sensing applications.

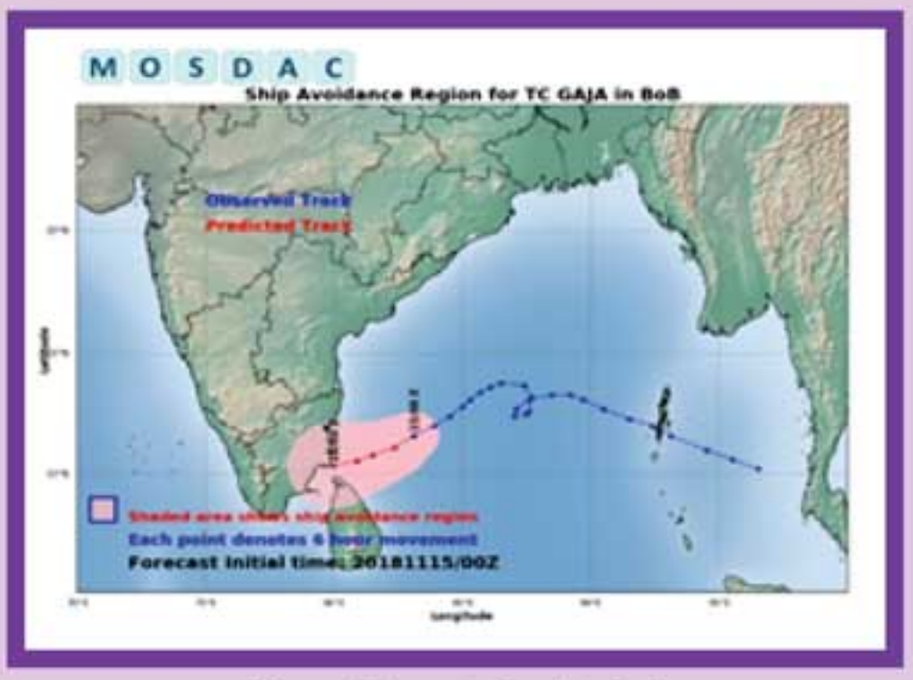
During this year, rice productivity models for 12 states have been developed using Scatsat-1 Ku-band and CCE data, and validated with existing state-level FASAL estimates. Phase – I report of CHAMAN project on horticulture crop assessment submitted to Ministry of Agriculture and Farmers' Welfare. District-level green fodder area assessment over 6 states have been completed, maps are made available in VEDAS. AMUL remote sensing Centre has been established for milk union-level fodder assessment. SAC has developed a web-portal for dissemination of ocean & weather forecasts (wind, wave, current & sea level pressure) along the shipping routes for Shipping Corporation of India (SCI). Desertification & Land Degradation status (1:50,000 scale) change analysis of 78 selected district of the country was carried out and atlas was prepared, It was released and submitted to MoEFCC, New Delhi and put on MoEF & CC and SAC Web-Portals.



Web GIS based vegetation Monitoring system



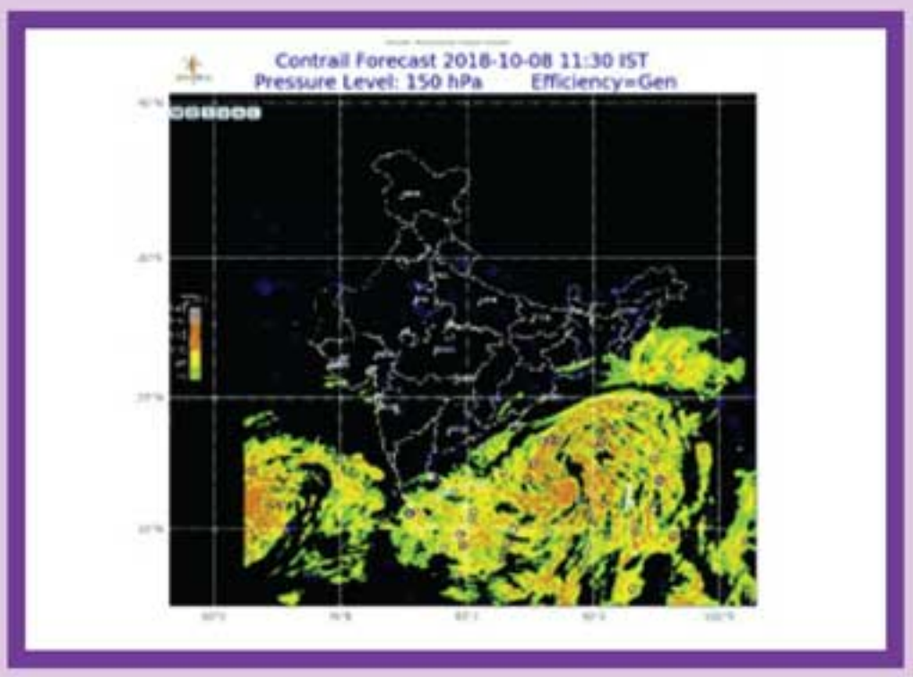
Detected flood inundated areas in Kerala, Gujarat, Assam in Monsoon 2018 using SAR and hydrological modelling

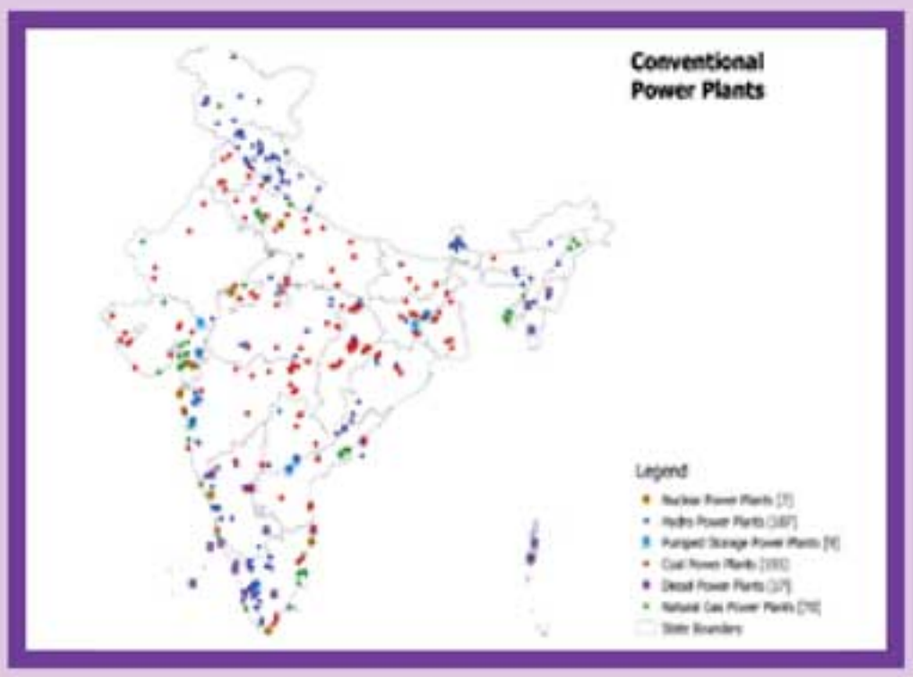


Ship Avoidance Region (SAR) for cyclone "GAJA"

Under SAMUDRA project, new state-of-art multi-purpose compact and low cost GNSS drifters are designed to measure sea surface current and developed an algorithm for PFZ using multi-parameters. Detected flood inundated areas in Kerala, Gujarat & Assam in Monsoon 2018 using SAR and Hydrological Modeling. SAC has developed many applications like prototype of the GIS based energy map of India for NITI Aayog, Solar Calculator for Africa, A multilingual Android App for wetland information data collection and dissemination, Dashboard for monitoring vegetation Condition for Rajasthan etc.

Our data platforms, MOSDAC and VEDAS have show cased data products of HySIS & GHRC. MOSDAC is updating with new products regularly. An operational web-based Air Quality Monitoring System using space based inputs was developed at SAC and this information is being regularly





Geo-spatial energy map of India for NITI Aayog

disseminated through SAC VEDAS Web portal as a societal application for regular use by Central Pollution Control Board and Indian Meteorological Department, Delhi for air quality monitoring. SAC has developed a web based visualization and analysis system, LIVE (Let's Interactively Visualise Earth) which provides NRT access for earth observation, meteorological & oceanographic products

derived from satellite & model forecast and ground observations. SAC is also conducting various training programmes under Training and Research in Earth Eco-System (TREES) and Satellite Meteorology and Oce-Anography Research and Training (SMART) programmes.

Fabrication and Test Facilities

The facilities at SAC includes highly sophisticated payload integration laboratories, electronic and mechanical fabrication facilities, environmental test facility, Image processing and analysis facilities and a well-stocked library. Technical infrastructure is established and maintained by the organization, which are required for the end- to-end payload realization. Some of the major facilities are: Microelectronic Facility for fabrication of Microwave Integrated Circuit (MIC) and Surface Acoustic Wave (SAW) devices, Payload Fabrication facility (PFF), Thermovac chambers, vibration and shock test facility etc. 6.5m Large thermovac, 1.5m Integrating Sphere for Calibration of next generation CARTOSAT Payloads, 3D contact Profilometer is some of the new facility established during the year. Augmentation and maintenance of existing facilities to cater to increased level of subsystem realization such as fabrication & test facilities is required for the development of the Centre. Horizontal Extension of antenna assembly integration and testing lab, Nano-electronics fabrication facility are some of the new critical facilities which are nearing completion.

LTVac Facility

Vendor Complex

LTCC Foundry

Systems Reliability

Systems Reliability Area of SAC, is responsible for the formulation and implementation of quality practices, to ensure that all projects undertaken in the centre, meet the high degree of quality and consistency that ISRO is recognised for. This is implemented through a comprehensive and all-encompassing quality programme, covering all aspects of product development that includes multi-tiered design review and approval; careful selection of components and materials which is followed by extensive acceptance testing; thorough qualification of fabrication processes along-with stringent quality control followed by comprehensive characterisation of the developed product through a rigorous test and evaluation. Each of these activities are regularly monitored through audits. The quality programme and practices are implemented not only within the centre, but at sub-contractor's facilities as well.

Library and Information services

SAC has a well-stocked library to support the R&D activities. Most of the functions are computerized

and connected through the campus-wide network called SACNET to facilitate the users. Library also provides bibliographic and current awareness services. Library also affiliated with many international repositories and national repositories like IEEE, SPIE etc., Users also have the facility of Wi-Fi network to download the e-papers and other online journals required for their activities. Library is equipped with vast number of Hindi journals and books for reference and research purposes.

Projects and Programme Management

Project and research activities are efficiently planned and managed in the centre by Planning & Projects Group. Regular reviews are conducted at multiple levels to monitor the progress of all activities and to address the issues before they become critical in an organized manner using IT Tools. It is also responsible for planning the budget and schedule of activities for the centre, monitoring the expenditure of funds allotted to various projects undertaken at the centre, and carrying out various budget exercises. In addition, the functions related to patents & IPR filing, technology transfer & industrial interface, human resources development, management information systems, networks planning & operations and management of research and technology development programs are carried out by PPG.

Future Outlook

This year is challenging to the ISRO community with more than 30 planned missions. SAC, one of the major Centre of ISRO, is developing new technologies and advanced techniques to meet the requirements of the country. This year ISRO is planning to launch Chandrayaan-2, India's second lunar mission, in which SAC contributed significantly by delivering 9 payloads. Gaganyaan, India's human space mission, activities is also going in full steam. The demand for transponders has enhanced significantly, in which SAC's contribution is remarkable. To meet country's high throughput requirement, GSAT-20 is planned to be launched this year, is also progressing well. Indigenous development of TWTA, which will be a big leap by ISRO in high power amplifier technology is also in progress. ISRO has already developed and placed in orbit, its own navigation system called Navigation with Indian Constellation (NavIC) and in future, more satellites will be augmented to improve the accuracy and new technology elements will be developed. SAC is indigenously developing Rb-atomic clock for IRNSS satellites. ISRO is also aiming to reinstate its microwave remote sensing capability through the Radar Imaging Satellite (RISAT) series. SAC has already delivered SAR payload for spacecraft integration and development work for other RISAT series is going on. The development work of GISAT series, to attain geo-imaging capability through geo imaging satellite is also progressing well. In addition to this, development of high resolution optical sensors (Cartosat series), hyper spectral sensors and its applications will be the major thrust areas during the coming years. NISAR, the biggest collaboration between ISRO & NASA to launch a dual frequency Synthetic Aperature Radar is also in advanced stage. In the applications front, major initiatives include the conceptualization of satellite data for the development of agriculture, disaster management, weather forecasting etc.

CSSTEAP Course on Satellite Meteorology and Global Climate, at SAC, Ahmedabad (SATMET- 11): A Report

Dr. B. Simon
Course Director (Retd).

Dr. Sanjib K Deb
Associate Course Director

Dr. Kaushik Gopalan
Course Coordinator

The Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), affiliated to the United Nations is imparting training in various disciplines including "Satellite Meteorology and Global Climate (SATMET)". The Eleventh Post Graduate Courses on Satellite Meteorology and Global Climate under the aegis of the UN affiliated CSSTEAP, is being conducted at Space Applications Centre (SAC) Bopal Campus, Ahmedabad during August 1, 2018 to April 30, 2019.

Thirteen participants from eight countries in Asia-Pacific region have been undergoing this course. They are mostly operational forecasters, meteorologists and researchers in their own country. After they learn about satellite meteorology, they will impart training to their own officers in this subjects once they go back. The participants are from the countries like Bangladesh, India, Kyrgyzstan, Maldives, Mongolia, Myanmar, Philippines , Tajikistan.

The course commenced on August 1, 2018 at SAC Bopal Campus, Ahmedabad. A joint inaugural function of the two courses i.e. the Satellite Meteorology and Global climate (SATMET) conducted by Space Applications Centre and the Space and Atmospheric Sciences (SAS) conducted by Physical Research Laboratory (PRL) was held at K.R. Ramnathan Auditorium, PRL on 6th August 2018. This function were presided over by Shri D K Das, Director SAC & Dr. Anil Bhardwaj, Director PRL, Dr. A. Senthil Kumar, Director CSSTEAP and Senior Officers from SAC and PRL graced the function.

A thoroughly detailed syllabus on the basis of Grenada and Frascati documents of UN-OOSSA was

adopted for the course. The Board of Studies (BoS) Committee of Satellite Meteorology & Global Climate constituted by Director, CSSTEAP had modified the syllabus.

This course has 2 semesters spread in 3- modules. The 1st module covers the fundamentals of Satellite Meteorology and Global climate, and 2nd module deals with Advance Concept of Satellite Meteorology, e.g., geophysical parameter retrieval and satellite products and their applications in NWP etc. The 3rd module, called pilot project module (duration: 3 months) the participants have to do project on a topic relevant to their own country under the guidance of an expert scientist from SAC, Ahmedabad.

During Module I and Module –II there were theory classes in the morning and practicals in the afternoon sessions. There were tutorials; weather discussion, climate seminar and the performance of the participants were assessed through written, interactive sessions and practicals exercises. On successful completion of the Phase I, the participants will be given the post graduate diploma, and they can complete their PHASE-II project work in their own county for one year, and the work can be submitted to Andhra University for the award of M. Tech.

A one-week orientation module, covering various topics related to space technology, with special emphasis on Remote Sensing & GIS, Satellite Meteorology, Satellite Communications and Space Sciences was introduced. Special lectures were delivered by eminent scientists in this module. The idea was to make all the course participants aware about the capabilities of space technology and related applications in various fields.

Recently new practicals, i.e., in temperature and humidity profiles from sounder data (SAT-3D/3DR), GPS Meteorology, Scatterometer applications, humidity profiles from SAPHIR sensor onboard Megha Tropiques, SARAL/Altika data were incorporated and these practicals were highly appreciated by the SATMET-11 students.

Faculty:

Faculty members are taking theory classes for SATMET-11 students

Faculty members for this course were drawn mostly from the Atmospheric and Oceanic Sciences Group (AOSG), SAC, Ahmedabad. A few scientists from the other groups of SAC, PRL, Indian Meteorological Department (IMD) and Andhra University etc. have also delivered lectures.

In addition to class room lectures during the morning hours, practicals using satellite data were conducted in the afternoon. The main work-horse for the practicals were data from INSAT and NOAA satellites. Microwave data: Mega Tropiques – SAPHIR, SARAL/ALTIKA SSM/I, TRMM and GCM outputs etc. were extensively used by the course participants. During the first module the emphasis was on data / image interpretation with many case studies on clouds, tropical cyclones etc. The second module consisted basics of geophysical parameter retrieval, assimilation of satellite data in NWP, validations and their applications.

Special Facilities:

SATMET-11 course was held in the spacious SAC, Bopal Campus. A special SATMET Laboratory with modular structure, uninterrupted power supply and networking was commissioned for the course with twenty personal computers and a server. This facilitated easy access to various satellite data sets, software etc. to each participant, particularly during their three months pilot project phase. Special terminals for e-mail purposes were provided, both in office and at hostel, which helped the participants in data downloading, browsing and also to remain in touch with their families/office.

Versatile software packages Python, Matlab etc. on each terminal provided much needed standardization in data processing (INSAT-3D/3DR, Megha Tropique (MT), SCATSAT-1, NOAA, MODIS etc.) to all the participants. This would help them immensely in the continuation of the project back home. A set of three volumes of lecture notes prepared especially for the SATMET course comprised the main resource material. These were distributed in the beginning itself to all the participants, and updated notes were also provided.

A separate CSSTEAP network was installed with access from class room, laboratory and hostel. With this network the students could access the study materials (Class room lectures) both in word and in presentation form, this facilitated them to recall the class room lectures again and benefited particularly the students with English language problem. Special English classes were held by professionals near SAC Bopal campus.

Hostel accommodation was arranged in the international hostel with good living facilities and with attached kitchenette. Canteen facility was provided to the participants in both technical campus and hostel. For entertainment DTH system was provided to them in their rooms. The participants used the recreation and gym facilities made available in the hostel area. Centre also provided medical facilities for minor ailments. There were no major health problems reported by the participants during the nine-months course.

Seminar, Tutorials and Map Discussions:

Each participant gave a number of seminars during the course, related to climate and meteorological problems affecting their region and also the topics related to their pilot projects. This exercise helped them greatly to improve their presentation skills. They also got an excellent exposure to working with numbers during the tutorial sessions where a number of simple, yet conceptual problems were discussed and solved in the class. Participants enjoyed these sessions meant to enhance the problem solving capabilities.

Director SAC Sri D K Das is interacting with SATMET-11 student.

Weekly map discussion of the current weather over Indian and the Asia-Pacific regions using satellite images, weather charts and model forecasts available from various sources, were conducted during the first three months. This gave them a good exposure to various web sites providing operational satellite data and forecasts and also helped them to keep track of various important meteorological events over their own region.

Technical Visits:

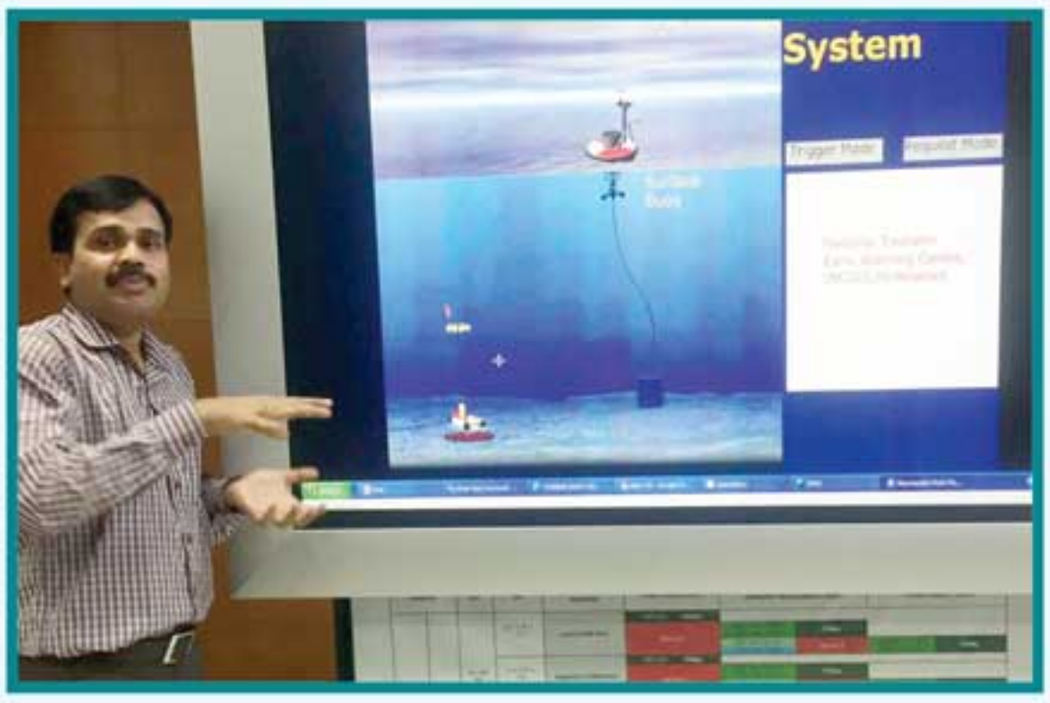
During the 9 months course, the participants visited some of the important institutions and laboratories in the country to have a first-hand experience of the utilization of satellite data in an operational environment. Some glimpses of different technical visits are shown here:

Doppler Weather Radar (DWR), Chennai

Andhra University, Visakhapatnam

Satish Dhawan Space Centre, Sriharikota

National Remote Sensing Centre, Hyderabad



Indian National Centre for Ocean Information Services (INCOIS) and Tsunami warning Centre, Hyderabad

IMD New Delhi

These tours were so designed that the participants not only had an opportunity to visit excellent facilities of ISRO and other national organisations, but also get familiarised with the cultural heritage, diversity and natural scenic beauty of various parts in India, including the famous Taj Mahal.

Pilot Projects:

The candidates learnt a lot during the 3 months pilot-project-about formulation of a problem of relevance to their country, specifying and acquiring data, execution, and communication both orally and in writing. The variety of coverage of themes can be appreciated from the list of projects given in this Memoir.

The pilot project could be listed in following broad topics:

- » Assimilation of satellite data and impact studies of severe weather model.
- » Sounding products using INSAT-3D / AIRS and MODIS data - validation/applications.
- » Mesoscale convective studies using satellite data., SAPHIR / MT Validation
- » Now-casting/rainfall and tropical cyclone studies using satellite data.
- » Radio occultation and applications.

The topics for one-year Project work were identified after several discussions with the participants. The field of interest of the participants, the needs of the sponsoring organisations and the facilities available in the countries of participants for supporting the project work were taken into account while deciding the project.

Acknowledgements

It has been possible to conduct the 11th post graduate course on Satellite Meteorology and Global Climate (SATMET-11) at SAC, Ahmedabad due to sincere and dedicated efforts put in by a large number of persons at SAC. We would particularly like to thank all faculty members, focal points and project guides, who in spite of their busy schedule delivered lectures, organized practical sessions, conducted tutorials and provided guidance to the participants for their project related activities. We thank SAC administration, SAC-Bopal campus administration, Controller SAC, Group Director CMG and his team, Head Purchase & Stores and his team, Head Accounts/IFA and his team, P & PR and his team, Head ESSA-ITND and his team, Medical Officers and other administrative staffs for the support extended to the course participants. We thank Dr. K. Sivan, Chairman ISRO, and Shri D K Das, Director SAC for all the support and encouragement in organizing the course satisfactorily fulfilling the commitments of SAC in conducting the SATMET course on behalf of CSSTEAP. We sincerely thank Dr. A. Senthil Kumar, Director CSSTEAP for his keen interest and support in making this course a great success.

COURSE AT A GLANCE

Module 1:
Fundamentals of Meteorology, Climatology and Remote Sensing (Three Months)

Module 1.1	**Concepts in Meteorology and Climatology**
Section 1 -1 MET	Basic concepts of Meteorology, Climatology and Oceanography
Section 1 -1 MATH	Mathematical and Computational Techniques for Satellite Meteorology
Module 1.2	**Concepts in Satellite Meteorology**
Section 1-2 SM	Principles of Meteorological Remote Sensing
Section 1-2 MSI	Overview of Meteorological Satellites / Orbits
Module 1.3	**Image Processing, Interpretation and GIS**
Section 1-3 DIP	Image Processing Techniques and Geographic Information System (GIS)
Section 1-3- WF	Image Interpretation in Meteorology and Weather Forecasting

Module 2:
Advance Concepts and Techniques in
Satellite Meteorology and Global Climate (Three Months)

Module 2.1	**Geophysical Parameter Retrieval**
Section 2-1 AP	R T Theory, Atmospheric Parameters
Section 2-1 LOP	Land and Oceanic Parameters
Module 2.2	**Applications of Satellite Derived Parameters**
Section 2-2 -AWF	Applications in Meteorology and Weather Forecasing
Section 2-2 -NM	Satellite Data Assimilation in Numerical Models
Module 2.3	**Global Climate and Environment**
Section 2-3- SC	Short Term Climate Variabiltiy
Section 2-3- LC	Long Term Climate Change
Section 2-3-ESI	Environment Issues and Societal Impacts

Module 3: PILOT PROJECTS (Three Months)

Break - up of Module 1 & 2 Lectures

Sub- MODULE 1.1: CONCEPTS IN METEOROLOGY AND CLIMATOLOGY

Section 1-1-MET: Basics Concepts of Meteorology, Climatology and Oceanography
Atmospheric, Dynamics & Physical Meteorology
Extra Tropical Weather Systems
Tropical Weather Systems, Monsoon
Climate of Asia-Pacific region and Variability
Ocean and Climate
Section 1-1-MATH: Mathematical and Computational Techniques for Satellite Meteorology
Matrices & Vectors
Partial & Total differential equation
Integral & Derivatives
Basic Concepts of Statistics
Basics of Computer Programming

Sub- MODULE 1.2: CONCEPTS IN SATELLITE METEOROLOGY

Section 1-2-SM: Principles of Meteorological Remote Sensing
Principles of Remote Sensing
Characteristics of Electromagnetic Radiation
Passive Remote Sensing
Active Remote Sensing
Parameter Retrieval & Validation
Section 1-2-MSI: Overview of Meteorological Satellites/Orbits
Orbits and Navigation
Operational Polor-orbiting satellites
Operational Geostationary Satellites
Other Satellites
Satellite data Archive

Sub - MODULE 1.3: IMAGE PROCESSING, INTERPRETATION & GIS

Section 1-3-DIP : Image Processing Techniques and Geographic Information System (GIS)
Map Projection

Satellite Positioning System
Image Registration, Radiometric & Geometric Correction
Image Classification
GIS
Section 1-3-WF : Image Interpretation in Meteorology and Weather Forecasting
Satellite Imagery
Spectral Properties
Identification of Meso Scale Systems
Tropical Synoptic Systems
Extra Tropical Synoptic Systems
Radar Meteorology

Sub Module 2.1: GEOPHYSICAL PARAMETER RETRIEVAL

Section 2-1 AP: RT Theory and Atmospheric Parameters
Winds
Temperature Profile
Humidity Profile
Precipitation
OLR
Clouds and aerosols
Section 2-1 LOP: Land and Oceanic Parameters
Sea Surface Temperature
Sea Surface Winds
Vegetation Index
Land Surface Parameters

Sub-MODULE 2.2: APPLICATIONS OF SATELLITE DERIVED PARAMETERS

Section 2-2-AWF: Applications in Meteorology and Weather Forecasting
Onset of Monsoon
Intra-Seasonal & Inter annual variability
Tropical Cyclones
Extra Tropical Cyclones
Weather Systems related to Tropics & Mid-latitude interaction

Agrometeorological Applications
Drought Monitoring
Air-Sea Interaction
Section 2-2-NM: Satellite Data Assimilation in Numerical Models
Atmospheric Models
Concepts of Data Assimilation
Satellite Data Assimilation
Impact of Satellite Data Assimilation

Sub-MODULE 2.3: GLOBAL CLIMATE AND ENVIRONMENT

Section 2-3-SC: Short Term Climate Variability
El-Nino & Southern Oscillation
Cloud Climatology
Land Surface Changes
Radiation Budget
Ozone and other Trace Gases
General Circulation Models & Regional Circulation Models
Section2-3-LC: Long Term Climate Change
Climate Change
Geosphere – Biosphere interaction
Green House Effect & Global Warming
Hydrological and Carbon Cycle
Changes in Cryosphere
Future Climate Scenario & Satellite Missions
Section 2-3-ESI: Environment Issues and Societal Impacts
Oceanic Biological Productivity
Coastal Zone Environment
Pollution
Disaster Management

LIST OF PRACTICALS

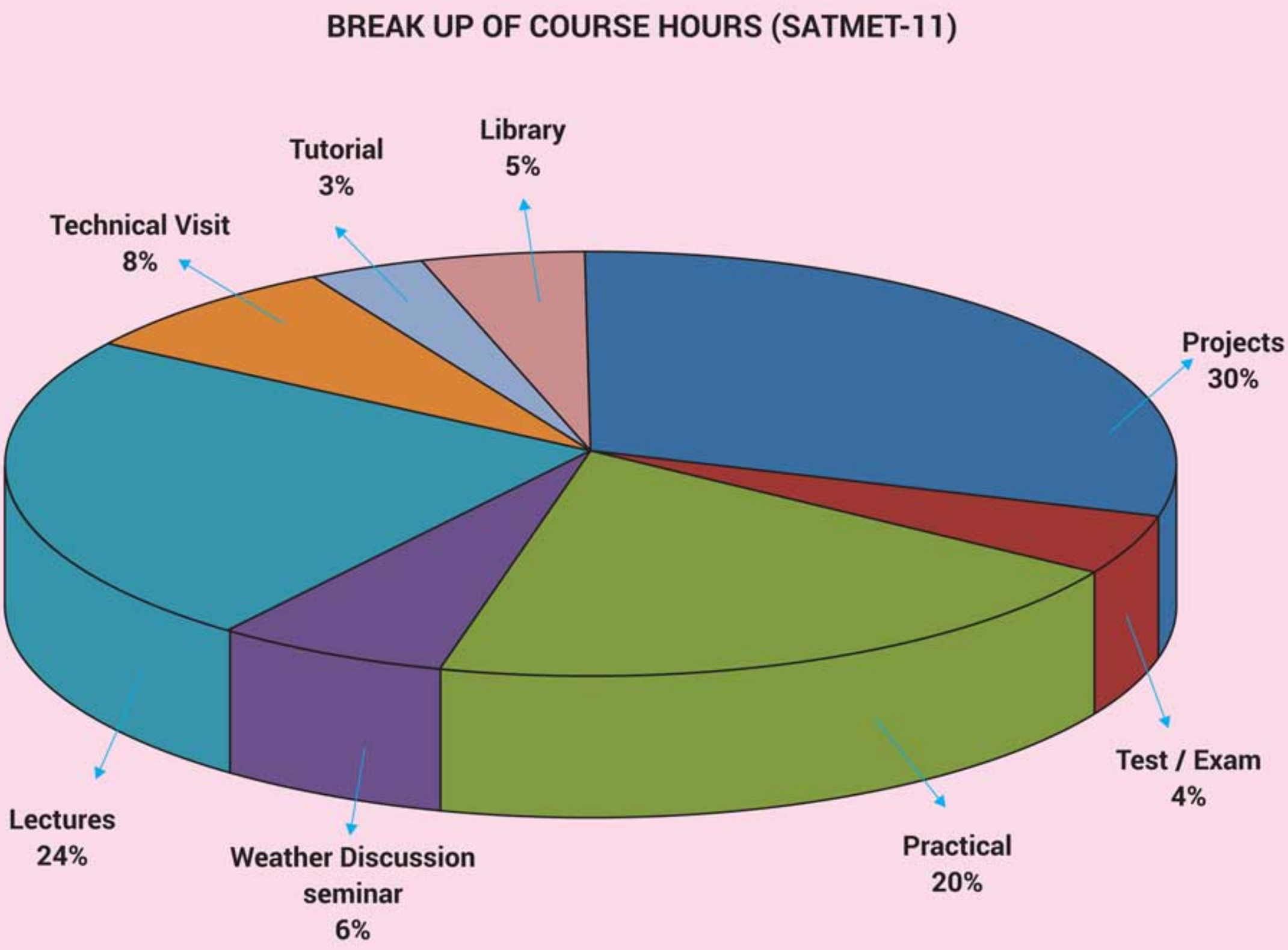
Module I: Operational Meteorological Satellite Data Handling & Applications	
Sr. No.	**Title**
1.	Computer Orientation I: Familiarization of SATMET Labs, systems & networks, visit to MOSDAC & AWS.
2.	Computer Orientation II: Visualisation tools using LINUX, GRADS, Fortran, Python and Matlab etc.
3.	INSAT-VHRR data handling, cloud characteristics, feature extractions and applications.
4.	NOAA-AVHRR Data Processing – Feature extractions and Applications
5.	Estimation of daily & weekly rainfall using INSAT-VHRR data.
6.	Meteorological Data Processing
7.	Cloud Motion Vectors using INSAT-VHRR data and computation of divergence & vorticity.
8.	Visualization & analysis of Meteorological Data – Demo of applications of satellite data in tropical cyclone.

Module II: Remote Sensing of Geophysical Parameters & Numerical Modelling Applications	
Sr. No.	**Title**
1.	Basic retrieval techniques
2.	Retrievals from microwave instruments
3.	Temperature & humidity profile
4.	Retrievals of ocean salinity
5.	Land: evapotranspiration, insolation
6.	SST retrieval
7.	Scatterometer applications
8.	GPS Meteorology
9.	Assimilation of satellite data using NWP model
10.	Climate modeling-Demo
11.	Satellite based nowcasting of weather systems
12.	Climate simulation using global NWP model

CORE PERSONNEL OF THE COURSE

Course Director (Retd).	:	Dr. B. Simon
Associate Course Director	:	Dr. Sanjib K Deb
Course Coordinator	:	Dr. Kaushik Gopalan
Focal Person-Pilot Projects	:	Dr. C.M.Kishtawal

BREAK UP OF COURSE HOURS



LIST OF FACULTY MEMBERS

	Theory: AOSG, SAC		Other Group, SAC
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4	Dr. Rashmi Sharma	4	Mr. S. Manthira Moorthi
5	Dr. A. K. Varma	5	Dr. R. K.Bhattar
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7	Dr. Sanjib K Deb	7	Mr. Darshan K Patel
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15	Dr. Smitha Ratheesh	15	Mr. Manoj Mishra
		16	Dr. Praveen K Gupta

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13	Mr. Anup Mandal	13	Prof. Harish Chandra, PRL, Ahmedabad
14	Mr. Ujjwal Kumar Gupta	14	Dr. Shashikiran Ganesh, PRL, Ahmedabad
15	Mr. Dinesh Sankhala (JRF)	15	Dr. Ramchandran, PRL

	Outside DOS, India
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3	Prof. S.S.V.S Rama Krishna, Andhra University
4	Dr. U. S. De, Ex. ADGM, IMD Pune
5	Dr. Shirish Ravan, UN OOSA, Vienna

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2.	Sqn Ldr Hari Prasad Sad	Indian Air Force **India**
3.	Lt Cdr K Praveen Kumar	Indian Navy **India**
4.	Ms. Aizhamal Mirtilekova	Department of Meteorology **Kyrgyzstan**
5.	Mr. Abdulla Hafiz Abdul Sattar Ali	Maldives Meteorological Service **Maldives**
6.	Ms. Dorjkhand Munkhjargal	National Agency for Meteorology and Enviromental **Mongolia**
7.	Ms. Khorolsuren Tojil	Department of Meteorology Hydrology And Environment Monitoring In Dornod Province **Mongolia**
8.	Ms. Sainjargal Baatarchuluun	Department of Meteorology Hydrology And Environment Monitoring In Dornod Province **Mongolia**
9.	Ms. Tergel Shijirtuya	Hydrology, Meteorology And Enviromental Monitoring Agency Of Dornogovi Province **Mongolia**
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Participants Profile and Pilot Project

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Md. Shaheenul Islam was born in Netrakona District of Bangladesh and now lives in the capital city, Dhaka. He completed his graduation and post - graduation in Physics from the University of Dhaka. He joined the Bangladesh Meteorological Department in 2012 as an Assistant Meteorologist and is currently working as a Forecaster (Meteorologist) in Storm Warning Centre, Agargaon, Dhaka.

The last student to join the course but a front runner in terms of smartness and intelligence. A fun-loving person; he is an omnipresent coach at the gym every evening. He is also known as the 'head' of the weekly “shopping group” of the course.

Md. Shaheenul Islam
Meteorologist
Guide: Dr. Neeru Jaiswal
SAC/EPSA/AOSG/ASD

Abstract

Tropical cyclone structure analysis using satellite observations

The accurate estimation of wind structure of tropical cyclones is highly important as they are used as input in various cyclone prediction models. The satellite observations play an important role in the estimation of these parameters. In the present study, wind products obtained from SCATSAT-1 and SMAP (Soil Moisture Active Passive Radiometer) satellites over the tropical cyclones formed in the North Indian Ocean (40°-100°E and 0°-30°N) during the period 2017-2018 have been analysed. The structural parameter of cyclones (center, Rmax, Vmax and critical wind radius) were computed and compared with the best track data obtained from India Meteorological Department (IMD) and Joint Typhoon warning Centre (JTWC).

The cyclone wind structural parameters from the 40 wind passes over six NIO (North Indian Ocean) cyclones (Marutha, Mora, Ockhi, Titli, Gaja & Phetai) obtained from SCATSAT-1 and SMAP were analysed and compared w.r.t. best track data. The maximum wind speed values measured by SCATSAT-1 were found to be over-estimated for 10 (ten) cases and under-estimated for 2 (two) cases out of 25 cases. However, For SMAP 3 (three) cases out of 15 were over-estimated and 2 (two) cases out of 15 were under-estimated. The SMAP was able to capture the high winds upto 45 m/s which cannot be estimated by SCATSAT-1 satellite.

The INSAT-3D TIR-1 data over the TCs have also been analysed. The relationship between brightness temperature (BT) values estimated by INSAT-3D TIR-1 channel and wind speed measured by SCATSAT-1, SMAP and RAPIDSCAT were analysed.

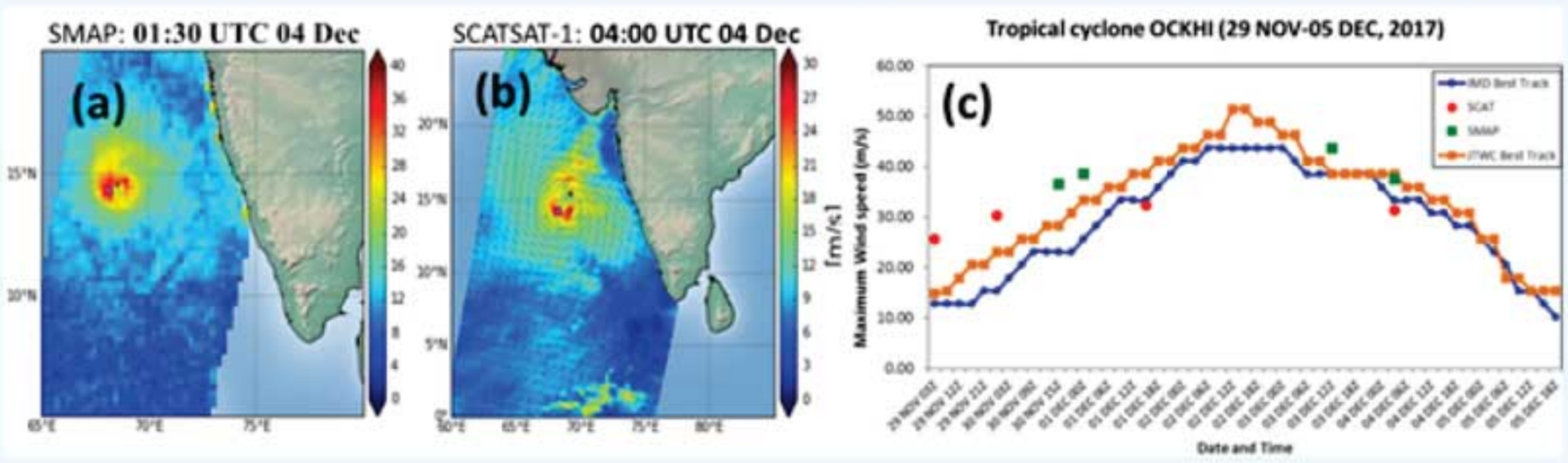

Fig.1: Wind passes over tropical cyclone OCKHI obtained from (a) SMAP and (b) SCATSAT-1. (c) Comparison of maximum wind speed estimated by SCATSAT-1 and SMAP w.r.t. IMD and JTWC best track for TC OCKHI.

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Squadron Leader Hari Prasad was born in Nagaur District of Rajasthan and Post- Graduated in Mathematics from North Bengal University, Darjeeling. He got commissioned in the Indian Air Force in the year 2007 as a Meteorological Officer. With postings ranging from Northeast states, Western, Central, Southern to Glacier region, he has gained experience in forecasting over varied terrain across the country. He had an opportunity to work as Senior Met Officer at two premium flying bases of IAF before joining this course. He has shown much commitment and interest in this course to sharpen his skill.

Hari is a level-headed bright leader, filled with determination and fury in pursuing his target relentlessly. He's always willing to share his opinion with the group. He never hesitates to lend out a helping hand to fellow colleagues especially in the academic sphere.

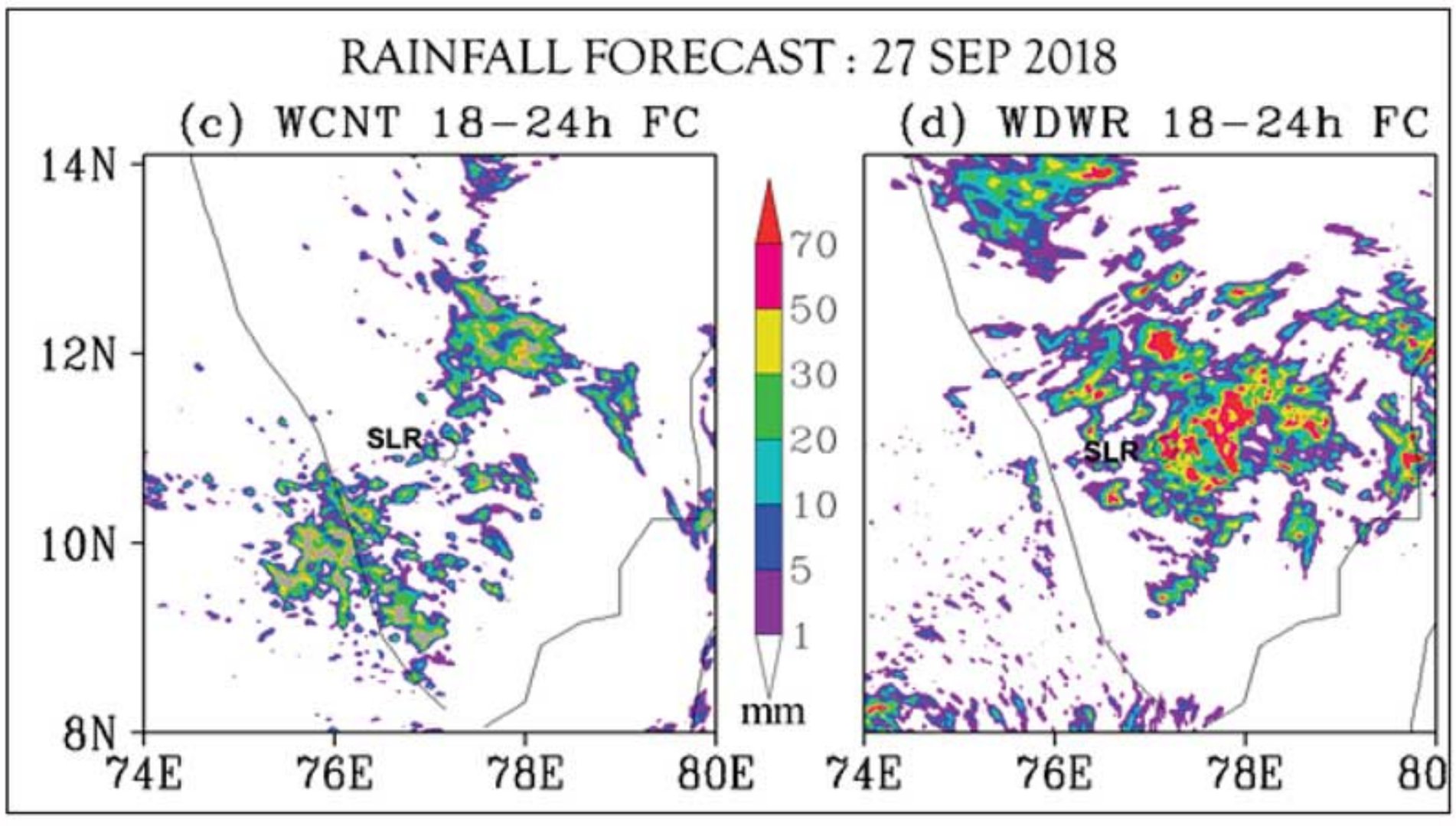
Squadron Leader Hari Prasad
Meteorological Officer
Guide : Dr. Prashant Kumar & Mr Sambit Kumar Panda
SAC/EPSA/AOSG/ASD

Abstract

High Resolution Rapid Refresh (HRRR) Data Assimilation of DWR Observation for Extreme Weather Event

The Numerical Weather Prediction (NWP) has been recognised as the front-runner in the operational weather forecasting. With the advent of the NWP models, reliable and accurate weather predictions are possible with high confidence. The disruption of normal life and loss of vital national assets due to extreme weather events over Indian region are well known. The precise initial condition and its error distribution in the NWP model are few major constraints to improve accuracy of the weather predictions.

The utilization of high frequency and resolution ground observations from Doppler Weather Radar (DWR) are still limited to improve the skill of the NWP model. In this project, high temporal frequency Sulur DWR observations are assimilated using High Resolution Rapid Refresh (HRRR) method in the Weather Research and Forecasting (WRF) model to improve model initial conditions for forecasting heavy rainfall event. The role of observation error and background error have been studied to demonstrate efficient use of DWR observations for extreme weather event. With the assimilation of DWR observations, the WRF model is able to predict selected rainfall event with less temporal, spatial and intensity error.



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Hailing from Madurai, Tamil Nadu; Lieutenant Commander K Praveen Kumar graduated as an Electronics and Instrumentation Engineer from SASTRA University, India. In 2007, he was commissioned in the Indian Navy. He is the third generation in his family to serve in the armed forces. His sea appointments were on board Indian Naval Ships Mysore, Magar and Tir. He was also an instructor at Indian Naval Academy, Kerala. He then underwent the Advanced Meteorology Course in the year 2014 at Meteorological Training of Institute of Indian Meteorological Department at Pune. Post completion of the course, the opportunity to apply his met skills came with his appointment to the naval air station, INS Hansa, Goa where he served as a Deputy Senior Met Officer from 2015 to 2018.

He is an awesome person who has the perfect say for all situations. He is a combination of intelligence and quick wit with a composure as cool as ice. He enjoys spending time with friends, reading books and watching movies. He has a good sense of humor and enjoys sharing a good laugh with all. He is a person with a frank opinion and is willing to call out your mistakes when required. As an honest and dependable person, you are sure to find a good friend in him.

Lieutenant Commander K Praveen Kumar
Meteorological Officer
Guide : Mr. Abhineet Shyam
SAC/EPSA/AOSG/GRD

Abstract

Demonstrating CYGNSS scalar wind product potential through comprehensive validation with scatterometer and in-situ buoy data

Ocean winds play a vital role in the Ocean-Atmosphere System. They are the largest source of momentum which transport heat, aerosols and moisture through the system. This, in-turn, affects the constantly changing weather pattern and the relative slow changes in the climate. The Cyclone Global Navigation Satellite System (CYGNSS) is a part of NASA's Earth System Science Pathfinder mission, consisting of constellation of eight small satellites at LEO with objective to take frequent ocean surface speed wind measurements in all precipitating conditions in particular during tropical cyclones.

In the validation process quality-controlled data of CYGNSS wind speed (WS) obtained from different algorithms ie. using Minimum Variance estimator (MVE), Normalised Bistatic Radar Cross Section and Leading Edge Slope Method in different sea Conditions-fully developed sea and young sea (during cyclone), were validated with collocated in-situ INCOIS buoy and SCATSAT winds speeds. The period of study was year 2017.

The analyses were done month-wise as well as annually; in addition to this, biases and standard deviations (SDEV.) were calculated. Fig.1a shows density scatter plot along with the bias (0.389 m/s) and SDEV. (1.847 m/s) of CYGNSS MVE WS w.r.t. buoy WS. Similarly, density scatter plots of the CYGNSS WS against SCATSAT have been analyzed. Monthly error trend analyses of CYGNSS MVE WS show SDEV. of 1.38 m/s (minimum, March) and 2.16 m/s (maximum, June) (fig. 1b).

For assessing CYGNSS performance during high wind conditions, comparison is being done of the CYGNSS WS from the above-mentioned different algorithms against IMD best track data of cyclones- Marutha, Ockhi and Mora, and analyzed alongside independent comparison of SCATSAT WS during these cyclones.

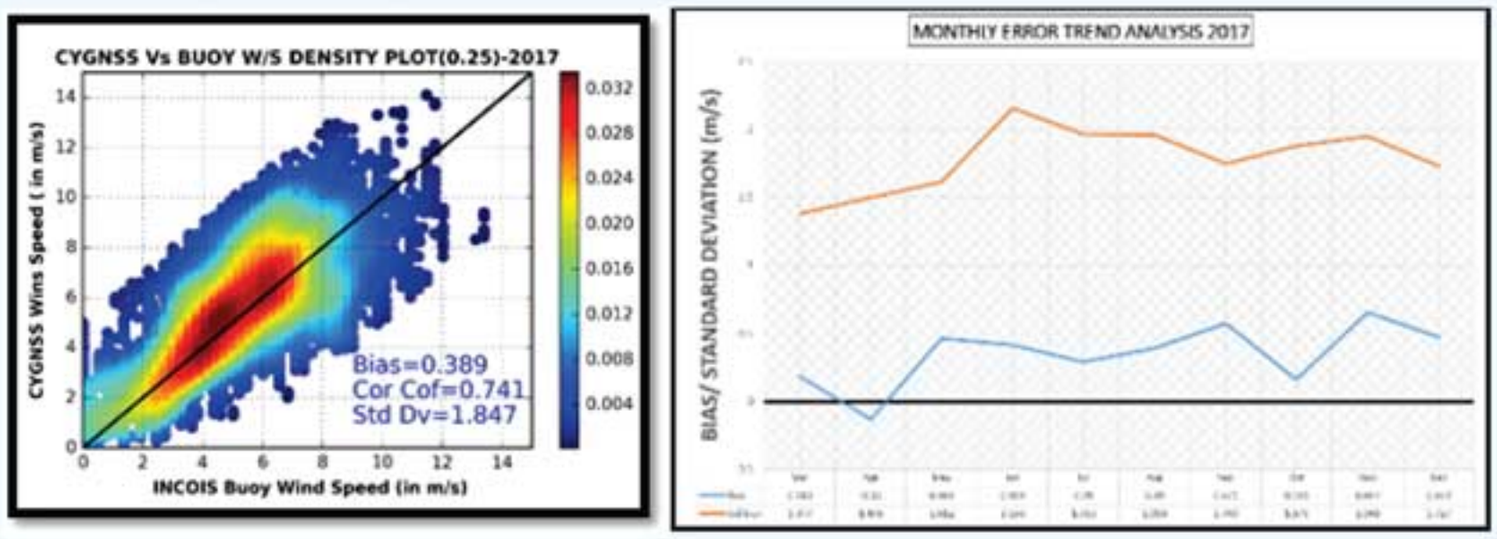

Figure 1 (a) Density Scatter Plot of CYGNSS and INCOIS buoy collocated at 25 km and 30 min. window size for the year 2017. (b) Monthly error trend analyses of CYGNSS Wind Speed against INCOIS buoy WS for the year 2017.

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Aizhamal Mirtilekova was born in Issyk-Kul, north part of Kyrgyzstan. She graduated in Bachelor of Hydrometeorology, Ecology and Environment Protection from the Kyrgyz-Russian Slavic University, Bishkek, in 2018. Now she lives and works in Bishkek city. She has been participating as a volunteer in different programs. She loves running, yoga, table tennis. In the future, she wants to become a specialist in her field.

The default volunteer of the course, she is always at hand to organize events in the course. A multitasker who loves to experience new things. She is full of energy and enthusiasm. She never misses a photo opportunity.

Ms. Aizhamal Mirtilekova
Meteorologist
Guide: Dr. Sasmita Chaurasia
SAC/EPSA/AOSG/GRD

Abstract

Night time fog detection using MODIS data over Kyrgyzstan

Fog is a meteorological phenomenon which reduces the ground level visibility to less than 1000 meters. Apart from the hazardous effect on aviation as well as land/water transportation system due to low visibility, it is having lots of socio-economic impact. In recent past, the crashing of aircraft and vehicular accidents in Kyrgyzstan leading to large number of causalities due to heavy fog has created lot of impetus for its regular detection, monitoring and forecasting. Onset of fog takes place in winter time due to decrease in surface temperature, increase in pollution level, low wind condition and surface level inversion. Because of the low density of surface observations for different meteorological parameters like visibility, relative humidity and surface wind etc. remote sensing techniques has been used to detect fog and low clouds and monitoring its evolution both temporally and spatially over large area. In the pilot project, MODIS AQUA and TERRA night time data for Thermal InfraRed (TIR) and Mid-InfraRed (MIR) Channel with spatial resolution of 1km, has been used for fog detection over Kyrgyzstan. The bi-spectral temperature difference (BTD) method has been used to detect fog and low clouds detection for January 2018, December 2018 and January 2019 and validated with in-situ visibility data.

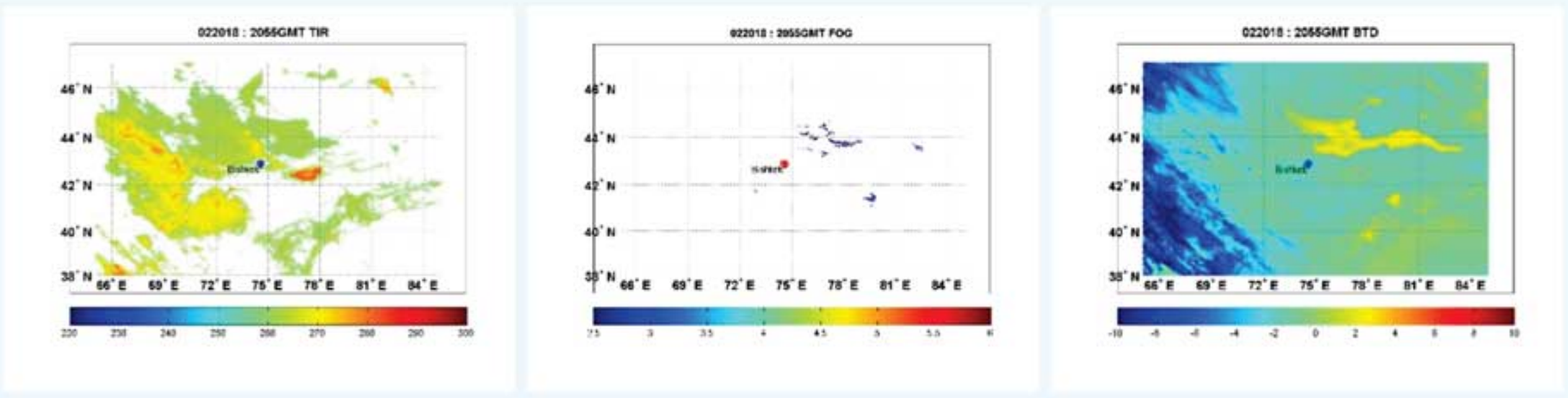

Figure 1. The TIR BT, BTD and fog map over 02 January 2018 at 2055UTC

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Hafiz was born on 28th February 1974 in Male', the capital city of the Maldives. He is a Graduate in Bachelor of Education (Mathematics) with Honours from the Open University of Malaysia. He always had a dream to be a pilot but ended up as a professional who guide them to overcome the meteorological phenomena's that might obstruct their smooth journey. He has been working in MMS from 23rd March 1994 and in his 24th year of dedicated service to the meteorological field.

Fun, energetic and humble, those three words are the most suitable words that describe Hafiz. There is definitely not a dull moment when you're with him. The "sport" of the course, everyone loves him. His patience and culinary skills are an all-time hit.

Mr. Abdulla Hafiz Abdul Sattar Ali
Meteorologist
Guide: Dr. V. Sathiyamoorthy,
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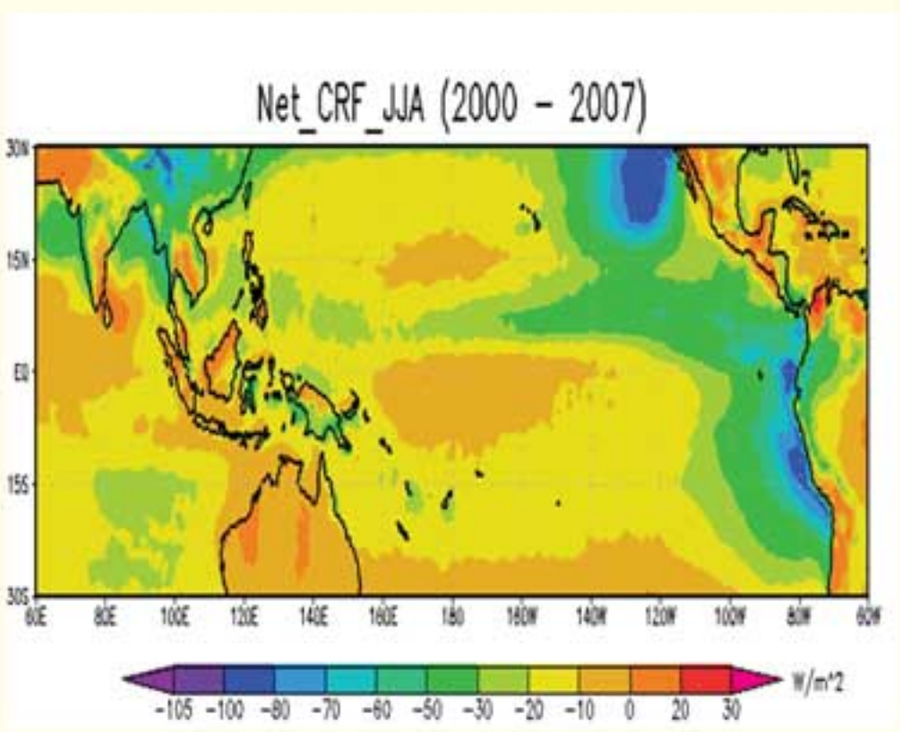
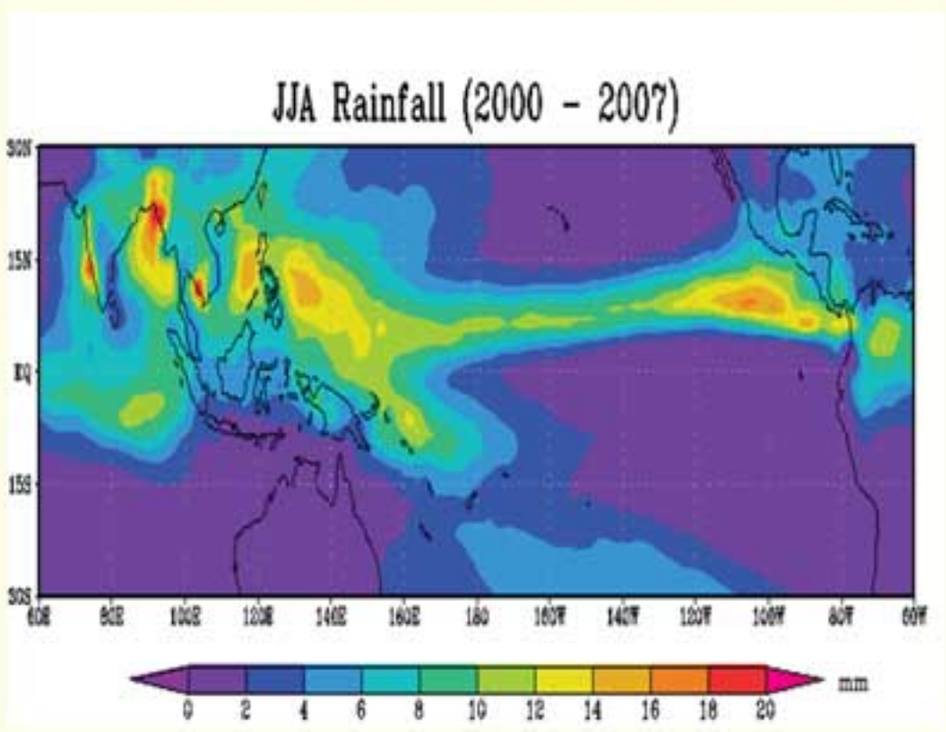
Abstract

Radiative Forcing by Different Cloud Regimes

Clouds play a major role in the radiation balance of the Earth – Atmosphere system. Cloud physical properties such as cloud cover amount, cloud top height, cloud optical depth, cloud droplet size and cloud phase (liquid/solid) affect the radiation balance of the earth-atmosphere system. Tropical belt is well known for different cloud regimes such as low level marine stratus over Cold Ocean upwelling regions, deep convective clouds over the Inter Tropical Convergence regions, etc. Four typical regions with the presence of different cloud types are identified during June to August months over the tropics using 8-year (2000-2007) International Satellite Cloud Climatology (ISCCP) monthly cloud data. The NCEP reanalysis atmospheric data is used to find out the possible reasons behind the formation of these unique clouds over these regions. The CERES top of atmosphere shortwave, longwave and net cloud radiative forcing data are used to study the radiative forcing of the clouds over these unique regions. Results suggests that the low level marine stratus clouds exert a net radiative cooling where as high level optically thin cirrus clouds exert a net warming effects to the earth-atmosphere system. The shortwave cooling and longwave warming effects of the tropical deep convective clouds cancels out on average sense. Clouds over the Indian summer monsoon regions exerts a net radiative cooling which is in contrast to the other deep convective clouds of the tropical belt.



Eight year (2000-2007) average top of atmosphere Net Cloud Radiative Forcing (Wm-2) from CERES during June to August months



Eight year (2000-2007) average rainfall (mm) from GPCP during June to August months.

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She was born on 1st of March 1995 in Ulaanbaatar city, Mongolia. She graduated high school in 2012 and graduated in Bachelor of Science (Meteorology) in 2016 from National University of Mongolia. Presently she is working in National Agency for Meteorology and Environment Monitoring (NAMEM) of Ulaanbaatar city, Mongolia since 2016. She likes to play basketball and sing with friends.

A lovely girl with a great smile on her face, she always lends a helping hand to those in need. Modern, sophisticated and trendy, she is full of energy. She's a friend you can always laugh and cry with; someone who will give you hope and lift you up.

Ms. Dorjkhand Munkhjargal
Weather Forecaster
Guide: Dr. Bipasha Paul Shukla
SAC/EPSA/AOSG/ASD

Abstract

Now casting Heavy Rainfall events using satellite data

In recent years, flash flood events have become one of the biggest issues in the world. Nowcasting, which refers to forecasting for a very short time range (up to 6 hours) is useful for predicting the development and dissipation of flash floods and heavy rainfall events. Satellite data, acquired from geostationary satellites provide valuable inputs for nowcasting of heavy rainfall due to their high spatio-temporal resolution. Satellite-based analysis shows that in comparison to cloud top temperature, cloud top cooling rate (CTCR) is a better indicator for extreme rain producing events over this region. CTCR can be very useful for identifying vigorous cloud growth if cloud-top parcels are much warmer than the environment. Thus, a model for Nowcasting of Extreme orographic Rain (NETRA) has been developed based on the premise that the updrafts characterizing orographic lifting bear a strong relationship to the spatial distribution of CTCR pixels.

In the present study NETRA has been applied for predicting heavy rainfall events over Mongolian region using INSAT-3D satellite sequence of images. NETRA comprises of three major components: first is computation of CTCR from half-hourly satellite data, second is calculation of thresholds, and third is the process of choosing those pixels which have a potential for causing flash floods. The result of this study is demonstrated for a very heavy rainfall over South Mongolian region on 12th August 2018. The figures below show that the CTCR is very high (1K/min) for the area surrounding AIRAG station, which reported more than 100mm of rainfall. Also, the number of alerts bears a good match with the rainfall recorded at 9 stations. This model shows good potential for very short term prediction over Mongolian region.

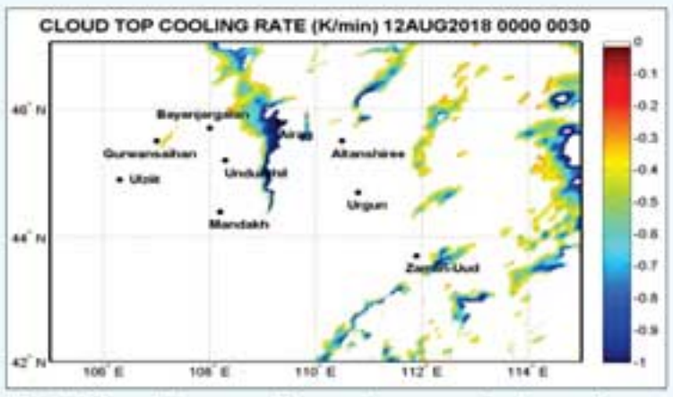

Fig1. Cloud top cooling rate over study region

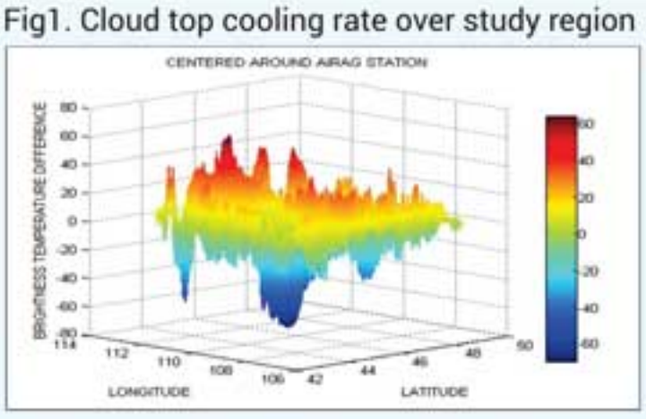

Fig2. Cloud top cooling rate in Airag station (3D plot)

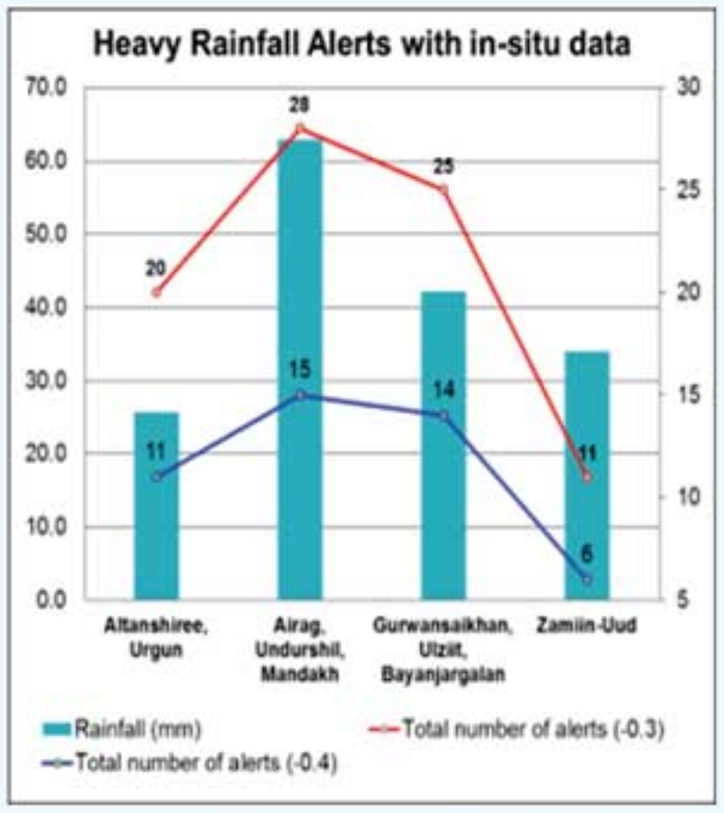

Fig3. Comparison of Heavy Rainfall Alert with in-situ data

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She was born on 22 March 1991 in Dornod Province, Mongolia. She earned her Bachelor of Science (Meteorology) in 2012 from National University of Mongolia. She worked as a weather forecaster for Aviation Meteorology for Centre, in Ulaanbaatar from 2012 to 2013. She completed 'Radar Meteorology for Developing Countries' training course in 2017 from Nanjing, China. She is presently working as a weather forecaster for Department of Meteorology Hydrology and Environmental Monitoring in Dornod province, Mongolia since March 2013.

A dedicated, hardworking student with a calm and soft-spoken personality. She loves to laugh and is a diligent and intelligent person. A keen sportsperson, she has a great hand at playing ping pong. Her strides in mastering English are excellent. She is determined to achieve all her goals in life.

Ms. Khorolsuren Tojil
Weather Forecaster
Guide: Dr. R. M. Gairola and Mr. Aman Waheed Khan
SAC/EPSA/AOSG/ASD

Abstract

IMSRA Rainfall estimation and validation over Indian region during GAJA Cyclone.

Accurate rainfall estimation is very important for many applications, such as water resource management for agriculture and power, and flood and drought monitoring. The objective of this study is to evaluate the potential of satellite-based rainfall retrieval using INSAT-3D Multispectral Rainfall Algorithm (IMSRA) rainfall products over Indian region (Tamil Nadu) during GAJA cyclone in November 2018. Severe Cyclonic Storm GAJA was the fifth named cyclone of the 2018 North Indian Ocean cyclone season. GAJA cyclone moved to Tamil Nadu on 16th of November, 2018. At least 45 people were killed and about 250,000 people were evacuated to relief camps. IMSRA retrieved rainfall products has been developed by the Indian Space Research Organization (ISRO) (Gairola et al. 2015). Thermal IR (TIR1) channel from INSAT-3D satellite data is used for rainfall estimation. The IMSRA estimated rainfall is also merged with the daily accumulated rainfall obtained from 32 IMD ground stations in Tamil Nadu on daily basis. The results are compared with two independent global multi-satellite rainfall products, namely the Integrated Multi-satellite Retrievals for GPM (IMERG) and Global Satellite Mapping of Precipitation (GSMAP) products, and their validation is performed with conventional rain gauge observations. The comparison between IMSRA-Merged and IMD station data gave a correlation coefficient of 0.95 with a bias of -0.67 and a root mean square error (RMSE) of 9.15, while between GSMAP-Gauge and IMD station data gave a correlation of 0.55 with a bias of 0.33 and a RMSE of 24.37 on 16 November 2018. Also, the comparison of IMSRA-Merged with GSMAP-Gauge showed a correlation of 0.68 and an RMSD of 17.37. The statistical results showed good correlations between merged IMSRA, IMERG and GSMAP-Gauge product, while the merged IMSRA gave much better correlation than IMERG and GSMAP on comparison with ground-based measurements during GAJA cyclone.

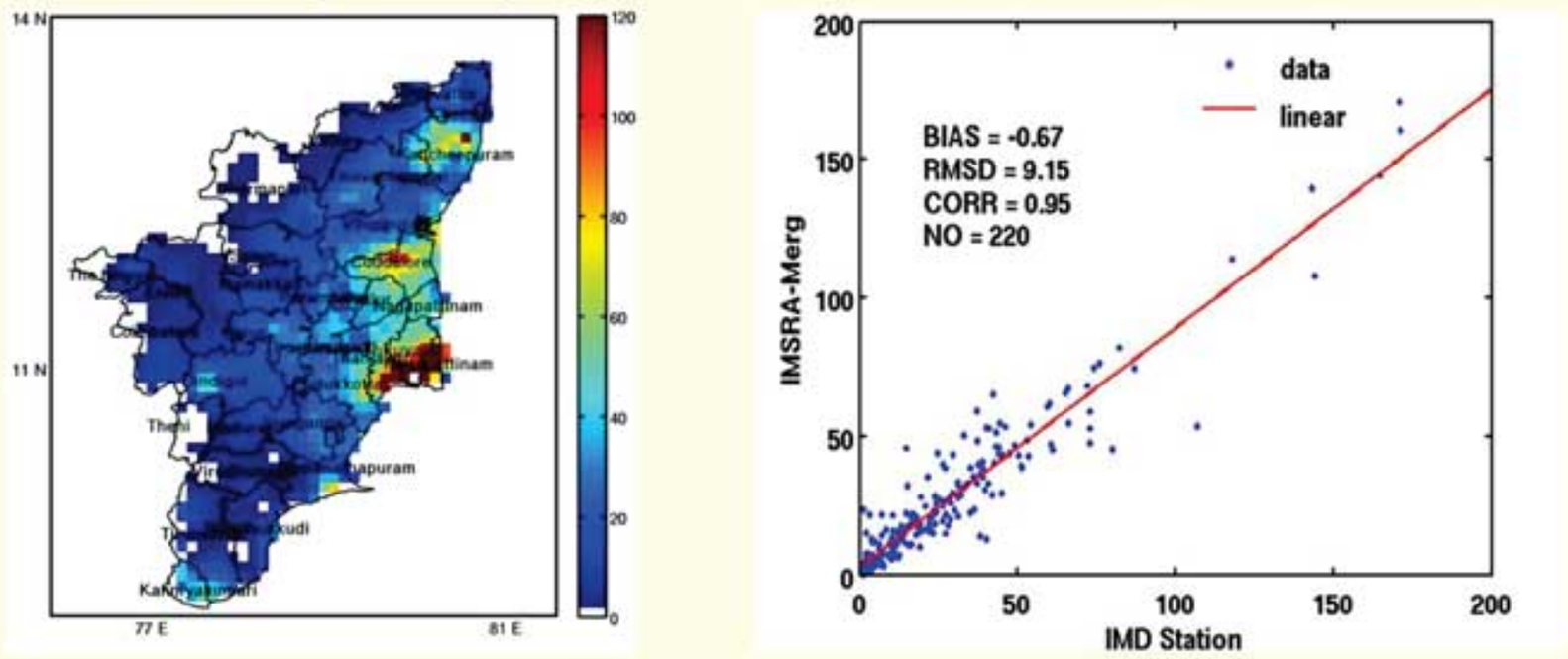

Figure shows the estimated rainfall from IMSRA-Merged (a) and its scatter plot with IMD station (b) over Tamil Nadu on 16 November 2018.

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She was born in Dundgovi province and currently living in the Darkhan province of Mongolia. She graduated in Bachelor of Science (Meteorology) in 2005 and Master of Science (Meteorology) in 2012. She is presently working with Department of Meteorology, Hydrology and Environmental Monitoring in Darkhan province, Mongolia since 2006.

She is a simple woman who is charming and is friendly with everyone. She is sweet, thoughtful and an intellect. Also called the fitness guru, she is always wise with her words. With a translation book at hand, she places learning and hard work as her priority.

Ms. Sainjargal Baatarchuluun
Forecaster Engineer
Guide: Dr. Bimal K. Bhattacharya & Dr. Rahul Nigam
SAC/EPSA/BPSG/AED

Abstract

"Estimating surface soil wetness over agriculture landscape in Mongolia"

Terrestrial surface exhibits extreme spatio-temporal moisture variations which controls fundamental hydrological processes and limits crop productivity. Remote sensing (RS) provides exceedingly powerful means for estimation of surface soil moisture at spatial scale especially rainfall deficit country like Mongolia for water security and guided irrigation. In the present study to estimate surface soil moisture indicator at moderate and high spatial resolution, Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) have been used. The 'triangle' based model has been used to estimate surface Soil Wetness Index (SWI) based on coupling of optical RS and thermal observations. Two-dimensional scatters between NDVI and LST were generated to obtain a SWI from time series of MODIS Terra (Figure 1a) and LANDSAT-8 over study region in Mongolia. In 2-D scatter dry and wet edges represent low and high surface soil wetness at different NDVI classes respectively. The upper limit of LST is obtained from 'dry edge' while the lower limit of LST is obtained from 'wet' edge for the study region as shown in Figure 1a. The dry and wet edges may not be fully determined if the area of interest does not include a full range of land surface types and conditions (e.g. dry bare soil, saturated bare soil, water stressed vegetation and well-watered vegetation). Hence in this study agricultural dominated Darkhan-Uul province of Mongolia was selected that includes all types of land cover types. The estimated SWI varied between 0.2 to 0.4 for May to June and gradually increases up to 0.7 for August month followed by gradual decrease in the month of September. The estimated temporal SWI during agricultural season is able to pick surface soil moisture variability as measured in ground from May to September (Figure 1c). The present study demonstrated the technique of using surface temperature–vegetation index triangular space to derive a soil wetness index as surrogate for volumetric surface moisture content in cropped soils at field and landscape scales over selected agricultural regions of Mongolia. This study showed that the validity of surface moisture indicator estimates largely depends on dynamic ranges of LST and NDVI, which often may not be sufficient as a result of restricted sampling window size due to low swath in case of finer resolution sensors.

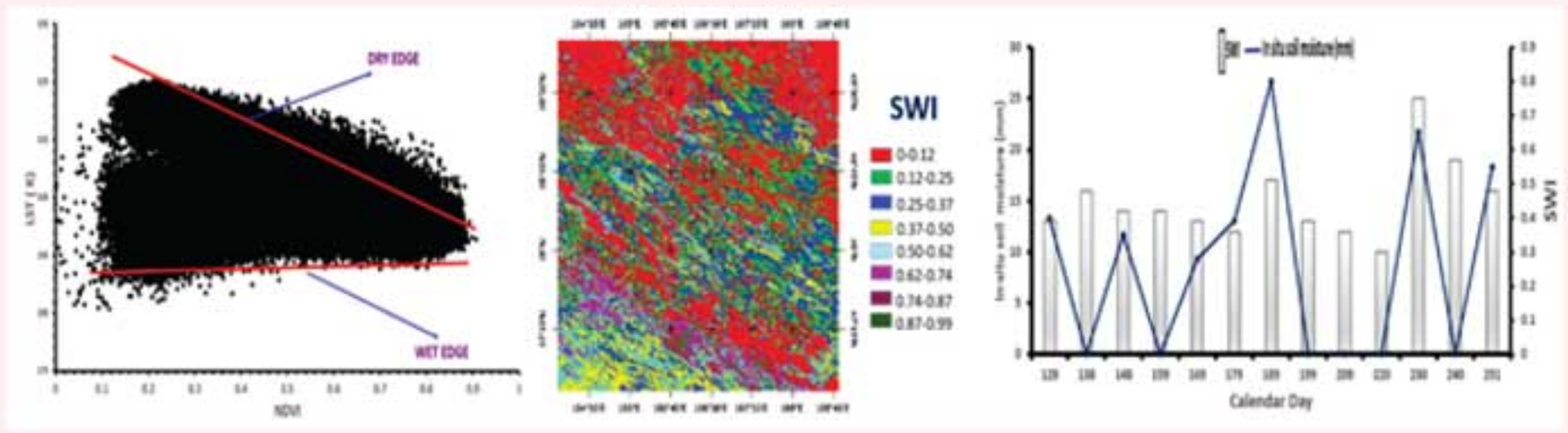

Figure 1. (a) Scatter between NDVI & LST (b) Spatial distribution of SWI (c) Temporal variation of SWI with in situ soil moisture over study area at Mongolia

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She Was born on 4th of July ,1996 in Sainshand, Mongolia. She Studied at 1 st secondary school in Sainshand, during 2003-2012. She graduated from the National University of Mongolia in 2016, in Bachelor of “Meteorology”. She started to work as an Engineer for Meteorological instrument at Hydrology, Meteorology and Environmental monitoring agency of Dornogobi province, since 2016.She underwent Training course for “Use and Maintenance of Meteorological instruments” at NUIST (Nanjing University of Information Science and Technology) – the Center of WMO in Nanjing, China in 2017.

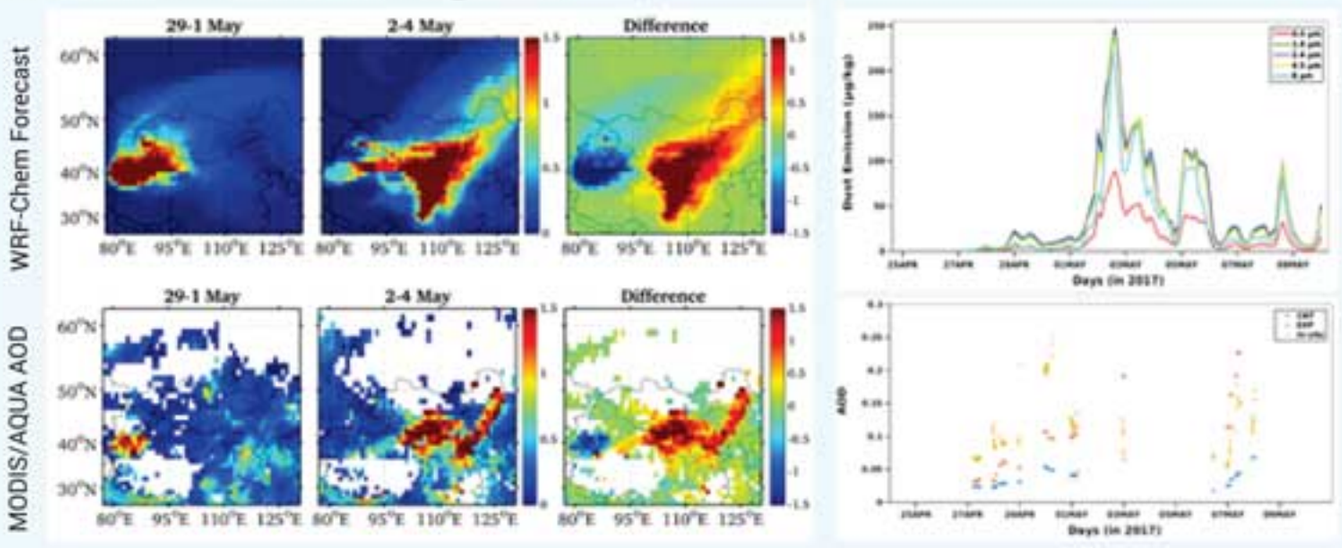
A lovely person with a kind heart, she lives in her own world. Suave, but simple she is Intelligent and humble. Her maturity and approach to life, inspires one and all.

Ms. Tergel Shijirtuya
Meteorologist
Guide: Mr. Aman Waheed Khan
SAC/EPSA/AOSG/ASD

Abstract

Aerosol simulation over Mongolia using WRF-Chem model: Source Analysis and Impact

MODIS AQUA AODDust storms frequently occur throughout the desert regions of the world, especially during springtime, injecting large amounts of mineral dust aerosols into the atmosphere. Dust aerosols have a wide range of potential consequences for ambient air quality, global climate and atmospheric chemistry. The purpose of this study is to simulate aerosols over Mongolia during a dust storm event using numerical model. A very severe dust storm that affected China and Mongolia during May 2017 is analyzed. The Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) is used to simulate the meteorological and chemical conditions over Mongolia. The model domain extends from 77º E to 131º E (200 grid points) and from 26º N to 62º N (200 grid points) at a horizontal spatial resolution of 30×30 km2. The model simulation is run for 15 days starting from 25 April 2017 at 00:00 UTC. The initial and boundary conditions for the meteorological fields are obtained from the National Center for Environmental Predictions (NCEP) Final Analysis (FNL) fields at a spatial resolution of 1º ×1º. The chemical fields are initialized from the Model for Ozone and Related Chemical Tracers (MOZART-4) analysis. During this event, hot and dry conditions with strong northwesterly winds were predominant over the Gobi Desert. There was also formation of a very strong low-pressure system over the Central Mongolia during 2-4 May 2017, which caused the dust particles to get transported from the Gobi Desert to Mongolia and Northern China. The model simulated Aerosol Optical Depth (AOD) forecast and MODIS Daily Global AOD product averaged before (29Apr-1May) and during dust storm (2May-4May) show similar spatial distribution with model overestimating slightly (figure-a,b). The difference plot shows that the origin of dust storm was over the south-west Gobi Desert in China, and it eventually transported to southern and eastern Mongolia. The comparison of model forecasted AOD with AERONET observations gives a good correlation of ~0.73 and an error of ~0.21 over Dalanzadgad (43º34'N 104º26'E) during the study period (figure-c). Overall, the WRF-Chem model is able to simulate the spatial distribution of dust storm over Mongolia.



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She was born on 10 Jan 1992 in Minhla city, Magway Region and now lives in capital city of Naypyitaw, Myanmar. She graduated in Bachelor of Science (Honours) Meteorology in Jan 2012 from Dagon University and Master of Science (Physics) in Jan 2015 from Magway University. She joined the Met department in 2012 at Magway region. Now she is working Assistant weather Forecaster at Meteorology section (Head Office), Department of Meteorology and Hydrology, Naypyitaw.

A smiling and generous girl, one would be surprised to know she loves to sleep and eat a lot. Her passion for cooking captivates everyone. Food fests in her room are enjoyable and memorable to all. Indeed a sweet and thoughtful friend, she always pushes hard to achieve her goals.

Ms. Thet Htar Aung
Assistant Weather Forecaster
Guide: Dr. Neerja Sharma
SAC/EPSA/AOSG/GRD

Abstract

Study of tilted clouds using microwave brightness temperature observations

Global Precipitation Measurement (GPM) mission's core observatory is equipped with two key precipitation measuring sensors (i) Dual-frequency Precipitation Radar (DPR) and (ii) GPM Microwave Imager (GMI). DPR is a dual frequency Ku (13.6 GHz) and Ka (35.5 GHz) band precipitation radar. Both Ka and Ku radar beams provide measurement at spatial and vertical resolutions of 5km and 250km respectively. Whereas, GMI is a 13 channels conically scanning microwave imager, which measures vertical and horizontal polarized brightness temperature in frequency range from 10GHz to 183GHz. The coinciding observations of precipitation and vertical structure of clouds from the GMI and the DPR respectively are utilized to identify and analyse the vertically tilted cloud structures. The identification and analysis of such clouds are important in estimating precipitation at ground, validation of precipitation from GMI and DPR and in improving the precipitation estimation accuracy. The signatures of vertically tilted clouds are prominently noticed in the vertical profile of reflectivity from DPR. The reflectivity profile of the tilted cloud observed by DPR is shown Figure 1(a) and the corresponding surface rain in Figure 1(b). GMI 18.7GHz brightness temperature that primarily responds to the surface rainfall found displaced from 89GHz brightness temperature that responds to the cloud ice (Figure 2) because of the tilted structure of cloud.

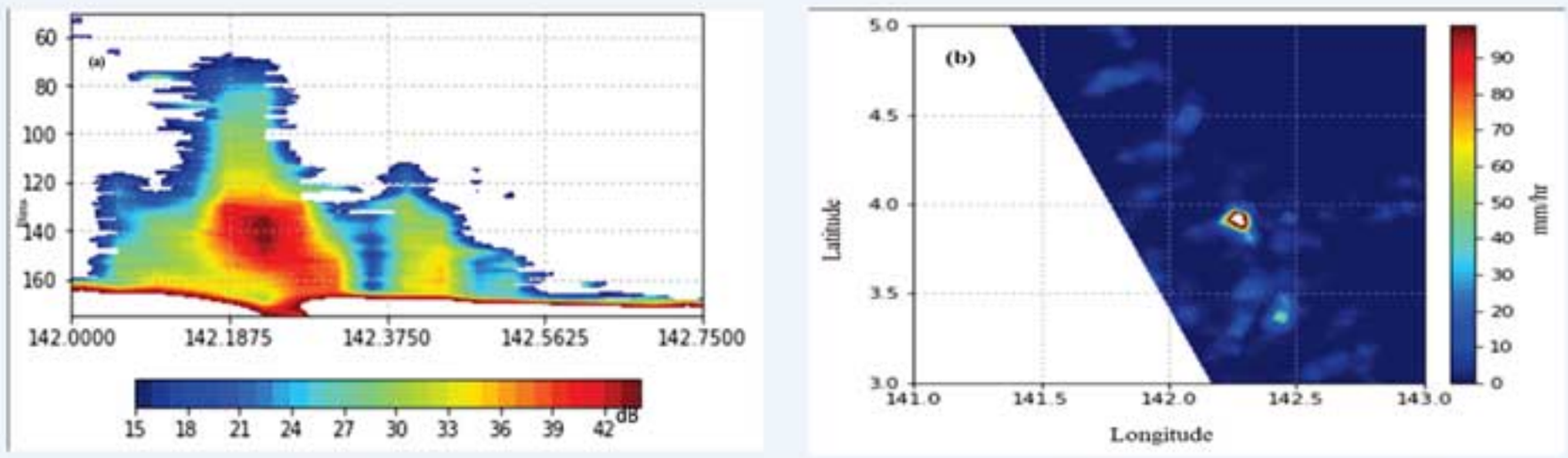

Figure 1. An example of tilted structure of cloud (a) vertical profile of DPR reflectivity and (b) surface rain.

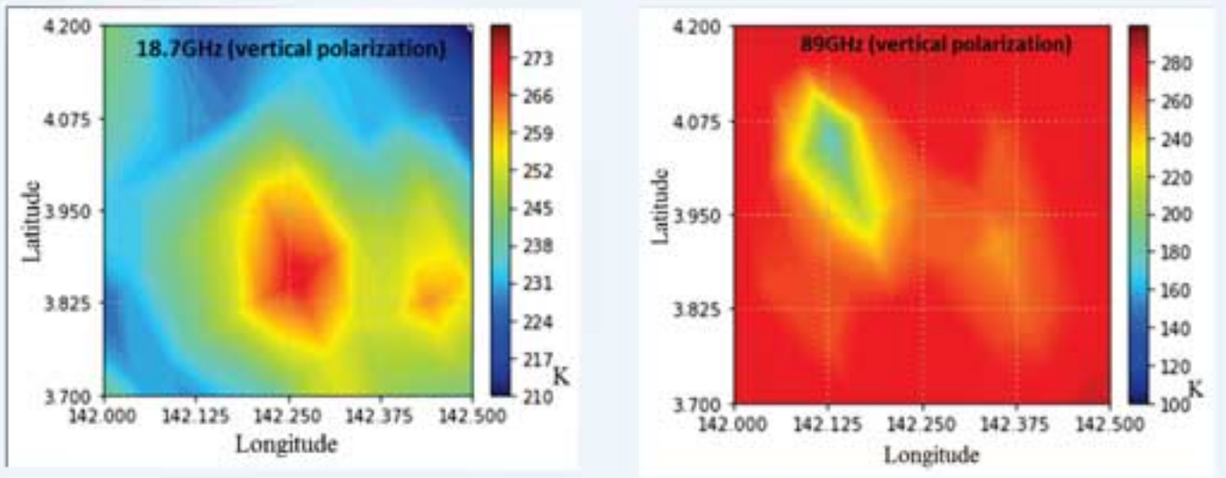

Figure 2. The spatial distribution of GMI 18.7 GHz and 89 GHz frequencies brightness temperature observation during tilted cloud.

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She was Born on 23rd May 1993 in Mandalay District of Myanmar. She graduated in Mathematics from Yandanabon University, Mandalay in 2013 and joined Department of Meteorology and Hydrology. Presently, she is working as Senior Observer at Department of Meteorology, Naypyitaw. Listening music and watching movies are her hobbies.

A great foodie, her drive and dedication in life are unmatched. She is easy to get along with because she quickly adjusts to other people's personalities. She always misses her family and friends. Her famous word is …. What Happened?? Wait, Wait, Wait !!!

Ms. Thet Mar Soe
Senior Observer
Guide : Dr. P. K. Thapliyal & Dr. Munn V. Shukla
SAC/EPSA/AOSG/GRD

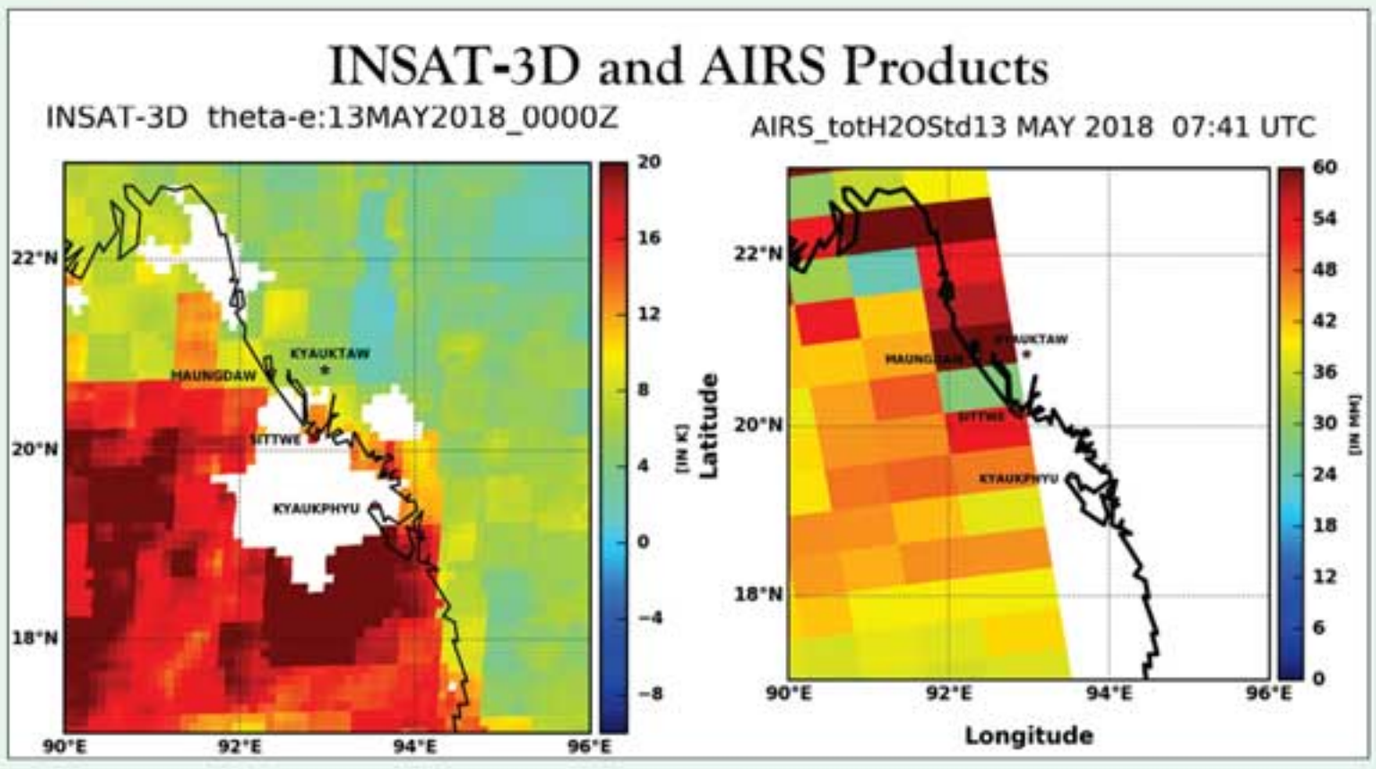
Abstract

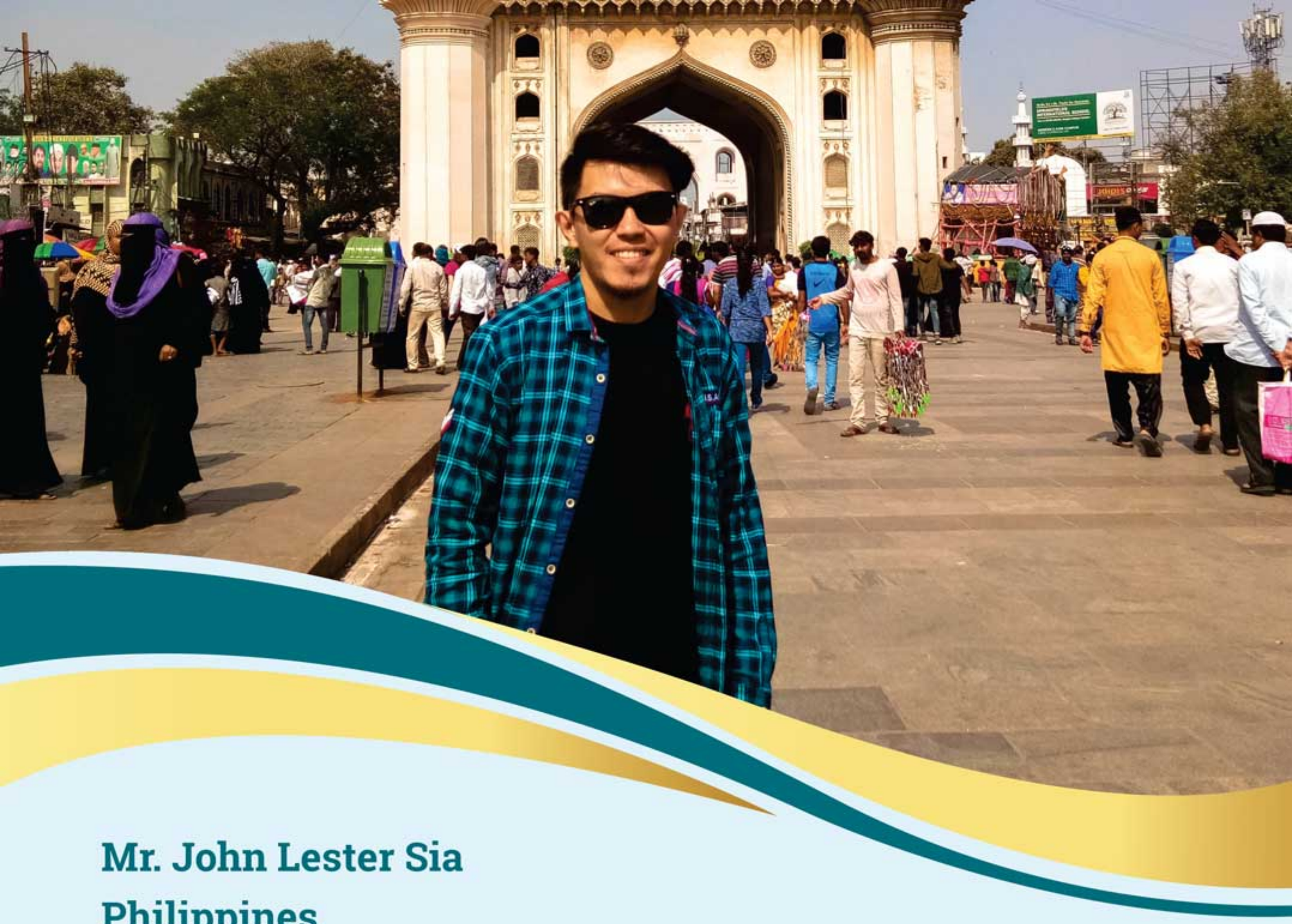
Hyperspectral Sounders AIRS / IASI / CrIS and Geostationary INSAT-3D Sounder: Validation and Applications over Myanmar

India launched the INSAT-3D satellite on 26th July 2013 to become the second country in the world after USA carrying onboard an atmospheric sounder in geostationary orbit. INSAT-3D has six channels Imager and 18 infrared channels Sounder. INSAT-3D sounder provides a unique opportunity to have hourly measurement of temperature and moisture profiles over clear regions of India and a few neighboring countries.

INSAT-3D sounder provides invaluable information of atmospheric structure with high temporal resolution. The atmospheric structure available in terms of temperature and moisture profile helps in understanding and predicting atmospheric stability. The state of atmospheric stability is studied by using parameters such as Total / Layer Precipitable Water (TPW/LPW), Convective Available Potential Energy (CAPE), Convective Inhibition (CIN), along with various stability indices such as Lifted Index (LI), K Index (KI), Total Total Index (TTI) and Theta-e etc.

In addition, hyperspectral sounder like Atmospheric Infrared Sounders (AIRS), onboard EOS-Aqua, Infrared Atmospheric Sounding Interferometer (IASI) onboard MetOp, Cross-Track Infrared Sounder (CrIS) on board JPSS satellites provide fine-resolution data even during cloudy conditions in combination with microwave sounder. Hence for the present study we used a combination of both, INSAT-3D sounder as well as hyperspectral sounder. The product from these sounders are used with an aim to enhance sufficient lead time in forecasting application over various locations of Myanmar. INSAT-3D data will be validated with AIRS, IASI and CrIs over Myanmar as no Radiosonde station is available over Myanmar.





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He was born in Manila, the capital of Philippines. He obtained his Bachelor of Science in Applied Physics from the University of Santo Tomas. He is currently with the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) - the National Meteorological and Hydrological Services agency as weather forecaster since 2014.

Lester, Man of few words but definitely, one with great talents and capabilities to astonish those around him. But make no mistake – he can surprise you in more ways than one. He lives in a world of humility and revels in the company of good friends. His sincere interest in learning, his openness to discovering and trying out new things has certainly made his world much more colourful. Motto in life, "Let us not become weary in doing good, for at the proper time we will reap a harvest if we do not give up." Galatians 6:9

Mr. John Lester Sia
Weather Specialist
Guide: Dr. Satya Prakash Ojha,
SAC/EPSA/MRG/MRTD

Abstract

Impact of the Assimilation of Conventional Observations On Heavy Rainfall Forecasts Over Southeast Asian Region

This study examines the impact of the assimilation of conventional observations on the prediction of heavy rainfall events over Southeast Asia using Weather Research and Forecasting (WRF) model and its three dimensional variational data assimilation (3DVAR) system. Six heavy rainfall events over the region of interest are considered for this study. For each event, two numerical experiments were performed, namely the CNTL and EXP. In the first experiment, namely the control simulation (CNTL), the GFS analyses are used as the initial and boundary conditions of the model. In the second experiment (EXP), the model integration was carried out by inserting additional observations in the model's initial conditions using the 3DVAR scheme. The observations from surface weather stations, buoy, ship, radiosonde, and satellite winds and oceanic surface winds are assimilated in the EXP experiments. After the successful inclusion of additional observational data using the 3DVAR data assimilation technique, the resulting reanalysis was able to successfully reproduce the structure of convective organization. The results demonstrate that the improved initial conditions of the WRF model using 3DVAR enhanced the location and amount of rainfall over the Southeast Asian region as shown in figure1.

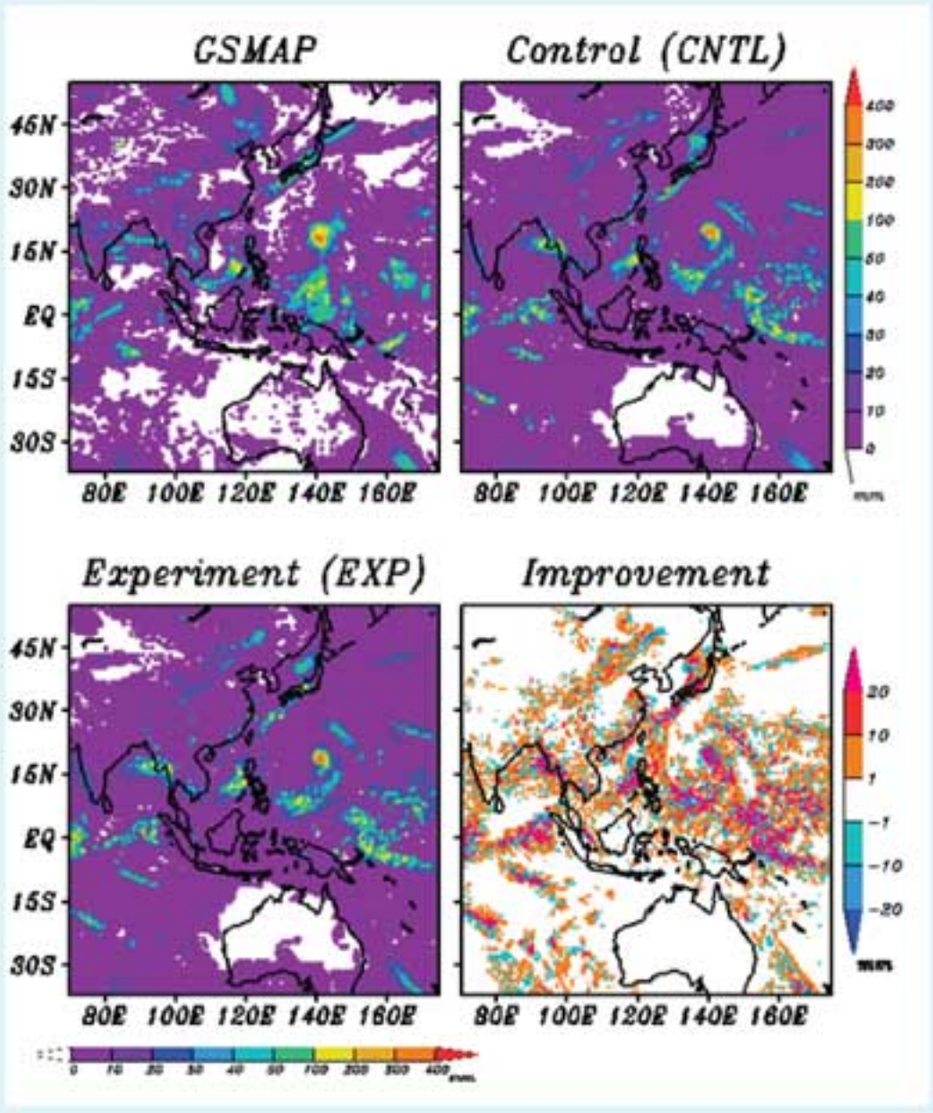

Figure 1. 24 hour accumulated rainfall on 07 July 2018 from
(a) GSMAP (b) Control simulation (c) Experiment simulation (d) Improvement

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Born on 5 September 1996 in Dushanbe Tajikistan. She graduated from the Uzbekistan Tashkent Metrological University. She has been working in department of weather forecast in Dushanbe Metrological Agency since 1 July 2016.

The storm from Tajikistan, being the true street fighter with a real Russian heart who always think about helping others. She loves to party, social gathering and charms the gang with her beauty as well as unique styles. Always happy and witty, she enjoys Indian sarees and traditional dresses. A great friend with kind heart.

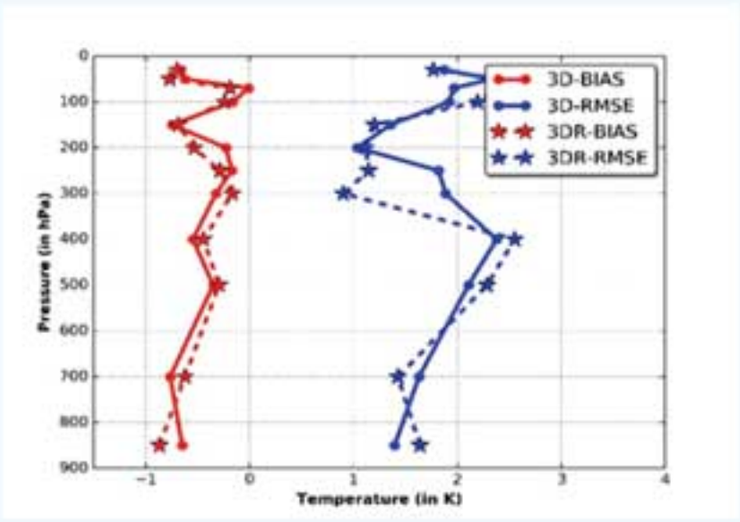
Ms. Shohina Safarmamadova
Leading Specialist
Guide: Dr. Kaushik Gopalan
SAC/EPSA/AOSG/GRD

Abstract

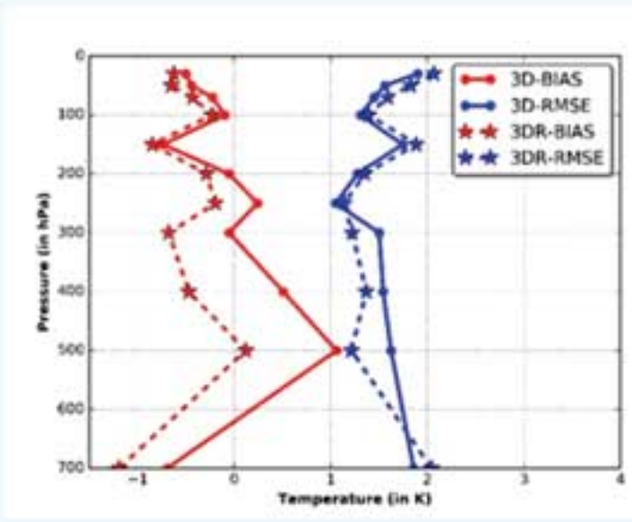
Validation of INSAT-3D/3DR Sounder profiles over Central Asia and nearby regions

To date, several satellites measurements are available which can provide profiles of temperature and water vapour with reasonable accuracies. However, the temporal resolution has remained poor, particularly over the tropics, as most of them are polar orbiting. Hence, the launch of INSAT-3D (Indian National Satellite System) by the Indian Space Research Organization (ISRO) on 26 July 2013 carrying an atmospheric sounder along with it made it possible to obtain profiles of temperature and water vapour over India with higher temporal and vertical resolutions and altitude coverage, besides other parameters. With the launch of the INSAT-3DR, the frequency on the weather monitoring of the atmosphere through the sounding system doubled. The study compared the INSAT-3D and INSAT-3DR data with radiosonde soundings over three stations (Kabul, Srinagar and Patiala.

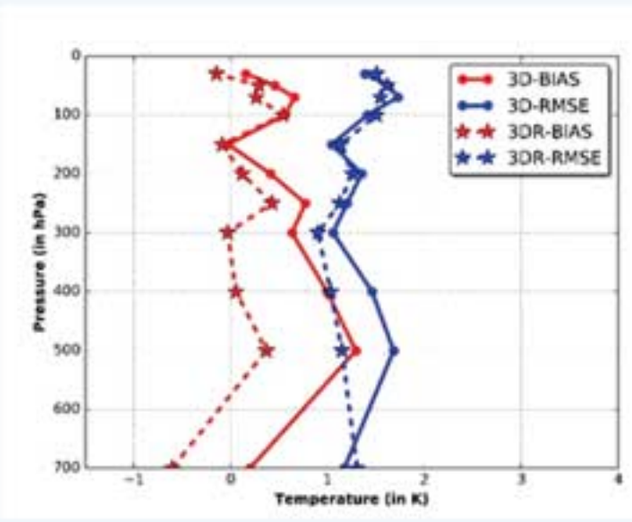
Good correlation in temperature between INSAT-3D/3DR and in situ measurements is noticed up to lower stratospheric regions (bias of 1-2°K). There is a mean bias of 10–20% in the humidity profile, outside the Indian monsoon months. The overall temperature retrievals exhibited small systematic errors (Biases) at almost all the levels. It is observed that temperature data from INSAT-3DR are of high quality and can be directly assimilated for better forecasts over India. Moreover, these profiles are available round the clock and can be effectively utilised by the meteorological section over Central Asia towards their day to day forecasting in real time with a frequency of sounder data available at 30 minutes' interval from INSAT staggered mode. INSAT-3D and INSAT-3DR have significant value in providing accurate weather forecast over India and neighbouring regions.



Srinagar

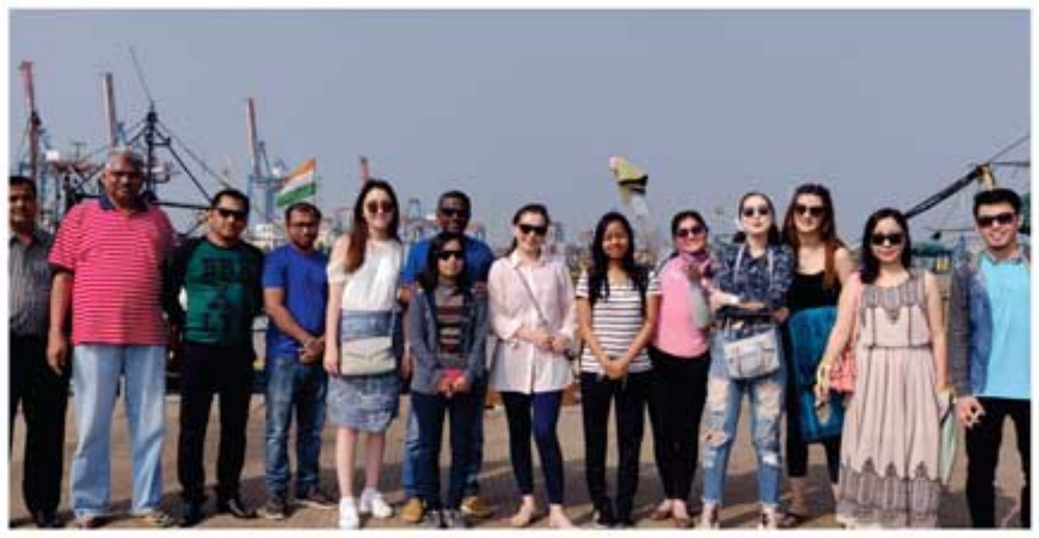


Patiala



Kabul

Educational and Cultural Exposure



Educational and Cultural Exposure

Educational and Cultural Exposure

Educational and Cultural Exposure

Impression of Participants

It was matter of pride and professional accomplishment for each one of use, to get detailed from our respective organizations for undergoing the internationally acclaimed CSSTEAP's PG diploma course in Satellite Meteorology and Global Climate (SATMET-11) being conducted from 01 Aug 2018 to 30 Apr 2019 at Space Application Centre (SAC), Ahmedabad, India. This course was not only a unique learning experience for all of us, but it was an eye opener for us to get an insight of scientists' way of looking at anything as well as exposure to cutting edge technology in the field of Satellite Meteorology.

Coming to the formal interaction, laying foundation for the bonding between all 13 participants from 8 different countries of the course, took place at auditorium at Physical Research Laboratory (PRL). The well planned one-week combined classes with 13 participants of Space and Atmospheric Science (SAS) Course, a parallel nine months course, helped in expanding our reach to new friends.

During the span of nine months the curriculum had covered a vast spectrum of subjects taught to us directly from the horses' mouth, i.e., the scientists and faculties who have directly worked hands on, in the field. All the theory subjects covered during the classes were helpful to understand the fundamentals of the Atmospheric behaviour and the science behind the Satellite technology. The practical sessions conducted during the course have been a high skill add-on for us. The pilot project under the guidance of experts in the respective fields, widened our horizon as we got an opportunity to work independently like a young but true scientist. Scientific tours to Delhi, Chennai, Sriharikota, Vishakhapatnam and Hyderabad not only gave us much needed break from the studies but also provided an opportunity to explore unique, rich and varied cultural heritage of India. We realized that India is truly a shoppers' paradise as we have bags full of gifts and souvenirs for our family and friends.

The curriculum and administration had ensured professional gain, but the immense personal gain and real happiness factor during the course, was to get an opportunity to make memorable friends from across the world. Successful accomplishment of the course was not possible without the untiring efforts and support given to us by the administrative staff. We all thank them with the bottom of our heart for making our stay at ISRO complex one of the most cherishable memory of our life. The Course Director, Course Co-ordinator and Professors were like the lighting beacon.As we bid adieu, we express our heartfelt thanks and sincere gratitude to all scientists and staff of Bopal campus and members of CSSTEAP Headquarter, Dehradun for their valuable help.

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Bangladesh

Sqn Ldr Hari Prasad Sad
India

Lt Cdr K Praveen Kumar
India

Ms. Aizhamal Mirtilekova
Kyrgyzstan

Mr. Abdulla Hafiz Abdul Sattar Ali
Maldives

Ms. Dorjkhand Munkhjargal
Mongolia

Ms. Khorolsuren Tojil
Mongolia

Ms. Sainjargal Baatarchuluun
Mongolia

Ms. Tergel Shijirtuya
Mongolia

Ms. Thet Htar Aung
Myanmar

Ms. Thet Mar Soe
Myanmar

Mr. John Lester Sia
Philippines

Ms. Shohina Safarmamadova
Tajikistan

CENTRE FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION IN ASIA AND THE PACIFIC (CSSTE-AP)

11th POST GRADUATE COURSE IN SATELLITE METEOROLOGY AND GLOBAL CLIMATE (SATMET - 11)

(01 AUGUST 2018 – 30 APRIL 2019)

Sitting: (L to R) Shri B.N.Panchal, Dr Kaushik Gopalan, Dr Sanjib Kumar Deb, Dr Rajkumar, Shri D.K.Das, Dr B.Simon
Ms.Harshida Modi, Shri Dharmendra Mahitkar, Shri Apurv Prajapati.

Standing: (L to R) Ms.Dorjkhand Munkhjargal (Mongolia), Ms.Tergel Shijirtuya (Mongolia), Ms.Aizhamal Mirtilekova (Kyrgyzstan),
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