TENTH POST GRADUATE COURSE IN

SATELLITE METEOROLOGY AND GLOBAL CLIMATE

[SATMET – 10]

August 1, 2016 to April 30, 2017

MEMOIRS

Organized By

SPACE APPLICATIONS CENTRE
INDIAN SPACE RESEARCH ORGANISATION (ISRO)
AHMEDABAD, INDIA

CENTRE FOR SPACE SCIENCE AND
TECHNOLOGY EDUCATION IN ASIA AND THE PACIFIC
CSSTEAP (AFFILIATED TO THE UN)

CSSTEAP GOVERNING BOARD MEMBERS

India
Chairman, CSSTEAP-GB
Shri A.S. Kiran Kumar
Secretary, Department of Space
Antariksh Bhavan
New BEL Road
Bangalore - 560 094
Email : chairman@isro.gov.in

DPR Korea
Dr. Hong Yong IL
Incharge of S&T
Science and Technology Section
Embassy of DPR Korea
C-17, First Floor, Lajpat Nagar-III
New Delhi – 110 024
E-mail: hongyongil@hotmail.com

Indonesia
Dr. Thomas Djamaluddin
Chairman, LAPAN
Indonesian National Institute of Aeronautics and Space Jl. Pemuda Persil No.1, Jakarta, Indonesia
Email: humaslapan@yahoo.com

Iran
Mr. Ali Sadeghi Naeini
Iranian Space Agency
No. 34- Sayeh Street
Afrigha Boulevard
Tehran, Iran
Email: info@isa.ir, naeini@isa.ir

Kazakhstan
H.E. Mr. Bulat Sergazievich Sarsenbayev
Ambassador of Kazakhstan to India
Embassy of Kazakhstan
61, Poorvi Marg, Vasant Vihar
New Delhi - 110057
Email: office@kazembassy.in

Kyrgyz Republic
Prof. Abdykalykov Akymbek Abdykalykovich
President
International University for Innovation Technologies
720048, Bishkek 1/17, Gorky Street
Kyrgyz Republic
Email : president@intuit.kg

Malaysia
H. E. YBhg Datuk Naimun Ashakli Mohammad
High Commissioner
Malaysia High Commission
50M, Satya Marg, Chankyapuri
New Delhi - 110 021
Email: maldelhi@kln.gov.my

Mongolia
Dr. Batbold Enkhtuvshin
President of Mongolian Academy of Sciences
Mongolian Academy of Sciences (MAS)
Floor 6th, bldg. Soyol Tuv Urguu
A.Amar gudamj, Sukhbaatar sq.3
Ulaanbaatar -210620A
Mongolia
Email: nomciv@magicnet.mn

Myanmar
Dr. Kyi Thwin
Acting Rector,
Myanmar Aerospace Engineering University,
Meiktila, Mandalay Division
Myanmar
Email: thwin.kmaeu@gmail.com

Nauru
Mr. Kartar Singh Bhalla
Hony. Consul General of Nauru
S-327, Greater Kailash-I
New Delhi - 110 048.
Email: kartarbhalla@hotmail.com

Nepal
Minister-Counsellor
Embassy of Nepal
Barha Khamba Road
New Delhi - 110 001.

Philippines
H.E (Mrs.) Ma.Teresita C. Daza
Ambassador of Philippines
Embassy of Philippines
50N, Nyaya Marg
Chanakyapuri
New Delhi - 110 021
Email: philippineembassynewdelhi@gmail.com, amb.newdelhipe@dfa.gov.ph

Republic of Korea
Mr. Ok-Kyu Lee
Principal Engineer
International Relation Team
Korea Aerospace Research Institute
45, Eoeun-Dong, You Seong-Gu
Daejeon - 305 333
Republic of Korea
Email : oklee@kari.re.kr

Sri Lanka
Mr. S. Panawennage
Director
Arthur C Clarke Centre for Modern Technology
Katubedda, Moratuwa, Sri Lanka
Email : dir@accmt.ac.lk

Thailand
The Executive Director
Geo-Informatics and Space Technology Development Agency
Government Complex, Building B, 6-7th Floor
120 Moo 3 Chaeng Wattana Road
Lakshi, Bangkok 10210
Bangkok 10900, Thailand
Email: anond@start.or.th

Uzbekistan
Dr. Kamol Muminov
GB CSSTEAP Member
Ulugh Beg Astronomical Institute of the Uzbekistan Academy of Sciences
33, Astronomicheskaya Str.,
Tashkent 100052,
Uzbekistan
Email : kmspcenter@mail.ru; info@astrin.uz; kmuminov@yandex.ru;
kmmuminov@mail.ru; ibragimov_igor48@mail.ru

UN-OOSA
Dr. Simonetta Di Pippo
(Observer)
Director
UN Office for Outer Space Affairs
Vienna International Centre
PO Box 500, A-1400
Vienna, Austria
E-mail : simonetta.di.pippo@unoosa.org

ITC, The Netherlands
Prof. Dr. Ir. A. (Tom) Veldkamp
(Observer)
Rector, ITC
Faculty of Geo-information Science and Earth Observation of the University of Twente
PO Box 217, 7500 AE Enschede
The Netherlands
Email : rector@itc.nl, veldkamp@itc.nl

Secretary
Dr. A. Senthil Kumar
Director, CSSTEAP
Indian Institute of Remote Sensing Campus
PB No.222, No.4, Kalidas Road
Dehradun - 248 001

TENTH POST GRADUATE COURSE IN
SATELLITE METEOROLOGY AND GLOBAL CLIMATE
AUGUST 1, 2016 TO APRIL 30, 2017

AT
SPACE APPLICATIONS CENTRE
AHMEDABAD

MEMOIRS

CENTRE FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION IN ASIA AND THE PACIFIC (CSSTEAP) (AFFILIATED TO THE UN)

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अन्तरिक्ष विभाग
भारत सरकार
अन्तरिक्ष भवन
न्यू बी ई एल रोड, बेंगलूर – 560 231, भारत
दूरभाष : +91-80-2341 5241 / 2217 2333
फैक्स : +91-80-2341 5328

इसरो isro

Indian Space Research Organisation
Department of Space
Government of India
Antariksh Bhavan
New BEL Road, Bangalore - 560 231, India
Telphone: +91-80-2341 5241 / 2217 2333
Fax : +91-80-2341 5328
e-mail : chairman@isro.gov.in

आ. सी. किरण कुमार / A. S. Kiran Kumar
अध्यक्ष Chairman

MESSAGE

I am pleased to note that the 10th Post Graduate Course on "Satellite Meteorology and Global Climate" organised by the Centre for Space Science and Technology Education in Asia and the pacific (CSSTEAP) and conducted by Space Applications Centre (SAC), Ahmedabad is closing successfully on April 30, 2017. I am also happy to understand that 13 participants from seven countries of the Asia Pacific region will be receiving their diploma certificates.

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 has now improved with capability of sounding of the atmosphere, especially temperature & humidity profile, which is an important input to numerical weather prediction models. Also the combination of INSAT-3D and 3D-R has improved the temporal and spatial resolution of the derived geophysical products, and Multi spectral images, which is important for weather monitoring, now-casting, short range forecasting, cyclone monitoring and contribute to disaster reduction.

The Mega Tropiques, SCATSAT and SARAL Altika Satellite Sensors cover the microwave regions, with enhanced radiometry and temporal resolutions, especially over tropical cloudy regions, has made the space data an indispensible component in weather monitoring and forecasting.

आ सी किरण कुमार

(A. S. Kiran Kumar)

Bangalore
April 04, 2017

Messages

UNITED NATIONS
Office for Outer Space Affairs

Simonetta Di Pippo
Director
Office for Outer Space Affairs

I wish to congratulate students of the 10th Post Graduate Course on "Satellite Meteorology and Global Climate" for their successful completion of the Post-Graduate Diploma Programme at the Centre for Space Science and Technology Education in Education in Asia and the Pacific, affiliated to the United Nations, (CSSTEAP).

The studies of satellite and meteorology are important for generating the human capital required by nations to improve their approach to building low-emission and resilient societies. This is important as all UN member states are engaged with – and acting upon - important global frameworks, namely the 2030 Agenda for Sustainable Development, the Sendai Framework on Disaster Risk Reduction 2015-2030, and the Paris Agreement stemming from the United Nations Framework Convention on Climate Change Conference of the Parties 21 (COP21). Earth observation plays a key role in providing crucial data needed to achieve targets envisaged in these frameworks. The knowledge gained by the participants in this course can be well utilized by their governments and institutions to address the challenges in achieving the 2030 Agenda and its Sustainable Development Goals.

"Capacity-building for the 21st Century" is one of our seven thematic priorities in our preparations for UNISPACE+50. UNISPACE+50 will be a special segment of the Committee on the Peaceful Uses of Outer Space (COPUOS) in June 2018 to mark the 50th anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE I), held in 1968 in Vienna. UNOOSA will work with CSSTEAP and all Regional Centres to develop a strategy and implementation plan to address this important thematic priority.

I am delighted with the continued and consistent performance of CSSTEAP in conducting Post Graduate Diploma programmes and short-term courses in the areas of space technology applications. I hope this memoir will be a greatest treasure for CSSTEAP alumni.

My very best wishes to all.

Simonetta Di Pippo
Director
Office for Outer Space Affairs

Office for Outer Space Affairs, United Nations Office at Vienna, Wagramerstrasse 5, 1400 Vienna, Austria
Tel. (+43-1) 26060-0, Fax (+43-1) 26060-5830, www.unoosa.org

Messages

ANDHRA UNIVERSITY

(NAAC - CGPA of 3.60 on four point scale at "A" grade)
"ISO 9001 - 2008 Certified"
5 - Star University by Careers 360 Magazine

Prof. G. NAGESWARA RAO Ph.D.
VICE-CHANCELLOR

Off. : 0891-2755547, 2844333
Res. : 0891-2755516, 2844194
Fax : +91-891-2525611
e-mail : auvicechancellor@gmail.com
VISAKHAPATNAM - 530 003, (A.P.) INDIA

30th March, 2017

MESSAGE

I am happy that the Andhra University is associated with the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) to conduct academic programmes for the member countries under a Memorandum of Understanding. The M.Tech. (Satellite Meteorology and Global Climate) course is being conducted jointly by Indian Space Research Organisation (ISRO) and Andhra University since 1998. A total of 22 countries from the Asia-Pacific region have participated in this course and a total of 164 participants are trained in this programme.

I consider this course a prestigious one as the CSSTEAP at the Space Application Centre (SAC), Ahmedabad organizes this course with faculty drawn from various research laboratories and Universities in India. Special mention has to be made towards the contribution of Scientists from SAC and the faculty of Andhra University.

I wish good luck to the participants in all their future endeavours.

(G.NAGESWARA RAO)

CSSTEAP Centres & The Course - A Report

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

CSSTEAP Centres & The Course - A Report

Dr. A. Senthil Kumar

Director, CSSTEAP

IIRS Campus, 4 Kalidas Road, Dehradun- 248001

Introduction

Space science and technology have contributed significantly to the socio-economic development of many developed and developing countries. Knowledge about time and space has economic and social benefits that contribute in meeting several societal needs, from human security to sustainable development. Continuous development of human resources is crucial to ensure the scientific & technological as well as economic, social and cultural development in any country. Strategies for developing human resources should be based on broad and long-term perspectives of the regional needs and resources through awareness, training and education. In order to develop these capabilities, nations or regions should be able to share their expertise and should also evolve opportunities to encourage awareness and train the manpower. In recognition of such a pre-requisite, a consensus has emerged within the international community that if effective assimilation and appropriate application of Space Science & Technology are to succeed in developing countries, devoted efforts must be made for the development of the necessary human and infrastructural capacity in all fields. 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 students 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 December 11, 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 a 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 programmes 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 ISRO Satellite Centre (ISAC), 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 ISAC. The Centre has a Governing Board consisting of signatories from 16 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.

The course curricula developed by the Centre and endorsed by the United Nations are adapted for the educational programmes. The educational programmes 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 a 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 programmes on specific themes in the four areas, highlighting how space-based information can be used for national development. These educational programmes have benefited many scientists/engineers who will be the future policy & decision makers in several countries.

CSSTEAP conducts all of its educational programmes 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

Shri A.S Kiran Kumar, Chairman, ISRO/Secretary Department of Space and present ChairmanCSSTEAPGoverning Board during the 21 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 students 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 UNAgencies like UNSPIDER, Beijing, China; UN-ESCAP in Bangkok, Thailand, UNESCO and UNDP.

Educational Programmes

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

1) Remote Sensing and Geographic Information Systems (RS & GIS),
2) Satellite Communication (SATCOM),
3) Satellite Meteorology and Global Climate (SATMET)
4) Space and Atmospheric Science (SAS), and
5) 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 Centre also organizes workshops & awareness programmes from time to time (Fig. 1 & 2).

The educational programmes are conducted in English and for students 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 excercises 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 institution (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 students 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 students who successfully complete 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 students in RS & GIS are being given fellowships to complete their M.Tech. thesis work at CSSTEAP. In year 2004 four PG students (one each from Azerbaijan, Bangladesh, Kyrgyzstan and Nepal), in year 2005 one student from Nepal, in 2007 one student from Mongolia, in 2008 one student from Indonesia, in 2009 one student from Myanmar were given M.Tech. fellowships to complete their M.Tech. research work at CSSTEAP and all have

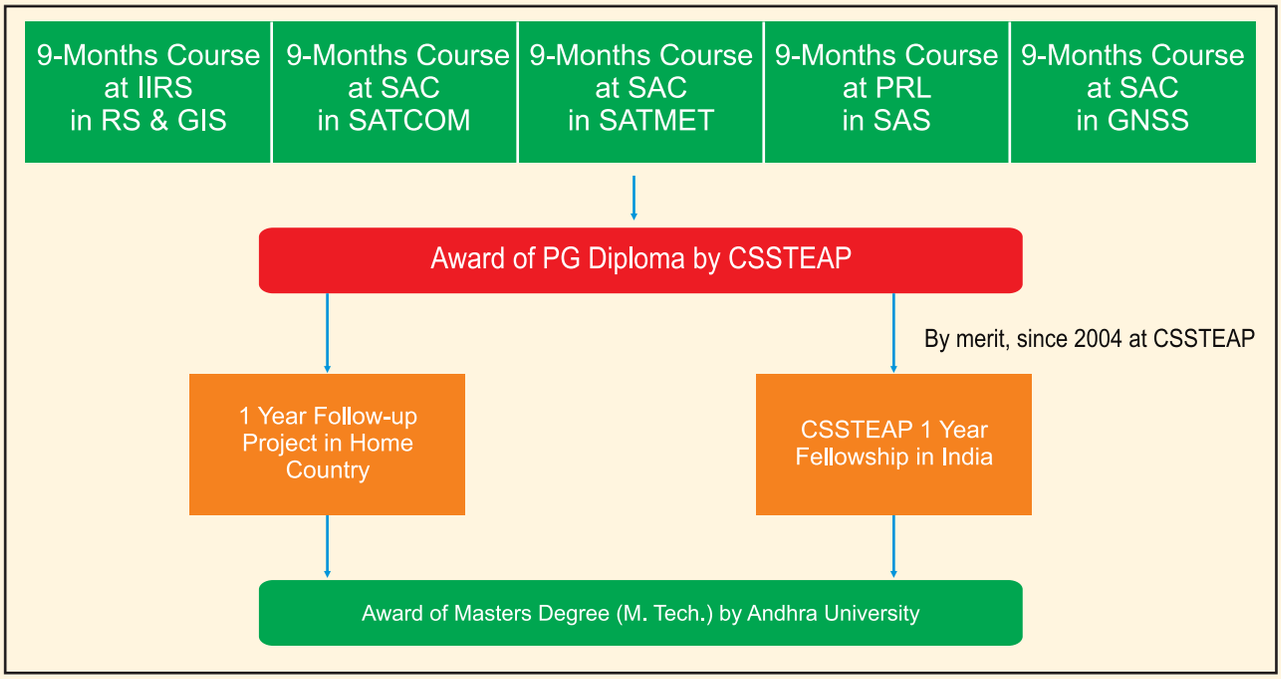


Fig. 1: Structure of PG diploma educational programmes at CSSTEAP

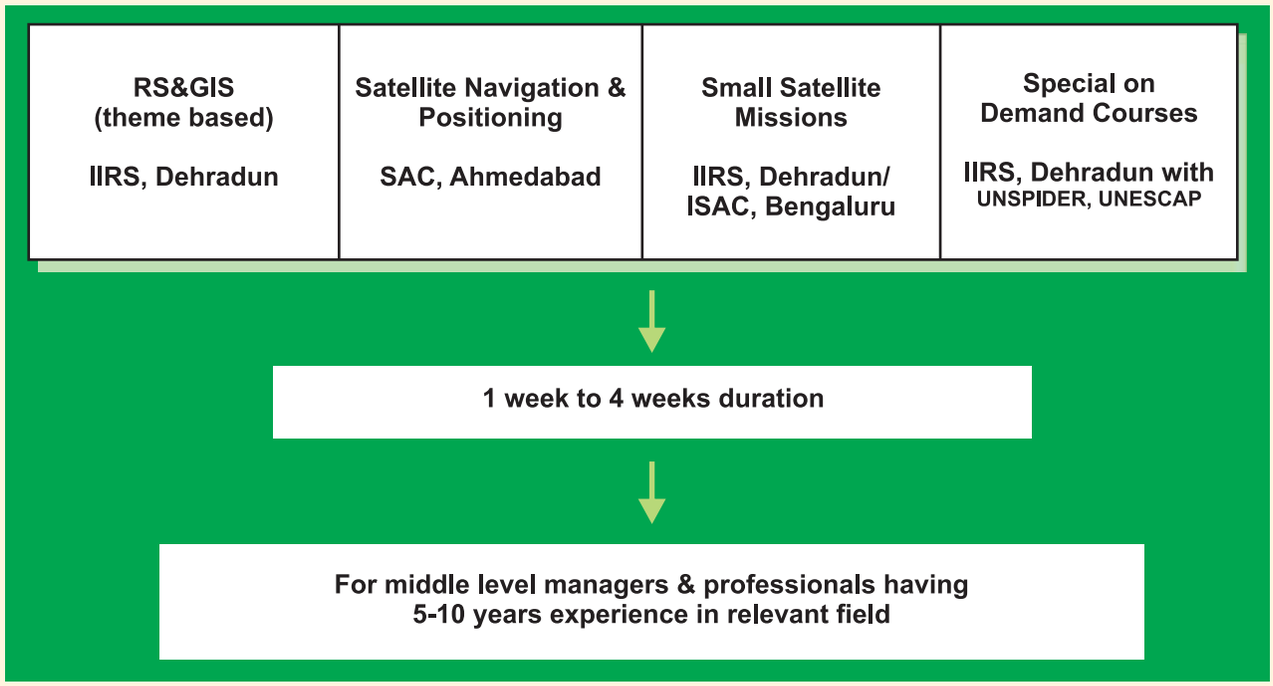


Fig. 2: Short-term training programmes at CSSTEAP

completed and degree has been awarded M.Tech. degree. In 2011 one student from Sri Lanka, in 2012 three PG students (one from each India, Nepal and Vietnam) have been awarded fellowship, in 2013 four students (one each from Bangladesh, Nepal and two from India), in 2014 two students (India & Nepal), in 2015 two participants from India and in 2016 two participants from India have been awarded scholarship.

Till date 143 PG students (69 in RS & GIS; 37 in SATCOM; 18 in SATMET and 19 in SAS) from 16 different countries have been awarded M.Tech. degree. The country-wise distribution of M.Tech. degree awarded in RS &GIS course is shown below: (Fig. 3).

Remote Sensing and GIS course

The RS & GIS course is directed towards university educators and researchers, natural resources managers and

professional in environmental management and to support disaster management. The Post Graduate course is divided into two semesters (semester-I of four months and semester-II of five months including three months pilot project work). Semester-I covers principles of RS, photogrammetry, image analysis, GIS and GPS, recent trends in RS & GIS technology, satellite meteorology, earth processes, natural disaster and environmental monitoring and analysis. Each of the course participants chooses one optional thematic application discipline in semester-II based on his/her academic qualification, professional experience and requirement of his/her parent organization. The thematic optional streams cover RS & GIS applications to (i) Agriculture and Soils, (ii) Forestry Ecosystem Assessment & Management, (iii) Geosciences & Geo-hazards, (iv) Water Resources, (v) Urban & Regional Studies (vi) Marine & Atmospheric Science, (vii) Satellite Image Analysis & Photogrammetry and (viii) Geoinformatics. This also consists of a pilot project which forms the basis for a one year project to be carried out in their home country of the course participant. The discipline-wise distribution of the students in the RS & GIS PG course is indicated below (Fig. 4). A new thematic area in technology Satellite Image Analysis & Photogrammetry was added from theyear 2012.

Achievements

Till date the Centre has been conducted 49 PG Courses: 20 in RS&GIS, 10 in SATCOM, 09 in each SATMET and SAS and 01 in Global Navigation Satellite System. Three courses are presently ongoing namely, RS&GIS, SATMET and SAS. In addition, the Centre has conducted 48 short courses and workshops in the past 21 years. These programmes have benefited some 1726 participants from a total of 35 countries in the Asia-Pacific region and 29 participants from 18 countries outside Asia Pacific region have also benefited from these educational programmes.

The centre has played a major role in the development of curricula of four courses which are currently being followed by

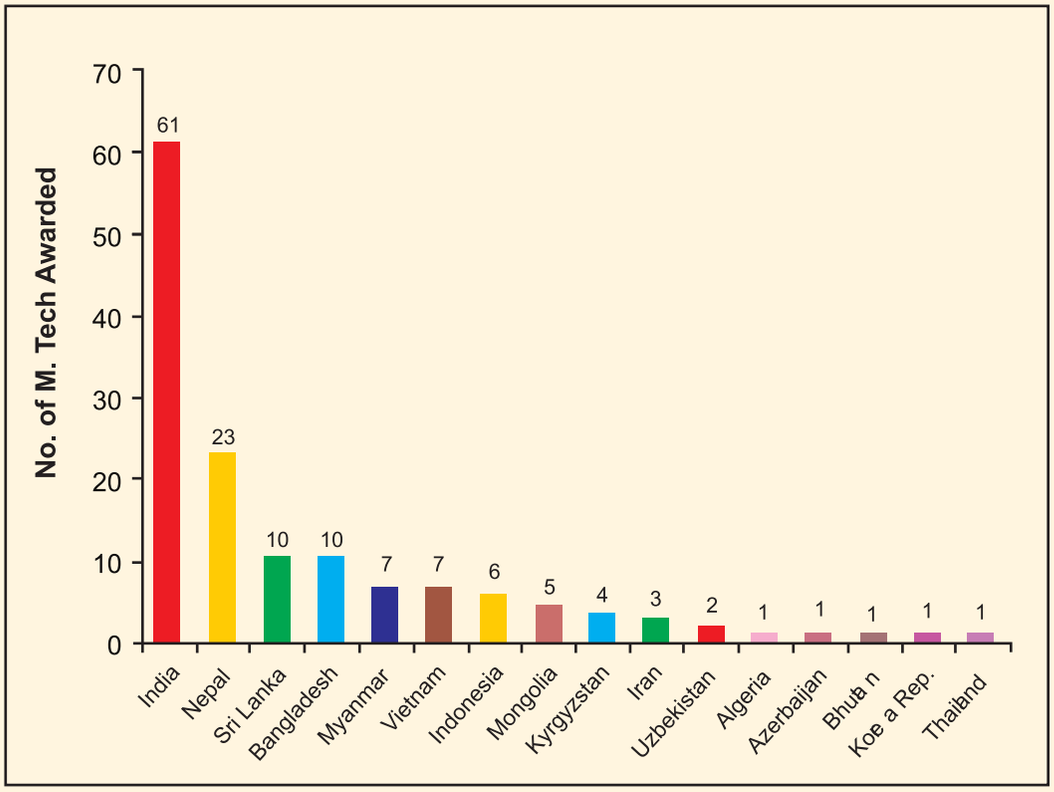


Fig. 3. Status of M. Tech. degree awarded

all the CSSTE's. 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 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; ITC Twente University 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 students. 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

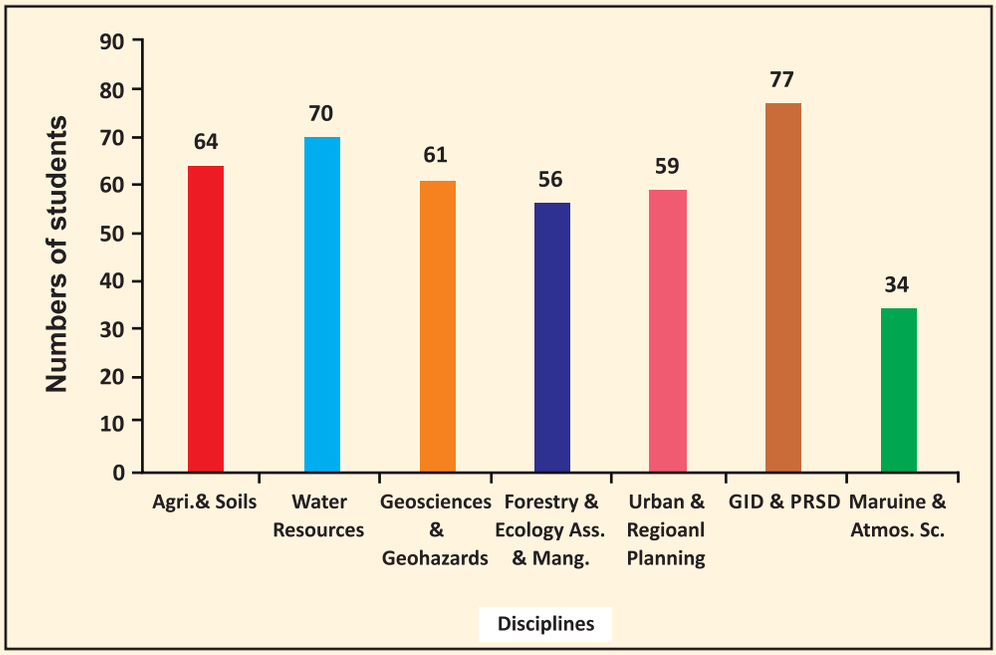


Fig. 4. Status of students in different disciplines

for analyses and logistics (accommodation, research lab, library access, etc.). This year two students from India for M.Tech degree have been supported. To generate awareness among users, researchers, engineers, professionals, decision makers and academicians. The Centre organized 3 short courses on specialized areas of Remote Sensing & its applications in the year 2016:

(a) Short course on Weather Forecasting using Numerical Prediction Models - April 18 - May 17, 2016
(b) Short course on Advances in Geospatial Tools in Forestry & Ecology Applications - May 23 - June 21, 2016;
(c) Short course on Disaster Damage and Loss Assessment in Natural Heritage and Cultural Sites using Geospatial Techniques- September 11 - October 02, 2016

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 programmes. In India, apart from DOS/ISRO Centers CSSTEAP has Collabration with many universities and academic institutions for imparting education/training.

Space Applications Centre
Ahmedabad

Harnessing space technology for societal benefits

Shri Tapan Misra

Director
Space Applications Centre

Space Applications Centre (SAC), is a major research and development centre of the Indian Space Research Organisation (ISRO). It plays a key role in realizing vision and mission of ISRO. The core competence of SAC lies in the development of space borne and air borne instruments/payloads and their applications, which contribute towards national development and societal benefits. These applications are in diverse areas and primarily addresses the communication, navigation and remote sensing needs of the country. SAC also contributes significantly in scientific and planetary missions of ISRO. The communication transponders developed at SAC 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. The payloads for major navigation systems of the country - Navigation with Indian Constellation (NavIC) and GPS Aided Geo Augmented Navigation (GAGAN) are developed by SAC. SAC designs and develops the optical and microware sensors for the satellites, signal and image processing software, GIS software and many applications for Earth Observation (EO) programme of ISRO. These applications are in diverse areas of Geosciences, Agriculture, Environment and Climate Change, Physical Oceanography, Biological Oceanography, Atmosphere, Cryosphere, Hydrosphere etc. 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 state-of-the-art in-house and mobile exhibitions to propagate space technology and applications amongst students and public. 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:

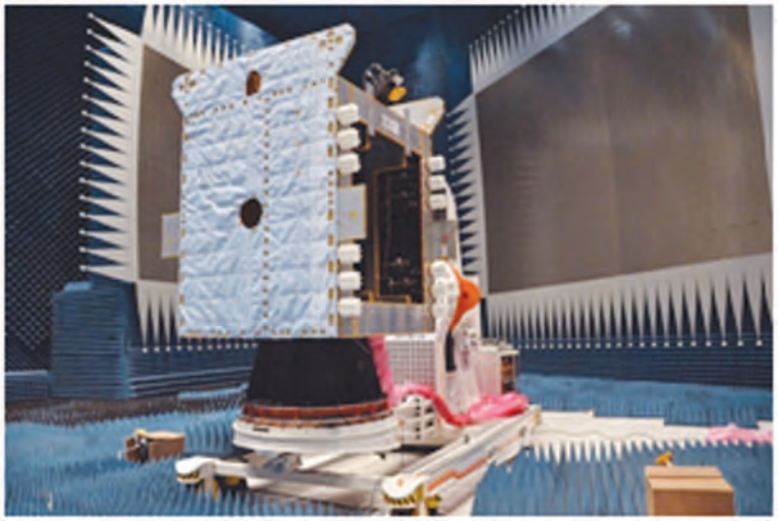
- SATCOM & Navigation Payload Area (SNPA)
- SATCOM & Navigation Applications Area (SNAA)
- Sensors Development Area (SEDA)
- Microwave Remote Sensors Area (MRSA)
- Earth, Ocean, Atmosphere, Planetary Sciences & Applications Area (EPSA)
- Electronic Support Services Area (ESSA)
- Mechanical Engineering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

In addition, administrative divisions deal with Personnel & General Administration, Purchase & Stores, Accounts & Finance, etc. SAC fraternity of about 1780 personnel comprises ofabout 1450 scientific & technical and 330 administrative personnel.

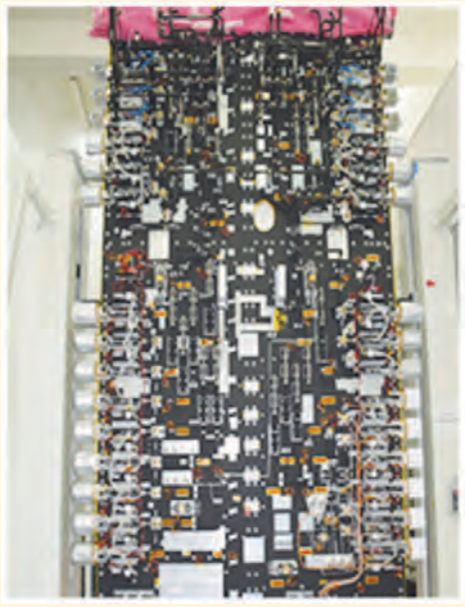
Satellite Communications Technology and Applications

SAC has been playing the key role in the conceptualization, design & development of advanced communication systems. SAC has developed a range of payloads operating from UHF to Ka band frequencies providing variety of services to individual users, institutional user and government agencies.

SAC is involved in the Conceptualization, design & development of advanced communication systems. About 48 transponders are added to the INSAT fleet in the last year.Payload development of GSAT-9 was completed, which comprises of 12 Ku Band transponders to support DTH applications. Subsystem development of GSAT-11, high through put satellite based on I-4 K bus, is in advanced stage of realisation. Payloads of GSAT-17 and GSAT-19 were delivered to ISAC for integration with spacecraft. Most of their subsystems have been realized and payloads are expected to be delivered as per the schedules of the missions. In addition to this, various payload development works are going on for GSAT-7A, GSAT 20, GSAT-6A, GISAT& INSAT-3DS.



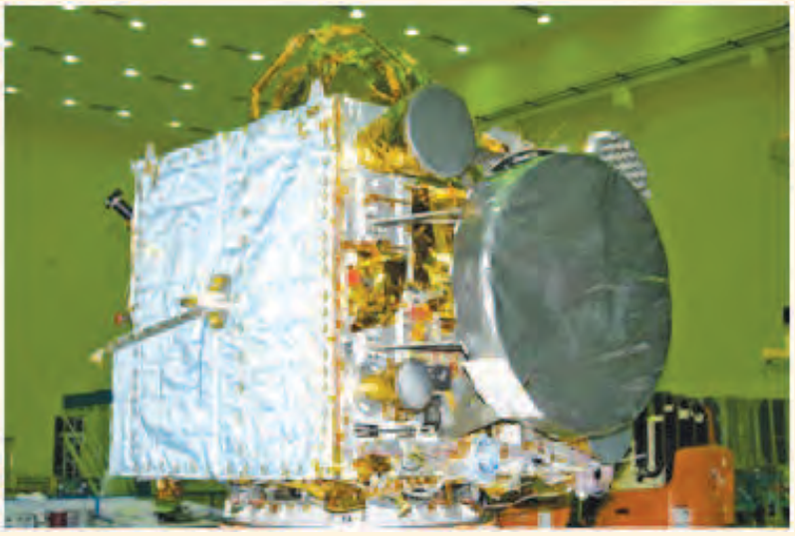
GSAT-9 at SAC CATF



GSAT-11 Payload Panel

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 service payloads required for IRNSS and GAGAN.

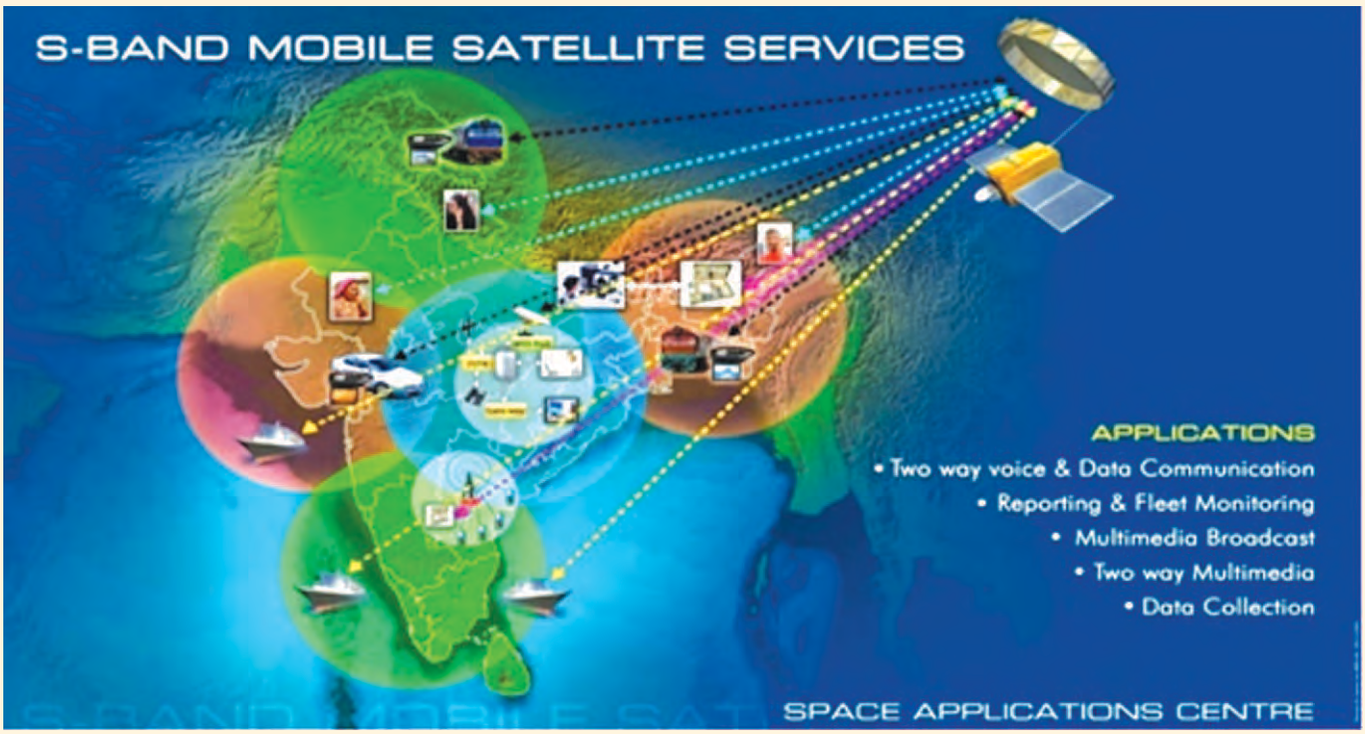
The need for positioning based services has tremendously increased for civilian as well as strategic usage. In order to meet this high demand, Indian navigation satellite system – IRNSS is getting established to provide highly accurate real time positioning for land/sea/air based users. IRNSS-1G was launched during the year 2016-17 and has completed the 7 constellations of IRNSS series. Subsystem development of IRNSS-1H & -1L is in advanced stage of development. With the view of having indigenous atomic clocks on board second generation IRNSS satellites, rubidium clocks are being developed at SAC.



IRNSS Integrated Satellite

multiple beam antennas&Ka-band Hub Beam Antenna for GSAT-11, Ku-band DGR and C-band DGR antennas for GSAT-18, DGR antenna for GSAT-17, 0.9m Dual Feed antenna for INSAT-3DS, Ku-band Gregorian Antenna for GSAT-7A, SAR antenna of Chandrayaan 2 are some of the achievements in this field.

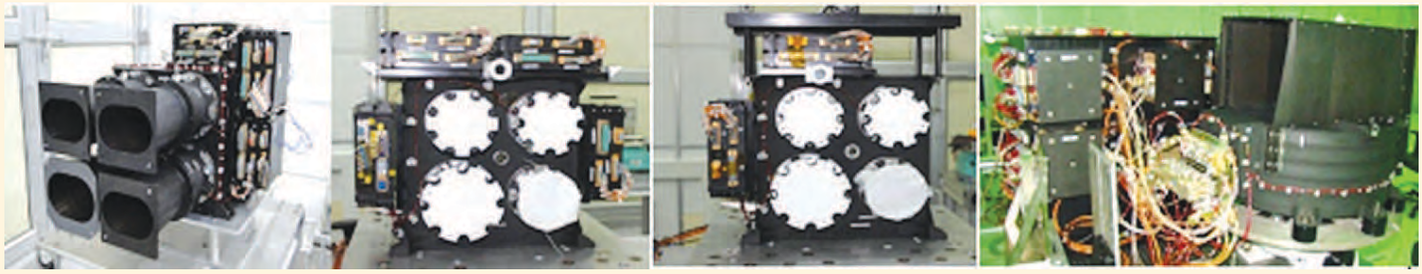
SATCOM applications form the back-bone of societal applications which demonstrates the usage of different satellites. In SATCOM Applications, the thrust areas are satellite based Tele-education, Tele-medicine, Village Resource Centres, satellite based Broadband Services & Mobile Satellite Service. In near future, Broadband Internet and similar VSAT applications will be provided using multi spot beam high power, high throughput satellites using Ku/Ka frequency bands. Distress Alert Transmitter (DAT) for Emergency position and Distress Alert by fisherman, Automatic Weather Station for Weather Prediction & Tsunami Early Warning System are some of the application systems developed by SAC for disaster management. SAC has developed four types of handheld and portable terminals with IP based Hub to support different S-band mobile communication services. SAC is developing a MSS network for Indian Railways to support automatic warning at Un-Manned Level Crossing and for Indian Navy and Indian Coast Guard to support tracking of small boats for Coastal Surveillance application. SAC has taken strides in the developments of receiver systems which can support our own IRNSS as well as other global navigation system. SAC is in advance stage of building Application Specific Integrated Circuit (ASIC) for NavIC to build miniaturized receiver for cost effective implementation of different positioning services. NavIC Receiver generates Position/ Velocity/Timing (PVT) information for vehicle tracking. The work for ground system for GSAT-11 & GSAT-19 is progressing well.



Remote Sensing Technology Development

Remote sensing techniques constitute an extremely sophisticated set of surveying approaches which include aerial photography, airborne or space borne digital imagery. SAC is playing a very important role in developing airborne and space borne sensors for the Meteorology, Scientific and Planetary programmes of ISRO. In last two decades, the optical observation capability has

improved from 35 meters to 60 cm. In order to cater to specific applications, the optical sensors have been developed to operate in different wavelengths covering Visible to Thermal Infrared. Recently ISRO has launched Cartosat-2 series satellites which provide Panchromatic and Multispectral Images with very flexible viewing capability. In April, 2011 Resourcesat-2 was launched and in December 2017, Resourcesat-2A was launched, a follow-on mission to Resourcesat-2. It is one of its kind with a three tier imaging capability with LISS-4 (5.8m), LISS-3* (23m), AWiFS-A&B (56m). All the payloads are multispectral with SWIR bands in LISS-3* and AWiFS. Prediction of Monsoon is one of the biggest challenge in the field of Meteorology. In September 2016, INSAT-3DR was launched to facilitate more frequent observations in the field of weather prediction.INSAT 3DS, the ground spare is also under development. Payload development activities for Cartosat-2E, Chandrayan-2, GISAT, Oceansat-3 are in advanced stage.

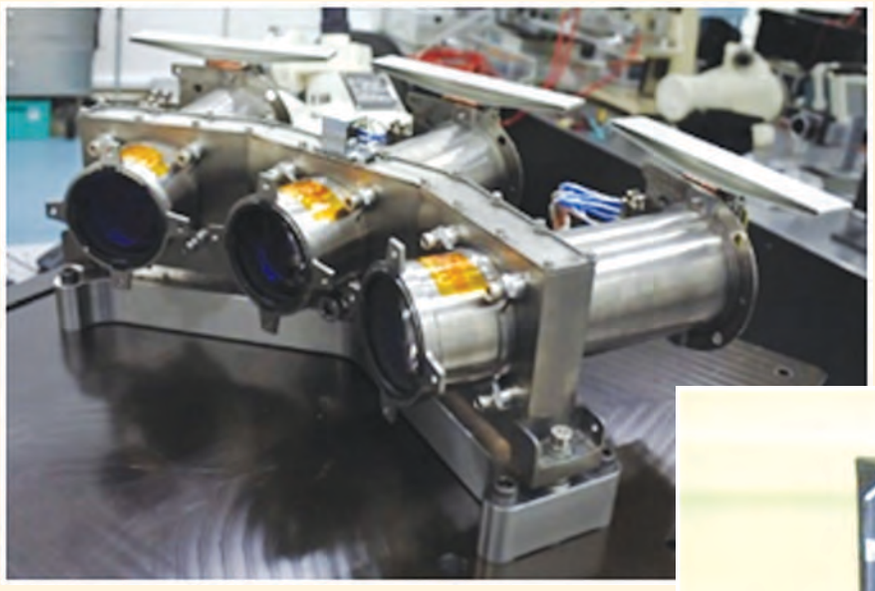


LISS-3* **AWIFS-A** **AWIFS-B** **LISS-4**

Resourcesat-2A Payloads

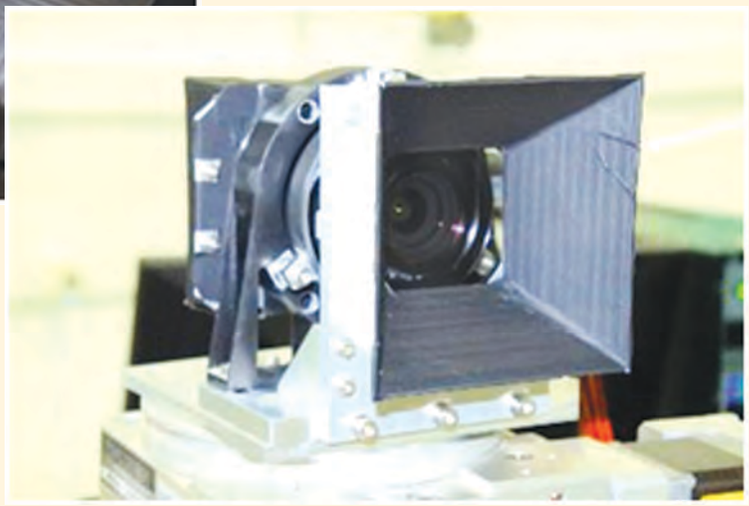
LISS-3*AWIFS-AAWIFS-BLISS-4Resourcesat-2A Payloads

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. India's first indigenously developed Synthetic Aperture Radar (SAR) satellite was launched on April 26, 2012. ISRO has already flown two Scatterometers. First one on OceanSat-2 and the second one on the ScatSat-1 as a continuity mission. OceanSat-2 Scatterometer happens to be the first operational active (radar) microwave sensor flown by ISRO. ScatSat-1 provides global coverage of oceans with a swath of 1400 Km (inner beam) and 1800 Km (outer beam) and repeat cycle of two days. Payload has been designed and characterized with an objective of meeting the quality parameters required to make the data, Climate Data Record compatible. Subsystem development of RISAT-1A & 2A is progressing well and many further developments are expected in the coming year. Development of L&S-band SAR of NISAR, the collaborative effort between ISRO and NASA, is in advanced stage.



TMC-2

Lander Position Detection Camera



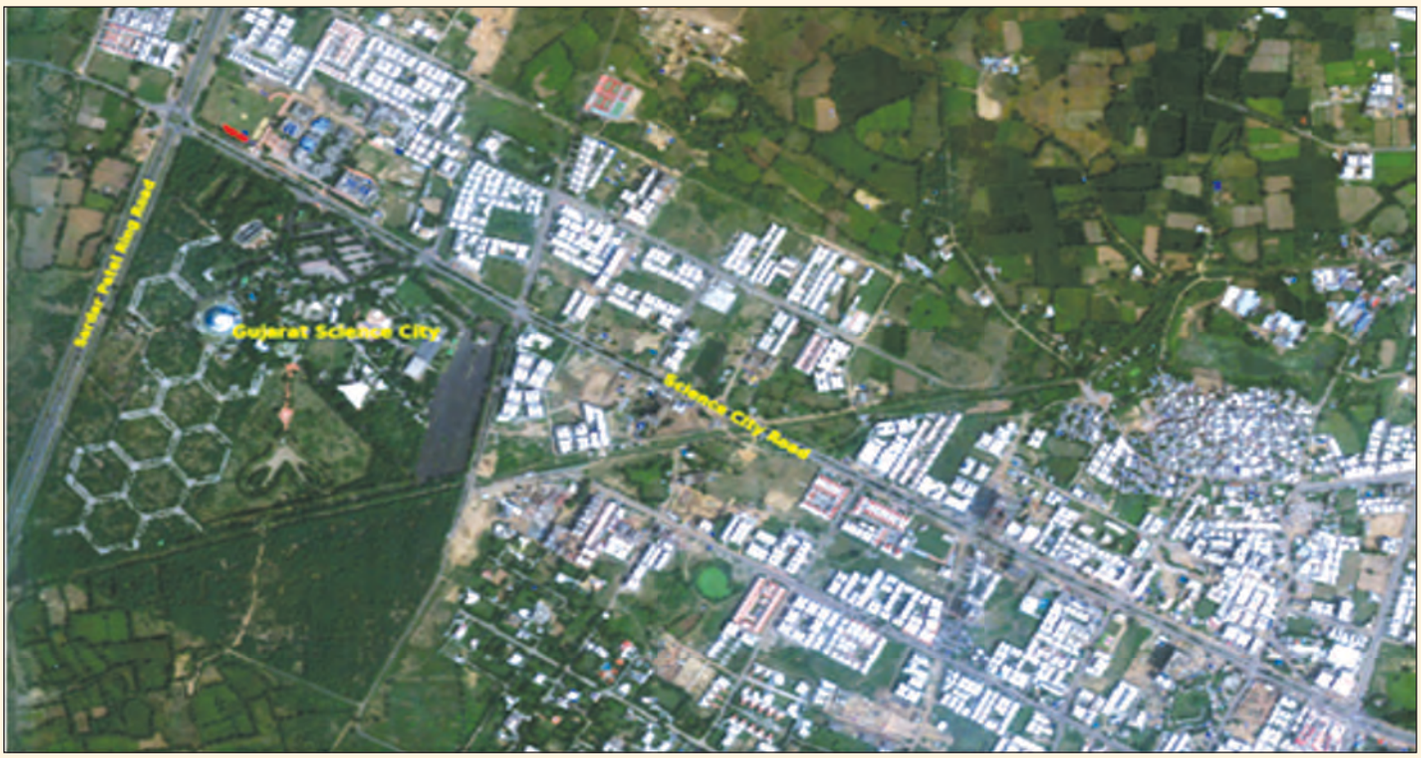
Chandrayan-2 Payloads

Remote Sensing – Image Processing and Applications

SAC has been developing the algorithms and 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. The software is transferred to NRSC, Hyderabad for operational dissemination of data products to users.

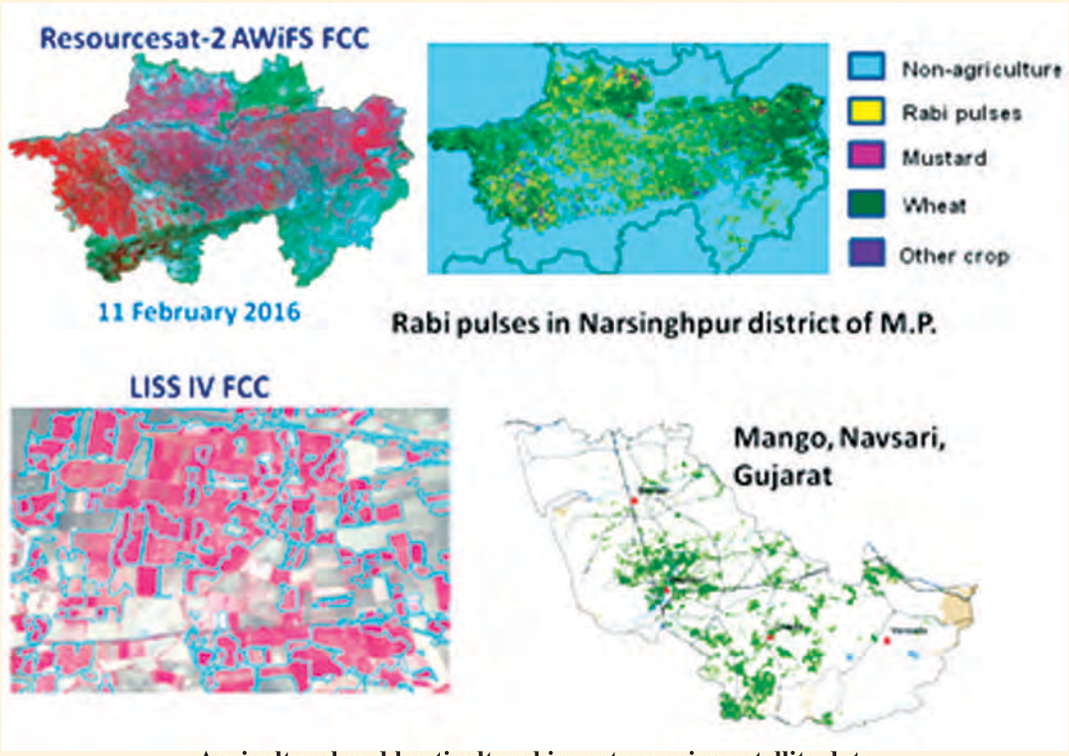
SAC has developed data processing software for Scatsat-1. From Day-1 onwards, all levels of data products are being generated successfully. High resolution data products (2 km) for India and Polar regions were generated. Software development for Chandrayan-2 is progressing well. SAC has developed software for processing real data of Cartosat-2 series and developed software for Optical Butting noise correction for Panchromatic and Multispectral (PAN & MX) payload and was operational at NRSC. Data processing & special product software for INSAT-3DR is completed and products were successfully evaluated.

In the area of remote sensing applications, SAC has made pioneering contributions in the field of agriculture, forestry, coastal zone management, fisheries, urban planning, watershed development, ground water prospecting, snow & glacier studies, oceanography and atmospheric studies. It involves retrieval of biophysical and geophysical parameters from space borne imaging sensors, assimilation of remote sensing derived parameters, in-process modelling pertaining to interactions within the geosphere-biosphere system and atmosphere.



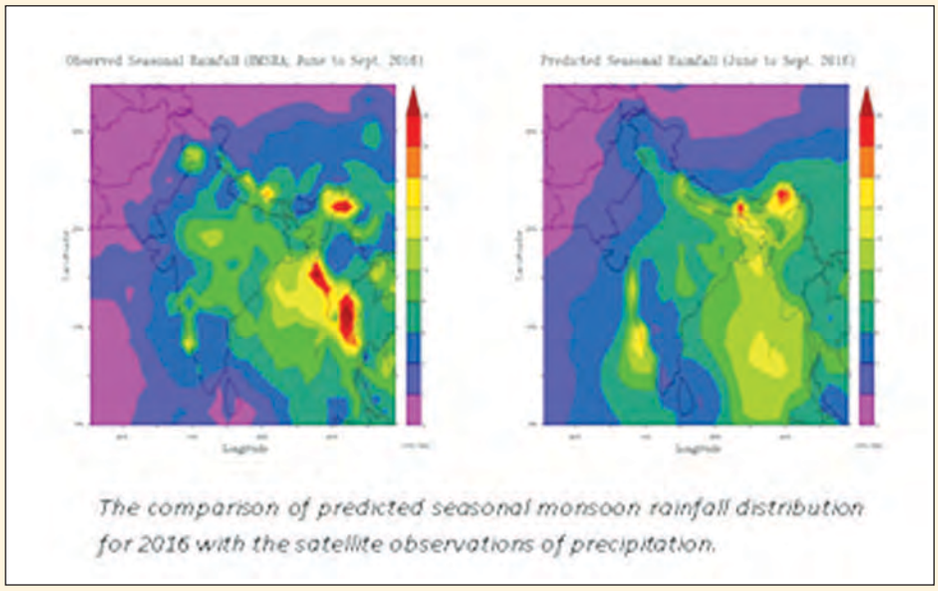
Cartosat-2S Image of Ahmedabad

Production forecasting of important agricultural crops using satellite remote sensing data is done through FASAL (Forecasting agricultural output using Space, Agro-meteorology and Land based observations) project supported by Ministry of Agriculture and Farmer's Welfare. Multiple forecast of crops like Jute, Kharif rice, Winter Potato, Rapeseed/Mustard, Wheat, Rabi Rice, Sugar Cane are done. Inventories of Banana, Citrus and Mango orchards created using IRS LISS-3/4 data (CHAMAN project) were verified in presence of officials from MNCFC, New Delhi, and directorate of state horticulture departments and state remote sensing centres.

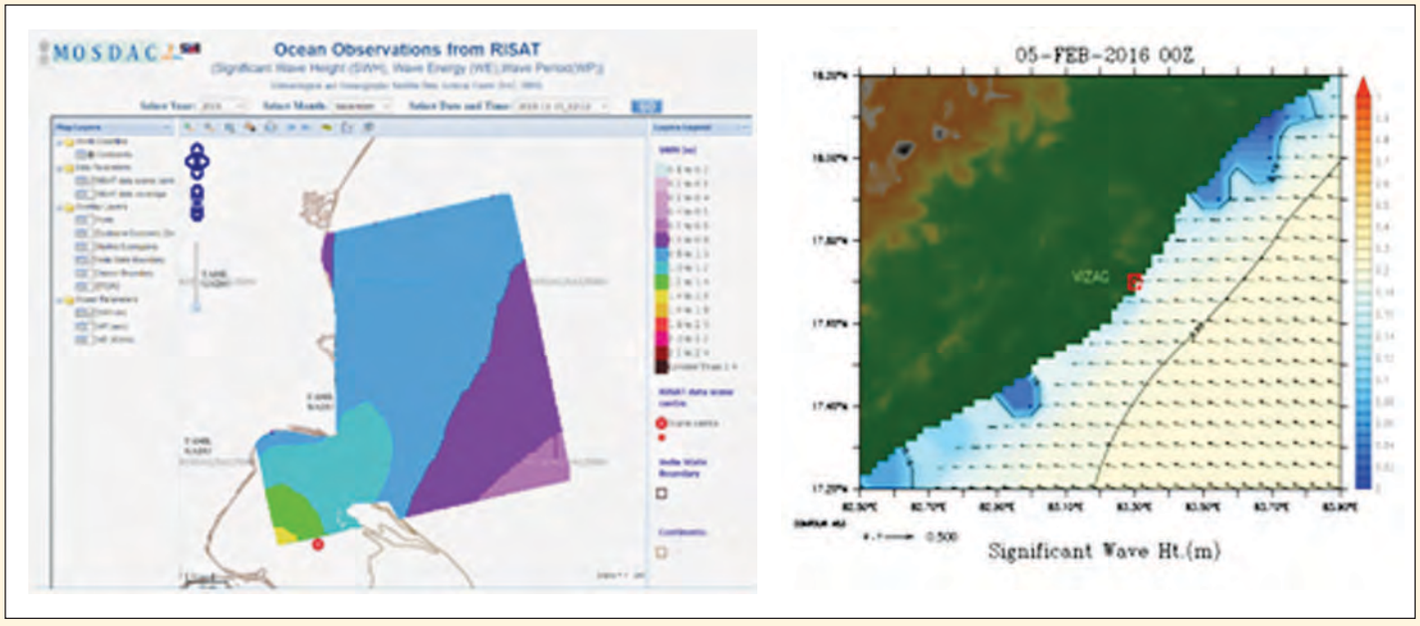


Agricultural and horticultural inventory using satellite data

The recent work on Himalayan Cryosphere studies include Glacier facies mapping from RISAT-1 SAR, LISS III and DEM data, updating Glacier inventory of Indus, Ganga and Brahmaputra basins. An atlas showing details of monitoring snow and glaciers of Himalayan region has been recently brought out by SAC. For Polar Cryosphere studies, Sea ice identification, Sea ice thickness estimation, Assessment of ice deformation around Antarctic margins, Velocity of ice sheet and polar glaciers, Morphological studies of Antarctic/Arctic region, Sea ice occurrence and ice-berg studies are being carried out. Studies are currently being carried out for the estimation for forest above-ground biomass in Shimoga district of Karnataka using SAR data. Forest biomass for Gujarat state has also been done. SAC carries out studies related to land hydrological modelling and applications. Numerical Weather Prediction model and advance satellite observations together help to provide short range (up to next 3 days) weather forecast over India. A large number of observations from ISRO satellites such as INSAT-3D, Scatsat, Megha-Tropiques etc. provide appropriate inputs to these models for highly reliable prediction of weather. These predictions are crucial for agriculture, planning, energy resources, aviation, disaster management etc. The forecasts of wind, surface pressure, rainfall, temperature and humidity are regularly disseminated to public through MOSDAC. VEDAS is a web based archival, dissemination and visualization of Earth Observation derived data products for various themes. Content generation in VEDAS is in progress. SAC has also initiated Data utilization programs like SMART (Satellite Meteorology and Oceanography Research and Training) & TREES (Training and Research in Earth Eco-System)



The comparison of predicted seasonal monsoon rainfall distribution for 2016 with the satellite observations of precipitation.



(a) Ocean surface wave energy estimated along the south-East Indian coastline using the observations from Synthetic Aperture Radar onboard RISAT satellite (b) Prediction of ocean wave height.

Fabrication and Test Facilities

SAC has a strong in-house infrastructure to support design, fabrication and testing of payload electronics and mechanical hardware while ensuring quality and reliability of the operation over mission life. 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), Environmental Test Facility (EnTF) having hot and cold chambers, Thermovac chambers, vibration and shock test facility etc., Precision mechanical fabrication facility with computer controlled CNC and EDM machines, components screening facility and Bonded store. Computer Aided Design (CAD) facility established in the centre facilitates mechanical and electronic design and drawing generation. Further upgradation of facilities is in progress with construction of new campus at Bopal, Ahmedabad in full swing. For measurement equipment a full-fledged calibration facility is operational. It has recently been enhanced for validation up to 220 GHz frequency. 4th time re-assessment for NABL accreditation has also been accomplished for SAC calibration lab. SAC has developed PLASIV facility.

PLASIV Facility

AIT Facility

Systems Reliability

SAC has Implemented mechanism, through Systems Reliability Group 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. Another thrust area of the organisation is Indigenisation of technologies. Towards this end, SAC has made significant contributions, by evaluating and qualifying a wide and diverse range of fabrication processes manufacturers and products from within the country

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 centreby Planning & Projects Group. Regular reviews are conducted at multiple levels to monitor the progress of each and every activity and to sort out the issues before they become critical. It is also responsible for planning the budget and

schedule for the centre, monitoring the expenditure of funds allotted to various projects undertaken at the Centre and their schedules, and carrying out various budget exercise. In addition, the functions related to progress monitoring, patents & IPR filing, technology transfer & industrial interface, human resources development, management information systems, networks planning & operations as well as managing Research and Technology Development Programs are carried out by PPG.

Future outlook

Growth in demand for transponders has enhanced exponentially.SAC is developing new technologies to meet the requirements of the country. GSAT-11 is a pre-cursor of High Throughput Satellite (HTS), which is planned to be delivered soon and GSAT-20, `another HTS satellite for higher broad band connectivity, is also progressing well. SAARCSAT is another project which will cater the SAARC countries for their communication needs. On the other side,Global Navigation Satellite Systems (GNSS) has become a key utility in much of the world's infrastructure. 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 relevant new ground segment technology elementswillalso be developed. High Resolution imaging sensors for better urban planning will also be addresses in the coming years which will be useful and helpful to the urban planners etc. SAC is indigenously developing Rb-atomic clock for futureIRNSS satellites. Development of Microwave sensors for remote sensing of earth & lunar surfaces, Hyper-spectral sensors operating in visible and IR region, sensors for greenhouse gases, development of sensors and its applications towards realization of inter-planetary missions will be the major thrust areas during the coming years. Tera Hertz (THz) technology is another area where SAC is making in-roads and a lot of developmental activity has been initiated and first model THz sensor is likely to be delivered in the coming two years. SAC is also increasing its collaboration with other international space agencies viz. NI-SAR (L&S-band) is a Joint ISRO-JPL/NASA Mission.The Advanced Visible and Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG) campaign over Indian region offer unique opportunity to extract useful information regarding atmospheric structure in diverse scenes with the help of high resolution shortwave imaging spectroscopy. At the applications front, major initiatives include the conceptualization of satellite data for the development of agriculture, disaster management, weather forecasting etc.Our data platforms – MOSADAC and VEDAS continue to provide data in various areas like agriculture, forestry, coastal zone management, fisheries, urban planning, watershed development, ground water prospecting, snow & glacier studies, oceanography and atmospheric studies. Recently we have showcased data products of Resourcesat-1/2 & 2A, Cartosat-2S, INSAT-3DR & SCATSAT-I payloads on these platforms. Weather Information Services and Decision Support for Oceanography and Meteorology (WISDOM) was uploaded on MOSDAC website. Using the available database in VEDAS, SAC has started conducting Research and training programmes under TREES (Training and Research in Earth Eco-System centre).Our Centre is also started RSS-based feed mechanism, ISROCAST, for publishing Satellite data products in near real time (NRT) with automatic identification and download of recent data by subscribers.It also includes the utilization of data from Lunar and Mars surfaces expected to be available from future missions for understanding Martian& Lunar surfaces. There are many more Pan India Applications projects are being targeted to optimally utilise the available space assets.

For SATCOM applications SAC is developing a MSS network for Indian Railways to support automatic warning at Unmanned Level Crossing, Train Tracking and Emergency communication. The network proof of concept has already been completed and SAC is in advance stage to conduct pilot project. Similarly line Coastal Surveillance applications are being developed.

SAC is going to play very important role in the development of advanced R&D programme. Currently major advanced R&D programme carried out within the Centre are towards Terahertz Observatory, Ground based standalone Pseudolite Navigation, Infrared Spectrometer Development, ASIC development for IRNSS receiver and High Throughput Satellite for enabling space based internet.

CSSTEAP Course on Satellite Meteorology and Global Climate, at SAC, Ahmedabad (SATMET- 10)

Dr. B. Simon
Course Director

Dr. Kaushik Gopalan
Course Coordinator

A REPORT

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 Tenth Post Graduate Courses on Satellite Meteorology and Global Climate under the aegis of the UN affiliated CSSTEAP, is being conducted at Space Applications Centre (Bopal Campus), Ahmedabad during August 1, 2016 to April 30, 2017.

Thirteen participants from Seven 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, Malaysia, Mongolia, Nepal, Thailand.

The course commenced on August 1, 2016 at the Bopal Campus of Space Applications Centre (SAC), Ahmedabad. A joint inaugural function of the two courses i.e. the Satellite Meteorology and Global climate conducted by Space Applications Centre and the Space and Atmospheric Sciences conducted by
Physical Research Laboratory was held at K.R. Ramnathan Auditorium, PRL on 4th August 2016. This function were presided over by Shri Tapan Misra, Director SAC & 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 SATMET-10 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 application 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 Space Applications Centre, 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 PG 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.

Recently we have incorporated new practicals, i.e., in Temperature and humidity profiles from Sounder data (INSAT-3D/3DR), GPS Meteorology, Scatterometer Applications, Humidity profiles form SAPHIR sensor onboard Megha Tropiques, SARL/Altika data Processing and related practicals from this course onwards, which was highly appreciated by the SATMET-10 students.

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.

Faculty:

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 Space Applications Centre, the Physical Research Laboratory, experts from India Meteorological Department (IMD) and Andhra University etc. 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 Sets – 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-10 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 PC's 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.

A versatile software package "ERDAS, MEAS, IDL, Python" on each terminal provided much needed standardization in data processing (INSAT, MT, 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 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.

A weekly Map discussion of the current Weather over Indian and the Asia-Pacific using Satellite images, weather charts and model forecasts available from various sources was 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. The active south-west monsoon conditions over India and Gujarat, in particular, gave a good feel of heavy monsoon spells to the participants and made the weather discussions very educative, informative and lively.

Technical Visits:

During the 9 months Course, the participants visited some of the important Institutions / Laboratories in the country to have a first hand experience of the utilization of satellite data in an operational environment. The technical tours included visits to:

- 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 Mehal.

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.
- Cryo-sphere (assessment of change) over Kyrgyzstan.
- Mesoscale convective studies using satellite data., SAPHIR / MT Validation
- Nowcasting/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 10th PG course on Satellite Meteorology and Global Climate at Space Applications Centre, 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 and Bopal Administration (especially B N Panchal and his team), and Controller SAC, CMD and his team, purchase, P & PR, Medical Officer, Vikramnagar colony for the support

extended to the course participants. We thank Shri Kiran Kumar, Chairman ISRO, and Shri Tapan Misra, 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 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)

Sub - 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
Sub - 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
Sub - Module 1.3	Image Processing, Interpretation and GIS
Section 1-3 DIP	Image Processing Techniques and Geogrphic 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 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 Statistical, 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 METEOROOGY

Section 1-2-SM Concepts in Satellite Meteorology

- Principles of Remote Sensing
- Characteristics of Electromagnetic Radiation
- Passive Remote Sensing
- Active Remote Sensing
- Parameter Retrieval & Validation

Section 1-2-MSI Overview of Met Satellites- Orbits, Instrumentation

- Orbits and Navigation
- Operational Polor-orbiting satellites
- Operational Geostationary Satellites
- Other Satellites
- Satellite data Archive

Sub - MODULE 1.3 : IMAGE PROCESSING & INTERPRETATION

Section 1-3-DIP **Image Processing Techniques and Geographic Information System (GIS)**

- Map Projection
- Satellite Positioning System
- Image Registration, Radiometric & Geometric Correction
- Image Classification

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 R T 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

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
- Mass Communication

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- LINUX, GRADS, Ferret, MIAS, IGIS, Fortran, Python, ERDAS Familiarisation
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 – Arkin's Technique.
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 Application of satellite data in tropical cyclone.

Module II: Remote Sensing of Geophysical Parameters & Numerical Modelling Applications

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 – Demo

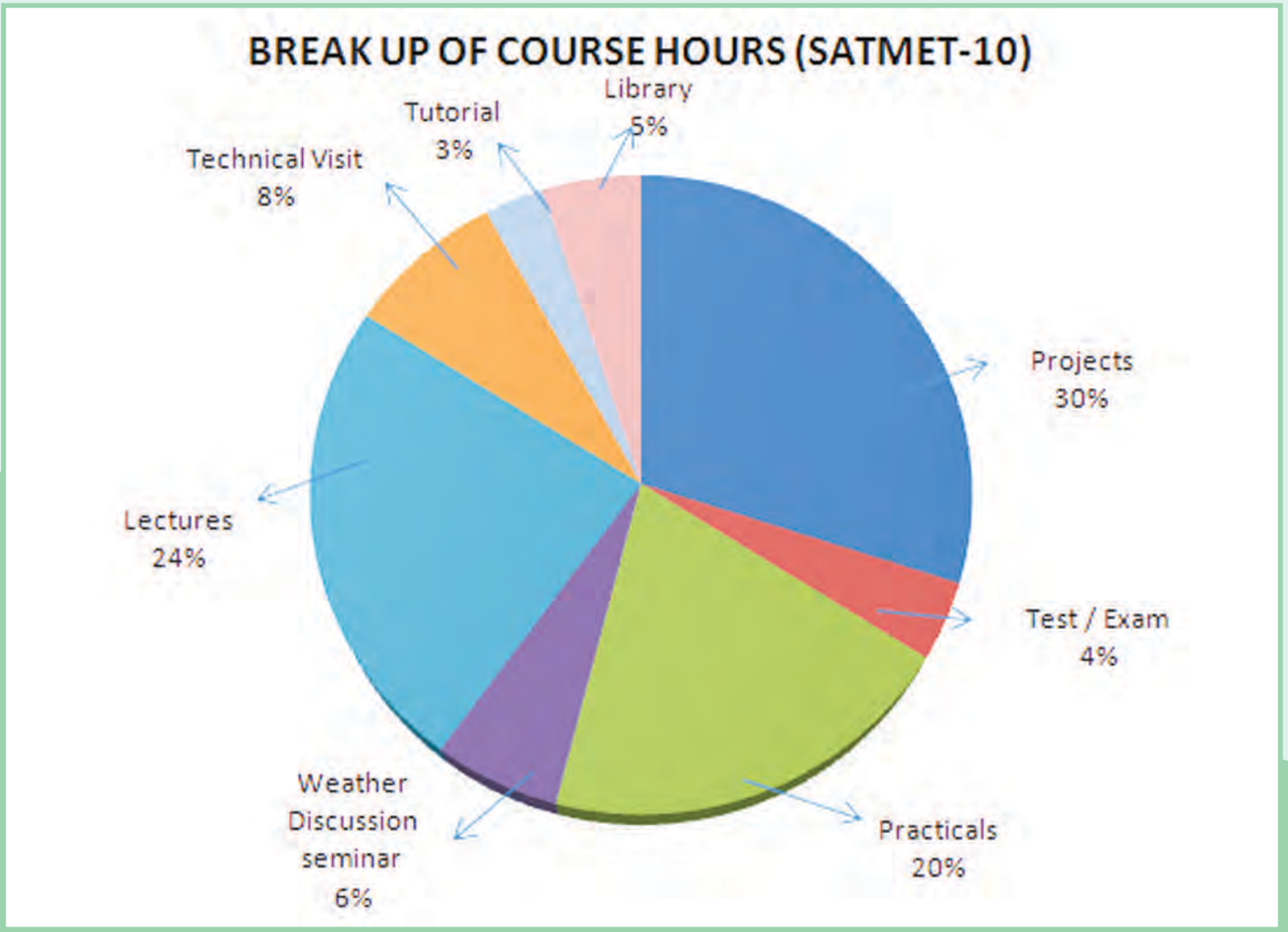
CORE PERSONNEL OF THE COURSE

Course Director : **Dr. B. Simon**

Course Coordinator : **Dr. Kaushik Gopalan**

Pilot Projects : **Dr. C.M.Kishtawal**

BREAK UP OF COURSE HOURS



LIST OF FACULTY MEMBERS

AOSG/DWD,SAC

Theory

No.	Name
1	Dr. A.K. Mathur
2	Dr. B.S. Gohil
3	Dr. B. Simon
4	Ms. Pushpalata Shah
5	Dr. C.M. Kishtawal
6	Dr. P.K. Thapliyal
7	Dr. Rashmi Sharma
8	Dr. Rajkumar
9	Dr. R.M. Gairola
10	Dr. V. Sathiyamoorthy
11	Dr. Sanjib Deb
12	Dr. M. P. Oza
13	Mr. Abhineet Shyam
14	Dr. A.K. Varma
15	Dr. Neeru Jaiswal
16	Dr. Neeraj Agrawal
17	Dr. Kaushik Gopalan

Practical

1	Shri Mahesh Patel
2	Mr. Rishi Gangwar
3	Ms. Shivani Shah
4	Mr. Ghansham Sangar
5	Dr. Sukanta Das
6	Ms. Ruchi Modi
7	Dr. Munn Vinayak Shukla
8	Dr. Mehul Pandya
9	Mr. Danish Hussain
10	Mr. Jishad
11	Dr. Neerja Sharma
12	Dr. Rahul Nigam
13	Dr. Rajesh Sikhakolli
14	Dr. Satya Prakash Ojha
15	Ms. Ipshita Dey
16	Dr. Prashant Kumar
17	Mr. Seemanth M
18	Mr. Prateek Kumar
19	Dr. Bipasha Paul Shukla
20	Mr. Aman Waheed Khan
21	Mr. Bushair M T (JRF)
22	Ms. Sneha Thakur (JRF)
23	Ms. Swati Bhomia (JRF)
24	Mr. Shashikant Patel (JRF)
25	Mr. Dinesh Sankhala (JRF)
26	Mr. Buddhi Prakash Jangid (JRF)

Other Group, SAC

1	Dr. Bimal Bhattacharya
2	Dr. R.P. Singh
3	Dr. Shashikant A. Sharma
4	Dr. D. Dhar
5	Dr. Prakash Chauhan
6	Dr. R.K.Bhattar
7	Smt. Rachna Patnaik
8	Ms. Sweta Mishra
9	Dr. Ram Rajak
10	Dr. Mini Raman
11	Dr. Randhir Singh

ISRO/Department of Space (DOS)

1	Dr. George Joseph, Ex., Director, CSSTEAP
2	Dr. A. Senthil Kumar, Director, CSSTEAP
3	Dr. M. Mohan, SPL/VSSC, Trivandrum
4	Dr. P.C. Joshi, Ex., SAC, Ahmedabad
5	Dr. A. Sarkar, Ex., SAC, Ahmedabad
6	Dr. S.K. Basu, Ex., SAC, Ahmedabad
7	Dr. P.K. Pal, Ex., SAC, Ahmedabad
8	Dr. Somkumar Sharma, PRL, Ahmedabad
9	Dr. Shankara Rama, PRL, Ahmedabad
10	Dr. Shashi Kiran Ganesh, PRL, Ahmedabad
11	Prof. Shyamlal, PRL, Ahmedabad
12	Dr. V.C. Joshi, PRL, Ahmedabad
13	Dr. Rajmal Jain, PRL, Ahmedabad
14	Prof. Ramesh, PRL, Ahmedabad
15	Prof. Harish Chandra, PRL, Ahmedabad

Outside DOS, India

1	Dr. R.C. Bhatia, Ex., ADGM, IMD, New Delhi
2	Dr. R. Suresh, IMD, Chennai
3	Prof. S.S.V.S Rama Krishna, Andhra University
4	Dr. U.S.De, Pune

LIST OF PARTICIPANTS AND THEIR ORGANISATION

Sr. No.	Name	Organisation
1	Ms. Mirza Nilufar Jahan	Bangladesh Meteorological Department **Bangladesh**
2	Ms. Nijhum Rokeya Ahmed	Bangladesh Meteorological Department, **Bangladesh**
3	Sqn Ldr Murali Krishna Chandragiri	Indian Air Force**, India**
4	Cdr TS Ramanathan	Indian Navy**, India**
5	Mr. Aleksei Saiapin	Department of Meteorology, **Kyrgyzstan**
6	Ms. Kunduz Abirova	Department of Meteorology**, Kyrgyzstan**
7	Ms. Zhamilia Asanbekova	International University of Innovation Technologies **Kyrgyzstan**
8	Mr. Noor Azam Bin Shaari	Malaysian Meteorological Department **Malaysia**
9	Ms. Davaabal Batsukh	National Agency for Meteorology and Enviromental **Mongolia**
10	Ms. Delgermaa Urtnasan	Information and Research institute of Meteorology, Hydrology and Environment **Mongolia**
11	Mr. Tsolmon Khishigsuren	Information and Research institute of Meteorology, Hydrology and Environment **Mongolia**
12	Mr. Dhruba Lochan Adhikari	Central Department of Hydrology and Meteorology **Nepal**
13	Acting Sub Lt. Preecha Jintanawat	Thai Meteorological Department **Thailand**

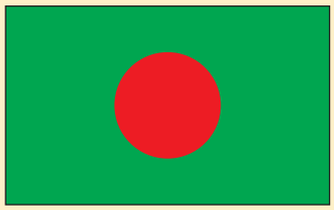
Participants Profile and Pilot Project

Ms. Mirza Nilufar Jahan
Bangladesh

Born in Mymensingh district of Bangladesh, completed graduation and post-graduation in Physics from National University,Gazipur ,Bangladesh. Joined Bangladesh Meteorological Department in 2008 and currently working in HazratShahjalal International Airport,Dhaka,Bangladesh as an Aviation Forecaster.

Office:
Bangladesh Meteorological Department
Agargaon,
Dhaka-1207
Bangladesh.
Phone : (O) +88-02-8901013, (M) +88-029135742
Fax : +88-02-8118230
Email : info@bmd.gov.bd, nilufar.zahan@yahoo.com

The storm from Bangladesh who charms people to her ways. An extremely hardworking and determined person. A professional Saaree lover who significantly contributed for the saree market hike during Chennai trip.



Abstract

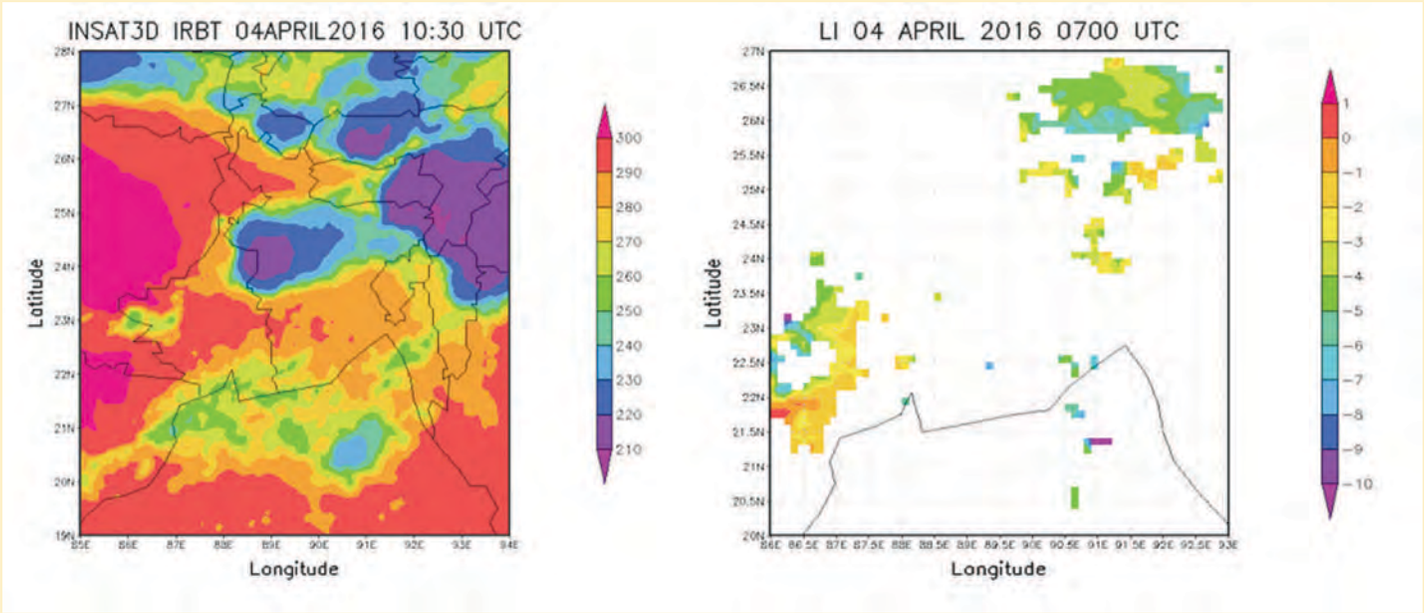
Ms. Mirza Nilufar Jahan
Meteorologist

Guide: Mr. Danish Hussain,
EPSA/MRG/MRTD/SAC

Analysis of Mesoscale Convective System using Satellite Data

Forecasting of Mesoscale Convective Systems (MCSs) has two contrasting sides. On positive side, they produce a significant amount of rainfall for agriculture. On negative side, slowly moving and long lasting MCSs produce very heavy rain, thunderstorms, strong winds and often hail which causes a lot of damage to agricultural crops, property and aviation.

Mesoscale Convective Systems (MCSs) were studied to understand the precursor environment associated with these systems over Bangladesh region($19^0 - 28^0$ N and $85^0 - 94^0$E) for the duration of two months (March, April and May of 2016 for which in-situ reports of convection were available over the study region) using stability indices from satellitedata. For this a number of MCSs were indentified and analyzed to understand their evolution. Different types of stability indices and some suitable dynamical parameters were selected based on the environmental conditions. Threshold values of these stability indices were set for these systems which give a clear indication of convective development.

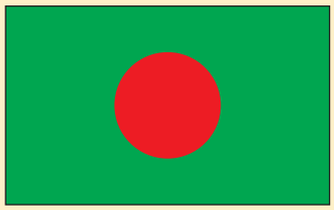


Ms. Nijhum Rokeya Ahmed
Bangladesh

Office :
Storm Warning Center,
Bangladesh Meteorological Department,
Agargaon, Dhaka-1207, Bangladesh.
Phone : (O) +88029135742, +88-02-9123838
(M) +88-01772158333
Fax : +88028118230
Email : nijhumrokeya@yahoo.com , info@bmd.gov.bd

Born in Narshingdi district of Bangladesh, completed Honours course in Mathematics and M.S. in Applied Mathematics from Dhaka University, Dhaka,Bangladesh. Joined Bangladesh Meteorological Department in 2012 and presently working in Storm Warning Centre,Dhaka,Bangladesh as a weather Forecaster.

She is the brave woman of Bangladesh. She finds oneness with everyone in her smile and disposition and is a friend always to remember. She is an obsessive fish hunter and an intelligent culinary specialist. She is always hooked to Amazon.



Abstract

Ms. Nijhum Rokeya Ahmed
Meteorologist

Guide: Dr. Neeru Jaiswal,
EPSA/AOSG/ASD/SAC

Estimation of Tropical Cyclone Structure using Satellite Observations

The accurate estimation of structural parameter of tropical cyclones viz., center, size, etc. are highly important as they areused as input in various cyclone prediction models. The satellite observations play an important role in the estimation of these parameters. In the present study, high resolution wind products (12.5 km) obtained from QuikSCAT satellite,during the period 2000-2009have been analysed for estimating the structural parameter of cyclonesformed in the North Indian Ocean which includes Bay of Bengal (BOB) and Arabian sea(ARB) region.

The size of TC has been estimated by computing the azimuthally averaged radial distance of the contour of 12 ms-1 wind speed and 1x10-5 sec-1 vorticity contour, around the cyclone center.Fig.1 shows the surface wind structure of a very severe cyclone SIDR observed by QuikSCAT satellite on 00 UTC 14 November, 2007. All such wind observations over the cyclones formed during the study period were analysed and TC size were estimated. The values of size of TCs were compared to the size based on radius of outermost closed isobar (ROCI) which is operationally given by Joint Typhoon Warning Centre (JTWC). The sizes of cyclones formed in the BOB regionand ARBregions were also compared. Fig 2 shows the histogram of TC sizes estimated for BOB and ARB region. The preliminary results show that the cyclones formed in the BOB region are larger in the size than the ARB region.

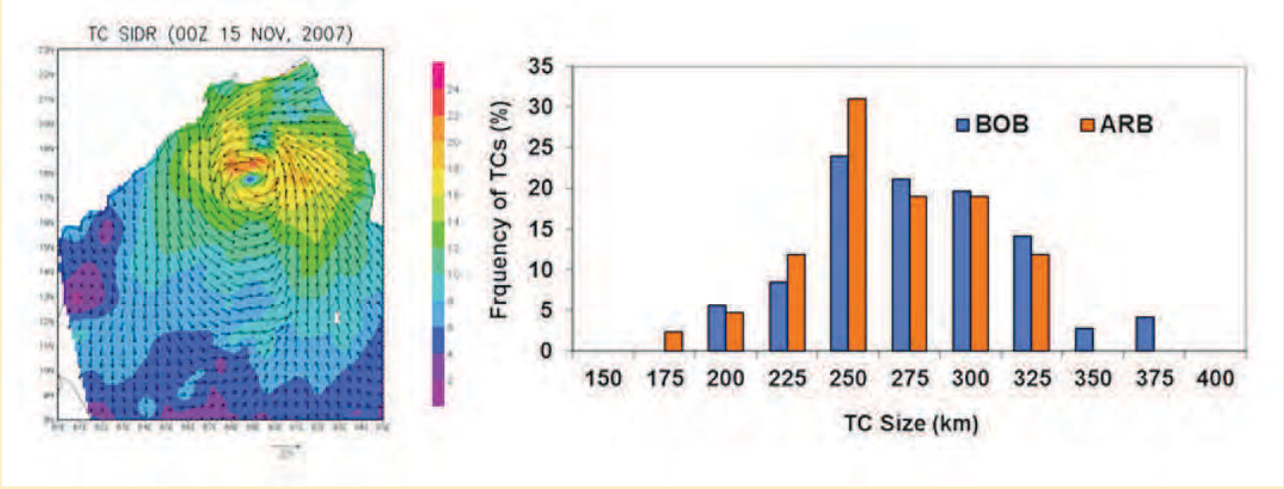


Fig 1: Surface wind structure of TC SIDR observed by QuikSCAT satellite

Fig 2: Histogram of size of tropical cyclones formed in the Bay of Bengal and Arabian Sea

Sqn Ldr Murali Krishna Chandragiri
India

Office:
Indian Air Force,
Directorate of Meteorology,
RCPO Complex, Air Force Station,
New Delhi Race Course,
New Delhi – 110003
India
Phone : (O) +91- 011-23019572,
(M) +919419992412
Fax : +91-011-23011042
Email : cmk524411@gmail.com

Squadron Leader Murali Krishna was born in a small village named Kota in Nellore district of Andhra Pradesh. His father was a Central Government employee with frequent postings, which gave him opportunity to study in various schools across the country. He finished his higher secondary schooling from Nashik in Maharashtra, Graduation & Post-graduation in Mathematics from Jodhpur and PG Diploma in Meteorology from Coimbatore. He received presidential commission in year 2004 & Joined Indian Air Force (IAF), since then he is working as Meteorological officer with IAF.

The leader and the 'man charming' of the SATMET Gang. He is an awesome and rare combination of extreme intelligence, extreme composure and extreme notoriety. He has been a great friend, philosopher and guide to all. He likes long walks and listening music.

Abstract

Sqn Ldr Murali Krishna Chandragiri
Senior Meteorological Officer

Guide: Dr. Satya Prakash Ojha,
EPSA/MRG/MRTD/SAC

Impact of assimilation of upper air observations on extreme weather events forecast over Indian region

India is a Tropical country which is surrounded by Himalayas to north and Indian Ocean to south. Because of its topographical variability, it experiences diverse climatic conditions and undoubtedly this makes it recognised as Indian Subcontinent. India is affected by both extra-tropical as well as tropical weather systems. At times when both these systems are present as well as they interact with each other, it leads to severe weather activity like heavy rainfall over the region. There have been few flood events over the Indian region in the past five years, especially during south west monsoon. These disasters have taken many lives to toll and assets to irreparable loss, two of such cases are unforgettable, Uttarakhand (2013) and Jammu & Kashmir (2014). Numerical Weather Prediction (NWP) models have been able to predict these events in the past, however accurate spatial and temporal prediction of rainfall is still a challenge. This study attempts to assimilate upper air observations (Radio Sonde & Pilot Balloon) in Weather Research Forecast (WRF) Model using three dimensional Variational (3DVar) technique and study its impact on predicting severe weather events over Indian region. Total five cases have been studied, one each over J&K and Uttarakhand and three over Central Indian region. WRF model has been set to nested domain with outer domain of resolution 30 km and inner domain of 10 km. Model was set to 'WSM-3' Microphysics, 'Yonsei University' Planetary Boundary Layer and 'Kain-Fritsch' Cumulus Parameterization scheme. Two model runs were performed, one CNT (without assimilation) and another EXP (with assimilation). Results revealed that the Root Mean Square Difference and Bias for 'OBSERVATION-ANALYSIS' was lesser than 'OBSERVATION-BACKGROUND', which suggested that analysis was closer to observations. ECMWF ERA interim data was used to compute the 'Improvement Parameter' for Analysis and Forecast for state Variables (Temp and Specific Humidity) while JAXA GSMAP rainfall data was utilised to verify the impact on rainfall. There was an improvement of an order of 30% in the state variables (Temp and Specific Humidity) in Analysis as well as in 24 and 48 hours forecast. Same magnitude improvement was also visible in 24 hours (Fig. 1) but slightly lesser in 48 hours predicted rainfall in EXP. Domain area with positive, negative and neutral impact was studied. It was found that after assimilation 50-60% area in the domain experienced positive impact while 20-30% area had negative and around 20% area was neutral i.e. no impact in almost all five cases.

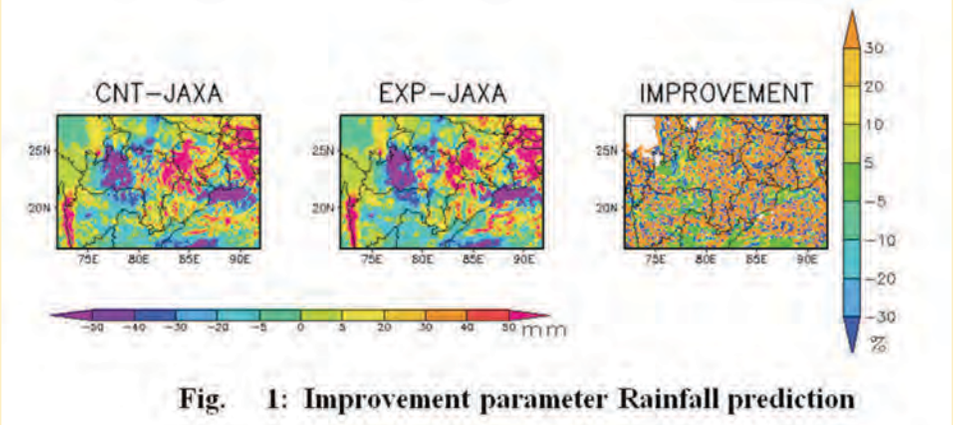


Fig. 1: Improvement parameter Rainfall prediction

Cdr TS Ramanathan
India

Born in Chennai, Rama (as popularly addressed by everyone) graduated as an Engineer from Madras University and got commissioned in Indian Navy in 2005. He got trained in Meteorology from IMD, Pune and acquired his Masters in Atmospheric sciences from Cochin University, He has served as training officer in INS Chilka, Met Officer in Naval Air Station INAS Rajali (in Arakkonam) and INAS Garuda (in Kochi), Indian Naval Met Analysis Centre, Kochi and onboard Aircraft Carrier INS Viraat.

The Officer is a cheerful, music enthusiast and an active member of the group. He enjoys spending time with friends and reading books. He is a team man who takes everyone along. A great musician who adores musical instruments as treasure of his life. Musical evenings spent at his room were refreshing, enjoyable and memorable for everyone. A kid at heart.

Office:
INS Viraat,
C/o Fleet Mail Office,
Naval Dockyard,
Mumbai 400001
India
Phone : (M) +919869985243 (H) +91-022-22146652
Fax : N.A
Email : insramnath@gmail.com , tsreesh@yahoo.co.in

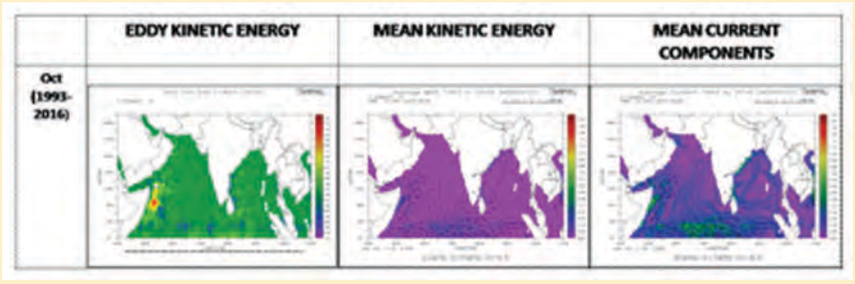
Abstract

Cdr TS Ramanathan
Metoc Officer

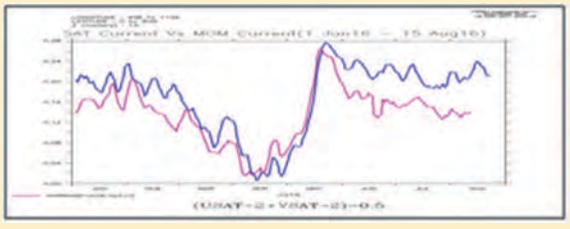
Guide: Dr. Rajesh Sikhakolli
EPSA/AOSG/GRD/SAC

STUDY OF VARIATION OF SATELLITE DERIVED SURFACE CURRENTS OVER NORTH INDIAN OCEAN

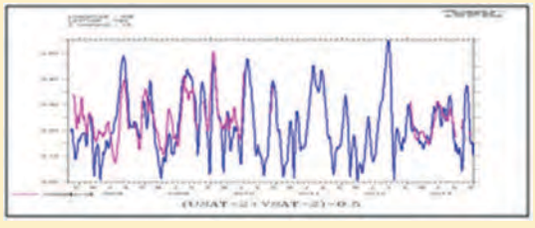
An **ocean current** is a continuous, directed movement of seawater generated by forces acting upon this mean flow, such as sea level gradient, associated breaking waves, winds, the Coriolis effect and sinking of water due to temperature and salinity differences. Ocean surface current is a dynamic parameter, the global and regional cycle and variability of which is difficult to capture from in-situ measurements. The advent of Satellites for measuring various atmospheric and ocean phenomenon is being utilized to measure the currents by observing sea level through Altimeter derived gridded Map of Absolute Dynamic Topography (MADT) generated from the suite of altimeters such as JASON-2, SARAL/ALTIKA, Cryosat etc., wind stress derived from scatterometers such as ERS-1,2, QuikSCAT and ASCAT wind data and SST data derived from AVHRR. The methodology uses the combination of the geostrophic component from altimeter data and the ageostrophic component from scatterometer and radiometer data (Bonjean and Lagerloef, (2002)). The surface currents thus derived are available for the period from 1 Jan 1993 to 31 Dec 2016 over the Indian Ocean region (from SAC). The data variability is critically analyzed for 15 meters depth currents and corresponding Eddy Kinetic Energy(EKE) and Mean Kinetic Energy(MKE). Variation of magnitude of zonal and meridional components over specific regions viz. SE Bay of Bengal, Head Bay, Coastal Tamil Nadu (to capture EICC), Konkan-Kerala Coast (to capture WICC) and Somali coast (to capture Somali current) are analyzed. The scope of the discussion also undertakes inter-comparison of above mentioned satellite derived currents with Modular Ocean Model (MOM) generated analysis current (used by Navy) and RAMA Buoy observed currents for available zone in the Indian Ocean Region. One of the vital variability that have been captured includes, reduction of peak strength of EICC during winters since 2006. Such cycles are discussed in relation with other events such as variation monsoonal shifts, Nino Index variation and Dipole mode index variability. The discussion concludes on the aspect of importance in continuity in utilization of satellite derived surface currents and how it would help in understanding long period cycles and local changes in the vast ocean.



Comparison of Eddy Kinetic energy, Mean Kinetic Energy and Ocean Currents



Comparison of Satellite derived mean currentsVs MOM derived mean currents over Indian Ocean Region



Comparison of Satellite derived mean currentsVs RAMA buoy currents over 15N,90E

Mr. Aleksei Saiapin
Kyrgyzstan

Office:
Department Of Metrology,
Ecology and Environment Protection
44 Kievskaya St,
Bishkek-720000
Kyrgyzstan.
Phone : (O) +996312360288,
(H) +996 0312 405835,
(M) +996 553 489520
Fax : N.A
Email : aleksei.say@gmail.com , meteo@elcat.kg
wass@protonmail.ch

Born on 19 April 1992 in Bishkek, Kyrgyzstan and joined the Department of Meteorology, Ecology and Environment Protection in Kyrgyz-Russian Slavic University (KRSU) in 2010. Since 2012 he has been working as an engineer in the Department. Since last year he has been working as a Junior Research Fellow in hydrogeology department of Institute of Water Problems and Hydropower, Academy of Science (Kyrgyzstan).

A person with a real Russian heart who is intelligent, shrewd and thinks about helping the community. A great friend and a happy buddy. His interpretation and old time saying are very impressive.

Abstract

Mr. Aleksei Saiapin
Senior Laboratory Assistant

Guide: Mr. Abhineet Shyam
EPSA/AOSG/GRD/SAC

Determination of ABL height and global characterization using GPS-Radio occultation data

An algorithm to determine Atmospheric Boundary Layer (ABL) height is established using the radio occultation refractivity data. The algorithm is based on quantitative estimation of the significant lapse of refractivity within the height range of 0.5 km to 3.5 km. It is known that the ABL is the region of significant lapse of humidity and temperature and is critical determinant of flux of energy and moisture in the troposphere and for air pollution meteorology. Whereas the humidity shows a sharp decrease inside the ABL region, temperature is found to show increasing trend, alsocalled the inversion. Since radio refractivity derived from radio occultation technique is related to temperature and water vapour partial pressure, more dominantly on the water vapour content in the lower troposphere where ABL is normally found, there is a high probability of detecting the ABL signature in the refractivity profile, as seen from fig.1(a-d).Refractivity from COSMIC radio occultation is uniformly interpolated at 5m vertical height and linear regression is applied in the sliding window of width 300 m. The height at which the change in slope of the straight line fit is maximum in the consecutive windows is the top of the detected ABL. The result is compared with collocated radiosonde data by applying the algorithm on interpolated radiosonde as well as with the ABL detected using the sharp lapse of humidity and derived-refractivity in the radiosonde. ABL height distribution is characterized using the occultation data for various geographical regions and in selected domains over land and oceans with reasonably good accuracy with this method.

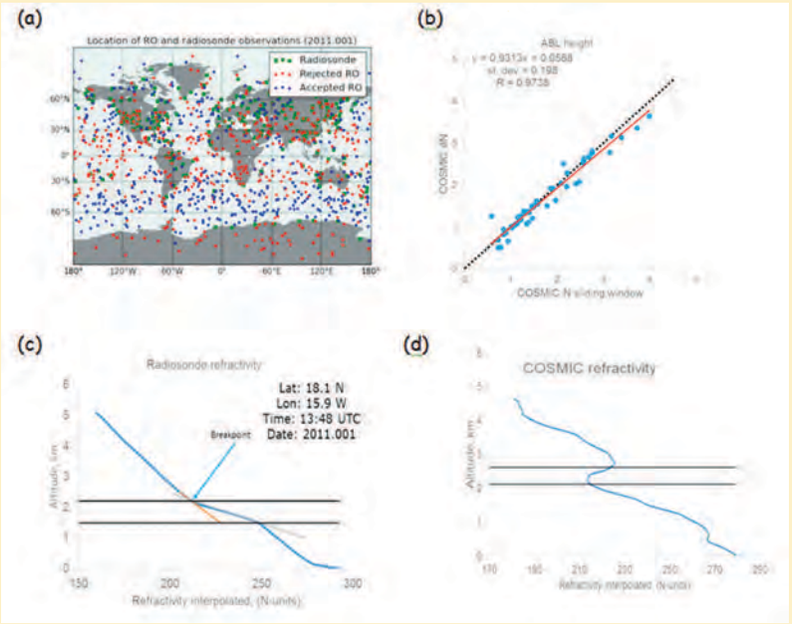


Figure1.(a) Location of COSMIC (all events and with penetration depth < 0.5 km) and collocated radiosonde. (b) ABL height scatterplot from COSMIC occultation using two different methods.(c & d) ABL height shown for all three data types in successive plots.

Ms. Kunduz Abirova
Kyrgyzstan

Office:
Department Of Metrology,
44 Kievskaya St,
Bishkek-720000
Kyrgyzstan.
Phone : (O) +996 558 587773, (H) +996 554 282729
(M) +996 558 987872
Fax : N.A
Email : kunduz1717@gmail.com , meteo@elcat.kg

She was born on 17 March, 1994 in Bishkek. She has graduated from the Kyrgyz-Russian Slavic University in Bachelor of Hydrometeorology in 2015. She has been working in department of weather forecasting in Kyrgyz Hydrometeorology agency under ministry of emergency situations since 2015.

The 'youngest and prettiest' member in the gang. She amazes everyone with her mingling and has smiling face. She enjoys every moment, and party's in the group, and makes the energy and environment vibrant.

Abstract

Ms. Kunduz Abirova
Junior Laboratory Assistant

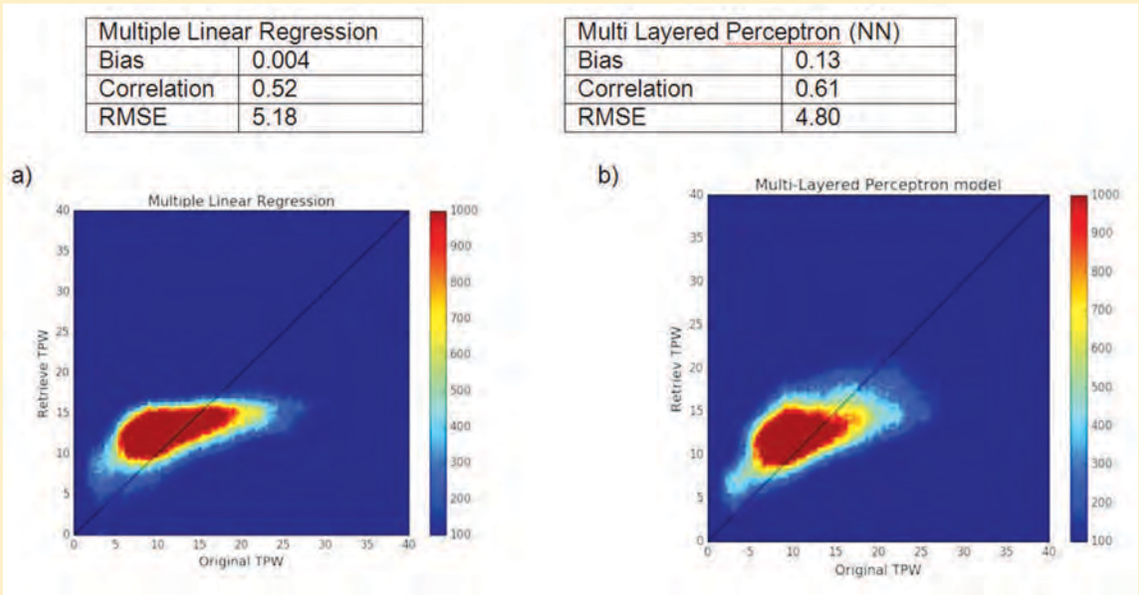
Guide: Dr. Kaushik Gopalan
EPSA/AOSG/GRD/SAC

ESTIMATION AND VALIDATION OF TOTAL PRESIPITABLE WATER OVER CENTRAL ASIA

Water Vapour in the atmosphere is vital for global weather and climate.The accurate temporal and spatial measurement of humidity is possible today by satellite observations. Satellite passive microwave observations around the 183.311 GHz water-vapour line can provide accurate monitoring of water-vapour profiles, with good temporal and spatial sampling for operational numerical weather prediction (NWP).

TheMetOp satellite carries two passive microwave sounders, Microwave Humidity Sounding(MHS) and Advanced Microwave Sounding Unit-A. MHS provides water vapor measurements in the 183.31±1,183.31±3 and 190.311 GHz, plus the two window channels at 89 and 150 GHz at 16 km spatial resolution.

In this project, we have estimated Total Precipitable Waterover Central Asia using MHS observations andTPW datafrom the six-hourly operational global analyses (European Centre for Medium Range Forecasting).The retrieval is performed using linear regression and Neural Network (NN) model by training collocated MHS and ECMWF data. Both of this methods gave similar results with the root mean square errors (RMSE) of ~4.8 – 5 mm, which is ~25% higher than the errors reported by NOAA for their operational retrievals. Also stratifying the retrieval method based on local zenith angle had negligible effect on the result. The validation of this retrieval schemes is performed using radiosonde observations over Central Asia.



Colored Scatter plot of Original TPW and retrieved TPW using a) Multiple Linear Regressionand b) Multi-Layered Perceptron (NN)

Ms. Zhamilia Asanbekova
Kyrgyzstan

Office:
International University of Innovation Technologies
1/17 Ankara (Gorkiy) street, Bishkek, 720048,
Kyrgyzstan
Mobile: (H) +996 556073160
Phone:(O) +996 312519223
Email : jajuje.76@gmail.com

Born in Karakol city, north-east of Kyrgyzstan. Currently she is in Bishkek, the capital of Kyrgyzstan. In 1998 she has graduated from the Issyk-Kul State University as a geography teacher. In 2012 she defended her thesis for a Master's degree in Geo-Ecology. Lives and works in Bishkek, in International University of Innovation Technologies. She likes traveling (trekking, hiking) and classical music.

She is the silent enjoyer in the gang. A very sportive and supportive person. She participates in all activities with zeal and enthusiasm.

Abstract

Ms. Zhamilia Asanbekova
Geography Teacher

Guide: Dr. Ram Rajak
EPSA/GHCAG/CSD/SAC

Estimation of ice surface velocity using LANDSAT-8 data over INYLCHEK Glacier

Glaciers, especially in mountain area are sensitive indicators of climate fluctuations. The study of glacier velocity is important to study mass balance of ice, glacier dynamics and predict glacier hazards. In Central Asia the glaciers are the primary resource for fresh water. Understanding the seasonal behavior of these glaciers would help to make efficient use of the available water reservoir. This article presents results of a study carried out to estimate ice surface velocity of the Inylchek glacier, Tien Shan range of in Kyrgyzstan. The availability of the high quality spectral bands of the Operational Land Imager (OLI) on board Landsat-8, the data allows us continuous monitoring of Earth's surface changes including geological processes, climate change and anthropic change. Surface changes related to displacement of the Earths Surfaces like Sand Dune migration, glaciers migration, co-seismic ground deformationlandslides can be measured using automatic ortho-rectification, co-registration and sub pixel correlation of satellite data available in COSI-Corr (Co-registration of Optically Sensed Images and Correlation) Software package. The displacement vector is deduced by applying sub-pixel image correlation technique on the temporal Landsat-8time series datasets (2014-2016-2017). Although, the Landsat-8 OLI data was terrain corrected geo-referenced images, we carried our accuracy assessment before subjecting them to COSI-Corr. We found that the relative geometric accuracy of the dataset was very good. The Digital Numbers (DN) values were converted to radiance and surface reflectance. The spatio-temporal variations were analyzed. Displacement vectors were obtained in EW and NS directions along with SNR using COSI-Corr. Sample of Correlation image obtained over the Inylchek glacier (2014 vs 2017) is shown in Figure 1. Displacement Vector figure 2

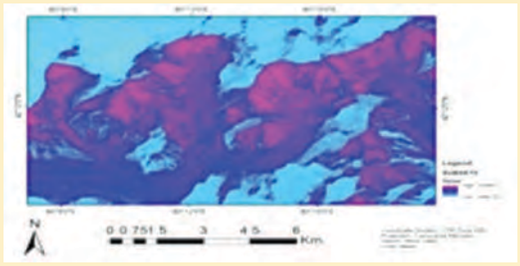


Figure 1. Warped image correlation of Landsat-8 images over the central Inylchek glacier for the period between 17 February 2006 and 4 March 2014.

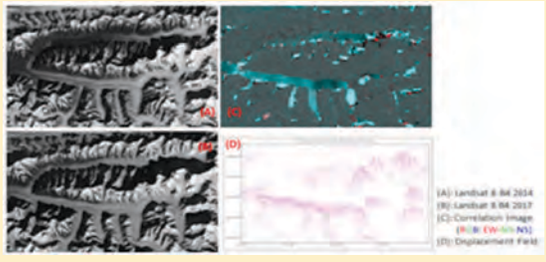


Figure 2. Correlation image and displacement field image of Inylchek glacier

Mr. Noor Azam Bin Shaari
Malaysia

Born on 20 January 1974 and raised in Penang, Malaysia. This research scholar has completed Master in Disaster Management and Tsunami from National Graduate Institute for Policy Studies (GRIPS), Japan. With the qualification of having Bachelor Science in Mathematics, he worked as a Mathematics Lecturer in Private College from 1999 to 2008. Presently working in Malaysian Meteorological Department as Meteorologist, Research and Development division, and has several years of experience in forecasting, especially for Public and Military aviation. He has shown much commitment and interest in this new discipline to develop his division particularly in satellite research application.

Office:
Butterworth Meteorological Department,
Pengkalan Udara Tudm-13050,
Butterworth, pulau Pinang,
Malaysia
Phone : (M) +6019-5684740
(O) +604-3314633
Email : noor_azam@hotmail.com ,
noorazam1975@gmail.com

The wise man and the gang controller. He is the person who has the perfect say for all situations. Azam is great at giving advice and leading. He is famous for 2 minutes conversation to a straight 2 hours talk show. He is a truly enticing man from truly Asia, Malaysia. He is serious in study but cheerful person and easy to get along with others.

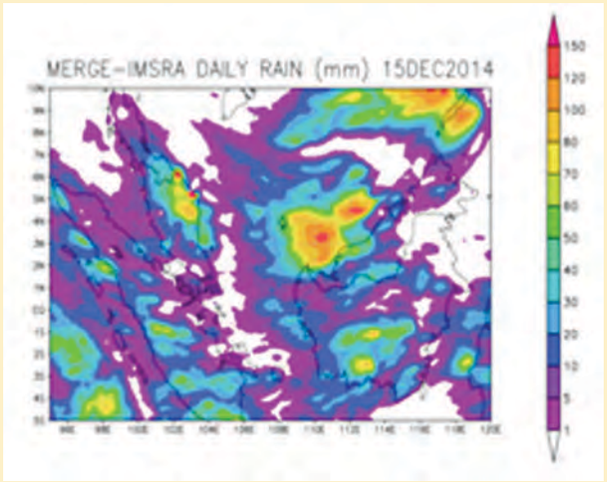
Abstract

Mr. Noor Azam Bin Shaari
Metrological Officer

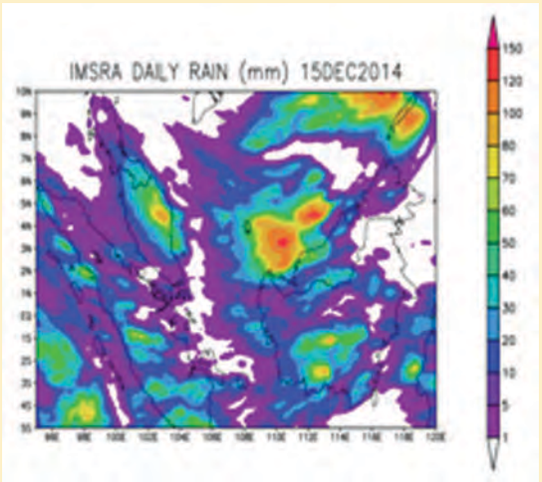
Guide: Dr. R. M. Gairola
EPSA/AOSG/ASD/SAC

Assessment of Rainfall From Insat-3D – IMSRA Technique for The Flood Event in Malaysia

Rainfall estimation over tropical region requires continuous efforts in order to understand the pattern and its distribution. The rainfall estimation from satellite is becoming the major interest now as the ground based observation stations are very limited. The estimation is very important for the national disaster mitigation agency as first- hand information for planning purposes. Insat Multispectral Rainfall Algorithm (IMSRA) is approach developed by SAC-ISRO (Gairola et al. 2015) to quantitatively estimate the rainfall over the Indian land and oceanic regions. The algorithm was developed based on the calibration of Thermal-IR radiances with TRMM-PR Microwave measured rainfall data for retrieval. The same technique is applied beyond the Indian regions to measure the model accuracy and performance. Malaysia is located slightly off from Indian region but within the INSAT-3D satellite observation domain. Extreme rainfall event in Malaysia from 13th to 25th December 2014 is chosen for the study. Thermal IR from INSAT-3D satellite data is used for rainfall estimation and is validated with TRMM-3B42 and GSMaP dataset. The IMSRA estimated rainfall is also merged with the surface rainfall obtained from 34 observation stations in Malaysia on daily basis. Picture (a) shows the estimated rainfall on the 15th December 2014 from plane IMSRA technique followed by the merged rainfall with the surface rainfall data. The statistical result showed strong positive correlations between merged IMSRA, TRMM-3B42 and GSMaP and ground based measurements. The overall result shows that the IMSRA technique is very well performing in Malaysian regions and thus can be applied beyond the Indian regions to understand the hydrology cycle and rainfall pattern.



Picture (a)



Picture (b)

Ms. Davaabal Batsukh
Mongolia

Office:
Centre for Hydrology, Meteorology and Enviromental service of Ulaanbaatar,
National Agency for Meteorology and Enviromental Monitoring of Mongolia,
Denjiin 2A, Khoroo-31,
Songinokhairkhan District,
Ulaanbaatar,
Mongolia
Phone : (M) +976-99021856,
(O) +976-70282323, +976-70282326
(H) +976-88281218
Fax : +976-70282323
Email : davka0620@yahoo.com,
davka6696@gmail.com

Born on 20th June 1987 in Khovd province and lives in the capital city of Ulaanbaatar, Mongolia. She graduated in Bachelor of Science (Meteorology) during the 2005-2009 and now, studying for her Master of Science (Meteorology) from National university of Mongolia. Presently she is working Center for Hydrology, Meteorology and Environment Monitoring of Ulaanbaatar city, NAMEM, Mongolia since 2013.

The Jenifer Aniston look alike and an obsessive perfectionist. The way she arranges her notes is an example for all of us. She loves to party and charms the gang with her beautiful rendition of Mongol Songs. An awesome singer.

Abstract

Ms. Davaabal Batsukh
Meteorologist

Guide: Mr. Prateek Kumar,
EPSA/AOSG/GRD/SAC

Validation and Application of IASI and INSAT-3D Temperature and Humidity Profiles using collocated profiles from Radiosonde observations

Atmospheric temperature and water vapor in air plays an important role in many global weather phenomena like thunderstorms, cyclonic storms etc. Hence, accurate information of temperature and moisture profiles is a critical factor for prediction of such phenomena.

In this study, we have taken Radiosonde temperature and moisture profiles (Mar-2016, February 2017) and collocated with 0.5 deglat/lon in space and 3 hours in time with IASI observations over Mongolia and INSAT-3D Observations from India. Unlike IASI, INSAT-3D is a geostationary satellite, hence it has a high temporal resolution and its data is available on an hourly basis but only on Indian subcontinent. So, we have maintained temporal collocation of 1 hour with INSAT-3D. While since IASI is a polar orbiting satellite it covers entire globe including Mongolia but only at certain specific times, so to increase number of radiosonde collocations with IASI, we have relaxed our criteria of temporal collocation up to 3 hours. At present, Mongolia have only 4 radiosonde stations. In this study, bias and root mean square error are computed along with time series of collocated profiles at various pressure levels. Similarly, all this analysis was done for individual Mongolian radiosonde station. Seasonal variation in error statistics is also have done for 4 major Mongolian seasons. (Spring, Summer, Autumn, Winter)

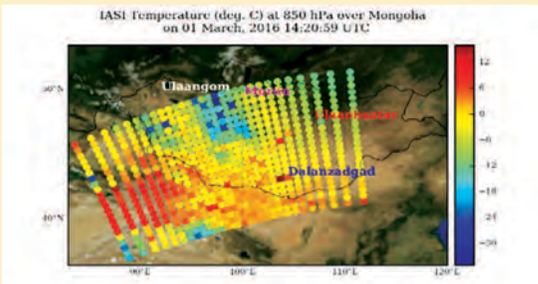


Figure 1. IASI Temperature at 850 hPa over Mongolia

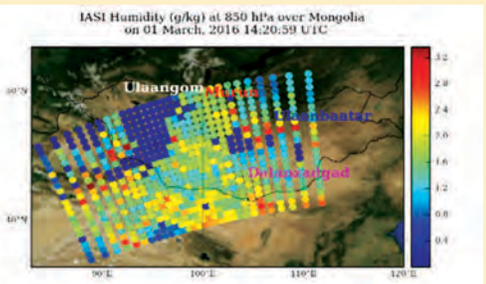


Figure 2.IASI Humidity at 850 hPa over Mongolia

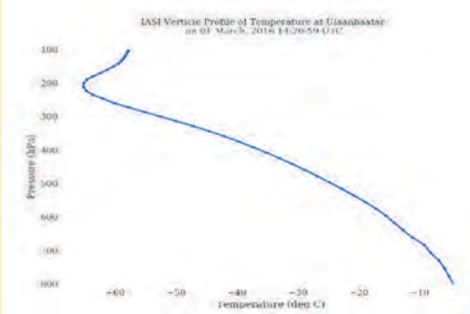


Figure 3. IASI vertical profile of Temperature at Ulaanbaatar

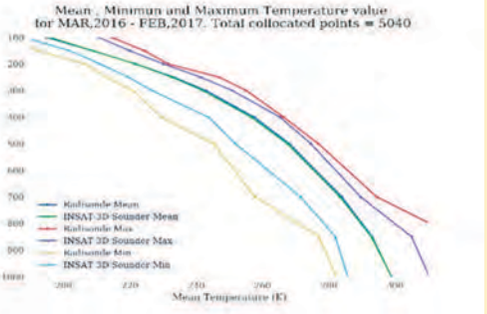


Figure 4. Average , Minimum and Maximum values of Temperature by Radiosonde and INSAT-3D Sounder over India for Mar-2016-Feb 2017

Ms. Delgermaa Urtnasan
Mongolia

Office:
Information and Research institute of
Meteorology, Hydrology and Environment,
Juulchny Gudamj-5,
Chingelteiduureg,
Ulaanbaatar-15160
Mongolia
Phone: (M) +976-96091290
(O) +976-11-326606
Fax : +976-11-329968
Email : dma0521@gmail.com , dma0521@yahoo.com

Born on 21st May 1991 in Khovd province and lives in Capital city of Ulaanbaatar, Mongolia. Hobbies are reading, surfing the internet and collecting souvenir. She earned Bachelor of Science (Meteorology) during 2009-2013 and Master of Science (Meteorology) during 2014-2016, both from national University of Mongolia. She joined Information and Research Institute of Mongolia, Hydrology and Environment since 2013 as Weather Forecaster.

An intelligent observer and a silent person. She is the popular beautician and stylist to all the girls in the course. The girl next door who really enjoys Indian dresses.

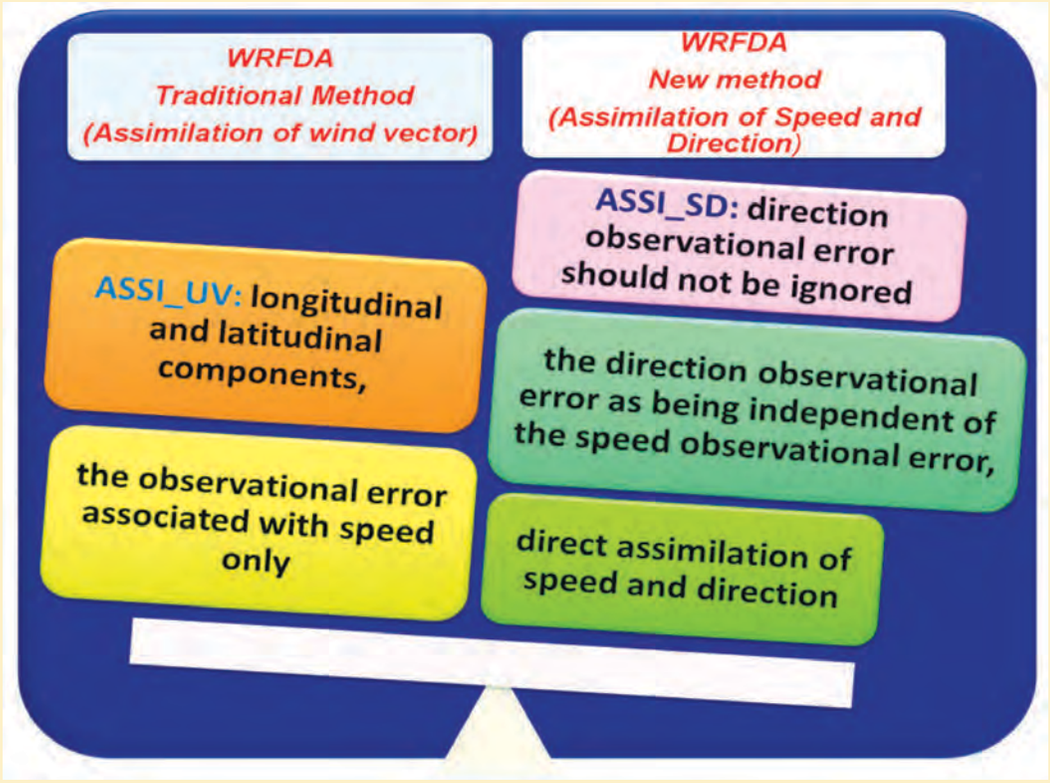
Abstract

Ms. Delgermaa Urtnasan
Weather Forecaster

Guide: Dr. Prashant Kumar,
EPSA/AOSG/ASD/SAC

Assimilation of Satellite Retrieved Winds in WRF Model

In this project, Indian geostationary satellite INSAT-3D retrieved atmospheric motion vectors (AMVs) were assimilated into the Weather Research and Forecasting (WRF) Model using three-dimensional variational (3D-Var)data assimilation. The objective of this work is to compare the importance of wind vectors assimilation (traditional method; ASSI_UV) against wind speed and direction assimilation (new method; ASSI_SD).Three parallel set of experiments are performed using with and without assimilation of AMVs in the WRF model. In addition to INSAT-3D AMVs, microwave radiances from the Advanced Microwave Sounding Unit-A (AMSU-A) and Global Positioning System Radio Occultation (GPS RO) refractivity data are assimilated in all the experiments. Results show that assimilation of INSAT-3D AMVs improve model analyses and subsequent forecasts compared to control experiments (No AMVs). Further, results show that assimilation of speed and direction (ASSI_SD) directly improve bias in analyses compared to ASSI_UV experiments. It is important to note that ASSI_SD run has positive impact on temperature and moisture predictions compared to ASSI_UV run which is due to multi-variate nature of variational data assimilation.



Mr. Tsolmon Khishigsuren
Mongolia

Office:
Information and Research institute of Meteorology,
Hydrology and Environment,
15160 Juulchny Street-5
Chingeltei District,
Ulaanbaatar
Mongolia
Phone: (M) +976-90067010
(O) +976-11-326603
Fax : +976-11-326614
Email : khishigsuretsoomoo@gmail.com,
tsoomoo_1124@yahoo.com

Born on 24th November 1991 in Ulaanbaatar, the capital of Mongolia. He graduated in bachelor of science (meteorology) during 2009 to 2013 from National University of Mongolia. He has been working as a weather forecaster in Institute of Meteorology, Hydrology and Environment since in August 2013.

The 'commando' of the group. Dresses to perfection and style with an inherent suave. A bright guy who is very quick to grasp the situation. He enjoys company and sportingly participates in all activities.

Abstract

Mr. Tsolmon Khishigsuren
Forecaster

Guide: Dr. Munn Vinayak Shukla,
EPSA/AOSG/GRD/SAC

Evaluation of atmospheric profiles of ECMWF analysis, GFS analysis and forecast using Radiosonde observations over Mongolian region

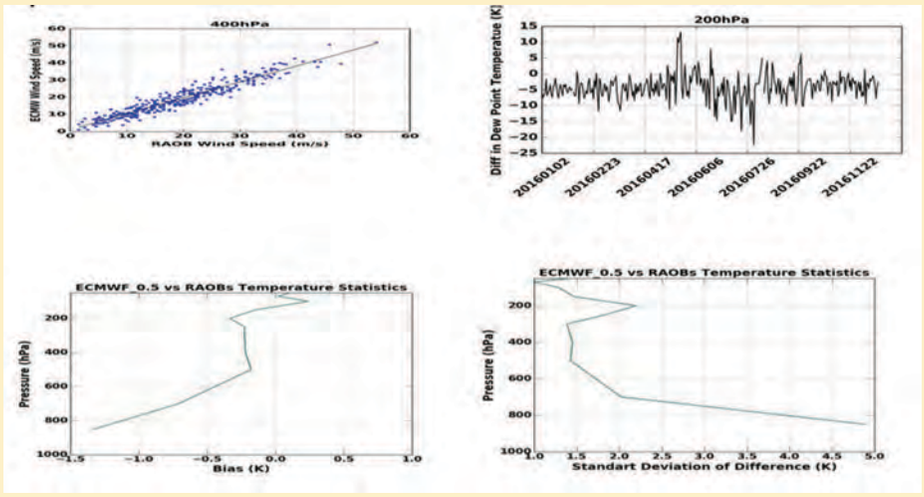
Mongolian economy is primarily governed by agriculture and livestock, therefore, weather plays a very important role in Mongolian economy. It is worth mentioning here that approximately 2.4 million livestock were lost in bad weather or natural disaster in year 2000, which resulted in fall of GDP from 3.2% to 1.3%.

An accurate weather forecast can not only save lives of human but of extremely valuable livestock too. Presently, there are only four stations Ulaanbaatar (47.93N, 106.98E), Dalanzadgad (43.58N, 104.42E), Murun (49.63N, 100.17E), Ulaangom (49.97N, 92.08E) that launch radiosondes for upper air observations and used in weather forecast. The distributions of these observations is not sufficient to cater the need of weather forecasting for the country like Mongolia. For providing weather forecasts over whole Mongolian more atmospheric profiles are needed over this region. This requirement can be fulfilled by taking observations from satellites or from global numerical weather prediction (NWP) models. As it is well known that quality of weather forecast depends on the data used for forecasting, therefore, it is desired to evaluate atmospheric profiles from a given source before using it for forecasting purpose. This study is primarily undertaken to evaluate the accuracies of atmospheric profiles of temperature, humidity, wind-speed and wind-direction from ECMWF analysis, GFS analysis and forecast.

The main advantage of using global NWP model based atmospheric profiles for weather forecasting is that NWP model output is freely available at each grid point and on regular time interval. This study is evaluating ECMWF analysis, GFS analysis and forecast profiles by validating it with RAOBS of four stations.

Scatter plot of the wind speed from the RAOB vs the ECMWF0.5 model at 400 hPa in Murun station for year 2016

Time series plot of the dew point temperature difference (RAOB minus GFS 12HF) at 200 hPa in Ulaangom station for year 2016.



ECMWF_0.5 vs RAOB Temperature statistics in Ulaanbaatar station for year 2016.

Mr. Dhruba Lochan Adhikari
Nepal

Office:
Central Department of Hydrology and Meteorology,
Tribhuvan University, Kirtipur,
Nepal
Phone : (O) +977-1-4333887, (M) +977-9841510968
(H) +977-9844319215
Fax : N.A
Email: dladhikari@gmail.com,
dladhikari@cdhmtu.edu.np

He was born in Ramechhap district, east of Kathmandu valley. He have completed his M.Sc. (Meteorology and Hydrology) from Tribhuvan University. He has been working as Hydrologist. He started as a Research Associate in Central Department of Hydrology and Meteorology, Tribhuvan University from 2013. He has travelled almost all parts of the country. He has been to Mt. Everest Base Camp several times. His hobbies include music, movies and travelling to new places.

He is the bollywood Hero of the gang. An intelligent Nepali from 'Punjab'. His inquisitive activities in class and hostel are attractive. He likes company and is a willful information seeker. He is a guy who keep tab as 'everything which is helpful around' freely help everyone.

Mr. Dhruba Lochan Adhikari
Teacher & Researcher

Guide: Dr. Sukanta Das
EPSA/AOSG/ASD/SAC

Simulation of Inter-annual Variability of Summer Monsoon Rainfall in a GCM over India and Nepal

Monsoon is one of the major phenomenon over the entire tropical belt that is associated with the regional climate primarily through rainfall. The importance of the monsoon rainfall is prolonged to a large fraction of the world's population and the socio economic prospect of the region. Thus the prediction of the monsoon rainfall well in advance assumes great significance. The present study aims to measure the skill of the state-of-art AGCM in simulation of ISM rainfall using the climatological and observed SST. Community Atmosphere Model (CAM) (v4, 0.47°×0.63°) developed by NCAR has been used for this study.Two experiments have been conducted; viz.CLIMO Exp. using climatological SSTand OBSST Exp. using observed monthly OI-SST.

The climatology of surface temperature, wind circulation and rainfall over the extended Indian monsoon (60°E–110° E;0°N–40°N) region has been generated through 30 years long-term simulation of CAM and analyzed using different observed Climatology viz. TRMM, NCEP reanalysis, IMD & DHM in-situ observations etc.Analysis revealed that the model simulated rainfall is affected by systematic bias. Both the simulations after rain-bias correction are able to capture the large scale features of observed climatology.The model derived temperature climatology averaged over 70°E–90°E is able to capture the variability of temperature over the different latitudinal belts of the region.The climatological wind circulation at 850 hPa and 200 hPa are also able to capture the reversal of wind during pre-monsoon and monsoon time over the region. Therefore, this study using high resolution modeled data provides an insight of the model credibility in capturing the climatic variability over the Indian Sub-continent (India, Nepal and its surroundings) and its capability for seasonal forecast.

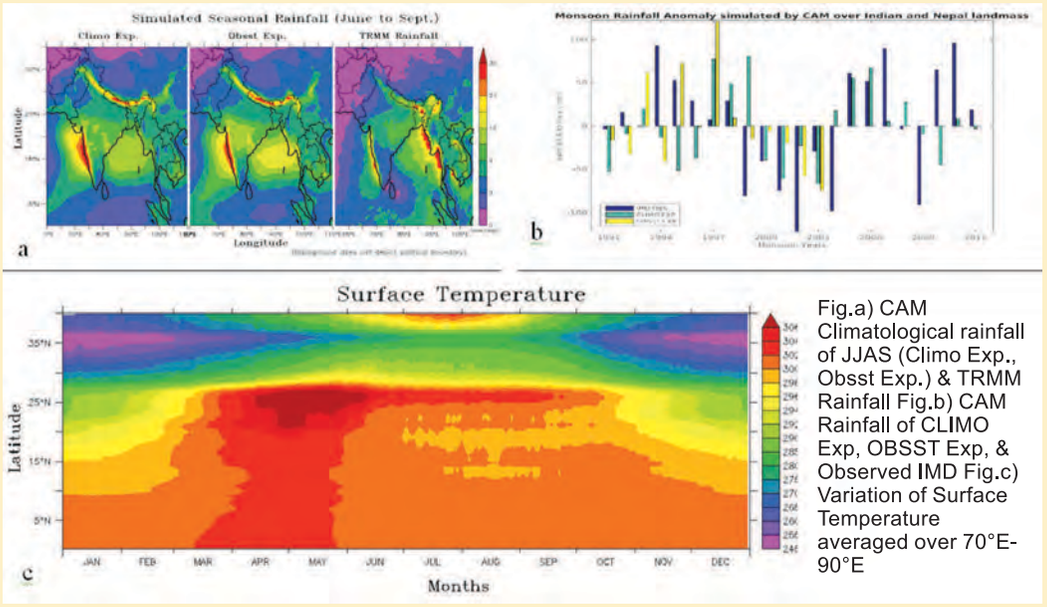


Fig.a) CAM Climatological rainfall of JJAS (Climo Exp., Obsst Exp.) & TRMM Rainfall Fig.b) CAM Rainfall of CLIMO Exp, OBSST Exp, & Observed IMD Fig.c) Variation of Surface Temperature averaged over 70°E-90°E

Acting Sub Lt. Preecha Jintanawat
Thailand

Office:
Northern Meteorological Centre,
Suthep Sub-District,
Mueang Chiang Mai,
Chiang Mai,
Thailand -50200
Phone : (O) +665 3277919
(M) +668 40041751
Fax : +665 3277815
Email : pre237@hotmail.com

Born on September 3rd ,1981 in Nakonpathom province near Bangkok. He obtained his Bachelor of Science (Physics) during 2000-2004 from Silpakorn University. He joined Thai Meteorological Department (TMD) in 2005, at Northern Meteorological Centre. He is involved in weather forecasting and aviation forecasting.

He is the lover boy of everyone in the class. The boy with a unique style which attracts everyone around. Everyone in the class will still enjoy the “Preecha” way of expression and try to imbibe his style.

Abstract

Acting Sub Lt. Preecha Jintanawat
Meteorologist

Guide: Dr. Bipasha Paul Shukla,
EPSA/AOSG/ASD/SAC

Satellite image based Nowcasting of Convective Systems

The observation and prediction of spatio-temporal structures in a Satellite Image Time Series is an integral element in satellite based weather nowcasting. Satellite observed thermal infrared(TIR) image sequence provides valuable insight into the vertical evolution of convective systems. Low Brightness Temperature (BT) values represent high cloud cells and marked increase in number of contiguous pixels having cold BT values indicate development of deep convective zones. Whilst individual Cumulonimbus clouds may have a lifetime of 1½ hours, the most intense Cumulonimbus development and thunderstorm/lightning activity is associated with Multi Cell Convective systems which may develop further into super cells. Such systems are long lived due to the spawning of daughter cells and may last for many hours. Nowcasting, which refers to forecasting for a very short time range (up to 6 hours) is useful for predicting the development and dissipation of such systems.

Satellite data, acquired from geostationary satellites provide valuable inputs for nowcasting due to their high spatio-temporal resolution. Scientists are continuously striving towards newer techniques to track and nowcast convective systems with higher accuracy and improved lead times. In this context, in the present study an image analysis technique i.e Source Apportionment (SA) algorithm has been applied for predicting individual convective systems over an air station using INSAT-3D and INSAT-3DR satellite sequence of images. The algorithm uses neighborhood search criteria to extract contiguous convective pixels. The extracted pixels are then used to trace the evolution and predict the development of convective system, using some identified nowcasting parameters.

The present technique has been applied over Thailand region for convective systems case studies for the year 2016. Tracking and nowcasting of the weather phenomenon is achieved by analyzing a few nowcasting parameters. The results of the study show that temporal variation of effective radii of convective systems and those of deep convective zones are suitable for identifying the mature stage while evolution of their slopes are good for identifying the dissipating stage. It is seen from the study that model is able to predict the mature and dissipation of a convective systems with a lead time up to 3 hours. It is also observed that by using combined 15 minutes INSAT-3D and INSAT-3DR observations, the error in predicting the size of the system is reduced considerably, especially during the dissipating stages.

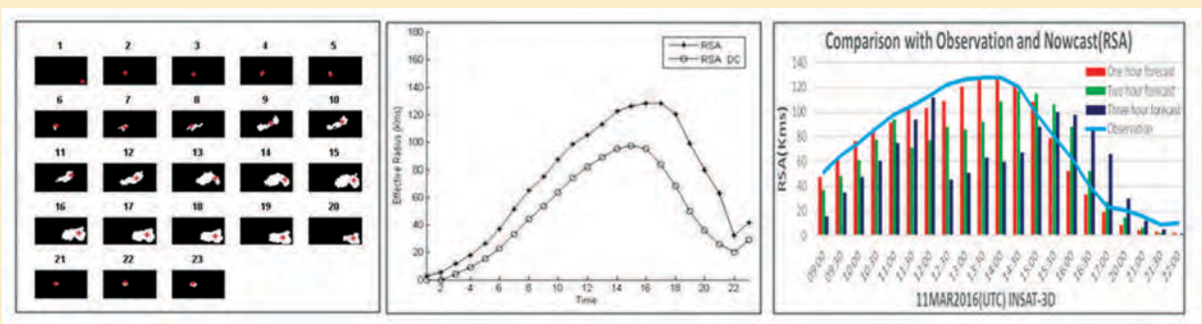


Figure 1
Source Apportionment Technique

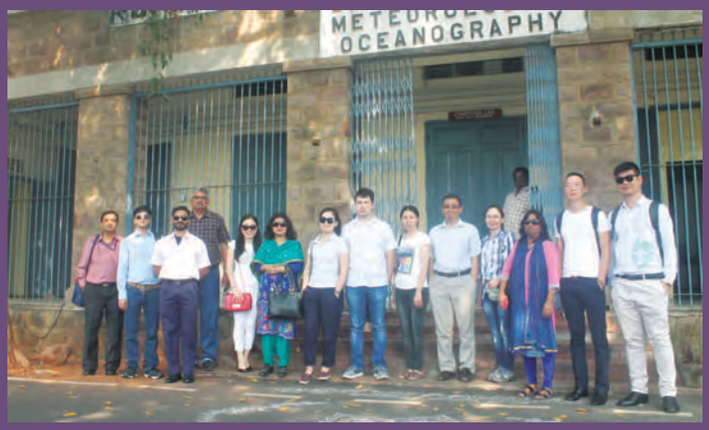
Figure 2
Nowcasting Parameters

Figure 3
Comparison with Observation and Nowcast

Educational And Cultural Tours

Educational And Cultural Tours

Educational And Cultural Tours



Educational And Cultural Tours

Impressions of the Participants

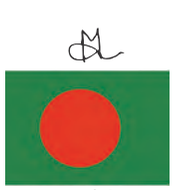
SATMET-10 course was not only a unique learning experience for all of us, but it was an eye opener for us to get an insight of scientists' way of looking at anything. It was indeed a matter of great pride for us to get selected for this course which is conducted by one of the most elite organizations of the world. Warm reception at the airport, comfortable stay in the hostel, amenities available in the room, homely and tasty food, green and clean surroundings, made all of us comfortable in our new home away from home within no time.

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. Relevant topics were covered in detail which would have direct application in our organization. The practical sessions conducted during the course have been a high skill add-on for us. The methodology used for teaching the software tools and language and finding its utilization in or project phase is indeed a well planned and successful approach to teaching. 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. Most memorable was the visit to Lotus Temple and Taj Mahal. Taste of Indian delicacies especially the Hyderabadi Biryani was enjoyed to the fullest. Shopping during these tours added to the fun. We realized that India is truly a shoppers' paradise as we have bags full of gifts and souvenirs for our family and friends. Some of our female co-participants enjoyed the opportunity to learn and master the art of wearing the most elegant Indian attire – Saree.

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 who enthused, motivated, encouraged, and enlightened us in such a way that we shall be inspired by them in our quest of knowledge throughout life.

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. The interaction with foreign students not only ensured professional exchange of ideas but even cross cultural exchange of our perspectives. The course was an overwhelming saga of scientific, professional and cultural odyssey of nine month.


Ms. Mirza Nilufar Jahan
Bangladesh


Ms. Nijhum Rokeya Ahmed
Bangladesh


Sqn Ldr Murali Krishna Chandragiri
India


Cdr TS Ramanathan
India


Mr. Aleksei Saiapin
Kyrgyzstan


Ms. Kunduz Abirova
Kyrgyzstan


Ms. Zhamilia Asanbekova
Kyrgyzstan


Mr. Noor Azam Bin Shaari
Malaysia


Ms. Davaabal Batsukh
Mongolia


Ms. Delgermaa Urtnasan
Mongolia


Mr. Tsolmon Khishigsuren
Mongolia


Mr. Dhruba Lochan Adhikari
Nepal


Acting Sub Lt. Preecha Jintanawat
Thailand

Sitting : (L To R) Shri Dharmendra Mahitkar , Shri. C. N. Lal , Dr B Simon, Shri Tapan Misra, Dr. Rajkumar , Dr. Kaushik Gopalan , Mr. Preecha Jintanawat (Thailand) Ms. Zhamilia Asanbekova (Kyrgyzstan)

Standing : (L To R) Ms. Delgermaa Urtnasan (Mongolia) , Sqn Ldr Murali Krishna Chandragiri (India), Lt Cdr T S Ramanathan (India), Mr. Tsolmon Khishigsuren (Mongolia), Mr. Dhruba Lochan Adhikari (Nepal) Mr Alekse Saiapin (Kyrgyzstan), Mr. Noor Azam Bin Shaari (Malaysia), Ms. Kunduz Abirova (Kyrgyzstan), Ms. Nijhum Rokeya Ahmed (Bangladesh), Ms. Mirza Nilufar Jahan (Bangladesh), Ms. Davaabal Batsukh (Mongolia).

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

IIRS Campus,
Post Box 222
4, Kalidas Road
Dehradun 248 001 (INDIA)
Tel : +91–135–2740 737, +91-135-2740 787
Fax : +91–135–2740 785
Email : cssteap@iirs.gov.in
Website : www.cssteap.org

IIRS Campus
Indian Institute on Remote Sensing
4, Kalidas Road
Dehradun - 248 001 (INDIA)
Tel : +91–135–2744 583
Fax : +91–135–2741 987
Website: www.cssteap.org

New Delhi Office
Department of Space
Lok Nayak Bhawan
3rd Floor, Khan Market, Prithviraj Lane,
New Delhi - 110 003 (INDIA)
Tel : 91-11-2469 4745
Fax : 91-11-2469 3871

SAC Campus
Space Applications Centre
Ambawadi Vistar P.O.
Jodhpur Tekra
Ahmedabad - 380 015 (INDIA)
Tel : 91-79-2691 6067, +91-79-2691 3344
Fax : 91-79-2691 6078, +91-79-2691 5843