THIRTEEN POST GRADUATE COURSE IN

SATELLITE METEOROLOGY AND GLOBAL CLIMATE

[SATMET - 13]

September 01, 2023 to May 31, 2024

MEMOIRS

Organised 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 UNITED NATIONS)

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[SATMET - 13]

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At

SPACE APPLICATIONS CENTRE AHMEDABAD

MEMOIRS

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

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MESSAGE

I am pleased to note that the 13th Post Graduate course in Satellite Meteorology and Global Climate (SATMET) organised by the UN Affiliated Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) and conducted by Space Applications Centre (SAC), Ahmedabad is successfully concluding. This course had seven participants from 4 countries of Asia Pacific region and they will receive diploma certificate from the CSSTEAP.

I am sure that the participants have been benefited from this course with the knowledge of the use of space based meteorological data products and services. I hope that it would enable them to develop similar applications to meet the requirements in their countries.

I congratulate all the participants of the course and wish them the very best in their future endeavors. I also compliment the faculty and staff of CSSTEAP and SAC for their efforts for successful conduct of the course.

सोमनाथ एस. / Somanath S.
Chairman, CSSTEAP Governing Board

Dated : May 13, 2024

United Nations
Office for Outer Space Affairs

16 May 2024

Message

It is with great pleasure that I extend my warmest congratulations to the graduates of the 27th RS&GIS Course, the 13th SATMET Course, and SAS Course. As you complete these rigorous programs at the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), you stand on the threshold of exciting opportunities to apply your newly acquired skills and knowledge in your respective countries.

The United Nations Office for Outer Space Affairs (UNOOSA) has always placed a strong emphasis on capacity building as a cornerstone of our mission. By fostering education and training in space science and technology, we aim to empower individuals and nations to harness the benefits of space for sustainable development. Fully in line with then vision of UNOOSA, the role of the Regional Centre for Space Science and Technology Education (CSSTEAP) is pivotal in this endeavour, particularly within the Asia-Pacific region. Through its comprehensive programs, CSSTEAP not only imparts technical knowledge but also nurtures a spirit of innovation and collaboration among its participants.

The impact of your work as graduates of these esteemed courses cannot be overstated. You are now equipped to drive advancements in remote sensing, satellite meteorology, and satellite communications. Your expertise will enable your countries to develop and enhance applications of space technologies, addressing critical issues such as disaster management, climate monitoring, and sustainable development. Your contributions will undoubtedly play a significant role in improving the quality of life and economic prosperity in your regions.

We are deeply grateful to the Indian Space Research Organisation (ISRO) and its esteemed Chairman for their unwavering support and partnership. ISRO's commitment to advancing space science and technology education is exemplified by its active involvement in CSSTEAP's initiatives. This collaboration has been instrumental in providing world-class training and fostering a global community of space professionals dedicated to leveraging space technology for the betterment of humanity.

D. Elhadani

Driss EL HADANI
Senior Adviser
United Nations Office for Outer Space Affairs

MONGOLIAN
ACADEMY OF SCIENCES

Message

Dear Colleagues at CSSTEAP

Congratulations to all the graduates who have successfully completed the 27th PG Course On Remote Sensing and GIS with a total of 18 participants from 10 countries, the 13th PG Course In Satellite Meteorology and Global Climate with a total of 7 participants from 4 countries, and the PG Course in Space and Atmospheric Science (SAS-13) with a total of 11 participants from 4 countries.
This achievement is a testament to your hard work, dedication, and commitment to advancing your knowledge and skills in these specialized fields. Your contributions will undoubtedly have a positive impact on research, innovation, and problem-solving in the areas of remote sensing, GIS, meteorology, global climate, space, and atmospheric science.

Since its foundation in 1995, the Center for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) has been provided the best contribution to build human capacity in the space science related GIS/ remote sensing, GNSS, Communication satellite and its technology development within their associated countries.

I hope that this post-graduate courses have provided the necessary knowledge and skills for the graduates and helped them to achieve their future careers and goals.

I would like to send my regards to the graduates that programs encouraged their research capability to utilize the experiences and knowledge's in developing their networks and contributes to the sustainable development efforts of their countries and wishing all success.

I extend my sincere gratitude to the Director of CSSTEAP to successfully organized those courses and training programs.

Sincerely yours,

Date

2024.03.21

Signature

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एम . शंकरन
M. SANKARAN
विशिष्ठ वैज्ञानिक/DISTINGUISHED SCIENTIST
निदेशक/DIRECTOR

MESSAGE

The Global climate change predictions are vital today more than ever before. Satellites plays a vital role in meteorology and climate monitoring globally. Space faring nations are extensively using satellite data for meteorological applications and Global Climate change studies. Advanced concepts and techniques are used for data retrieval to study and understand the movement of dust storms, cloud patterns, ice mapping, snow cover, boundaries of ocean currents, energy flows etc.

I am happy to know CSSTEAP, IIRS, Dehradun has successfully completed **13th SATMET Course** for a team of 07 Participants representing Bangladesh, Mongolia, Myanmar including 3 Indian participants at SAC, Ahmedabad. I urge the students to utilise the knowledge and experience gained through this PG course to be effectively utilised and to contribute for the betterment of home countries.

I take this opportunity to congratulate CSSTEAP, IIRS Dehradun Course coordinators, organisers, support staff and all the students for their commendable efforts in organising the PG Course. I wish all the participants success in their future endeavours.

एम . शंकरन
M.SANKARAN

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डॉ. प्रकाश चौहान / Dr. Prakash Chauhan
उत्कृष्ट वैज्ञानिक & निदेशक
Outstanding Scientist & Director

Message

I am delighted to note that CSSTEAP has successfully organized three 9 months courses starting from September 01, 2023, to May 31, 2024. I congratulate the CSSTEAP Faculty and the organizers IIRS Dehradun, SAC Ahmedabad for training 36 participants from over 10 countries spreading the technology prowess of ISRO in the areas of RS&GIS, SATMET, and SAS in the Asia & the Pacific region. I am happy to be associated with the conduct of these CSSTEAP courses and witnessing the growth of CSSTEAP activities. My best wishes and appreciation to the participants from countries across the Asia & Pacific region. I am hopeful that CSSTEAP courses will make a greater impact and outreach in the days ahead.

May 16, 2024

(Prakash Chauhan)

भौतिक अनुसंधान प्रयोगशाला
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विशिष्ट प्राध्यापक / **Distinguished Professor**
निदेशक/Director

20 मई, 2024

MESSAGE

I am happy to note that the 13th PG Course on Satellite Meteorology and Global Climate being conducted from September 1, 2023, at SAC, Ahmedabad with 7 participants from 4 countries, will be concluding on May 31, 2024.

I hope that the participants will be able to utilize the knowledge and experience gained from this course in the socio-economic development of their home countries.

I thank the faculty and staff of SAC for the successful organization of the course and extend my warm wishes to all the participants.

अनिल भारद्वाज

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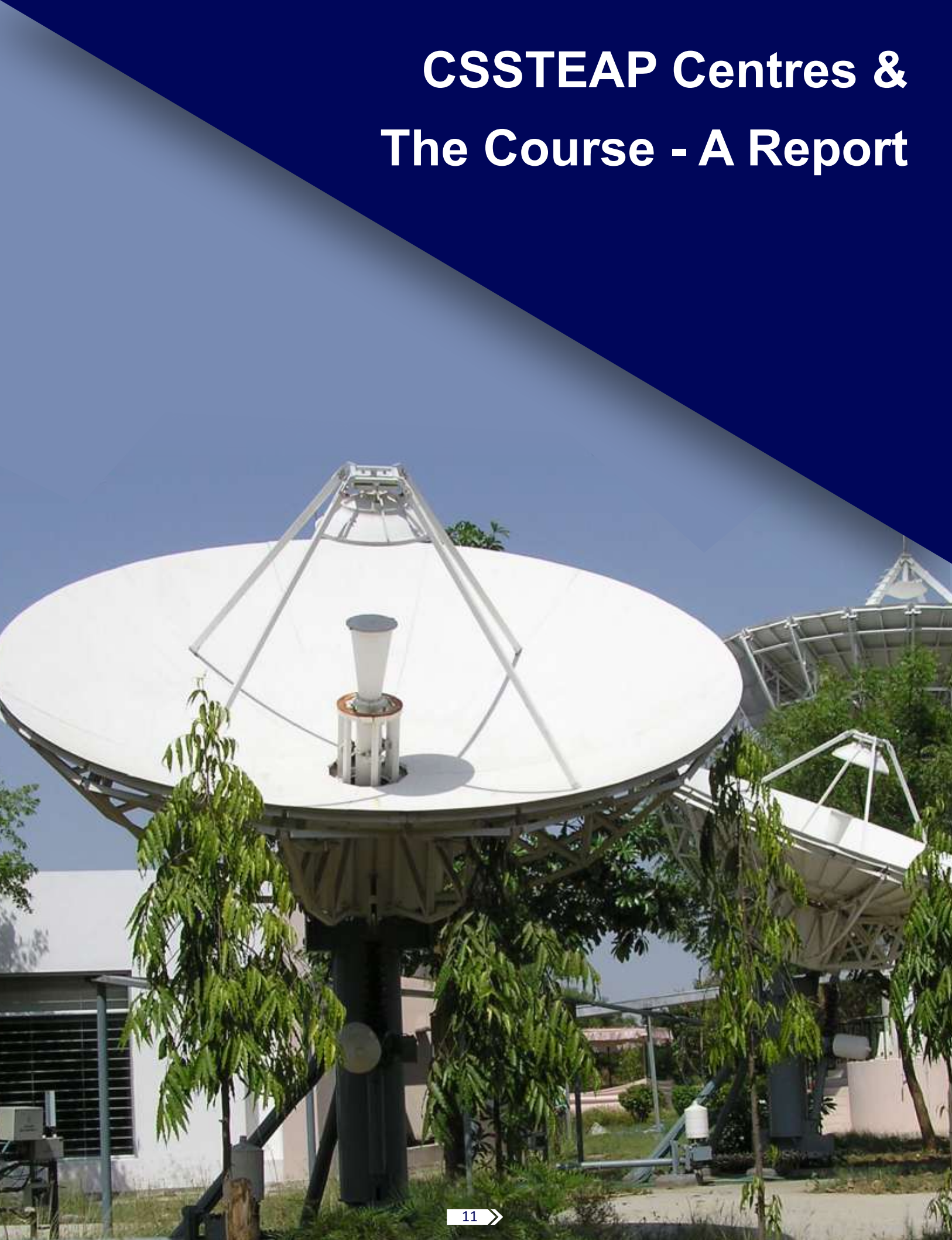
CSSTEAP Centres & The Course - A Report



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

Dr. Raghavendra Pratap Singh
Director, CSSTEAP

Introduction

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

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

Despite advances in the availability and quality of space-derived information, several gaps and challenges remain for their effective use at the AP regional and national level. A lack of capacity and resources in terms of finance, space-derived data, knowledge and expertise, specific tools and well trained human resources is a common problem. Many developing countries in the AP region still do not have the capacity to utilize, analyze and interpret space-derived data. Other challenges include issues related to policies, procedures, guidelines and standards for acquiring, sharing and utilizing space-derived products and services, and the lack of procedural harmony between agencies and countries. A comprehensive training and education in Remote Sensing & Geographic Information System (RS & GIS) would enable developing countries to build a capability in the field, and to educate and stimulate participants in other disciplines as well.

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

The Centre's headquarter is located in Dehradun, India, and its programs are executed by faculty of the Department of Space (DOS) at campuses in Dehradun, Ahmedabad, Hyderabad and Bengaluru. The Centre has arrangements with Indian Institute of Remote Sensing (IIRS), Dehradun for RS & GIS course; with Space Applications Centre (SAC), Ahmedabad for Satellite Communication (SATCOM), Satellite Meteorology and Global Climate (SATMET) and Global Navigation Satellite System (GNSS) and Navigation and Satellite Positioning Systems (NAVSAT) short courses; with Physical Research Laboratory (PRL), Ahmedabad for Space & Atmospheric Science course and UR Rao Satellite Centre (URSC), Bengaluru for short course on Small Satellite Missions and National Remote Sensing Centre (NRSC), Hyderabad for short course on Data Processing and Data Acquistion. 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, URSC and NRSC. The Centre has a Governing Board consisting of signatories from 18 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 programs. The educational programs of the Centre are oriented towards the dissemination of knowledge in relevant aspects of space science and technology. The Centre offers Post Graduate level courses in these five areas. The model of the PG courses is designed as to emphasize university educators, researchers and application scientists on the development and enhancement of knowledge and skills coupled with an application project with a small component (3 months) in India and major one (one year) in their home country with a view to transfer the technology

in their home organization. This gives an opportunity to the scholar to apply their knowledge and training received to deal with a 'real life' problem, where inputs from space technology can be used. Besides the Post Graduate level courses, the Centre also conducts short courses, workshops, awareness programs on specific themes in the four areas, highlighting how space-based information can be used for national development. These educational programs have benefited many scientists/engineers who will be the future policy & decision makers in several countries.

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

Shri S. Somanath, Chairman, ISRO/Secretary, Department of Space and Chairman CSSTEAP 28th Governing Board Meeting

to providing facilities, infrastructure and skilled manpower , the Government of India, through the Department of Space provides most of the funding. Funding grants for international travel of participants, subject experts, tuition fees and scholarships of participants and the management of the Centre are mainly provided by Department of Space on behalf of Host country. UN-OOSA and UNESCAP in Bangkok also provides funding for travel of a few selected participants.

Educational Programs

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

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

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

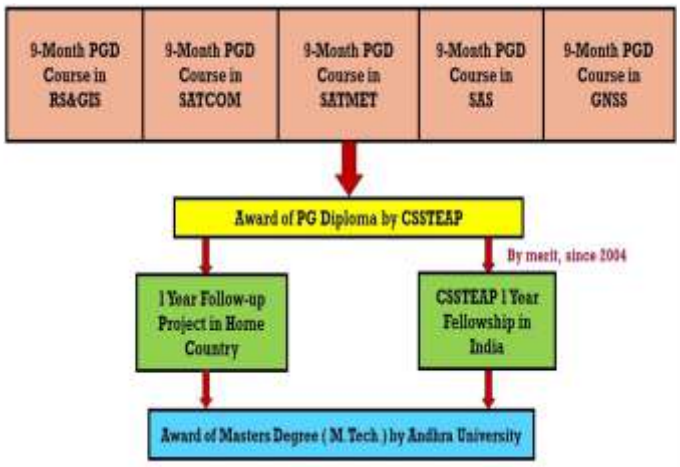


Fig. 1: Structure of PG Diploma Educational Programs at CSSTEAP

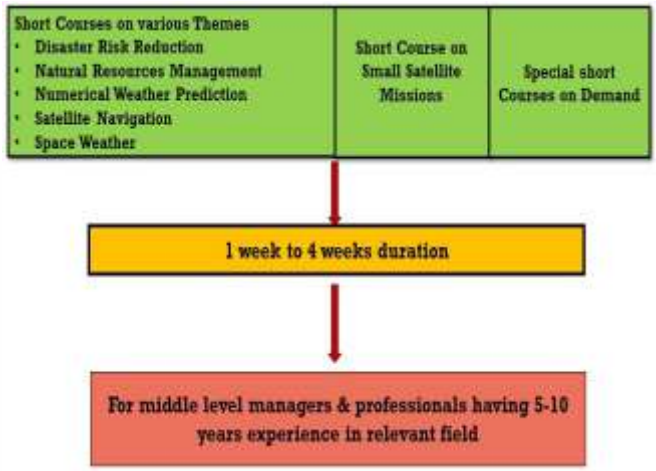


Fig. 2 Short term training programs at CSSTEAP

The educational programs are conducted in English and for participants who need help to improve their English language skills, facilities are made available upon their arrival in campus. The courses are taught in smart classroom environments with the use of modern teaching methods and tools, and also include multimedia tutorials for self-study. Practical are given in the laboratories and skill development environments of the DOS institutions. In each of the host institutions, most of the faculty are drawn from the host institutions (about 80% of the teaching time). Whenever desirable or needed, faculty is drawn from other DOS/ISRO institutions, or professional, scientific or academic institutions in India (~10%) or from institutions or organizations outside India, from the Asia-Pacific Region as well as globally (~ 5%). In order to provide wider exposure to the participants in their respective fields, the Centre provides opportunities for technical visits to scientific institutions, laboratories and national symposia in India. The successful completion of the 9-month PG-Phase of the programme leads to the award of a Post Graduate diploma by the Centre. For the participants who successfully finish their PG course and are interested in continuing for a Master of Technology (M.Tech.) degree, the Centre offers the opportunity to do so, in collaboration with Andhra University (AU) in Visakhapatnam, India. To this end, the student has to complete a 1-year research project in an application of space science or technology. This project has to be approved by CSSTEAP and AU, and the research is supervised by designated academic staff of CSSTEAP, AU and the institution where the research is carried out. In most cases the 1-year project is carried out at the home institution of the student concerned.

Till date 196 participants from 17 countries have been awarded M. Tech. Degree in the 5 disciplines (85 participants in RS & GIS; 55 in SATCOM; 23 in SATMET; 27 participants in SAS and 06 in GNSS). (Fig. 3)

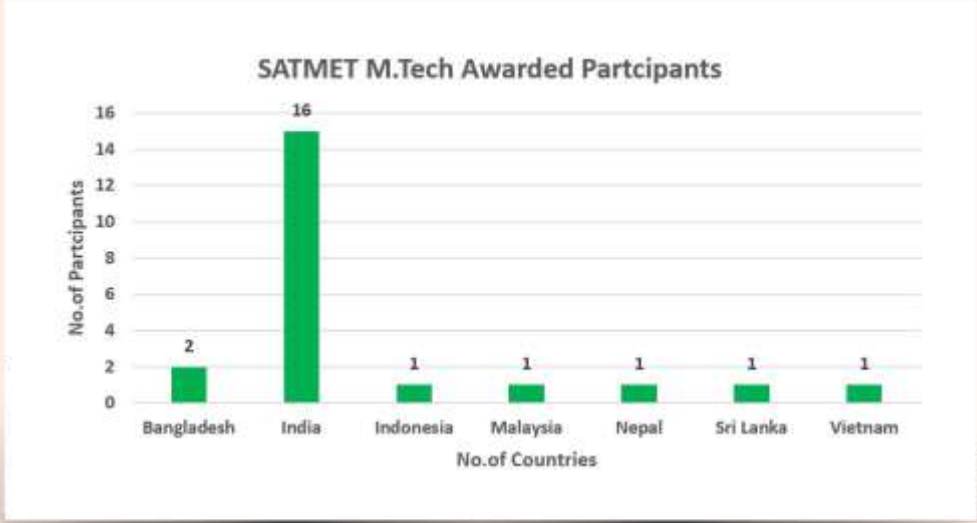


Fig. 3: Status of MTech degree awarded

Satellite Meteorology course

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

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

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

This is followed by a pilot project. The topics of pilot project are decided based on the relevance to the participant's region.

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

Achievements

Till date the Centre has conducted 70 PG Courses: 27 in RS&GIS, 13 in SATCOM, 13 each SATMET and SAS and 04 in Global Navigation Satellite System. In addition, the Centre has conducted 92 short courses including webinar and workshops in the past 28 years. These programmes have benefited more than 3600 participants from a total of 38 countries in the Asia-Pacific region and 74 participants from 26 countries outside Asia Pacific region have also benefited from these educational programmes.

CSSTEAP has collaborated with GISTDA to organize an off campus course on “Crop Classification and Inventory” at GISTDA, Bangkok, Thailand where the expert from ISRO / CSSTEAP has trained around 89 participants. CSSTEAP has also planned an off campus course at Jakarta, Indonesia with BRIN to provide capacity building for participants from Indonesia and neighboring countries.

Space Applications Centre (SAC)

Harnessing Space Technology for Societal benefits

Nilesh M Desai
Director, SAC

Space Applications Centre (SAC) is spread across three campus having multi-disciplinary activities. The core competence of the Centre lies in development of space borne and air borne instruments / payloads and their applications for national development and societal benefits. These applications are in diverse areas and primarily meet the communication, navigation and remote sensing needs of the country. Besides these, the Centre also contributed significantly in scientific and planetary missions of ISRO like Chandrayaan-2/3, Aditya-L1 etc. The communication transponders developed at this Centre for Indian National Satellite (INSAT) and Geo Synchronous Satellite (GSAT) series of satellites are used by government and private sector for VSAT, DTH, Internet, broadcasting, telephones etc.

This centre also designs and develops the optical and microwave 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 include 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. The Centre also conducts nine-month post graduate diploma courses for students from the Asia Pacific region under the aegis of the Centre for Space Science and Technology Education (CSSTE-AP) in satellite meteorology and communication.

The Organisation Structure of SAC

SAC has organized into the following major Areas or Groups:

- SATCOM & Navigation Payload Area (SNPA)
- SATCOM & SATNAV Applications Area (SSAA)
- Sensors Development Area (SEDA)
- Microwave Remote Sensors Area (MRSA)
- Earth and Planetary Sciences and Applications Area (EPSA)
- Electronics Support and Test Services Area (ESSA)
- Mechanical Engineering Systems Area (MESA)
- Systems Reliability Area (SRA)
- Signal & Image Processing Area (SIPA)

- Antenna Systems Area (ASA)
- Human Spaceflight & Advanced Technology Area (HSTA)
- Management & Information Systems Area (MISA)
- Cyber services & Information Technology Area (CITA)

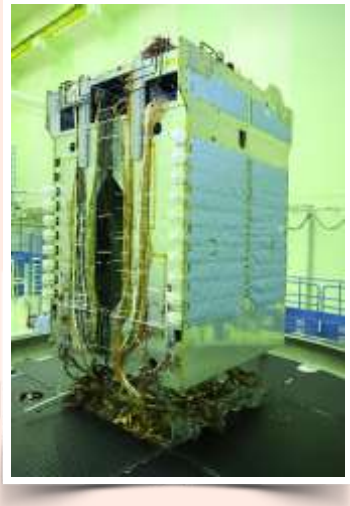
The Administrative areas comprises of Personnel & General Administration, Purchase & Stores, Accounts & Finance, Construction & maintenance etc. SAC fraternity of 1859 personnel includes 1598 scientific & technical and 261 administrative personnel.

A profile of SAC Activities

SATCOM & SATNAV Payloads

SAC designs and develops payloads for Communication & Navigation satellites. SAC delivered large variety of payloads operating from UHF to Ka, Q/V band & optical band to high through put satellites.

To boost the capacity of satellite communication, SAC developed Ka band HTS payload for GSAT-20 communication satellite, which will provide a wide range of broadband as well as multimedia services. The payload development activity of IDRSS system, a constellation of two satellites located in two widely separated GEO slots to provide data relay between Antarctica & NRSC and LEO TC/TM Support, is under advanced stage of realization. Design & development of payloads for GSAT-7R, which is a multiband communication satellite in UHF, S, C, Ku bands to provide operational continuity of GSAT-7 services is under progress. The development activities of indigenous technologies like high power TWTA, EPS, Q-band beacon transmitter, space service GNSS receiver are under advanced stage. To cater the requirements of the users, SAC is also working on the development of GSAT-32, GSAT-7B etc.



GSAT-20 integrated payload

The next generation navigation satellite NVS-01 of NavIC , India's own Navigation system is configured with L1, L5, S and C band payloads. It was launched on May 29, 2023 and is performing satisfactorily. NavIC L1 signal design contains indigenous spreading codes, modulation scheme and other signal structure elements, which is a significant achievement in the navigation domain. The design & development of NVS-02 is under progress.

SATCOM & SATNAV Technology and Applications

Space based applications have great importance in India. It found a plethora of applications in broadcasting, backhauling, MSS services etc. Commissioning of ground segment facilities of MSS & high throughput satellites have enhanced the internet connectivity (BharatNet) and the VSAT-based applications of our Nation. HTS gateways of GSAT-11, 19, & 29 are operational & providing broadband connectivity. More than 3400 user terminals in GSAT-11 network, more than 1300 user terminals in GSAT-19 network is operational for the broadband services. Installation and testing of GISAT ground stations are completed and ready for operation. ISRO is also providing VSAT, DTH & internet services to south Asian countries through GSAT-9 applications.

SAC has developed various MSS applications (through GSAT-6 & GSAT-17) such as Real-time Train-tracking Information System (RTIS), SATCOM devices for Ministry of Home Affairs (MHA) etc. RFP for National Roll-out of Maritime Asset Monitoring system through NSIL for the User terminal development and Ground Segment establishment was finalized. The two way MSS Terminal capabilities was demonstrated to Kerala fisheries department and performed a feasibility study for the implementation of this network for tracking of motorized boats at Kollam, Kerala. Second set of ground trials of Real Time Aircraft Tracking Terminals System (RTAS) on Helicopters were conducted to test the feasibility of accommodating RTATS MSS terminal antenna in the tail boom for communication using DES 11.5m C-band MSS hub. SAC/ISRO has developed an indigenous technological solution namely Distress Alert Transmitter (DAT) for the fishermen at sea to send emergency messages from fishing boats. The DAT is operational since 2010 and till now more than 20000 DATs are being used. After the successful T&E the second generation of DAT was handed over to INMCC, ISTRAC and its services were declared operational by Chairman, ISRO on January 15, 2024 at ISTRAC Bengaluru.

GISAT-2 Ku-band 11 m Antenna

GISAT-1 Ku-band 9.1 m Antenna

SAC developed Pseudolite System was successfully used for precise lateral guidance at ATR runway under high dynamics scenario. SAC has developed in-house multi-constellation multi-frequency Carrier-Phase RTK receiver for High Accuracy Service (HAS) applications and Continuously Operating Reference Stations (CORS). Testing of 5 units of NavIC Receiver for Radio Sonde is carried out successfully at SCL, Chandigarh. Based on successful completion of pilot project between SAC and Unique Identification Authority of India (UIDAI), UIDAI has decided to integrate wireless NavIC Receivers in their vehicles at around 1 lakh enrolment centres. Under NavIC simulator development, a modified version of the 11 channel memory based Dummy short code simulator has been developed and tested with Accord Receiver, In-House Payload test receiver and RS user receiver successfully and long term testing is periodically being done.

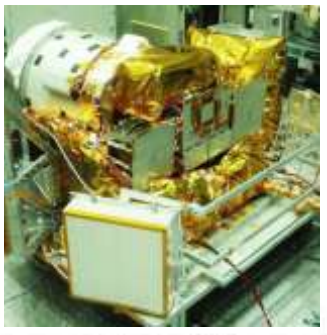
Reusable Launch Vehicle Landing Experiment (RLV-LEX-01) test

Earth Observation payloads

SAC has undertaken many space based technologies that can benefit to the society. It includes design & development of a spectrum of optical and microwave sensors covering a plethora of applications like Agriculture, weather Monitoring, Fishery, Forestation, Urban mapping, Surveillance and so on. SAC has developed instruments operating in optical as well as microwave wavelengths providing capability of high-resolution imaging.

SAC developed S-band SAR for ISRO-NASA joint mission, NISAR, to determine earth change in ecosystems, deformation & cryosphere sciences. Meteorological payloads of INSAT-3DS was launched recently and all the payloads are performing satisfactorily. GISAT-1R is a follow-on mission of GISAT-1 is a multi-spectral, multi-resolution imaging instrument capable of imaging full or part of the earth disk with high resolution multi-spectral VNIR (HRMX-VNIR), Hyper spectral VNIR (HyS-VNIR), Hyper spectral SWIR (HyS-SWIR) and High resolution Multi-spectral LWIR (HRMX-LWIR) from an agile geostationary platform. Developmental activities of High Resolution Camera (HRC), Miniaturized Multi-spectral camera (MMX) and Radiation Monitor (RadMon) for Space Docking Experiments (SPADEX) is under progress. GNSS Reflectometry payload of Microsat-2C is ready for the shipment. C band SAR of RISAT-1B is in advanced stage of development. Design & development of OceansAt-3A, Resourcesat-3/3A are under progress.

Reusable Launch Vehicle Landing Experiment (RLV-LEX-01) test



GNSS-R Payload

SAC is also developing pre-processing and post processing software systems using image processing, computer vision, AI/ML based algorithms for every SAC developed remote sensing payloads.

Space Science & Planetary Payloads

SAC is continuing its contributions towards interplanetary missions like Lunar missions, Solar missions, Venus missions etc.

Chandrayaan-3's exploration of the lunar South Pole signifies a new era in India's Space endeavors. This achievement made India the fourth Country to achieve soft landing on the lunar surface. SAC developed Lander Camera successfully operated in post-launch Earth manoeuvring phase. Ka band altimeter provide altitude update during the descent phase of landing and has given excellent performance.

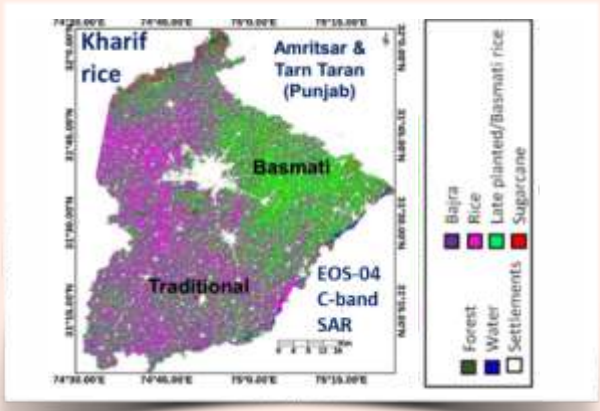
Images captured by CH3-Rover Imager

Aditya-L1, India's first solar observatory mission was launched on September 2, 2023 and it successfully placed halo orbit around Lagrange point (L1). SAC has significantly contributed in the development of Visible Emission Line Coronagraph (VELC) instrument to study the Sun Corona.

SAC is also working on the design & development of ISRO's Venus mission and ISRO-JAXA Lunar Lander-Rover Mission, LuPEX.

Earth Observation Applications

The data from earth observation satellites are used for several applications covering Agriculture, Forestry, Terrestrial, Coastal and Marine Environment, Satellite Meteorology, Oceanography, Cryosphere, Geosciences, Hydrology, Marine and Water Resources and so on.

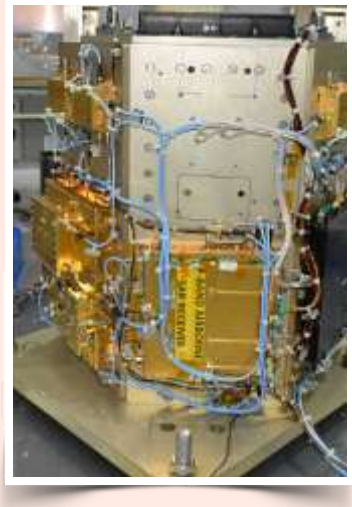


Kharifcropinventoryusing EOS-04 SAR and Automatic Machine Learning towards operationalization at MNCFC

SAC developed Semi-physical yield model (SPM) for rice and wheat, has been selected for operational roll out of YES-TECH programme under PMFBY of Ministry of Agriculture & Farmer Welfare (MoA&FW) for crop insurance claim settlement. SAC has developed Country-level crop mask for computation of Soil Moisture Indicator (SMI) and shared it with MNCFC for the drought portal under Krishi-DSS. This portal on VEDAS platform was presented to MoA&FW and is ready for operationalization. Based on the analysis related to spatial distribution of wetlands an "Information Brochure cum Highlights of National Wetland Inventory and Assessment" has been prepared. Machine Learning models have been developed for future prediction of Gross Primary Productivity (GPP) of global cropland at 0.25 grid using future climatic scenarios. SAC has estimated Green fodder yield for four rabi-summer fodder types using a semi-physical model in the AMUL catchment consisting of Mahisagar, Kheda and Anand districts. SAC has designed & developed four applications (Desertification & Land Degradation, Solar Energy, Snow Cover and Hydrology) under LAMA Geoportal on VEDAS platform. ISRO-JAXA precipitation product (GSMaP_ISRO) was developed under mutual Implementation of Agreement (IA) and is operationalized on MOSDAC.

Technology development

SAC is one of the major Research & development Centre of ISRO, which promotes & develop critical technologies that lead to self-reliance of Indian space programme. Currently, more than 300 Technology Development Projects (TDP)/Advanced R&D projects are progressing in SAC.



Integrated P band ASAR Payload

SAC indigenously developed Rubidium atomic clock was used for the first time in 2G navigation satellite and is performing normal. The Travelling Wave Tube Amplifier (TWTA) technology is one of the most critical technology-gap area for achieving the self-reliance in realizing fully indigenous communication payloads and is being developed at SAC. Development activities of P Band SAR, Ground Based Temperature & Humidity Sounder (GBS), Space borne GNSS

Reflectometry are completed. QuantESS is an experimental payload to be flown as part of the Technology Demonstration Satellite (TDS) mission. The payload is in the final stages of FM realisation. SAC contribution towards Quantum Satellite communication, Optical Communication Technologies, Hyper spectral imager technologies, Tera-Hertz sensor activities, Artificial Intelligence (AI) mission is under advanced stage of development.

Human Spaceflight Programme (Gaganyaan)

SAC is responsible for the design, development, testing and delivery of Crew Communication System and Cabin Sub-systems including Environmental Monitoring System, Fire Detection & Suppression System, Display & Camera System and Cabin Lighting System. Crane tests of X-band Altimeter for TV-D2 conducted at SAC and performance was normal. SAC has achieved major milestone towards the realization of Location Transmitter Payload for Test Vehicle Mission. SAC team also deployed the Cabin and Communication systems for the Gaganyaan Static Mock-up Simulator at HSFC, Bengaluru.

X-RA under field Test in SRC ground

Fabrication and Test Facilities

SAC is spread across four campus including Delhi Earth Station (DES). SAC has highly sophisticated facilities to meet various Space missions & research requirements. This includes payload integration laboratories, electronics and mechanical fabrication facilities, environmental test facility, Image processing and analysis facilities, Antenna test facility etc. The enhancement & maintenance of these facilities are undertaken periodically for the smooth functioning of the Centre.

Systems Reliability

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

Capacity Building & Outreach Programme

The industry has been the back bone for the Indian Space programme since inception. Indian Industry has reached a maturity level of self-sufficiently to produce materials, components & subsystem for both launch vehicle & satellites. Industries utilised various technical facilities of SAC

to test various subsystems of SAC projects as well as non-ISRO projects. The Centre continued its efforts to collaborate and strengthen its ties with various institutes for joint collaborative research. SAC has signed more than 25 MoUs with different Government & non-government institutes during last financial year. The fields of collaboration include, academic research collaboration, testing of systems, development of hardware, disaster management capacity building etc.

SAC has its own Exhibition Centre 'Vikram Sarabhai Space Exhibition (VSSE)' inside the SAC campus to give awareness of ISRO activities to the public of Gujarat and surrounding states. VSSE conducted virtual Mobile exhibitions at various educational institutes, which has received encouraging response. The Centre also conducts courses for students from the Asia Pacific region under the aegis of Centre for Space Science and Technology Education in Asia and Pacific (CSSTEAP) affiliated to United Nations. SAC is also conducting online training programmes under TREES/SMART. SAC is also responsible for the coordination of various research program including in-house TDP/R&Ds as well as Respond, Space Technology Cell (STC) and Space Technology Incubation Centre (STIC) activities at various academic and research institutions.

To support continuous learning, SAC has a well-stocked library focusing in new information delivery mechanisms and providing more and more online information and resources. Library also affiliated with many international repositories and national repositories like IEEE, SPIE etc., and users also have the facility to download the e-papers and other online journals required for their activities.

Future Outlook

SAC plays a pivotal role in the development of critical technologies that make the Country independent & self-reliant in Space programme. In this regard, SAC is involved in research activities related to Quantum Frontiers which is essential for National security & development of quantum communication, Quantum sensors & Quantum Cryptography. Artificial Intelligence is another field in which significant advances have been made in data collection, image processing & computation power. SAC is also working on several advanced TDPs to make 100% indigenous Payloads. SAC has already initiated development of Optical communication technology, which is one of the leading trend in telecommunication industry.

SAC is developing of High throughput satellites that provide greater data transmission capacity to meet the high demand of the users. SAC is already working on the development of second generation navigation satellites to augment NavIC constellation with improved accuracy & new technology elements. ISRO is also aiming to strengthen its microwave remote sensing capability through the Radar Imaging Satellite (RISAT) series with improved SAR sensors. Hyper spectral sensors and its applications will be the major thrust areas during the coming years.

Gaganyaan, India's human space mission, activities are also going in full swing. ISRO's future planetary missions Lunar missions, Venus mission is also progressing well. In the applications front, major initiatives including the conceptualization of satellite data for the development of agriculture, disaster management, weather forecasting etc are undertaken.

CSSTEAP Course on Satellite Meteorology and Global Climate, at SAC, Ahmedabad (SATMET- 13)

Dr Sasmita Chaurasia
Course Director, CSSTEAP SATMET-13

The Thirteenth 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. The duration of the course is September 1, 2023 to May 31, 2024.

Seven participants from four countries in Asia-Pacific region participated in this course. They are mostly operational forecasters, meteorologist, and researchers in their own country. After they learn about satellite meteorology, they will impart training to their own officers in these subjects once they go back. The participants are from the countries like Bangladesh, Mongolia, Myanmar and India.

A joint inaugural function of the two courses: (i) Satellite Meteorology and Global climate conducted by Space Applications Centre (SAC) and (ii) Space and Atmospheric Science conducted by Physical Research Laboratory (PRL) was held at K. R. Ramanathan Auditorium of PRL on 06th October, 2023. Shri Nilesh M Desai, Director of SAC, Dr. Anil Bhardwaj, Director of PRL, and senior officers from SAC and PRL graced the occasion.

Group photo of joint inaugural function held on October 06, 2023 at PRL Ahmedabad.

The SATMET-13 course which is of 9 months' duration is comprised of 2 semesters spread in 3-modules. The 1st module covers the fundamentals of Satellite Meteorology and Global climate, and 2nd module deals with Advanced Concept of Satellite Meteorology, e.g., Geophysical Parameter Retrieval and Satellite Products and their application in NWP etc. In the first two modules, everyday lectures are delivered from the subject experts in the morning session followed by practical in the afternoon session. In the 3rd module, called the pilot project module (of 3 months' duration), 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.

The performance of the participants was assessed through written, interactive sessions and practical exercises, tests & examinations. On successful completion of the phase I, the participants will be given the post graduate diploma and they can complete their phase 2 project work in their own county for one year and the work can be submitted to Andhra University for the award of M. Tech.

Each participant gave a number of seminars during the course, related to climate and weather of their region, on satellites of different counties etc. A weekly weather discussion over Indian and the Asia-Pacific region 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. In the next 3 months weather discussion was carried out apart from the presentation related to space activities of different country and specifically the meteorological satellites. Feedback was given to each participants and the

presentation was evaluated. This helped them to prepare for the presentation of their pilot project. 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.

Apart from the regular lectures and practicals, some special seminars by eminent scientist from India as well as from abroad was also conducted. This enabled the participant to have one-to-one interaction with the speakers as well as broaden their horizon in different areas of research in meteorology.

They also visited other research institute like Physical Research Laboratory (PRL) and different facilities of SAC, IMD Delhi, IIRS Derhadun apart from few places of importance like the Tajmahal in Agra, Statue of Unity, Gujarat. They also visited the launch pad at SDSC, Sriharikota, other facilities and had interaction with the scientist which helped them to know about the nature of weather forecasting required during the time of launch as the participants are mostly operational forecaster of their country.

SATMET-13 participants with PRL Director and other faculties

Interaction with Director General of Meteorology, IMD, New Delhi during the facility visit

SATMET-13 participants visited Tajmahal at Agra

Visit to Sensor Electronic Development Area (SEDA) clean room of SAC

Visit to PLASIV facility of SAC along with SAS-13 and 27th RS&GIS participants

Visit to Microwave Remote Sensing Area (MRSA) clean room of SAC

The candidates learnt a lot during the 3 months pilot-project like the 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. In the current year following seven topics were chosen as pilot projects:

- Variability in Sonic Layer Depth in perspective of Climate Change
- Tropical cyclone intensity estimation from satellite generated images using Machine Learning Approaches
- Investigating Land Cover Changes by Remote Sensing and GIS Methods: A Case Study of Ganges-Brahmaputra
- Relation of Normalized Difference Vegetation Index (NDVI) to land surface temperature, soil moisture and precipitation over Saurashtra region, Gujarat, India
- Advancements in Weather Parameter Visualization using Web GIS for Naval Decision-Making
- Trend analysis of very heavy rainfall events over Bangladesh
- A Data Driven Approach for precipitation Nowcasting for Aviation Application

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 organizations and the facilities available in the countries of participants for supporting the project work were taken into consideration while deciding the project.

For the first time the present batch of SATMET participants attended an international conference, iRAD-2024, during 10-12 January, 2024, covering Radar Meteorology, which is very relevant to their field of work as most of them are operational forecaster in their respective organization.

Attending iRad 2024 Conference at IIT, Indore

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, Physical Research Laboratory, experts from India Meteorological Department (IMD) and Andhra University have also delivered lectures.

SATMET-13 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. WiFi connection is provided in the hostel as well as internet facility in the office for downloading the data for work and browsing. The lectures are being recorded and available to participants for revising the lectures in office.

A versatile software package Python, Matlab etc. on each terminal provided much needed standardization in data processing (INSAT-3D/3DR, Megha Tropique, SCATSAT-1, NOAA, MODIS etc.) to all the participants. A set of three volumes of lecture notes prepared especially for the SATMET course comprised the main resource material. These were distributed to all the participants, and updated notes and presentation materials were also provided.

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.

It has been possible to conduct the 13th PG course on Satellite Meteorology and Global Climate at SAC, Ahmedabad due to sincere and dedicated efforts put in by a large number of persons at SAC. We would particularly like to thank all faculty members, focal points and project guides, who in spite of their busy schedule delivered lectures, organized practical sessions, conducted tutorials and provided guidance to the participants for their project related activities. We thank SAC administration, SAC-Bopal campus administration, Controller SAC, Group Director CMG and his team, Senior Purchase Officer and his team, Head Accounts/IFA SAC and his team, P & PR, Medical Officer and other administrative staffs for the support extended to the course participants. We thank Shri S Somnath, Chairman ISRO, and Shri N M Desai, 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)

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

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

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

Module 3 : PILOT PROJECTS (Three Months)

Break - up of Module 1 & 2 Lectures

Sub- MODULE 1.1 : CONCEPTS IN METEOROLOGY AND CLIMATOLOGY

Section 1-1-MET : Basics Concepts of Meteorology, Climatology & Oceanography
❖ Atmospheric, Dynamics & Physical Meteorology
❖ Extra Tropical Weather Systems
❖ Tropical Weather Systems, Monsoon
❖ Climate of Asia-Pacific region and Variability
❖ Ocean and Climate

Section 1-1-MATH : Mathematical and Computational Techniques for Satellite
❖ 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 : Principles of Meteorological Remote Sensing
❖ Principles of Remote Sensing
❖ Characteristics of Electromagnetic Radiation
❖ Passive Remote Sensing
❖ Active Remote Sensing
❖ Parameter Retrieval & Validation

Section 1-2-MSI : Overview of Meteorological Satellites / Orbits
❖ Orbits and Navigation
❖ Operational Polor-orbiting Satellites
❖ Operational Geostationary Satellites
❖ Other Satellites
❖ Satellite data Archive

Break - up fo Module 1 & 2 Lectures

Sub - MODULE 1.3 : IMAGE PROCESSING, INTERPRETATION & GIS

Section 1-3-DIP : Image Processing Techniques and Geographic Information System (GIS)
❖ Map Projection
❖ Satellite Positioning System
❖ Image Registration, Radiometric & Geometric Correction
❖ Image Classification
❖ GIS

Section 1-3-WF : Image Interpretation in Meteorology and Weather Forecasting
❖ Satellite Imagery
❖ Spectral Properties
❖ Identification of Meso Scale Systems
❖ Tropical Synoptic Systems
❖ Extra Tropical Synoptic Systems
❖ Radar Meteorology

Sub Module 2.1 : GEOPHYSICAL PARAMETER RETRIEVAL

Section 2-1-AP : 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 DERIVED PARAMETERS

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

Section 2-2-NM : Satellite Data Assimilation in Numerical Models
❖ Atmospheric Models
❖ Concepts of Data Assimilation
❖ Satellite Data Assimilation
❖ Impact of Satellite Data Assimilation

Sub-MODULE 2.3 : GLOBAL CLIMATE AND ENVIRONMENT

Section 2-3-SC : Short Term Climate Variability	Section2-3-LC : Long Term Climate Change
❖ El-Nino & Southern Oscillation	❖ Climate Change
❖ Cloud Climatology	❖ Geosphere – Biosphere interaction
❖ Land Surface Changes	❖ Green House Effect & Global Warming
❖ Radiation Budget	❖ Hydrological and Carbon Cycle
❖ Ozone and other Trace Gases	❖ Changes in Cryosphere
❖ General Circulation Models & Regional Circulation Models	❖ Future Climate Scenario & Satellite Missions

Section 2-3-ESI : Environment Issues and Societal Impacts	
❖ Oceanic Biological Productivity	❖ Pollution
❖ Coastal Zone Environment	❖ Disaster Management

LIST OF PRACTICALS

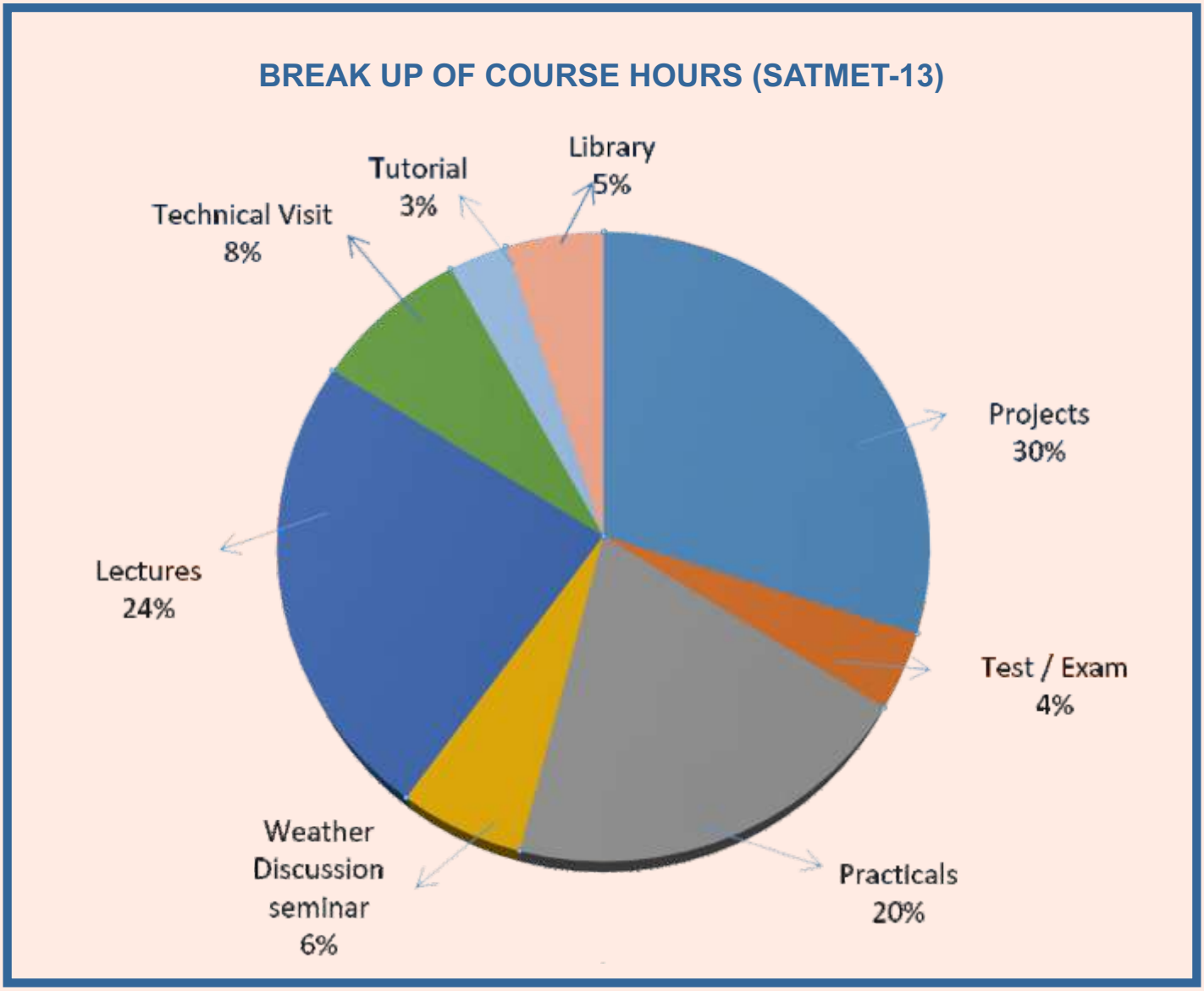
Module I : Operational Meteorological Satellite Data Handling & Applications	
Sr.No.	**Title**
1	Computer Orientation I: Familiarization of SATMET Labs, systems & networks, visit to MOSDAC & AWS.
2	Computer Orientation II: Visualisation tools using LINUX, GRADS, Fortran, Python and Mat lab etc.
3	INSAT-VHRR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

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

Course Director : Dr. Sasmita Chaurasia

Focal Person-Pilot Projects : Dr. Rashmi Sharma

BREAK UP OF COURSE HOURS



LIST OF FACULTY MEMBERS

SAC	
No.	**Name**
1	Dr. Abhineet Shyam
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4	Mr. Aman Waheed Khan
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11	Mr. Ghansham Sangar
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33	Dr. S. Manthira Moorthi
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SAC	
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37	Mr. Shashikant A Sharma
38	Ms. Shivani Shah
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7	Dr. R. Suresh, Ex. IMD, Chennai
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LIST OF PARTICIPANTS AND THEIR ORGANISATION

Sr.No.	Name	Organisation
1	**Mr. Md. Mizanur Rahman**	Bangladesh Meteorological Department **Bangladesh**
2	**Mr. Ujjwal Kanti Pal**	Bangladesh Meteorological Department **Bangladesh**
3	**Lt Cdr. Chaitanya Malhotra**	Indian Navy **India**
4	**Cdr. Deepak Kumar Singh**	Indian Navy **India**
5	**Sqn Ldr. Shashwat Kumar Singh**	Indian Air Force **India**
6	**Mr. Telmen Purevsuren**	Mongolian Academy of Sciences **Mongolia**
7	**Ms. Phyu Phyu Aung**	Myanmar Aerospace Engineering University, **Myanmar**

Participants Profile and Pilot Project

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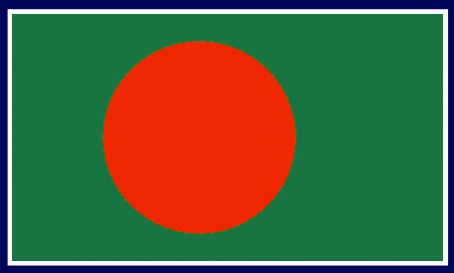
Md.Mizanur Rahman is the Meteorologist of the Bangladesh Meteorological Department (BMD).He has been joined in BMD on 07 November 2012 after successfully qualifying the competitive examination conducted by Bangladesh public service commission(BPSC).

Before that he had completed B.Sc(Hon's) and M.Sc in statistics from Jahangirnagar university,and completed one (1) year course on basic instruction of Meteorology from Bangladesh Meteorological Deprtment.

Mr. Rahman has extensive research experiences in different field of Meteorology including cyclone forecasting,storm surge,monsoon system,seasonal,medium range and long range forecasting.



Md.Mizanur Rahman
Meteorologist

Guide: **Dr. Dr.Neerja Sharma**
Sci/Eng-SF
EPSA-AOSG-ASD

Abstract

Trend Analysis of Very Heavy Rainfall Events over Bangladesh

Bangladesh is recognized by low lying delta topography and varying geography. Due to its unique location, it is in the list of countries which are highly prone to climate change. Thus, it is prerequisite to understand the long term changes in the frequency of very heavy rainfall (>88 mm/day) (VHR) events over the country. The present study is formalized with this objective and analyzed the trend of VHR using in-situ and satellite measurements over the four sectors (North-West, North-East, South-West and South-East) of Bangladesh during 2000-2023. For this purpose, study utilizes in-situ rain gauges observations from Bangladesh Meteorological Department and satellite products from INSAT-3DR and Integrated Multi-Satellite Retrievals for Global Precipitation Measurement (IMERG). Majority of the stations exhibit decline trend in VHR events except Chandpur (Figure-1). Frequency of VHR events show significant drop over Northern region than Southern part of the country. In addition, Dhaka, which is located over the central part of the country also show substantial decline. The high frequency of VHR events are observed over Cox's Bazar, which is located in the southernmost part of the country. The station also displays a decreasing trend but less significant. Further, the decreasing trend observed in in-situ rain gauges observation is supported by the satellite measurements. The outcomes of the study would be useful to distinguish the varying trends of VHR events on annual and seasonal scales over the four different sectors of Bangladesh. Additionally, results also important to understand the changing patterns of VHR over the country.

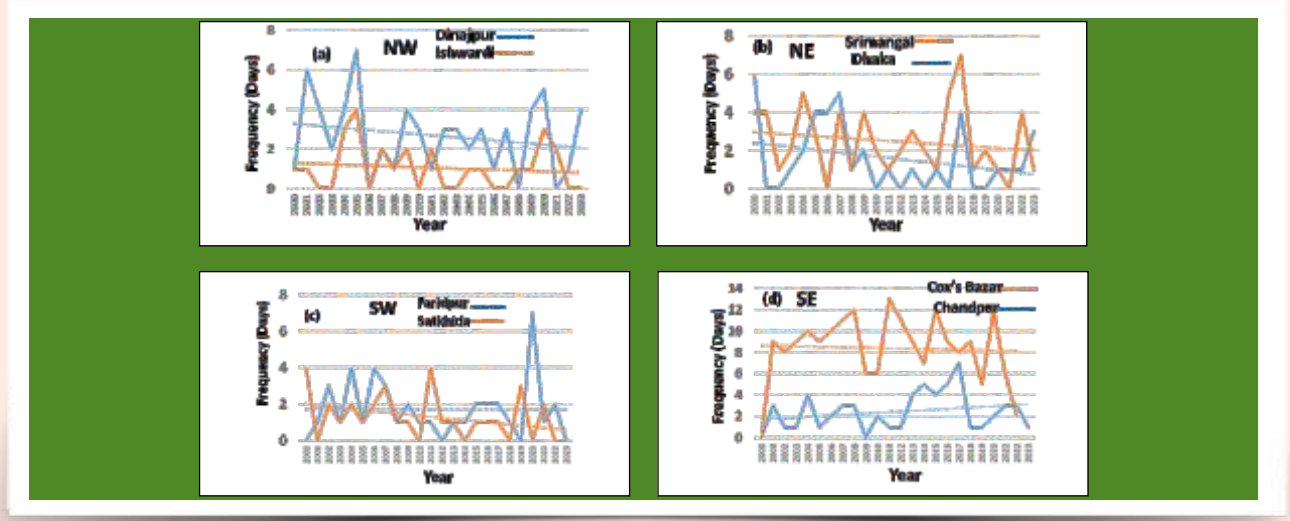


Figure-1. Annual trend in VHR over four regions (a) North-West (NW), (b) North-east (NE), South-West (SW) and South-East (SE) of Bangladesh using in-situ rain gauges observations from 2000 to 2023.

Mr. Ujjwal Kanti Pal
Bangladesh

He was born on 15th November 1984 in a very reputed aristocratic family at District Chattogram, Bangladesh. His father, Late Babul Chandra Pal was a Freedom Fighter (Liberation War of Bangladesh-1971) and Army Personnel. He completed his Graduation (Honours) and Master's Degree in Physics from National University of Bangladesh. He has also done Post Graduate Diploma in Computer Science from IIUC-Bangladesh. He joined the Bangladesh Meteorological Department in June 2017 as an Assistant Meteorologist (Weather Scientist) and presently working at Main Meteorological Office (M.M.O), Shah Amanat International Airport, Chattogram as an Operational Duty Forecasting Officer (D.F.O). He is pursuing the MPhil cum Ph.D. Course in Atmospheric Physics at Chattogram University of Engineering & Technology (CUET).

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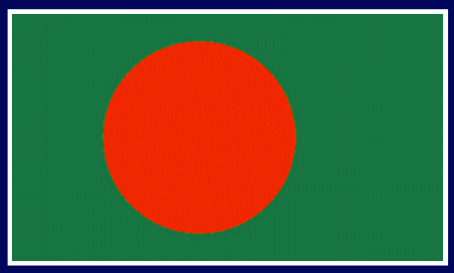
He has attended different online training/short courses in Meteorology at Space Applications Centre (SAC)-ISRO, Physical Research Laboratory (PRL) & CMATC-China and completed Advanced Meteorology Course (1-year) from BMD Training Institute. His research areas are Tropical Cyclones (TC), NWP model operation & Aviation Weather Forecasting.

He is a very studious, serious, intelligent and calm person. He is a kind hearted, helping and emotional person. He loves to explore new places especially religious places and temples.



Mr. Ujjwal Kanti Pal
Assistant Meteorologist

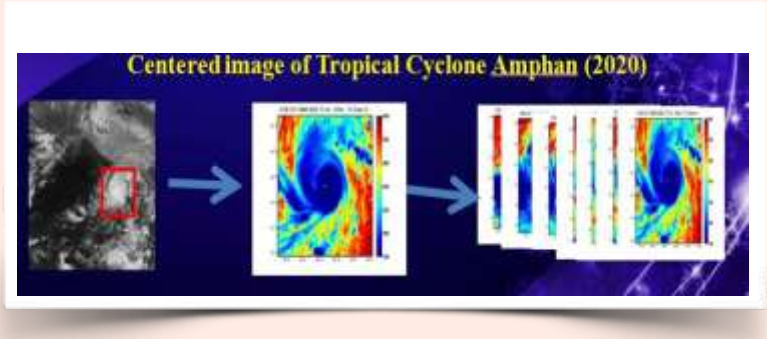
Guide: **Dr Neeru Jaiswal**
Sci/Eng-SF
EPSA-AOSG-ASD

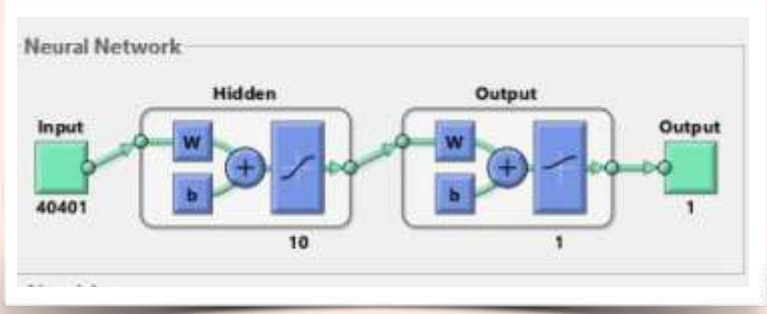
Abstract

Tropical cyclone intensity estimation from satellite generated images using Machine Learning Approaches

Tropical cyclone (TC) intensity estimation is highly useful as it is directly associated to storm related hazards like winds, rainfall and storm surge. Thermal Infrared (TIR) imageries generated from geostationary satellites provide continuous high temporal and spatial observations over TCs. Such images are used worldwide for the estimation of intensity of Tropical Cyclones (TCs). This involves the calculation of indirect relationships between IR-measured brightness temperature (BT) values and intensity of the cyclone. In recent years, machine learning (ML) techniques have gained much attention and shown significant potential in dealing with large dataset. In the present work, machine learning based approaches are investigated for estimating intensity of TCs. For this, a database has been prepared using the INSAT-3D satellite generated TIR-1 images over cyclones of diverse intensities. This includes the observation over cyclones formed in the North Indian Ocean during 2013-2023. The study focuses on the objective classification of the cyclone intensity using satellite generated cyclone centric TIR-1 images.

Key Word: TC, TIR, INSAT-3D, BT, ML





Lt Cdr Chaitanya Malhotra
India

Lt Cdr Chaitanya Malhotra was Born and raised amidst the bustling streets of Delhi, a city as dynamic as its history, and embarked on a remarkable journey upon commissioning into the Indian Navy in December 2011. Prior to joining the Navy, he pursued higher education at Punjab University, where he completed his graduation in 2010. Following graduation, Chaitanya began his professional career at Infosys, Chandigarh as a Systems Engineer, specialising in various web-based technologies. He played a pivotal role in deploying projects overseas for TomTom (client), contributing to his skills and experience in the IT sector.

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However, destiny took a different turn for him when he got commissioned into the Indian Armed Forces in Dec 2011. Since then, Chaitanya has dedicated his career to serving in the Indian Navy, holding significant roles such as Commissioning crew for INS Vikrant, the first commission staff to a Indian Naval Dornier squadron, and fulfilling responsibilities as a Staff Meteorological Officer and Staff Officer (Meteorology) at Command Headquarters, Andaman and Nicobar Command.

Transitioning from the corporate world to the military, Chaitanya brings a unique blend of technical expertise and operational acumen to his naval career, embodying a steadfast commitment to serving the nation's maritime interests.

Lt Cdr Chaitanya Malhotra
Meteorological Officer, Indian Navy

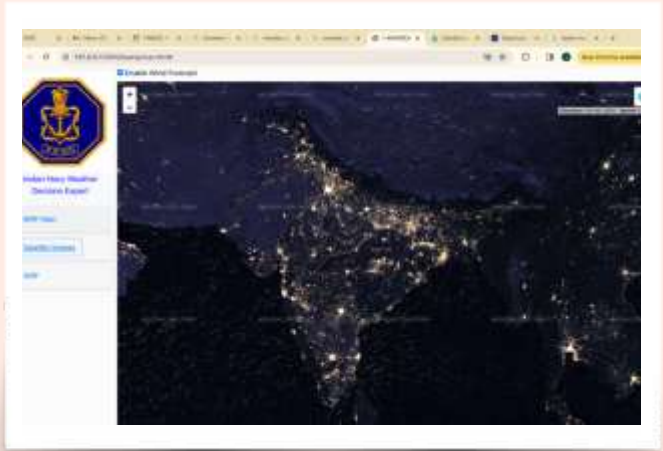
Guide: **Mr. Utkarsh Tyagi**
EPSA/GAWG/MWAD

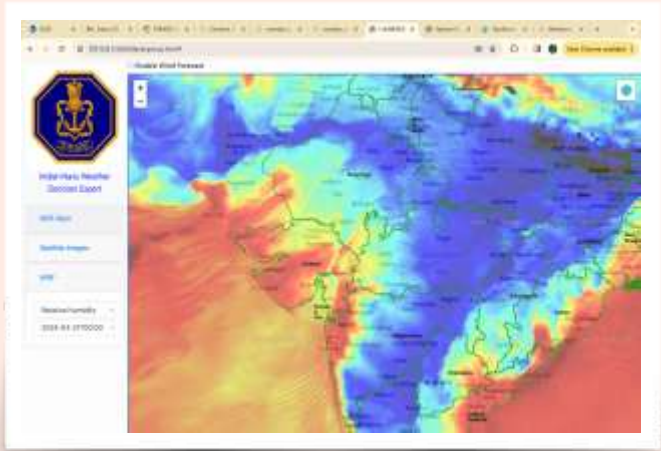
Abstract

Advancements in Weather Parameter Visualisation using Web GIS for Naval Decision-Making

Meteorological forecasting plays a pivotal role in supporting diverse military operations, ensuring safety, efficiency, and strategic decision-making. This project presents an innovative approach to enhancing weather-related decision support through advanced visualisation techniques and novel forecasting products tailored for maritime operations.

The project harnesses the capabilities of a sophisticated Web GIS (Geographic Information System) platform powered by REST (Representational State Transfer) technology, Python, Java, HTML, and API development to provide comprehensive route forecasts and precise wind predictions tailored for maritime operations. MetPy and WRFPython, advanced scientific libraries, are utilised to extract detailed meteorological variables from WRF (Weather Research and Forecasting) output files. These libraries facilitate the processing of complex atmospheric data, focusing on the creation of detailed actionable operational insights. The study introduces two weather forecasting products: Surface Helicity and Supercell Convective parameter. Surface helicity measures the potential for horizontal vorticity near the surface, providing critical insights into tornado formation and severe weather events. The supercell convective parameter assesses the likelihood of supercell thunderstorms, essential for predicting high-impact weather phenomena. The scalable and adaptable decision support system enables real-time access to critical meteorological data, empowering naval personnel with the tools needed to navigate safely and effectively in challenging environmental conditions.





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Deepak was born on 22nd of August 1986 in Ballia, a city in East Uttar Pradesh. He got commissioned in Indian Navy in the year 2011 after completing his graduation in Bachelor in Information Technology from Babu Banarasi Das institute of Technology, Ghaziabad in 2011.

Physically fit and an active sportsman, who loves playing cricket, badminton and doing physical exercise. He is dedicated, confident and ambitious. He values self-reliance. He tends to have a positive outlook towards life. His strong will can sometimes brand him stubborn, inflexible and resistant to changing their minds.

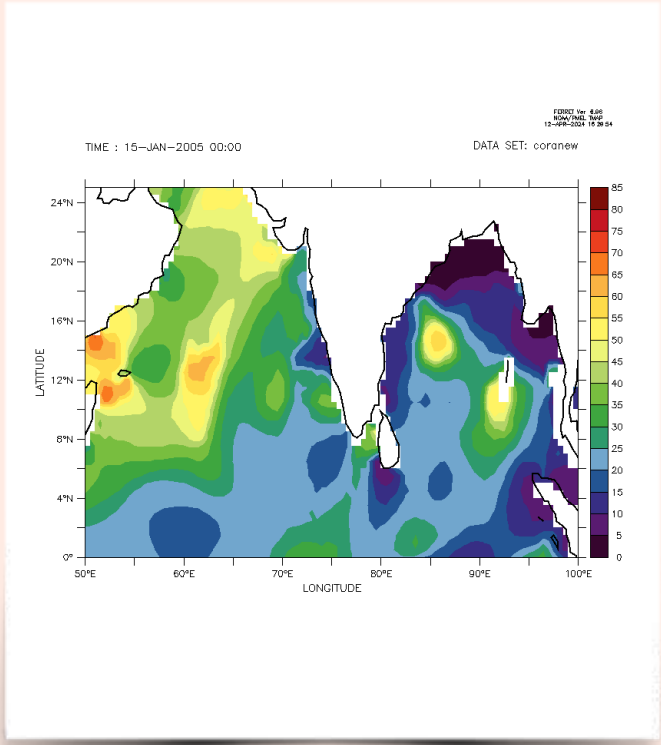
Cdr Deepak K Singh
Meteorologist,

Guide : **Dr Suchandra Aich Bhowmick**
Scientist/ Engineer-SF
EPSA-AOSG-OSD

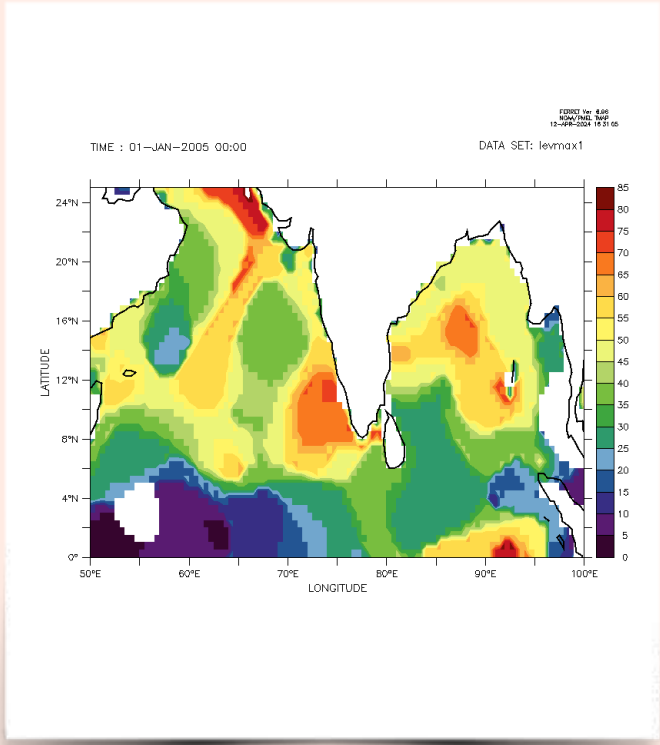
Abstract

Variability in Sonic Layer Depth in perspective of Climate Change

Sonic layer depth (SLD), an important parameter in underwater acoustics, is the near surface depth of first maxima of the sound speed in the ocean. SLD plays an important role in antisubmarine warfare in terms of identifying the shadow zones for submarine safe parking The lack of direct observations of vertical profiles of velocimeters or temperature and salinity, from which sound speed and SLD can be calculated, hampers the investigation of SLD. In this study, we demonstrate comparison between Mixed Layer Depth (MLD), SLD and SLD estimation using sound velocity profiles (SVP) in the North Indian Ocean (0 to 25ºN and 50-110ºE) which is in turn is obtained from temperature and salinity (T/S) profiles from gridded Argo observations for the years 2005-2011. Thereafter, the variability of SLD in perspective of changing climate is studied using model data. Comparison of MLD and SLD is as depicted below.



MLD



SLD

Sqn Ldr Shashwat Kumar Singh
India

Sqn Ldr Shashwat Kumar Singh, an Indian Air Force Officer, belongs to 'City of Nawabs' known as Lucknow, the capital city of Uttar Pradesh, India. He was commissioned in June 2017 as a Meteorological Officer, post completing his Master's degree from IISER Kolkata. His interest in the field of Physics and allied research was from his inception and he took it further and pursued higher studies. His INSPIRE Scholar award by the Department of Science and Technology, Govt of India in the year 2011, held as a testimony to his hard work and zeal in the field of applied physics. He achieved many laurels in academics which includes S.N. Bose Fellowship and CSIR fellowship.The Officer has also penned down various research articles in international and national journals. Further, the Officer is pursuing his Doctoral Degree from IIT-Kharagpur (Dept. of Geophysics).

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He is physically fit and fosters good relationships with his colleagues. A keen learner who is always enthusiastic to learn new things and explore ways to implement in his organization. He volunteers himself to shoulder any kind of responsibility bestowed upon him and achieves the desired objectives to the utmost satisfaction of his superiors. His immaculate planning and eye for detail of things has fructified in successful conduct of various events and get-togethers. Driven by the ideology of 'Together we achieve more' and his motto of life is 'Nation before self'.

Sqn Ldr Shashwat Kumar Singh
Meteorological Officer

Guide: **(1) Dr. Bipasha Paul Shukla**
Sci/Eng.-SG, EPSA-SESG-ESD
(2) Abhishek Chhari
Sci/Eng-SE, EPSA-AOSG-ASD

Abstract

A Data Driven Approach for precipitation Nowcasting for Aviation Application

Weather affects aviation activities at various stages of operation. In order to ensure safe operations in all-weather situations, “precipitation nowcasting” plays an important role in mitigating the impacts caused by heavy rainfall systems by providing forecasts for preparation, decision-making, and management. Since the network of weather radars and temporal resolution of geostationary satellites and their geophysical products are increasing day by day, the nowcasting techniques will be a boon for operational meteorologists.

In this study, we used the Hydro-Estimator (HE) nowcast model and a radar-based nowcasting model which is using INSAT-3DR derived HE precipitation intensity and radar reflectivity data obtained from the Thumba Equatorial Rocket Launching Stations Doppler Weather Radar (TERLS DWR) respectively. Both the models are utilizing the python framework for short-term ensemble prediction systems (PySTEPS) where motion field vectors from precipitation fields are generated using an optical flow algorithm and then advected using an extrapolation method. To address the uncertainties associated with precipitation forecasting more effectively, the models generate ensemble forecasts. We determine different skill scores like Fractional Skill Score (FSS), Receiver Operating Characteristic Curve (ROC) and Reliability Curve for validation of several selected cases of Heavy rainfall of 2023 over Trivandrum region in India. The system's output can be integrated and utilized as an important component for early warning systems for severe weather.

Keywords: nowcast, PySTEPS, DWR, optical flow, ensemble, Hydro-Estimator, INSAT-3DR

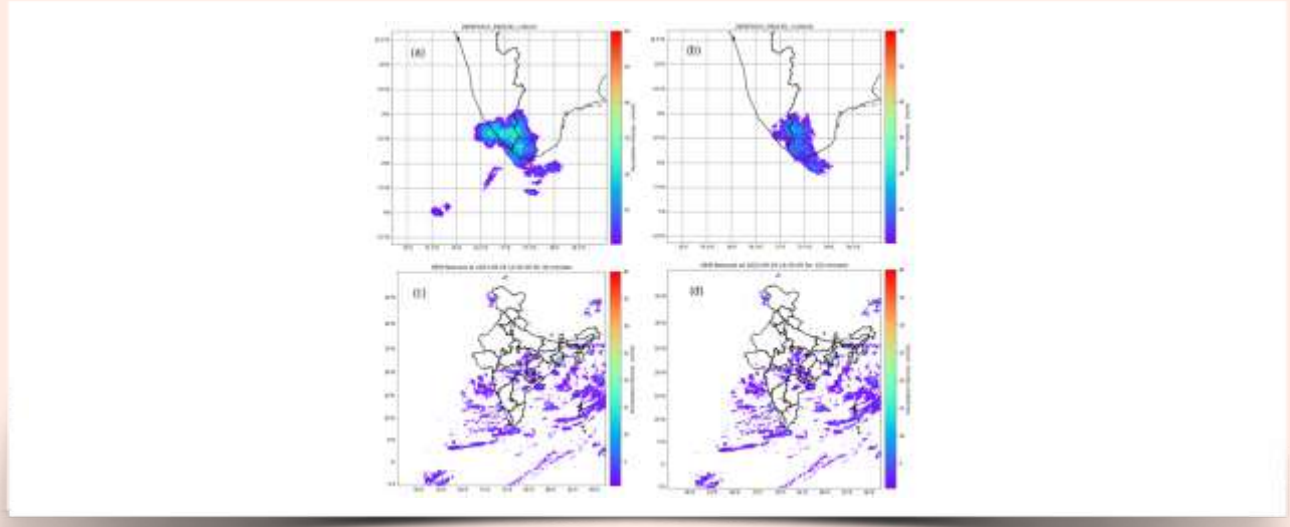

Figure 1. Nowcast generated using radar-based nowcasting model over Trivandrum region (a) & (b) and Hydro-Estimator (HE) Nowcast model over India (c) & (d).

Mr. Telmen Purevsuren
Mongolia

Born on April 9th, 2001, in Purevsuren, Telmen graduated from the University of Mongolia with a degree in geography in 2022. Shortly after, he embarked on a career as a researcher at the Mongolian Academy of Sciences.

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Telmen is currently engaged in research focusing on the classification of croplands by crop type, alongside investigating grazing land dynamics and restoration. His ambitions extend beyond personal gain, aiming to contribute research that benefits both his nation and the global community. To support these aspirations, Telmen dedicates himself to crafting software tailored for his research endeavors.

Deeply passionate about software development, Telmen continually advances his skills in this field. Possessing both competence and humility, he actively seeks assistance when needed and gladly offers support to his colleagues.

Mr. Telmen Purevsuren
Researcher

Guide: **Shashikant A. Sharma**
Sci/Eng - G
EPSA-GAWG

Abstract

Relation of Normalized Difference Vegetation Index (NDVI) to land surface temperature, soil moisture and precipitation over Saurashtra region, Gujarat, India

This study examines the trends in MODIS/TERRA derived Normalized Difference Vegetation Index (NDVI) and its correlation with Land Surface Temperature (LST), Soil Moisture (SM), and Precipitation over Saurashtra (India), during the period 2000–2023.

Saurashtra, situated in the western region of Gujarat, India, exhibits a semi-arid climate marked by distinct seasonal variations. Summers are characterized by intense heat, often surpassing 40°C, while winters are mild and dry. The monsoon season, from June to September, brings the bulk of Saurashtra's rainfall, though precipitation can be erratic and unevenly distributed. In addition, the impact of certain study factors within this region was deemed minimal, attributed to its comparatively modest irrigation infrastructure in contrast to other regions.

The NDVI-derived vegetation growth patterns across the Saurashtra region of India depict robust seasonal cycles and interannual variations. An examination of correlations reveals that the relationship between NDVI and Land Surface Temperature (LST) is stronger (-0.57) compared to the correlations between NDVI and Soil Moisture (SM) (r = 0.62/0.40) and precipitation (r = 0.31). This suggests that NDVI is more sensitive to LST than to SM and precipitation, Evapotranspiration /ET/, while SM exhibits a noteworthy positive correlation (r = 0.63) with precipitation. Seasonally, NDVI registers higher values during winter (0.35 ± 0.05), followed by the monsoon (0.39 ± 0.1), post-monsoon (0.44 ± 0.04), and pre-monsoon (0.22 ± 0.02) periods. Furthermore, this study aims to delineate the phased status of NDVI and associated parameters within the Saurashtra region.

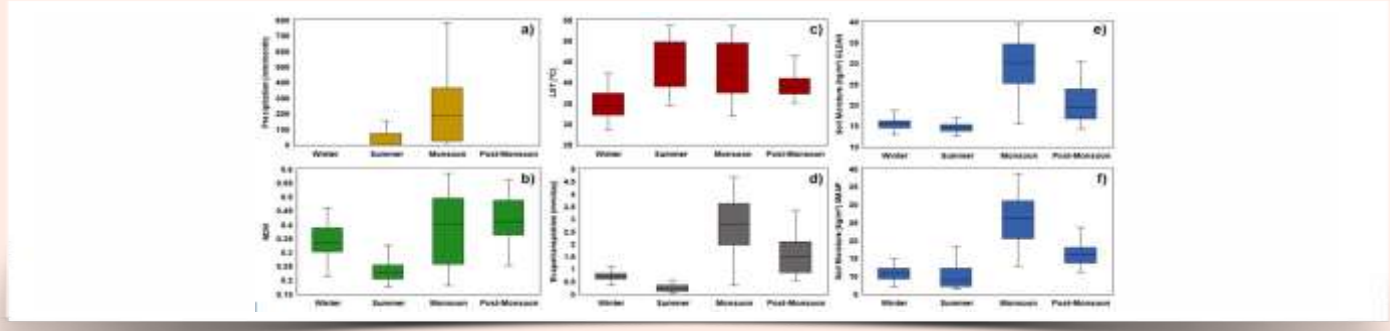

Fig 1. Seasonal Box whisker plots of **a** Precipitation **b** NDVI **c** Land Surface Temperature **d** Evapotranspiration **e** Soil Moisture /GLDAS/ **f** Soil Moisture /SMAP/

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Phyu phyu Wang was born on 19th of April 1990 in Meiktila, which is a commercial city of golden land Myanmar. She joined Myanmar Aerospace Engineering University in the year 2016 and later went on to complete her graduation from this university, which is located in Meiktila, Mandalay District in Myanmar and received the degree of master Engineering-Avionics in 2017. Currently, She is serving the government as a lecturer in the avionics department at Myanmar Aerospace Engineering University.

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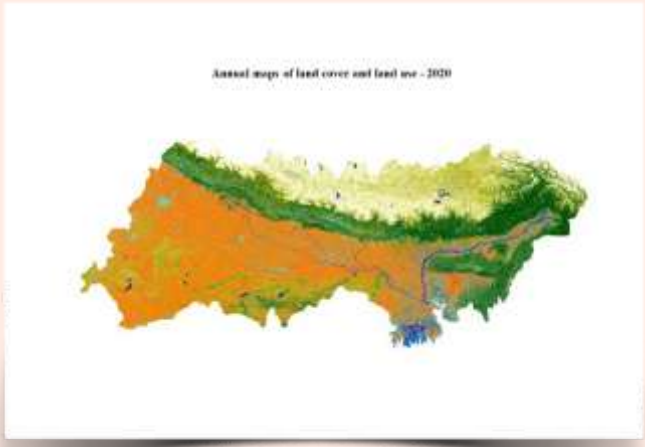
Abstract

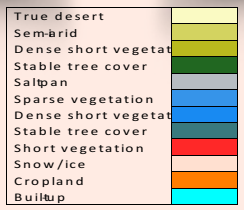
Identifying Land Use Land Cover Changes and Land Surface Temperature: A Case Study of Ganges-Brahmaputra

Climate change is changing the existing patterns of land use land cover (LULC) globally, which is consequently increasing the land surface temperature (LST) in many regions. The present study is focused on estimating LULC and LST trends of Ganges-Brahmaputra river basin, India. Past patterns of LULC and LST were identified through derived satellite images during 2000, 2020 data period. Open source software help to enhanced capabilities to effectively classify satellite images and monitor changes with temporal data.

This project focused on LULC change and LST using available datasets for the region of Ganges-Brahmaputra. The work extended on comparing LULC and LST over the period, it will be further extended to study climate change. Change detection for GIS (geographical information systems) is a process that measures how the attributes of a particular area have changed between two or more time periods. Change detection often involves comparing satellite imagery of the area taken at different times.

The process is most frequently associated with environmental monitoring, natural resource management, or measuring urban development The change detection method used in this work to study change in spatial data over the region. Analysis ready data available on various dataset provider helps as a source to work using change detection method. This study will help for understanding the effects of LULC change on LST which will aid greatly in the future research work.
Key Words: LULC, LST, change detection





During Republic Day (26, January 2024) celebration with Director, SAC

Visiting Forest Research Institute at Derhadun

Enjoying Rajasthani Culture at Chhokhi Dhani, Indore

Participants during lectures and lab sessions with Faculties

Educational and Cultural Exposure

Impressions of the Participants

It was a matter of pride and professional accomplishment for each one of use, to get selected from our respective organizations for undergoing the internationally acclaimed CSSTEAP's PG diploma course in Satellite Meteorology and Global Climate (SATMET-13) being conducted from 01 September 2023 to 31 May 2024 at Space Applications Centre (SAC), Ahmedabad, India. This course was not only a unique learning experience for all of us, but it was also an eye opener to get an insight of scientist's way to find solutions to a problem. The course also gave us exposure to cutting edge technology in the field of Satellite Meteorology. 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 new environment.

Coming to the formal interactions, laying foundation for the bonding between all 07 participants from 04 different countries of the course, took place at auditorium at Physical Research Laboratory (PRL) with course inaugural function. The Director SAC, Director PRL, Course Directors, Course Coordinators and other eminent scientists addressed and interacted with the participants. The well planned one-week combined classes with 10 participants of Space and Atmospheric Science (SAS-13) Course, and the succeeding nine month, helped us in bonding as a class.

The refined and streamlined organisation of the curriculum, during the span of nine months had covered a vast spectrum of subjects taught to us viz,. remote sensing techniques, satellite data interpretation, weather forecasting models and the application of satellite imagery in meteorological analysis by subject/ field expert having hands on experiences in the field. All the theory subjects covered during the classes were helpful to understand the fundamentals of the atmospheric behavior and the science behind the satellite technology. Relevant topics were covered in detail which would have direct applications 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 our 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. It has been truly transformative immersing ourselves in this comprehensive curriculum.

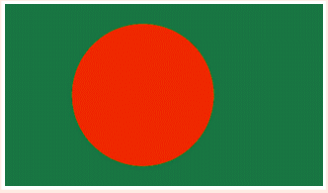
Scientific tours to Delhi, Dehradun, Sriharikota and Vishakhapatnam not only gave us much needed break from the studies but also provided an opportunity to explore unique, rich and varied cultural heritage of India. Most memorable was the visit to Satellite Lauch facility and Taj Mahal. Taste of Indian delicacies especially the Mutton Biryani were enjoyed to the fullest. Shopping during these tours added to the fun. We realized that India is truly a shopper's paradise as we have bags full of gifts and souvenirs for our family and friends.

The curriculum and administration had ensured professional gain, but the immense personal gain and real happiness factor during the course, was to get an opportunity to make memorable friends from across the world. 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 months.

Impressions of the Participants

Successful accomplishment of the course was not possible without the untiring efforts and support given to us by the administrative staffs. 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 coordinator and Professors were like the lighthouse 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.

As we bid adieu, we express our heartfelt thanks and sincere gratitude to all scientists and staff of Bopal campus and members of CSSTEAP Headquarter, Dehradun for their valuable help and unconditional support throughout our training and stay at SAC, ISRO, Ahmedabad.



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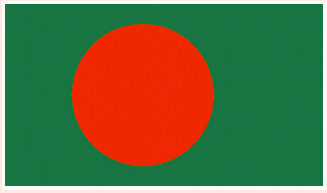

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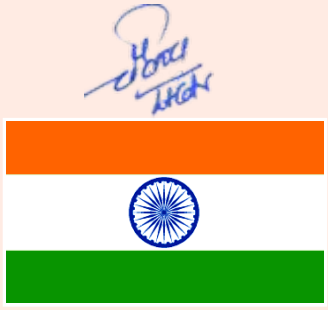

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CENTRE FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION IN ASIA AND THE PACIFIC (CSSTE-AP)

13th POST GRADUATE COURSE IN SATELLITE METEOROLOGY AND GLOBAL CLIMATE

[SATMET – 13]

(September 01, 2023 to May 31, 2024)

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Standing: (L to R) Ms. Phyu Phyu Aung (Myanmar), Ms. Samadrita Basu (India), Mr. Telmen Purevsuren (Mongolia), Mr. Deepak Kumar Singh (India), Mr. Md. Mizanur Rahman (Bangladesh), Mr. Ujjwal Kanti Pal (Bangladesh), Mr. Shashwat Kumar Singh (India)

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सीटita द्वारा डिजाइन
मई-2024