

# Satellite Meteorology & Global Climate (SATMET)

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## INTRODUCTION

Meteorological information and their timely and real-time distribution are 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 a few other mid latitude weather phenomenon. Agenda 21 concerning safeguard of global environment is also of great relevance for many countries of the 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.

From a meager start 40+ years ago, with the launch of TIROS-1 satellite, meteorological and oceanographic satellites are now used for a variety of applications that span scales from nowcasting to climate and include atmosphere, ocean and land applications. The focus is now centered on to quantitative estimation and numerical weather modeling from the traditional qualitative analysis of weather patterns and cloud distributions. Use of temperature and moisture analyses for weather prediction, analysis of atmospheric stability, estimation of tropical cyclone intensity and position and the global analysis of clouds constitute some of the important applications.

In the coming years we should expect great improvements to the global space based observing system, including very high spatial and spectral sampling from UV to microwave wavelengths, with both active and passive sensors. Data volumes will be tremendous in comparison with today's systems. The benefits of space technology, both direct and indirect, have introduced new dimensions into the study and understanding of Earth's processes and in improving the quality of life for the people living on it. All countries should have access to space technology and must share the benefits. An essential pre-requisite to partaking in these opportunities is the building of various indigenous capacities for the development and utilization of space science and technology. In recognition of such a pre-requisite, a consensus has emerged with in the international; community that if



Bopal campus, SAC, Ahmedabad - SATMET host institute

effective assimilation and appropriate application of space technology are to succeed in the developing countries, devoted efforts must be made at the local level, for the development of necessary high-level knowledge and expertise in space technology fields. In the context of Satellite Meteorology, educating meteorologists in this rapidly changing technological world is a demanding challenge.

The importance of conducting training course in Satellite Meteorology has been realized by many national meteorological agencies for their operational needs. The issues related to global warming, ozone depletion, ENSO and ocean atmosphere interactions, global climate, once academic have become now extremely relevant. To address some of these issues, besides imparting knowledge in basics of satellite meteorology, a course has been designed by the Centre catering primarily to education in this field. Handling of satellite digital data, working with dynamical models, problem solving, and executing projects of relevance to the home country have been the prime focus of attention.

## COURSE AT A GLANCE

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

Sub-Module 1.1	Concepts in Meteorology and Climatology	No. of Lectures
Section 1-1 MET	Basic concepts of Meteorology, Climatology and Oceanography	30
Section 1-1 MATH	Mathematical and Statistical, Computational Techniques for Satellite Meteorology	15
Sub Module 1.2	Concepts in Satellite Meteorology	
Section 1-2-SM	Radiative Transfer in Satellite Meteorology	25
Section 1-2-MSI	Meteorological Satellites Orbit, Instrumentation	15
Sub Module 1.3	Image Processing & Interpretation	
Section 1-3-DIP	Image Processing Techniques and Geographic Information System (GIS)	15
Section 1-3-WF	Image Interpretation in Meteorology and Weather Forecasting	30

### Module 2 : Advanced Concepts In Satellite Meteorology and Global Climate (Three Months)

Sub Module 2.1	Geophysical Parameter Retrieval	15
Section 2-1 AP	Atmospheric Parameters	10
Section 2-1 LOP	Land and Oceanic Parameters	
Sub Module 2.2	Applications of Satellite Derived Parameters	30
Section 2-2-AWF	Applications in Meteorology and Weather Forecasting	15
Section 2-2-NM	Satellite Data Assimilation in Numerical Models	
Sub Module 2.3	Global Climate and Environment	25
Section 2-3-SC	Short Term Climate Variability	25
Section 2-3-LC	Long Term Climate Change	10
Section 2-3-ESI	Environment Issues and Societal Impacts	

### Module 3: PILOT PROJECTS (Three Months)

The phase I of nine months of this PG Course is conducted at Space Applications Centre (ISRO), Ahmedabad. During phase II of the course the participants are required to complete detailed 1 year project work in their respective countries. After successful completion of the project work, Masters' (M. Tech) degree of Andhra University, India is being conferred on these participants.

## COURSE CURRICULUM

A thoroughly detailed syllabus on the basis of Grenada document of UN-OOSA has been made for the course. The total syllabus is divided into 3 Units, each of 3 months duration. Unit-1 consists of lectures covering Concepts in General Meteorology, and Remote Sensing, Satellite and Ground systems, applications related to mainly qualitative interpretation of satellite imageries etc (including basics related to Mathematics, Statistics and Computer Programming). In Unit II, Radiative transfer, Geophysical Parameter Retrieval, applications in Meteorology, Oceanography and climate studies using digital data are covered, besides Numerical modeling. Unit-III consists of Pilot Project. This is later expanded into a one year Project to be carried out in the respective home countries of the Participants. At the end of the course, based on the feedback from course participants as well as the faculty, the course curricula is updated to make sure that it serves the requirement of the participants and incorporates latest developments.

The course has been organized through lectures, tutorial, laboratory, multimedia CDs', visits library, class tests and examinations. Morning sessions are mostly used for class room lectures where as afternoon sessions are devoted for practicals, tutorials, visits etc. Afternoon practicals involving analysis of various satellite data, interpretation of satellite imagery, parameter retrievals etc. are conducted using a specially created computer facility with 20 dedicated Pentium computers. Various s/w packages like GRADS, ERDAS etc are used by the participants for visualizing various output results. Practical involve extensive use of INSAT-VHRR, NOAA AVHRR / TOVS, SSMI, TRMM, MSMR data sets. A number of practicals which involve analysis of the GCM, MM5 and other model output are also carried out. Some of the important applications addressed are tropical cyclone intensity analysis and track prediction, monsoon monitoring, retrieval and use of SST, OLR, rainfall and WV, temperature and humidity profile, NDVI etc.

## FACULTY

Faculty members for this course is drawn mostly from the Meteorology & Oceanography Group, SAC. A few scientists from other groups in SAC, the Physical Research Laboratory, experts from India Meteorological Department, Indian Institute of Tropical Meteorology, National Institute of Oceanography, Andhra University, National Centre for Medium Range Weather Forecasts also deliver lectures. International experts in Satellite Meteorology are also invited to the Centre. Dr. Paul Menzel (NOAA,USA), Dr. Masami Tokuno (JMA, Japan), Dr. John Le



Dr. B.M. Rao delivering lecture to course participants

Marshall (BoM, Australia), Dr. Volker Gaertner (EUMETSAT, Germany), Dr. J Schultz (DLR, Germany), Dr. Koji Yamazaki (Hokkaido University, Japan), Dr. Kenji Nakamura (Japan), Dr. Chean Boon Khean, Malaysia and Mr. Jose Prieto (EUMETSAT, Germany), Dr. Guoshang Liu (FSU, USA) are some of the eminent scientists who have visited the Centre.

## SPECIAL FACILITIES

In November 2002, Dr. K Kasturirangan, then Chairman GB and Secretary DOS, inaugurated a new campus of Space Applications Centre at Bopal, in the outskirts of Ahmedabad. A special Satmet Laboratory with modular structure, uninterrupted power supply and networking is commissioned for the course with 20 Pentium PCs' and servers. This facilitates easy access to various satellite data sets, software etc to each participant, particularly during their three months pilot project phase.



A view of the SATMET laboratory

A dedicated high-speed Internet facility is established at the new campus. Special terminals for e-mail purposes are provided, which help the participants in data downloading, browsing and also remain in touch with their office/families. Library and e-mail facilities are also made available in good measure to the participants, both at the hostel and office. A set of three volumes of Lecture Notes specially edited and compiled comprises the main resource material for the course. These are distributed in the beginning of the course itself to all the participants.

A new well equipped residential complex is also part of the new campus. Accommodation in the hostel with all modern amenities including kitchen facility are made available to the course participants. It is generally seen that some of the students lack a proficiency in English Language and this hampers their progress in the class room activities. For such students a special English class is held in the evenings to improve their spoken and writing communication skills. It is seen that this generally results in their increased participation in the classroom activities.

## TECHNICAL VISITS

During the Nine months Course, the participants visit some of the important institutions/laboratories in the country to have a first hand experience of the utilization of satellite data in an operational environment. The technical tours include visits to :

- India Meteorological Department, New Delhi, (Satellite Meteorology Division, NHAC)
- National Centre for Medium Range Weather Forecasts (NCMRWF), New Delhi
- ISRO Satellite Centre, Regional Remote Sensing and Service Centre (RRSSC), Bangalore

- Indian Institute of Remote Sensing, CSSTEAP Head Quarters, RRSSC, Dehradun
- National Institute of Oceanography, Goa
- National Centre for Antarctic & Oceanic Research (NCAOR), Goa
- Andhra University, Visakhapatnam
- National Remote Sensing Agency (NRSA), Hyderabad



Course participants at NCAR Laboratory, Goa

These tours are so designed that the participants not only get an opportunity to visit excellent facilities of ISRO and other national organisations, but also get familiarized with the cultural heritage, diversity and natural scenic beauty of various parts of India.

## PILOT PROJECTS

The course participants learn a lot during the three months Pilot Project phase about formulation of a problem of relevance to their country, specifying and acquiring data (satellite and ground truth), execution and communication both orally and writing. The broad coverage of themes can be appreciated from the projects carried out by the participants. These could be listed in the following broad topics :

- Applications to tropical cyclone studies including storm surge using INSAT, GMS, TRMM data
- Meso scale studies using MODIS data & MM5 model, El-Nino, Ocean process studies
- Monitoring of Climate parameters like NDVI, Snow cover, ERB studies etc
- Merged rainfall products and validation
- Analysis of GCM outputs
- Geophysical parameter retrievals using MW data

The topics for one year project work of the participants are formally finalized after detailed discussions with the course participants, taking into account their countries' requirement and the facilities available locally with them. Participants are encouraged and provided help in acquisition of the data sets, required s/w support, analysis etc during this phase.

## ACHIEVEMENTS IN THE PAST 10 YEARS

- The Centre has so far conducted 4 nine months PG courses in Satellite Meteorology & Global Climate in 1998, 2000, 2002 and 2004. A total of 72 participants from 18 countries in A-P region have been benefitted from these courses. The breakup is given in table 1 :

Table - 1: output of long term PG courses of SATMET in past 10 years

Sl. No	Country	No of Participants
1	Bangladesh	7
2	China	1
3	DPR Korea	4
4	Republic of Korea	1
5	India	9
6	Indonesia	5
7	Islamic Republic of Iran	3
8	Kazakstan	7
9	Kyrgyzstan	2
10	Maldives	1
11	Malaysia	1
12	Mongolia	9
13	Nepal	6
14	Philippines	6
15	Sri Lanka	3
16	Thailand	1
17	Uzbekistan	3
18	Vietnam	3
	<b>Total</b>	<b>72</b>

The themes of pilot project carried out in these courses are given in table 2

Table - 2: SATMET (CSSTEAP) P. G. course student's pilot project work themes

S.No.	Trainees Country (No. of student)	Application Theme
1.	Bangladesh (7)	Rainfall estimation, soil moisture estimation using NOAA-AVHRR data, tropical cyclone track prediction using INSAT-VHRR data, rainfall features of bay of Bengal cyclones observed by satellite data and their comparison with surface observations, re-estimation of surface winds in the neighborhood of cyclones in BoB using TOPEX/POSEIDON altimeter data, TRMM-Meteosat merged daily rainfall, storm surge prediction and inundation along Bangladesh coast using satellite data.
2.	China (1)	impact of ground surface reflectance on AOD using Terra and Aqua MODIS over Ahmedabad.
3.	DPR Korea (4)	Monitoring of crops using NOAA-AVHRR data, vegetation and LST monitoring, use of vegetation index and thermal channels for soil moisture availability, aerosol optical depth over Indian ocean using satellite data
4.	India (9)	NWP model output with satellite derived products, ocean circulation modeling using satellite data, diurnal cycle of rainfall during Asian summer monsoon using TRMM observations, SST and sea surface winds over Indian sea using TRMM Microwave imager and IRS-P4 MSMR, sea state estimated by satellite data and conventional feet forecast over Arabian sea, assimilation of Quikscat data into a Mesoscale modeling

		system, cloud radiative forcing over the Indian region during 1987 El Nino event, MODIS atmospheric data validation and application for MESO scale processes studies, heights of atmospheric motion vector winds using geostationary satellite images.
5.	Indonesia (5)	Rainfall estimation, SST monitoring in El Nino region from satellite, dynamical modeling of forest fire spread, rainfall climatology over Indonesia using TRMM data
6.	Iran (3)	Coastal upwelling, snow cover monitoring , MSMR BT over Iran and its potential for drought monitoring through soil moisture analysis, Watershed management, Geomorphological studies.
7.	Kazakhstan (7)	Cloud analysis, MSMR BT data over India and Kazakhstan and its potential for large area soil moisture estimation, verification of different model forecast, exploration of linkages between Kazakhstan climate and the polar sea ice, internnual variability of boundary layer heat fluxes and related parameters over Caspian sea using SSM/I and AVHRR, T-80 model temp, forecast and NCEP data, temp, and moisture profiles with radiosonde and NCEP analysis
8.	Kyrgyzstan (2)	Qualitative rainfall estimation using VIRS an TMI observation using ANN approach, estimation of global insolation at surface using METEOSAT coverage
9.	Malaysia (1)	validation of NOAA-AVHRR pathfinder SST over Malaysian waters
10.	Maldives (1)	Climatology of SST, surface winds, significant wave height and SSHA using satellite data
11.	Mongolia (9)	wildfire danger estimation and monitoring using NOAA-AVHRR, retrieval and application of atmospheric temperature and humidity profiles from NOAA/TOVS satellite sounding data, vegetation and soil estimation tendency estimation, climatology of Mongolia using NCEP/NCAR data, retrieval of temperature and humidity profiles from NOAA/TOVS satellite data, intra & interseason variation in vegetation index over Mongolia, verification of extended range forecast over Mongolia, drought assessment using RS and meteorological data, characterization of dust aerosols from satellite remote sensing data.
12.	Nepal (6)	Onset of monsoon over Nepal using satellite data, break and active monsoon, western disturbances using satellite data, verification of extended range model output with Oceansat 1 data, climatic variability of mountain valley glacier, impact of MODIS data in Meso-scale model to predict rainfall over Nepal
13.	Philippines (6)	Tropical cyclone track prediction using cloud top temperature analysis, rainfall estimation over a cyclone using cloud indexing technique, tropical cyclones using GMS water vapor imagery, humidity profiles over the Arabian sea and the BoB using MSMW total precipitable water, variability of the 1990's El Nino using the derived satellite parameters, oceanic thermal response to tropical cyclones around Philippines using satellite data.
14.	Republic of Korea (1)	Rainfall from TRMM-RADAR and radiometer.
15.	Sri Lanka (3)	Retrieval, validation and applications of SST using NOAA-AVHRR and ERS ATSR data, identification of the oceanic features using NOAA-AVHRR data, SSM/I derived meteorological parameters for southwest monsoon studies
16.	Thailand (1)	Variation in thermal structure of Indian ocean using a limited area ocean model.

17.	Uzbekistan (3)	Temperature and humidity profile using NOAA/TOVS sounding data, rainfall estimation using cloud indexing, humidity and temp. profile from NOAA/TOVS package
18.	Vietnam (3)	Satellite cloud top temperature method for cyclone track prediction over Vietnam, movement of tropical cyclone using GMS vapor and NCEP data, wave modeling over the south China sea.

**Total 72 students from 18 countries**

- A total of 11 participants have completed their one year project and after the scrutiny of the suitability of the thesis, they have been awarded a post graduate M. Tech degree by Andhra University. The table 3 gives the list of candidates awarded the M Tech degree.

**Table 3 : Status of M.Tech degrees awarded in SATMET Course**

S.No	Name of the Candidate	Country	Year of Course attended	Title of the M Tech Project
1.	Mr. Siri Ranjith Jayasekera	Sri Lanka	1998	Retrieval, validations and applications of Sea surface temperatures
2.	Mr. Wahyu Subektiyo	Indonesia	1998	Rainfall estimation over Indonesian region using Arkin's technique
3.	Mr. R P Shrestha	Nepal	1998	Break and active monsoon over Nepal
4.	Mr. M H Sarker	Bangladesh	1998	Characterisation of the growth of Rabi crops and Boro rice in the context of Bangladesh based on NOAA-AVHRR data
5.	Mr. R M Khaladkar	India	1998	Comparison of satellite derived sea surface winds with NWP model analysis and forecast
6.	Mr. Aftab Ahmed Can	India	1998	Ocean circulation modeling using satellite data
7.	Mr. H N Singh	India	2000	Investigations into relationship between extreme wet/dry conditions over India and space-based OLR observation over global tropics
8.	Mr. D Vijaykumar	India	2000	Validation of 3g-WAM Wave predictions over Arabian sea for operational implementation in Naval environment
9.	Mr. G Rambabu	India	2002	Quikscat Scatterometer wind data impact on tropical cyclone forecasts by a mesoscale model
10.	Mr. A S M Urooj	India	2002	MODIS atmospheric data validation and application for Mesoscale processes studies
11.	Mr. Viet Van Luong	Vietnam	2002	Wave modeling over the South China Sea

- In addition to long terms PG course on SATMET last 10 years CSSTEAP organized 2 Workshop mainly for the benefit of planners, educators and researchers. These courses/workshop had benefitted 25 scientific/technical personnel from 10 countries of Asia Pacific region.



The various themes covered are mentioned below: -

- Workshop on “Emerging trends in satellite meteorology: Technology & Applications (ETSAMTA)” during March 9-12, 1998. The workshop was dedicated to the memory of Prof. Verner E Suomi, father of Satellite Meteorology
  - A short course on "Emerging trends in satellite meteorological applications with special emphasis on microwave remote sensing" was conducted during May 6-17, 2002 at SAC, Ahmedabad. 16 participants from 9 countries in AP region attended the course.
- During the last ten years the SATMET Course personnel have published 3 Lecture Notes Volumes in book form (covering about 1000 pages) for the 9-months PG course. This is used as the resource material by the participants, besides two workshop proceedings.

It is great pleasure that CSSTEAP has completed ten years of its existence. It is appropriate that we look back and review the progress made so far. The primary objective of CSSTEAP of capacity building in Satellite Meteorology and other areas of Space Science & Technology is being met successfully. It is a matter of great satisfaction for all of us that seventy two participants from 18 countries in A-P region have been trained in the field of Satellite Meteorology and are expected to transfer this knowledge further, bringing new technologies in their daily routine, improving the skills leading to better analysis and better weather outputs. The fact that four courses so far have attracted such enthusiastic response from the participating countries shows that the programme is self sustaining and meeting the requirements of the participating organizations. These training courses have contributed in the augmentation of national capabilities in the Asia-Pacific region. There are no two opinions that the new technologies must be exploited for the benefit of the Asia-Pacific countries and the world at large. Here, the CSSTEAP is playing a very important role in human resources development.

However, it is felt that efforts should be made to bring in more countries in A-P region to participate in these programmes to reap the benefits of the emerging new technologies. World Meteorological Organization (WMO), UN-OOSA and other International organizations should be approached to spread this message in all the countries to enhance the level of participation.