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Role of Satellites in Meteorology

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Among the courses conducted by CSSTE-AP, one concerns "*Satellite Meteorology and Global Climate*". In this article, we look at the role of satellites in meteorology, which may help to understand the rationale for such a course, and the wide interest it is attracting (in the 2 courses on this topic, one conducted in 1998 and another in progress in 2000, a total of 38 students from 13 countries have participated).

Figure 1 : *Weather Systems over India and adjoining oceans tracked by INSAT*

Satellites can play two distinct roles in meteorological services - Remote Sensing and Communications. The later encompasses Relay of Data from Data Collection Platforms, Disaster Warnings, Broadcast/ Telephony via satellite, Tracking of Drifting Buoys at Sea, and Data Exchange between ground stations as well as from other satellite to ground station via Weather/Climate related parameters/features by Satellite and their benefits/applications.

To set the stage, we begin by noting that meteorological satellites generally are placed in either of two distinct orbits : low-earth orbit (usually, with nearly same equator-crossing time everyday) and geosynchronous orbit over the equator, appearing 'fixed' as its orbital period is 24 hours, matching with the rotation of the earth. The altitude of a geosynchronous satellite is a rather high (around 36000 km). The period of the low (1000 km) satellite is around 100 minutes.

A low-earth satellite (exemplified by the US-NOAA, Russion METEOR and forthcoming ESA's METOP) see different parts of the earth in its different orbits, as the earth moves forward by about 25 degrees' longitude in the time the satellite completes one orbit. Generally the satellite is equipped with wide-swath cameras or "Scanning radiometers" to be precise, besides atmospheric "sounders". Cloud imagery and (in cloud free areas) sea surface temperature (ocean)/vegetative index (land) are provided by the radiometer, whereas the sounder provides temperature and humidity profiles (from which "geostrophic wind-flows can be inferred in mid-and high-latitudes). Considering day and night (ascending / descending) passes, a given area would be seen by the satellite twice a day (of course in the night, only the thermal infrared channels would be useful, not the visible).

A geosynchronous satellite (exemplified by ESA's METEOSAT, India's INSAT, Japanese GMS, Chinese FY2) can generally create an image of the one-third or so global disc that it can view from its fixed

Inside this issue...

vantage point, in about half-an hour. Thus in principle it can take 48 images in 24 hours - although in practice generally only 10 images are taken again, with the provision that the visible channel would give useful image only in daylight hours whereas the infrared channel works all the time.

The usefulness of such a platform for monitoring the important weather phenomena affecting Indian (and surrounding) region is shown in figure 1. These weather phenomena viz. Tropical cyclones and South-West Monsoon originate over the data-sparse Oceans, where satellites are the only means of getting informations/observations concerning them, besides of course a few ships and island station data.

The other output of NOAA type satellite, Viz. Vegetation index, is generally not available from geosynchronous satellite excepting India's INSAT which has a separate camera for this purpose. A special 'water-vapour' channel is available on most geosynchronous satellite to map mid-tropospheric water-vapour. Sounder, available on NOAA, is not available on Asian/European geosynchronous satellites (yet)-only on US GOES.

In the tropical region, especially near-equatorial belt, wind cannot be inferred from thermal field by geostrophy; here geosynchronous satellite comes to help by permitting small could to be used as 'tracer' in successive imagery to estimate winds - these tracer clouds are largely located at 850 and 200mb. The water-vapour features at mid-troposphere (around 400mb) can give flows at that level also.

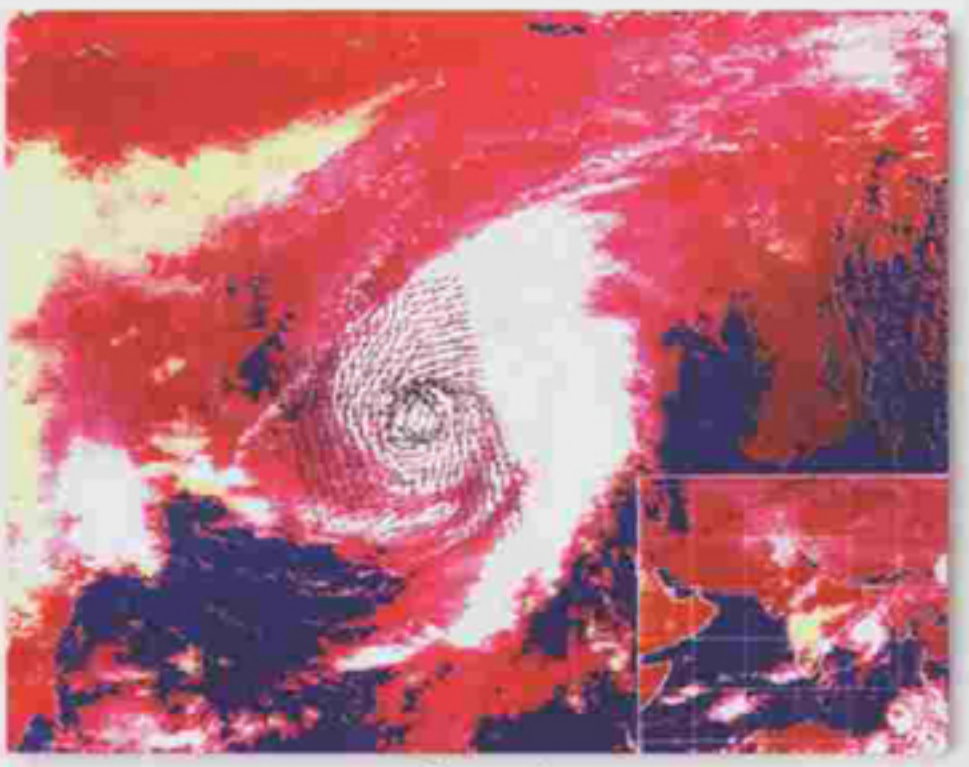

Figure 2

Besides the above-mentioned 'operational satellites' there are many 'experimental' satellites/sensors which after due testing, become quasi-operational. ESA's ERS, India's Oceansat-1 are satellites oriented to oceanography/marine-meteorology; their data are also useful in meteorology. The US- Japanese TRMM is a tropical orbiting rain mapping mission. The US DMSP has microwave radiometers giving useful oceanic/atmospheric parameters. The US UARS is devoted to stratospheric trace-gas measurements for climate/ozone studies. Armed with the above outline of met/ocean satellite and the type of data they can provide, we now touch upon some applications, which can be addressed with these data.

Satellites provide synoptic, frequent data-coverage, this is especially vital over otherwise data sparse regions e.g. oceans, deserts, mountains. In this context it is obvious that storms approaching a country either from oceanic area (e.g. cyclone/typhoons striking coastal countries, from South China Arabian Sea etc.) or moving over deserts, (e.g. Western Disturbance across Iran-Afghanistan-Pakistan-India) can be more effectively and accurately tracked, and with a longer lead-time, by satellites (particularly geosynchronous ones) than ground-based systems like say, radars which have a limited coverage. Similar is the case with less severe yet important synoptic system, e.g. monsoon depressions over the Bay of Bengal. The sea surface temperature is also very useful (e.g. for knowing El-Nino). Beside cloud/sea imagery, the sounder data, though less spectacular (we generally do not make a 'visual' product out of it), are also important particularly in delineating front approaching thermal fronts moving across high latitudes, blocking highs, humidity front approaching at the onset of monsoon, etc. Now-a-days, numerical weather prediction using model on computers is done (e.g. at NCMRWF, Delhi, Japan Met. Agency etc.). These need 'initial conditions' and 'forcing functions', some of which are provided by satellite sounders (temperature, humidity, radiation, etc.).

An example of ERS-1 Wind Scatterometer observations of surface wind fields beneath a severe cyclone in Bay of Bengal is shown in figure-2. These can be successfully used as initial conditions ('bogus vortex') for simulating these cyclones using models.

We can think of 'research use' of satellite data also e.g. in snow-cover/snow-melt mapping/estimations, rainfall estimation, tracking dust-storms/sand-dunes, etc. All in all, satellite observations are becoming nearly indispensable in meteorology/climatology.

Annual Day Celebration of CSSTE-AP

The CSSTE-AP affiliated to the UN has crossed a major milestone by completing five years of its fruitful and productive existence after it was formally established on Novermber 1, 1995. To mark this important occasion a programme was organized at the Space Applications Centre (SAC), Ahmedabad on November 1, 2000.

The programme was attended by the CSSTE-AP participants of the second Post Graduate Course on Satellite Meteorology (SATMET) being held at SAC and of the second PG Course on Space Science concurrently being conducted at the Physical Research Laboratory (PRL), Ahmedabad. Prof. G.S. Agarwal, Director, PRL was the Chief Guest and Shri A.K.S. Gopalan, Director, SAC, the Guest of Honour. Dr. Volker Gaertner, User Support Manager, EUMETSAT, Germany was the special invitee. Besides several senior Scientists from SAC and the PRL were also present to mark the occasion.

Prof. B.L. Deekshatulu, Director, CSSTE-AP since its inception, Prof. G.S. Agarwal, Shri A.K.S. Gopalan, Dr. P.C. Joshi, Course Director, SATMET, Dr. H.S.S. Sinha, Course Director, Space Science and two participants from each of the courses addressed the gathering and expressed their views on past performance of the Centre and about what the future may hold. All the speakers were unanimous in expressing their appreciation over the highly satisfactory performance of the first Centre of its kind in the world despite certain constraints. They also expressed their views on the possible future course for the Centre.

Dr. Volker Gaertner made a detailed and interesting presentation on "EUMETSAT and its Activities"on the occasion. The morning programme of presentations was followed by a get together over dinner of all the participants of both courses and senior persons connected with the CSSTE-AP activities at Ahmedabad along with Director, CSSTE-AP and Dr. Gaertner.

Fifth RS & GIS Course

The fifth Post Graduate Course (2000-2001) on Remote Sensing and Geographic Information System (RS & GIS) of CSSTE-AP is in progress at Indian Institute of Remote Sensing (IIRS), Dehra Dun, the host institution of CSSTE -AP. The course commenced on October 1, 2000 and is being attended by 19 participants from 13 countries of Asia and Pacific region. The first module of phase I of three months duration ended on December 31, 2000. The first module covered fundamentals of principles and techniques of Remote Sensing, GIS and GPS (Global Positioning System). In addition to major faculty members drawn from IIRS, some specialised faculty from reputed institutions/ organisations of India such as SAC (Space Applications Centre), Ahmedabad; ADRIN (Advanced Data Processing Research Institute), Hyderabad; SOI (Survey of India), Dehra Dun; ISAC (ISRO Satellite Centre), Bangalore; CSRE, Indian Institute of Technology, Mumbai also delivered guest lectures. International experts like Dr. K. Jacobson, Institute of Photogrammetry, University of Hannover, Germany; Dr. Bruce Forster, School of Survey, Centre of RS & GIS, University of New South Wales, Australia and Dr. R. Thomas, GDTA, CNES, France were also invited to deliver guest lectures on special topics like mapping from space, microwave Remote Sensing and digital photogrammetry. The participants also attended 4 days International UN/ESA/COSPAR Workshop on Satellite data reduction and analysis techniques at

Dr. Bruce Forster delivering lecture at RS & GIS Course, IIRS, Dehra Dun

IIRS, Dehradun during 27-30 November, 2000. Serval field excursions were arranged during this module for ground truth collection and demonstration of various ground truth equipments and these information were utilized for interpretation and analysis of Remote Sensing Data. Academic performance of the participants were evaluated through class tests, tutorials, written and practical examinations. In order to have little diversion from the very hectic academic schedule, a three day trip to world famous Taj Mahal at Agra and Capital city of India, Delhi was also arranged. A special cultural evening was jointly organised by CSSTE-AP and IIRS Course participants during this period and all the course participants performed dances/sang songs in the cultural programme.

Short Term Course on RS & GIS

Second Short Term international course on "Remote Sensing and GIS- Technology and its application in Natural Resources and Environmental Management" was conducted at Indian Institute of Remote Sensing (IIRS), Dehra Dun during August 28, 2000 to September 22, 2000. 14 participants from 9 countries viz. Uzbekistan, Ghana, Mauritius, Kazakhstan, Vietnam, Romania, Lao PDR, Kenya and India, attended the course. The objective of this course was to make middle level resource managers familiar with techniques of Remote Sensing and GIS and its applications for sustainable natural resources and environmental management in a cost effective manner. The course was modular in structure and provided a balanced treatment of theory, application, computer aided practical handson experience and field excursion. The major topics covered in this course were: Fundamentals of Remote Sensing, GIS and GPS technology, advanced concepts of Remote Sensing and GIS, RS & GIS applications in Natural resources and environment assessment, monitoring and management. The course participants also had a glimpse of India's rich culture and heritage during their 3 days educational excursion to the cities of Agra and Delhi. The valedictory function was held at IIRS on September 21, 2000. Shri A.K.S. Gopalan, Director, Space Applications Centre, ISRO, Ahmedabad delivered the valedictory address and distributed the certificates to the course participants.

SATMET Activities

The second 9 months Post Graduate Course on Satellite Meteorology & Global Climate, which commenced on July 1, 2000 is being attended by 21 participants from 13 countries. The first module covering basic concepts of Satellite Meteorology, Climatology, Mathematics, Computer programming, Statistics etc were completed on September 30, 2000. At the end of the module I examinations (both theory and practical) were conducted. Apart from the core faculty from ISRO, a few faculty members from reputed Institutions like India Meteorological Department (IMD), Indian Institute of Tropical Meteorology, (IITM, Pune), Gujarat University delivered lectures. Prof. Yamazaki of Hakkaido University, Japan, Prof. Shukla (COLA, USA) also delivered lectures in Module I.

The participants undertook a Technical Tour to New Delhi and visited Satellite Meteorology Division, of India Meteorological Department and had a first hand experience of utilization of INSAT and NOAA data for operational forecasting purposes. They visited National Centre for Medium Range Weather Forecasts (NCMRWF) and were briefed about Operational Modelling activities. They also visited CSSTE-AP Head Quarters and Indian Institute of Remote Sensing (IIRS) at Dehradun. A one day trip to world famous Taj Mahal at Agra was also arranged.

The second module covering advanced topics like Radiative Transfer, Satellite Data Applications, Parameter Retrievals, Global Climate etc

- *Dr. Subrat Sharma has been provided financial grant by Dr. Shunji Murari to attend the Asian Conference on Remote Sensing (ACRS) during December 4-8, 2000 at Taipei. Dr. Subrat Sharma, CSSTE-AP alumni who had undergone the PG course in RS & GIS at Dehra Dun during 1997-98 and has been awarded M.Tech. degree by Andhara University, India.*
- *Sponsored by UN/OOSA, Dr. K Bandyopadhyay of Space Application Centre, Ahmedabad and member of teaching staff for CSSTE-AP SATCOM course attended the UN/Malaysia Workshop at Kualalumpur during November 20-24,2000.*

began on October 1. The afternoon practical sessions involving satellite data analysis and applications are being continued. The weekly Weather Discussions of current weather over India and Asia-Pacific using satellite images and other ancillary data from various sources including Internet have proved very useful. Some of the major weather events like Monsoon-2000 performance, severe cyclones/ Typhoons over Pacific, affecting coasts of Philippines/Vietnm (e.g. Bebinca), floods etc. were discussed in great detail.

The participants in consultation with the faculty members have identified their pilot projects to be undertaken during January-March, 2001. The participants met Dr. K. Kasturirangan, Chairman, Governing Board, CSSTE-AP during his visit to Space Applications Centre, Ahmedabad and was briefed about the progress of the participants.

The SATMET course participants had undertook their Second Technical Tour during November 28 to December 8, 2000. During this tour they visited Mumbai, Bangalore (ISRO Satellite Centre) and Goa (National Institute of Oceanography). They also visited the Oceanographic Research Vessel "SAGAR-KANYA" at Goa to acquaint themselves with the marine measurements.

Prof. Yamazaki of Hokkaido University, Japan delivering lecture at SATMET - 2K course in Ahmedabad

The participants along with the faculty and their family members celebrated the festival of lights "Deepawali" and enjoyed the social event.

Space Science Activities

The second Space Science course of the CSSTE-AP, which started at the Physical Research Laboratory (PRL), Ahmedabad, India on August 1, 2000, is nearly halfway through. The first module of the course, which deals with the theoretical aspects of Structure and Composition of Neutral Atmosphere, Plasma Aspects of Earth's Environment and Astronomy and Astrophysics was completed in November, 2000. In addition to the senior faculty members of PRL, faculty members from Institute for Plasma Research (IPR), Gandhinagar, Indian Institute of Geomagnetism (IIG), Mumbai, National Centre for Radio Astrophysics (NCRA), Pune and University of Arizona, USA, gave lectures in this module. The second module involved performing six state of the art experiments in the field of space science. These experiments were Measurement of mass suspended particles, Surface monitoring of minor constituents, Determination of the slit function of a monochromator using a He-Ne laser as light source, Ionospheric sounding using an ionosonde, Low current measurement using Langmuir probe, Optical imaging of plasma depletions. Participants were examined through class tests, seminars, written and practical examination in these topics.

Faculty and Students at PRL's IR Observatory, Gurushikar, Mt. Abu

After a very hectic schedule of work, all the participants were taken on a study tour to PRL's IR Observatory at Gurushikhar, Mt. Abu, Udaipur Solar Observatory, Udaipur. A trip to Agra was also arranged to see the famous Tajmahal monument.

The third module dealing with the theoretical aspects of Ionospheric Physics and "Radio Wave Propagation", "Optical and Laboratory Studies of space processes" and "Modeling of Atmospheric processes" has already started. The fourth module dealing with another six space science experiments is also in progress. After completion of modules 3 and 4, there will be final examinations for theory and experiments. All the participants will be taken for a second study tour, wherein they will be shown a few selected space research facilities in India.

A pilot project of two month's duration would be conducted next. As many of the participants do not have a clear-cut idea of what is feasible as a one year home project in their country, this pilot project at PRL will initiate the foundation of their one year project at home. The pilot project is undertaken in

consultation with the supervisors in India as well as in the home country. During this two month period, the participants are supposed to work under the guidance of one Indian supervisor and get the guidance on the line of action to be pursued at home, all the necessary experimental data, if available and necessary software tools, etc.

Meeting of Board of Studies for SATMET Course

As per the recommendations of the Advisory Committee of CSSTE-AP meeting held on 4th July, 2000 at Dehra Dun, India, a Board of Studies (BOS) was constituted for the PG course on Satellite Meteorology and Global Climate (SATMET). The first meeting of the BOS was held at Andhra University, Vishakhapatnam on September 30, 2000. In addition to the committee members, Prof. Yamazaki of Japan was invited as the subject expert. The status of the existing curriculum for the SATMET course and related activities were discussed in detail and suggestions for improving the course curriculum were provided by members.

COURSES IN PROGRESS

- Second Post Graduate Course on Satellite Meteorology and Global Climate at SAC, Ahmedabad from July 1, 2000. (21 participants from 13 countries)
- Second Post Graduate Course on Space and Atmospheric Sciences at PRL, Ahmedabad from August 1, 2000 (9 participants from 5 countries)
- Fifth Post Graduate Course on Remote Sensing and GIS at IIRS, Dehra Dun from 1 October, 2000. (19 participants from 13 countries)

FORTHCOMING COURSES

- Third 9 months PG Course in Satellite Communications commencing from July 1, 2001 at SAC, Ahmedabad.
- International short course on Application of Space Science & Technology for Social Scientists of Asia-Pacific region during 9-21 July, 2001 (first week at NRSA, Hyderabad and second week at SAC, Ahmedabad).

Director Speaks

You may have noticed over the past in our previous issues that we have pursued the initiative of this newsletter with not only an intension to provide information on our progress but also to project the opinion of our governors and eminent scientists on the prospect of Space Science & Technology as well as our role in the subject. Through this exercise, we now appreciate that there is a convergence in objectives of space science capacity building world over. Therefore, it should be possible for us now to use the medium of CSSTE-AP newsletter to converge global ideas, concerns and opinion on the subject. Already, our 150 post graduates are projecting the benefits of their learning in their realms of activity and we are documenting the process of the spread of knowledge in the region. With the convergence of ideas from the wide horizon of space science & technology educators, professionals and administrators from around the world through the newsletter, we could also sense the purpose of establishing a forum for information exchange and intellectual debate. In this background, it is solicited that articles from the readers on topics of relevance to space science and technology are welcome.

We are also in the process of establishing a databank of scientific, environmental, institutional professional, socio-economic and general information on the region of Asia-Pacific. Once established, this databank could serve as a clearing house of information. The readers are solicited to write about themselves and their organizations. It is also appreciated to receive information brochures and technical reports of their institutions and initiatives.

I wish you all a very happy, prosperous and gainful New Year 2001.

-Prof. B.L. Deekshatulu

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