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INDIAN INITIATIVES AND STATUS OF METEOROLOGICAL/ OCEANOGRAPHIC SATELLITE PROGRAMMES

A NOTE FOR CONSIDERATION IN NOAA' S PROPOSED FUTURE POLAR ORBITING OBSERVATION SYSTEM

The Indian activities in Weather Forecasting through space observations can be traced to mid 1960s, when the first Automatic Picture Transmission (APT) stations were established for receiving NOAA pictures at five centres of the India Meteorological Department (IMSD). In the 1970 – 80s there were regular M-100 rocket soundings from the Thumba Equatorial Rocket Launching Station (TERLS) with the cooperation of USSR for studying the Equatorial atmosphere up to mesosphere. The reception of high resolution NOAA imagery in 5 – bands since 1979, along with data from Indian geostationary satellite – INSAT, has now become an integral component of the operational weather forecast in the country for the short to medium ranges.

The weather systems of major interest to India, with a vast ocean surrounding it, are the Southwest monsoon and the tropical cyclones. The observations and forecasting rely to great deal on the satellite observational inputs. The onset on monsoon, intra seasonal fluctuations – the active break phases of the monsoon, formation and movement of depressions in Bay of Bengal, the interannual variability, cyclogenesis, cyclone track and intensity prediction etc., are some of the issues that have been engaging the attention of the meteorologists and climate scientists for several decades. Satellite observations and General Circulation Models (GCM) have become important modern tools for these studies. The satellite products (temperature, pressure, humidity, winds etc.,) available from Global Telecommunication System (GTS), besides the conventional data and the INSAT – derived products (eg., Cloud Motion Vectors) are assimilated in the National Centre for Medium Range Weather Forecasts (NCMRWF) Global Data Assimilation System (GDAS) for producing daily analysis fields and operational forecasts in the medium range. INSAT data are used also to produce daily OLR and weekly precipitation index.

The MONEX / FGGE (1979), TOGA (1985-95), International Geosphere Biosphere Programme (IGBP), INDOEX (1997-99), CLIVAR and several international programs have given impetus to many of these studies. Starting with the INSAT-1 series of satellites (with VIS, IR channels) since 1984, the indigenously built INSAT-2 series of geostationary satellites have been the main work horse for operational short, medium range and synoptic forecasts. INSAT-2E with water vapour channel imageries has been a highly important channel for the monsoon and cyclone development monitoring and forecast. The impending onset and withdrawal of monsoon are well captured in the water vapour channel imageries. INSAT-2E has a CCD camera providing 1km spatial resolution with around 600km swath.

INSAT-3A and Metsat to be launched [*]by 2001/2002, will have similar capabilities to image in 3 bands. INSAT-3D (~2004) will be a leap frog effort with channels (including 2 split thermal channel) contributing to continuous SST monitoring – so that even during monsoons, one may get some partly clear scenes on a few occasions to derive SST from IR sensors. It also will have the 19 channel sounder to estimate the temperature and humidity profiles of the atmosphere. This will give a fillip to study the mesoscale phenomena in tropical latitudes (Refer Appendix-A for INSAT-3A and 3D specifications).

India has a very ambitious plan for microwave observations for meteorology and oceanographic studies. Indian OCENSAT-1 satellite in May 1999 with Multichannel Scanning Microwave radiometer (MSMR) along with Ocean Colour Monitor (OCM) is a first major step in this direction. Very useful data since June 1999 for more than a year have been obtained from MSMR. SST, total water vapour content over the marine atmosphere, sea surface winds etc., have been provided to the scientific and operational weather forecasting community. These data are being used in NCMRWF and many numerical experiments have been carried out to study the impact of MSMR data in the assimilation scheme. It has been shown that nearly 80% of the MSMR products are being assimilated by the system. The MSMR data have also been validated using three approaches – insitu, inter-satellite and model analysis. These validation have given enough confidence, and shortly these data are to be used operationally in the NCMRWF model for medium range forecasts upto 5 days (Refer Appendix-B for MSMR specifications).

On an experiment mode, the Antarctic sea is being monitored and the seasonal fluctuations in the extent has been studied. The Weddel sea ice cover decrease established by SMMR (Nimbus) trend has been confirmed by these observations. Also using the 6.6 GHz brightness temperature, soil moisture over the Indian peninsula is being mapped – an important input for Extended Range Monsoon simulations by Dynamical models.

Indian space programme addresses the important area of Ocean Sate Forecast in the medium time scale. Ocean circulation, wave height and direction, mixed layer depth, sea level variability, etc., are some of the important parameters that will be of interest to be obtained from scatterometers, altimeters and radiometers from space platforms. The OCEANSAT-2 of India planned beyond year 2005 may contain a complement of MM wave of passive radiometers and altimeter in a near polar orbit for these observations. Attempts are also made to develop Synthetic Aperture Radiometers to get higher resolutions with a view to obtain global soil moisture and snow cover that will be used as an input to weather prediction models.[*]

The Department of Ocean Development provides the required infrastructure for validation of the parameters from these space observations. It has a fleet of research vessels, providing insitu data taken during special cruises. It also operates coastal and deep sea Buoys. There are also plans to deploy about 150 ARGO submersible buoys in the Indian

[*] Input from AKS Gopalan, Director, Space Applications Centre, Indian Space Research Organisation, Ahmedabad-380053, India

Ocean for providing thermal, salinity observations up to about 2 km deeper in the ocean waters. These observations, along with space data will be invaluable inputs for the International CLIVAR programme.

India has many International cooperation programmes with many countries, through Announcement of Opportunity programmes and also through bilateral cooperation. ERS – scatterometer and altimeter data, TRMM etc., are being analysed for studies of cyclones and monsoon. Indian MSMR and OCM data are also being made available to international community. There is also a major NASA/NOAA – DST/DOS collaboration programme in meteorology for exchange of INSAT and other satellite data and scientific studies. ISRO as Member of International Committee on Earth Observation Satellite (CEOS), has been activity involved in various initiatives including Integrated Global Observing System (IGOS).

ISRO has been pursuing international collaboration in its IRS programme also wherein, through, Space Imaging Inc., USA, the IRS data is received globally and marketed. Similarly, the OCEANSAT-1 data (both Ocean Colour Monitor and MSMR) are also planned to be made available to the global scientific community through an Announcement of Opportunity. Efforts are also on to make data reception arrangements through M/s Seaspace Corporation, and another 7 satellites are through advanced stages of development and conceptualization.

India has been actively participating in the international calibration/validation programmes initiated by CEOS and is engaged in developing inter sensor calibration models.

ISRO has built about 14 operational satellites of INSAT and IRS series so far. The launch vehicle required for placing Remote Sensing satellites in sun synchronous orbits has been developed and successfully used in IRS programmes. Geo synchronous launch vehicle is in an advanced stage and is expected to be operationalised in the near future. Multiple satellite launches of an Indian, Korean and German satellites using Indian Polar Satellite Launch Vehicle in 1999 is noteworthy. IRS-P3 spacecraft had the MOS payload from DLR.

In conclusion, India can participate and contribute to the future polar orbiting observation systems envisaged by NOAA in the following areas :

- Providing/supplementing research and operational instruments in both optical and microwave regions.
- Satellite platforms for both low earth orbiting Remote Sensing payloads as well as for weather monitoring geosynchronous satellites.
- Data reception, data processing, data dissemination, data utilization and value added services
- Calibration and validation activities
- Launch vehicles for both low earth orbiting sun-synchronous satellite and for geosynchronous orbit spacecrafts

India is also willing to collaborate/cooperate with other Space Agencies in global observation systems on a mutual benefit/cost sharing basis.

Appendix-A

INDIAN NATIONAL SATELLITE (INSAT) – PAST & PRESENT

INSAT-1 : Geotationary Satellite Series

Satellite	Launch Date	Met. Payload with Wavelength Bands	Major Applications
INSAT-1A	April 10, 1982	Very High Resolution Radiometer (VHRR)	• Monitoring cyclones & monsoon • CMV Winds • OLR • Rainfall Estimation
INSAT-1B	August 8, 1983		
INSAT-1C	July 22, 1988	Bands : 0.55.0.75µm 10.5-12.5µm	
INSAT-1D	June 12, 1990		

INSAT-2 : Geotationary Satellite Series

Satellite	Launch Date	Met. Payload with Wavelength Bands	Major Applications
INSAT-2A	July 10, 1992	Very High Resolution Radiometer (VHRR) Bands : 0.55.0.75µm 10.5-12.5µm	• Monitoring cyclones & monsoon • CMV Winds • WV Winds • OLR • Rainfall Estimation • Mesoscale features • Flood/intense precipitation advisory • Snow detection • Crop discrimination • Aerosols studies
INSAT-2B	July 23, 1993		
INSAT-2E	April, 1999	1. VHRR : As above + WV Band : 5-7.1µm 2. CCD Payload Bands: 0.63.0.79µm 0.77-0.86µm 1.55-1.70µm	

Appendix-A (contd)

INDIAN NATIONAL SATELLITE (INSAT) – FUTURE

INSAT-3 : Geotationary Satellite Series

Satellite	Launch Date	Met. Payload with Wavelength Bands	Major Applications
INSAT-3A (Similar to INSAT-2E)	2001	1. VHRR : As above + WV Band : 5-7.1μm 2. CCD Payload Bands: 0.63-0.79μm 0.77-0.86μm 1.55-1.70μm	• Monitoring cyclones & monsoon • CMV Winds • WV Winds • OLR • Rainfall Estimation • Mesoscale features • Flood/intense precipitation advisory • Snow detection • Crop discrimination • Aerosoles studies Temperature/humidity profile (with INSAT-3D)
INSAT-3D	2004	1. Imager Bands : 0.52-0.75μm 1.55-1.70μm 3.80-4.00μm 10.2-11.2μm 11.5-12.5μm 2. Sounder Bands : 19 channels between 0.69-14.71μm	
Metsat	2001	VHRR : Similar to INSAT-3A	• Monitoring cyclones & monsoon • CMV Winds • WV Winds • OLR Rainfall Estimation

Appendix-B

INDIAN REMOTE SENSING SATELLITE (IRS-P4) / OCEANSAT-1

Date of Launch : May 26, 1999

Launch Vehicle : PSLV (India)

Payloads : Ocean Colour Monitor (OCM)
Multichannel Scanning Microwave Radiometer (MSMR)

Orbit : Near Polar (Inclination : (98.25°), Sun-synchronous with equator crossing time at 1200 noon and night

Swath : 1420 km (OCM); 1380 km (MSMR)

MSMR

Frequencies & Polarisation : 6.6 GHz, 10.6 GHz, 18 GHz and 21 GHz; V&H

Beam Footprint : ~40-120 km

Products Available : Integrated Water Vapour, Sea Surface Temperature
Wind Speed and Cloud Liquid Water

Major Applications

- Sea State Forecast : Waves, Circulation and MLD
- Monsoon and Cyclones Forecast – Medium and Extended Range
- Rain rates over Oceans
- Large Scale Soil Moisture
- Antarctic Sea Ice

OCM

Instantaneous Geometric FOV : 360m at nadir

Repetivity : 2 days

Spectral Bands : 412nm, 443nm, 500nm, 510nm, 665nm (with 20nm width), 765nm, 865 nm (with 40nm width)

Major Applications

- Fisheries and Primary Productivity Estimation
- Detection and Monitoring of Phytoplankton Blooms
- Sediment Dynamics