# SATELLITE APPLICATIONS IN CLIMATE CHANGE STUDIES

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## *Abstract*

*The potential climate changes and possible adverse impacts on the economy and society at large are causing concern. In India, one of the major concerns is the variability of monsoon rainfall and effects on agriculture and water management. The effects of global warming on the Indian subcontinent vary from the submergence of low-lying islands, frequent flooding, coastal degradation and melting of glaciers in the Indian Himalayas. While studying the environment scenarios, it is essential to build up necessary strategies at local level to reduce the adverse impacts especially on agriculture and water management. It may be necessary to adopt improved agriculture practices with resistant seeds, efficient water management etc. It will be a challenging task to counter the effect of climate change through scientific means. INSAT and IRS satellites in early 1980s heralded the era of Space observations. The IRS satellites are providing observations of parameters such as land use/cover, forest, water bodies, crops etc. while INSAT provides quantitative products such as Cloud Motion Vectors (CMVs), Quantitative Precipitation Estimates (QPEs), Outgoing Long-wave Radiation (OLR), Vertical Temperature Profiles (VTPRs), Sea Surface Temperature. Currently INSAT satellites are providing global and regional observations. It carries Very High resolution Radiometer (VHRR) payload which operated in two spectral bands – visible [0.55-0.75 µm] and thermal infrared [10.5-12.5 µm]. The INSAT satellites give every hour weather imageries of the country showing the cloud systems, their movement and potential severe weather events. The paper presents capability of satellites to improve weather forecasts and give valuable inputs to climate models.*

***Key words:***

## Introduction

Accurate and reliable weather and climate prediction holds the key for socio-economic development and is essential for food security of the human society. The day-to-day changes in weather are another factor that has direct impact of human society. The agricultural operations of ground preparation, tilling, sowing, weeding, fertilizer/pesticide applications, irrigation, harvesting etc. are decided based on weather situation and trends. The crop selection to a large extend is based on arrival of monsoon and its expected performance. Further, the post-harvest operations such as drying, transportation etc. also critically depend on fair weather. Availability of weather information to the rural community through forecasts in short and medium range can significantly reduce the risk involved in agriculture operations and lead to improved productivity.

### Variability in Indian Weather

In India, we experience in general four major seasons of winter, summer, monsoon and post monsoon. The severe winter conditions are experienced by northern india while summer heat occurs across the country. The monsoon is a global flow of moist air mass across the equator to the Indian sub continent bringing copious rainfall. The monsoon dynamics is very systematic and year and year shows consistency with respect to its onset, movement of rainfall belt across the country and withdrawal. The monsoon season extends from June to September. During the post monsoon season, cyclonic storms form over the Bay of Bengal

and rarely over Arabian sea and move into the coastal areas. One of the concerns is with respect to the variability of monsoon rainfall. Every monsoon is distinct and shows changes from the expected normal. It is interesting to note that while the overall rainfall remains within ± 10% of Long Term Average of 900 mm, there is large variability in rainfall at district and local scales. Indian agriculture is heavily dependent on the monsoon as a source of water. In some parts of India, the failure of the monsoons result in water shortages, resulting in below-average crop yields. This is particularly true of major drought-prone regions such as southern and eastern Maharashtra, northern Karnataka, Andhra Pradesh, Orissa, Gujarat, and Rajasthan. In the past, droughts have periodically led to major Indian famines.

## Satellite Observations

The launch of the first meteorological satellite TIROS-1 by USA in April 1960 heralded the era of Space observations and gave the first glimpses of the dynamic cloud systems surrounding the Earth. Since then the technology has developed by leaps and bounds in observation capabilities in terms of spatial, spectral and temporal resolutions. A global system of Space observations with both geostationary and polar orbiting satellites has evolved. The advantages of Space observations emanate from several factors such as: Synoptic view of large areas, bringing out the inter-relations of processes of different spatial scales. Frequent observations from geostationary satellites provide continuous monitoring while polar orbiting satellites give typical twice daily coverage; such data is relevant for study of weather system dynamics. The inherent spatial averaging is more representative than the point in-situ observations and readily usable for weather prediction models. High level of uniformity of space observations overcomes the problem of inter-calibration needed for ground based instruments. Filling of gaps in observations; Space data covers large oceanic areas and inaccessible and remote land areas, thus giving global coverage. New types of data and observations; parameters such as sea surface (skin) temperature, sea surface wind stress, sea level, cloud liquid water content, radiation balance, aerosol are some of the unique parameters provided only by satellites**.** The Indian Meteorological Department is the primary agency to monitor weather and give predictions. A network of weather observatories in the country provide surface and upper air weather data. The INSAT satellites give every hour weather imageries to supplement these observations and help in weather forecasting. (Fig. 1). The quantitative products available from INSAT data computes the following numerical products: *Cloud Motion Vectors (CMVs). Quantitative Precipitation Estimates (QPEs). Outgoing Long-wave Radiation (OLR). Vertical Temperature Profiles (VTPRs). Sea Surface Temperatures (SSTs).* All these data are input into weather models which generate forecast of weather for 24 hrs to 72 hours. These models require good quality weather data at regular intervals.

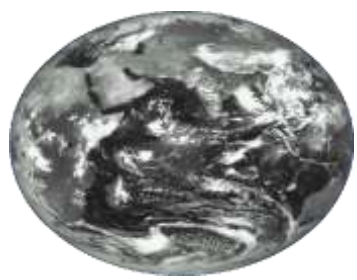

Figure 1. INSAT imagery.

## Satellite Applications to Climate Studies

Over the past two decades, several climate studies have been taken up. The salients aspects of these projects and the note worthy results is described below.

a) **Monsoon Variability** : One of the earliest studies using satellite data showed the 30-40 day oscillatory nature of monsoon flow. The critical role played by the sea surface temperature in the Indian and Pacific ocean regions were clearly brought out by several studies.

Based on the weather forecast for next few days, agromet advisories are generated for helping the farmers. The forecasts relating to heavy rain or deficient rain help in recommending suitable actions to save crops. Currently IMD is providing agromet advisories at district level. With the use of mesoscale models, it is possible to extend this service to taluk level benefiting farmers.

b) **Tropical Cyclones**: Meteorological data along with satellites are valuable for monitoring and forecasting of cyclones. INSAT/VHRR images are being used to identify cloud systems over the oceans, where no observational data is available, as well as for cyclone tracking, intensity assessment and prediction of storm surges, etc. Current research around the globe is concentrating on use of meso-scale models with satellite data inputs to improve the cyclone intensity and track prediction (See figures 3 (a to c).

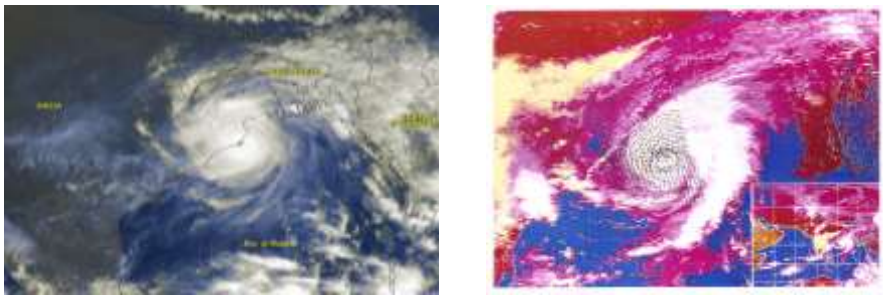

Figure 2. (a) : INSAT image of Super Cyclone of Orissa Coast ;

2 (b) : Scatterometer derived wind data over the cyclone

c) **Agricultural Drought** : Early warning of drought is useful for on-farm operations and to arrive at an optimal local water utilization pattern. Satellite derived vegetation index (VI) which is sensitive to moisture stress is now being used continuously to monitor drought conditions (Fig. 4) on a real time basis often helping the decision makers initiate strategies for recovery by changing cropping patters and practices.

**d) Ocean temperature monitoring :** Ocean temperatures play a very crucial role in the Indian Monsoon and in the ocean productivity in terms of fishery potential and chlorophyll production. The satellite data from NOAA and INSAT geostationary satellite is used to prepare weekly Sea Surface Temperature maps. The accuracy achieved is in the region of ± 0.7 $^{0}$ C . These maps form the basic data for analysis of El Nino/La Nina conditions in Pacific Ocean and Cyclogenesis conditions in the Indian oceans (Fig. 5).

## Future satellite missions

Several satellite missions have been planned to support the operational data needs and ongoing research efforts. The future Metsat missions will carry improved VHRR and vertical sounders for temperature/humidity profiles. The Megha -Tropiques Mission, a joint project by

ISRO and CNES, France was launched in 2012 with advanced payloads in an inclined orbit around the Equator plane, for studying the water cycle and energy exchanges in the tropics (Fig. 4). With an equatorial inclined orbit, the satellite will have high repetitively over tropical regions.

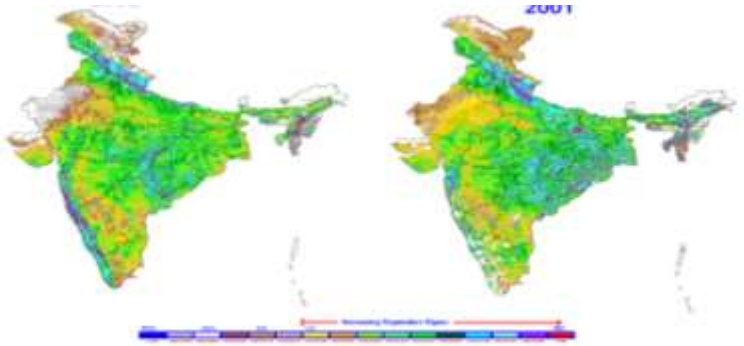

Figure 3. Vegetation monitoring using Indian remote sensing satellite (2001 & 2003)

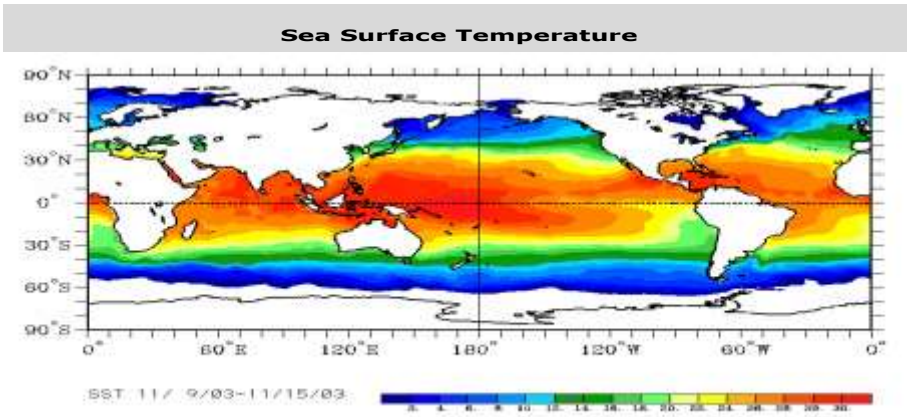


Figure 4. Global Sea Surface Temperature Moitoring using NOAA data

**SAPHIRE** **SCARAB** **MADRAS**

Figure 5. Advanced Payloads of Megha Tropiques

Another advanced satellite launched recently was the INSAT 3D with 18 channel vertical profilers and multi channel radiometer.. The future appears bright for our space-based observing system. Advanced, multispectral (visible, IR, and passive microwave) imagers, sounders (infrared and microwave) and scatterometers are planned for launch in the near future. Hyperspectral measurements from newly developed interferometers are expected to be flown experimentally by 2006. The information content will vastly exceed that of the current measuring devices. Instead of a few dozen viewing channels, these instruments will have more than a thousand channels over a wide spectral range.

## Effects of global warming

Several global climate models run by leading meteorological agencies have indicated possible increase in rainfall over Indian region. This could mean large intensity rain events leading to floods etc. The intensity of cyclones are also expected to increase. The effects of global warming on the Indian subcontinent vary from the submergence of low-lying islands and coastal lands to the melting of glaciers in the Indian Himalayas, threatening the volumetric flow rate of many of the most important rivers of India and South Asia. In India, such effects are projected to impact millions of lives. As a result of ongoing climate change, the climate of India has become increasingly volatile over the past several decades; this trend is expected to continue. While studying such scenarios, it is essential to build up necessary strategies at local level to reduce the adverse impacts especially on agriculture and water management. It may be necessary to adopt improved agriculture practices with resistant seeds, efficient water management etc.

## Conclusions

Recent launches of INSAT -3D with vertical sounders and Megha Tropiques with advanced payloads for study of tropics has led to formulation of national projects on Monsoon, Disaster management and Climate Change. The future planning needs to take cognizance of climate change scenarios. A suitable mix of satellite and ground observations with high resolution weather modelling holds the keyfor future of weather forecasting and climate change assessments. The data is being used for natural resources surveys, environment assessment, disaster mitigation and weather forecasting. With several satellite missions in the past two decades, India has emerged as a strong operational user of satellite data for applications of direct relevance to the society.

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