Space Observations and Monitoring of Climate Changes - Indian Initiatives



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46th Session of the Scientific and Technical Subcommittee of United Nations Committee On the Peaceful Uses of Outer Space IAF SYMPOSIUM

9th February2009, Vienna

Climate Change over India – The Concerns

Increase in rainfall by 15-40% by the end of the 21st century with high regional variability

Increase in annual mean temperature by 3 to 5°C by the end of 21st century under SRES A2 scenario (more warming is projected in Northern India)

- Changes in frequency and/or magnitude of extreme temperature and events precipitation events.
- These changes would result in adverse impacts on agriculture, water resources, health, forests, vulnerability to extreme events, and coastal areas.

Climatic Changes - Indian Perspective

 India has actively invested in Earth Observation from Space and presently has a strong cluster of Polar and GEO satellites

National Action Plan on Climate Change (June 2008)



- 1. National Solar Mission
- 2. National Mission for Enhanced Energy Efficiency
- 3. National Mission on Sustainable Habitat
- 4. National Water Mission
- 5. National Mission for Sustaining the Himalayan Ecosystem
- 6. National Mission for a Green India
- 7. National Mission for Sustainable Agriculture:
- 8. National Mission on Strategic Knowledge for Climate Change

Temperature Trends : 1901 to 2008





- Annual mean temperature, averaged over India increased by 0.48°C over 100 years
- Increasing trends are observed in both max. and min. temperatures over most parts of India



Trend in the Monsoon Season Rainfall: 1901-2008



All India Monsoon Rainfall (1901-2008)

- All India monsoon season rainfall shows multidecadal variations
- Overall no long term trend but there are significant long term trends in the spatial pattern of annual rainfall
- Heavy rainfall events (rainfall amount >15 cm in 24 hours) over Central India show an increasing trend of about 6% per decade



Variation of very heavy rainfall events (Rainfall > 15 cm) over Central India



Trends in sea-level rise

Cirrus Clouds (Indian Subcontinent)



- Coastal tide gauge records in India for 40 years show a regional MSL rise of 1.29 mm per year
- This is consistent with the global sealevel-rise estimates of IPCC

Ref : Unnikrishnan and Shankar, 2007, Global and Planetary Change

- Spatial distribution of Semi-Transparent Cirrus Clouds (KALPANA-1-VHRR)
- Large dominance of convective outflows in the generation of cirrus clouds

(Updated from Rajeev et al., Geophys. Res. Lett., '08)

Glacier Retreat – Gangotri Glacier



IRS LISS-III SEP 1999



GANGOTRI GLACIER FULLVIEW



IRS LISS-III SEP 2006

SI no	Year	Loss in area (Sq.km)
1	1962 – 1999	2.9
2	1999 - 2006	0.6

Long Term Monitoring of Aerosols





Kerala

W.Ghats (Ref : IRS)





Flora: 7.0% of world's Fauna: 6.5% of world's

Thiruvanantapuram

CORAL REEFS (SEEN FROM IRS LISS-III DATA)



Consequences of Climate Changes

- Changes in Earth's Surface Temperature, Evaporation & Monsoon rainfall
- **7** Retreating of Glaciers
- Rising Sea levels & increasing ocean acidity; Coral bleaching
- Ocean Currents; Shift in Conveyor belt behavior
- **7** Damages from storms, coastal erosion and floods
- **7** Impact on Biodiversity: Moving Species & extinction



- Droughts, Heat waves, wildfires
- Impact on farms, forests, & fisheries
- Health (Asthma, Cancer, Malaria etc.
- オ Impact on Economy





Long Term National Programs

ISRO-GBP Projects Towards Climate Studies

- 1. Aerosol Radiative Forcing over India (ARFI)
- 2. Atmospheric Trace Gases, Chemical Transport & Modelling over India
- 3. Atmospheric Dust, Chemistry & Transport modeling over India
- 4. Atmospheric Boundary Layer Network & Characterization
- 5. Energy and Mass Exchange in Vegetative System
- 6. Land Use Land Cover Dynamics & Impact of Human Dimensions in Indian River Basins
- 7. National Carbon Project
- 8. Quantitative Multi-proxy Paleo-monsoon Reconstruction for the past 21000 years BP
- 9. Regional Climate Modeling

ISRO-GBP NETWORK OF AEROSOL

OBSERVATORIES (ARFI)

Other National Initiatives

- Centre for Climate Change Research CCCR (IITM, Pune)
- DST, MoES, MoEF, CSIR Programs focusing on different aspects of Earth-Atmosphere Systems

Shipboard and Airborne Measurements

Satellite Systems for Observing Climate Changes : Present & Future

Atmosphere		Land	
OceanSat-I	Aerosols	IRS Series	Vegetation, Land Use, Coastal Zone, Glaciers
MSMR	Rain rate, Column Integrated Water Vapour Cloud Liquid Water Content	Oceansat-1	Ice/Snow (MSMR)
INSAT Series	Clouds, Radiation	Cartosat-1	Land use, Urbanization
KALPANA-1	louds, Radiation, Upper Tropospheric	INSAT Series	Vegetation Future Satellites
	Humidity	IRS Series,	Vegetation, Land Use,
Future Satellites		Oceansat-2	Coastal Zone, Glaciers
OceanSat-II Aerosols		RISAT	Land Profile
			Vegetation
INSAT Series	Clouds, Radiation	Ocean Present	
INSAT-3D	Temperature, humidity profiles, clouds		
Megha- Tropiques	Radiation budget, Water vapour profile, Integrated Water Content, Satellite Occultation for temperature and humidity	Oceansat-1	Ocean color, Chlorophyll, Ocean sediments (OCM) SST, Surface Wind (MSMR)
I-STAG	Aerosols (Profiles and column integrated), Air Chemistry	Future OceanSat-II	Ocean color, Chlorophyll, Ocean sediments (OCM-II) , Altimetry, Surface Wind (SAR)
		INSAT Series	Sea Surface Temperature
		Megha- Tropiques	Sea Surface Wind, SST

Megha-Tropiques (Indo French Project)

- **7** Dedicated Satellite to measure water and energy budget simultaneously over the tropics
- Altitude: 867 km, Period: 102.16 min, Orbits per day: 14.12, Repetivity: 7 days (97 orbits)
- Inclination 20°: High frequency observations over the tropics (3-8 observations per days over any location)

MADRAS (Microwave Analysis and Detection of Rain & Atmospheric Structures)

- Observes at 5 frequencies (18.7, 23.8, 36.5, 89, 157 GHz)
- Swath: 1700 km, Spatial resolution: 6-40 km
- Parameters: Surface wind, integrated water vapour, liquid water in clouds, rain over ocean, ice at cloud tops

SAPHIR: Sounder for Probing the Vertical Profiles of Humidity

- Observes at 6 frequencies within the band of 183.31 GHz ±11GHz
- Swath: 2200 km, Resolution: 10 km

ScaRaB: Scanner for Radiation Budget

- 4 Channel sensor for the solar and terrestrial radiation budget
- Wavelength : 0.5-0.7 $\mu m,\, 0.2\text{-}4.0 \; \mu m$, 0.2-100 μm , 10.5-12.5 μm
- Swath: 2200 km, Resolution: 40 km





GPS - ROS (Radio Occultation Sensor) for vertical profiling of temperature and humidity

Climate Monitoring Systems





Space Observations (GEO, Polar, Low Inclination Orbits)





Air borne



Ship



Buoys & Floats



Glacier Observations



Studies on Climate Change : The Strategy

Integrated Approach

- Satellite-based observations
- National Network of Land Stations for Aerosols
- National Network of Metrological Observatories for surface and upper-air
- Buoys
- Dedicated Ship-borne and Air-borne Observations

Leading to

- Integration into CLIMATE MODELS for understanding of the phenomena
 VALIDATION OF THE CLIMATE MODEL projections (particularly shortterm projections)
- Integration into climate models for LONG-TERM FORECASTING of climate
- **7** Undertaking the necessary CORRECTIVE MEASURES AND PLANNING

Leading to the Realisation of the Objectives of National Mission on Climate Change

Thank You