



# **Indian Space Programme**

**Contributions to  
Atmosphere and Climate Change research  
for  
Sustainable Development**

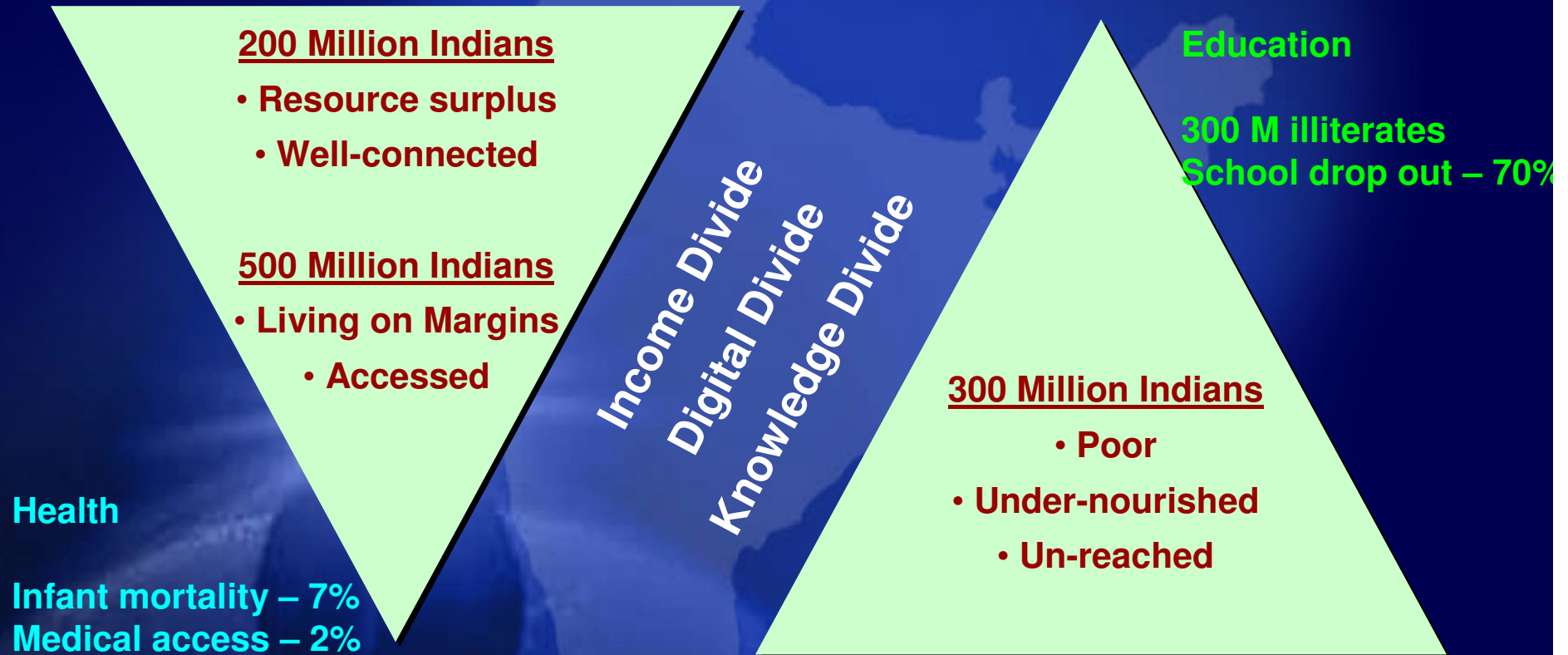
**Dr CBS Dutt**

Indian Space Research Organisation  
BANGALORE , INDIA  
[dutt\\_cbs@isro.gov.in](mailto:dutt_cbs@isro.gov.in)

UNOOSA meet : Sept 11<sup>th</sup> –14<sup>th</sup> 2007, GRAZ, AUSTRIA

# Bridging The Divides...

1000 Million+ Indians

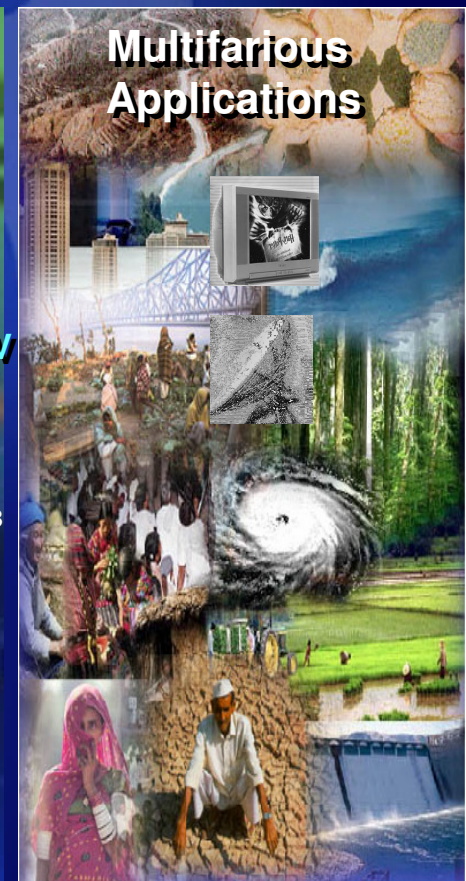


The social transformation in India lies in bridging these divides

# Four Decades of Indian Space Programme



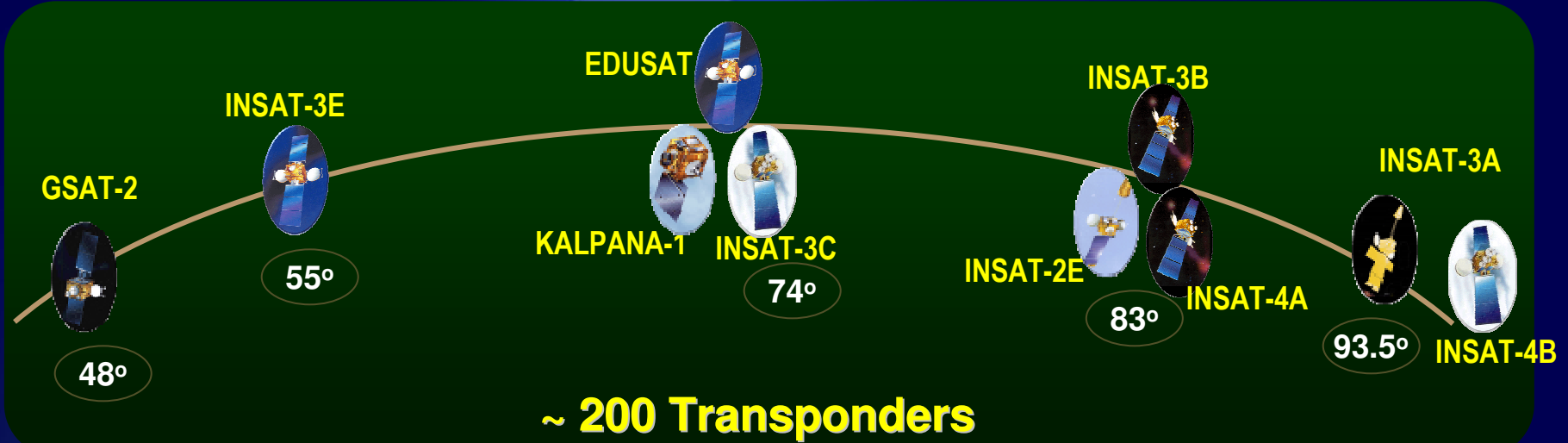
*“.....we must be second to none in the applications of advanced technologies to the real problems of man and society.”*



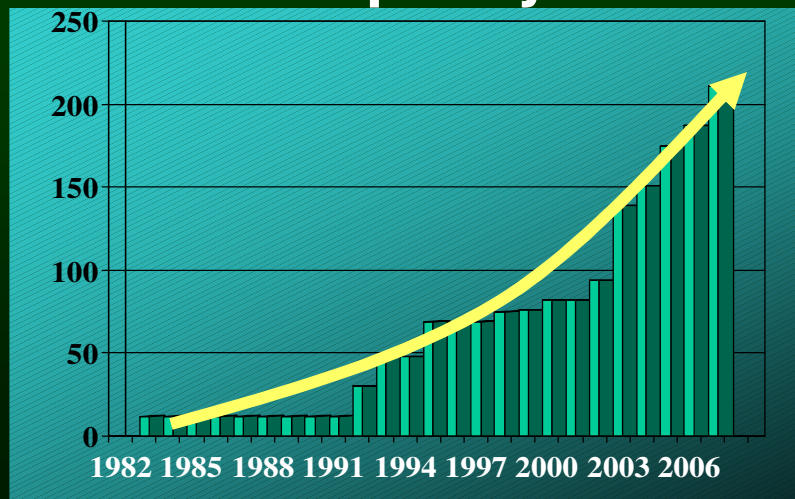
**Applications-driven Self reliant Programme**



# India's Communication Capabilities



## Capacity



## INSAT- 4B coverage





# INSAT Applications

## BROADCAST

- Television Broadcasting
- Direct To Home (DTH)
- TV & Radio Networking



## COMMUNICATION

- Speech Circuits On Trunk Routes
- VSAT Connectivity



## METEOROLOGICAL

- Meteorological Imaging
- Data Collection Platform
- Disaster Warning



## DEVELOPMENTAL

- Tele-health
- Tele-education
- Emergency Communication

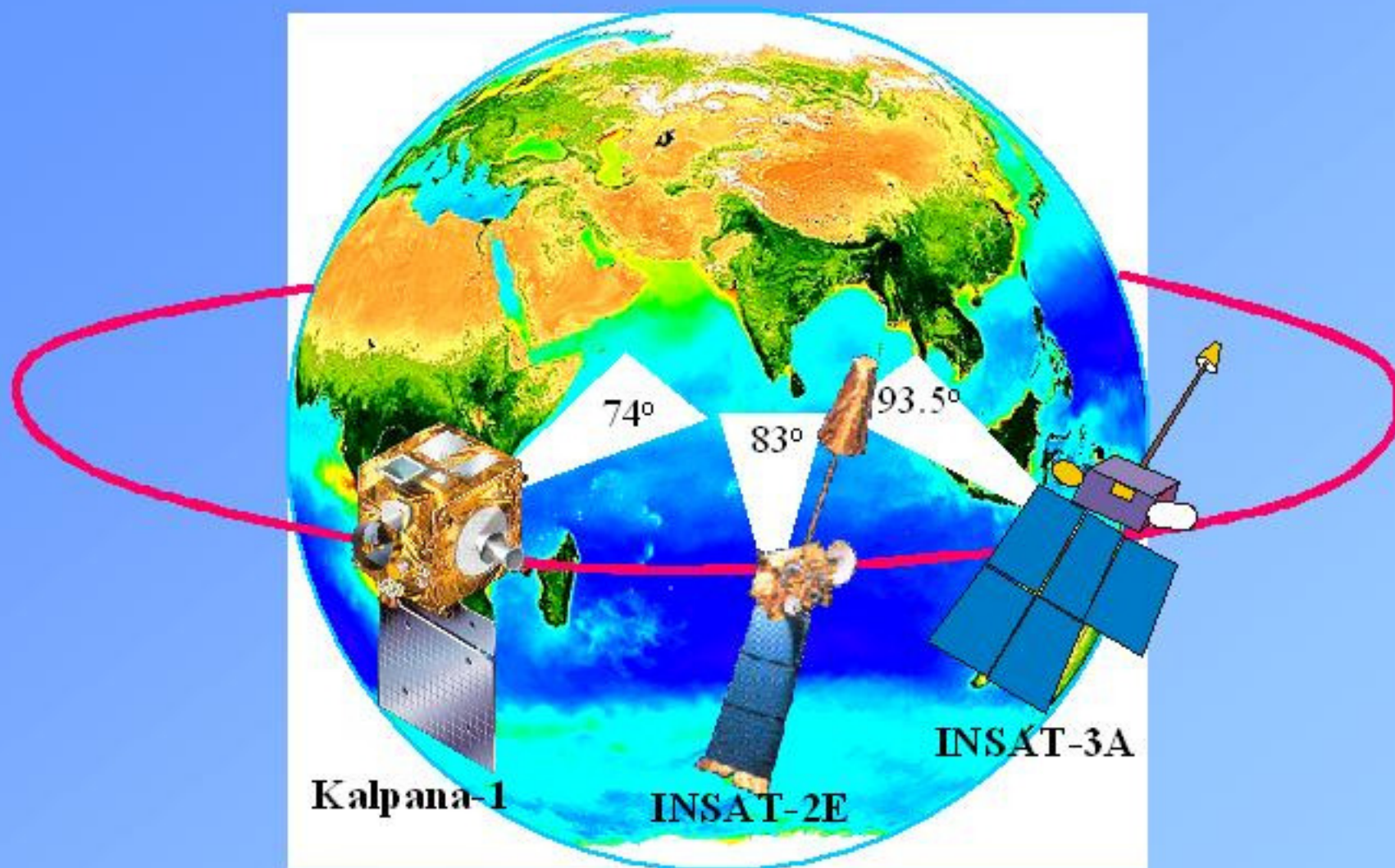


## OTHERS

- Mobile Satellite Service
- Search and Rescue
- Satellite Navigation

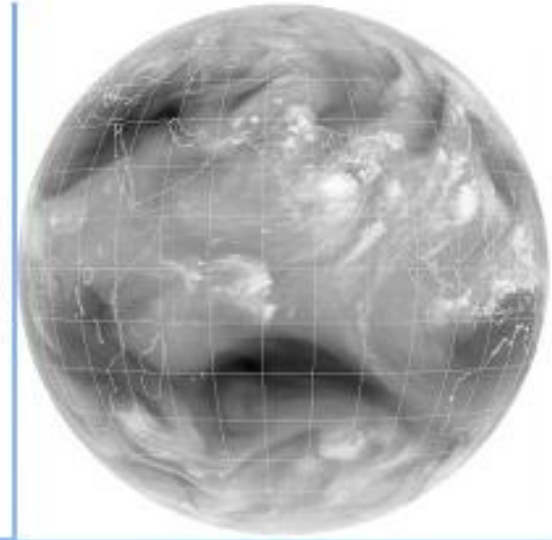
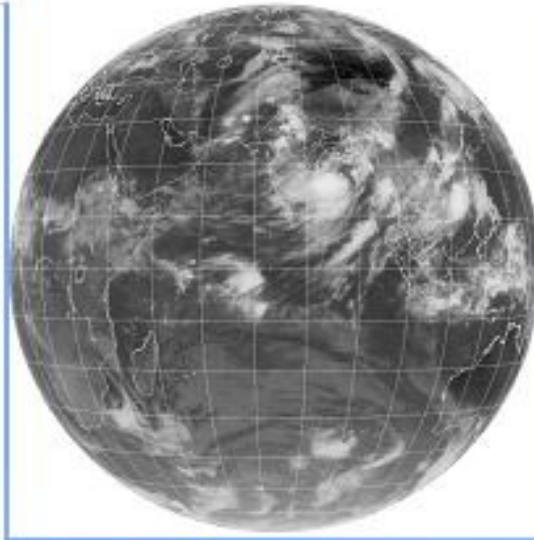
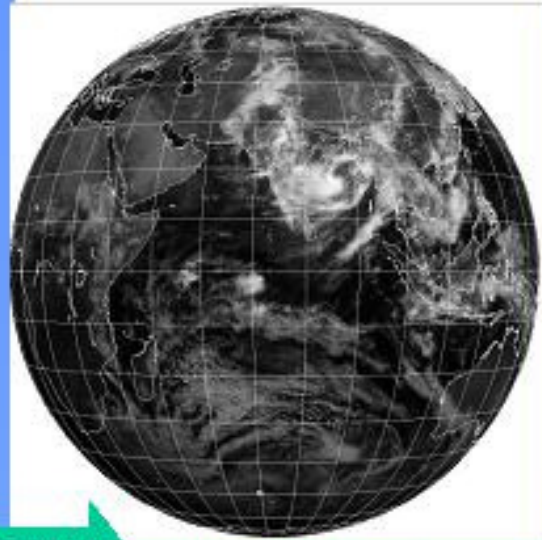


# Current Indian Geostationary Meteorological Satellites





## Continuous Monitoring of Weather from INSAT



Channel

VIS (0.5-0.7  $\mu\text{m}$ )

IR (10.5-12.5  $\mu\text{m}$ )

WV (6.7-7.3  $\mu\text{m}$ )

USE

- Cloud Detection
- Cloud Tracking
- Aerosol
- Vegetation

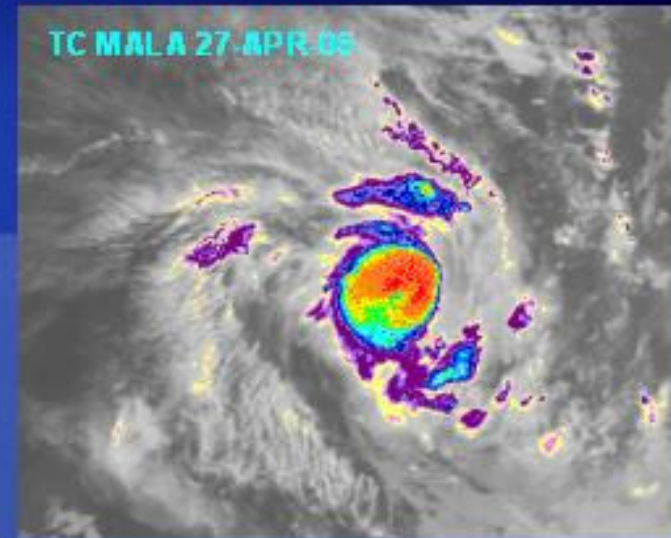
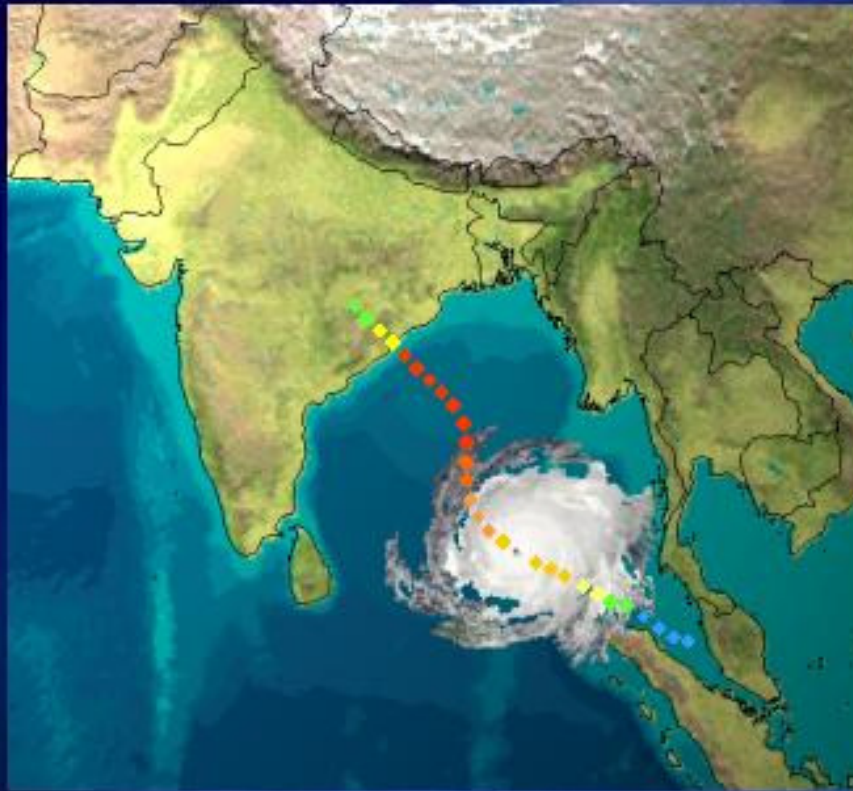
- Cloud Top Temp.
- Cloud Tracking
- Earth-surface Temp
- Cloud Height

- Upper Tropospheric Humidity
- Cloud & Water Vapor Tracking
- Height Assignment to semitransparent Clouds

There are 3 INSAT systems at present covering most of the Indian Ocean. These Systems generate images and products at frequent intervals day and night using one (VIS) responsive to daylight, infrared (IR) channels responsive to the temperatures of clouds and the surface, another IR channel to measure atmospheric water vapour.



## Tracking Tropical Cyclones



One of the more important justifications of meteorological satellites is their ability to detect, monitor and track severe tropical cyclones that can cause Immense loss of life and property. Satellites play a vital role in providing information about hurricanes, enabling forecasters to track them for days before they make landfall, and helping to provide essential warnings of huge economic and social importance.



# Tele Education

9 National Net work  
35 regional Net work

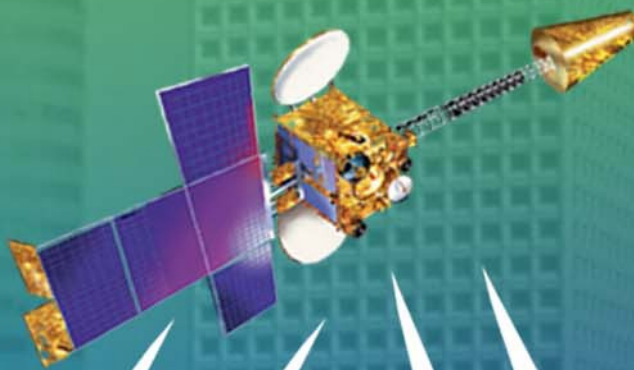
## EduSat



5 Spot Beams in Ku Band  
1 National Beam in Ku Band  
1 National Beam in Ext C Band  
(6 Channels)



**Teaching-End**



One way video &  
Two way Audio



**Class Room-1**  
ROT Backed by solar Power



**Class Room-2**  
SIT

**Present Scenario**  
As part of Governmental  
Education Policy

24 Hr. Educational Team  
Channel called Gyandarshan  
focused on Rural Areas

Support 6 Open Universities

Development &  
Communication Channel  
since 1995

Engg College & Primary  
School Networks in  
Karnataka

Education Network in Kerala

30,000 Virtual Classrooms  
.....

Two  
way  
Video  
&  
Audio

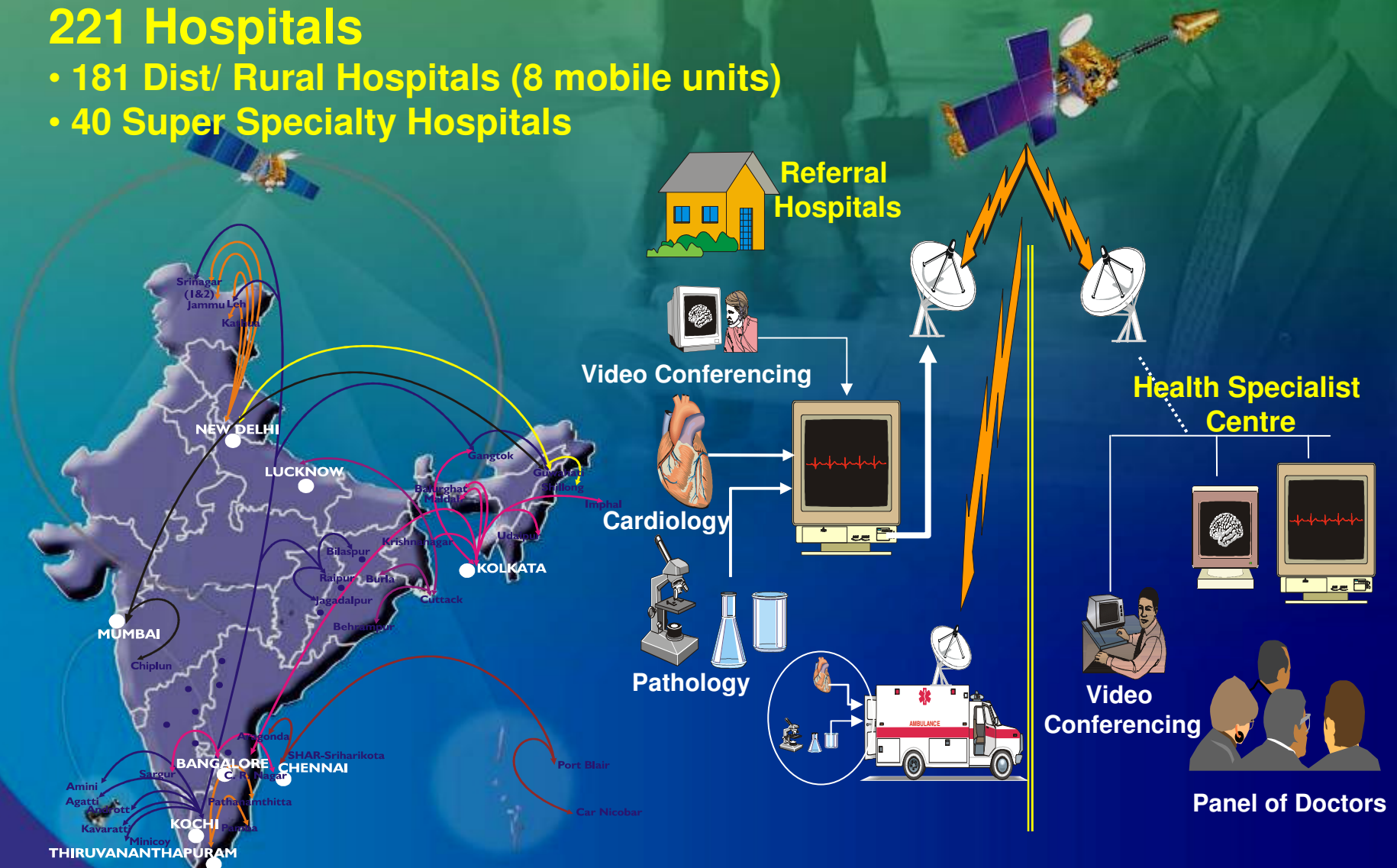




# Tele-Medicine

## 221 Hospitals

- 181 Dist/ Rural Hospitals (8 mobile units)
- 40 Super Specialty Hospitals



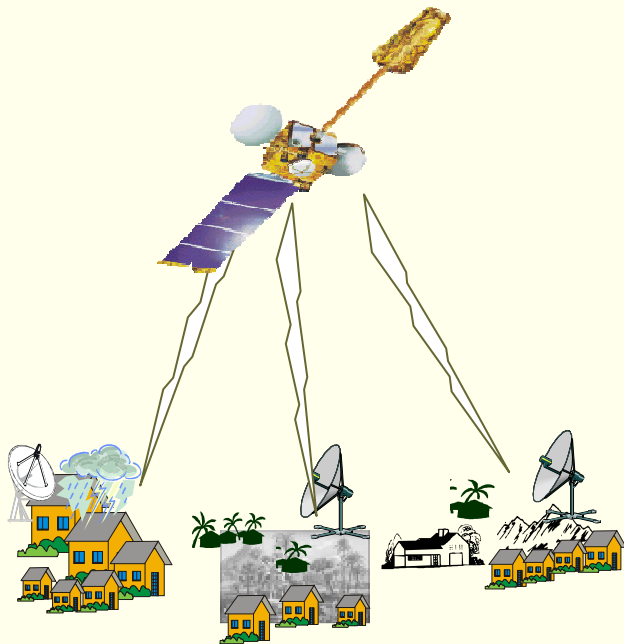
*Far-flung & Remote Areas: North-East, Andaman & Nicobar, Lakshadweep, Jammu & Kashmir, ...*



# Village Resource Centre

## Components

- EO based Information
- Advisory related to Agriculture, Fisheries, ...
- Digital Connectivity
- Tele-Education, Tele-Medicine



## Query Shell in local language

**Multilingual interface**

**PRA Summary**

Name Of The Farmer : **Chandrasekhar**

Patta Number : **634**

Survey Number : **172**

Sub Number : **3**

Wet Land : **7.5**

Dry Land :

**CURRENT LANDUSE**

**FIELD**

**SOIL CHARACTERISTICS**

Type : **WETLAND**

Number : **WETLAND**

Location : **WETLAND**

**ALTERNATIVE CROPS**

Wet Land : **WETLAND**

Wet Land : **WETLAND**

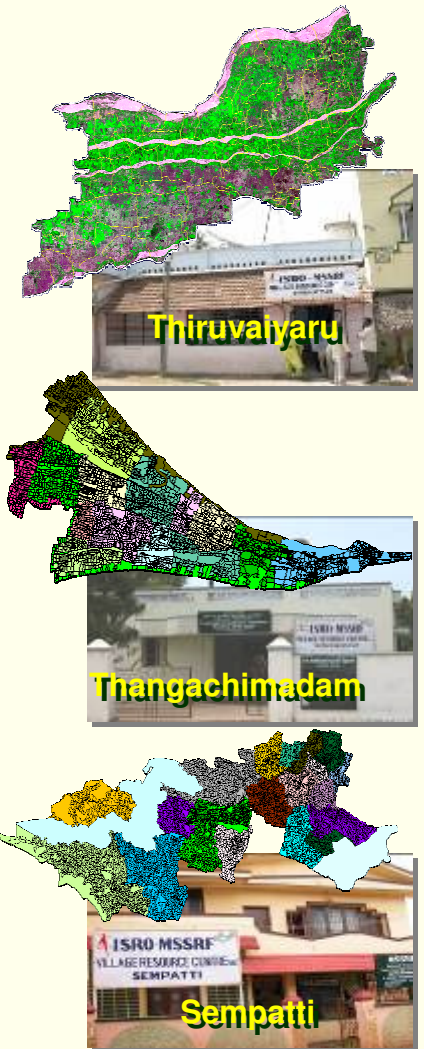
**WATER RESOURCE**

Field : **WETLAND**

Location : **WETLAND**

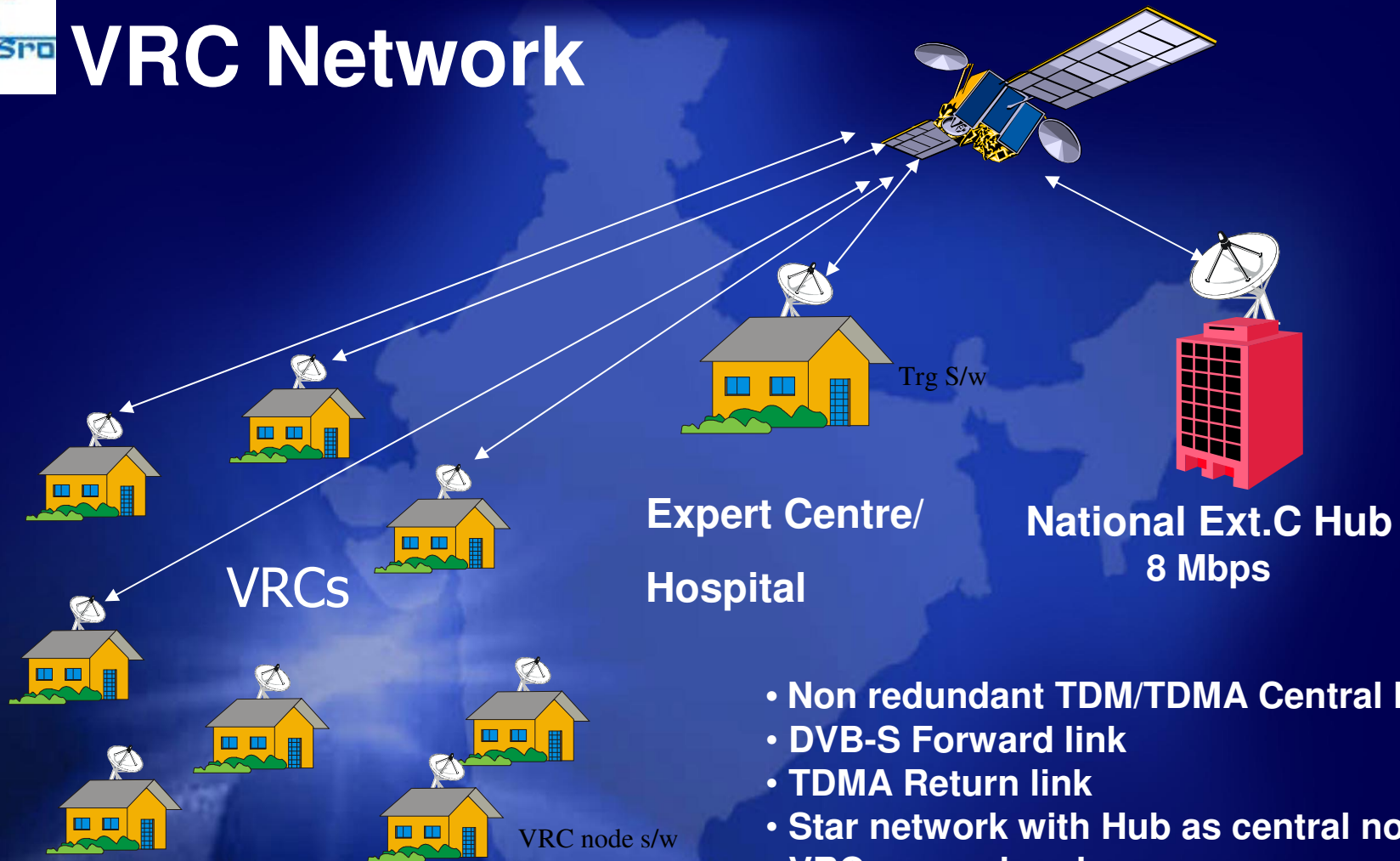
Sub location : **WETLAND**

## NR & Socio economic database



Plus more...

# VRC Network



1.8 M Antenna  
2W BUC  
384 Kbps Max

Expert Centre/  
Hospital

National Ext.C Hub  
8 Mbps

- Non redundant TDM/TDMA Central Hub
- DVB-S Forward link
- TDMA Return link
- Star network with Hub as central node
- VRCs as end nodes
- With One Ext C Transponder to start with
- Either in Edusat
- 4.5 m Antenna – 40W Power amplifier
- 8-10 Simultaneous videoconferencing

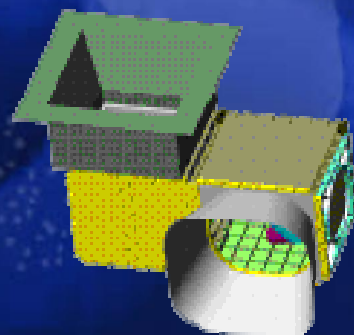


# INSAT - 3D

## Improved Understanding of Mesoscale Systems

### 6 Channel IMAGER

- Spectral Bands ( $\mu\text{m}$ )
  - Visible : 0.55 - 0.75
  - Short Wave Infra Red : 1.55 - 1.70
  - Mid Wave Infra Red : 3.80 - 4.00
  - Water Vapour : 6.50 - 7.00
  - Thermal Infra Red – 1 : 10.2 - 11.3
  - Thermal Infra Red – 2 : 11.5 - 12.5
- Resolution : 1 km for Vis, SWIR  
4 km for MIR, TIR  
8 km for WV

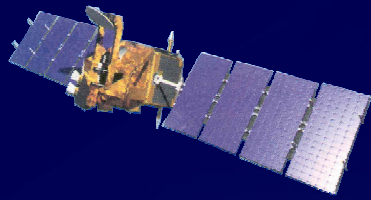


### 19 Channel SOUNDER

- Spectral Bands ( $\mu\text{m}$ )
  - Short Wave Infra Red : Six bands  
(3.98, 4.13, 4.45, 4.52, 4.57  $\mu\text{m}$ )
  - Mid Wave Infra Red : Five Bands  
(6.51, 7.02, 7.43, 9.71, 11.03  $\mu\text{m}$ )
  - Long Wave Infra Red : Seven Bands  
(12.02, 12.66, 13.37, 13.64, 14.06, 14.37, 14.71  $\mu\text{m}$ )
  - Visible : One Band
- Resolution (km) : 10 X 10 for all bands
- No of simultaneous sounding per band : Four

CO<sub>2</sub> bands    Water Vapor bands





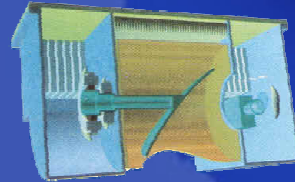
# Megha Tropiques

**For studying water cycle  
and energy exchanges in  
the tropical belt**

**Low inclination (20°) for  
frequent simultaneous  
observations of tropics**

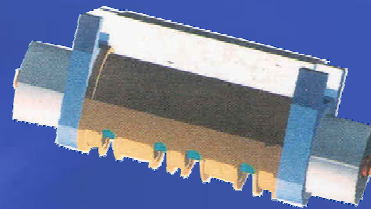
- Water vapour
- Clouds
- Cloud condensed water
- Precipitation
- evaporation

## SAPHIR



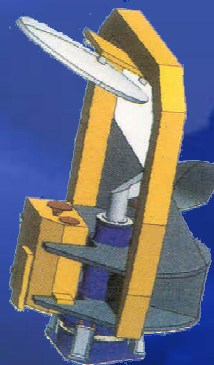
- Frequency:  $183.31 \pm 0.2$ , 1.1, 2.7, 4.2, 6.6, 11.0 GHz
- Water vapour profile
- Six atmospheric layers upto 12 km height

## SCARAB



- 10 km Horizontal Resolution
- Outgoing fluxes at TOA
- 40 km Horizontal Resolution

## MADRAS



- Precipitation and cloud properties
- 89 & 157 GHz : ice particles in cloud tops
- 18 & 37 GHz: cloud liquid water and precipitation
- 23 GHz : Integrated water vapour

## GPS Occultation

**Contributing to Global Precipitation Mission (GPM)**

## **Specific Atmospheric Assessment Projects (SAAP)**

Aerosol Radiative Forcing Over India (ARF)

Atmospheric Trace Gases & Transport Modeling (ATC & TM)

Atmospheric Dust Composition & Transport Modeling (ADC & TM)

Atmospheric Boundary Layer Network & Characterization ((ABLN & C)

Energy, Water & Mass Exchange in Vegetative Systems (EWM & VS)

Soil & Vegetation Fluxes using Flux Towers (SV & F)

## **Integration Land Ecosystem & Atmospheric Projects (ILEAP)**

LULC & Impact of Human Dimensions in the Indian River basins (LULC & RB)

Multi Proxy Quantitative Paleo-monsoon Reconstruction (QMPRC)

Regional Climate Modeling & Impact Analysis (RCM & IA)

## **Intense Observational Projects (IOP)**

National Vegetation Carbon Pool Assessment (NCP-VCPA)

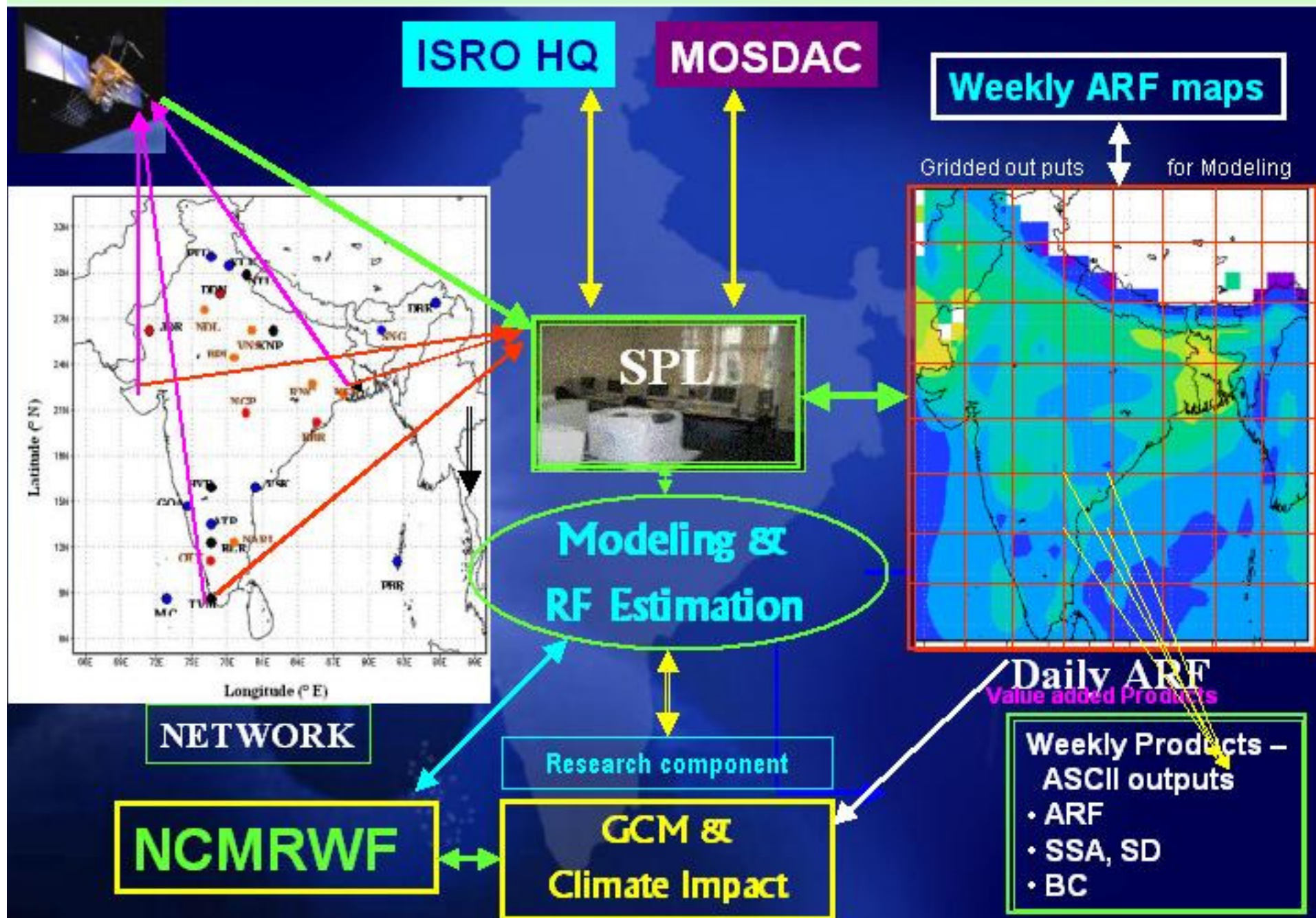
National Soil Pool Assessment (NCP-SCPA)

## **Small Satellite Utilization Projects (SS-UP)**

**Climate sats-Small satellite plans**

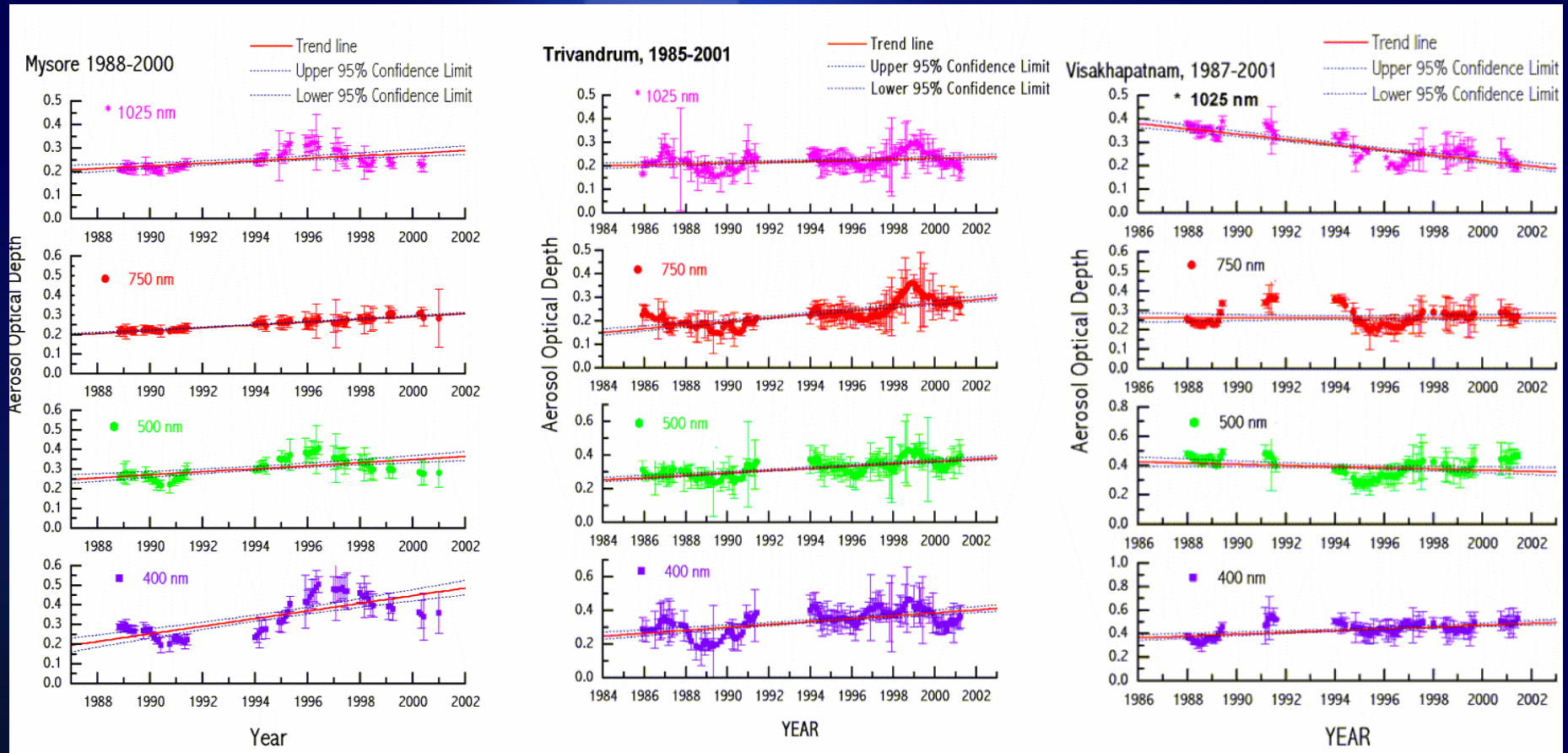


# AEROSOL RADIATIVE FORCING OVER INDIA





# Decadal Trends in AOD (% Yr<sup>-1</sup>)



9.83, 3.13,  
3.60, 2.99

3.50, 2.78,  
5.12, 1.02

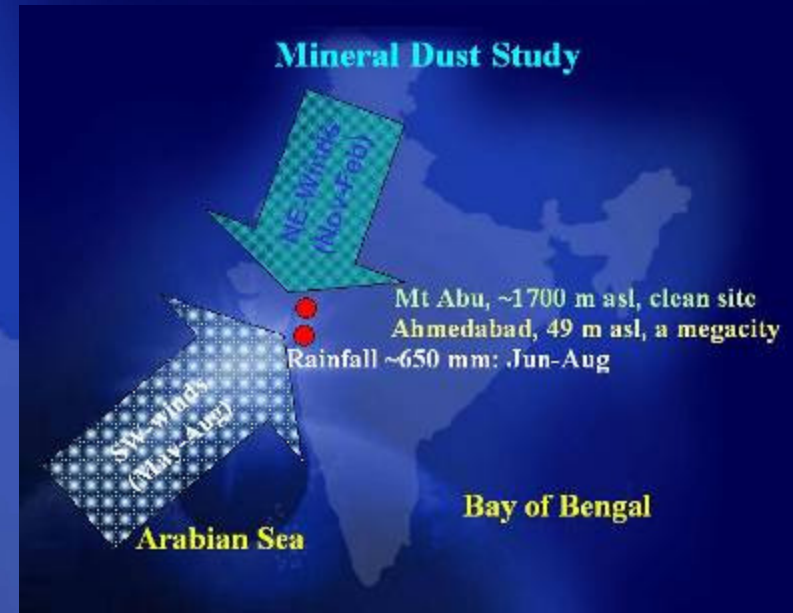
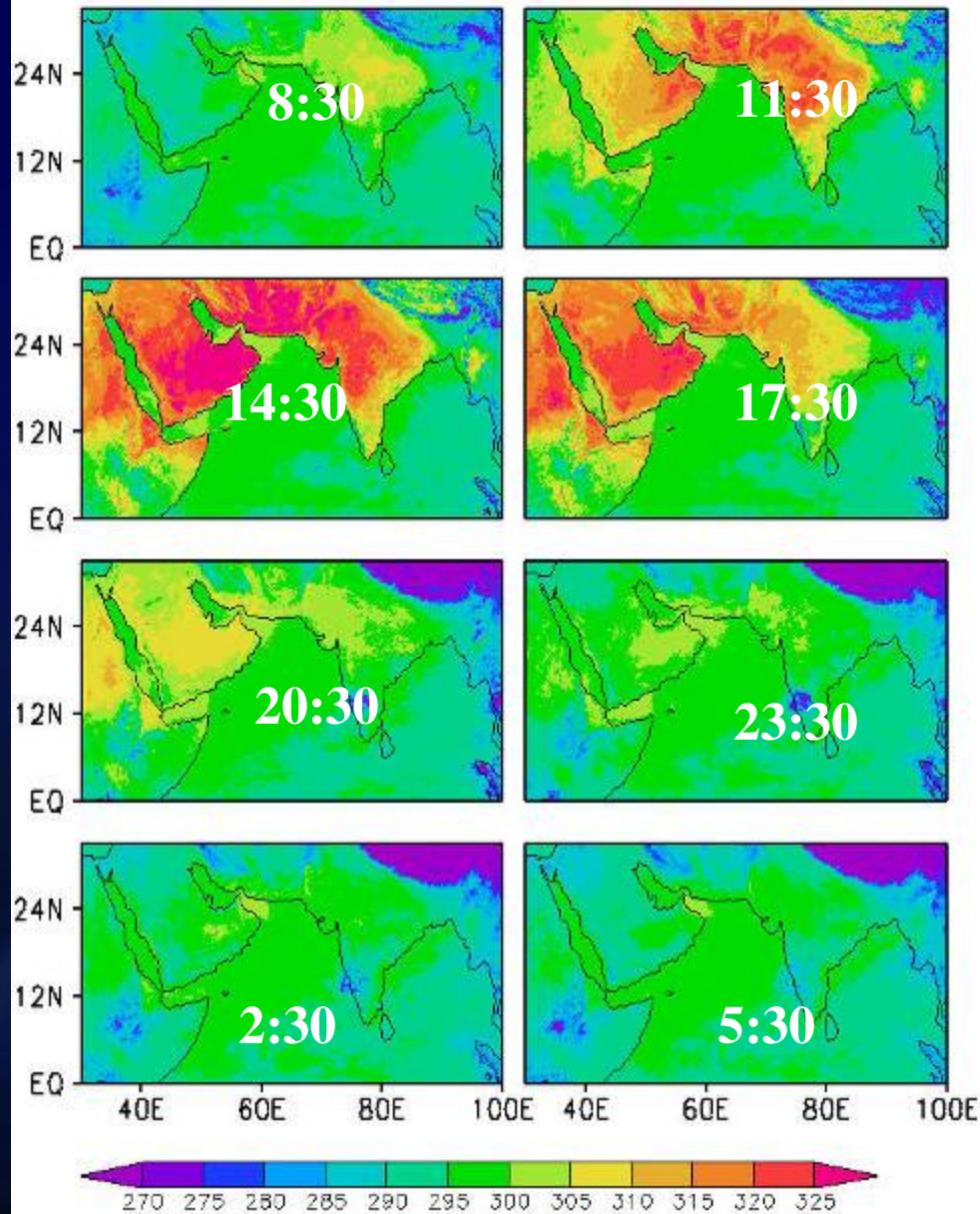
1.19, -1.12,  
0.04, -6.00



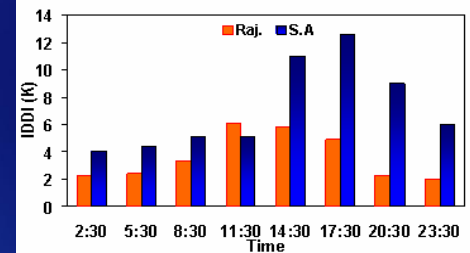
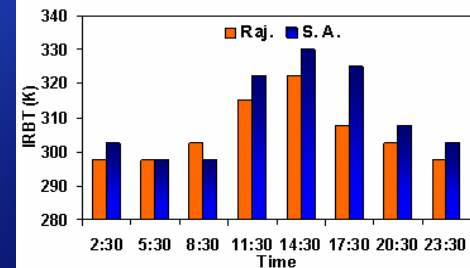
# Mineral Dust Studies & Aerosol chemistry

Min

3 Hrly Reference Images May (1-15) 1999



Diurnal Variation of IRBT and IDDI

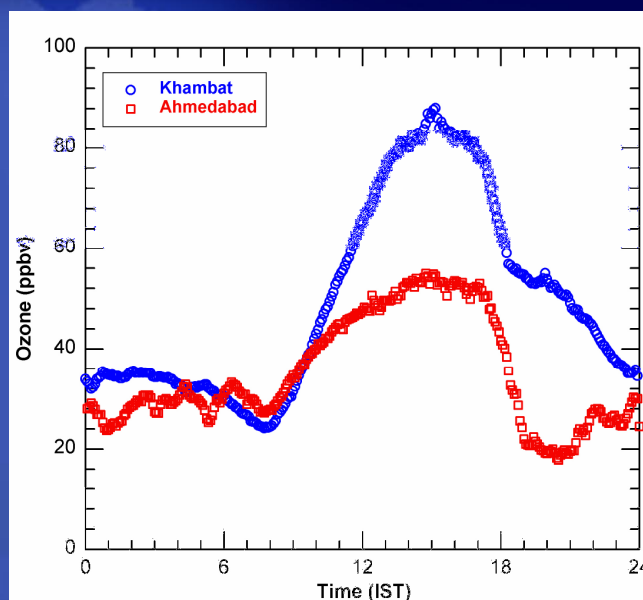
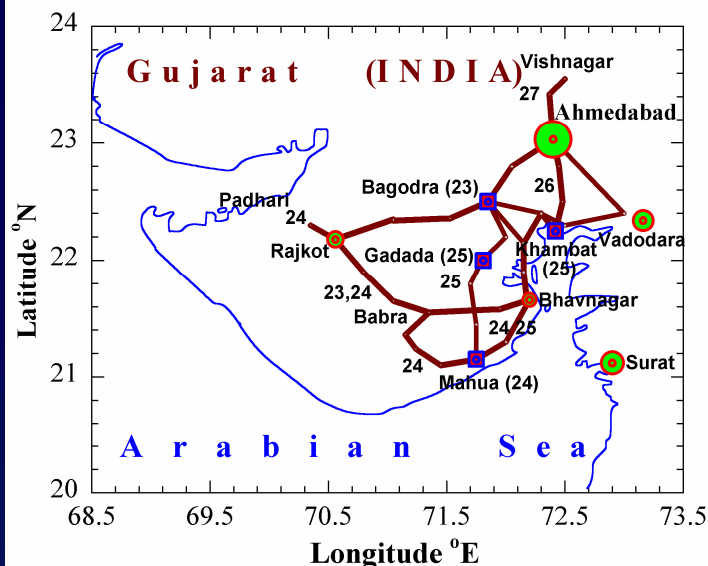


$\Delta T = 2 \text{ K}$



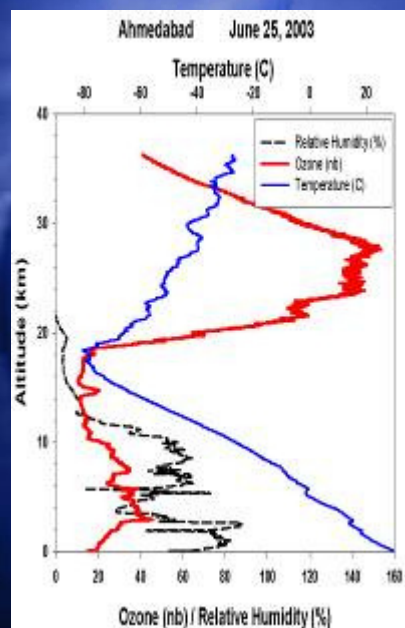
# Ozone measurements & Mobile Laboratory Experiment

Mobile Lab Experiment (MOLEX), January 2001

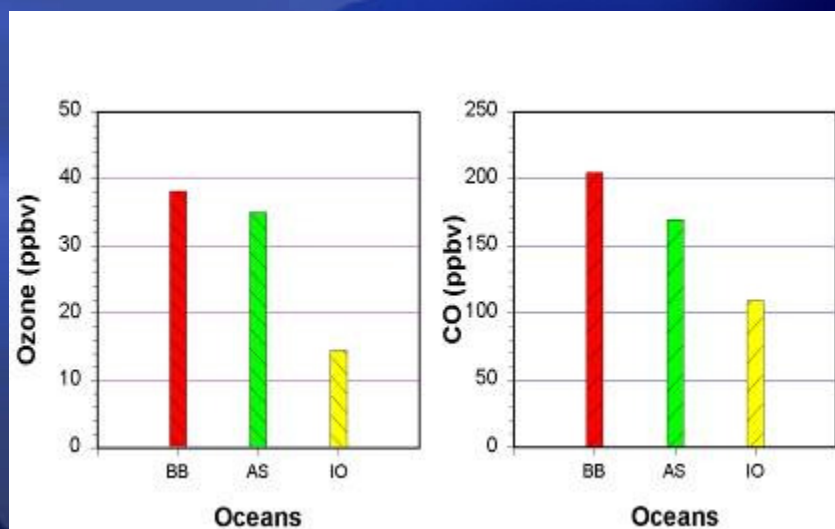


Observed higher levels of ozone at a remote site, Khambhat, than at Ahmedabad, an urban site. This is due to net efficient production of ozone at Khambhat.

## OZONE SONDES



Comparison of measurements made in February -March over the Bay of Bengal with Indian Ocean and Arabian Sea



Prof Shyam Lal PRL



MWR / MTS



Micropulse Lidar

## Extensive Aircraft measurements



## Instrumental Setup





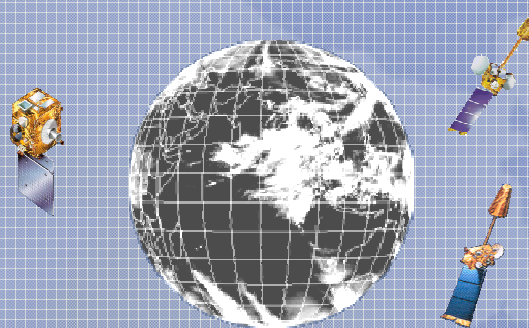
# Towards improving Agromet Services

## Densifying Weather Observation Network

### Automatic Weather Station



### Space Observations



#### EO instrument capabilities

- Radiometers & Spectrometers
- Atmospheric Sounders
- Rain Radars
- High resolution imagers
- Polarimetric radiometers
- Altimeters/Scatterometers

#### INSAT-3A & KALPANA

DP software installed at IMD

INSAT 3D

Development of Techniques

### Doppler Weather Radar

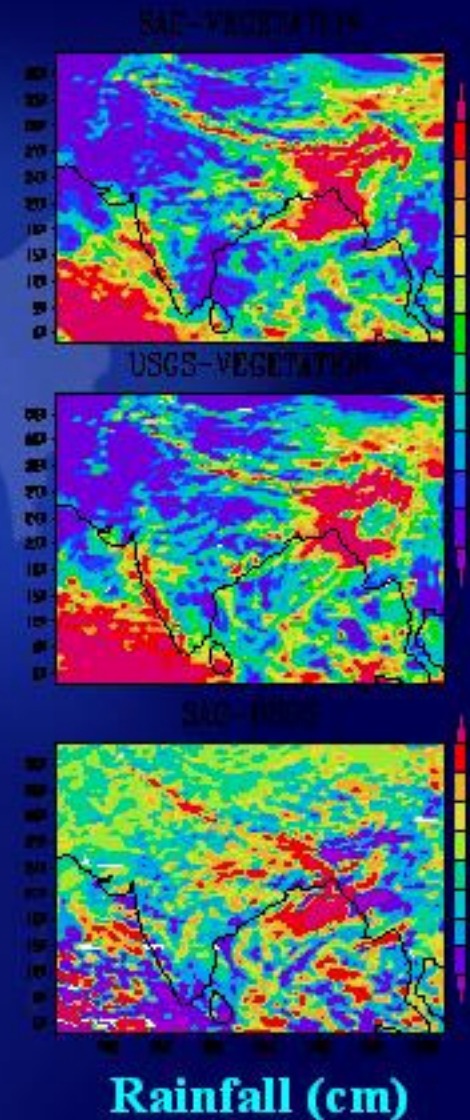
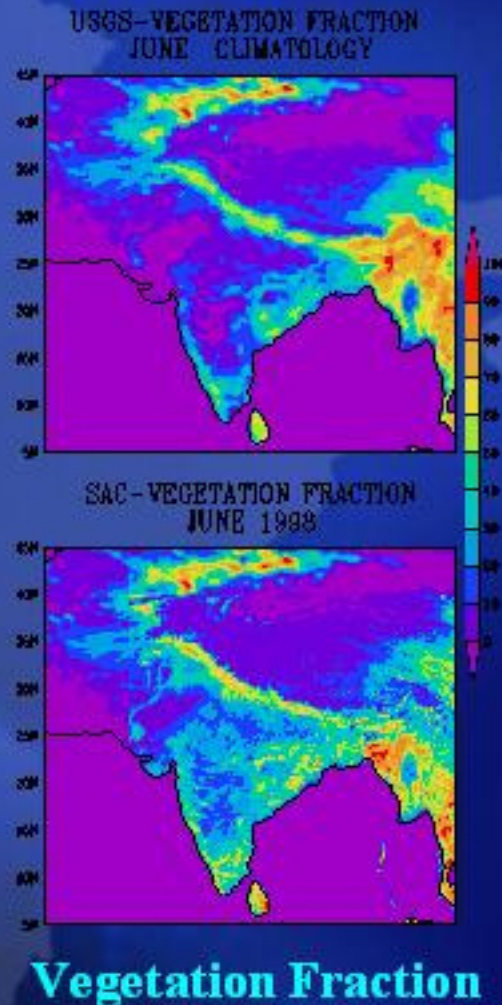


- Continuous monitoring of severe weather events
- Radar network for entire coastal areas, NE region, major cities, ...

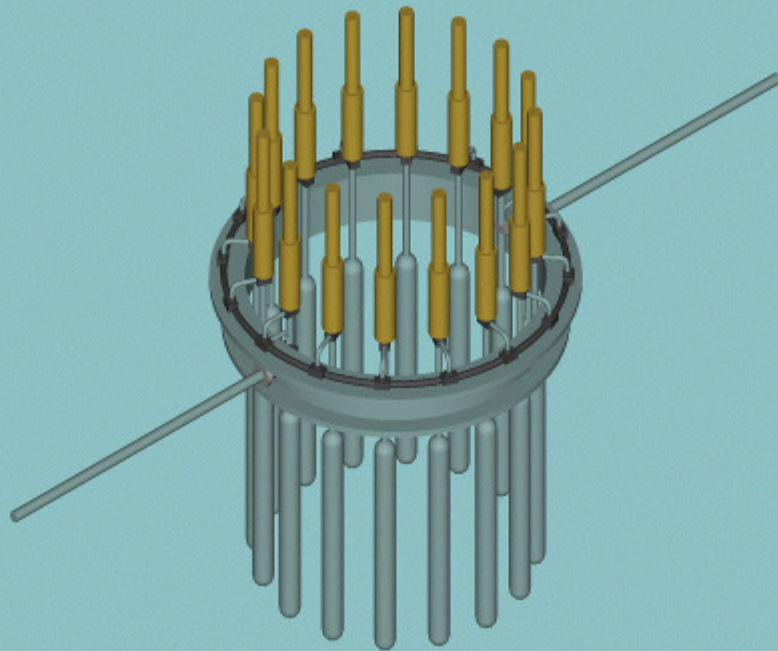
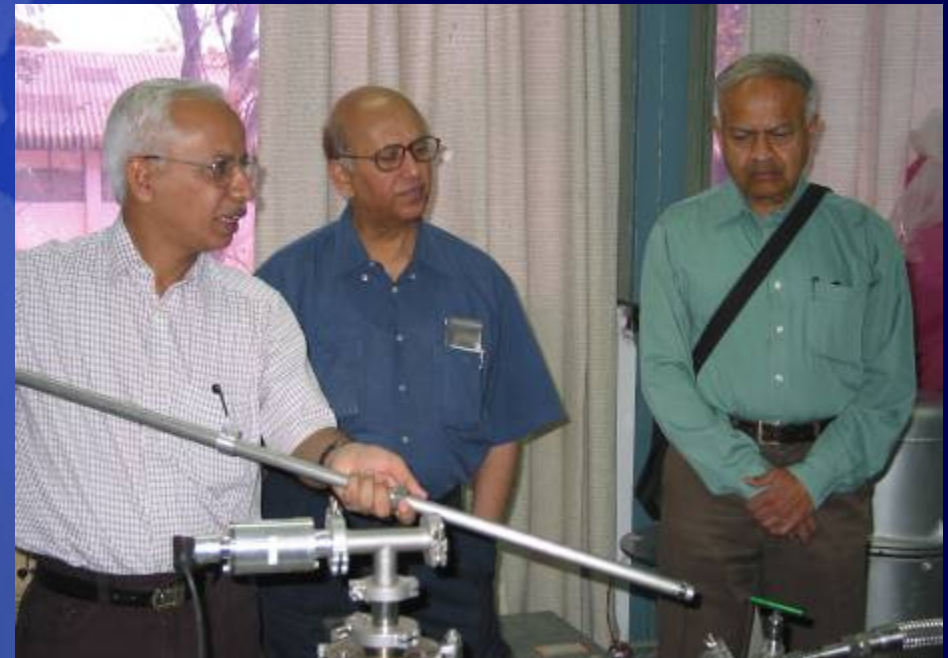


# Regional Climate Simulation

- **MM5 used for regional climate studies.**
- **Preliminary simulations made including satellite-derived land surface parameter generated at SAC for July 1998.**
- **Significant improvement in the simulated rainfall was detected using SAC generated vegetation fraction data to initialize the model.**



# High altitude balloons for GHG's & Astrobiology Payload



CBS DUTT 2005

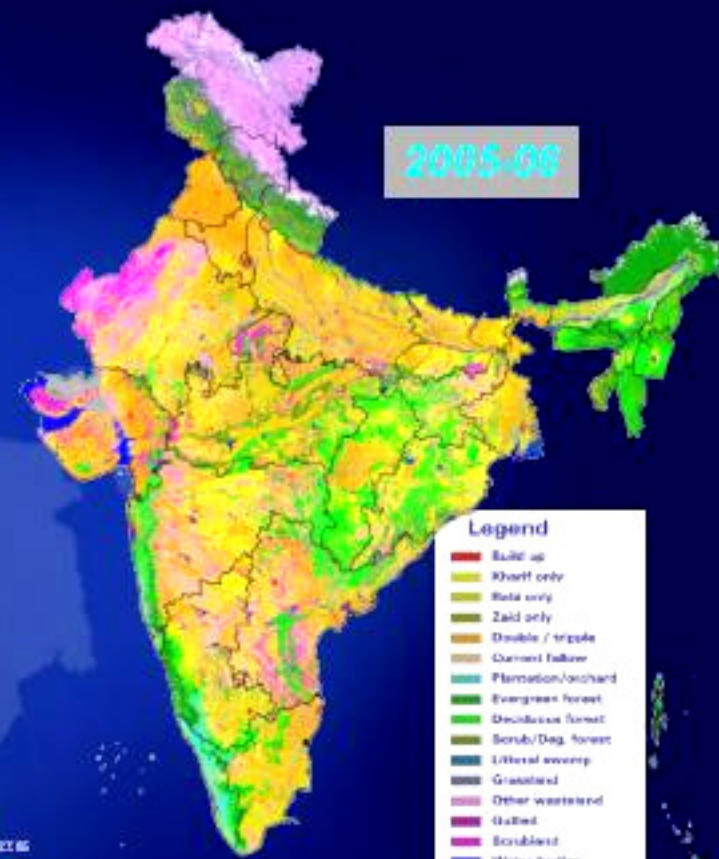


# National Landuse / Landcover mapping using Multitemporal AWiFS Data

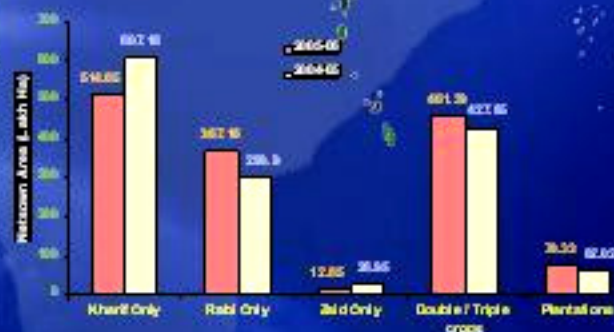
NRR-NRC ISRO/DOS

## LULC-Web

Land Use Land  
Cover Mapping-  
Web Enabled  
Information  
System



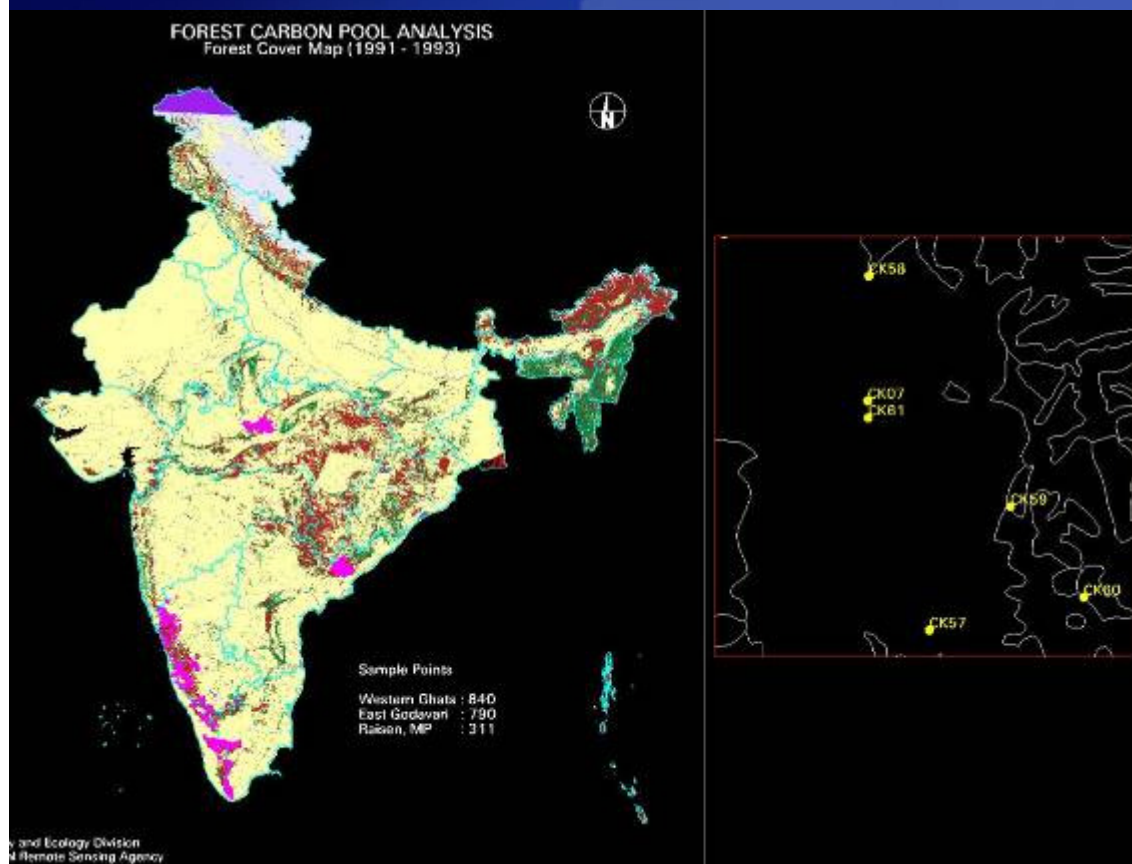
- Legend**
- Build up
  - Kharif only
  - Rabi only
  - Zaid only
  - Double / triple
  - Current fallow
  - Plantation/orchard
  - Evergreen forest
  - Deciduous forest
  - Scrub/Deg. forest
  - Littoral swamp
  - Grassland
  - Other wasteland
  - Barren
  - Scrubland
  - Water bodies
  - Snow covered
  - Shifting Cultivation



**3rd Cycle Status ( 2006-07) :** Geometric rectification of all products is completed  
Kharif data analysis is in progress  
Report preparation for kharif will be completed in two weeks



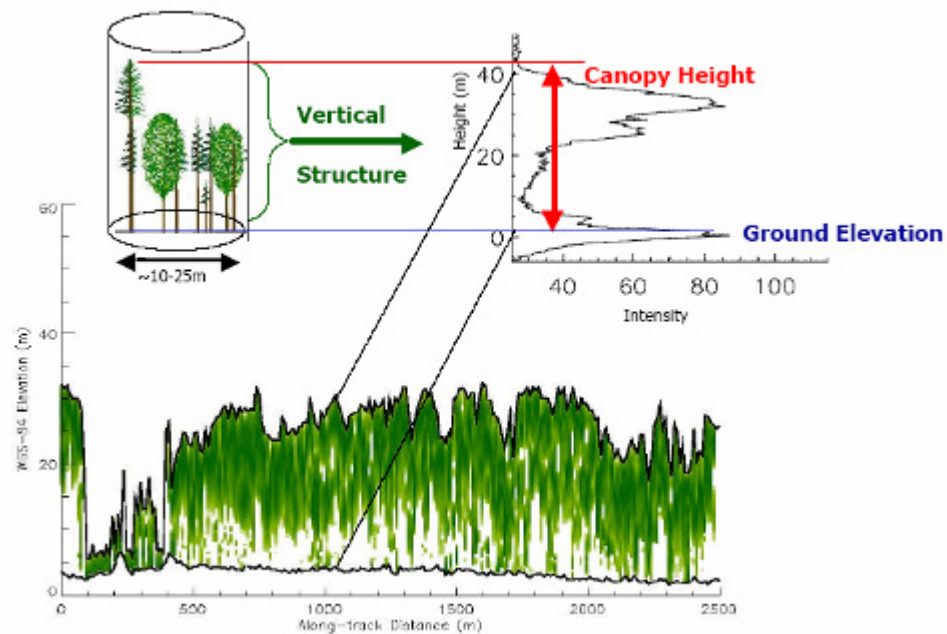
S.NO	FOREST TYPE	FOREST DENSITY CLASSES (VOLUME IN MCU.M.)					TOTAL VOLUME (MCU.M)	BIOMASS (MT)
		DENSE_FOR	OPEN_FOR	MANGROVE	SCRUB	TREECLAD		
1	EVERGREEN	300.25	63.24	0.13	3.47	0.25	367.33	414.35
2	SEMI EVERGREEN	76.02	6.98	0.12	1.47	0.18	84.77	80.87
3	MOIST DECIDUOUS	48.10	23.95	0.46	11.63	0.15	84.29	88.00
4	DRY DECIDUOUS	334.88	212.06	2.92	97.55	0.17	647.57	676.06
	<b>TOTAL</b>	<b>759.25</b>	<b>306.23</b>	<b>3.62</b>	<b>114.12</b>	<b>0.74</b>	<b>1183.96</b>	<b>1259.28</b>



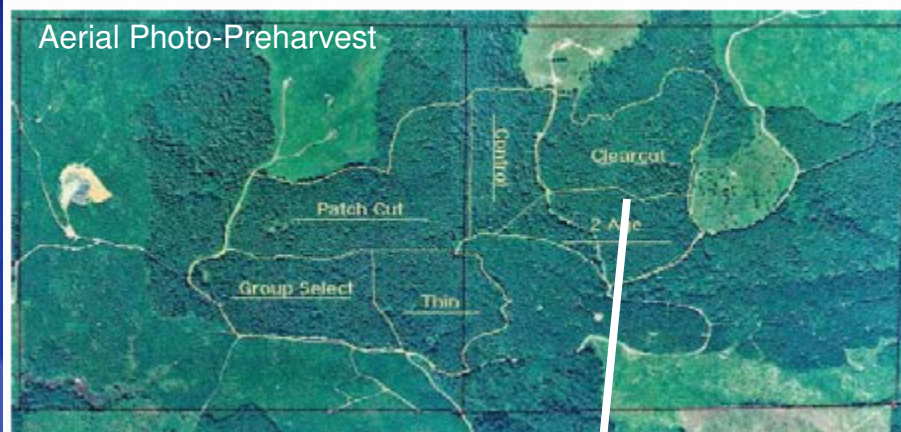
S.NO.	FOREST TYPE	MEAN VOLUME (CU.M / HA)	# PLOTS
1	SEMI_EVERGREEN	74.76	35
2	MOIST_DECIDUOUS	62.82	278
3	DRY_DECIDUOUS	54.86	247
4	PLANTATION	59.32	175
5	FBLANK	71.60	8
	<b>OVERALL</b>	<b>59.93</b>	<b>743</b>

REGION	MEAN C POOL (Mg C / ha)
WESTERN GHATS	80.54
EASTERN GHATS	43.38
CENTRAL INDIA	22.78
NORTH EASTERN	128.64
<b>NATIONAL AVERAGE</b>	<b>68.835</b>

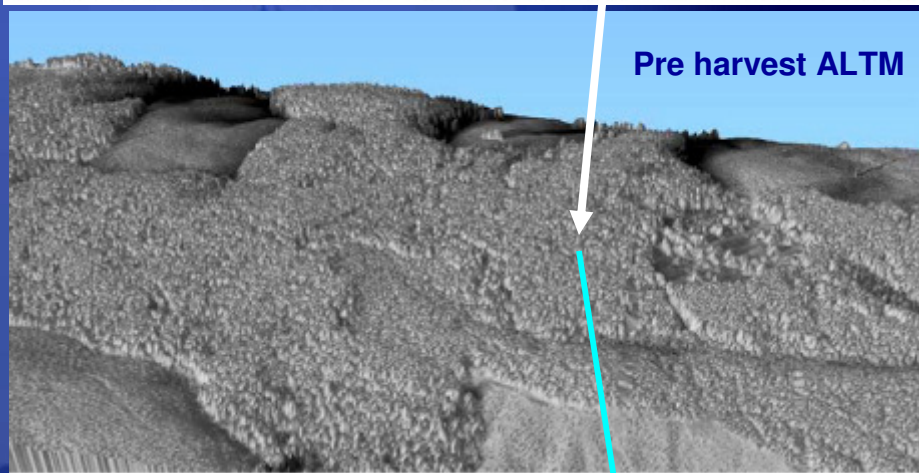
# ALTM Applications-SBL



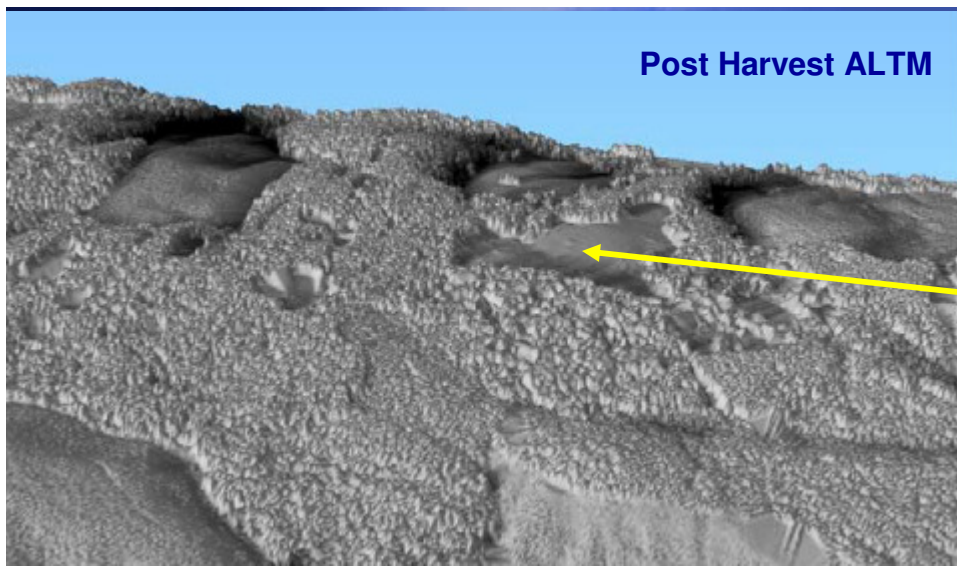
Aerial Photo-Preharvest



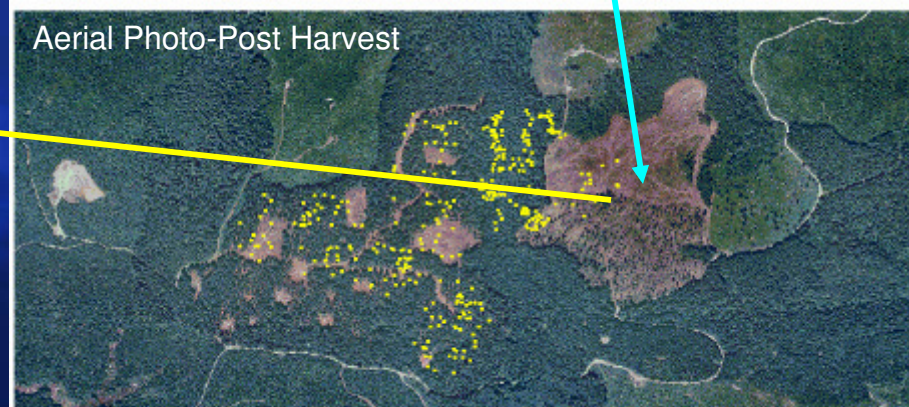
Pre harvest ALTM



Post Harvest ALTM



Aerial Photo-Post Harvest





# Multi-Satellite Launch: PSLV-C7

4 satellites of 1292 kg in 635 km PSSO

Cartosat-2 : 680 kg

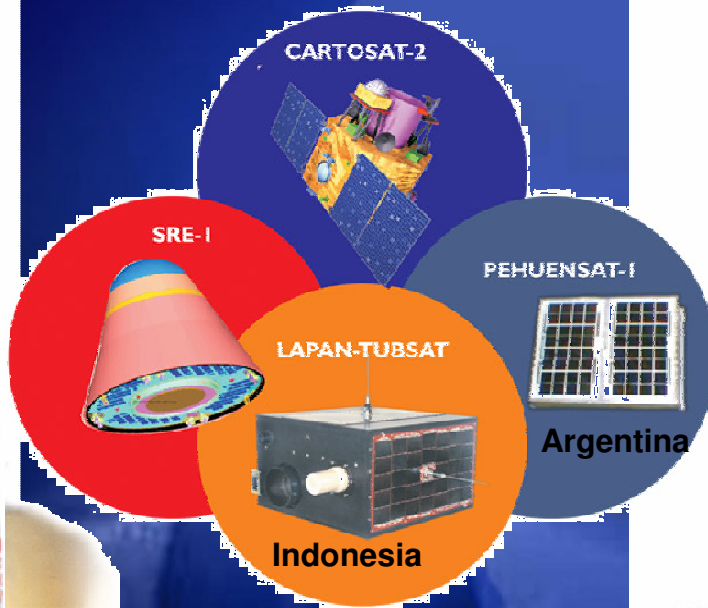
SRE-1 : 550 kg

LAN TUBSAT : 56 kg

PEHUENSAT-1 : 6 kg

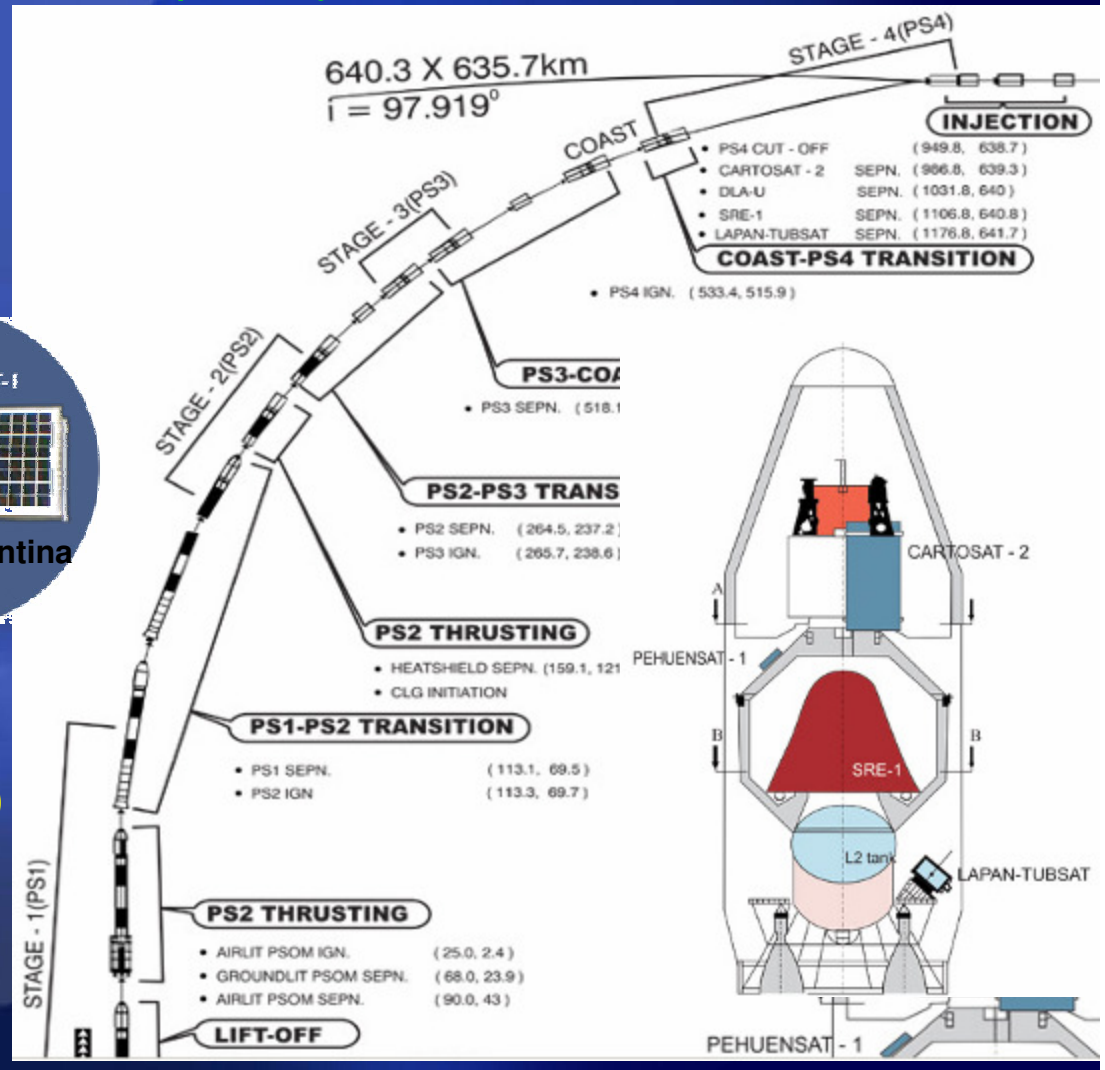
9<sup>th</sup> Consecutive  
successful flight

Capability for Small Satellite missions



Dual Launch Adopter (DLA)

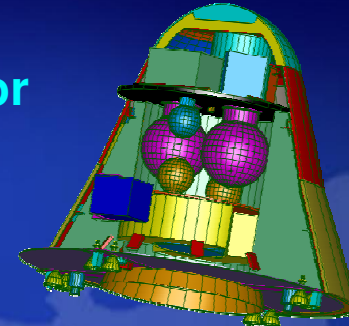
Launch:  
January 10, 2007



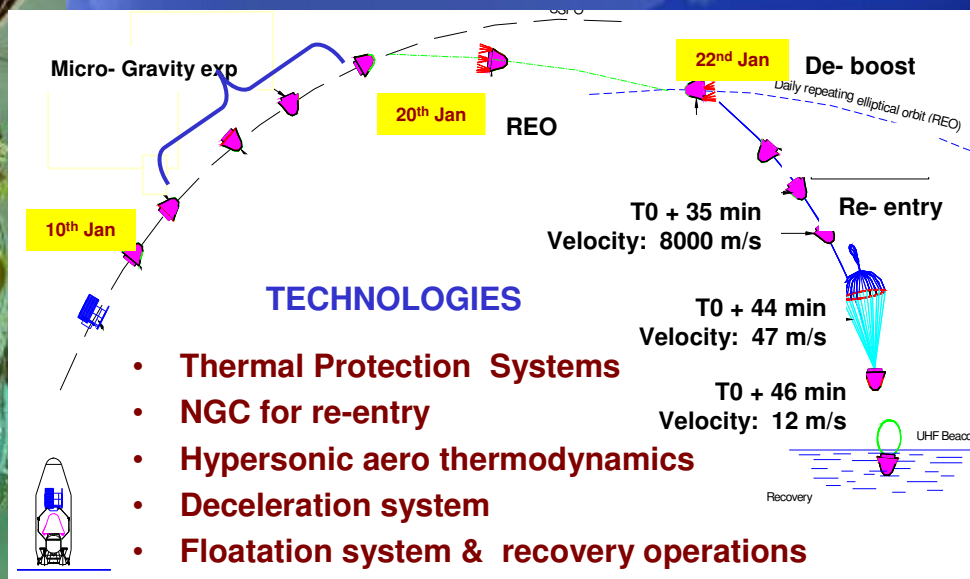
# Space Capsule Recovery Experiment



- Providing a platform for Micro-gravity experiments in space
- Demonstration of technology for recovery of space capsule



## MISSION PROFILE

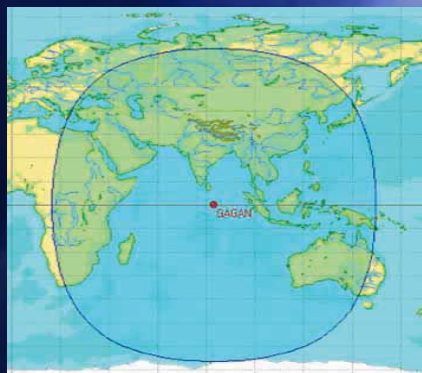
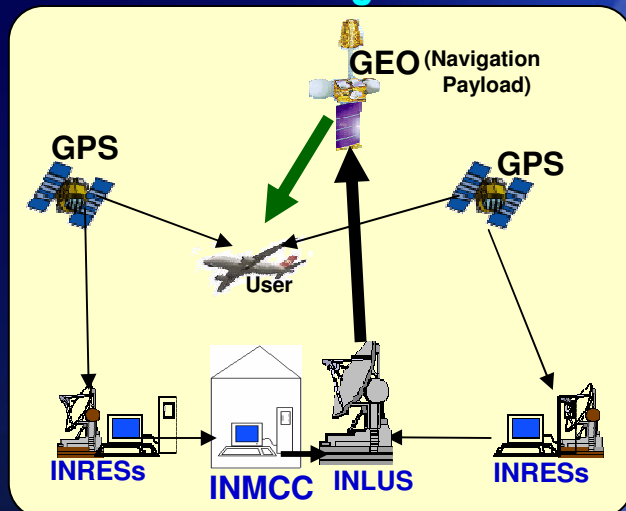




# Indian Satellite Navigation Programme

## Augmentation System

**GAGAN: GPS and Geo Augmented Navigation**



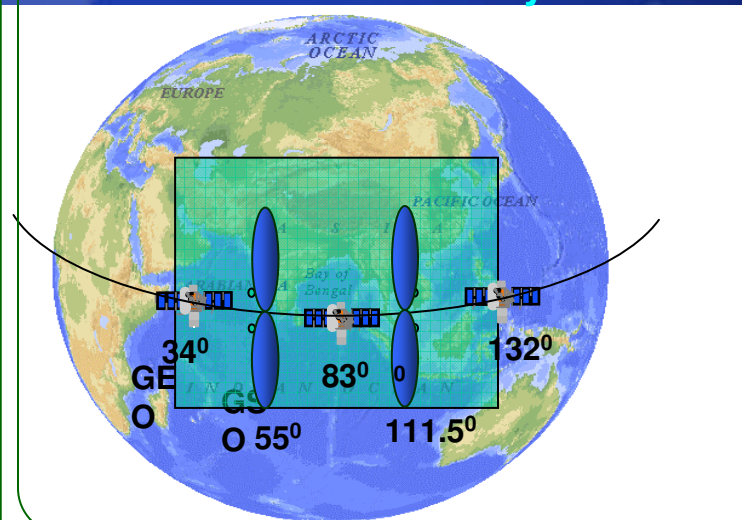
**GAGAN Coverage**

**Improved GPS accuracies (from 30m to 6m)**

**Correction signals transmitted to user through Geo-satellite**

## Independent Navigation System

**IRNSS: Indian Regional Navigation Satellite System**



Accuracy over  
Indian  
Region  
Accuracy over  
&  
countries



**Gagan Uplinking Facility**



**Ref. Station Antenna**





# Earth Observation - Applications



## AGRICULTURE & SOIL

- Crop Acreage & Production
- Soil & Land Degradation Mapping
- Watershed Development
- Horticulture Mission



## LAND

- Land use/Land cover Mapping
- Wasteland Mapping
- Urban Sprawl Studies



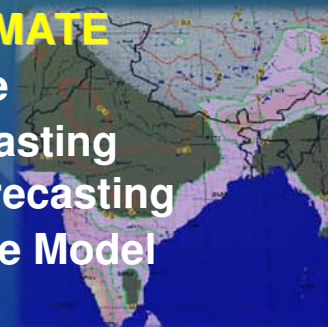
## FOREST, ENVIRONMENT, BIO

- Forest Cover & Type Mapping
- Forest Fire and Risk Mapping
- Biodiversity Characterisation
- Environmental Impact Studies



## WEATHER & CLIMATE

- Extended Range Monsoon Forecasting
- Ocean State Forecasting
- Regional Climate Model



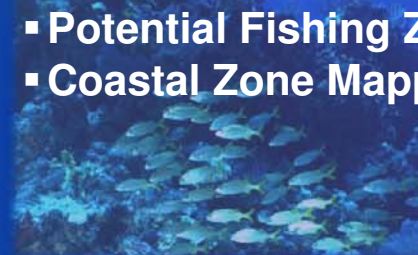
## WATER

- Drinking Water Prospect Zones
- Command Area Management
- Reservoir Sedimentation



## OCEAN

- Potential Fishing Zone (PFZ)
- Coastal Zone Mapping



## DISASTER MGT. SUPPORT

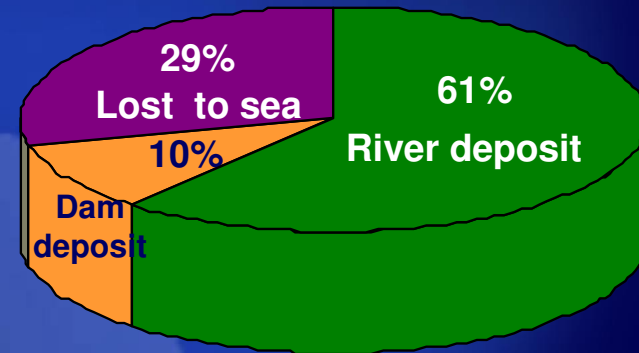
- Flood Damage Assessment
- Drought Monitoring
- Land Slide Hazard Zonation



# Natural Resources : Scenario

**700 M. Indians depend on Natural Resources for their Livelihood and Marketable Surplus**

**India's Annual Soil Loss 5334 Mt**

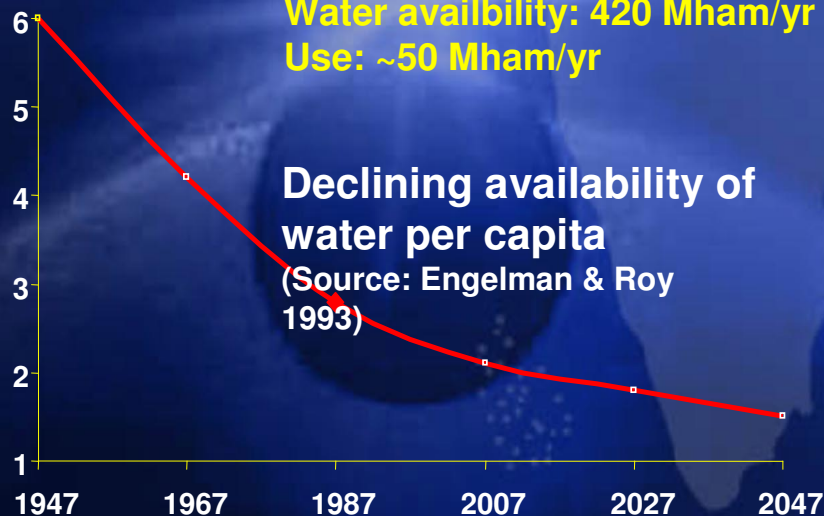


**Loss to 4.5% of the GDP due to Degradation of Natural Resources**

- TERI: 1998

\*000 cubic metres

**Water availability: 420 Mham/yr**  
**Use: ~50 Mham/yr**



## Space Perspectives:

- **Efficient Land and Water Resources Management**
- **Empowering People for Sustainable Development**



# EO Products & Services

*For Natural Resources Assets building*

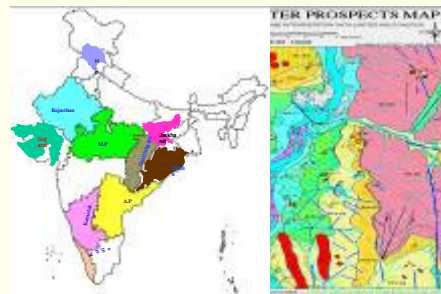
## Land Resources

- Wasteland inventory (55 Mha in 2003)
- Natural Resources Census
- Natural Resources Repository



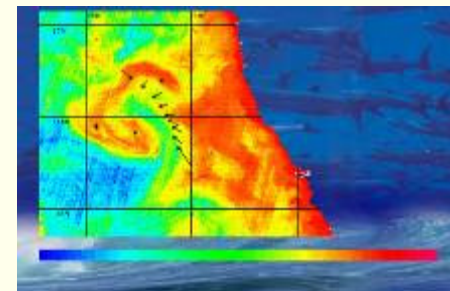
## Water Resources

- Potential Drinking Water Zones (~200,000 wells drilled with ~90% success; over 7000 recharge structures)
- Command Area Management
- Reservoir Sedimentation



## Ocean Resources

- Potential Fishing Zone - PFZ (Search time reduced by 30-70%)
- Coastal Zone Mapping

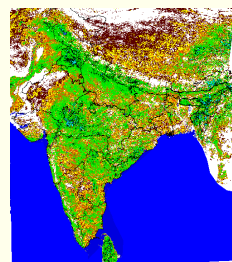


## Rural Connectivity Corridors

- Under Bharat Nirman
- High potential with Cartosat 1 & 2 products



## Risk Reduction



Agri. Drought Assessment

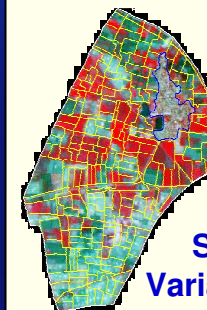


AWS

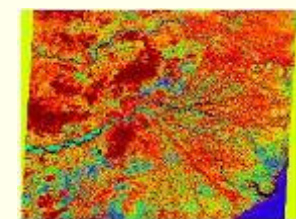
### Agri. Insurance

- Small area Statistics,
- Area Yield
- Weather Indexing
- Access to Credit

## Precision Agriculture



Soil Variability



Yield Variability

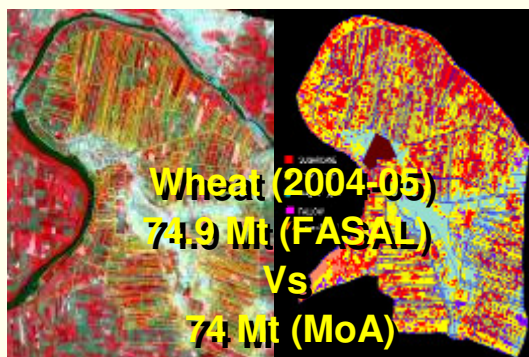
Crop Weather Interaction

Crop Simulation Model

# EO Products & Services

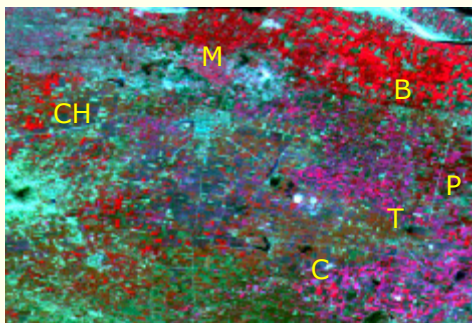
*For Enhancing Agricultural Productivity*

## *In-season forecast...*



**CAPE/ FASAL: Area Statistics  
(MoA)**

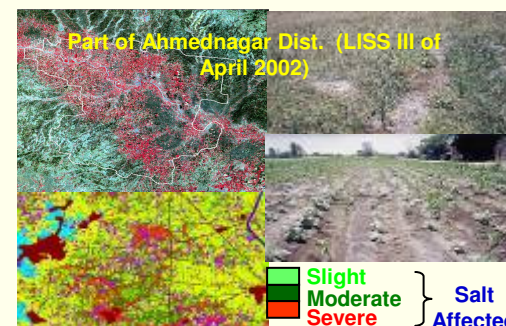
## *Horticultural Inventory*



Banana; Maize; Tobacco;  
Chillies; cotton; Paddy

**National Horticulture  
Mission (MoA)**

## *Crop intensification/ extensification*



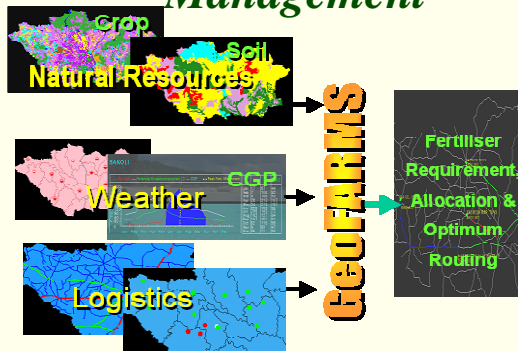
**Salinity Mapping for  
reclamation  
(CWC)**

## *Diversification...*



**Cropping System Study  
(MoA)**

## *Effective Input/ Output Management*



**Fertiliser Req. Assessment  
(IFFCO)**

## *Empowering farmers...*



**Farmers' Advisory &  
Decision Support  
(Plg. Commn.; GoK)**





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