Current status and Future Prospects of Indian Satellite

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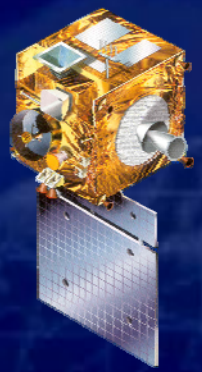
Indian Space Programme for Earth Observations

- **Payload and Satellite: Design & Fabrication**
- **Launch (Design, Fabrication & Launch):**
  - **» Polar: Operational**
  - **» Geostationary: Operational**
- **Retrievals**
- **Applications with Users**

Indian Missions for Weather & Climate Studies : Current & Future

Kalpana-1
2002



VHRR

CMV, OLR, Rainfall

INSAT-2E/3A
(1999/2003)

VHRR, CCD

CMV, OLR, Rainfall
Aerosol

INSAT-3D
(2008)

6-Ch VHRR
IR Sounder

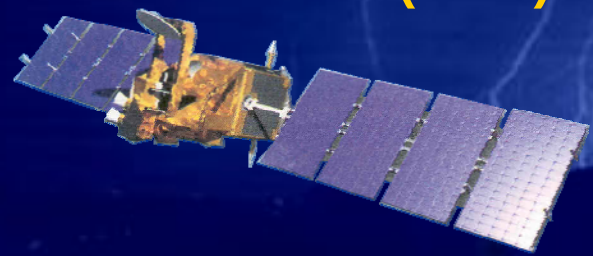
SST, CMV, OLR,
Rainfall,
T, h Profile

OCEANSAT–1/2
(1999/2008)

MSMR,
OCM,
Scatterometer

Vector Winds
Aerosol

MEGHA-TROPIQUES
(2008)



MW Imager,
WV Sounder,
ScaRaB

SS Wind, TWV, Rainfall
T, h Profile,
Radiation Budget

INDIAN NATIONAL SATELLITE (INSAT) FOR METEOROLOGICAL APPLICATIONS

INSAT -1 : Geostationary Satellite Series

Satellite	Launch Date	Met. Payload with Wavelength Bands	Major Applications
INSAT-1A	10 April 1982	Very High Resolution Radiometer (VHRR) Visible 0.55-0.75μm IR 10.5 - 12.5μm	▪ Monitoring cyclones & monsoon ▪ CMV Winds ▪ OLR ▪ Rainfall Estimation
INSAT-1B	8 August 1983	-do-	-do-
INSAT-1C	22 July 1988	-do-	-do-
INSAT-1D	12 June 1990	-do-	-do-

INSAT -2 : Geostationary Satellite Series

Satellite	Launch Date	Met. Payload with Wavelength Bands	Major Applications
INSAT-2A	10 July 1992	Very High Resolution Radiometer (VHRR) Bands 0.55-0.75 μm & 10.5 - 12.5μm	▪ Monitoring cyclones & monsoon ▪ CMV Winds ▪ OLR ▪ Rainfall Estimation ▪ Mesoscale features ▪ Flood/intense precipitation advisory ▪ Snow detection
INSAT-2B	23 July 1993	Very High Resolution Radiometer (VHRR) Bands : 0.55-0.75 μm &10.5 - 12.5 μm	
INSAT-2E	April 1999	**VHRR** : As above + WV Bands : 5-7.1 μm **CCD** : Bands : 0.63 - 0.79 μm 0.77 - 0.86 μm 1.55-1.70 μm	

Location of INSAT-2E : 83ºE

INSAT 2E - CCD

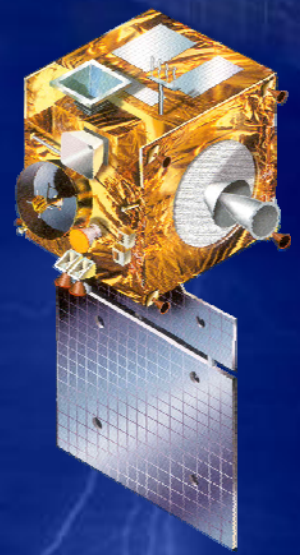
Detectors	Spectral Bands (μm)	Spatial Resolution
Visible (Vis)	**0.63-0.68**	**1 Km**
Near Infrared (NIR)	**0.77-0.86**	**1 Km**
S W Infrared (SWIR)	**1.55-1.7**	**1 Km**

INSAT-3A & Kalpana-1

(2003) (2002)

Location : INSAT 3A : 93.5ºE
Kalpana-1 : 74ºE

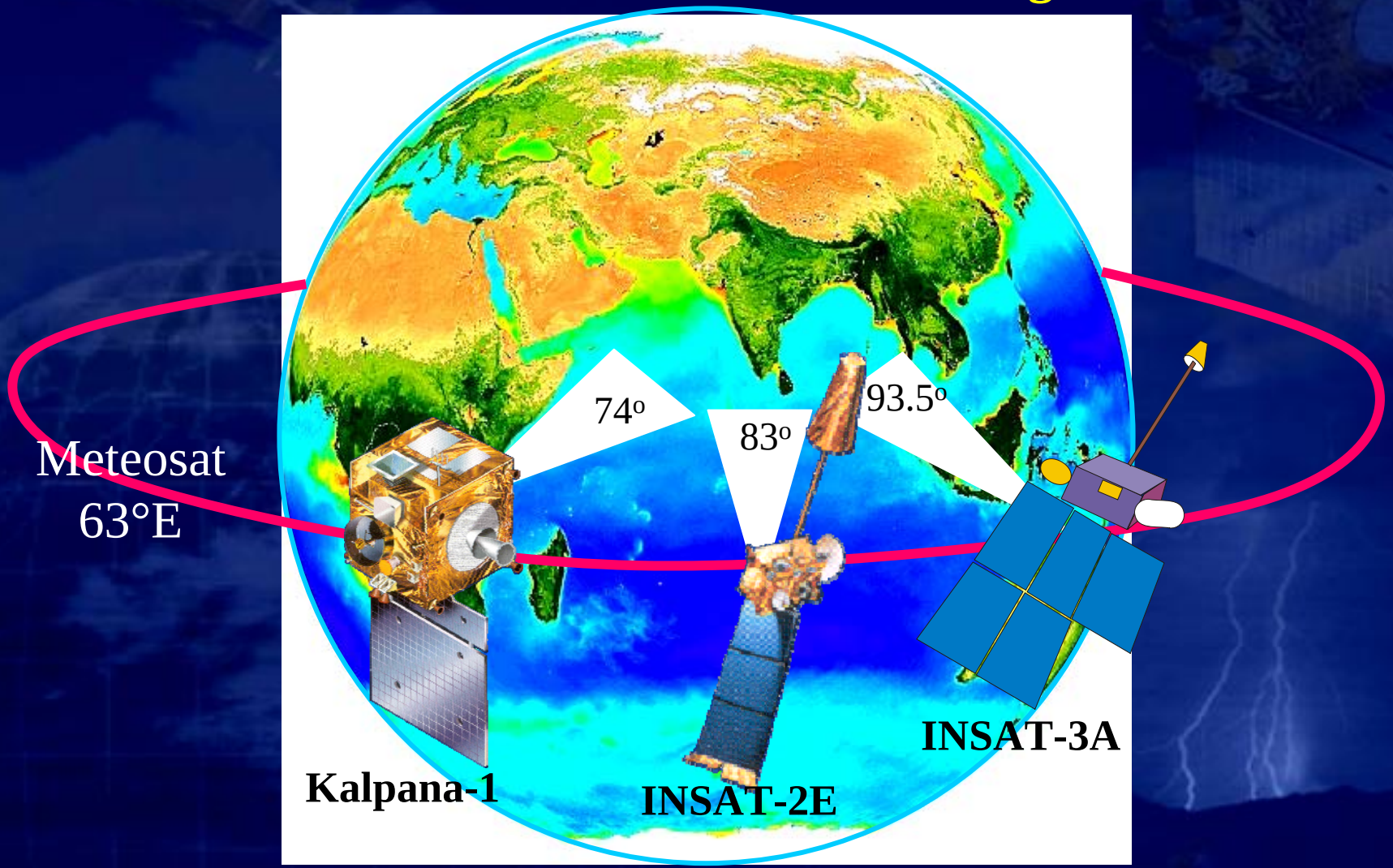
Payload : (i) VHRR & CCD camera in INSAT 3A
(ii) VHRR in Kalpana-1



- **VHRR Bands (µm)**
  - Visible : 0.55 – 0.75
  - Water vapour : 5.70 – 7.10
  - Thermal Infra Red : 10.5 – 12.5
- Resolution (km) : 2 X 2 for Visible
  8 X 8 for WV & TIR

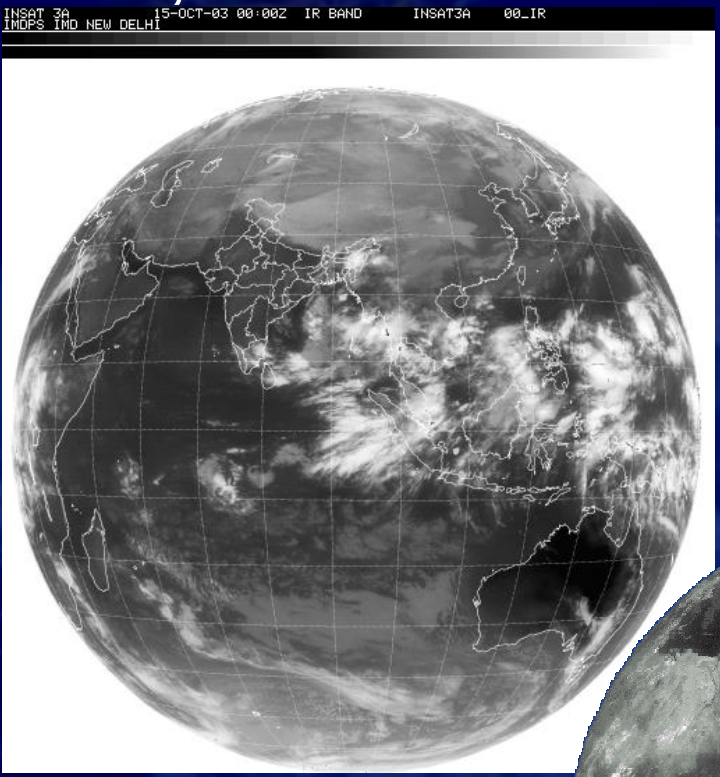
- **CCD Camera Bands (µm)**
  - Visible : 0.62 – 0.68
  - Near Infra Red : 0.77 – 0.86
  - Short Wave Infra Red : 1.55 – 1.69
- Resolution (km) : 1 X 1 for all bands

Current Geostationary Meteorological Satellites the South and South West Asian Region

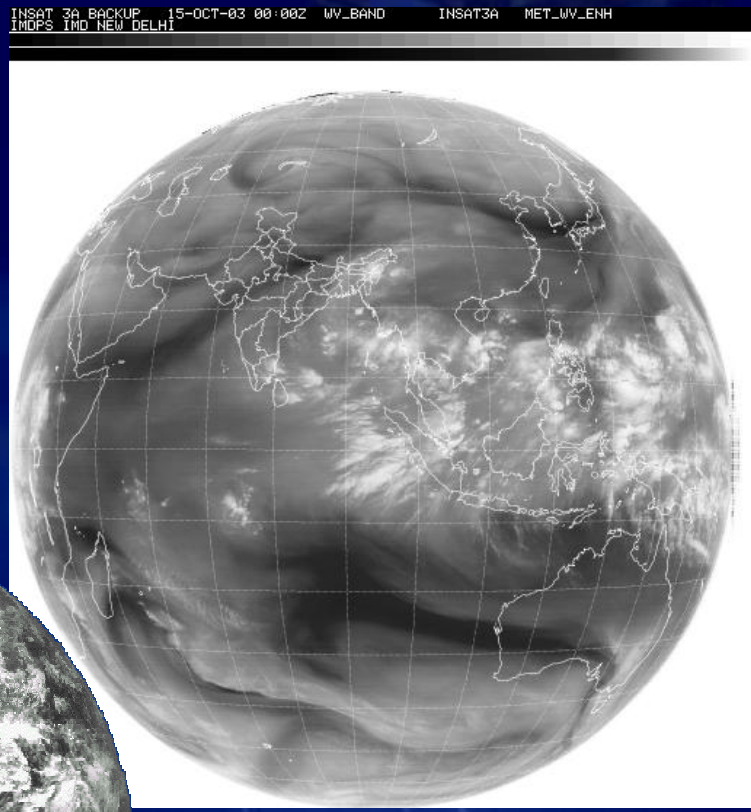


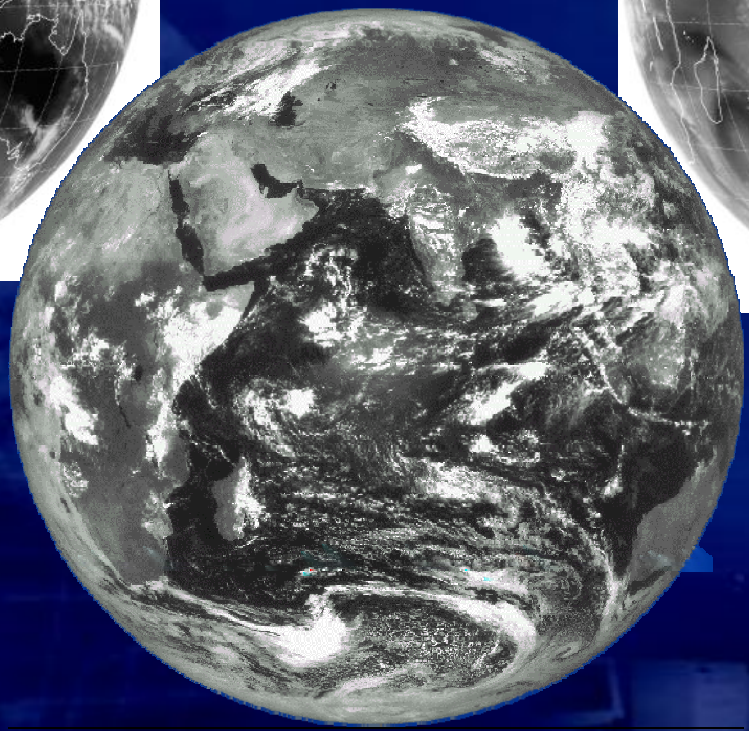
INSAT-3A

IR, 15 Oct 2007



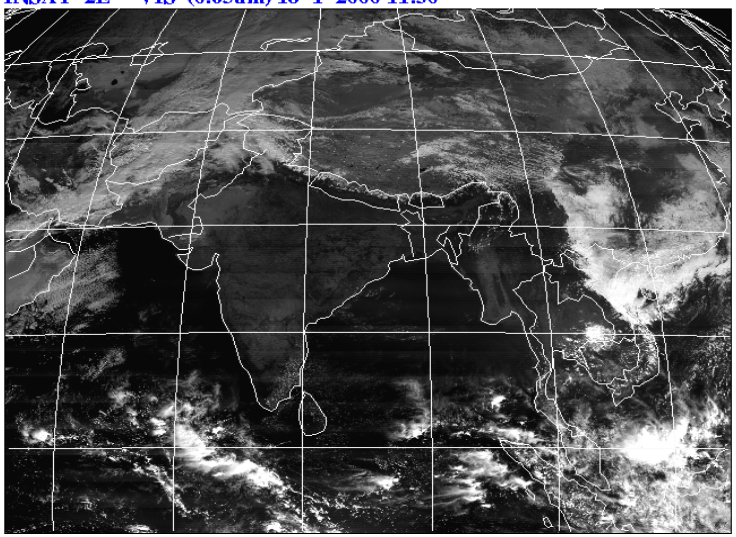
WV, 15 Oct 2007



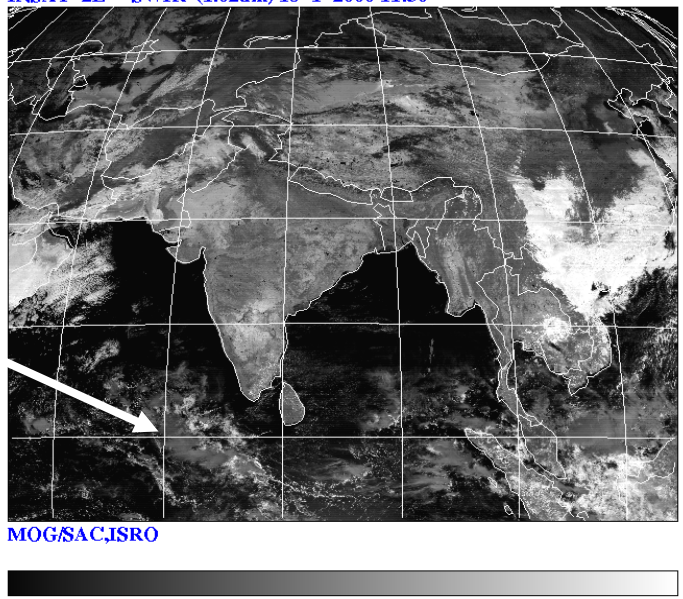


Kalpana-1 Vis 19 Sep 2006

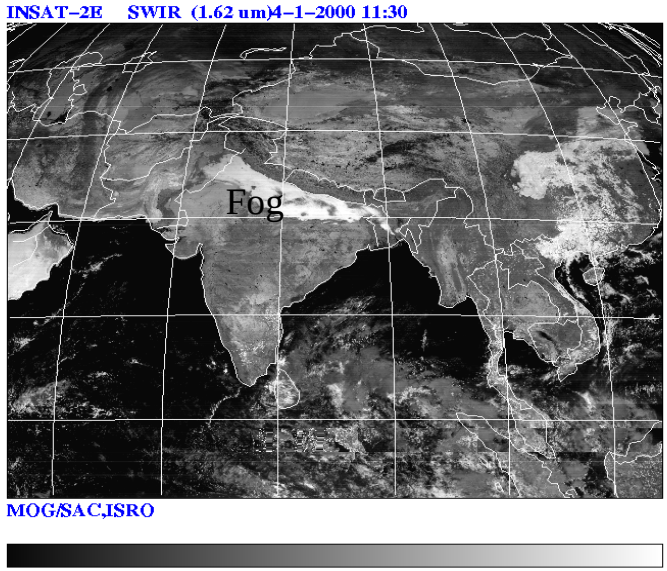
High Convective clouds and Fog Detection using INSAT-2E –CCD data



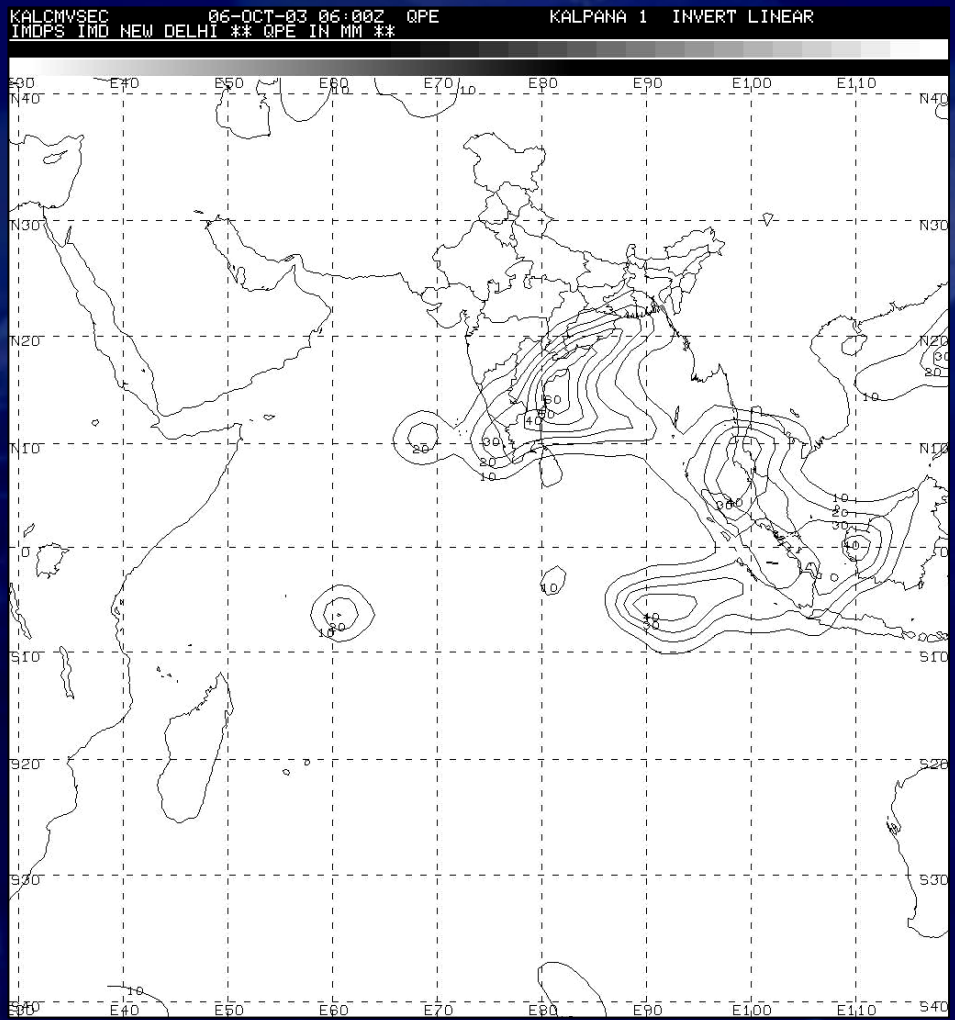
Deep Convective Clouds



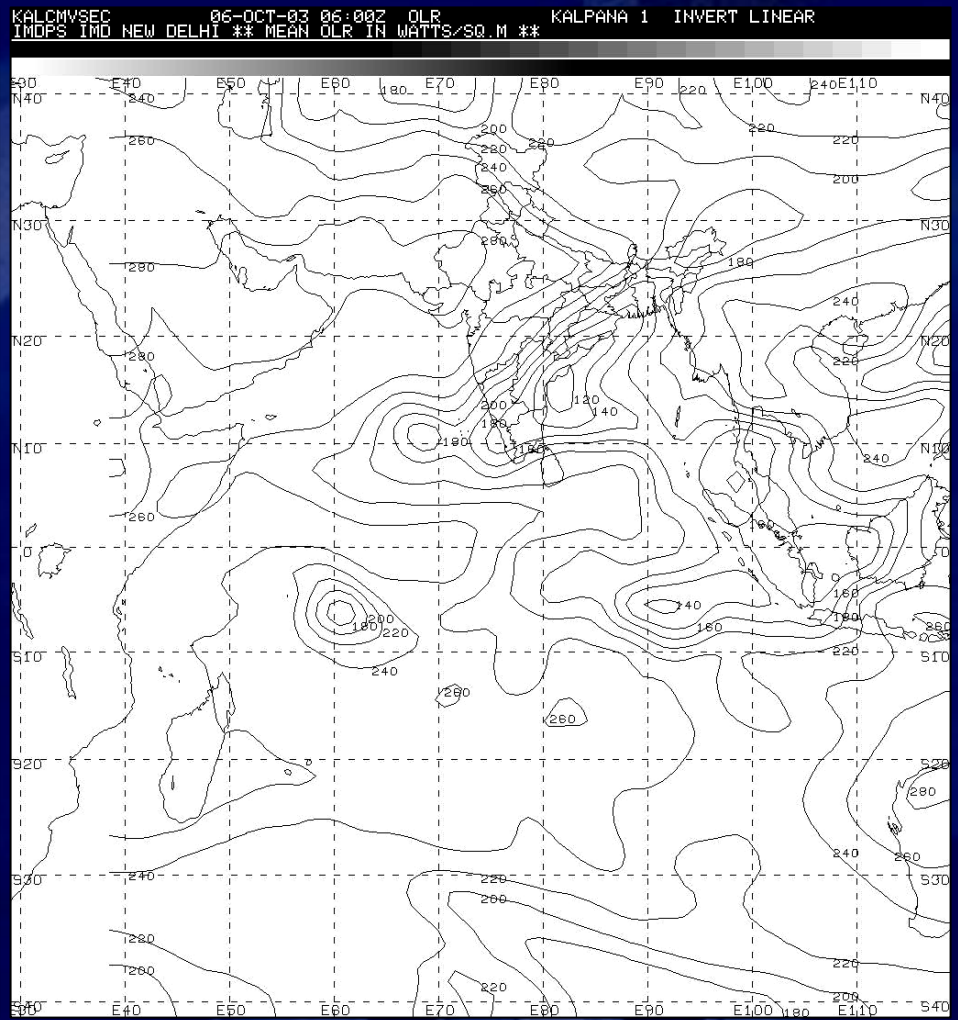
FOG



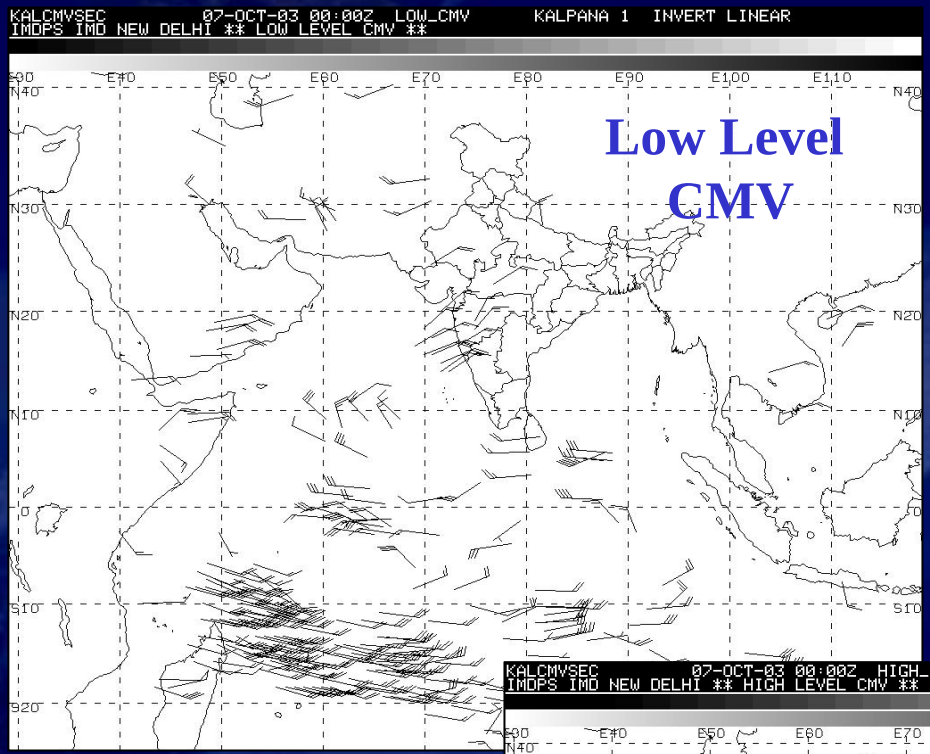
QPE in mm 06-Oct-05 06:00Z Kalpana-1 (IMD, N Delhi)

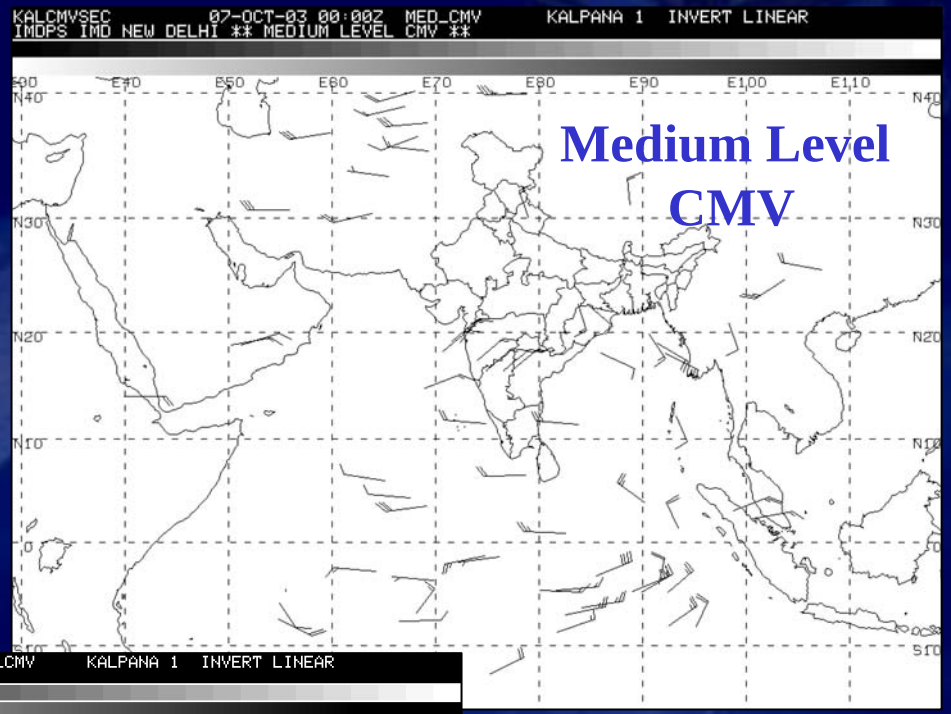


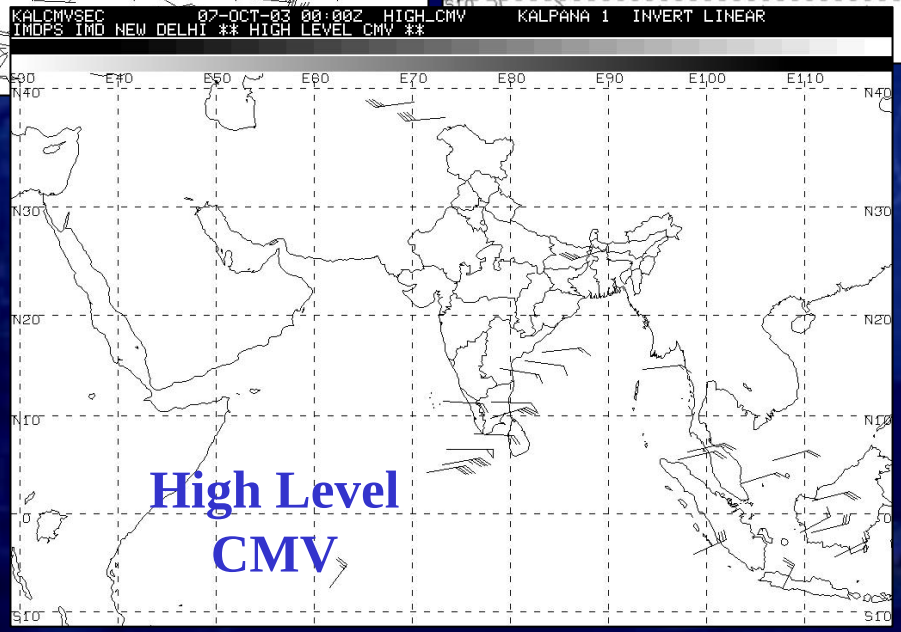
OLR in W/m^2 06-Oct-05 06:00Z Kalpana-1 (IMD, N Delhi)



CMV 07-Oct-05 00:00Z Kalpana-1 (IMD, N Delhi)

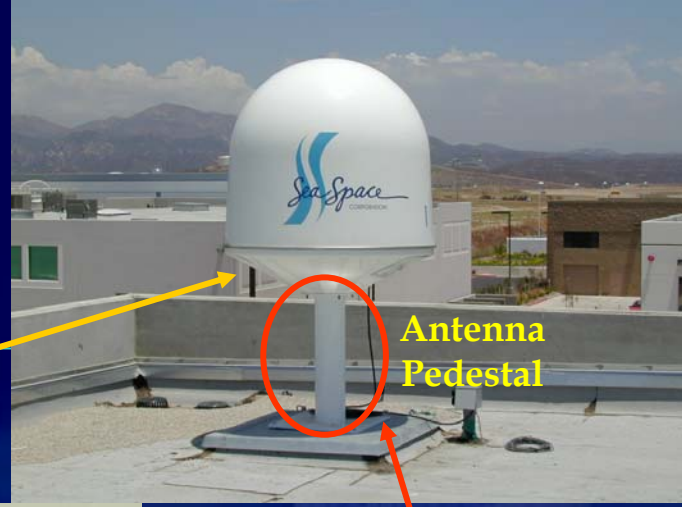






TeraScan HRPT Acquisition and Processing System

1.2m HRPT Tracking Antenna



Sun Ultra-10 Acquisition and Processing

HRPT Receiver

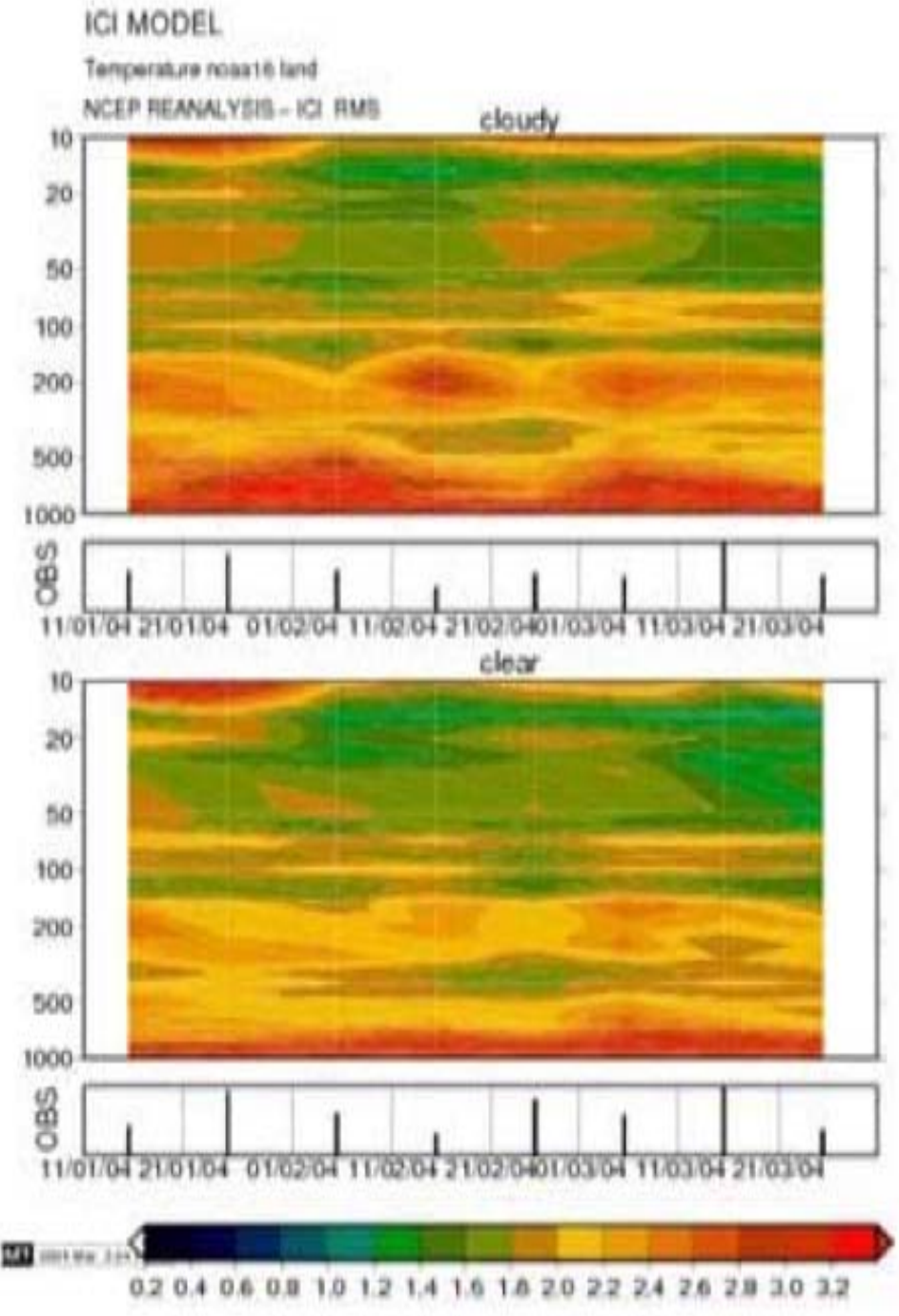
DAT Drive

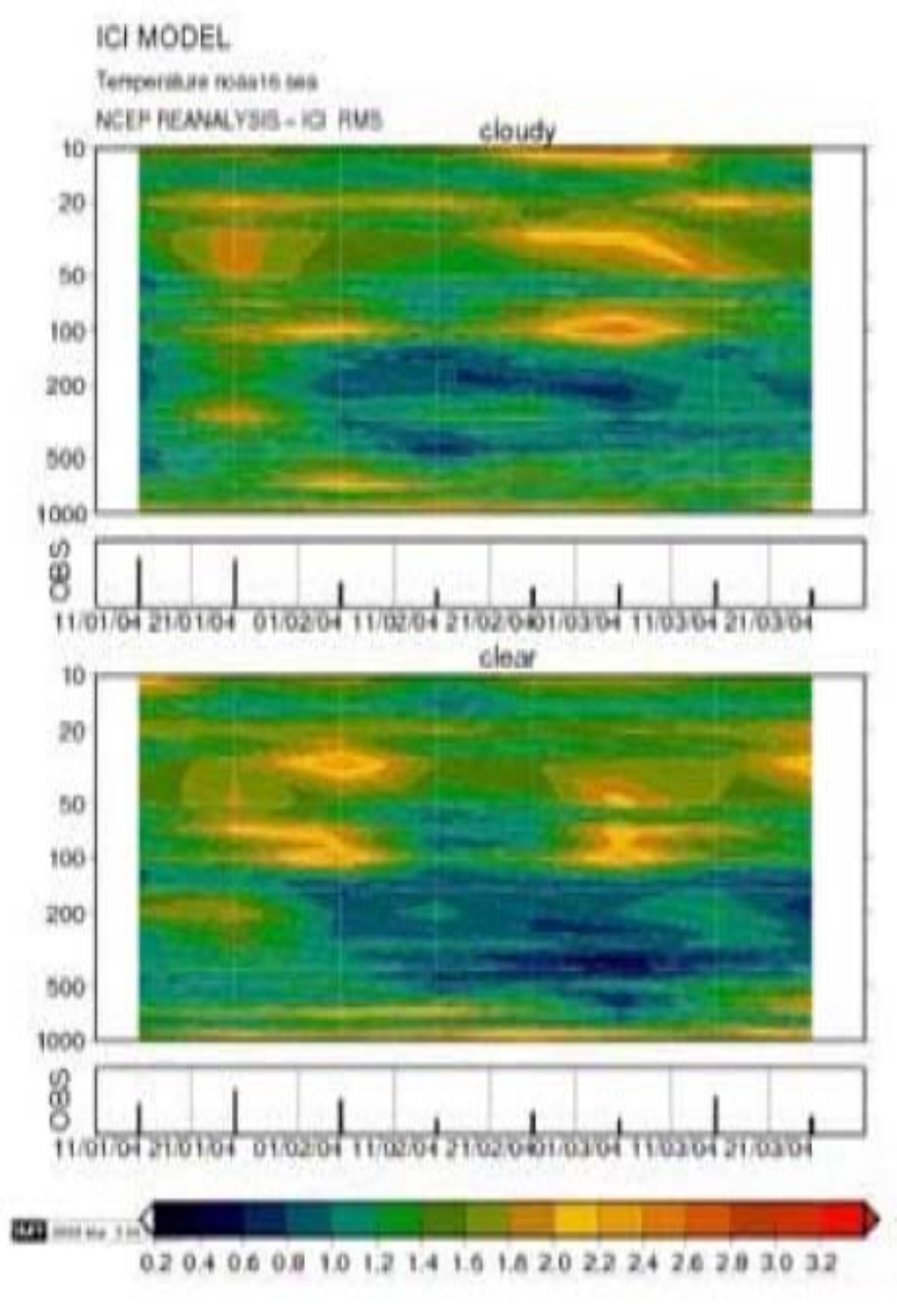
Optional Items

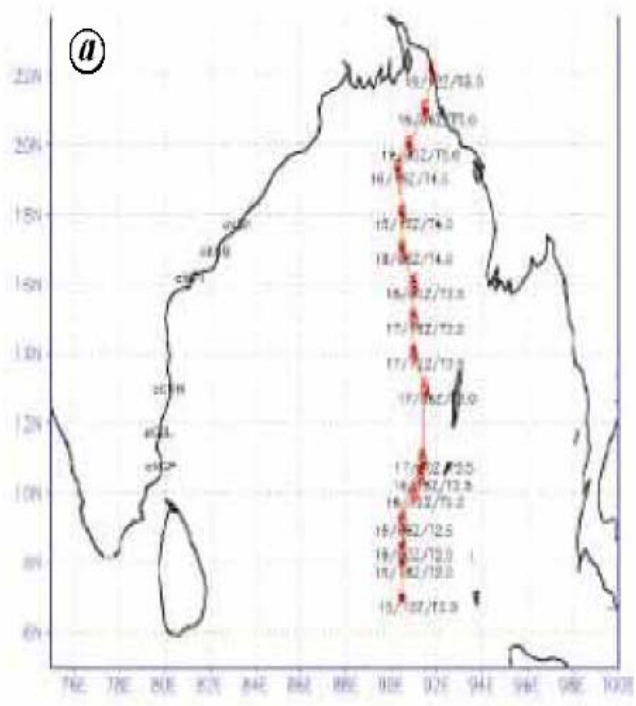
Color DeskJet Printer

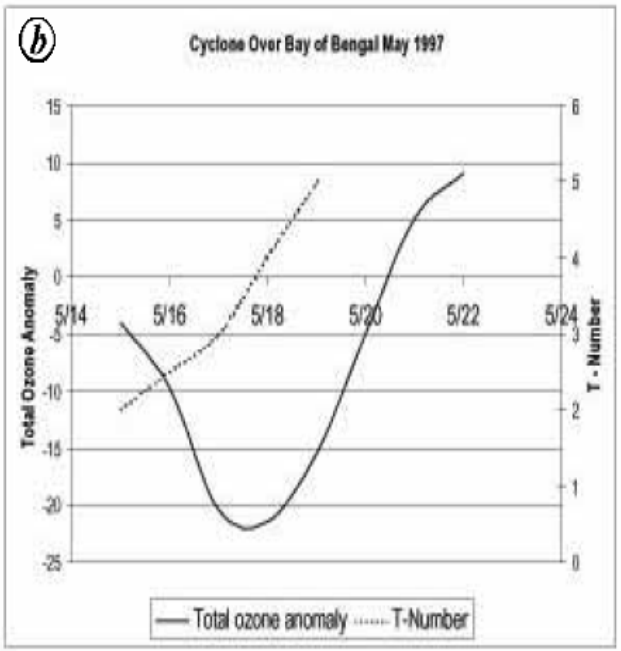
UPS

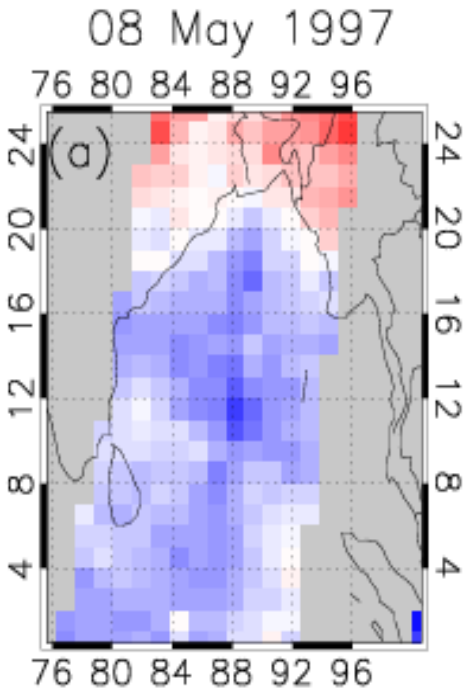

Antenna Coverage
4
Minimum Elevation in degrees
Dehradun
40N
20N
0N
60E
90E
120E

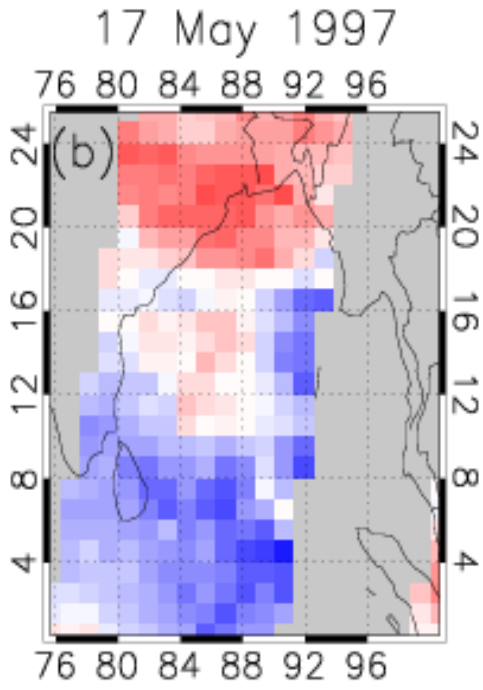

ICI MODEL
Temperature noaa16 land
NCEP REANALYSIS - ICI RMS
cloudy
10
20
50
100
200
500
1000
OBS
11/01/04 21/01/04 01/02/04 11/02/04 21/02/04 01/03/04 11/03/04 21/03/04
clear
10
20
50
100
200
500
1000
OBS
11/01/04 21/01/04 01/02/04 11/02/04 21/02/04 01/03/04 11/03/04 21/03/04
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2

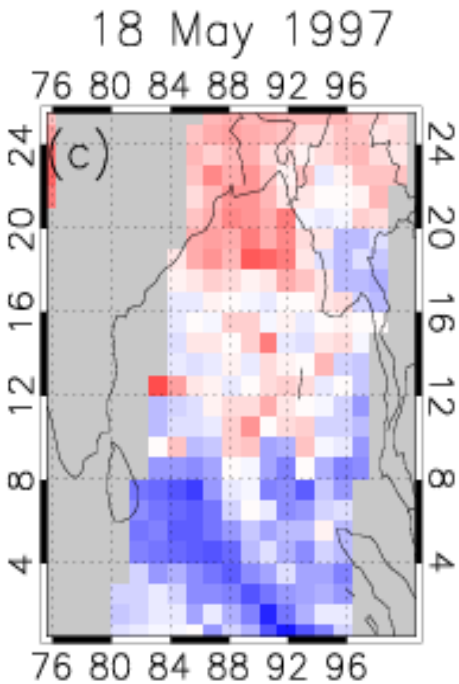

ICI MODEL
Temperature noaa16 sea
NCEP REANALYSIS - ICI RMS
cloudy
10
20
50
100
200
500
1000
OBS
11/01/04 21/01/04 01/02/04 11/02/04 21/02/04 01/03/04 11/03/04 21/03/04
clear
10
20
50
100
200
500
1000
OBS
11/01/04 21/01/04 01/02/04 11/02/04 21/02/04 01/03/04 11/03/04 21/03/04
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2

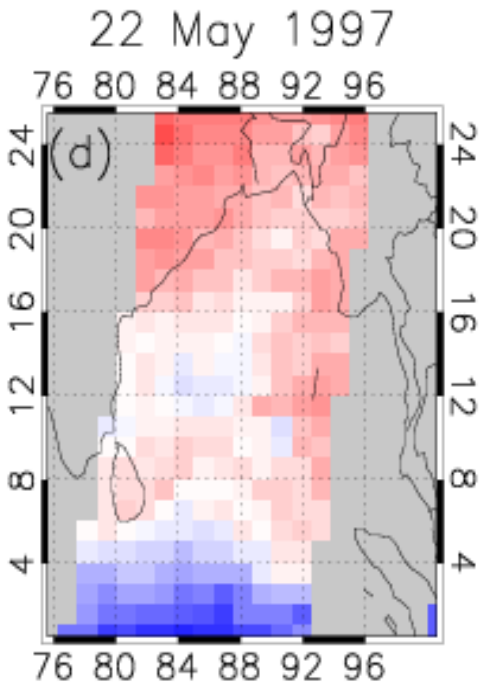

(a)

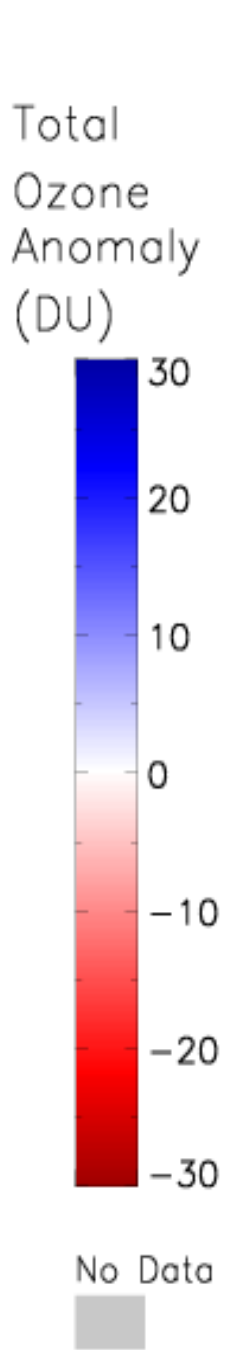

(b)
Cyclone Over Bay of Bengal May 1997
Total Ozone Anomaly
T - Number
5/14
5/16
5/18
5/20
5/22
5/24
Total ozone anomaly
T-Number

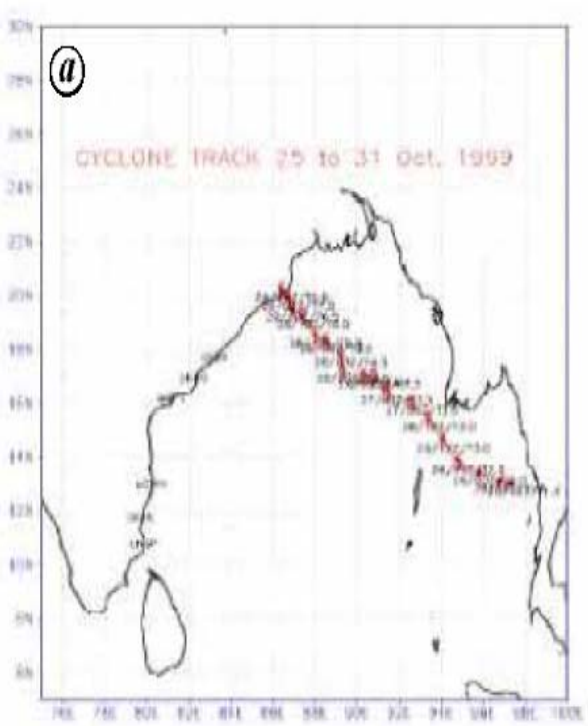

08 May 1997
(a)

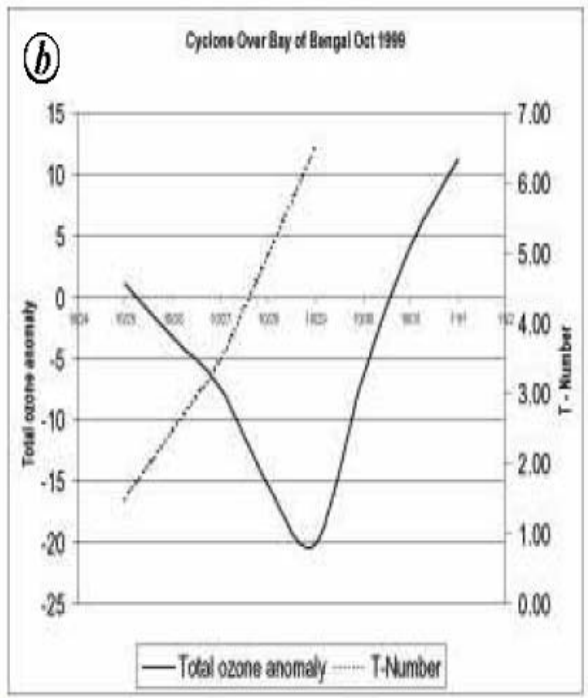

17 May 1997
(b)

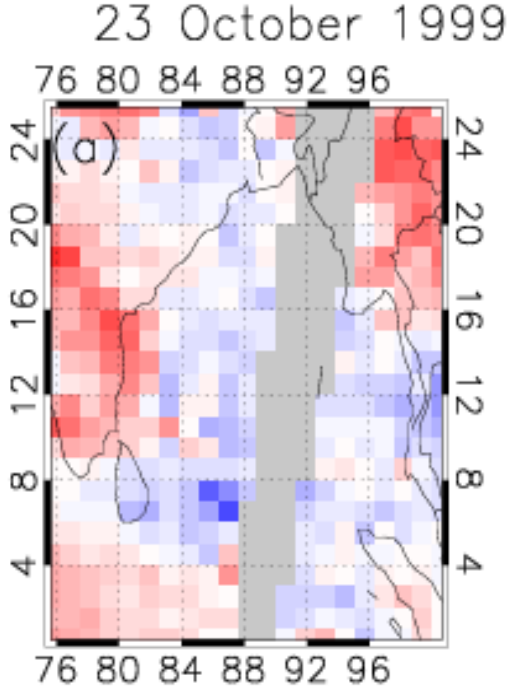

18 May 1997
(c)

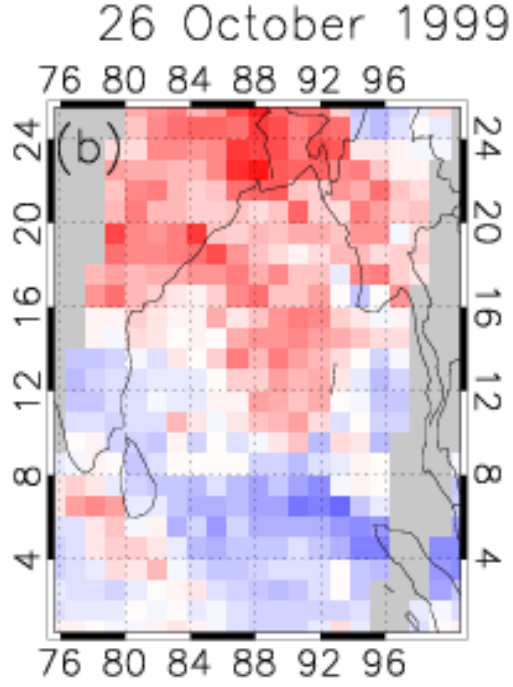

22 May 1997
(d)

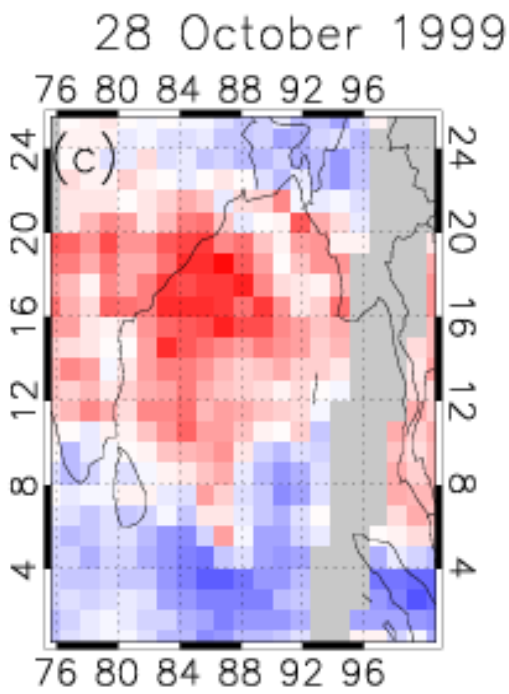

Total
Ozone
Anomaly
(DU)
30
20
10
0
−10
−20
−30
No Data

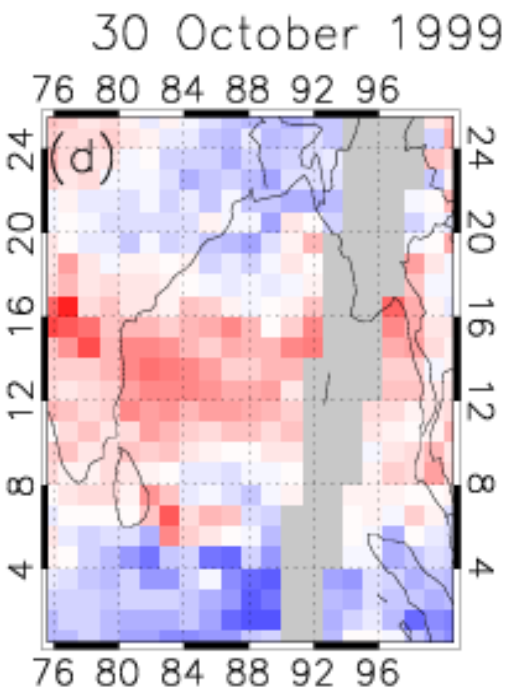

(a)
CYCLONE TRACK 25 to 31 Oct. 1999

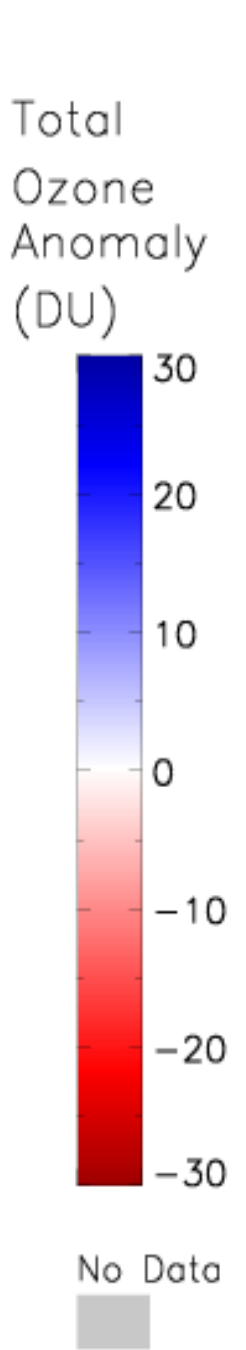

(b)
Cyclone Over Bay of Bengal Oct 1999
Total ozone anomaly
T - Number
Total ozone anomaly
T-Number


23 October 1999
(a)


26 October 1999
(b)


28 October 1999
(c)


30 October 1999
(d)


Total Ozone Anomaly (DU)
30
20
10
0
−10
−20
−30
No Data

Indian Remote Sensing Satellites (IRS)

IRS Sensors

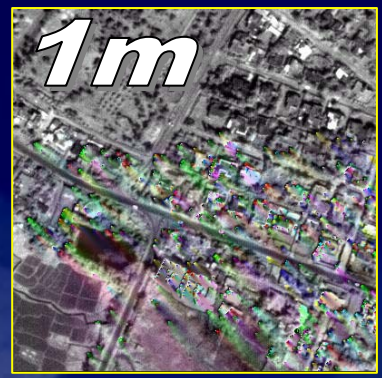
Satellite	Launch Date	Sensors	Channels	Resolution	Swath / Repetivity
IRS-1A	17.03.1988	LISS-1	0.45-0.52µm 0.52-0.59µm 0.62-0.68µm 0.77-0.86µm	72.5 m	148 km / 22 days
		LISS-2	0.45-0.52µm 0.52-0.59µm 0.62-0.68µm 0.77-0.86µm	36.25 m - - -	147 km / 22 days - - -
IRS-1B	29.08.1991	Same as IRS-1A			
IRS-1C	28.12.1995	LISS-3	0.52-0.59µm 0.62-0.68µm 0.77-0.86µm 1.55-1.70µm	23.5 m - - 70.5 m	141 km / 24 days - - 148 km / 24 days
		WiFS	0.62-0.68µm 0.77-0.86µm 1.55-1.69µm	188 m - 188 x 246 m	770 km / 24 days - -
		PAN	0.50-0.75µm	5.8 m	70 km / 5 days
IRS-1D	29.09.1997	Same as IRS-1C			
IRS-P3	21.03.1996	WiFS	Same as IRS-1C but additional band in MIR		
		MOS-A MOS-B MOS-C	0.755-0.768µm 0.408-1.01µm 1.5-1.7µm	1569 x 1395 m 523 x 523 m 523 x 644 m	195 km / 24 days 200 km / 24 days 192 km / 24 days
IRS-P4	26.05.1999	OCM	402-422nm 433-453nm 480-500nm 500-520nm 545-565nm 660-680nm 745-785nm 845-885nm	360 x 236 m - - - - - - -	1420 km / 2 days
		MSMR	6.6, 10.6, 18, 21 for SST, SSWS, TWV, LWC		

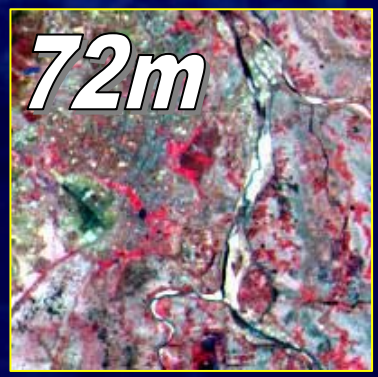
IRS Applications

IRS data is being used for a diverse range of applications such as:

- crop acreage and production estimation of major crops,
- drought monitoring and assessment based on vegetation condition,
- flood risk zone mapping and flood damage assessment,
- hydro-geomorphological maps for locating underground water resources,
- irrigation command area status monitoring,
- snowmelt run-off estimation,
- land use and land cover mapping,
- urban planning,
- biodiversity characterisation,
- forest survey,
- wetland mapping,
- environmental impact analysis,
- mineral prospecting,
- coastal studies,
- integrated surveys for developing sustainable action plans

INDIAN IMAGING CAPABILITY





RESOURCESAT - 1

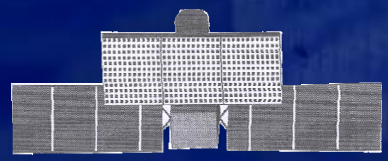
In-orbit replacement for IRS 1C/1D with enhanced capabilities

Launch	: 17th October, 2003
Orbit	: Sun synchronous, 817 km
Payloads	: LISS-4, LISS-3, AWiFS & PAN
Camera Tilt	: ± 26°

SENSOR	BANDS	RESOLUTION (m)	REPETIVITY (Days)	SWATH (km)
LISS-3	G, R, NIR, SWIR	23.5	24	140
LISS-4	G, R, NIR	5.8	5	23
PAN (R)		5.8	5	70
AwiFS	G, R, NIR, SWIR	55	5	700

RISAT - 1

Multimode C-band SAR to provide all weather imaging capability



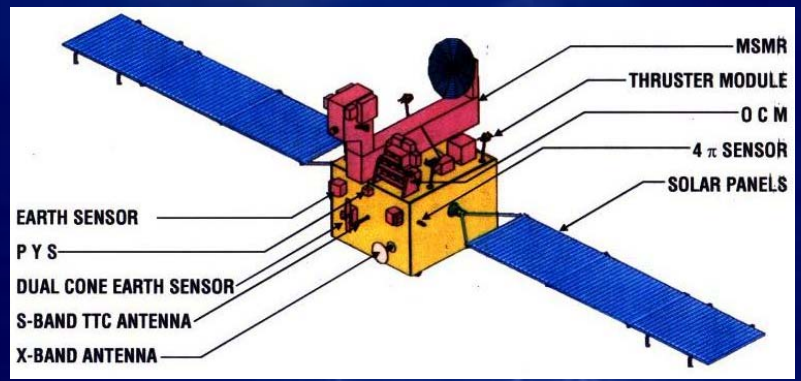
Launch	: 2005
Orbit	: Sun synchronous, 586 km
Payload	: SAR
Spectral Range	: C - band
Resolution	: 3-50 m in different modes
Swath	: 10-240 km in different modes

Indian Remote Sensing – R&D Satellites for Climate / Weather

IRS-P4

Specifications

Altitude	720 Km
Swath	1360 Km
Repetivity	2 days
Orbit inclination	98
Launch	May 26, 1999
Sensors	MSMR & OCM



MSMR

Weight	65 Kg
Frequency	6.6, 10.6, 18 and 21 GHz
Polarization	V & H
Spatial Resolution	40 to 120 Km
Temperature Resolution	1 K

OCM

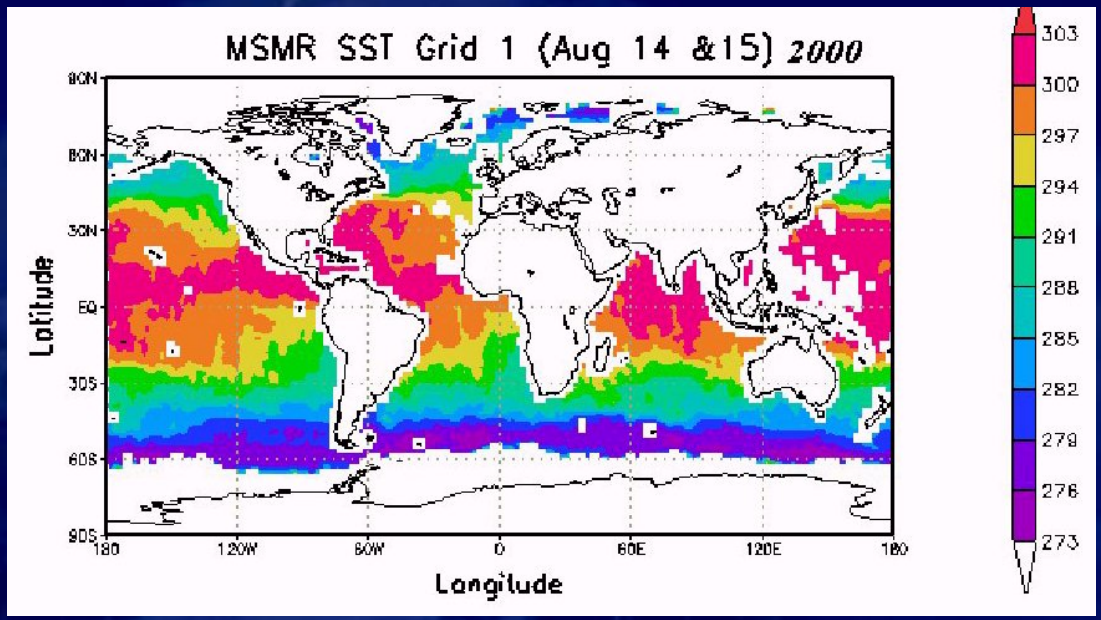
Sensor	OCM - 1
Resolution (km)	0.360
Swath(km)	1420
Repeativity(days)	2
Equatorial crossing (hrs)	12:00
Spectral bands (nm)	412±10 443±10 490±10 510±10 555±10 670±10 765±20 865±20
Radiometric quantisation	12
SNR	~350

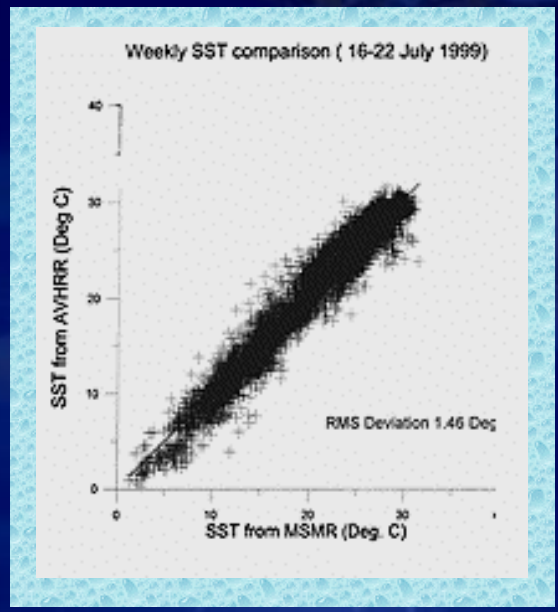
Parameters from MSMR

Parameters	Channels	Accuracy	Resolution	Range	
WV	21 with 18 & 10	0.4 g/cm^2	50 x 36 Km	0.2-7.5 Kg/cm^2	Grid-3
CLW	21 with 18 & 10		50 x 36 Km	0 - 80 mg/cm^2	
SSW	10 with 6,18 & 21	2.0 ms^{-1}	75 x 75 Km	2 - 24 ms^{-1}	Grid-2
SST	6 with 10,18 & 21	1.5 K	150 x 146 Km	273 - 303 K	Grid-1

R & D Parameters: Rainfall
Sea Ice
Soil Moisture

SST from MSMR



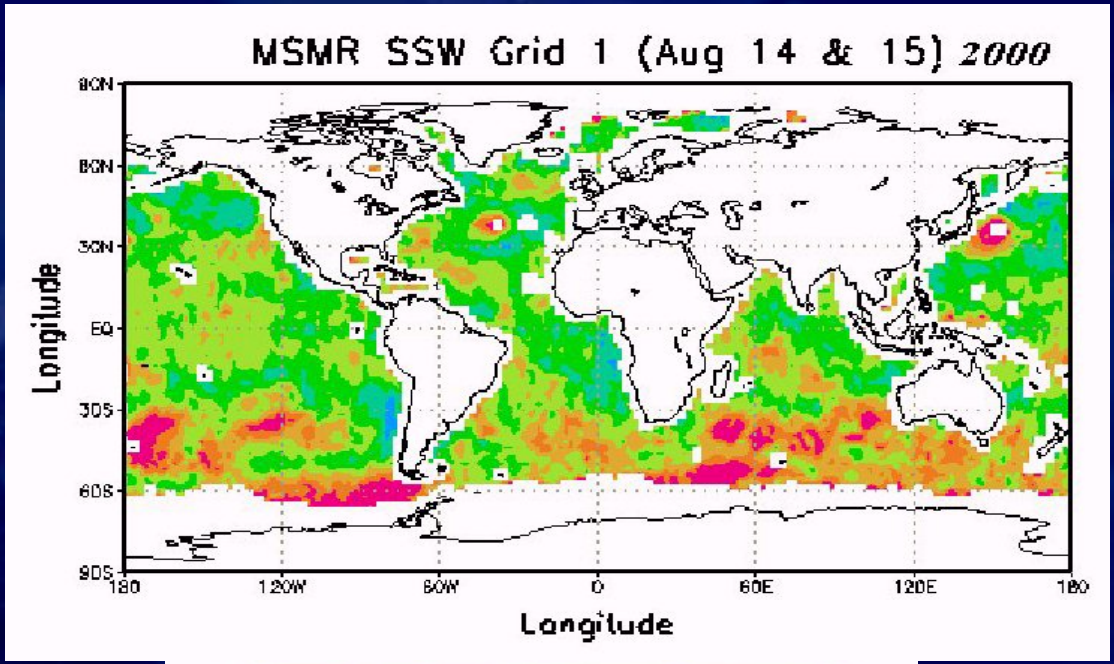


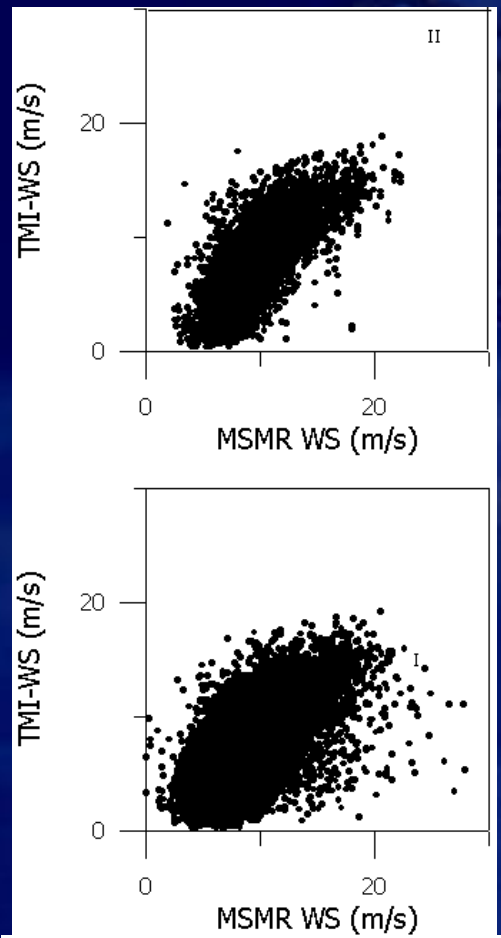
At present MSMR on Oceansat-1 happens to be only spaceborne microwave sensor with 6 GHz channel, and hence with better SST sensing capability compared to microwave sensors.

MSMR provides SST estimations over global oceans even under cloud cover.

A reasonable comparison of MSMR SST is found with AVHRR SST.

MSMR Wind Speed





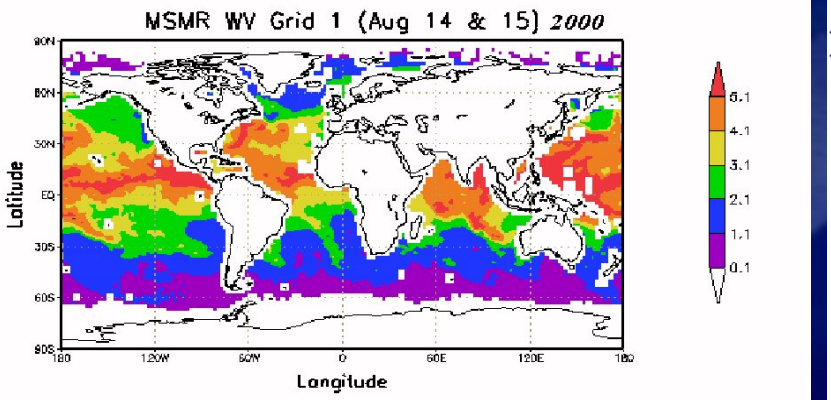
For Temporal Diff. < 1 hour

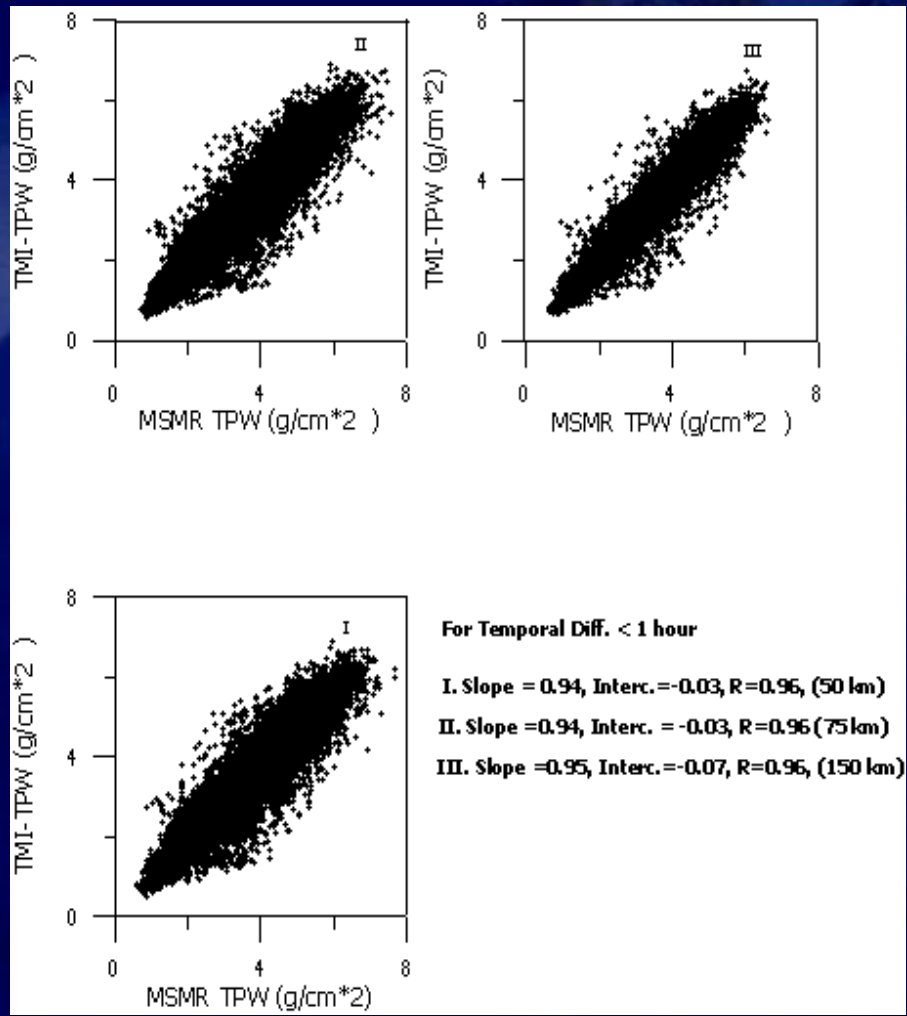
I. Slope = 0.71, Interc.= 0.87 m/s, R=0.66, (75 km)

II. Slope =0.84, Interc. = -0.31 m/s, R=0.73 (150 km)

OCEANSAT-1 MSMR having 6, 10, 18 and 21 GHz frequencies (V & H Pol.), provides global ocean surface wind speed with 2 days repitivity. These products are feeding into ocean state and atmospheric models.

Humidity over Oceans



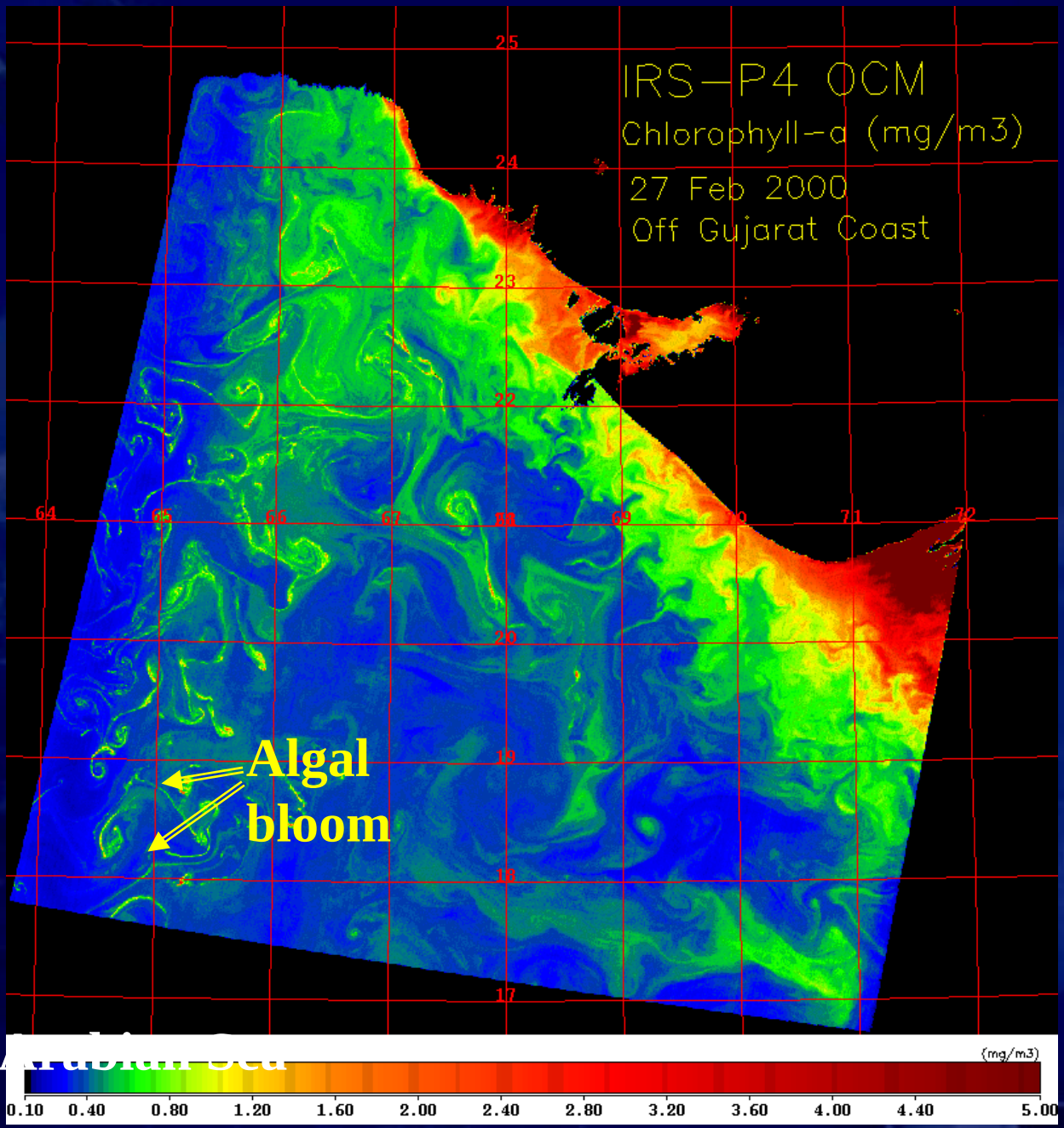


MSMR like other microwave sensors is capable of total integrated precipitable water (water vapour) measurements in the marine atmosphere.

A reasonably good comparison is found with TMI / SSM/I derived WV.

Ocean Colour Monitor

Sensor	OCM - 1	OCM - 2
Resolution (km)	0.360	0.360
Swath(km)	1420	1420
Repeativity(days)	2	2
Equatorial crossing (hrs)	12:00	12:00
Spectral bands (nm)	412±10 443±10 490±10 510±10 555±10 670±10 765±20 865±20	412±10 443±10 490±10 510±10 555±10 620±10 745±20 865±20
Radiometric quantisation	12	---
SNR	~350	---



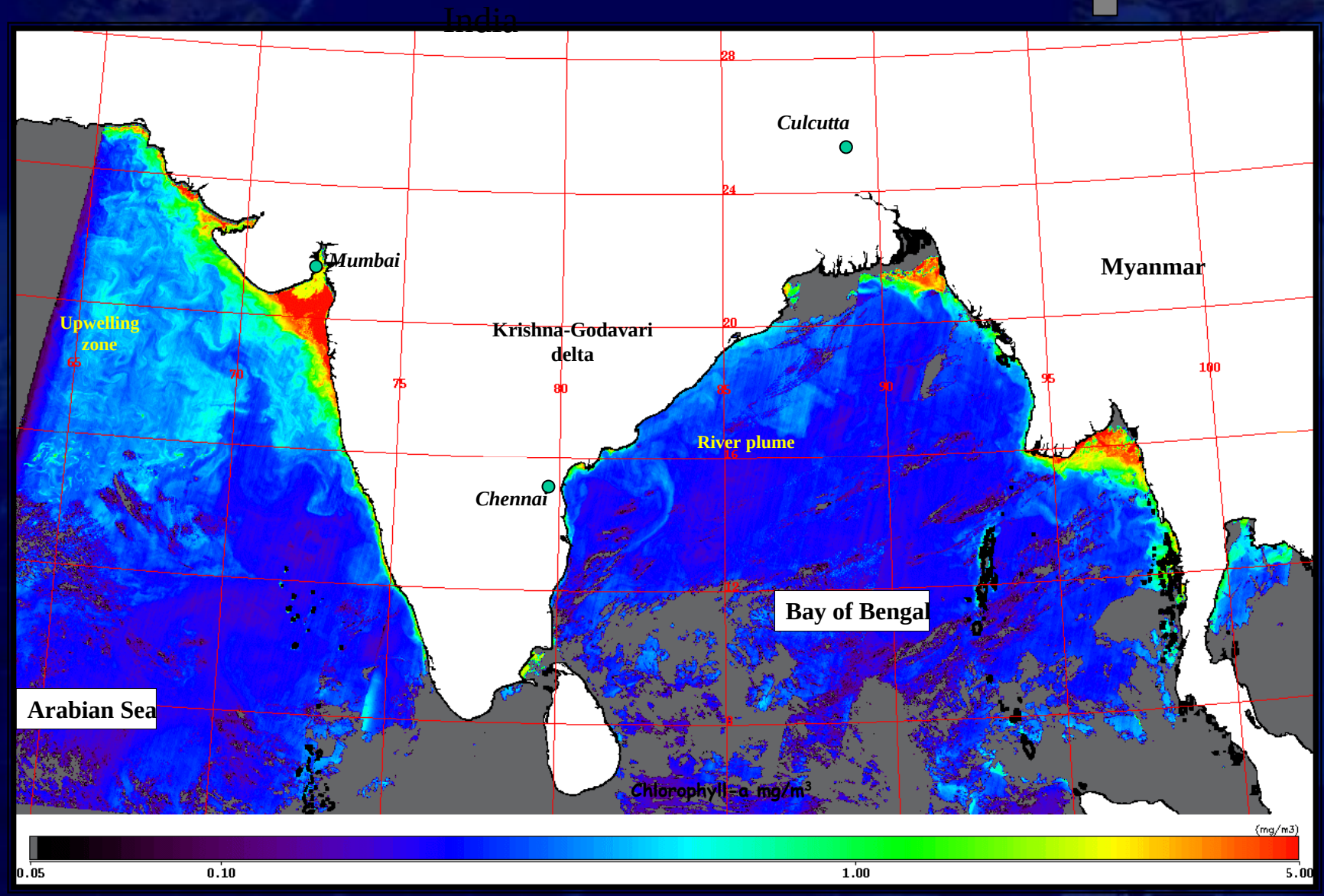
IRS-P4 OCM

Chlorophyll-a
(mg/m^3)

Off Gujarat coast, India (27 Feb, 2000)

Image shows distribution of algal bloom in open ocean waters of Arabian sea. High pigment patches are present in bottom-left corner of image.

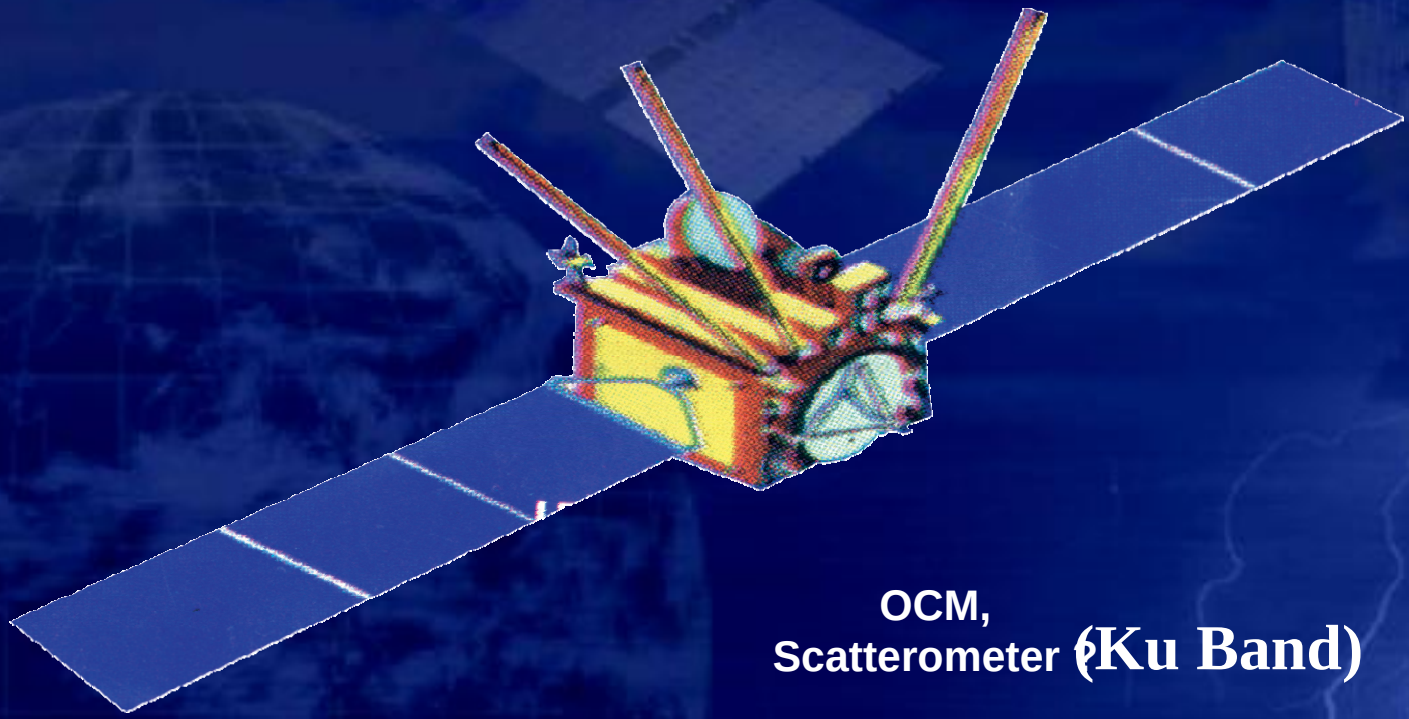
Chlorophyll-a distribution in Arabian Sea and Bay of Bengal using IRS-P4 OCM data 29 & 30 January 2000



FUTURE INDIAN METEOROLOGICAL SATELLITES

- OCEANSAT-2 (2008)
- INSAT-3D (2008)
- MeghaTropiques (2008)

OCEANSAT–2



OCM,
Scatterometer (Ku Band)

Vector Winds
Aerosol

INSAT - 3D

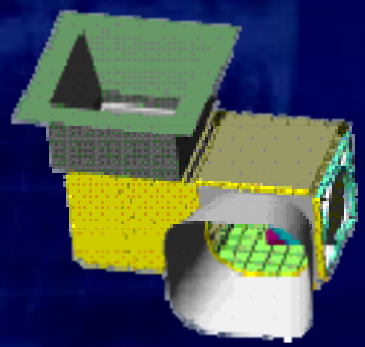
Improved Understanding of Mesoscale Systems

6 Channel IMAGER

- Spectral Bands (μm)

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 (μm)

Short Wave Infra Red	: Six bands
Mid Wave Infra Red	: Five Bands
Long Wave Infra Red	: Seven Bands
Visible	: One Band

- Resolution (km) : 10 X 10 for all bands
- No of simultaneous sounding per band : Four

NINETEEN CHANNEL ATMOSPHERIC SOUNDER

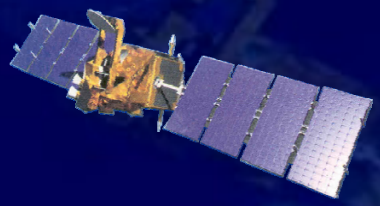
A-19 channels atmospheric sounder for derivation of vertical temperature and moisture profiles with a resolution of 10 km at Sub-Satellite and capability of full disk coverage every half-hour is proposed on board INSAT 3D.

Channel No.	Central Wavelength in um	Principal absorbing constituents
1	14.71	CO-2 band
2	14.37	CO-2 band
3	14.06	CO-2 band
4	13.96	CO-2 band
5	13.37	CO-2 band
6	12.66	water vapor
7	12.02	water vapor
8	11.03	window
9	9.71	ozone
10	7.43	water vapor
11	7.02	water vapor
12	6.51	water vapor
13	4.57	N-2 0
14	4.52	N-2 0
15	4.45	CO-2
16	4.13	CO-2
17	3.98	window
18	3.74	window
19	0.69	vis

SIX CHANNELS IMAGER ON INSAT 3D

Channel No.	Wavelength Band	Resolution (Km)
1	0.55 - 0.75 um	1
2	1.55 - 1.70 um	1
3	3.7 - 3.95 um	4
4	6.5 - 7.1 um	8
5	10.3 - 11.3 um	4
6	11.3 - 12.50 um	4

Megha Tropiques

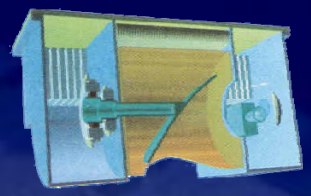


For studying water cycle and energy exchanges in the tropical belt

Low inclination (20º) for frequent simultaneous observations of tropics

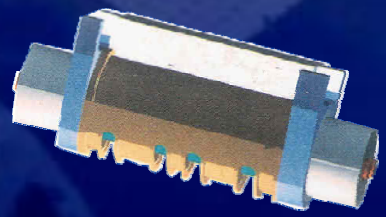
- Water vapour
- Clouds
- Cloud condensed water
- Precipitation
- evaporation

SAPHIR



- Water vapour profile
- Six atmospheric layers upto 12 km height
- 10 km Horizontal Resolution

SCARAB



- 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

AND ……???

Contributing to Global Precipitation Mission (GPM)

Mission Objective

- Understanding the water cycle and energy exchanges that characterize the Tropical Convective System (TCS)
- Improving models for weather prediction particularly of cyclones, floods etc.

Our Objective

- Retrieval and Validation of rainfall over ocean and land and their Assimilation in Atmospheric & Oceanic Models.
- Understanding the Interannual variation of rainfall in relation to the Intraseasonal oscillation (ISO)


Thanks

International TOVS Study Conference, 16th, ITSC-16, Angra dos Reis, Brazil, 7-13 May 2008. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2008.