

INSAT Satellite : Current status and Future Prospects

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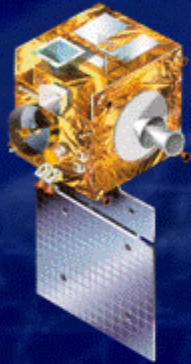
INDIA

Indian Space Programme for Climate 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

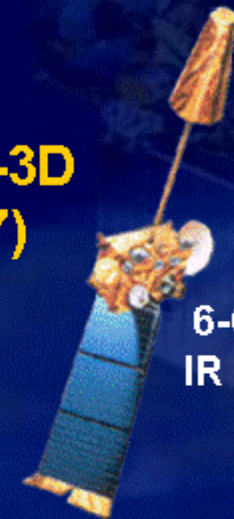
**INSAT-2E/3A
(1999/2003)**



VHRR, CCD

CMV, OLR, Rainfall
Aerosol

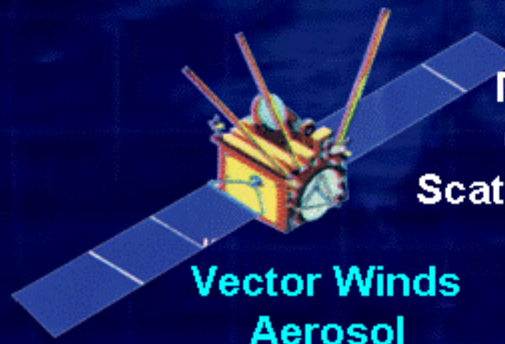
**INSAT-3D
(2007)**



6-Ch VHRR
IR Sounder

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

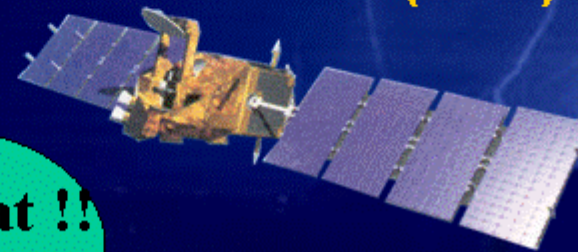
**OCEANSAT-1/2
(1999/2007)**



MSMR,
OCM,
Scatterometer

Vector Winds
Aerosol

**MEGHA-TROPIQUES
(2008)**



MW Imager,
WV Sounder,
ScaRaB

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

**Climatsat !!
(2010)**

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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 0.55-0.75 μm IR 10.5 - 12.5 μm	<ul style="list-style-type: none">▪ 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 - 12.5 μm	<ul style="list-style-type: none"> ▪ 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 : 83°E

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 : 93.5°E
Kalpana-1 : 74°E

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

- **VHRR Bands (μm)**

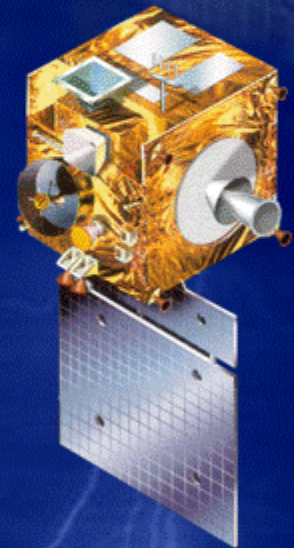
- Visible : 0.55 – 0.75
- Water vapour : 5.70 – 7.10
- Thermal Infra Red : 10.5 – 12.5

- **Resolution (km)** : 2 X 2 for Visible
8 X 8 for WV & TIR

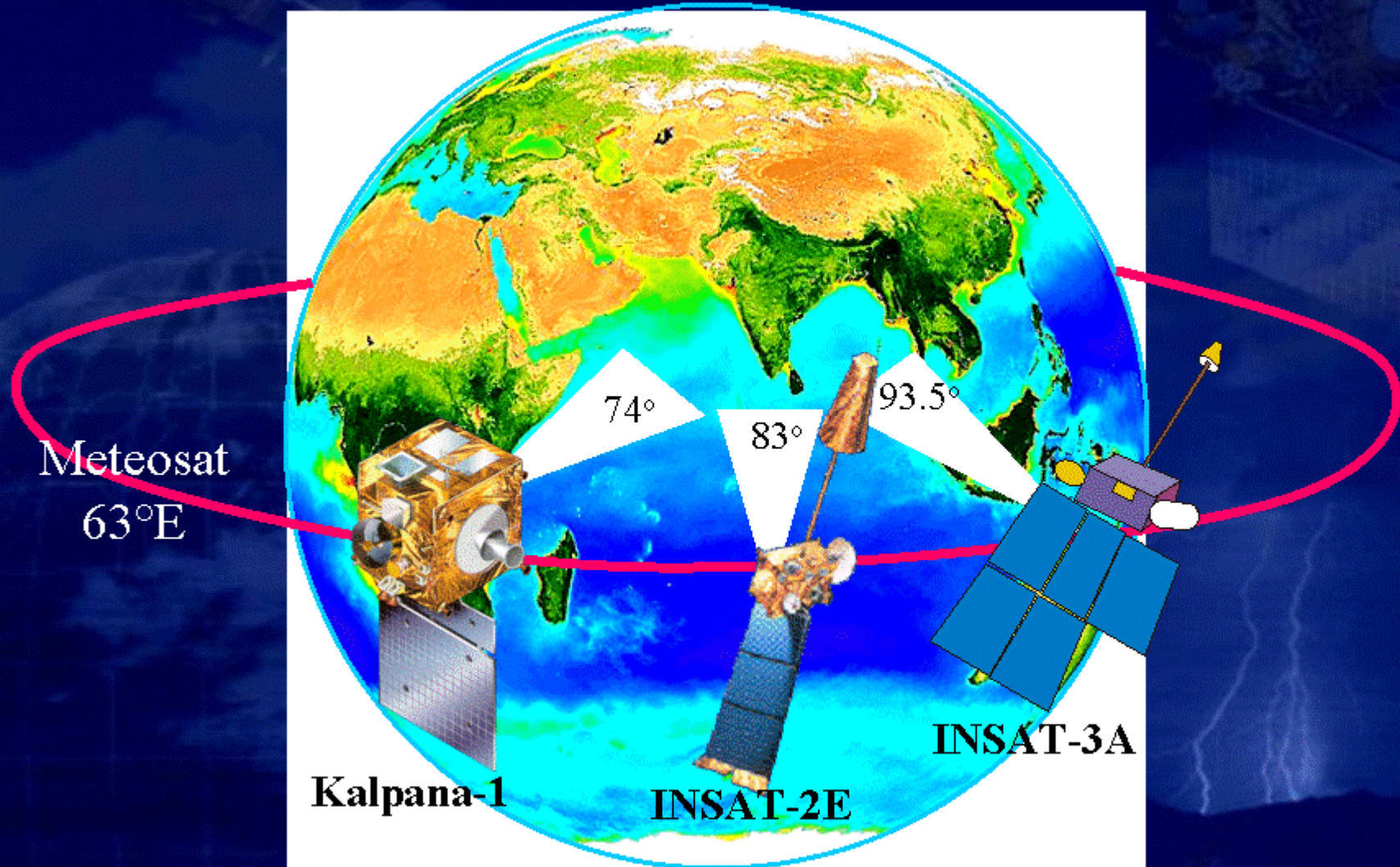
- **CCD Camera Bands (μm)**

- 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

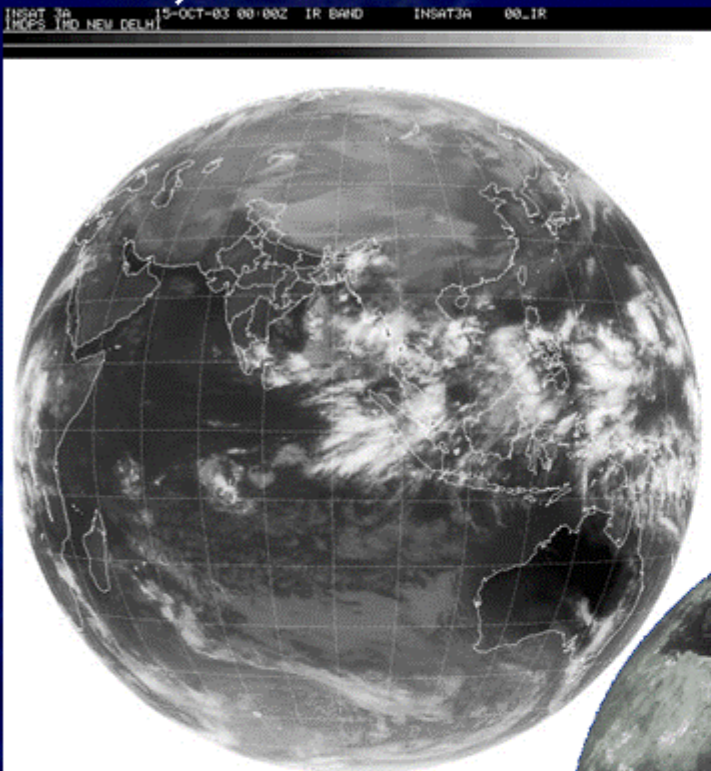


Current Geostationary Meteorological Satellites the South and South West Asian Region

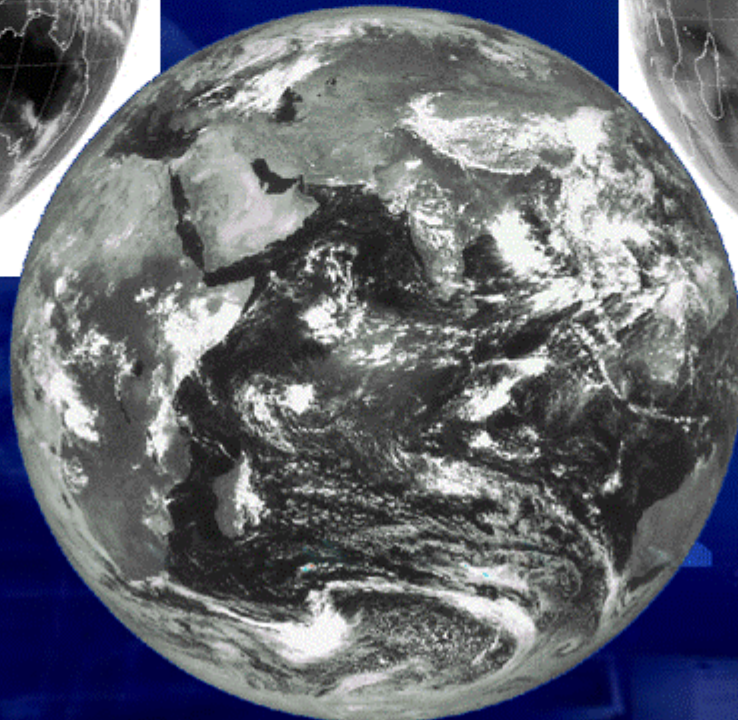
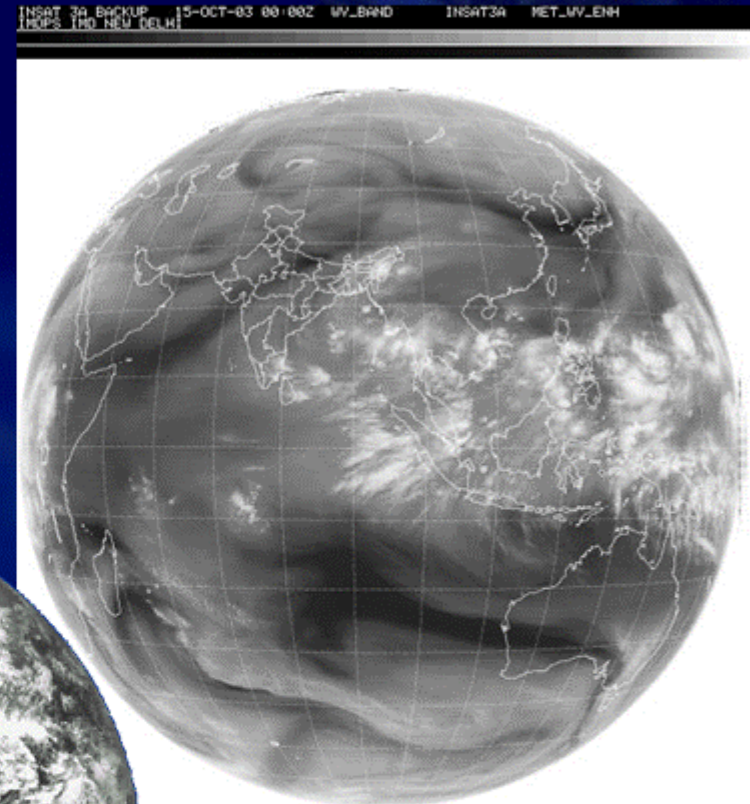


INSAT-3A

IR, 15 Oct 2005



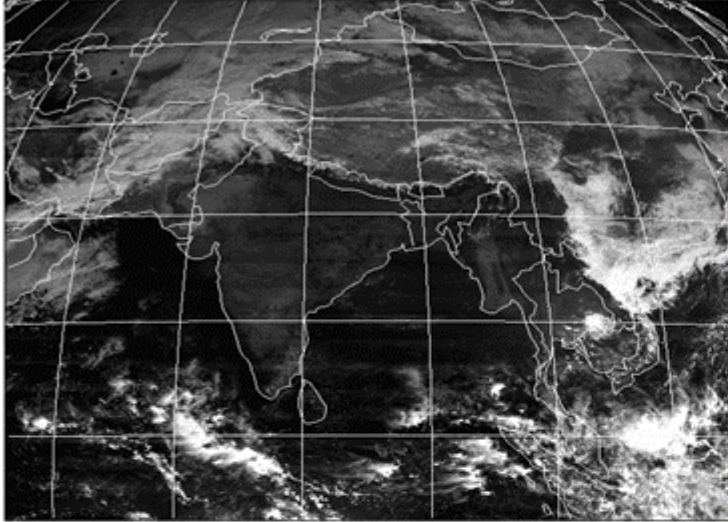
WV, 15 Oct 2005



Kalpana-1 Vis 19 Sep 2005

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

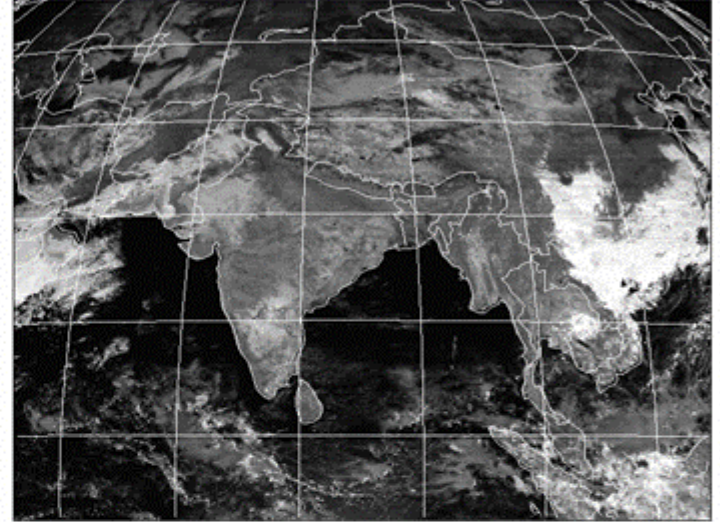
INSAT-2E VIS (0.65um) 18-1-2000 11:30



Deep Convective Clouds

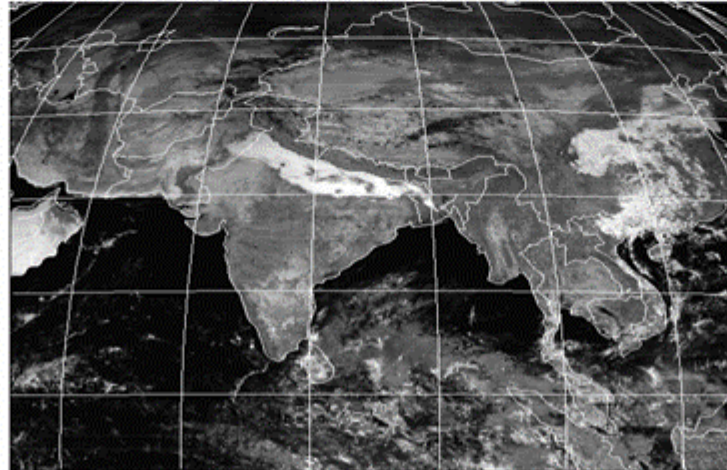


INSAT-2E SWIR (1.62um) 18-1-2000 11:30



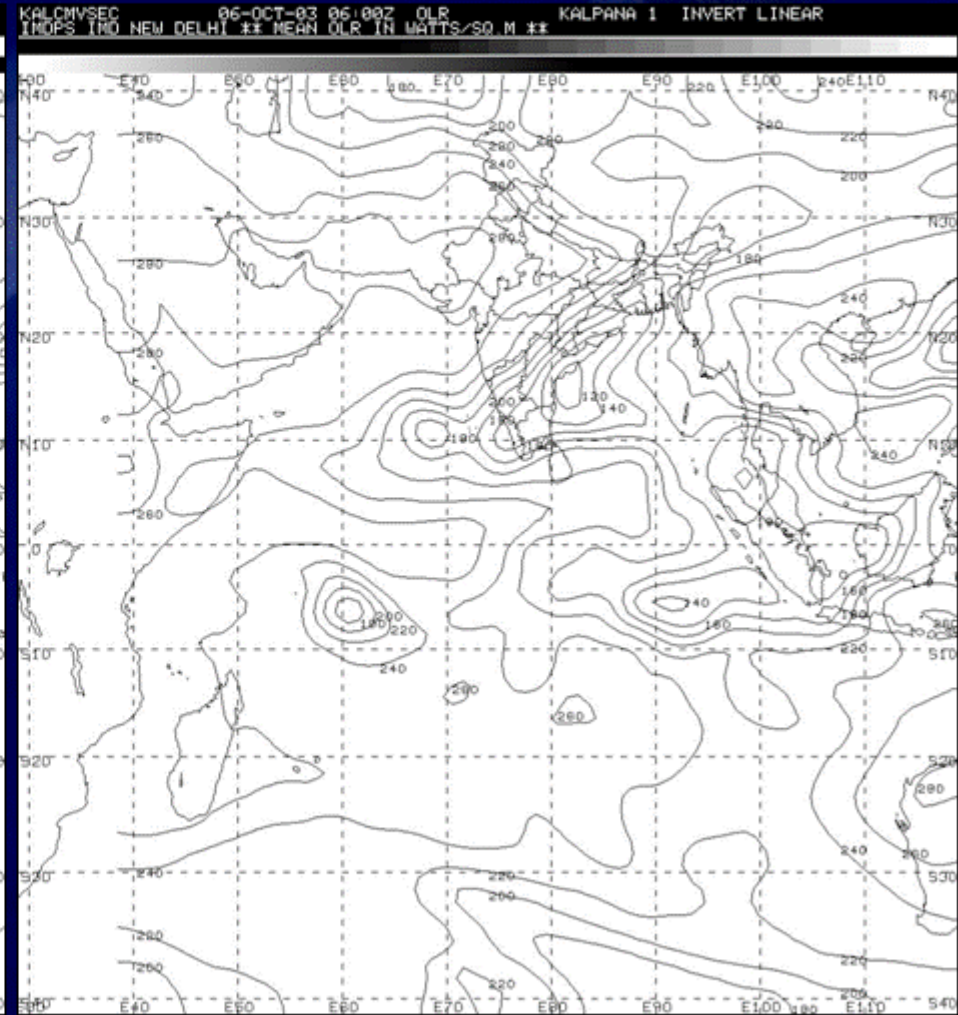
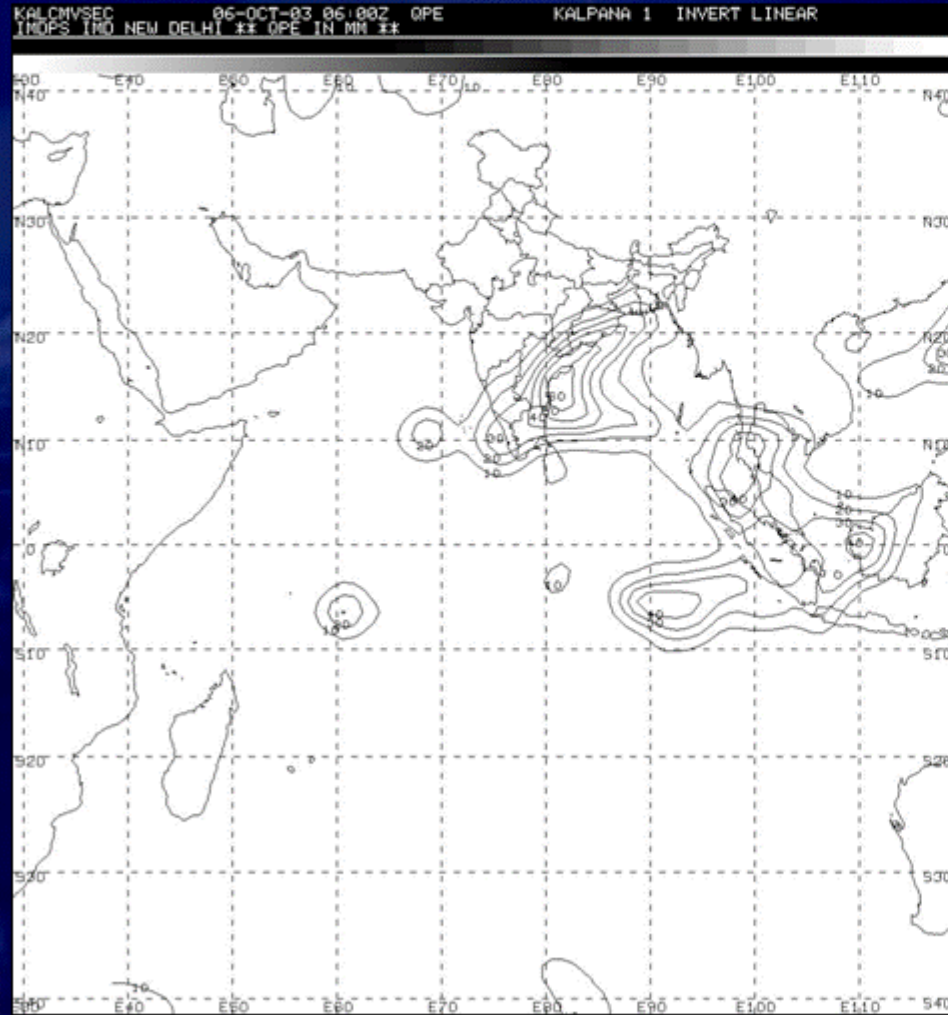
FOG →

INSAT-2E SWIR (1.62 um) 4-1-2000 11:30

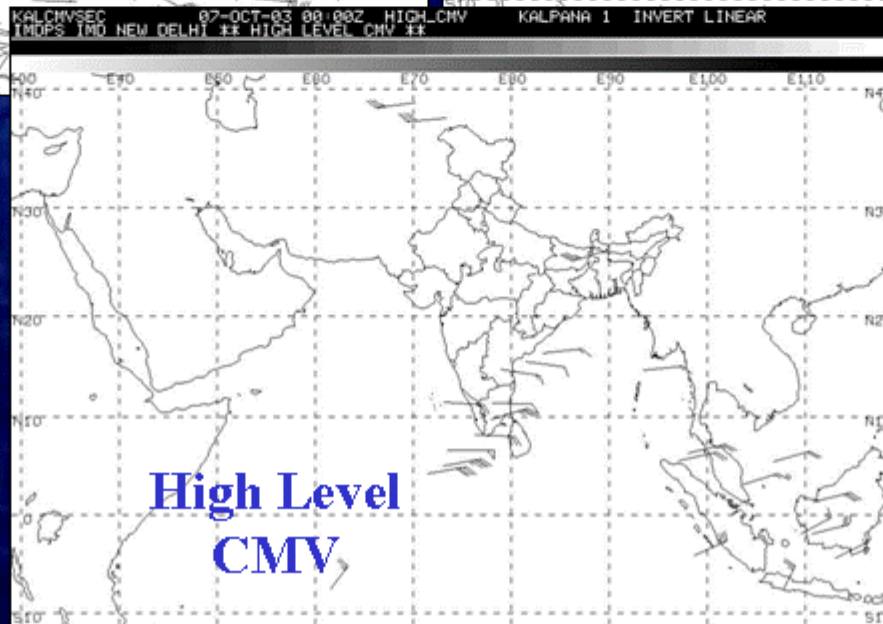
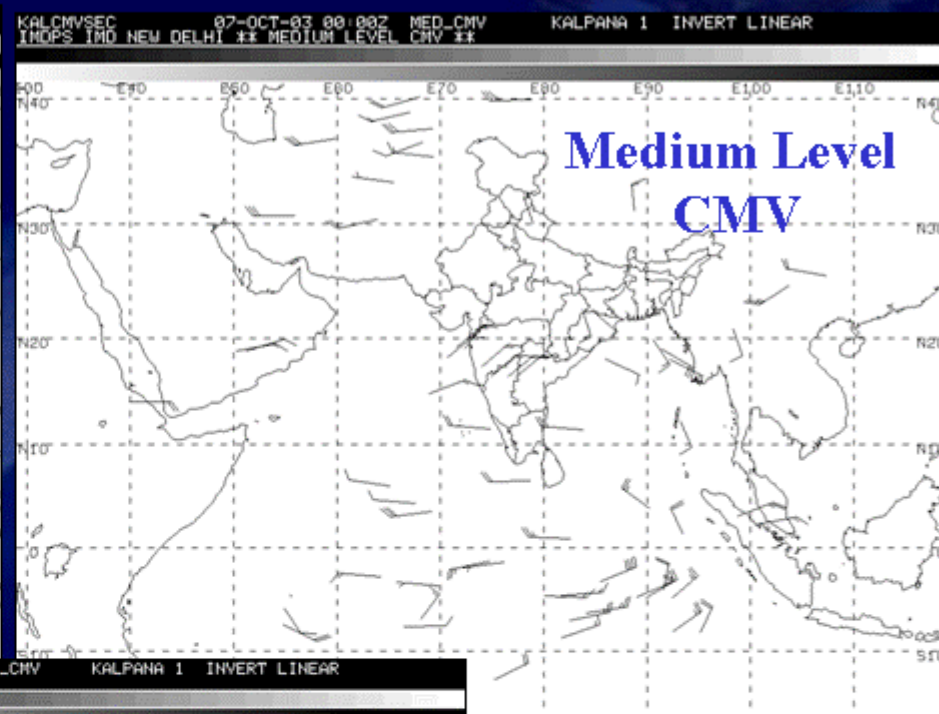
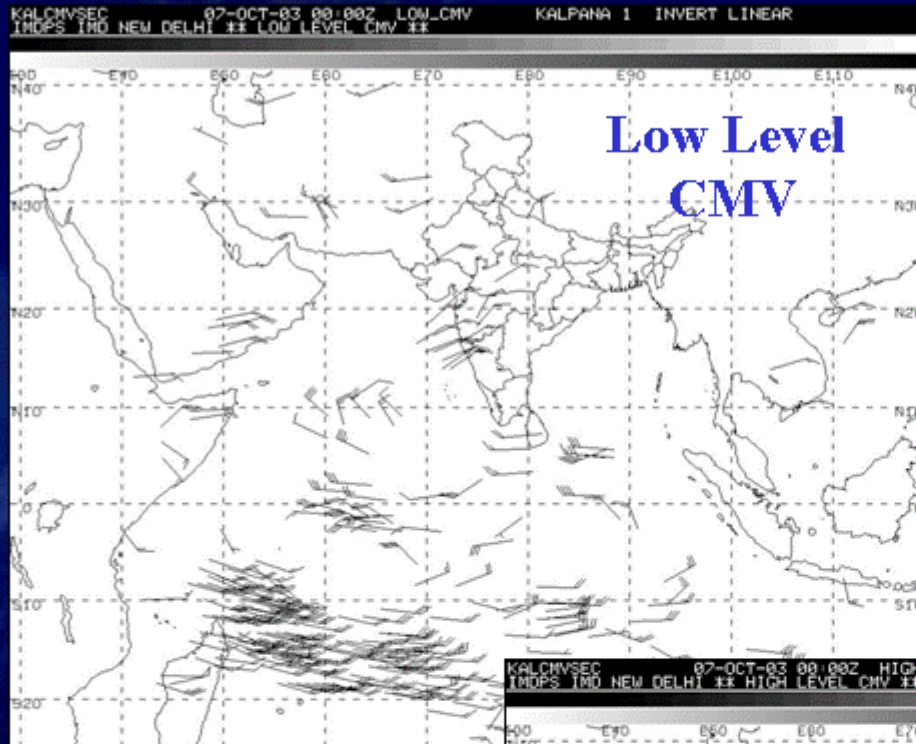


QPE in mm 06-Oct-05 06:00Z
Kalpana-1 (IMD, N Delhi)

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)



The background is a dark blue collage. In the top left, there's a satellite in orbit. In the top right, a satellite component is shown. In the bottom right, a control room with several computer monitors is visible. In the bottom center, a lightning bolt strikes a dark landscape. On the left side, there's a faint grid pattern over a satellite image of Earth.

Indian Remote Sensing Satellites (IRS)

IRS Sensors

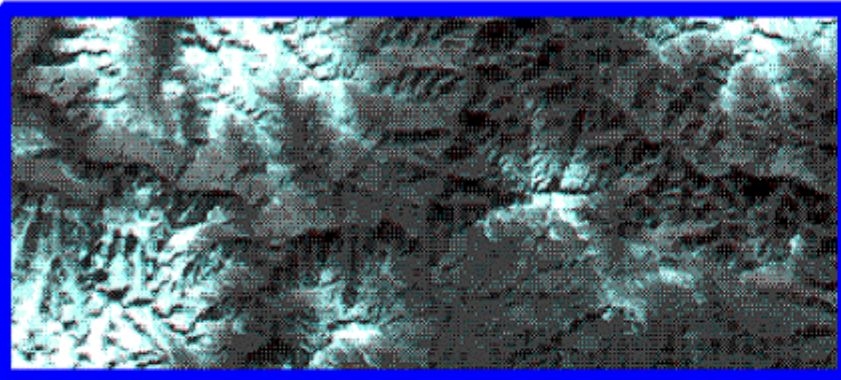
Satellite	Launch Date	Sensors	Channels	Resolution	Swath / Repetivity
IRS-1A	17.03.1988	LISS-1	0.45-0.52µm 0.52-0.59µm 0.62-0.68µm 0.77-0.86µm	72.5 m	148 km / 22 days
		LISS-2	0.45-0.52µm 0.52-0.59µm 0.62-0.68µm 0.77-0.86µm	36.25 m - - -	147 km / 22 days - - -
IRS-1B	29.08.1991	Same as IRS-1A			
IRS-1C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

IRS Applications

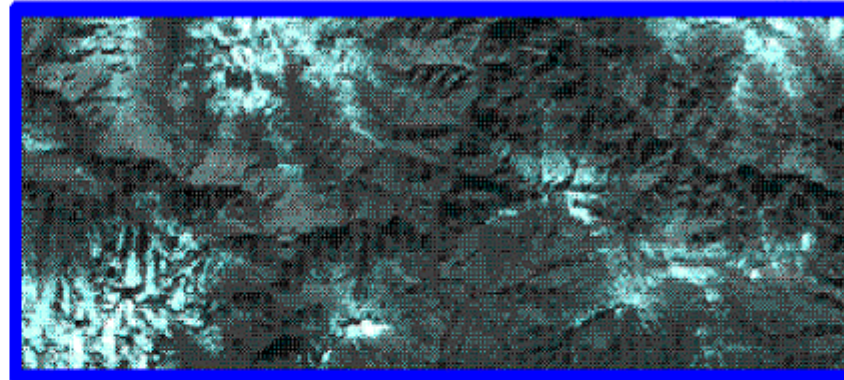
IRS data is being used for a diverse range of applications such as:

- 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

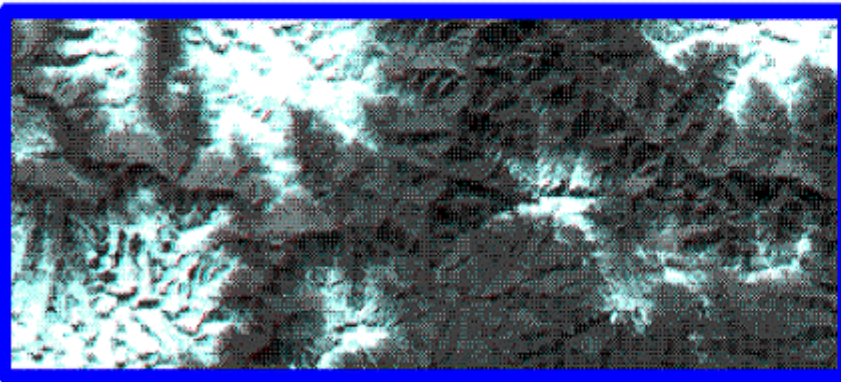
MONITORING OF SEASONAL SNOW IN WESTERN HIMALAYAS



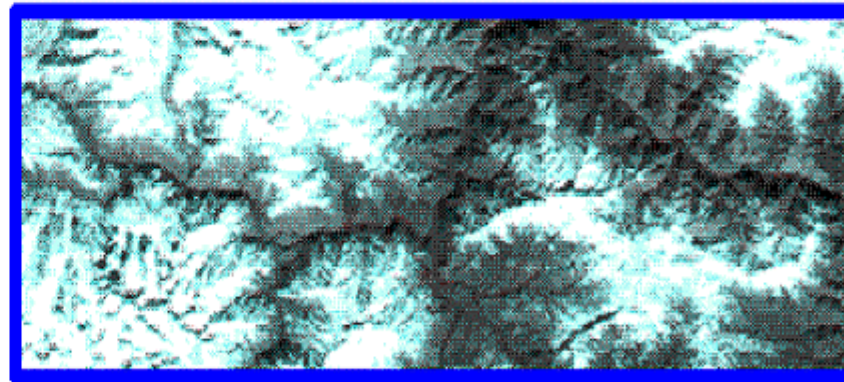
IRS-1C of Nov. 26, 1996



IRS-1D of Nov. 09, 1998



IRS-1C of Nov. 11, 1997

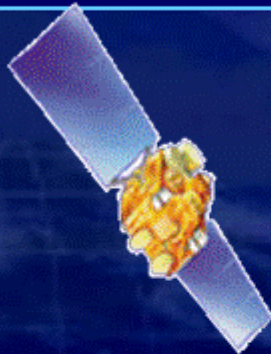


IRS-1C of Nov. 09, 1999

SEASONAL SNOW COVER LESS IN EARLY WINTER OF 1996-99

RESOURCESAT - 1

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

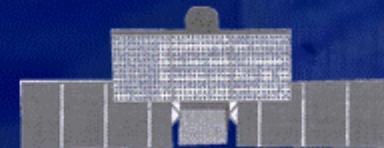


Launch : 17th October, 2003
Orbit : Sun synchronous, 817 km
Payloads : LISS-4, LISS-3, AWiFS & PAN
Camera Tilt : $\pm 26^\circ$

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

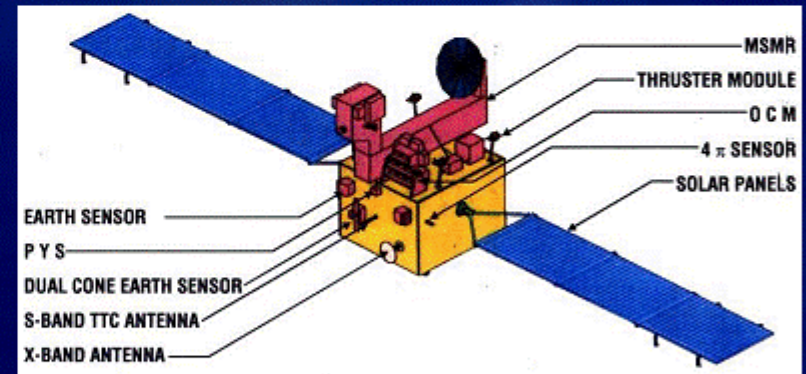


Indian Remote Sensing – R&D Satellites for Climate / Weather

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
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
SST	6 with 10,18 & 21	1.5 K	150 x 146 Km	273 - 303 K

Grid-3

Grid-2

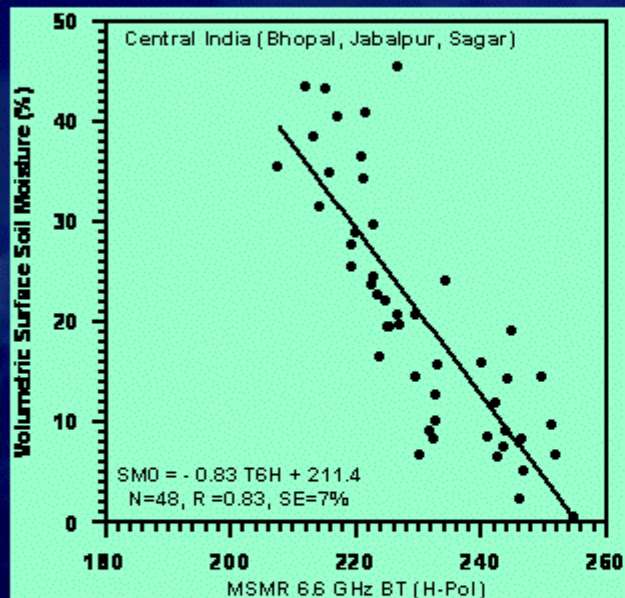
Grid-1

R & D Parameters: Rainfall

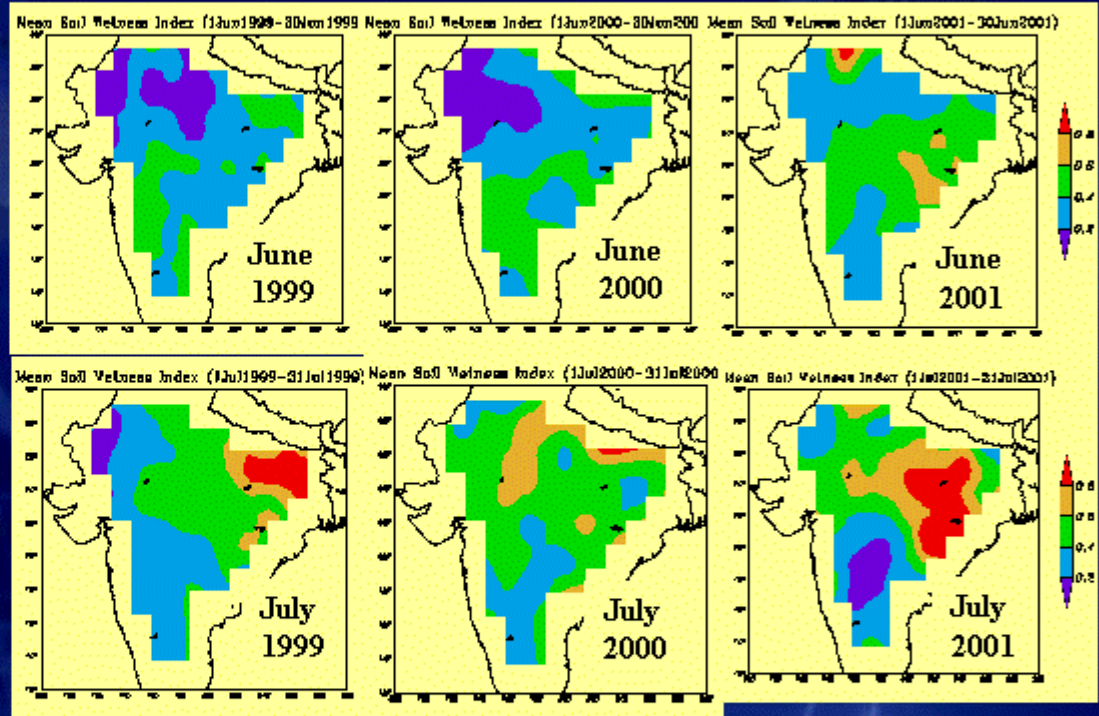
Sea Ice

Soil Moisture

Large Area Soil Moisture using IRS-P4 MSMR Brightness Temperature



**Regression Equation of Observed Soil
Moisture with the MSMT 6.6 GHz BT**



**Monthly Soil Wetness Index Computed from MSMT 6.6 GHz
BT data for June and July 1999, 2000, 2001**

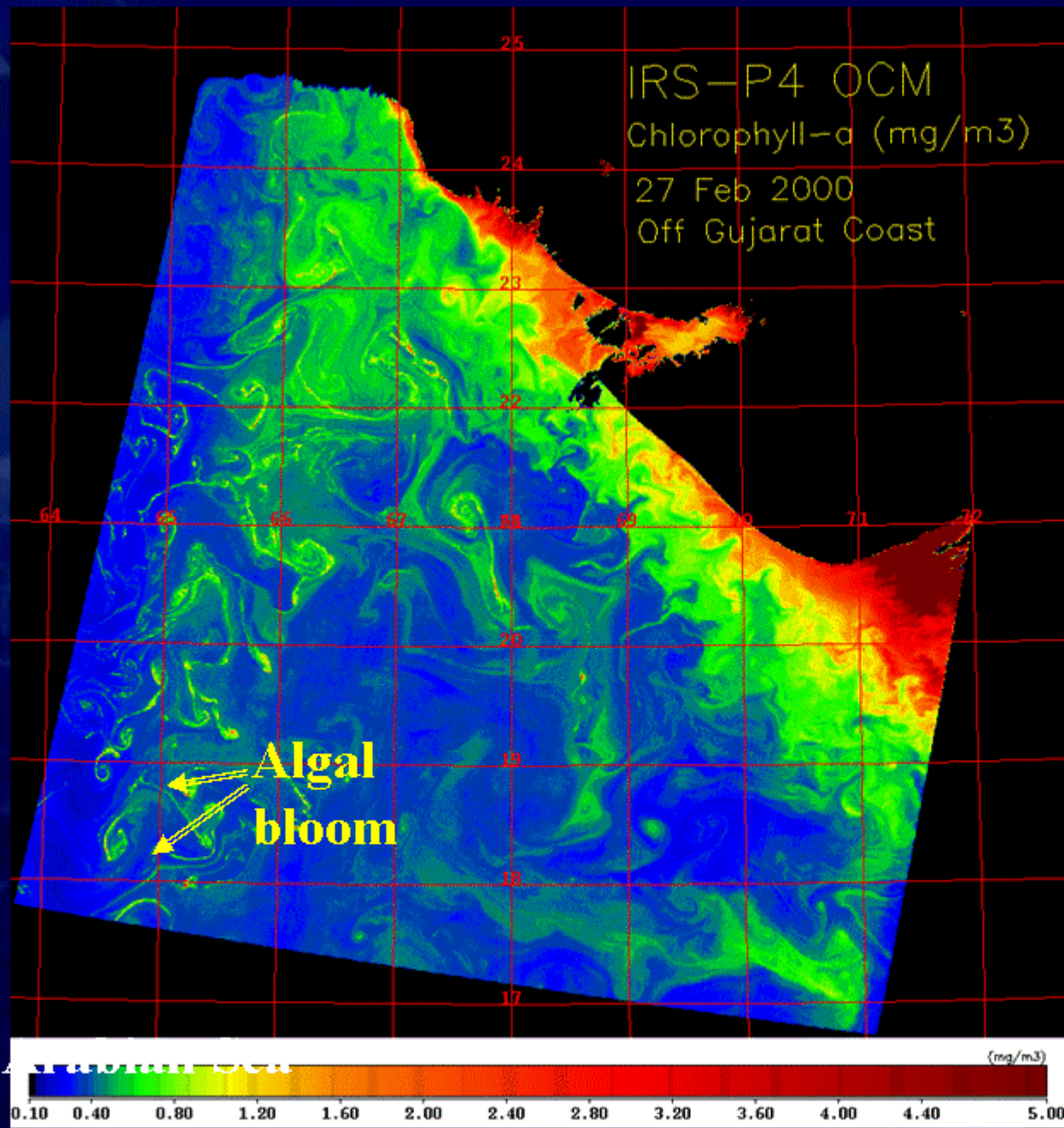
$$SWI = \frac{T_{b,max} - T_b}{T_{b,max} - T_{b,min}}$$

$SWI = 0 \rightarrow$ Dry Soil

$SWI = 1 \rightarrow$ Saturated Soil

Ocean Colour Monitor

<i>Sensor</i>	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	---



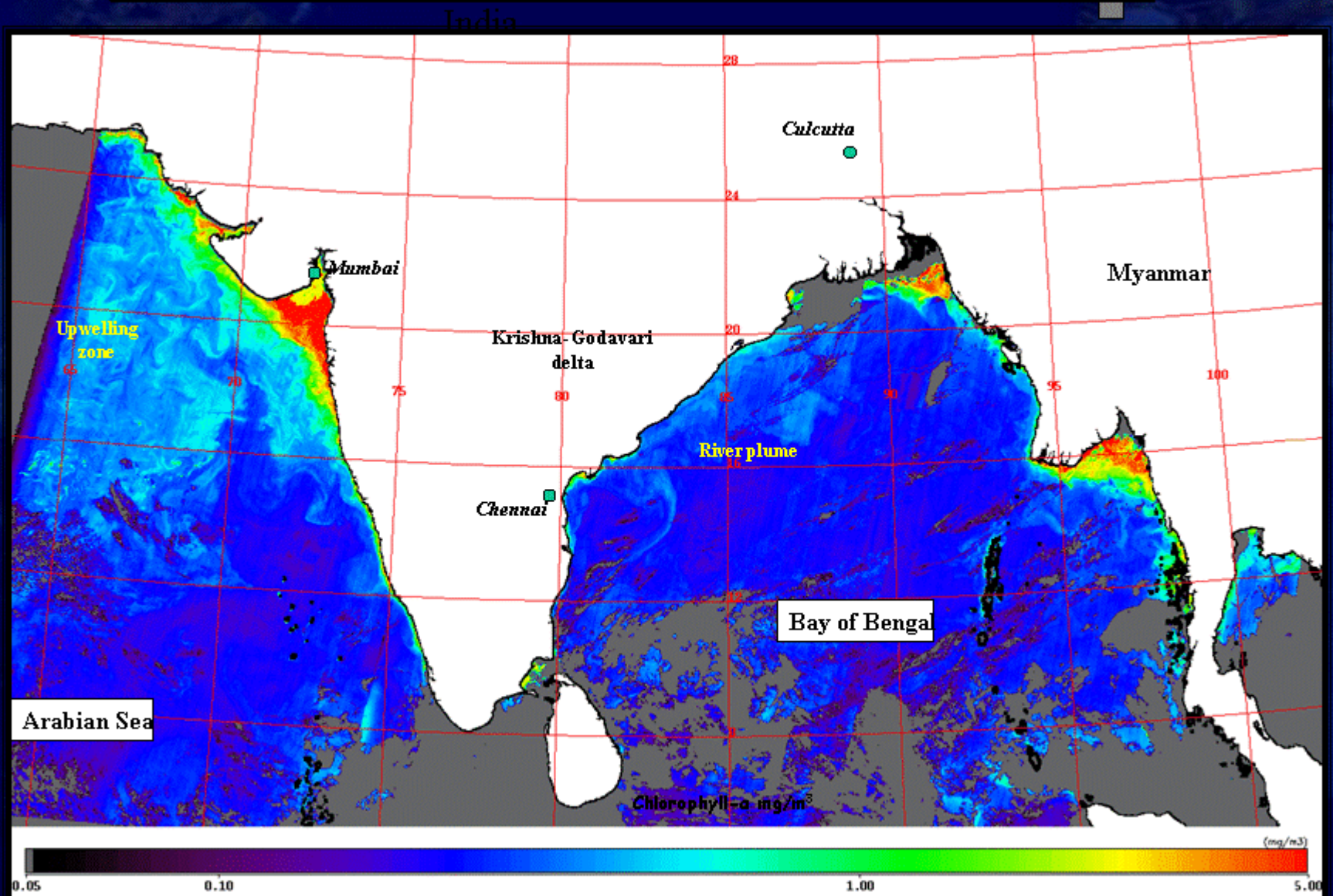
IRS-P4 OCM

Chlorophyll-a
(mg/m³)

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



**Other satellite missions
for S&SW ASIA Region**

NOAA

ADEOS(2)

TRMM

ERS

DMSP

**Aqua / Terra
(MODIS)**

TOPEX

QUICKSCAT

JASON

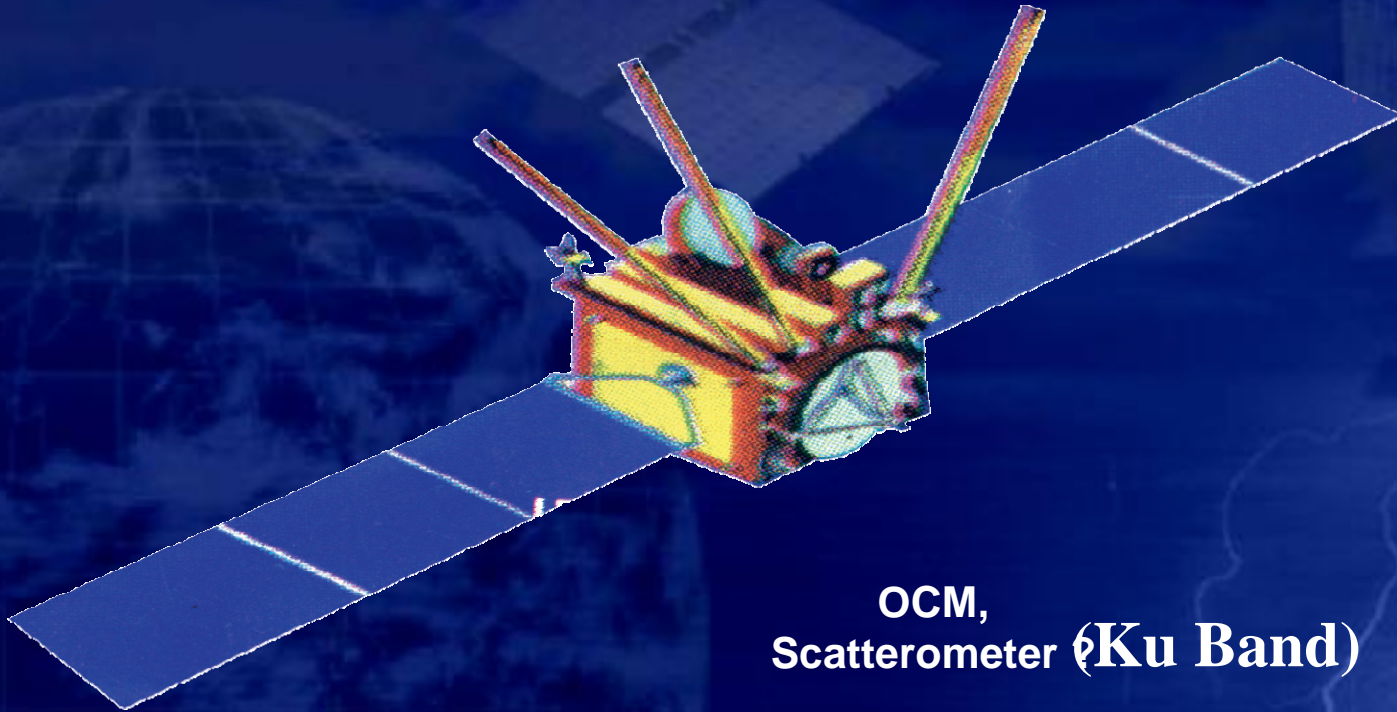
Meteosat

ENVISAT

FUTURE INDIAN METEOROLOGICAL SATELLITES

- OCEANSAT-2 (2007)
- INSAT-3D (2007)
- MeghaTropiques (2008?)
- Climatsat (?)

OCEANSAT-2



OCM,
Scatterometer (Ku Band)

Vector Winds
Aerosol

INSAT - 3D

Improved Understanding of Mesoscale Systems

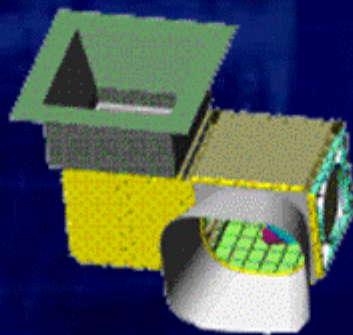


6 Channel IMAGER

- 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

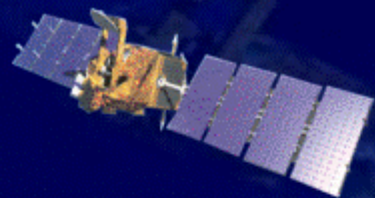
A-19 channels atmospheric sounder for derivation of vertical temperature and moisture profiles with a resolution of 10 km at Sub-Satellite and capability of full disk coverage every half-hour is proposed on board INSAT 3D.

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

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 O
14	4.52	N-2 O
15	4.45	CO-2
16	4.13	CO-2
17	3.98	window
18	3.74	window
19	0.69	vis

Megha Tropiques

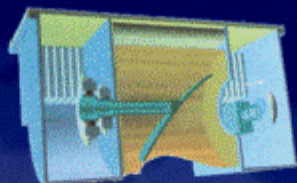


**For studying water cycle
and energy exchanges in
the tropical belt**

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

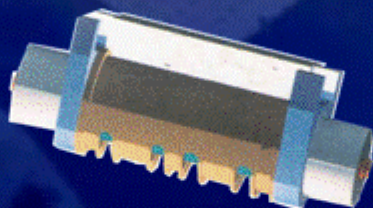
- Water vapour
- Clouds
- Cloud condensed
water
- Precipitation
- evaporation

SAPHIR



- 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)**

The background is a dark blue collage. In the top left, a satellite with solar panels is visible. In the top right, a satellite component is shown. On the left, a globe with a grid overlay is partially visible. In the bottom right, a control room with several computer monitors is shown. A bright lightning bolt strikes a dark landscape in the lower right quadrant.

Thanks

International TOVS Study Conference, 15th, ITSC-15, Maratea, Italy, 4-10 October 2006
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,
Cooperative Institute for Meteorological Satellite Studies, 2006.