Latest status and developments at IMD since CGMS-45

CGMS-46, Plenary session, agenda item IMD-ISRO-WP-01
Presenter: S K Peshin

Overview - Planning of Indian satellite systems

- **INSAT-1**
  - 10 April 1982

- **INSAT-1A**
  - 1983

- **INSAT-1B**
  - 1989

- **INSAT-1C**
  - 21 July 1989

- **INSAT-2**
  - 1990

- **INSAT-2A**
  - 10 July 1992

- **INSAT-2B**
  - 23 July 1993

- **INSAT-3A**
  - 10 April 2003

- **INSAT-3B**
  - 26 July 2013

- **INSAT-3DR**
  - 8th Sept. 2016

- **Kalpana-1**
  - 12 Sept 2002

- **OceanSat-1**
  - 26 May 1999

- **OceanSat-2**
  - 23 Sept. 2009

- **Megha-Tropiques**
  - 12 Oct. 2011

- **SARAL**
  - 25 Feb 2013

- **INSAT-3D-3DB**
  - 26 Sept. 2016

- **SCATSAT-1**

- **Upcoming Satellites**
  - GISAT
  - INSAT-3DS
  - OceanSat-III

- **INSAAT-3D-3DB**
  - 6 Imagers
  - 1km Vis, 4km IR & 6km WV
  - 15 min temporal resolution with staggered mode

- **Kalpna (VHRR)**
  - First Indian Dedicated Meteorological Satellite
  - VHRR: 2.0 km Vis, 8 km IR & WV

- **OCEANSAT-1**
  - VHRR: 2.75 km Vis, 11 km IR
### Overview - Planning of Indian satellite systems

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<td>INSAT-1A (1982)</td>
<td>VHRR (VIS,TIR)</td>
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<td>INSAT-1B (1983)</td>
<td>VHRR (VIS,TIR)</td>
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<td>INSAT-1C (1988)</td>
<td>VHRR (VIS,TIR)</td>
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<td>INSAT-1D (1990)</td>
<td>VHRR (VIS,TIR)</td>
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<td>INSAT-2B (1993)</td>
<td>VHRR (VIS,TIR)</td>
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<td>INSAT-2E (1999)</td>
<td>VHRR (VIS,WV,TIR), CCD (VIS,NIR,SWIR)</td>
<td>OLR, AMV, UTH, Rain, Cloud Image</td>
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<tr>
<td>Kalpana-1 (2002)</td>
<td>VHRR (VIS,WV,TIR)</td>
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<td>INSAT-3A (2003)</td>
<td>VHRR (VIS,WV,TIR), CCD (VIS,NIR,SWIR)</td>
<td>OLR, AMV, UTH, Rain, Cloud Image</td>
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<tr>
<td>INSAT-3D (2013)</td>
<td>Imager (VIS, SWIR, MIR, WV, TIR1, TIR2), Sounder (18 IR + VIS)</td>
<td>OLR, AMV, UTH, Rain, Cloud Image, Temperature, humidity profiles, Ozone</td>
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<td></td>
<td></td>
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<tr>
<td>INSAT-3DR (2016)</td>
<td>Similar to INSAT-3D</td>
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<tr>
<td>INSAT-3DS (2022)</td>
<td>Similar to INSAT-3D</td>
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</table>
Current Indian Geostationary Meteorological Satellites

INSAT-3DR: 8th September 2016

INSAT-3D: 2013
Current Indian Geo stationary Meteorological satellites

At present the following three INSAT satellites are in operation

**INSAT-3D** is a India's advanced weather satellite and was launched in the early hours of July 26, 2013 from Kourou, French Guiana, and has successfully been placed in Geosynchronous orbit. It is a dedicated meteorological satellite and carries four payloads: Imager (Six Channels), Sounder (Nineteen Channels), Data Relay Transponder (DRT) & Satellite Aided Search and Rescue (SAS & R).

**INSAT-3DR** is a India's advanced dedicated meteorological satellite and was launched on 8th September, 2016 which carries four payloads: Imager (Six Channels), Sounder (Nineteen Channels), Data Relay Transponder (DRT) & Satellite Aided Search and Rescue (SAS & R).

INSAT-3DR is being used in staggered mode with INSAT-3D in order to get effective temporal resolution of 15 minutes.
Operational scenario of INSAT-3D/3DR

<table>
<thead>
<tr>
<th>INSAT Series</th>
<th>Temporal Resolution</th>
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<tbody>
<tr>
<td>3D -Imager (6 Channel)</td>
<td>½ hourly (xx00 &amp; xx30 UTC)</td>
</tr>
<tr>
<td>3D -Sounder (19 Channel)</td>
<td>1 ½ hourly (two times region-B) and hourly (Three times Region-A)</td>
</tr>
<tr>
<td>3DR -Imager (6 Channel)</td>
<td>½ hourly (xx15 &amp; xx45 UTC)</td>
</tr>
<tr>
<td>3DR -Sounder (19 Channel)</td>
<td>Hourly (Three times Region-A) and 1 ½ hourly (two times region-B)</td>
</tr>
</tbody>
</table>

Modified scan strategy of INSAT-3D and INSAT-3DR sounder payload has been implemented with effect from 12.08.2017. INDIAN region sector data is now available on hourly basis and Ocean region data is available on one and half hourly basis.

Coordination Group for Meteorological Satellites
Rapid Scan Strategy of Imager of INSAT-3DR has been tested in operational scenario to be adopted during Cyclone/ specific weather event.

SOP has Been finalized and it will be activated on requirement basis

- Extent of coverage: 6 Blocks (3° coverage of 234 lines) each of 4 minute
- No. of repetitions: 6
- Time required: 27 minutes
- (6 blocks with 6 repetitions)
IMD generate the different types of spectral band, RGB, BD and NHC curve images at full globe & special sectors level to serve different stake holders for their specific use in aviation, tourism and power sectors.
Geophysical parameters/products of INSAT-3D/3DR Imager

1. VIS/MIR winds
2. WV winds
3. CMV
4. LL winds
5. HL winds

1. QPE
2. IMR
3. HE

SST
OLR
AMV
Cloud mask
Smoke
AOD
Fire

LST
INS
UTH
Rain Estimate
CTBT
Fog
Snow
Wind Derived Products from INSAT-3D/3DR Imager Winds

Vorticity

Wind Shear

Convergence & Divergence

850 hPa

700 hPa

500 hPa

200 hPa

Low Level Convergence

Upper level Divergence
Monitoring of Monsoon onset through OLR value of INSAT-3D Imager in the box 5-10N & 70-75 E
New Set of Products started during this year- Cloud fraction, clear Sky-BT, CTP, CTT from Imager
Geophysical parameters OF INSAT-3D/3DR Sounder

- Temperature profile
- Total ozone
- Geo potential height Profile
- Humidity profile
- Lifted Index
- Maximum vertical theta–e differential
- Dry microburst index
- Layer & perceptible water index (1000-900, 900-700, 700-300hpa)
Present Status of INSAT-3D/3DR Radiances and Winds

INSAT-3D/3DR radiances (Imager/Sounder) are being assimilated to the IMD NWP models.

INSAT-3D/3DR derived Winds (CMV/WVW) are being assimilated to NCMRWF model.
OLR Validation

<table>
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<tr>
<th></th>
<th>CORR</th>
<th>BIAS</th>
<th>RMSD</th>
<th>URMSD</th>
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<tbody>
<tr>
<td></td>
<td>0.97</td>
<td>6.31 W/m²</td>
<td>10.85 W/m²</td>
<td>8.58 W/m²</td>
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</tbody>
</table>

**INSAT-3D vs CERES-NPP**

- BIAS
- RMSD
- URMSD
- Linear (BIAS)
- Linear (RMSD)
- Linear (URMSD)

Regression lines:
- $y = 0.0421x + 10.052$, $R^2 = 0.1323$
- $y = 0.0448x + 5.4619$, $R^2 = 0.0464$
- $y = 0.0157x + 8.287$, $R^2 = 0.036$
Coordination Group for Meteorological Satellites - CGMS

SST Daytime and Nighttime validation

<table>
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<tr>
<th></th>
<th>CORR</th>
<th>BIAS</th>
<th>RMSD</th>
<th>URMSD</th>
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</thead>
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<tr>
<td>DAY</td>
<td>0.99</td>
<td>-0.62 K</td>
<td>1.32 K</td>
<td>1.11 K</td>
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<tr>
<td>NIGHT</td>
<td>0.99</td>
<td>-0.29 K</td>
<td>1.42 K</td>
<td>1.33 K</td>
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**INSAT-3D vs AQUA DAY**

**INSAT-3D vs AQUA NIGHT**

**INSAT-3D vs TERRA DAY**

**INSAT-3D vs TERRA NIGHT**
## AMV-validation

<table>
<thead>
<tr>
<th>WIND</th>
<th>RMSE (m/sec)</th>
<th>Bias (m/sec)</th>
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<tr>
<td></td>
<td>High</td>
<td>Medium</td>
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<tr>
<td>IR</td>
<td>5.30</td>
<td>4.83</td>
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<td>WVW</td>
<td>6.14</td>
<td>5.47</td>
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<tr>
<td>MIRW</td>
<td>_</td>
<td>3.97</td>
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<tr>
<td>VISW</td>
<td>_</td>
<td>3.89</td>
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</table>
Development of IPWG inter-comparison site over India—in progress
Dr Chris Kidd and IMD team is working—it will be completed by the end of 2018
Calibration Activities at IMD

- Establishment of In-situ Calibration and Validation site for INSAT-3D/3DR satellite for Visible and SWIR sensors at (Site Selected-Bhuj, Gujarat)[IMD-ISRO], Three filed campaigned has been carried out so far.
- Sustained and Coordinated Processing of Environmental Satellite data for Climate Monitoring (SCOPE-CM) IOGEO Project for Kalpana-1/INSAT-3D[IMD-EUMetSat].
- Lunar/Moon Calibration of INSAT-3D/3DR

Name of Site = Khawda (40km away from Bhuj), Great Rann of Kutchh, Gujarat

Calibration Coefficients IR channels are being updated on daily basis by using GSICS corrections of last 30 days dynamically carried out by SAC Ahmedabad, in IMDPS system.
GTS dissemination

- RO Data of ROSA payload of Megha-Tropics are being disseminated via GTS in BUFR format since last week of September 2017.
- Scatsat-1 wind data is being disseminated on GTS since April 2018.
- INSAT-3D derived Winds (IR/WV/Vis) as in BUFR format is also being provided to UKMET Office through GTS.
- IMD is also contributing to the WMO’s RARS group by providing the direct broadcast of NOAA and Metop data from the Delhi and Chennai receiving stations.
Dissemination through a dedicated IMD web site Updated every fifteen Minutes

http://satellite.imd.gov.in/insat.htm
Dissemination through a dedicated IMD web site Updated every fifteen Minutes

http://satellite.imd.gov.in/insat_new.htm

- Provision to view last 48 channel images/products images through drop down menu.
- Product description of all Imageries and Products are made available on webpage.
- Provision for running Animation for all channel images/products images for last 48 scans along with date and time selection.
Online Archival of all channel images & products images are available of last six months

http://satellite.imd.gov.in/archive/

Index of /archive

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<td>07-Mar-2016 13:16</td>
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<td>INSAT-3D-SOUNDER/</td>
<td>14-Jan-2015 14:31</td>
<td>-</td>
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<td>KALPANA-1/</td>
<td>15-Jan-2015 03:05</td>
<td>-</td>
<td></td>
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<td>MODIS/</td>
<td>14-Jan-2015 14:56</td>
<td>-</td>
<td></td>
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<tr>
<td>REQUESTS/</td>
<td>12-Jan-2017 09:41</td>
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<td></td>
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Apache/2.2.15 (Red Hat) Server at satellite.imd.gov.in Port 80
RAPID (Real time Analysis of Products & Information Dissemination) :- It is a web based quick visualization and analysis tool for satellite data on a real time basis. This introduces Next Generation Weather Data Access & Advanced Visualization.
http://www.rapid.imd.gov.in
The user manual for the use of RAPID was prepared and document may be accessed http://satellite.imd.gov.in/desc/RAPID_User_Guide.pdf.
Coordination Group for Meteorological Satellites - CGMS

Provision of generation of T-phi gram for 105 locations.

T-Phi Grams Derived From INSAT-3D Sounder

20AUG2015_0300_Ahmedabad

Nearest Sounding Location
Distance = 0.21 Deg.
LAT: 23.25, LON: 72.80

Tcl: 22.0 °C
Td: 23.10 °C
LCL: 935.84 hpa
LFC: 935.84 hpa
CAPE: 160.15 J/kg
CIN: -430.08 J/kg
CCL: 953.1 hpa
Conv. Temp: 26.4 °C
Psfc: 998.10 hpa
Possible Areas for Cooperation

Requirement of Nowcasting Tools – Indian region specific nowcasting tool need to be provided using INSAT-3D/3DR and Microwave data of LEO Satellites.

Basic Nowcasting:--- RGB Composite

Advanced Nowcasting/Forecasting:- Duststrom, FOG, Thunderstorms

Advanced Nowcasting:- Blended satellite global precipitation product (GEO+LEO)
IMD - GNSS Network – Present Status

25 GNSS + 5 GPS

Workflow in Atmosphere App (IPWV)

- Met data
- Receiver 1, Met data
- Receiver 2, Met data
- Receiver n, Met data
- Synchronizer
- Atmosphere Watch RT
- Radiosonde files
- IPWV, 15 min
- Weather Condition
- ZTD
- Radiosonde files
- Storage (RINEX, T02)
- Web Application
- Met files (RINEX)
- Web Application
- Atmosphere Watch PP
Dissemination through a dedicated IMD web site Updated every fifteen Minutes

http://gnss.imd.gov.in/TrimblePivotWeb/
GNSS Network data are also being used for variation of XYZ Coordinate with respect to IGS Reference Stations for seismological use.
TCIN50 DEMS 120600
A. TROPICAL DISTURBANCE (VARDASH)
B. 12/0600Z
C. 13.2N
D. 50.3E
E. INSAT 3D
F. T 4.8/4.9
G. VIS/IR
H. REMARKS: EYE PATTERN WITH EMBEDDED DISTANCE CANTER THAN 0.75 DEGREE (E 5, EYE ADJUSTMENT FOR RAGGED EYE = 1.0 E. P. = 0.5) VEILING DT = 4.5 P.T. = 4.0
PT IS BASED ON PT.
I. ADDL. POSITIONS NIL
TOO: 12/1250ZFT=
2050N
3 Hourly Satellite Bulletin

**Western Disturbance (W.D.)**
- SCT (Scattered) clouds over NE, S of the Bay of Bengal, and over area BET LAT 27.5°N TO 33.5°N, LONG 80°E TO 88°E over the area.

**Clouds Description Within India**
- **NORTHWEST:**
  - SCT (Scattered) clouds over parts west of 87°E.
- **NORTH:**
  - SCT (Scattered) clouds with EMIS (EO) satellite over parts of the region.
- **EAST:**
  - SCT (Scattered) clouds over parts of the region.
- **SOUTH:**
  - SCT (Scattered) clouds over parts of the region.
- **SOUTHWEST:**
  - SCT (Scattered) clouds with EMIS (EO) satellite over parts of the region.
- **BAY OF BENGAL & ANDAMAN SEA:**
  - SCT (Scattered) clouds with EMIS (EO) satellite over parts of the region.

**Vortex Description (G懂ondona) (G)/**
- Vortex (Lonjor) over the Bay of Bengal, centered near (14.0°N, 96.2°E), with intensity, WYO (WY: Pathfinder), MINT (Minimum) at 1800 UTC.
- SCT (Scattered) clouds with EMIS (EO) satellite over parts of the region.

**FOC (Focus)**
- 13.12.2016 0500 UTC

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**Satellite Bulletin Based on Post PIC of 1800 UTC**
- Region covered between LAT 60°N TO 90°N AND LONG 40°E TO 120°W.

**Important Features**
- Vortex (Lonjor) over the Bay of Bengal, centered near (14.0°N, 96.2°E), with intensity, WYO (WY: Pathfinder), MINT (Minimum) at 1800 UTC. SCT (Scattered) clouds with EMIS (EO) satellite over parts of the region.
IMD is in process to install Multi-Mission Meteorological Data Receiving & Processing System (MMDRPS), for reception, processing and dissemination of meteorological data of INSAT-3D/3DR/3DS and Kalpana-1.

MMDRPS will have very high end processing system which will cut down the processing time from currently 15 minutes to 5 minutes.

MMDRPS will have storage capacity of the order of 1PB which will facilitate online sharing of processed data for all Indian meteorological satellites to the registered users as per IMD data policy.
FUTURE GEO SATELLITES – GISAT-1

Launch Schedule: 2019, Geostationary orbit, 83E

<table>
<thead>
<tr>
<th>Band</th>
<th>Ch</th>
<th>SNR/N EdT</th>
<th>IFOV (m)</th>
<th>Range (µm)</th>
<th>Channels (µm)</th>
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<tbody>
<tr>
<td>MX-VNIR</td>
<td>4</td>
<td>&gt; 200</td>
<td>50</td>
<td>0.45 - 0.875</td>
<td>B1: 0.45-0.52</td>
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<td>B2: 0.52-0.59</td>
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<td>B3: 0.62-0.68</td>
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<td>B4: 0.77-0.86</td>
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<td>B5N: 0.71-0.74</td>
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<td>B6N: 0.845-0.875</td>
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<td>&gt; 400</td>
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<td>0.375 - 1.0</td>
<td>Δλ &lt; 10 nm</td>
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<td>HyS-SWIR</td>
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<td>&gt; 400</td>
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<td>0.9 - 2.5</td>
<td>Δλ &lt; 10 nm</td>
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<td>MX-LWIR</td>
<td>6</td>
<td>NEdT &lt; 0.15K</td>
<td>1500</td>
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<td>CH6: 13.0-13.5</td>
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</tbody>
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GISAT Scan scenario
Scan area for two scan scenario (5° & 10°)

- Every 10 minute interval
- 30-minutes triplet every 6 hour for winds
  - Tropical Cyclone
  - Nowcasting
  - Cloud properties
  - SST/LST
  - Rainfall
  - Radiance Assim
  - Winds
  - Ozone wind
  - Total Ozone
  - SO2 Monitoring
  - Atmospheric turbulence
  - Fog application
  - Climate application

GISAT Scan scenario
To be considered by CGMS:

- To ensure the availability of FY-4A satellite payloads data to IMD for Now-casting and assimilation in NWP models
Thank You