CURRENT AND FUTURE STATUS OF INDIAN METEOROLOGICAL SATELLITES

VIRENDRA SINGH, P. K. PAL*, A.K.SHARMA AND R.K.GIRI
INDIA METEOROLOGICAL DEPARTMENT, NEW DELHI
*SPACE APPLICATION CENTRE, ISRO AHEMDABAD

Executive summary

Currently two satellites are in operations, namely; KALPANA-1 and INSAT-3A. With the help of these two satellites, IMD is able to monitor most of the systems like, Cyclones, Western Disturbances, Thunderstorms etc. and provide early warnings to the affected areas. The next major upgrade in observations from geostationary platform will be in the INSAT-3D satellite scheduled for launch in July, 2013, and which will be an exclusive meteorological satellite carrying advanced meteorological payloads, viz. a 6-channel imager and a 19-channel sounder. The sounder will provide data for the retrieval of vertical profiles of temperature and humidity over the clear sky region of data-sparse Indian Ocean at a 10 km spatial resolution. INSAT-3D (Repeat) is planned to be launched in 2015. It will have similar payloads as in INSAT-3D for the continuation of operational service. GISAT (Geo-stationary Imaging Satellite) ,next generation geo-stationary imaging satellite providing continuous imaging of earth disk or region of interest with high resolution is planned in near future .

The following three satellites, namely, Oceansat –2,RISAT-1 and SARAL are Indian Polar orbit Operational Space Missions and Megha-Tropiques in low inclination (20^0) orbit for Atmospheric and Oceanic Science studies. **Oceansat-2**is a three axis body stabilized spacecraft placed into a near circular sun synchronous orbit, at an altitude of 720 Km, with an equatorial crossing time of around 1200 hrs launched on 23 September 2009 at an inclination 98.280 degree. The Megha-Tropiques satellite was successfully placed into a non-sun synchronous orbit at altitude of 867 km orbit with an inclination of 20 degrees to the equator on October 12, 2011 with the objective of studying the water cycle and energy exchanges in the tropics. The Radar Imaging Satellite (RISAT-1), launched on April 26, 2012, placed in the Polar Sun-synchronous orbit of 536 km height. carries a multimode C- band (5.35 GHz) Synthetic Aperture Radar (SAR) as the payload for wide applicability in the thrust areas like flood mapping, Agriculture & crop monitoring, generic Vegetation, Forestry, Soil Moisture, Geology and Sea Ice and Coastal processes etc. The Satellite with ARGOS and ALTIKA (SARAL) is a joint Indo-French satellite mission for oceanographic studies. SARAL will perform altimetric measurements designed to study ocean circulation and sea surface elevation. It was successfully launched on February 25, 2013 into 781 km polar Sun synchronous orbit 98.538 degree.

CGMS

REPORT ON THE CURRENT AND FUTURE STATUS OF INDIAN METEOROLOGICAL SATELLITES

1 CURRENT SATELLITE SYSTEMS

The program of Indian National Satellite System (INSAT) was started during late seventies and the first satellite INSAT-1A was launched on 10th April, 1982. The India Meteorological Department processed the first earth image transmitted by INSAT-1A was successfully with the help of a new processing system installed at IMD Campus, New Delhi. Since then, IMD is fully involved in processing data from all INSAT-1 and INSAT-2 series of satellites and the imagery and products derived from the imagery data are being utilized in the daily, medium range and long range weather forecasts. Currently two satellites are in operations, namely; KALPANA-1 and INSAT-3A. With the help of these two satellites, IMD is able to monitor most of the systems like, Cyclones, Western Disturbances, Thunderstorms etc. and provide early warnings to the affected areas. The next major upgrade in observations from geostationary platform will be in the INSAT-3D satellite scheduled for launch in July, 2013, and which will be an exclusive meteorological satellite carrying advanced meteorological payloads, viz. a 6-channel imager and a 19-channel sounder. The sounder will provide data for the retrieval of vertical profiles of temperature and humidity over the clear sky region of data-sparse Indian Ocean at a 10 km spatial resolution. India Meteorological Department (IMD) New Delhi has set up INSAT-3D Meteorological Data Processing System (IMDPS) which is catering the requirements of a Real Time data acquisition and quick look processing (DAQLS) and processing of all data transmitted by CCD (VIS, NIR, SWIR) ,VHRR(VIS,WV,IR) payloads of INSAT-3A and VHRR payload of KALPANA-1 satellite and will be also be cater the requirements of a Real Time INSAT-3D 6 channels IMAGER(VIS,SWIR, MIR, WV, TIR1, TIR2) and 19 Channels IR Sounder payloads. INSAT-3D (Repeat) is planned to be launched in 2015. It will have similar payloads as in INSAT-3D for the continuation of operational service. GISAT (Geo-stationary Imaging Satellite) ,next generation geo-stationary imaging satellite providing continuous imaging of earth disk or region of interest with high resolution is planned in near future .

Currently the following three satellites, namely, Oceansat –2,RISAT-1 and SARAL are Indian Polar orbit Operational Space Missions and Megha-Tropiques in low inclination (20o) orbit for Atmospheric and Oceanic Science studies. Oceansat-2is a three axis body stabilized spacecraft placed into a near circular sun synchronous orbit, at an altitude of 720 Km, with an equatorial crossing time of around 1200 hrs launched on 23 September 2009 by PSLV-C14 at an inclination 98.280 degree. The orbital period is 99.31 minutes and the repetevity cycle is 2 days. It carries the following payloads, Ocean Colour Monitor (OCM), 8-band multi-spectral camera operating in the Visible – Near IR spectral range. Ku-band pencil beam Scatterometer and Radio Occultation Sounder for the Atmosphere (ROSA) sensors. Megha-Tropiques(A joint project by ISRO and CNES, France with the objective of studying the water cycle and energy exchanges in the tropics) is placed at an altitude of 866 km and 20 degree inclination to the equator by the Indian Space Research Organization through its Polar Satellite Launch Vehicle (PSLV-C18) on October 12, 2011.The orbital period is 101.93 minutes and the repetevity cycle has more than 3.5 visibilities per day of each point of the zone of situated between 22 degree S and 22 degree N and reaches more than 5 per day around 13 degree N and 13 degree S .It carries the following payloads, SAPHIR 6 bands around 183 GHz (10 km Res.), SCARAB Radiation instrument in short & long wave (40 km Res.) ,MADRAS 89 & 157 GHz radiometer 10, 18 & 37 GHz radiometer (10 km Res.) and Radio Occultation Sounder for the Atmosphere (ROSA) sensors. The ISTRAC ground station at Bangalore will be used for spacecraft control and also for receiving the science data. Geophysical parameters are retrieved at Space Applications Centre and disseminated through MOSDAC, SAC Ahemdabad and data processing centre ICARE where level 2 & 3 processing is also carried out for France. The Radar Imaging Satellite (RISAT-1), is a Polar Sun-synchronous satellite. It is the first satellite imaging mission using an active RADAR sensor system. RISAT - 1 carries a multimode C- band (5.35 GHz) Synthetic Aperture Radar (SAR) as the payload. The Satellite with ARGOS and ALTIKA (SARAL) is a joint Indo-French satellite mission for oceanographic studies. SARAL will perform altimetric measurements designed to study ocean circulation and sea surface elevation. It was successfully launched on February 25, 2013 into 781 km polar Sun synchronous orbit 98.538 degree. The

Megha-Tropiques satellite was successfully placed into a non-sun synchronous orbit at altitude of 867 km orbit with an inclination of 20 degrees to the equator on October 12, 2011. Megha-Tropiques is a one-tonne satellite which will be operated as part of a joint programme between the Indian Space Research Organisation (ISRO) and France's Centre National d'EtudesSpaciales (CNES).

1.1 CURRENT GEOSTATIONARY SATELLITES

Sector	Long	Name	Operator	Launch	Instruments	Details
Indian Ocean	55 ° E	INSAT-3E (Operational)	ISRO	2003-09-08		
	74 ° E	INSAT-3C (Operational)	ISRO	2002-01-24		
	74 ° E	Kalpana-1 (Operational)	ISRO	2002-09-12	VHRR DRT SAS&R	Primary operational satellite, scanning on half hourly basis. DRT is not being used at present as satellite is in inclined orbit of 3.8 degree.
	93.5 ° E	INSAT-3A (Operational)	ISRO	2003-04-10	CCD DRT SAS&R VHRR	Secondary operational position, scanning on hourly basis of VHRR and six times in day of CCD. DRT is in operation for all AWS and ARG network.

1.2 Status of current GEO satellite systems

Kalpana-1/ METSAT

It is a main operational satellite being used in normal mode covers a range of 14deg in N-S direction and 20deg in E-W direction and takes 23 minutes and number of scanned lines are 1092, used for exclusive meteorological purpose. Its DRT payload is not being used at present as satellite reached in inclined plane at about 3.8degree inclination.

INSAT-3A

It is a secondary operational satellite, its VHRR payload is being used in full frame mode covers a range of 20deg in N-S direction and 20deg in E-W direction and takes 33 minutes and number of scanned lines are 1560 i.e 24 no's of scan received and processed in day on hourly basis. Its CCD payload is being operated in Normal frame mode at fixed time i.e. 0300, 0500, 0600, 0700, 0900&1100 GMT during day. It is also being used for

communication and search & rescue services. The whole network of AWS/ARG stations of India is operational through DRT payload of INSAT-3A

1.2.1 Mission objectives, payload/instruments, products

Kalpana-1/ METSAT

Kalpana-1 is an exclusive meteorological geostationary satellite which was launched on 12th September, 2002 and is located at 74 degrees E, Originally named METSAT, renamed after Kalpana Chawla who perished in the space shuttle Columbia. The main objective are

To establish a small satellite I-1000 bus system this can meet the exclusive service requirements of a meteorological payload for earth imageries.

Collection of weather data from low cost unattended data collection platforms-to configure Metsat spacecraft within the lift-off mass constraints of upgraded existing polar satellite launch vehicle for deployment in geo-synchronous transfer orbit (GTO) mission.

The payloads on kalpana-1 are as follows:

VHRR (Very High Resolution Radiometer)

VHRR is an opto-mechanical system (whiskbroom type imager). The incoming solar radiation is reflected onto a Ritchey-Chretien telescope of 20 cm aperture by a beryllium scan mirror mounted at 45° to the optical axis. The optical system includes a gold-film dichoric beam-splitter that transmits visible light energy and reflects WV/TIR energy, so that the radiation from the Earth is channelized to the visible and IR focal planes simultaneously.
The visible band detector configuration consists of two staggered arrays of four silicon photodiodes each; while two sets of mercury-cadmium telluride (MCT) detector elements operating nominally at 100-110 K sense the WV/thermal radiation. The scan mirror is mounted on a two-axis, gimballed scan mechanism system to generate a 2-D image by sweeping the detector instantaneous field of view (FOV) across the Earth's surface in east to west (fast scan) and north to south (slow scan).

DRT (Data Relay Transponder)

The DRT (Data Relay Transponder) is part of a DCS (Data Collection System) of ISRO. The objective is to collect data from unattended meteorological platforms in the ground segment. DRT receives receives signals from unattended weather data collection platforms and retransmits them to the central station. The data from these payloads are being used for comprehensive weather status and forecasting.
RF communication of DRT: Uplink frequency = 402.75 MHz; downlink frequency = 4506.05 MHz; bandwidth =± 100 kHz; EIRP = 21 dBW (min).

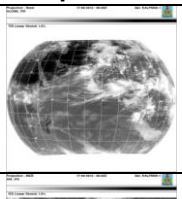
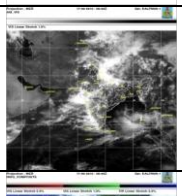
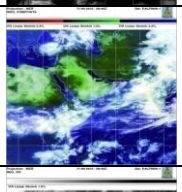
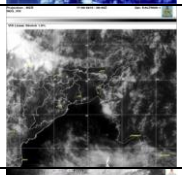
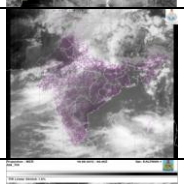
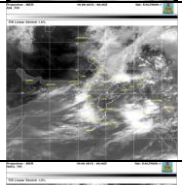
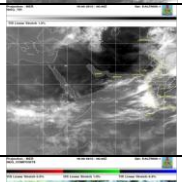
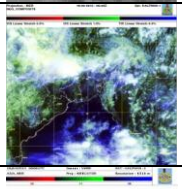
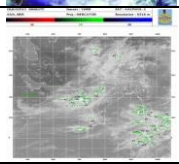
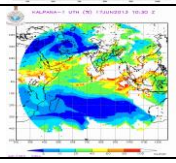
Payloads	Channel	Resolution	Data Rate	RF Frequency
VHHR (very high resolution radiometer)	visible(0.55-0.75uM)	2x2 Km	526.5 kbps	4503.5 MHz
	Infrared (10.5-12.5uM)	8x8 Km		
	water vapour (5.7-7.1uM)	8x8 Km		
DRT		402.75 MHz MHz uplink	4.8 kbps	4506.05 MHz downlink

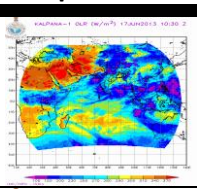
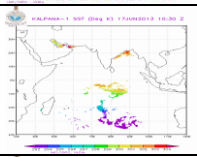
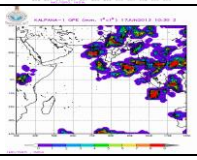
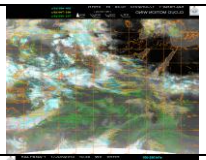
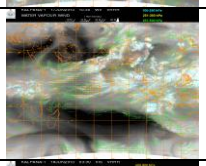
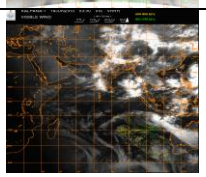
Modes of Operation: There are three types of modes of operations, namely Full Frame, Normal and sector modes. The range of full frame mode is 20deg in both N-S and E-W direction and takes 33 minutes and number of lines are 1560. The normal mode covers a range of 14deg in N-S direction and 20deg in E-W direction and takes 23 minutes and number of lines are 1092. The sector mode is very useful for tracking the synoptic systems like cyclones etc. and covers a range of 4.5 deg in N-S direction (selectable) and 20deg in E-W direction takes 7minutes (3 scans in 23 minutes) and number of lines are 351. Presently this satellite is providing half hourly normal scans round the clock.

Mode of Operation	Time of coverage	Coverage Area
Full frame mode	33 minutes	20x20 degrees
Normal scan mode	23 minutes	14 degrees in NS & 20 degrees in EW
Sector scan mode	7 minutes	4 degrees in NS & 20 degrees in EW

The Various levels of Data Products derived from Kaplana-1 are (LEVEL-0, LEVEL-1, LEVEL-2 and LEVEL-3) in the HDF-5 formats and also in the generic binary format.
The various types of products generated by the Data Products System are

- LEVEL - 0 (Raw) – for internal use and archival
- LEVEL - 1 (Full Globe)
- LEVEL - 2 (Sector)
- LEVEL - 3 (Geo-Physical)

Products	Frequency	Format	Availability	Sample
KALPANA-I FULL DISC(Vis,WV,IR&Composite)	Half Hourly	Jpg	Through web	
KALPANA-IAsia SECTOR (Vis,WV,IR&Composite)	Half Hourly	Jpg	Through web	
KALPANA-I NW SECTOR (Vis,WV,IR&Composite)	Half Hourly	Jpg	Through web	
KALPANA-I NE SECTOR (Vis,WV,IR&Composite)	Half Hourly	Jpg	Through web	
KALPANA-IDISTRICT BOUNDARIES(Vis,WV,IR & Composite)	Half Hourly	Jpg	Through web	
Kpalan—1 ASIA SECTOR(Vis,WV,IR&Composite)	Half Hourly	Jpg	Through web	
Kpalan—1 NW SECTOR(Vis,WV,IR& Composite)	Half Hourly	Jpg	Through web	
Kpalan—1 NE SECTOR(Vis,WV,IR& Composite)	Half Hourly	Jpg	Through web	
CLOUD TOP TEMPRETURE	Half Hourly	Jpg	Through web	
UPPER TROPOSPHERIC HUMIDITY(UTH)	Half Hourly/Daily/Weekly	Jpg/HDF	Through web	

Products	Frequency	Format	Availability	Sample
OLR	Half Hourly/Daily/Weekly/Monthly/ Seasonal	Jpg/HDF	Through web	
SST	Half Hourly/Daily/Weekly	Jpg/HDF	Through web	
QPE	Half Hourly/Daily/Weekly/Monthly/ Seasonal	Jpg/HDF	Through web	
ATMOSTPHERIC WIND VECTOR PRODUCTS				
CMV	Half Hourly	Jpg/HDF/bufr	Through web and GTS	
WVW	Half Hourly	Jpg/HDF/bufr	Through web and GTS	
VISW	Half Hourly	Jpg/HDF/bufr	Through web and GTS	

INSAT-3A: INSAT-3A is a geostationary satellite which was launched in April 2003. It is located at 93.50 east longitude in the geostationary orbit. INSAT-3A is the third satellite in the INSAT-3 series. INSAT-3B and INSAT-3C were launched in March 2000 and January 2002 respectively. INSAT-3A is a multipurpose satellite for providing telecommunications, television broadcasting, meteorological and search & rescue services. The main objective are

- Telecommunications
- Television broadcasting
- Meteorological
- Search and Rescue services

INSAT-3A

It is a secondary operational satellite, its VHRR payload is being used in full frame mode covers a range of 20deg in N-S direction and 20deg in E-W direction and takes 33 minutes and number of scanned lines are 1560 i.e 24 no's of scan received and processed in day on hourly basis. Its CCD payload is being operated in Normal frame mode at fixed time i.e. 0300, 0500, 0600, 0700, 0900&1100 GMT during day. It is also being used for communication and search & rescue services. The whole network of AWS/ARG stations of India is operational through DRT payload of INSAT-3A -W direction and takes 33 minutes and number of scanned lines are 1560 i.e 24 no's of scan received and processed in day on hourly basis. Its CCD payload is being operated in Normal frame mode at fixed time i.e. 0300, 0500, 0600, 0700, 0900&1100 GMT during day. It is also being used for communication and search & rescue services. The whole network of AWS/ARG stations of India is operational

through DRT payload of INSAT-3A lines are 1560 i.e 24 no's of scan received and processed in day on hourly basis. Its CCD payload is being operated in Normal frame mode at fixed time i.e. 0300, 0500, 0600, 0700, 0900&1100 GMT during day. It is also being used for communication and search & rescue services. The whole network of AWS/ARG stations of India is operational through DRT payload of INSAT-3A

Very High Resolution Radiometer (VHRR) with imaging capacity in the visible (0.55-0.75 µm), thermal infrared (10.5-12.5 µm) and Water Vapour (5.7-7.1 µm) channels, provide 2x2 km, 8x8 km and 8x8 km ground resolutions respectively. Kalpana-1/ METSAT
It is a main operational satellite being used in normal mode covers a range of 14deg in N-S direction and 20deg in E-W direction and takes 23 minutes and number of scanned lines are 1092, used for exclusive meteorological purpose. Its DRT payload is not being used at present as satellite reached in inclined plane at about 3.8degree inclination.

A Data Relay Transponder (DRT) operating in UHF band (400 MHz) uplink for real-time Hydrological, Agro-Meteorological and Oceanographic data collection from unattended platforms located on land and river basins based Automatic Weather Stations (AWS). The data is then relayed in extended C-band (4506.05 MHz) downlink to a central location at Pune and Delhi. The whole network of AWS/ARG stations of India is operational through this payload.

A Satellite Aided Search and Rescue (SAS&R) SARP payload having global receive coverage with 406 MHz uplink and 4500 MHz downlink with India coverage, for relay of signals from distress beacons in sea, air or land

The metrological payloads on INSAT-3A are as follows:

Payloads	Channel	Resolution	Data Rate	Frequency
VHHR (very high resolution radiometer)	visible (0.55-0.75 um)	2x2 Km	526.5 kbps	4501.5 MHz
	Infrared (10.5-12.5um) water vapour (5.7-7.1um)	8x8 Km		
CCD	Visible (0.62-0.68 um)	1x1 Km	1.28875 Mbps	4508.9 MHz
	NIR (0.77-0.86 um)			
	SWIR (1.55-1.69 um)			
DRT		402.75 MHz MHz uplink	4.8 kbps	4506.05 MHz downlink

Modes of Operation of INSAT-3A, VHRR:

There are three types of modes of operations, namely Full Frame, Normal and sector modes. The range of full frame mode is 20deg in both N-S and E-W direction and takes 33 minutes and number of lines are 1560. The normal mode covers a range of 14deg in N-S direction and 20deg in E-W direction and takes 23 minutes and number of lines are 1092. The sector mode is very useful for tracking the synoptic systems like cyclones etc. and covers a range of 4.5 deg in N-S direction (selectable) and 20deg in E-W direction takes 7minutes (3 scans in 23 minutes) and number of lines are 351.At present INSAT-3A VHRR is being operated in Full frame mode i.e 24 no's of scan received and processed in day on hourly basis.

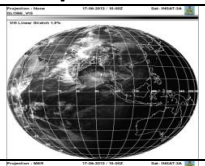
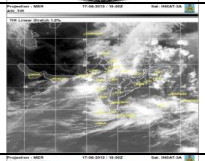
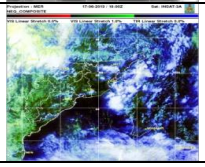
Mode of Operation	Time of coverage	Coverage Area
Full frame mode	33 minutes	20x20 degrees
Normal scan mode	23 minutes	14 degrees in NS & 20 degrees in EW
Sector scan mode	7 minutes	4 degrees in NS & 20 degrees in EW

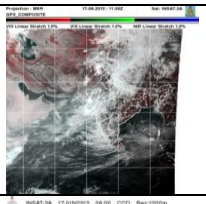
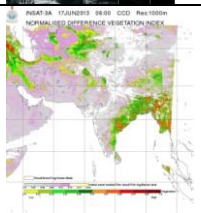
Modes of Operation of INSAT-3A, CCD: There are two Modes of Operation for CCD payload. The scan coverage in East-West is 10deg in all modes whereas North-South coverage will vary depending upon the mode. The two modes are Normal and Program mode. The coverage in the normal mode will be 10 deg. Positioned by ground command within 20 deg. Field where as in the Program mode 1 to 25 lines, each covering 0.395 deg. Currently IMD is processing hourly images during day time only. At present INSAT-3A communication, weather and search & rescue services

Mode of Operation	Time of coverage	Coverage Area
Normal frame mode	25 minutes	10 X10 deg
Program mode	Programmable	Programmable

Communication Payload: It also have on-board 12 Normal C-band transponders (9 channels provide expanded coverage from Middle East to South East Asia with an EIRP of 38 dBW, 3 channels provide India coverage with an EIRP of 36 dBW and 6 Extended C-band transponders provide India coverage with an EIRP of 36 dBW).
It also has on-board 6 upper extended C-band transponders having India beam coverage providing an EoC-EIRP of 37 dBW.
It also has on-board 6 Ku-band transponders provide India coverage with EIRP of 48 dBW

Products:
The Various levels of Data Products derived from INSAT-3A are (LEVEL-0, LEVEL-1, LEVEL-2 and LEVEL-3) in the HDF-5 formats and also in the generic binary format.
- LEVEL - 0 (Raw) – for internal use and archival
- LEVEL - 1 (Full Globe)
- LEVEL - 2 (Sector)
- LEVEL - 3 (Geo-Physical)

Products	Frequency	Format	Availability	Sample
INSAT-3A FULL DISC	Half Hourly	Jpg	Through web	
INSAT-3A ASIA SECTOR	Half Hourly	Jpg	Through web	
INSAT-3A NE SECTOR	Half Hourly	Jpg	Through web	

INSAT-3A CCD	0300.0500,0600,0700,0900 &1100 GMT	Jpg/HDF	Through web	
INSAT-3A CCD NDVI	0300.0500,0600,0700,0900 &1100 GMT	Jpg/HDF	Through web	
INSAT-3A CCD AOD	0300.0500,0600,0700,0900 &1100 GMT	Jpg/HDF	Through web	

1.2.2 Ground segment matters

INSAT-3D Meteorological Data Processing System (IMDPS)

INSAT-3D Meteorological Data Processing System (IMDPS) is the ground segment system for data Processing and Products Generation installed by ISRO in IMD New Delhi in the year 2009.The proposed system acquire raw data from serial data streams, producing quality Data Products (DP) and generate various quantitative Geo-Physical products (GPR) from the processed data for operational utilization by various users. The Products thus produced are being operationally displayed for the current KALPANA-1, INSAT-3A missions by the indigenous designed Satellite Imagery Display System throughout the campus of IMD, Delhi, SAC-BOPAL, and Ahmedabad on an 24 x 7 basis for every half hour images processed. Additionally, the system is capable of processing, ingesting and analyzing Automatic Weather Station (AWS) and Global Telecommunication System (GTS) data. A large number of meteorological parameters and application-products are required to be derived from the raw data of satellite-sensors, AWS and GTS data as well as conventional meteorological data.

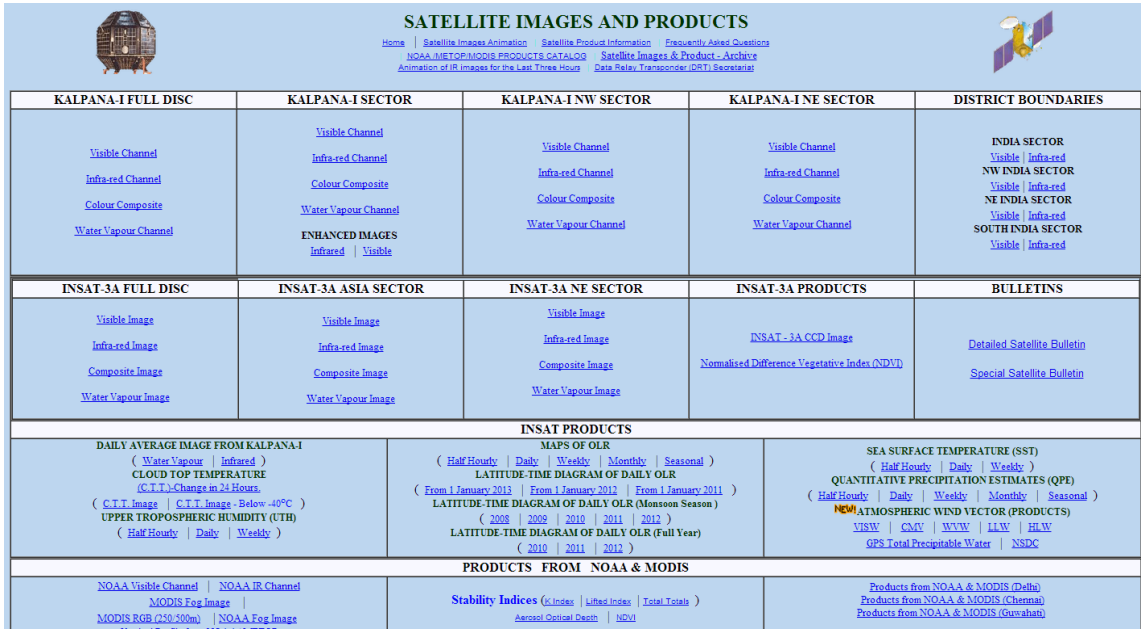
The deliverables will include Data acquisition quick display system, Data products generation, Parameter retrieval and image processing and Visualization display system solutions, data visualization comprising of both hardware and software systems for the near real time Data Processing and dissemination of Meteorological Data Products on the WEB. The Radiometric calibration as part of data pre-processing is carried out based on the extensive ground calibration data supported by ground and on-board calibration techniques, which tracks changes in the instrument response due to in-orbit thermo-mechanical environment, radiation effects and aging. The geometric correction, re-sampling is performed on the radiometric corrected pixel-data based on static and dynamic models of the instrument and satellite as well as orbit and attitude parameters available simultaneously with the imaging data and produces various levels of data products. A further precision/improved accuracy is necessary which requires in registering the image-pixels on fixed lat-long grids would be achieved through image navigation and registration algorithm in an automatic/interactive approach. The Data Products Software providing the capability for generation of Various levels of Data Products (LEVEL-0, LEVEL-1 , LEVEL-2 and LEVEL-3) on the user requested media and in the required formats HDF-5 and also in the generic binary format.

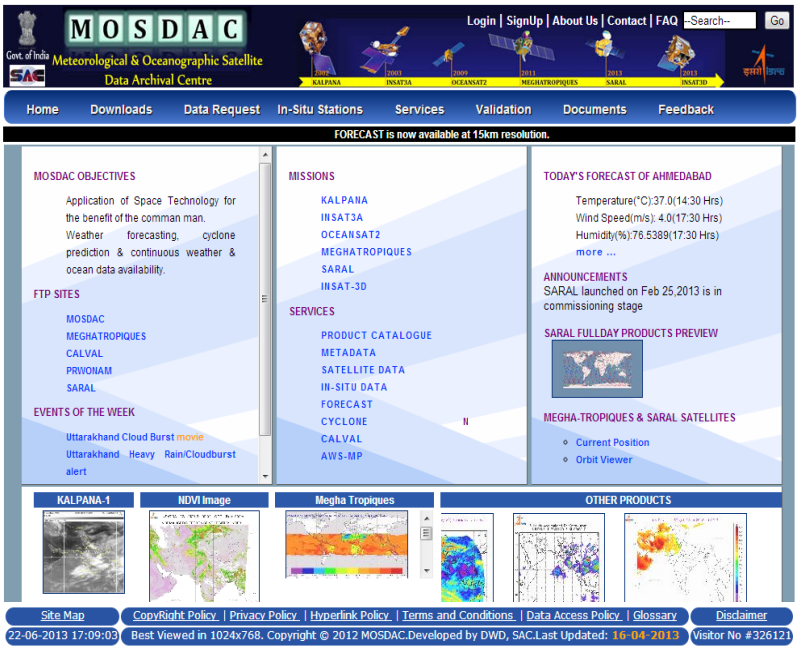
The various types of products generated by the Data Products System are

- LEVEL - 0 (Raw) – for internal use and archival
- LEVEL - 1 (Full Globe)
- LEVEL - 2 (Sector)
- LEVEL - 3 (Geo-Physical)

1.2.3 Data Dessimination

The processed data, imagery and products are disseminated through IMD, ISRO official websites on a real time basis. IMD website http://www.imd.gov.in/
and ISRO website http://www.mosdac.gov.in


SATELLITE IMAGES AND PRODUCTS
Home | Satellite Images Animation | Satellite Product Information | Frequently Asked Questions
NOAA /METOP/MODIS PRODUCTS CATALOG | Satellite Images & Product - Archive
Animation of IR images for the Last Three Hours | Data Relay Transponder (DRT) Secretariat
KALPANA-I FULL DISC
Visible Channel
Infra-red Channel
Colour Composite
Water Vapour Channel
KALPANA-I SECTOR
Visible Channel
Infra-red Channel
Colour Composite
Water Vapour Channel
ENHANCED IMAGES
Infrared | Visible
KALPANA-I NW SECTOR
Visible Channel
Infra-red Channel
Colour Composite
Water Vapour Channel
KALPANA-I NE SECTOR
Visible Channel
Infra-red Channel
Colour Composite
Water Vapour Channel
DISTRICT BOUNDARIES
INDIA SECTOR
Visible | Infra-red
NW INDIA SECTOR
Visible | Infra-red
NE INDIA SECTOR
Visible | Infra-red
SOUTH INDIA SECTOR
Visible | Infra-red
INSAT-3A FULL DISC
Visible Image
Infra-red Image
Composite Image
Water Vapour Image
INSAT-3A ASIA SECTOR
Visible Image
Infra-red Image
Composite Image
Water Vapour Image
INSAT-3A NE SECTOR
Visible Image
Infra-red Image
Composite Image
Water Vapour Image
INSAT-3A PRODUCTS
INSAT - 3A CCD Image
Normalised Difference Vegetative Index (NDVI)
BULLETINS
Detailed Satellite Bulletin
Special Satellite Bulletin
INSAT PRODUCTS
DAILY AVERAGE IMAGE FROM KALPANA-I
(Water Vapour | Infrared)
CLOUD TOP TEMPERATURE
(C.T.T.)-Change in 24 Hours.
(C.T.T. Image | C.T.T. Image - Below -40°C)
UPPER TROPOSPHERIC HUMIDITY (UTH)
(Half Hourly | Daily | Weekly)
MAPS OF OLR
(Half Hourly | Daily | Weekly | Monthly | Seasonal)
LATITUDE-TIME DIAGRAM OF DAILY OLR
(From 1 January 2013 | From 1 January 2012 | From 1 January 2011)
LATITUDE-TIME DIAGRAM OF DAILY OLR (Monsoon Season)
(2008 | 2009 | 2010 | 2011 | 2012)
LATITUDE-TIME DIAGRAM OF DAILY OLR (Full Year)
(2010 | 2011 | 2012)
SEA SURFACE TEMPERATURE (SST)
(Half Hourly | Daily | Weekly)
QUANTITATIVE PRECIPITATION ESTIMATES (QPE)
(Half Hourly | Daily | Weekly | Monthly | Seasonal)
NEW! ATMOSPHERIC WIND VECTOR (PRODUCTS)
VISW | CMV | WVW | LLW | HLW
GPS Total Precipitable Water | NSDC
PRODUCTS FROM NOAA & MODIS
NOAA Visible Channel | NOAA IR Channel
MODIS Fog Image |
MODIS RGB (250/500m) | NOAA Fog Image
Stability Indices (K Index | Lifted Index | Total Totals)
Aerosol Optical Depth | NDVI
Products from NOAA & MODIS (Delhi)
Products from NOAA & MODIS (Chennai)
Products from NOAA & MODIS (Guwahati)


MOSDAC
Meteorological & Oceanographic Satellite Data Archival Centre
Govt. of India
SAC
Login | SignUp | About Us | Contact | FAQ
--Search--
Go
KALPANA
INSAT3A
OCEANSAT2
MEGHATROPIQUES
SARAL
INSAT3D
Home
Downloads
Data Request
In-Situ Stations
Services
Validation
Documents
Feedback
FORECAST is now available at 15km resolution.
MOSDAC OBJECTIVES
Application of Space Technology for the benefit of the comman man. Weather forecasting, cyclone prediction & continuous weather & ocean data availability.
FTP SITES
MOSDAC
MEGHATROPIQUES
CALVAL
PRWONAM
SARAL
EVENTS OF THE WEEK
Uttarakhand Cloud Burst movie
Uttarakhand Heavy Rain/Cloudburst alert
MISSIONS
KALPANA
INSAT3A
OCEANSAT2
MEGHATROPIQUES
SARAL
INSAT-3D
SERVICES
PRODUCT CATALOGUE
METADATA
SATELLITE DATA
IN-SITU DATA
FORECAST
CYCLONE
CALVAL
AWS-MP
TODAY'S FORECAST OF AHMEDABAD
Temperature(°C):37.0(14:30 Hrs)
Wind Speed(m/s): 4.0(17:30 Hrs)
Humidity(%):76.5389(17:30 Hrs)
more ...
ANNOUNCEMENTS
SARAL launched on Feb 25,2013 is in commissioning stage
SARAL FULLDAY PRODUCTS PREVIEW
MEGHA-TROPIQUES & SARAL SATELLITES
Current Position
Orbit Viewer
KALPANA-1
NDVI Image
Megha Tropiques
OTHER PRODUCTS
Site Map
CopyRight Policy | Privacy Policy | Hyperlink Policy | Terms and Conditions | Data Access Policy | Glossary
Disclaimer
22-06-2013 17:09:03
Best Viewed in 1024x768. Copyright © 2012 MOSDAC.Developed by DWD, SAC.Last Updated: 16-04-2013
Visitor No #326121

1.3 Status of current LEO satellite systems

India has its foot prints in remote sensing and meteorological applications through its polar orbit /Low earth Orbiting (LEO) since 1988 and had launched number of Indian Remote Sensing (IRS) and meteorological satellites. They are providing the information in a variety of spatial resolutions, spectral bands and swaths. At present India has the following meteorological polar/ LEO orbiting operational satellites. Oceansat -2 was launched in September, 23, 2009 into 720 km, Sun-Synchronous Polar Orbit (SSPO) carried three payloads namely Ocean Color Monitor (OCM), Ku Band Pencil beam Scatterometer & Radio Occultation Sounder for Atmospheric Studies (ROSA) is an evolution of IRS-P4 (Oceansat -1) launched in 1999 as a dedicated satellite for ocean applications.

The Radar Imaging Satellite (RISAT-1), launched on April 26, 2012, placed in the Polar Sun-synchronous orbit of 536 km height. RISAT – 1 is a new class of remote sensing satellite, distinct from the established IRS class, is developed by Indian Space Research Organization (ISRO) as its first satellite imaging mission using an active RADAR sensor system. RISAT - 1 carries a multimode C- band (5.35 GHz) Synthetic Aperture Radar (SAR) as the payload.

The Satellite with ARGOS and ALTIKA (SARAL) is a joint Indo-French satellite mission for oceanographic studies. SARAL will perform altimetric measurements designed to study ocean circulation and sea surface elevation. It was successfully launched on February 25, 2013 into 781 km polar Sun synchronous orbit 98.538 degree. It is an operational class satellite bus with complete redundancy in mainframe systems by the modular mounting concept miniaturization The SARAL satellite is result of common interest of ISRO and CNES to study the ocean from space using altimetry system.

1.3.1 Mission objectives, payload/instruments, products

OCEANSAT-2:

OCEANSAT-2 is a global mission and is configured to cover global oceans, and provide continuity of ocean colour data with global wind vector and characterization of lower atmosphere and ionosphere. Oceansat-2 was launched on 23 September 2009 using PSLV-C14 and carried three payloads Ocean Colour Monitor (OCM-2),Ku-Band Pencil beam Scatterometer&Radio Occultation Sounder for Atmospheric studies (ROSA) - Developed by Italian Space Agency .The telemetry, tracking and command subsystem of oceasat-2 works in S band and its payload data is relays trough X band. He satellite has 64GB solid state recorder to store the imagery for later read out. A host of earth and sun sensors as well as gyroscopes provide the directional reference for its processor based attitude and orbit control system to properly orient th spacecraft and provide sufficient stability during phases of mission, especially during imaging. Four reaction wheels and mono propellant hydrazine thrusters are used as actuators to control its orientation. Thrusters are also used for satellite orbit control.

The primary mission objectives of Oceansat-2 are:

- To design, develop, launch and operate a three axis stabilized spacecraft carrying an Ocean Colour Monitor and Ku-band Scatterometer,
- To develop / implement algorithms for retrieval of geophysical parameters like wind vector on an operational basis.
- To promote new applications in the areas of ocean studies including prediction of cyclone trajectory, fisheries, coastal zone mapping etc.

The main objectives of OceanSat-2 are

- To study surface winds and ocean surface strata, observation of chlorophyll concentrations, monitoring of phytoplankton blooms, study of atmospheric aerosols and suspended sediments in the water,
- The major applications of data from Oceansat-2 are identification of potential fishing zones, sea state forecasting, coastal zone studies and inputs for weather forecasting and climatic studies.

Payload:

Ocean Colour Monitor (OCM)

OCM-2 is a solid-state camera operating in push broom scanning mode, using linear array Charge Coupled Devices (CCDs) as detectors. OCM is a 8-band multi-spectral camera operating in the Visible – Near IR spectral range. This camera provides an instantaneous geometric field of view of 360 meter and a swath of 1420 km. This wide swath enables the OCM to provide a repetivity of two days for any given area. To avoid sun glint due to specular reflection from ocean surface, there is provision to tilt the OCM camera by +20 deg in the along the track direction. OCM and Scatterometer data on a single Carrier with QPSK modulation at 42.45 Mbps rate. The OCM data is transmitted on I-channel and SCAT / ROSA data will be transmitted on Q-channel each of 21.4515. Bitsyncdemod should be of 42.4515 Mbps capability.

Ocean Colour Monitor (OCM-2) Characteristics:

Payloads	Band	Wavelength	Application	swath	IGFOV /Resolution	Data Rate	Quantisation	Data Transmission
Ocean Color Monitor (OCM)	1	404-424 nm	Yellow substance Identification	1420 km	360x236 m	42.4515 Mbps	12bit	X Band(8300 MHz)
		431-451 nm	Chlorophyll absorption					
	3	476-496 nm	Chlorophyll and other pigments					
	4	500-520 nm	Turbidity and suspended sediments					
	5	546-566 nm	Chlorophyll reference					
	6	610-630 nm	Total suspended matter estimation					
	7	725-755 nm	Atmospheric correction					
	8	8845-885 nm	Atmospheric correction/aerosol optical thickness					

OCM-2 Modes of Operation

Oceansat-2 OCM LAC Coverage 360 m Spatial Resolution Real time transmission

Oceansat-2 OCM GAC coverage 1 Km/ 4 Km Spatial resolution Onboard recording and Playback

Oceansat-2 OCM Products:

- Local Area Coverage (LAC) - scene based products – 360m X 236m Resolution
- Global Area Coverage (GAC) Strip based products for -70 to + 70 deg (1 km resolution)

The LAC data is the full resolution products and the GAC data is the sub sampled data to approximately 1km X 1km spatial resolution. GAC data will be supplied free of cost through web and LAC data is charged as per the pricing cost.

OCM-II Data ProductsTypes:

LEVEL-1 Radiance Product
LEVEL-2 Geometrically corrected
LEVEL-3 Geometrically corrected Special Products
3A : Single Scene Product
3B : Binned Product

Sl. No.	Product type	Level	Aligned	Format Supported
1	Standard Product	Level-1	Path	HDF, LGSOWG
2	Geo-referenced	Level-2	North	HDF, LGSOWG
3	Special Products	Level-3	North	HDF

Special Products

- Chlorophyll Concentration Product
- Yellow Substance Concentration Product
- Total Suspended Sediment Concentration Product
- Atmospheric corrected Product

– Normalized water leaving radiances in Band-1 to Band-6

- NDVI using band 6 and band 8
- Aerosol Optical Depth at 865 nm
- Diffused Attenuation Coefficients (K-490nm)

Scatterometer:

Scanning Scatterometer (SCAT) - SCAT is an active microwave device designed and developed at ISRO/SAC, Ahmedabad. It will be used to determine ocean surface level wind vectors through estimation of radar backscatter. The scatterometer system has a 1-m parabolic dish antenna and a dual feed assembly to generate two pencil beams and is scanned at a rate of 20.5 rpm to cover the entire swath. The Ku-band pencil beam scatterometer is active microwave radar operating at 13.515 GHz providing a ground resolution cell of size 50 x 50 km. It consists of a parabolic dish antenna of 1 meter diameter which is offset mounted with a cant angle of about 46 degree with respect to earth viewing axis. This antenna is continuously rotated at 20.5 rpm using a scan mechanism with the scan axis along the +ve Yaw axis. By using two offset feeds at the focal plane of the antenna, two beams are generated which will conically scan the ground surface. The back scattered power in each beam from the ocean surface is measured to derive wind vector. It is an improved version of the one on Oceansat-1.[3] The inner beam makes an incidence angle of 48.90° and the outer beam makes an incidence angle of 57.60° on the ground. It covers a continuous swath of 1400 km for inner beam and 1840 km for outer beam respectively. The inner and outer beams are configured in horizontal and vertical polarization respectively for both transmit and receive modes. The aim is to provide global ocean coverage and wind vector retrieval with a revisit time of 2 days

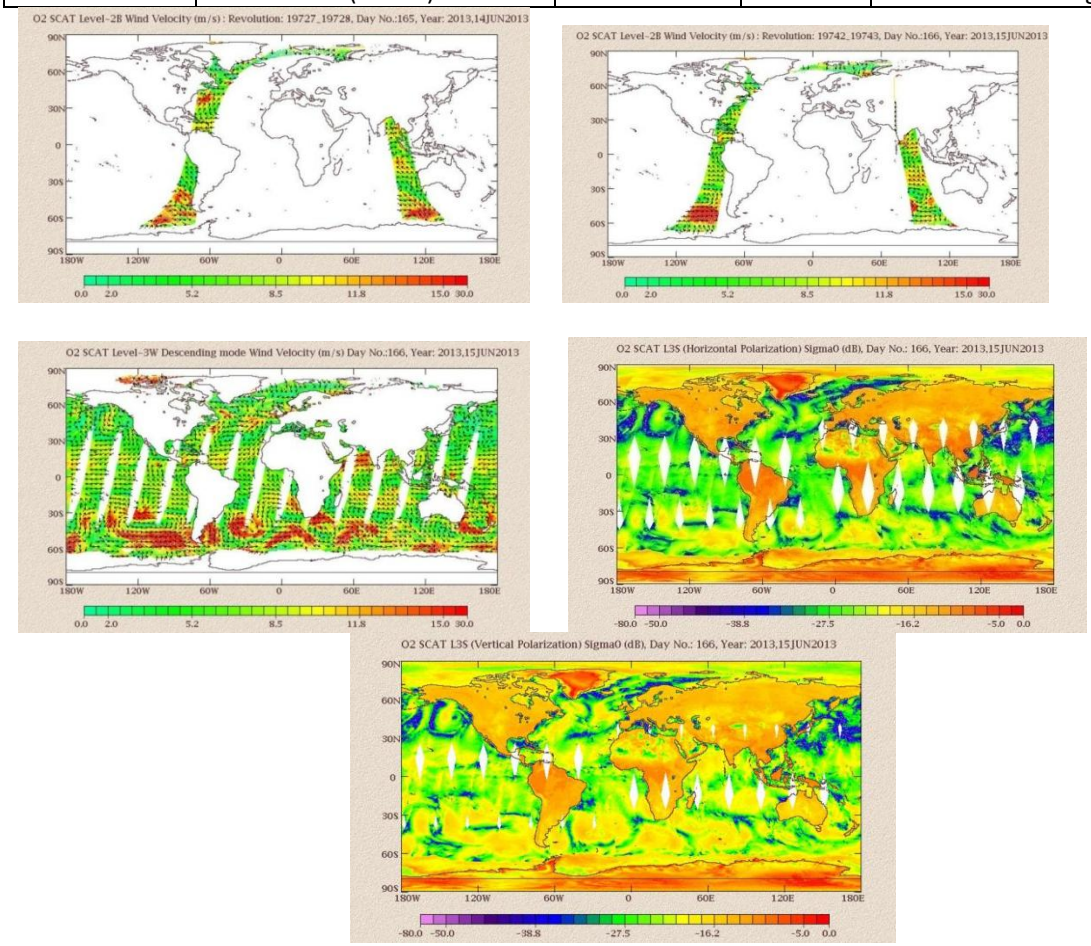
PARAMETER	SPECIFICATION
Frequency	13.73GHz
Wind speed range	4 to 24 m/s
Wind speedAccuracy	Better than 20%(RMS)
Wind DirectionAccuracy	20º rms
Resolution	50 X50 Kms
Polarisation	HH (inner) VV (outer)
Swath	1450 Km (inner) 1820 km (outer)

Data Products from Scatterometer:

Level 2A: Sigma - 0 values for a given orbit
Level 2B: Wind vectors for a given orbit
Level 3W: Global wind vectors
Level 3S (HH): Global sigma - 0 values in HH polarization
Level 3S (VV): Global sigma - 0 values in VV polarization

Scatterometer provides back scatter coefficients over the oceans. With these values, sigma - 0 and wind vectors in the entire globe will be computed and corresponding HDF products will be generated. These products will be supplied to users free of cost in HDF 5 format. Level 2A products will be provided to selected users. Level - 2B, Level - 3 products will be provided to all users through internet.

Processing Level	Parameter	Cell Size	Format	Availability
Level 2A	Sigma-0 (for each orbit)	50 x 50 km2	HDF	Selected users
Level 2B	Wind vector (for each orbit)	50 x 50 km2	HDF	Global users through Web
Level 3S	Sigma-0 (Global)	0.5º x 0.5 º	HDF	Global users through Web
Level 3w	Wind vector (Global)	0.5º x 0.5 º	HDF	Global users through Web



Sample products of Oceansat 2 Scatterometer winds

Radio Occultation Sounder for Atmosphere (ROSA): Radio Occultation Sounder for Atmospheric Studies (ROSA) - ROSA is a new GPS occultation receiver provided by ASI (Italian Space Agency). The objective is to characterize the lower atmosphere and the ionosphere, opening the possibilities for the development of several scientific activities exploiting these new radio occultation data set

PARAMETER	SPECIFICATION
Frequencies Of Operation	LI 1560 – 1590 MHZ L2 1212 – 1242 MHZ
GPS Codes used	C/A AND P- CODE
Antenna Gain	+ 5 DBI for navigation antenna + 12 DBI for RO antenna
Polarisation	RHCP
Horizontal Resolution	< 300 KMS for temperature & humidity
Vertical Resolution	0.3 KM (Low Troposphere) 1 – 3 KM (High Troposphere)
Accuracy	< 1.0 K Temperature 10 % OR 0.2G/KG Humidity
Input Signal Range	127 TO –133 DBM POD Antenna -130 TO –148 DBM RO Antenna

Radar Imaging Satellite (RISAT - 1):

The Radar Imaging Satellite (RISAT-1), launched on April 26, 2012, placed in the Polar Sun-synchronous orbit of 536 km height. RISAT – 1 is a new class of remote sensing satellite, distinct from the established IRS class, is developed by Indian Space Research Organization (ISRO) as its first satellite imaging mission using an active RADAR sensor system. RISAT - 1 carries a multimode C- band (5.35 GHz) Synthetic Aperture Radar (SAR) as the payload. The choice of C- band frequency of operation and RISAT - 1 SAR capability of imaging in HH,VV,HV,VH and circular polarizations will ensure wide applicability in the thrust areas like flood mapping, Agriculture & crop monitoring, generic Vegetation, Forestry, Soil Moisture, Geology,and Sea Ice and Coastal processes etc

	RISAT-1
Orbit	Circular Polar Sun Synchronous
Altitude	536.6 Km
Inclination	97.63°
No. of Orbits per Day	14
Antennae Type	Micro strip Active antenna
Antennae size	6m (along flight direction) 2m (across flight direction)
Attitude and Orbit Control	3-axis body stabilized using Reaction Wheels, Magnetic Torquers, and Hydrazine Thrusters Power
Swath Selectability	107 – 659 Km
Repitivity	25 days (MRS Mode) 13 days(CRS Mode)
Revisit Capability	3 - 4 days

Products &Services:

Products:

Following products are available from RISAT -1 as on 25Feb2013

•Level 0:•Raw data for FRS-1, MRS & CRS

•Level 1: Slant range Geo-tagged products for FRS-1 &MRS.Ground range Products - FRS 1,MRS&CRS

•Level 2: Terrain Corrected Geo Coded Products for FRS-1, MRS&CRS

• Projection: UTM/Polyconic (Level 2)

• Datum: WGS 84 (Level 2)

• Resampling: CC (Level 2)

• Format: CEOS (For all)/GeoTiff (Level 2)

SARAL:

The Satellite with ARGOS and ALTIKA (SARAL) is a joint Indo-French satellite mission for oceanographic studies. SARAL will perform altimetric measurements designed to study ocean circulation and sea surface elevation. It was successfully launched on February 25, 2013 into 781 km polar Sun synchronous orbit 98.538 degree. It is an operational class satellite bus with complete redundancy in mainframe systems by the modular mounting concept miniaturization The SARAL satellite is result of common interest of ISRO and CNES to study the ocean from space using altimetry system. Belongs to the global altimetry system for the precise and accurate observations of ocean topography, circulation and sea surface monitoring with same accuracy as ENVISAT and complementary to the JASON-2 mission.

SARAL/AltiKa main scientific objective is divided in sub-themes including:

- Intrinsic scientific studies of ocean at meso-scale dynamics: observations, theoretical analyses, modelling, data assimilation, parameterization.
- Improvement of our understanding of the oceanic component in the climate system: investigation of local processes at small or medium scale poorly known and understood at present, but which have an impact on the modelling of climate variability at large spatial and temporal scales.
- Contribution to the study of coastal dynamic processes, especially small or medium scale phenomena, whose retrieval will enable to anticipate many downstream applications.
- Contribution to operational oceanography which is seeking large amounts of in situ and space observation data.

SARAL/AltiKa secondary objectives are

- The monitoring of the main continental waters level (lakes, rivers, closed seas).
- The monitoring of mean sea level variations, the observation of polar oceans,

- The analysis and forecast of wave and wind fields,
- The study of continental ices and sea ices
- Tthe access to low rains climatology (enabled in counterpart to the sensitivity of Ka-band to clouds and low rains)
- Tthe marine biogeochemistry (notably through the role of the meso and sub-meso-scale physics).

Payloads:

Payload Interface Module (PIM) containing ARgos and ALtika

AltiKa Payload:ALtika payload is the first oceanographic Ka-band based altimeter. The use of Ka-band leads to a better spatial resolution and a high vertical resolution. ALtiKa instrument consists of Ka-band altimeter and an embedded dual frequency radiometer. This is coupled with the DORIS (Doppler Orbitography and Radio positioning Integrated by Satellite) tracking system for precise orbit determination and an LRA (Laser Retro reflector Arrray) for calibration i.e.

- A Ka-band (35.75 GHz, BW 500 MHz) radar altimeter
- A dual-frequency MW radiometer (23.8 and 37 GHz), for tropospheric range correction
- DORIS: For achieving adequate orbitography performances
- LRA: For orbitography and system calibration

Argos is a data collection platform and a Solid State C-Band Transponder:

Argos data collection platform helps in collecting data from more than 21,000 transmitters located throughout the globe. These data will be used for environmental monitoring, fleet management, tracking of animals & birds, locating buoys, enforcing maritime security etc.

Solid State C Band Transponder (SCBT) from VSSC, ISRO: for (SCBT) for calibration of Ground Radars at SDSC, SHAR.

Products:

The altimetry mission is focused to have repetitive global measurements of sea surface height, significant wave heights, back scatter coefficient, mean topography, sea surface height anomaly , range, altitude and wind speed for operational oceanography (study of mesoscale ocean circulation, coastal region observations, inland waters, marine ecosystems etc). It will also help in understanding of climate and developing forecasting capabilities. SARAL Applications: SARAL data products will be useful for operational as well as research user communities in many fields like

- Marine meteorology and sea state forecasting
- Operational oceanography
- Seasonal forecasting
- Climate monitoring
- Ocean, earth system and climate research
- Continental ice studies
- Protection of biodiversity
- Management and protection of marine ecosystem
- Environmental monitoring
- Improvement of maritime security

There are three different data products shall be produced and distributed to the users:

- Operational Geophysical Data Record (OGDR) produced in near real time,
- Interim Geophysical Data Record (IGDR) produced in 1 to 1.5 days,
- Geophysical Data Record (GDR) produced in 60 days.

The first one is a NRT product. The other two are OFL products.

In addition to the native NetCdf format a 1Hz BUFR-formatted dataset from the OGDR family (OGDR-BUFR) for distribution via the World Meteorological Organization (WMO) Global Tele-communication System (GTS) and EUMETCast is also generated.

Netcdf OGDR/IGDR/GDR products will have the same information and format. The only difference will be related to auxiliary data (orbit, meteo files, calibrations,).

Taking into account Jason-1/2 heritage, products will be split into several data sets:

- One "reduced" file, close to the current Jason-1/2 NRT-SSHA, limited to 1 Hz sampling,

- One "standard" file, close to the current Jason-1/2 I/GDR, containing 1 Hz and 40 Hz values,
- One "expertise" files, close to the current Jason-1/2 SGDR, containing 1 Hz, 40 Hz and waveforms values. This file will not be generated in NRT.

1.3.2 Status of spacecraft

IMAGING GEOMETRY AND MODES OF OPERATION: RISAT-1 is operated in the following modes in different Polarizations. In the absence of the emergency/user request the default mode of collection will be MRS descending, left looking, with dual polarization with a repeat cycle of 25 days

Imaging Modes	HRS*	FRS-1	FRS-2*	MRS CRS	CRS
Swath (Km) 10*10 25 25 115 223	Swath (Km) 10*10 25 25 115 223	Swath (Km) 10*10 25 25 115 223	Swath (Km) 10*10 25 25 115 223	Swath (Km) 10*10 25 25 115 223	Swath (Km) 10*10 25 25 115 223
Polarization	Single, Dual, Circular	Single, Dual, Circular	Quad, Circular	Single, Dual, Circular	Single, Dual, Circular
Resolution (Azimuth* Slant Range) (m)	1*1	3*2	9*4 3*4	21-23*8	41-55*8

MRS - Medium Resolution ScanSAR ; FRS- Fine Resolution StripMap ;CRS –Coarse Resolution ScanSAR: HRS- High resolution SPOT Light

Satellite& Orbit parameters:

SARAL

The data from the SARAL ALtika is being received at NRSC and is presently undergoing calibration and validation. The data is continuously being received in real time at shadnagar,INDIA in IMGEOS environment. The information is extracted and provided to ISTRAC for each Orbit for assessing the satellite health parameters.

Ground segment matters

Data reception:

NRSC's Ground Station is located at Shadnagar, 60 km south of Hyderabad city and is equipped with data acquisition systems which receive data from Indian Remote Sensing Satellites and foreign satellites based on the acquisition schedule. The Antenna Receive Systems are capable of receiving data in the frequencies of 2200-2300 MHz (S-Band) and 8000-8400 MHz (X band). The down converted demodulated data is fed to the processing.

Processing:

Pre-processing of data involves direct capturing of satellite data on high performance disk storage provide quick look displays for quick visual quality assessment. Pre-processing handles direct ingest of the data received from Demodulators through front end processor and archives the data in appropriate form. The data archived is processing to generate pre-processing inputs like orbit and attitude parameters and accession catalogues. Data product generation is done based on the user requests taking the data archives and pre-processing inputs like orbit and attitude and other mission parameters like sensor model, radiometric look up tables. The processed data is projected and packaged as per the user input. All generated products are verified to ensure the output complies with the quality criteria set. Special provisions are made to process the data in less than three hours' time from the time of acquisition to meet the emergency needs.

SARAL:

The two ground stations at Kiruna and Inuvik are regularly receiving the data from ALTIKA & ARGOS and data sets are made available in EUMETSAT Server after base processing. This data is fetched by NRSC using the dedicated link established for this activity

1.3.3 Data Dissemination

NRSC disseminates more than 50,000 satellite data products annually which are used for various operational projects addressing resource monitoring, cartographic applications, disaster management, climate change studies, ocean studies etc. The products are disseminated through media and FTP service.

1.3.4 Projects, services

SARAL

LIST OF INDIAN AO PROJECTS

	PI	Organisation	Title of the Project
1	Remko Scharroo	Altimetrics LLC, USA	Cross-calibration and validation of AltiKa altimeter data in the framework of the decadal sea level record, cal/val, sea level,
2	Ing. Wolfgang Bosch	DGFI, Munchen, Germany	Cross-calibration of SARAL-AltiKa altimeter data for improved estimation of ocean tides and ocean topography
3	Yi Chao	JPL, CIT, USA	Synergistic Applications of SARAL/ALTIKA Radar Altimetry in Regional Oceanographic Investigations
4	Ananda Pascual	CSIC Tenured Scientist Institut Mediterrani d'Estudis Avançats, Spain	On the use of SARAL/Altika products for coastal and MEsoscale studies in the BAlearic Sea: synergy with other sensors (SAMEBA)
5	Dimitris Menemenlis	JPL, CIT, USA	Evaluation and utilization of SARAL/AltiKa data for global ocean data assimilation
6	A. Ananda	RRSC, ISRO-DOS, Nagpur, India	Study of relationship between mesoscale oceanographic features and pelagic fisheries of Andaman and Nicobar Islnds
7	Satyendra M. Bhandari	ICCSIR, Ahmedabad – 380009, India	Microwave Signature characterization and study of the Environmental State of Sambhar Salt Lake using Radar Altimeter and PMR data from SARAL-AltiKa
8	Satyendra M. Bhandari	ICCSIR, Ahmedabad – 380009, India	Investigations of the Structure and Dynamics of the Polar Sea ice over the Marginal ice Zone in relation to climate

LIST OF FRENCH AO PROJECTS

	PI	Organisation	Title of the Project
1	Arnault Sabine	LOCEAN-IRD, FR	Tropical Atlantic Regional Studies using SARAL/Altika
2	Birol Florence	LEGOS, FR	Regional analysis at the Centre de Topographie des Oceans et de l'Hydrosphere (CTOH)
3	Calmant Stephane	LEGOS-IRD, FR	ALTIKAMALA
4	Chapron Bertrand	IFREMER, FR	Sea ice, rain, spectral analysis and high resolution measurements with AltiKa
5	SN Tripathi	IIT, Kanpur	Modeling and parameterization of microphysical and optical properties of mixed-phase clouds over Indian subcontinent
6	Cretaux Jean-Francois	LEGOS, FR	AltHydroKa
7	Dibarbourre Gerald	CLS, FR	Validation, Cross-calibration and Multimission Merging for High Resolution Altimetry, Ocean
8	Durand Fabien	LEGOS-IRD, FR	Circulation studies and Coastal Applications
9	Eymard Laurence	LOCEAN, FR	In-flight Calibration Validation, processing and exploitation of the MicroWave Radiometer onboard

CGMS

LIST OF INTERNATIONAL AO PROJECTS

	PI	Organisation	Title of the Project
1	Birkett Charon M.	University of Maryland USA	The Application of the SARAL/AltiKa radar altimeter data to Inland Surface Water Projects
2	BoschWolfgang	Deutsches Geodatisches Forschungsinstitut (DGFI)	Global Cross Calibration of SARAL/AltiKa altimeter data for improved estimates of Ocean Tides and Ocean Topography (CASA4OT2)
3	Bowers Todd	Naval Meteorology and Oceanography Command–OCEANO, USA	Inclusion of SARAL/AltiKa altimetry OGDR and IGDR data products into NAOCEANO altimetry data processing for ingest into oceanographic circulation models, as a follow-on to Envisat mission
4	Chao Yi	JPL, USA	Synergistic Applications of SARAL/ALTIKA Radar Altimetry in Regional Oceanographic Investigations
5	Cheng Kai-Chien	National Chung Cheng University, Taiwan	Absolute Calibration for AltiKa Altimeter Data in Taiwan Seas and the Great Lakes
6	Deng Xiaoli	University of Newcastle	Satellite AltiKa altimetry for monitoring of mesoscale variability of the Leuwin Current off Western Australia in Indian Ocean
7	Esselborn Saskia	GFZ	Comparison of Coastal AltiKa and tide gauges data around the Indian Ocean
8	Fenoglio-Marc Luciana	Darmstadt University of Technology	Regional Coastal Altimetry in Europe and Asia-Indonesia (RCA_EUR-IND)
9	Filizola Naziano	Amazonas State University, UEA	ALAMKA : Altimetric profiles of the Amazon rivers using AltiKa
10	Griffin David	CSIRO	Assimilation of AltiKa sea level data into the Australian Bluelink ocean nowcasting and forecasting systems
	Ichikawa Kaoru	Kyushu University	Detection of Coastal Velocity Variations in the Tsushima Strait
12	Janssen Peter	ECMWF, UK	Global Validation and Assimilation of SARAL/AltiKa Wind and Wave Products
13	Lazaro Claire	Universidade do Porto, Faculdade de Ciencias (FCUP)	Characterization of the subtropical Atlantic from the synergistic use of satellite altimetry and remote sensing data (AtlantiKa)
14	Lee Hyongki	PT	Surface water dynamics over the Congo Basin and over Arctic lakes using AltiKa altimeter data
15	Menemenlis Dimitris	JPL, USA	Evaluation and utilization of SARAL/AltiKa data for global ocean data assimilation
16	Mertikas Stelios	Technical University of Crete, GR	GAVDOS-AltiKa: Monitoring, Calibration and Validation of SARAL/AltiKa satellite altimeter measurements using the permanent facility on the island of Gavdos and Crete, Greece
17	Nerem Steve	University of Colorado, USA	Measuring global mean sea level variations from the SARAL/AltiKa mission
18	PascualAnanda	Institut Mediterrani d'Estudis Avancats, IMEDEA, ES	On the use of SARAL/Altika products for coastal and MEsoscale studies in the BAlearic Sea: synergy with other sensors (SAMEBA)
19	Quartly Graham	National Oceanography Center, Southampton (NOC), UK	KaNUTE

20	Richman James	Naval Research Laboratory, Navy, USA	Application of SARAL/AltiKa altimeter sea surface height data to global mesoscale ocean prediction
21	Scharroo Remko	Altimetrics, USA	Cross-calibration and validation of AltiKa altimeter data in the framework of the decadal sea level record
22	Shum C.K.	Ohio State University, USA	Interdisciplinary Science Using AltiKa Altimetry over Coastal Ocean, Solid Earth and Ice-Sheets
23	Turiel Antonio	Institut de Ciències del Mar- CSIC, ES	A synergistic approach to study oceans for climate purposes
24	Vigo Isabelle	Universidad de Alicante, ES	Surface geostrophic currents from altimetry and space gravity for the global ocean and the Mediterranean
25	Watson Christopher	University of Tasmania, AU	An Australian contribution to SARAL/AltiKa calibration and validation over ocean and ice

1.4 Status of current HEO [or other] satellite systems

Megha-Tropiques:

The tropical belt receives more energy from Sun than it radiates back into space. The excess energy is transported to temperate regions by the motion of atmosphere and oceans. Any variation in the energy budget of the tropics will therefore affect the whole planet. The energy exchanges are strongly linked to the water cycle and particularly to the tropical connective systems: huge amount of latent heat are released in the tropical rains, while high humidity and thick clouds strongly affect the radiation budget. Many interactions between radiation, water vapour, clouds, precipitation and atmospheric motion determine the life cycle of convective cloud systems, and the occurrence of extreme events like tropical cyclones, monsoons, flood and droughts. Due to dynamic nature of above parameters, the frequency of observation from low orbiting sun-synchronous orbits is inadequate. Only geo-stationary satellites allow continuous monitoring of the Tropics, but their Vis-IR sensors give limited information on the cloud surface properties or horizontal distribution of water vapour. Low orbiting (~800 km) satellites with low inclinations provide high repetitivity. An inclination at 20 degrees provides 6 observations of each point on the Inter-Tropical Convergence Zone (ITCZ). The most energetic tropical systems, such as the cloud clusters of ITCZ, the Monsoon systems and the Tropical cyclones, extend over hundreds of kilometers. Hence, a ground resolution of about 10 km is adequate for these observations.

The Megha-Tropiques satellite was successfully placed into a non-sun synchronous orbit at altitude of 867 km orbit with an inclination of 20 degrees to the equator on October 12, 2011. Megha-Tropiques is a one-tonne satellite which will be operated as part of a joint programme between the Indian Space Research Organisation (ISRO) and France's Centre National d'Etudes Spaciales (CNES). The spacecraft was constructed by ISRO, based around the IRS bus developed for earlier Indian satellites, and carries four instruments which will be used to study the Earth's atmosphere. ISRO is responsible of the system and the satellite. ISRO provides the launcher, the platform, part of the MADRAS instrument, the GPS receiver and the mission operation center, which will process all the products until level 1. ISRO also performs the integration and test of the MADRAS instrument, of the complete payload and of the satellite.

The major orbit parameters are:

Altitude:	**867 km, circular**
Inclination:	20°
Period:	102.16 minutes
Repetitivity:	97 orbits in 7 days
No. of Orbits Per day:	14 (approx.)

1.4.1 Mission objectives, payload/instruments, products

Megha-Tropiques is an Indo-French Joint Satellite Mission for studying the water cycle and energy exchanges in the tropics. The Megha-Tropiques is a unique satellite for climate research that should also aid scientists seeking to refine prediction models. The Megha-Tropiques has day, night and all-weather viewing capabilities;

it passes over India almost a dozen times every day, giving scientists an almost real- time assessment of the evolution of cloud.
The payloads have swaths of around 1700-200km. It is necessary to measure the above parameters for a minimum duration of 3 years in order to observe the inter-annual variability and getting an opportunity to observe El Nino-type events in the tropics
The main objective of the Megha-Tropiques mission is to study the convective systems that influence the tropical weather and climate. The Megha-Tropiques mission goals are as follows:

- To provide, simultaneous measurements of several elements of the atmospheric water cycle (water vapour, clouds, condensed water in clouds, precipitation and evaporation),
- To measure the corresponding radiative budget at the top of the atmosphere,
- To ensure high temporal sampling in order to characterize the life cycle of the convective systems and to obtain significant statistics.

Megha-Tropiques carries the following four payloads:
Microwave Analysis and Detection of Rain and Atmospheric Structures (MADRAS), an Imaging Radiometer developed jointly by CNES and ISRO, SAPHIR is sounder for Probing Vertical Profiles of Humidity from CNES, ScaRAB-Scanner for Radiation Budget from CNES and Radio Occultation Sensor for Vertical Profiling of Temperature and Humidity (ROSA), procured from Italy.

MADRAS is a microwave imager, with conical scanning (incidence angle 56°), close from the SSM/I and TMI concepts. MADRAS is a conical scanning microwave imager: the incidence has to be constant to take advantage of the polarization information. The spot size is always the same but the scan track follows a circle arc.The main aim of the mission being the study of cloud systems, a frequency has been added (150 Ghz) in order to study the high level ice clouds associated with the convective systems, and to serve as a window channel relative to the sounding instrument at 183 GHz.

Channel	Frequencies	Polarisation	Spatial resolution	Mission
M1	18.7 GHz	H+V	< 40 km	Rain above oceans, Wind speed
M1	23.8 GHz	V	< 40 km	Integrated water vapour
M1	36.5GHz	H+V	< 40 km	Liquid water in clouds, rain above
M1	89 GHz	H+V	< 10 km	Convective rain areas over land and
M1	157GHz	H+V	< 6 km	Ice in clouds

SAPHIR is a sounding instrument with 6 channels near the absorption band of water vapor at 183 Ghz. These channels provide relatively narrow weighting functions from the surface to about 10 km, allowing retrieving water vapor profiles in the cloud free troposphere. The scanning is cross-track, up to an incidence angle of 50°,the scan track is perpendicular to the satellite track and the spots enlarge with the scan angle. The resolution at nadir is of 10 km.
SAPHIR (Microwave Sounder) Characteristics(Swath: about 1700 km)

CHANNEL	CENTRAL FREQ. (GHZ)	POLARISATION
S1	183,31±0.20	V or H
S2	183,31±1.10	V or H
S3	183,31±2.70	V or H
S4	183,31±4.20	V or H
S5	183,31±6.60	V or H
S6	183,31±11.00	V or H

ScaRaB:
ScaRaB is a scanning radiative budget instrument, which has already been launched twice on Russian satellites. The basic measurements of ScaRaB are the radiances in two wide channels, a solar channel (0.2 - 4 µm), and a total channel (0.2 - 200 µm), allowing to derive longwave radiances. The resolution at nadir will be 40 km from an orbit at 870 km.

SCARAB CHANNEL CHARACTERISTICS:

Channel	Wave length	dynamics	Noise
Sc 1 -Visible	0,5 to 0,7 µm	120 W.m≤.sr-1	<1 W.m≤.sr-1
Sc 2 - Solar	0,2 to 4 µm	425 W.m≤.sr-1	<0,5 W.m≤.sr-1
Sc3 - Total	0,2 to 100 µm	500 W.m≤.sr-1	< 0,5 W.m≤.sr-1
Sc 4 - IR Window 1	0,5 to 12,5 µm	30 W.m≤.sr-1	< 0,5 W.m≤.sr-1

Main channels: Sc2 and Sc3
Sc1 and Sc4 are for scene identification and for compatibility with operational satellites. Longwave irradiance is calculated from the difference between Sc3 andSc2.

ROSA Radio Occultation Sensor:

Parameter	Specification
Frequency	L1 1.56 to 1.59 GHz; L2 1.212 to 1.242 GHz
GPS code used	C/A and P Code
GPS code used	<300 km
Hor Res	0.3 km (Low Troposphere); 1-3 km (High Troposphere)
Vert Res	<1 K Temperature; 10% or 0.2g/Kg Humidity

A large number of climate/atmospheric parameters from a common platform:
- Oceanic winds, humidity profile, liquid water, clouds,ice-clouds, radiation
Three types of L1 products will be disseminated to science users: L1A, L1B, L1C. The products are defined in the following sections.
Level-1A
It is the brightness temperature geo-tagged product for all channels in scan mode in HDF-5 Format.
Level-1B
It is the brightness temperature product in grid mode in HDF-5 Format
Orbit wise products will also be generated.
Level-1C
It is the brightness temperature geo-tagged product in co-located in scan mode in HDF-5 Format.
Two types of L2 products will be disseminated to science users: L2A, L2B. The products are defined in the following sections. In the frame of the MEGHA-TROPIQUES, some L2 products have to be disseminated in Near Real Time. They will be mentioned as NRT products and the other products as standard products..
All products L2A, L2B will be available as standard and NRT products

STANDARD PRODUCT
Standard products are defined orbit wise
Data latency of standard products is six hours (TBC) from data acquisition in nominal situation at MOSDAC.

NRT PRODUCTS
NRT products are dumping wise products. The amount of data of one NRT file will depend on the quantity of data transmitted to the ground station over one pass. Generally, the size of a NRT product will on average be equal to one orbit's data.
Data latency of the NRT products is expected to be less than 3.30 hours from sensing to users.

CGMS

1.4.6 Projects, services

Megha-Tropiques

LIST OF INDIAN AO PROJECTS

	PI	Organisation	Title of the Project
1	C Balaji	IIT, Madras	Development of Geo-Physical Retrieval Schemes and Validation of Data for the Megha Tropiques Mission
2	K Rajendran	CMMACS, Bangalore	The impact of physical assimilation of vertical profiles of latent heating and moistening on short range numerical weather prediction
3	OP Sharma	IIT, Delhi	Aerosol induced clouds microphysical property changes in a Chemistry GCM and their evaluation with Megha Tropiques Data
4	GS Bhat	IISc, Bangalore	Spatio-Temporal variation of water vapour and cloud characteristics derived from microwave sensors
5	SN Tripathi	IIT, Kanpur	Modeling and parameterization of microphysical and optical properties of mixed-phase clouds over Indian subcontinent
6	Animesh Maitra	Calcutta Univ.	Studies on Tropical Rain and Atmospheric Water content using ground based measurements and satellite data related to Megha Tropiques Mission
7	DM Puranik	Pune Univ.	Preparing for Megha-Tropiques: Diurnal variation of convection and cloud evolution using AMSU-B and Infrared data
8	K Kishore Kumar	SPL-VSSC, Trivandrum	A comprehensive study on tropical mesoscale convective systems using Ground based radars and Megha Tropiques
9	Sanjay Sharma	Kohima College	Study of the tropical Mesoscale Convective Systems by passive microwave sensors of Megha Tropiques mission in association with the Doppler radars and fast response rain gauges
10	D Narayana Rao	NARL, Gadanki	Megha Tropiques validation program
11	K Rajeev	SPL-VSSC, Trivandrum	A quantitative assessment of the cloud and aerosol radiative forcing over the Indian subcontinent and the adjoining oceanic environments
12	M Mahakur	IITM, Pune	Evolution and Spatial Distribution of Deep Convective Systems over the Indian Region
13	C Venkata Srinivas	IGCAR, Kalpakkam	Assimilation of Megha Tropiques Satellite Data in Meteorological and Atmospheric Dispersion Models for Environmental Studies at South East coast of India
14	C Suresh Raju	SPL-VSSC, Trivandrum	Modeling of Land surface emissivity in the microwave regime for Megha Tropiques
15	S Sampath	CESS, Trivandrum	Rainfall validation & characterisation and cloud physics studies using Megha Tropiques data
16	KVS Badarinath	NRSC, Hyderabad	Aerosol radiative forcing estimation from combined MODIS, MISR, OCEANSAT-2 Aerosol Optical Depth (AOD) and MT-SCARAB measurements
17	NVP Kiran Kumar	SPL- VSSC, Trivandrum	Studies related to precipitation by making use of existing ground based instruments and Megha-Tropiques
18	IML Das	Uni. of Allahabad	Rainfall estimation over ocean using MADRAS sensor of Megha-Tropiques and its validation

19	MR Ramesh Kumar	NIO, Goa	Diurnal cycle of precipitation over tropical Indian Ocean
19	MR Ramesh Kumar	NIO, Goa	Diurnal cycle of precipitation over tropical Indian Ocean
20	Mihir Kumar Dash	IIT, Kharagpur	Study of Variability in the Air-Sea Interaction over the Tropical Indian Ocean using the observations from Megha-Tropiques
20	Mihir Kumar Dash	IIT, Kharagpur	Study of Variability in the Air-Sea Interaction over the Tropical Indian Ocean using the observations from Megha-Tropiques
21	GV Rama	SDSC, SHAR	Participation in Validation and Utilisation of Megha-Tropiques data and Development of Algorithms for MADRAS
22	Kusuma Rao	ISRO HQ, Bangalore	On Mesoscale Convective Systems and Indian Monsoon Variability
23	V Sathyamoorthy	SAC, Ahmedabad	Effect of clouds on Radiation Budget over the Asian Monsoon Region using CERES and SCARAB data.
24	Randhir Singh	SAC, Ahmedabad	Assimilation of SAPHIR/Megha-Tropique Derived Moisture Profiles in Mesoscale Weather Prediction Model
25	Rashmi Sharma	SAC, Ahmedabad	Air-sea fluxes and circulation studies using Ocean General Circulation Model (OGCM)
26	Bimal Bhattacharya, Dr R P Singh	SAC, Ahmedabad	Retrieval of hydrological and radiation budget parameters using Megha Tropiques data for Land surface process studies
27	A K Sharma	IMD, Delhi	Analysis/Distribution of radiative fluxes and wind over Indian sub-continent and adjacent seas and their relationship with the regional climate.
28	A K Sharma	IMD, Delhi	Use of vertical humidity profile from Megha-Tropiques in NWP models of IMD.
29	V S Prasad	NCMRWF, Noida	Utilisation of Megha Tropique (MT) data at NCMRWF
30	Arindam Chakraborty	IISc, Bangalore	New Cloud Parameterisation scheme for GCM using MT
31	M Rajeevan	NARL, Gadanki	Earth Radiation Budget studies using MT SCARAB Data
32	M Sekhar	IISc, Bangalore	Validation of MT Rain rate Products and its applications in hydrology in Kabini river basin

LIST OF INTERNATIONAL AO PROJECTS

	PI	Organisation	Country	Title of the Project
1	Brett Candy	Met Office	UK	An Investigation Into Humidity Profiles Arising From The Assimilation of SAPHIR Data Within The Met Office Global NWP System
2	Steven Sherwood	Univ of New South Wales	Australia	Using MeghaTropiques data to test simulated extreme convection and convection-humidity interaction
3	Peter Bauer	ECMWF	Australia	ECMWF 4D Var assimilation of MT MADRAS and SAPHIR radiancve observations
4	Mathias Milz	Lulea Univ of Technology	Sweden	Validation of SAPHIR measurements with radiosondes, AMSU-B, and MHS and use of microwave satellite data to observe diurnal cycles in upper tropospheric humidity and cloud ice
5	Ziad Haddad	NASA-JPL	USA	Instantaneous vertical profiling of precipitation using MADRAS and SAPHIR
6	Arthur Hou	NASA Goddard	USA	Contributions of NASA Precipitation Science Research to the Megha-Tropiques Mission

7	Kenji Nakamura	Nagoya Univ	Japan	Impact Experiment of Megha-Tropiques to the Global Satellite Mapping of Precipitation (GSMaP) products
8	Byung-Ju Sohn	Seoul National Univ	Korea	Synergistic use of MT and COMS to understand the role of tropical convection in the upper tropospheric moistening and associated radiation balance
9	David Doelling	NASA Langley	USA	Comparisons of Scarab-3 and Ceres data and applications
10	Abdou Ali	Agrhymet	Niger	Evaluation of MeghaTropiques rainfall products over West Africa and their exploitation in the framework of AGRHYMET food security assessment activities
11	Edward Kim	NASA Goddard	USA	Intersatellite brightness temperature comparison and RFI surveying with the Madras and Saphir microwave radiometers on Megha-Tropiques
12	Lakshmi Kumar	SRM University City Campus	India	Development of a technique (Training and Genetic algorithm methods) for improved estimation of CNES rainfall product from Megha Tropiques over India, validation of new rain products, and assessing the impact of Megha Tropiques measurements
13	Hareef Baba Shaeb	ISRO-DOS, Nagpur	India	Retrieval of Solar insolation using SCARAB data: Validation and operational Applications
14	Flávio Ponzoni	NISR – INPE	Brazil	In-flight absolute calibration of ScaRAB sensor data
15	Mark Ringer	Met Office, Hadley Center	UK	Use of Megha-Tropiques data for climate model development and evaluation
16	Sante Laviola	ISAC-CNR	Italy	Convective and stratiform warm rain investigation
17	V. Chandrasekar	Colorado State University	USA	Collaborative research on Megha-Tropiques on radiometric retrievals and ground validation
18	Carlos Angelis	INPE	Brazil	Megha Tropiques data and products validation over South America
19	Eric A. Smith	CRCES	USA	Advancing Understanding of Monomodal and Multimodal Diurnal Variability of Precipitation at Tropical Latitudes by Combining Megha-Tropiques Datasets with TRMM and CloudSat Datasets
20	Arona Diedhiou	IRD-LTHE	France	Variability and Efficiency of Precipitating Systems over Africa
21	R A Houze	Univ. of Washington	USA	Monsoon studies using Megha-Tropiques

2 FUTURE SATELLITE SYSTEMS

2.1 Status of future GEO satellite systems

The next major upgrade in observations from geostationary platform will be in the INSAT-3D satellite which is scheduled for launch in July, 2013, and which will be an exclusive meteorological satellite carrying advanced meteorological payloads, viz. a 6-channel imager and a 19-channel sounder. It is similar to GOES satellite of USA. This INSAT-3D satellite will have many additional features like, 6-channel imager, 19 – channel Sounder, Data Relay Transponder (DRT) and satellite aided search and rescue (S&SR) payloads. INSAT-3D (Repeat) is planned to be launched in 2015. It will have similar payloads as in INSAT-3D for the continuation of operational service.

2.2 Future Geostationary Satellites

Sector	Long	Name	Operator	Launch	Instruments	Details
Indian Ocean	74 ° E	INSAT-3D-prime (Planned)	ISRO	≥2015	DRT (INSAT) IMAGER (INSAT-3D) SAS&R SOUNDER (INSAT-3D)	
	82 ° E	INSAT-3D (Planned)	ISRO	JULY 2013	DRT (INSAT) IMAGER (INSAT-3D) SAS&R SOUNDER (INSAT-3D)	

2.2.1 Mission objectives, spacecraft, payload/instruments, products

INSAT-3D:

The main objective are :-

- To monitor earth surface, carry out oceanic observations and its environment in various spectral channel of metrological importance.
- To provide vertical profile of various metrological parameters of the atmosphere.
- To provide data collection data decimation capability from automatic weather station (AWS) and automatic range gauges (ARG) platforms.
- To provide satellite aided search and rescue.

The metrological payloads on INSAT-3D are as follows:

Payloads	Channel	Resolution	Data Rate	Frequency
Imager	visible (0.52-0.77 um)	1x1 Km	3.92725 Mbps	4781 MHz
	SWIR (1.55-1.70 um)	1x1 Km		
	MIR (3.8-4.0 um)	4x4 Km		
	WV (6.5-7.1 um)	8x8 Km		
	TIR-1 (10.3-11.3 um)	4x4 Km		
	TIR-2 (11.5-12.5 um)	4x4Km		
Sounder	LWIR -7 channel (14.71-12.02 um)	10x10 Km	40.00 Kbps	4798 MHz
	MWIR-5 Channel (11.03-6.51 um)			
	SWIR-6 Channel (4.57-3.74 um)			
	VIS (0.695 um)			
DRT	Up link 402.75MHz			4506.05MHz

S&SR	Up link 406.05MHz			4507 MHz

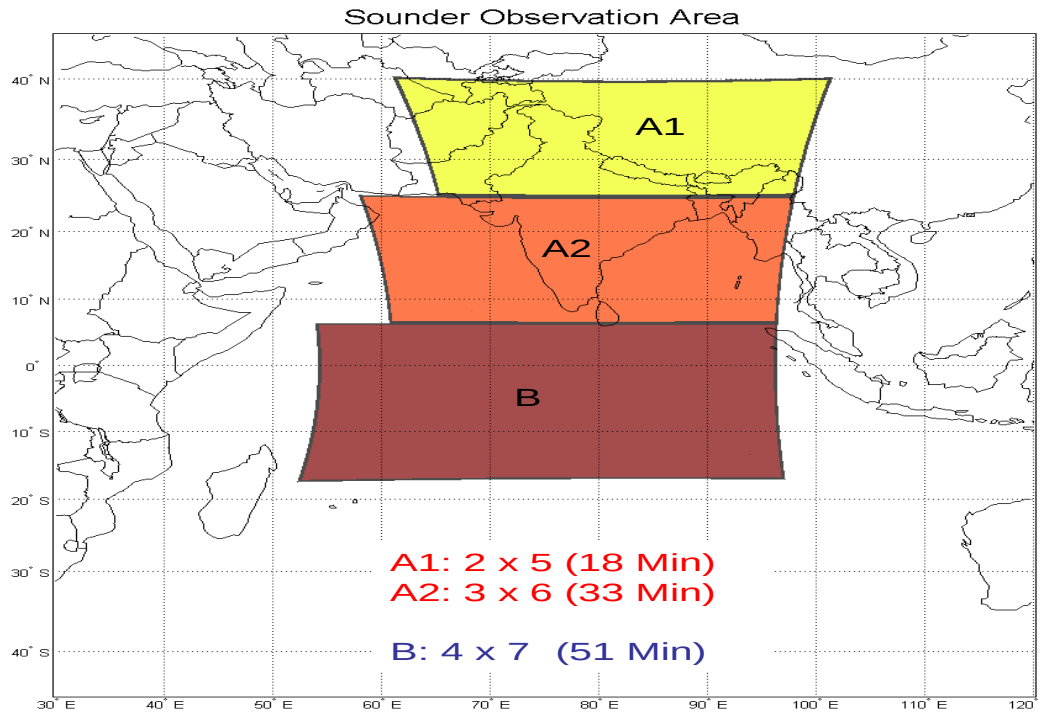
Proposed mode of operation of INSAT-3D, Imager and Sounder:

There are three modes of operation of INSAT-3D satellite for Imager & Sounder payloads:

Mode of Operation	Time of coverage	Coverage Area
Full frame mode	26 minutes	18x18 degrees
Programmed Normal scan mode	23 minutes	14x18degrees
Programmed Sector scan mode	6 minutes	4 degrees in NS & 18 degrees in EW

Sounder Scan Schedule (6 Hour cycle):

00:00-00.18Z : Region A1 00:20-00.52Z : Region A2
01:00-01.18Z : Region A1 01:20-01.52Z : Region A2
02:00-02.18Z : Region A1 02:20-02.52Z : Region A2
03:00-03.18Z : Region A1 03:20-03.52Z : Region A2
04:00-04.18Z : Region A1 04:20-04.52Z : Region A2
05:00-05.52Z: Region B



INSAT-3D Imager & Sounder Schedule:

Imager Time Schedule	IMAGER	REMARKS	SounderTime Schedule	SOUNDER
00:00	Full Frame		00:00-00:52	Region: A1,A2
00:30	Programmed			
00:52-00:59		House keeping		
01:00	Full Frame		01:00-01:52	Region: A1,A2
01:30	Full Frame			
02:00	Full Frame		02:00-02:52	Region: A1,A2
02:30	Full Frame			
03:00	Full Frame		03:00-03:52	Region: A1,A2
03:30	Programmed			

03:52-03:59		House keeping		
04:00	Full Frame		04:00-04:52	Region: A1,A2
04:30	Full Frame			
05:00	Full Frame		05:00-05:52	Region B
05:30	Full Frame			
06:00	Full Frame	(Repeat Cycle)	06:00 – 06:52	Region A1,A2, B (Repeat Cycle)

Full Frame : 18deg x 18 deg
Programmed Normal scan mode: 14deg x 18 Deg
Programmed Sector scan mode will be based on user requirement: 4 degrees in NS & 18 degrees in EW

Product to be retrieved from INSAT-3D

S. No.	Product
1	Atmospheric Motion vector
2	Water vapour wind
3	Sea surface temperature (SST)
4	Temperature, Humidity vertical profile and total ozone
5	Outgoing long wave radiation (OLR)
6	Quantitative precipitation estimate (QPE)
7	Snow cover, snow depth
8	Fire
9	Smoke
10	Aerosol
11	Fog
12	Geopotential height
13	Layer and total perceptible water
14	Lifted index
15	Upper tropospheric humidity (UTH)

2.2.2 Ground segment matters

INSAT-3D Meteorological Data Processing System (IMDPS)
INSAT-3D Meteorological Data Processing System (IMDPS) is the ground segment system for data Processing and Products Generation installed by ISRO in IMD New Delhi in the year 2009.The proposed system acquire raw data from serial data streams, producing quality Data Products (DP) and generate various quantitative Geo-Physical products (GPR) from the processed data for operational utilization by various users. The Products thus produced are being operationally displayed for the current KALPANA-1, INSAT-3A missions by the indigenous designed Satellite Imagery Display System throughout the campus of IMD, Delhi, SAC-BOPAL, and Ahmedabad on an 24 x 7 basis for every half hour images processed. Additionally, the system is capable of processing, ingesting and analyzing Automatic Weather Station (AWS) and Global Telecommunication System (GTS) data. A large number of meteorological parameters and application-products are required to be derived from the raw data of satellite-sensors, AWS and GTS data as well as conventional meteorological data.
The deliverables will include Data acquisition quick display system, Data products generation, Parameter retrieval and image processing and Visualization display system solutions, data visualization comprising of both hardware and software systems for the near real time Data Processing and dissemination of Meteorological Data Products on the WEB. The Radiometric calibration as part of data pre-processing is carried out based on the extensive ground calibration data supported by ground and on-board calibration techniques, which tracks changes in the instrument response due to in-orbit thermo-mechanical environment, radiation effects and aging. The geometric correction, re-sampling is performed on the radiometric corrected pixel-data based on static and dynamic models of the instrument and satellite as well as orbit and attitude parameters available simultaneously with the imaging data and produces various levels of data products. A further precision/improved accuracy is necessary which requires in registering the image-pixels on fixed lat-long grids

would be achieved through image navigation and registration algorithm in an automatic/interactive approach. The Data Products Software providing the capability for generation of Various levels of Data Products (LEVEL-0, LEVEL-1 , LEVEL-2 and LEVEL-3) on the user requested media and in the required formats HDF-5 and also in the generic binary format.
The various types of products generated by the Data Products System are
- LEVEL - 0 (Raw) – for internal use and archival
- LEVEL - 1 (Full Globe)
- LEVEL - 2 (Sector)
- LEVEL - 3 (Geo-Physical)

2.2.3 Data Transmission

The processed data, imagery and products will be disseminated through IMD, ISRO official websites on a real time basis. Status of future R&D satellite systems
GISAT (Geo-stationary Imaging Satellite) is planned as geo-stationary imaging satellite providing continuous imaging of earth disk or region of interest with high resolution.

2.2.4 Mission objectives, spacecraft, payload/instruments, products

The main objectives of GISAT are meteorology, weather forecasting, agriculture, forestry, oceanography, mineralogy, disaster monitoring, etc. In order to cater to these requirements, the payloads are configured to cover visible to long-wave infrared region of the spectrum with high spectral and spatial resolution as well as high sensitivity.
The imaging system is based on telescope with large-sized mirror which collects energy received from earth. Collected energy is focused onto the focal plane where it is dispersed spectrally, integrated using photosensitive detectors and subsequently digitized and processed in electronics chain. The payloads consist of four spectral bands:
1. Multi-spectral visible and near-infrared (MX-VNIR)
2. Hyper-spectral visible and near-infrared (HySI-VNIR)
3. Hyper-spectral shortwave-infrared (HySI-SWIR)
4. Multi-spectral long wave-infrared (MX-LWIR)

The payloads are push-broom type with line imaging. Two-dimensional imagery is generated by slewing the spacecraft in a particular direction and stepping in orthogonal direction. All the bands can be operated simultaneously, or some combination can be selected depending upon observation requirement. The imaging system is configured around Cartosat-2 telescope with modified RC system consisting of two-mirror telescope with 700mm clear aperture and field correcting optics (FCO). Spectral elements consist of multi-band strip-filters (MX-VNIR and MX-LWIR) and grating spectrometers (HySI-VNIR and HySI-SWIR). Detectors are placed at separate field points to minimize energy loss. Electronics systems comprise of detector interfaces, video processing, control and data handling, spacecraft interfaces and power electronics. Instrument design is modular and separate for each band.

ACTIONS AND/OR RECOMMENDATIONS FOR CONSIDERATION BY CGMS PLENARY SESSION

3 CONCLUSIONS

…