Frequently Asked Questions - Satellite Related

1.What is a Satellite ?

Circling the earth, high above our heads, satellites are messengers and observers in the sky. They relay telephones calls, watch the weather, guide ships and aircrafts and carry out tasks that are impossible on the ground.

2.What is Satellite Meteorology ?

Satellite Meteorology refers to the study of earth's atmosphere and oceans using data obtained from remote sensing devices flown onboard satellites orbiting the earth. Satellite make measurements indirectly by sensing electromagnetic radiations coming from the surfaces below.

3.What is Satellite Orbit ?

A satellite's orbit is the curved path it follows around earth. The pull of gravity is stronger closer to the earth, so a satellite in a low orbit must travel faster than one in a geostationary orbit.

4.Geostationary orbit ?

Satellite in a circular orbit about 36000 km above the equator move in time with earth. Satellites in this orbit are called geostationary because they are stationary with respect to the earth and appear to be fixed in sky.

5.Polar orbiting satellites ?

Due to the rotation of the Earth, it is possible to combine the advantages of low-altitude orbits with global coverage, using near-polar orbiting satellites, which have an orbital plane crossing the poles.

These satellites are launched into orbits at high inclinations to the Earth's rotation (at low angles with longitude lines), such that they pass across high latitudes near the poles.

6.Which satellites are being used to monitor the weather of Indian region ?

Kalpana-1 located at Longitude 74° E and Insat-3A located at 93.5° E both geostationary satellites are being used to monitor the weather of Indian region.

For meteorological observation, INSAT-3A carries a three channel Very High Resolution Radiometer (VHRR) with 2 km resolution in the visible band and 8 km resolution in thermal infrared and water vapour bands. In addition, INSAT-3A carries a Charge Coupled Device (CCD) camera which operates in the visible, near infra Red and short wave infrared bands providing a spatial resolution of 1 km. A Data Relay Transponder (DRT) operating in UHF band is incorporated for real-time hydro meteorological data collection from unattended platforms located on land and river basins. The data is then relayed in extended C-band to a central location. Kalpana -1 Satellite has a 3- Channel VHRR and DRT similar to INSAT -3A Satellite.

7. What is a satellite image?

It is a pictorial representation measuring the electromagnetic energy recorded by a sensor, not by photography. A photograph is normally taken within a certain spectral range (visible light). Satellites take images outside this limited range.

8.What do IR and VIS mean? What do we see on IR and VIS images?

IR stands for infrared. On an image, IR is usually followed by a wavelength in micrometers (e.g. 10.7). In the IR spectrum, clouds at different heights show up very well as differences in radiances (quantity of light energy detected) from ground level (radiances vary with cloud height). Radiances can then be converted into temperatures with some calculation. So what we see on an IR image is the distribution of temperatures as detected by the satellite's sensor, and the temperature in the legend corresponds to the temperature of whatever the satellite sensor "sees" (clouds at different heights, sea surface, and earth surface).

VIS stands for visible. A VIS satellite image (taken in the visible spectrum) is a picture of the earth from space, just as you would see it if you were looking out the window from a spacecraft in orbit. During nighttime the picture is dark.

9.Which products are being derived from operational Indian Geostationary Meteorological Satellites?

The following products are being derived from INSAT satellites
Outgoing Longwave radiation (OLR)

Sea surface temperature (SST)

Quantitative precipitation estimate (QPE)

Cloud Motion vectors (CMV)

Water Vapour Wind (WVW)

Cloud Top Temperature (CTT)

Visible Channel Image

Infrared Channel Image

Colour Composite Channel Image

Water vapour Channel Image

10. Outgoing long wave radiation (OLR)

Majority of meteorological sensors operate in long wave range of radiation so that:

1. They operate day and night
2. The problem of low albedo is not encountered
3. The earth radiation is maximum and thermal IR and ocean emissive is nearly unity.

Keeping the above into mind the outgoing flux of long wave radiation at the top of atmosphere is an important parameter in the earth atmosphere radiation budget. This parameter can be derived by physical/statistical algorithm from the narrow band.

11.Sea Surface Temperature (SST):

As we know oceans are the major storage of heat in the earth climate systems. Sea Surface Temperature (SST) is one of the key controllers of climate variability and acts as a vast thermal reservoir. SST regulates the transfer of long wave radiation to the atmosphere as well as the latent and sensible heat fluxes into the lower atmosphere.

12.Quantitative Precipitation Estimate (QPE)

It is one of the key meteorological parameter. A detailed knowledge of its distribution in space and time is essential for understanding weather & climate. Information about rainfall is of great value in variety of discipline beside being control to human survival scientifically The latent heat released during the process of condensation water into cloud and rain drops is one of the significant energy source responsible for atmospheric heat engine.

13. How the CMVs generated

In general, there are five steps in the derivation of Cloud Motion Vectors :

1.Registration of Triplet
2.Cloud Tracers selection
3.Tracking of Cloud Tracer in the Target image
4.CMV Computation
5.Height Assignment
6.Quality Control of Cloud Motion Vectors.

INSAT-based CMVs are particularly useful in the analysis of upper winds during the monsoon season to study the formation of eddies, cross –equatorial flow, approach of the two separate branches of the monsoon.

Three levels of the INSAT CMV are:

Low Level CMV – 1000 hpa – 700 hpa.
Medium Level CMV – 700 hpa – 300 hpa
High Level CMV – 300 hpa and above.

14.What is a sector ?

To study the weather condition of a particular region, we can select that area which is known as sector. We are interested in the weather of India, so we select that area.

15.What is a Geostationary Satellite?

Geostationary satellites are positioned at an height above the earth about 36000 Km. At this height they rotate around the earth at the same speed as the earth rotates around its axis, so in effect remaining stationary above a point on the earth (normally directly overhead the equator).

As they remain stationary they are ideal for use as communications satellites and also for remote imaging as they can repeatedly scan the same points on the earth beneath them.

Polar Orbiting satellites by comparison have a much lower orbit, moving around the earth fairly rapidly, and scanning different areas of the earth at relatively infrequent periods.

16.What are the advantages / disadvantages of Geostationary Satellites for remote imaging?

As they are positioned at such a high altitude the spatial resolution (i.e. amount of detail shown) of their images (typically 2.5 Km per pixel) tends to be not as good as some polar orbiting satellites (typically 1 Km to 50m per pixel), which are much closer to the earth.

However the advantage of their great height is that they can view the whole earth disk below them, rather than a small subsection, and they can scan the same area very frequently (typically every 30 minutes). This makes them ideal for meteorological applications.

One big problem with Geostationary satellites is that since they are always positioned above the equator they can't see the north or south poles and are of limited use for latitudes greater than 60-70 degrees north or south. The farther from the equator the lower the spatial resolution of each pixel and the greater the possibility of being hidden by the earth's curvature.

17.What are Image Channels?

The satellites typically scan the earth using different wave lengths (channels). Current INSAT geostationary meteorological satellites have 3 channel imager with the following channels:

i) VISIBLE wavelengths (0.55 - 0.75 um) (reflected solar radiation).

ii) IR (thermal infra-red) (10.5 - 12.5 um). (emission channel. Each point on the earth emits radiation in proportion to its hotness/coldness. So this channel gives a thermal image of the earth)

iii) WV (water-vapour) (5.7 - 7.1 um). (This is also an emission band. The image shows differences in water vapour absorption in the atmosphere).

18.Why are some images missing?

There are times when there are glitches in our system, but a more likely explanation is the problem in reception or dissemination of the image. The problems in reception include, an artifact effect in the images, patch temperature variation, or satellite maintenance problems. However, these are relatively rare.

19.How are water vapor satellite images used?

Basically, water vapor images and loops/movies show how moist or dry the middle and upper atmosphere is. They also show the air circulation in the middle and upper atmosphere.

20.What is GMT or UTC?

GMT stands for Greenwich Mean Time, now called UTC (Universal Coordinated Time), and is the local time at Greenwich-England, which is at 0° longitude. Weather observations, including satellite images, are recorded in GMT as a way of solving the problem of trying to use weather data from different time zones.

21.Why are meteorological satellites needed?

Meteorological satellites provide important information to be used in more accurate weather forecasts and global climate monitoring.

22.What is the difference between geostationary and polar orbiting satellites?

A geostationary satellite is positioned above the Equator and orbits the Earth at the same rotation speed as the Earth itself, making it appear stationary from the point of view of an observer on the Earth's surface. It flies very high above the surface of the Earth (altitude almost 36000 kilometers), and thus is able to capture the whole Earth disc at once. A polar orbiting satellite circles the Earth at a near-polar inclination, meaning that it always passes almost exactly above the poles. The satellite passes the equator and each latitude at the same local solar time each day, meaning the satellite passes overhead at essentially the same solar time throughout all seasons of the year. The low Earth orbit (800 - 850 kilometers) is much closer to Earth than a geostationary orbit, and thus can see a smaller part of the Earth below than a geostationary satellite, but in finer detail.

23.What is validation?

In order to check the validity of the satellite measurements, it has to be compared against ground measurements (balloon soundings, lidar measurements, UV measurements etc.). This process is called validation.

24.What are the new geostationary satellites that will be launched by India?

INSAT –3D meteorological geostationary satellite will be launched in the latter half of 2009 by ISRO.

25.What is special about the INSAT 3D satellite?

It will have two payloads- a 6-channel Imager and a 19 −channel Sounder almost similar to GOES satellites of USA. It will also have a Data Relay Transponder (DRT) similar to Kalpana-1 and INSAT-3A.

Unlike previous geostationary meteorological satellites launched by India, this satellite will permit programmable scanning of a special sector, with defined N-S and E-W coordinates. Scanning will also be faster and the data will be at a higher resolution as compared to the currently operational satellites. So the geophysical products derived during the scanning will be more accurate and of higher resolution.

26.What are the specifications of the INSAT 3D satellite imager channels?

Spectral Band	Wave length(um)	Ground Resolution	Quantization bits	IGFOV (urad)
VIS	0.55-0.75	1 Km	10	28
SWIR	1.55-1.70	1 Km	10	28
MIR	3.80-4.00	4 Km	10	112
WVP	6.50-7.10	8 Km	10	224
TIR 1	10.2-11.3	4 Km	10	112
TIR 2	11.5-12.5	4 Km	10	112

27.What are the specifications of the INSAT 3D satellite sounder channels?

ChannelNo	Central Wavelength(υm)	Bandwidth(υm)	Principalabsorbingconstituents
1	14.71	0.281	CO_2
2	14.37	0.268	CO_2
3	14.06	0.256	CO_2
4	13.96	0.298	CO_2
5	13.37	0.286	CO_2
6	12.66	0.481	Water Vapour
7	12.02	0.723	Water Vapour
8	11.03	0.608	Window
9	9.71	0.235	Ozone
10	7.43	0.304	Water Vapour
11	7.02	0.394	Water Vapour
12	6.51	0.255	Water Vapour
13	4.57	0.048	N_2O
14	4.52	0.047	N_2O
15	4.45	0.0456	CO_2
16	4.13	0.683	CO_2
17	3.98	0.0663	Window
18	3.74	0.140	Window
19	0.695	0.050	Visible

N.B. All bands have spatial resolution of 10 km. All bands have radiometric resolution of 12 bits/sample

28.What products will be derived from INSAT –3D imager payload?

1. **Outgoing Long wave Radiation (OLR)** using TIR -1, TIR -2, WV channels
2. **Quantitative Precipitation Estimation (QPE)** using TIR -1, TIR -2, WV channels
3. **Sea Surface Temperature (SST)** using SWIR,TIR -1, TIR -2, MIR channels
4. **Snow Cover** using VIS, SWIR, TIR -1, TIR –2 channels
5. **Snow Depth** using VIS, SWIR, TIR -1, TIR –2 channels
6. **Fire** using MIR, TIR -1 channels
7. **Smoke** using VIS, TIR -1, TIR -2, MIR channels
8. **Aerosol** using VIS, TIR -1, TIR –2 channels
9. **Cloud Motion Vector (CMV)** using VIS, TIR -1, TIR –2 channels
10. **Water Vapor Wind (WVW)** using WV, TIR -1, TIR –2 channels
11. **Upper Tropospheric Humidity (UTH)** using WV, TIR -1, TIR –2 channels
12. **FOG** using SWIR, MIR , TIR -1, TIR –2 channels
13. **Normalized Difference Vegetation Index** using CCD payload channels
14. **Flash Flood Analyzer** using TIR -1, TIR -2, VIS channels
15. **HSCAS** using VIS channels
16. **Tropical Cyclone-intensity /position by AODT technique** using TIR-1,TIR-2

29.What products will be derived from INSAT –3D sounder payload?

1. **Temperature and Humidity profile** using Brightness temperatures for 18 Sounder Channel and grey count for channel 19
2. **Geo-potential Height** using Sounder retrieved temperature and humidity profiles at 40 pressure levels
3. **Layer Perceptible Water** using Retrieved humidity at standard pressure levels
4. **Total Perceptible Water** using Retrieved humidity at standard pressure levels
5. **Lifted Index** using Sounder retrieved temperature and humidity profiles at standard pressure levels
6. **Dry Microburst Index** using Sounder retrieved temperature and humidity profiles at standard pressure levels
7. **Maximum Vertical Theta-E Differential** using Sounder retrieved temperature and humidity profiles at standard pressure levels
8. **Wind Index** using Geo- potential Height and retrieved temperature and humidity profiles at standard pressure levels
9. **Ozone** using Brightness temperatures for 18 Sounder Channel and grey count for channel 19

Frequently asked questions – GPS Related

1. What is GPS?

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit in six orbital planes at an altitude of 20200 Km above the earth surface with an orbital period of 12 hrs by the U.S. Department of Defense. GPS works in any weather conditions, anywhere in the world, 24 hours a day.

2. What is GPS signal?

Each GPS satellites carries onboard atomic clocks and transmits low power radio signals at L1=1575.42 MHz and L2 =1227.6 MHz. A GPS signal contains three different bits of information — a pseudorandom code, ephemeris data and almanac data.

3. How does GPS receivers determine its 3D position from GPS signal?

The GPS receiver compares the time a signal was transmitted by a GPS satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position by triangulation. Precise location of interest to geophysists required correction of position errors due to atmospheric delays.

4. What are the errors involved in the GPS signal measurements?

- Satellite clock error
- Orbital error,
- Receiver errors
- Atmospheric/ionospheric error and
- Selective Availability etc.,

5. What is GPS Meteorology?

A technique which uses the atmospheric delay error of the GPS signals to determine the amount of Integrated Precipitable Water Vapour (IPWV) in the troposphere.

6. What is Integrated Precipitable Water Vapour (IPWV)?

The amount of atmospheric water vapour (in kilogram) overlying per unit area of the earth surface. Its unit is kg/m^2.

7. What is Precipitable Water Vapour and how it is related with IPWV?

PWV is defined as the height (mm) of liquid water that would result from condensing all the water vapour in a column from the surface to the top of the atmosphere. In other words $PWV = IWV/\rho$, where ρ is the density of water in kg/m^3.

8. What are the two types of atmospheric Delay? And how it can be removed?

The atmospheric delay can be divided into two parts, Ionospheric delay and neutral atmospheric delay (or Tropospheric delay). Both Ionosphere and neutral atmosphere introduce propagation delays into the GPS signals. The ionospheric delay can be determined and removed by measuring the time of flight between two RF signals (L1 and L2) that travel along similar paths using dual frequency receiver and exploiting the known dispersion relations for the ionosphere.

The troposphere, which contains most of the water vapour delays both the L1 and L2 signal equally. Signal delays in this region are due to changes in pressure, temperature and water vapour. Therefore tropospheric delay cannot be minimized by using the dual frequency receiver since the electrically neutral atmosphere is nondispersive below 30 GHz. However this can be removed by using special geodetic algorithms.

9. What are the components of Tropospheric delay? And how it can be calculated?

Tropospheric delay has two components: Hydrostatic and Wet delay. The Hydrostatic delay is due to the total mass of the atmosphere which can be determined by accurate measurement of surface pressure and wet delay is due to total amount of water vapor along the GPS signal path and can be calculated by subtracting hydrostatic delay from the tropospheric delay.

10. What is Mapping function? And how IPWV derived from the wet delay?

Mapping function relates the Zenith path delay to delays along paths with arbitrary elevation angle. Depending on the mapping function used, the hydrostatic and wet components can be incorporated together or treated separately. The IPWV derived from wet delay by multiplying with some constants, which is function of mean temperature of the atmosphere and the specific gas constant for water vapour.

11. How Accurate is the GPS derived IPWV?

GPS data can be reliably used to estimate PWV with 1-2 mm accuracy and 30 minute temporal resolution.

12. What is the use of GPS derived IPWV?

- Nowcasting (for example Fog forecast, Flash flood monitoring, Thunderstorm etc)
- NWP model for short term forecast between 6-12 hours
- Climate studies
- IPWV comparison with other independent method