Information about Satellite Products on Website

1.Quantitative Precipitation Estimate (QPE)

The technique used here for QPE was developed by Arkin (1979) to estimate tropical precipitation for climatological purposes. Arkin found that radar-estimated precipitation was highly correlated with the fraction of the area covered by pixel colder than 235 K. Of course, the correlation coefficient depends on the area and time over which the precipitation is estimated. Richard and Arkin (1981) tested averaged areas between 0.5x0.5 and 2.5x2.5 latitude and averaging time from 1 to 24h. They found that correlation increases with averaging area and with averaging time.

Arkins and Meisner (1987) call their precipitation estimate GOES Precipitation Index (GPI). They use a 235 K threshold and a constant rain rate R of 3 mm/h. The precise equation is;

$$GPI = Rf\Delta t$$

where GPI is an estimate of the mean rain depth (millimeters) in the area, f is the fraction of area colder than the threshold (235K), and Δt is time in hours for which f applies (e.g. if the images are collected each 1h, then $\Delta t = 1$).

References

Arkin, P. A (1979) . The relationship between fractional coverage of high cloud and rainfall accumulation during GATE over the B-scale array. Mon. Wea. Rev, 107, 1382-1387.

2.Outgoing Long wave Radiation (OLR)

The total amount of the radiation that is emitted from the earth-atmosphere system to the outer space in 3 – 100 µm wavelength bands is called Outgoing Long wave Radiation (OLR).

OLR is an important value for the earth radiation budget. Absorption of solar radiation and emission of terrestrial radiation drive the general circulation of the atmosphere and are largely responsible for the earth's weather and climate.

The Very High Resolution Radiometer (VHRR) infrared channel data has been used for the computation of OLR. The spectral response characteristics of this window channel has been considered for obtaining the OLR flux given by

$$T_f = T_{BB}\,(a + T_{BB}\, b \cos(\alpha))$$

Where T_f is flux equivalent temp in K, T_{BB} is the equivalent blackbody temperature in K measured by satellite, b and a are constants and α is the satellite zenith angle.

OLR is then computed as

$$OLR = \sigma T_f^4$$

Where σ is the Stefan Boltzmann constant (Ohring et al., 1984) and . OLR has been computed in units of Watts/m^2.

References

Ohring, G., and R. G. Ellingson, 1984: Satellite determination of the relationship between total long wave radiation flux and infrared window radiance, J. Climate Appl. Meteor., 23, 416-425.

3.Atmospheric Motion Vectors

The Cloud Wind Motion algorithm measure the displacement of cloud patterns between currently 3 slots of images and through this displacement computes the wind vectors. Automatic tracking is done primarily using the cross-correlation method. In the first of the two images, a target array of typically 20x20 pixels (*defined by the user*) is selected. The problem is to locate this area in the second image, assuming that the clouds have moved but changed little, during the time interval between images. A search array typically 60x60 pixels (for IR) and 50x50 (for Water Vapor) centered on the location of the target array is chosen in the second image.

The extraction process runs in two different modes. In the backward correlation mode, one tries to locate a cloud pattern (tracers) found in the segment of a target image in the previous image, the search image, and to derive from the displacement of the patterns in the two images the wind speed and direction. In the forward correlation mode, the same analysis is performed using the succeeding image as the search image. Currently, the winds of a backward correlation are combined with the winds of a forward correlation using the same slot as target in the two correlation processes. The target slot is therefore the central slot of consecutive triplets of images. Since the same target slot is used, there is no problem in identifying half-winds belonging together, performing a consistency check on them with respect to speed and direction and combining them into one wind. The quality of the individual spectral winds is characterized by a set of quality indicators which are amalgamated into a quality mark.

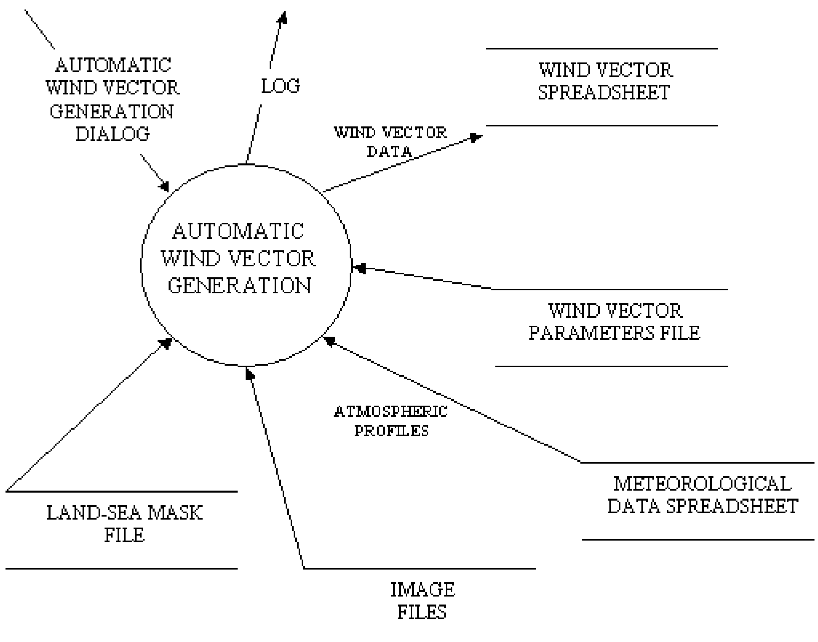
Several methods can be used to make the height estimate of the wind, comparison of the equivalent blackbody temperature of the cloud top with a numerical forecast of the vertical profile and the H_2O-intercept (Nieman et al, 1997). The H_2O-intercept is predicated on the fact that the radiances from a single-level cloud deck for two spectral bands vary linearly with cloud amount. Radiances from the infrared window and H_2O absorption bands are measured and compared to Planck body radiances as a function of cloud top pressure. A numerical forecast of temperature and humidity profile in the region is used for the necessary radiative transfer calculations .Measured and calculated radiances will agree for clear sky and opaque cloud conditions. The cloud-top height is inferred from the linear extrapolation of measured radiances onto the calculated curve of opaque cloud radiance.

The advantage of water-vapor track winds compared to the cloud tracked winds is that they may be estimated in areas free of clouds.

The automated quality control is based on EUMETSAT approach. For each final wind candidate, a set of marks is computed:

- The wind direction consistency mark.
- The wind speed consistency mark.
- The wind vector consistency mark.
- The correlation consistency mark.
- The Slot-to-Slot height consistency mark.
- The spatial consistency mark.
- The forecast consistency mark.

The final AQC mark is calculated from a linear combination of these marks with different weights (user-defined) for each mark.



References

1. *(Nieman, 1997) Nieman, S.J., Meanzel, W.P., Hayden, C.M. et al., Fully Automated Cloud-Drift Winds in NESDIS Operations, Bulletin of Am. Meteo. Soc., Vol. 78, No 6, June, p 1122-1133.*

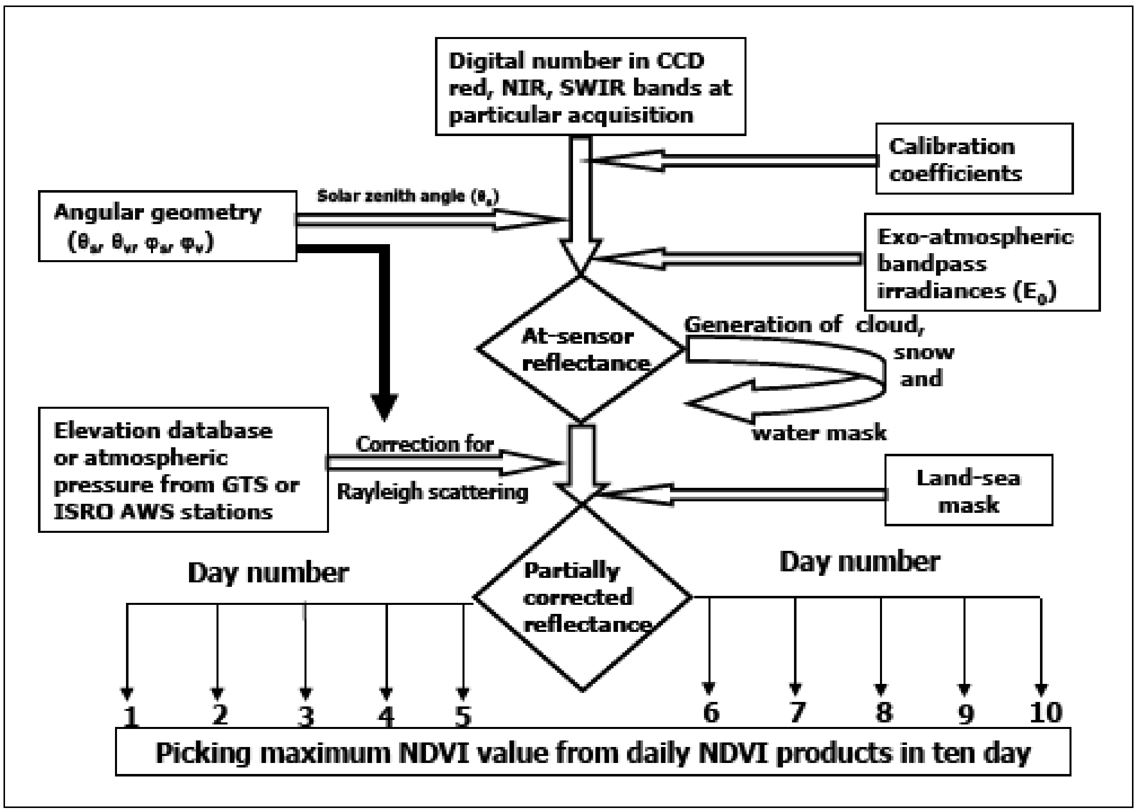
4. Normalized Difference Vegetation Index (NDVI)

The “Normalized Difference Vegetation Index” (NDVI) is widely used for vegetation monitoring in remote sensing. NDVI was originally used as a measure of green biomass (Tucker *et al*, 1986). It has a strong theoretical basis as a measure of the solar photosynthetic active radiation absorbed by the canopy (Sellers,1985).The NDVI relates reflectance (or radiance) in the red range and in the NIR range to vegetation variables such as leaf area index (LAI), canopy cover, and the concentration of the total chlorophyll. It is sensitive to low chlorophyll contents, to low fraction of vegetation cover and, as a result, to low level of absorbed photosynthetic active solar radiation. But it is not sensitive at higher chlorophyll contents or to rate of Photosynthesis for large vegetation coverage. For land surfaces dominated by vegetation, the NDVI values normally range from 0.1 to 0.8 during the growth season, the higher values being associated with greater density and greenness of the plant canopy.

Algorithm for derivation:
Step 1 : Computation of angular geometry
Step 2 : Conversion of gray count (DN) to at-sensor reflectance (Ri)
Step 3 : Elimination of cloud, snow and water body and generation of no land mask
Step 4 : Generation of daily Rayleigh corrected and angular normalized surface (Level 1A) reflectances (Ri_surf) for clear land pixels
Step 5 : Generation of daily NDVIcorr over clear land pixels by the following formula:

$$NDVI_{corr}[nday] = ((R_{NIR}\_surf - R_{red}\_surf)/(R_{NIR}\_surf + R_{red}\_surf)) * (water\_snow\_cloud\ mask) * land\_sea\_mask$$

Step 6 : Generation of ten-day composite NDVI (NDVId)



References:

1. B.K. Bhattacharya, M. R. Pandya: 2007, IMDPS PR ATBD Document, 271-284

5. Daily Average IR Image

This is an image created by averaging the grayscale values of the IR channel for four images (00, 06, 12,18 UTC) of a day at each pixel location and then displayed.

6. *Daily average WV Image*

This is an image created by averaging the grayscale values of the WV channel for four images (00, 06, 12,18 UTC) of a day at each pixel location and then displayed.

7. *Latitude –Time Diagram of daily OLR from 1st January 2009*

This image displays the daily progression of OLR (daily mean) through the latitude belt 15 S to 40 N. The OLR values are averaged over 50 E to 110 E for each latitude.

8. Latitude–Time Diagram of daily OLR (Monsoon Season 2008)

This image displays the daily progression of OLR (daily mean) through the latitude belt 15 S to 40 N during monsoon season (01June to 30 September) of 2008. The OLR values are averaged over 50 E to 110 E for each latitude.

9. *Maps Daily, weekly, Monthly, Seasonal Mean OLR*

This image displays the OLR value averaged over a day / week / month / season over 0.25 X 0.25 grid boxes for a region 40 E to 120 E and 40 S to 40 N.

10. Cloud Top Temperature Contours

This products indicates the contours of the Cloud top temperature of the IR channel. The range of values for which contours are drawn is –20 to –80 deg.C. in intervals of 10 deg.C. Another image displays contours of CTT below –40 deg.C.

11. Visible Band Imagery

Imagery derived from reflected sunlight at visible wavelengths of 0.55-0.75 µm. The ground resolution at the sub-satellite point is nominally 2 km x 2 km and in the normal mode of operation the instrument is designed to scan 20 deg east-west covering 50 deg.N to 40 deg S latitude.

12. Infra-red Band Imagery

Imagery derived from emission by the Earth and its atmosphere at the thermal –infrared wavelengths of 10.5-12.5 μm. The ground resolution at the sub-satellite point is nominally 8 km x 8 km and in the normal mode of operation the instrument is designed to scan 20 deg east-west covering 50 deg.N to 40 deg S latitude.

13. Water Vapor Band Imagery

Imagery derived from water vapor emissions at 5.7-7.1 μ m. The ground resolution at the sub-satellite point is nominally 8 km x 8 km and in the normal mode of operation the instrument is designed to scan 20 deg east-west covering 50 deg.N to 40 deg S latitude.

14. Color Composite Imagery

False Color Composite imagery created by mixing together data from one or more satellite bands with different enhancements in the R,G,B channels. Generally IR and Visible band data is mixed together to create an user friendly image.

15. CCD imagery

The INSAT satellite CCD payload data is received in the following wavelength bands:

(a) Visible band at 0.62–0.68 μ m,
(b) Near IR band at 0.77–0.86 μ m and
(c) Short wave IR band at 1.55–1.69 μ m.

The ground resolution at the sub-satellite point is nominally 1 km x 1 km and in the normal mode of operation the instrument is designed to scan a 10° x 10° field of view, which corresponds to a ground area of about 6300 x 6300 km. The image displayed, is a false color composite image created by mixing together data from one or more satellite bands with different enhancements.

16. NOAA APT Visilble and IR images

The National Oceanographic and Atmospheric Administration (NOAA) of the United States of America supports several Weather Satellites in Low Earth Orbit. Currently these are NOAA-16, NOAA-17 and NOAA-18, all of which make descending (i.e. from north to south) orbits during the morning.

All three satellites broadcast using a system termed **Automatic Picture Transmission** (APT) in which they scan the Earth, 840 kilometers beneath them, continuously. This results in images that build up line by line, rather like the image on a TV screen. However, a complete APT image takes 12 to 14 minutes to build up at a rate of two lines per second. These transmissions are received on frequencies in the 137MHz band.

A typical NOAA satellite APT image consists of two frames, one in visible wavelengths; and the other imaged in infrared. These images are transmitted as greyscale images (i.e. no colour). and have resolution of 4X4Km. in Visible as well as in Infra Red bands.

17. GPS Precipitable Water vapour data:

Ground based GPS systems are used for the estimation of Integrated Precipitable water vapour (IPWV). It is measured by computing the delay in GPS signals due to the moisture present in the atmosphere. The main sources of delay in GPS dual frequency radio signals (L1=1575 Mhz, L2=1225 Mhz) are Ionosphere and Troposphere. The Ionosphere delay or error is removed by the linear combination of L1 and L2 frequencies. But Troposphere delay cannot be removed easily. The total delay in the Zenith direction is estimated with the help of GPS observational data. The total delay in zenith direction (ZTD) is the sum of two parts; dry delay in zenith direction called zenith hydrostatic delay (ZHD) and wet delay, which is known as zenith wet delay (ZWD). ZTD values are estimated from the observation file getting from the GPS receiver of each site by measuring the pseudo range or phase delay methods .The brief computation procedure of estimation of Integrated Precipitable Water Vapour (IPWV) is given below:

$$ZTD = ZHD + ZWD$$

ZHD values are more sensitive to station level pressure and temperature and calculated by the following formula:

$$\boxed{ZHD = 0.00278 * P_s * \{1 + 0.0026 * \cos(2\phi) + 0.00000028 * H_s\}}$$

Where, Ps =Station level pressure in milibar

Hs = Surface height above geoid in Km

ϕ = Latitude of the station

$$PWV = K * ZWD$$

Where,

$$K = \{10^{-6}(\frac{k_3}{T_m} + k'_2)R_v\rho\}^{-1}$$

ρ = Density of water in Kg/m^3

$$k'_2 = (17 \pm 10)Kmb^{-1}, k_3 = (3.776 \pm 0.004)10^5 K^2 mb^{-1}$$

vapour gas constant

T_m = weighed mean temperature

$$T_m = 53.8(^0K) + 0.77 * T_s(^0K)$$

Ts = Surface temperature

ZHD values can be modeled properly and ZWD values cannot be modeled properly due to its in homogeneity in space and time. The final output product of precipitable water will be in mm. Its estimation from GPS is more precise and timely which is very useful in assimilating it into numerical models to modify the moisture fields.

18. Upper Tropospheric Humidity

Upper Tropospheric Humidity (UTH) is an estimate of the mean relative humidity of the atmosphere between approximately 600 hPa and 300 hPa. UTH is basically a measure of weighted mean of relative humidity according to the weighting function of the water vapor channel. Therefore, UTH is more likely a representative of the relative humidity around the atmospheric layer where weighting function of water vapor channel peaks.

The UTH estimation is in principle the computation of weighted mean column values of the upper tropospheric relative humidity. It involves quantitative description of the transfer of radiation by radiative transfer model in the water vapor channel from the surface to the satellite sensor through atmosphere. The transfer calculations are performed for a set of different constant humidity values for the upper tropospheric atmosphere for standard atmosphere. Since geostationary satellites are located over equator, we have used standard tropical atmosphere to represent the vertical temperature structure.

References:

1. R Singh, PK Thapliyal and Shivani Shah : 2007, IMDPS PR ATBD Document,178-190

2. P K Thapliyal, M Vinayak, K S Ajil, S Shah, P K Pal and P C Joshi : Estimation of Upper Tropospheric Humidity from water vapour channel of Very High Resolution Radiometer onboard INSAT-3A and Kalpana Satellites, SPIE, pp 1-7

19. Sea Surface Temperature

Sea surface temperature has been derived from a single thermal window channel (10.5-12.5 µm) over cloud free oceanic regions. The most important part of the SST retrieval from IR observations is the atmospheric correction. Retrieval of sea surface temperature (SST) from thermal infrared window channels (10- 12 um) requires atmospheric corrections arising due to attenuation of signal by intervening moisture. This correction is more in tropics due to higher amount of atmospheric moisture. The algorithm for SST retrieval using single thermal window channel of KALPANA and total water vapor content has been developed using radiative transfer simulations for Indian tropical marine conditions. In absence of a suitable channel for total water vapor estimation in KALPANA, the atmospheric correction is being carried out by using total water vapor fields from TRMM/TMI. Accordingly, based on radiative transfer simulations, water vapor dependent SST retrieval coefficients have been developed.

References:
1. Aloke K Mathur and Neeraj Agarwal: 2007, IMDPS PR ATBD Document, 68-77
2. Aloke K Mathur, Neeraj Agarwal, Naveen Shahi and Abhijit Sarkar ***: Impact of water vapour fields on sea surface temperature retrievals from KALPANA data****:, 1-10*
