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15.	<p><b>Abstract:</b>Cloud Fraction is derived from the cloud cover product generated using the radiance and reflectance measurements from the thermal infrared and visible channels respectively along with water vapour channel from Very High Resolution Radiometer (VHRR) onboard Indian Geo-Stationary Satellite INSAT-3D. The approach followed is to generate a clear sky composite using visible and thermal channels reflectance and radiance measurements respectively and then applying thresholds to arrive at detection of a cloudy pixel. A pixel is defined as cloudy if it satisfies the above mentioned criteria in all three channels used. Cloud fraction products are being made available at half-hourly intervals (i.e. 48 products per day). This methodology will be applied to generate cloud fraction from INSAT-3D starting from year 2013 to present, and eventually for INSAT-3DR. For validation results, refer <a href="https://www.tandfonline.com/doi/full/10.1080/01431161.2018.1479792">https://www.tandfonline.com/doi/full/10.1080/01431161.2018.1479792</a></p> <p><b>Key Words:</b>Cloud Cover, Cloud Fraction, Insat-3D, Very High Resolution Radiometer</p>			

# **Cloud Fraction retrieval using Indian Geo-stationary Satellite (INSAT-3D/VHRR)**

**Shivali Verma, Hareef Baba Shaeb. K and P.V.N. Rao.**

## **Abstract**

Cloud Fraction is derived from the cloud cover product generated using the radiance and reflectance measurements from the thermal infrared and visible channels respectively along with water vapour channel from Very High Resolution Radiometer (VHRR) onboard Indian Geo-Stationary Satellite INSAT-3D. The approach followed is to generate a clear sky composite using visible and thermal channels reflectance and radiance measurements respectively and then applying thresholds to arrive at detection of a cloudy pixel. A pixel is defined as cloudy if it satisfies the above mentioned criteria in all three channels used. Cloud fraction products are being made available at half-hourly intervals (i.e. 48 products per day). This methodology will be applied to generate cloud fraction from INSAT-3D starting from year 2013 to present, and eventually for INSAT-3DR. For validation results, refer <https://www.tandfonline.com/doi/full/10.1080/01431161.2018.1479792>

**Keywords:** Cloud Cover, Cloud Fraction, INSAT-3D, Very High Resolution Radiometer

## **Introduction**

Clouds play a critical role in the radiative balance of the Earth's atmospheric system. They provide the link between the two key energy exchange processes that determine earth's climate, namely, solar and terrestrial radiation exchanges and water exchanges (Rossow and Garder, 1993). The exchange of radiation at the top of atmosphere establishes the fundamental constraint on the climate (Lorenz 1967; Hartmann et al., 1986; Peixoto and Oort 1992). Small changes in cloud cover may lead to major changes in the climate (Coakley, Francis and Bretherton et al., 1982).

Cloud fraction is one of the Essential Climate Variable's (ECV's) required by scientific community for both current and historical observations needed to study the climate change. It is the fraction of area covered by cloud to the total area in a given pixel. A cloud fraction of one implies that the pixel is completely covered with clouds, while zero represents totally cloud free pixel. This product finds application in various fields like earth's radiation budget studies, prediction of future climate of the earth by better understanding of changes in cloud cover, impact on agricultural monitoring activities, solar energy forecasting and resource assessment and various pollution and climate models use cloud fraction as an input to study the dispersion of pollutants in atmosphere.

## **Data and Methodology**

Estimation of Cloud fraction is carried out using radiance and reflectance measurements from thermal infrared (TIR) and visible (VIS) channels respectively along with water vapour (WV) channel from VHRR onboard INSAT-3D, which is a geo-stationary platform at an altitude of 35,800km. VHRR acquires data round the clock at half-hourly intervals (i.e. 48 acquisitions per day). Channels used in INSAT-3D are VIS (0.55-0.75  $\mu\text{m}$ ) at 1km resolution, WV (6.5-7.1  $\mu\text{m}$ ) at 8km, TIR1 (10.2-11.3  $\mu\text{m}$ ) and TIR2 (11.5-12.5  $\mu\text{m}$ ) at 4km resolution each, to retrieve cloud fraction.

In this study, we follow (Schadlich et al., 2001) methodology, which employs a series of visible and infrared threshold consistency tests to observe an unobstructed view of the earth's surface. A set of minimum 30 days is taken to find out the minimum reflectance and the maximum radiance for every pixel location to generate a clear sky composite at a given time. For example, the surpassing of a preset radiance levels at visible wavelengths indicates that the field is cloud covered. If the level is not surpassed, the field is cloud free (Coakley, Francis and Bretherton et al., 1982). In addition to this, water vapour channel is also used, where a check is applied that a pixel will be classified as cloudy if its brightness temperature value is less than 246K, else it will be a clear pixel. This helps to generate a cloud cover for a given scene. Following this, Cloud fraction is estimated over the Indian region at a spatial resolution of  $0.25^\circ \times 0.25^\circ$ .

## Results and Discussion

Cloud fraction is generated over Indian region [ $-10^\circ\text{N}$  to  $44.5^\circ\text{N}$  and  $45.5^\circ\text{E}$  to  $105.5^\circ\text{E}$ ], using the methodology described above. 48 products, on a daily basis, at half-hourly interval each are being generated from the month of Jan, 2015. Figure 1(a), (b) and (c) shows the TIR, VIS and WV channels respectively. Figure 3(a) and (b) shows the cloud cover and cloud fraction respectively, generated by implementing the methodology.

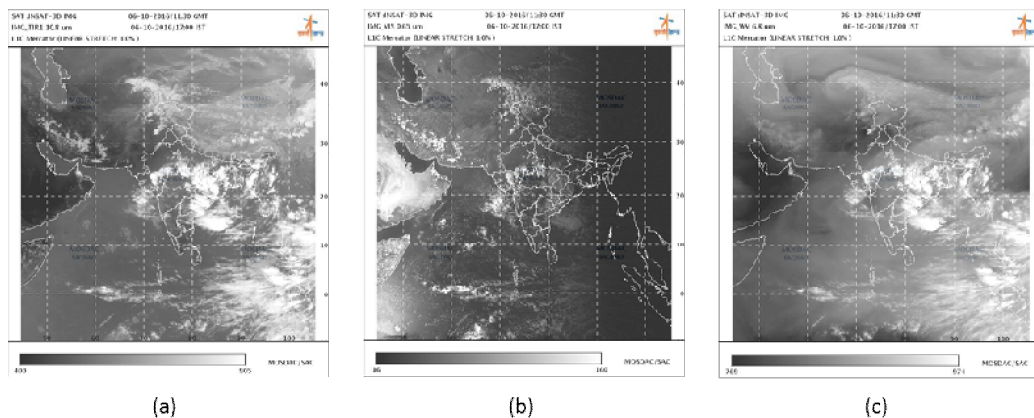


Figure 1: (a) thermal channel, (b) visible channel, (c) water vapour channel from MOSDAC (6<sup>th</sup>Oct, 2016 at 1130 UTC)

Figure 2(a) and (b) depict the satellite measured maximum radiance and minimum reflectance respectively, for each pixel location, obtained over a period of 30 days,

using all the 48 acquisitions. Maximum radiance is measured using TIR channel and minimum reflectance using visible channel. These images are then used as clear sky composites to generate cloud cover and cloud fraction.

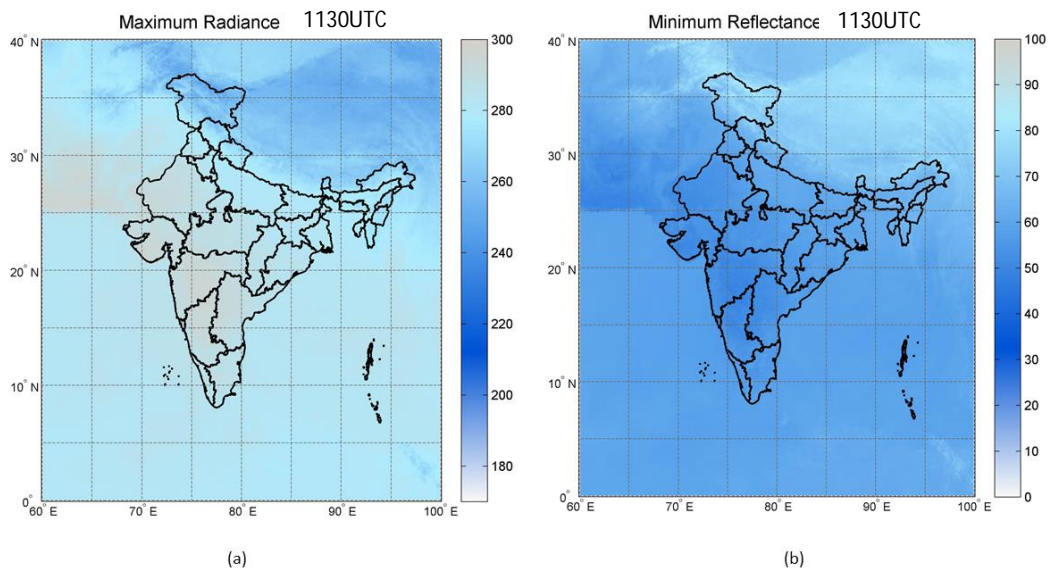


Figure 2: (a) maximum radiance and (b) minimum reflectance for 30 days at 1130UTC

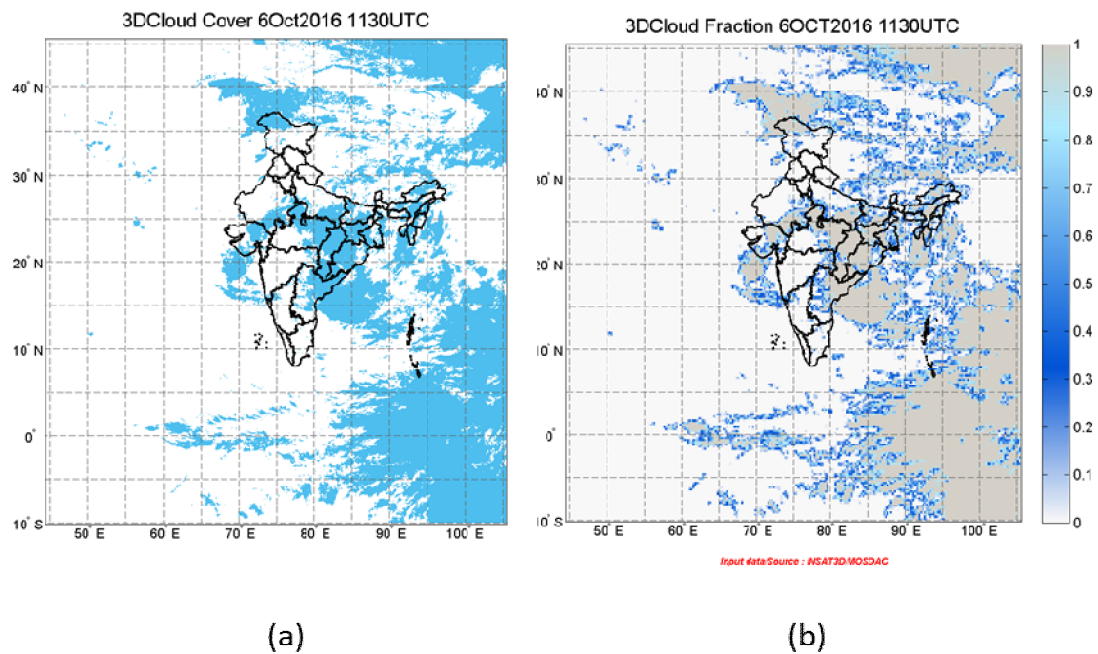


Figure 3: (a) cloud cover and (b) cloud fraction for 6<sup>th</sup>Oct, 2016 at 1130 UTC

## Conclusion

Cloud Fraction is retrieved from cloud cover product which is generated using the radiance and reflectance measurements from the thermal infrared and visible channels respectively along with water vapour channel from VHRR data. The products are being made available at half-hourly intervals (i.e. 48 products per day).

We are referring this Cloud fraction product as version 1.0. In future, using this methodology, cloud fraction products will be generated starting from the year 2008. Validation has been done using satellite data. Efforts will be made to improve the algorithm after validation with in-situ data. For validation results, refer <https://www.tandfonline.com/doi/full/10.1080/01431161.2018.1479792>

### **Description of Data**

FileName(Daily-from Kalpana):XXXX\_ZZZ\_L3\_PP\_VVV1.0\_DYYYYMMDD  
(X- Sensor, Z-Satellite, L-Level3, P-Product name, V- version, **D-Date**, Y-Year, M-Month, D-Date)

(from INSAT-3D) : XXX3X\_L3\_PP\_VVV01\_DYYYYMMDD  
(X- Satellite, L-Level3, P-Product name, V-version, D-Date, Y-Year, M-Month, D-Date)

Geographic Coverage : -10°N -45.5°N; 44.5°E-105.5°E

Unit :meter<sup>2</sup>/meter<sup>2</sup>

Spatial Resolution :0.25°×0.25°

Temporal Resolution :Half-hourly

File Format (Data) :NetCDF

File Format (Image) :n/a

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We express our sincere thanks to all concerned who contributed either directly or indirectly for the successful completion of Cloud fraction estimation and product generation using Kalpana-1/VHRR and INSAT-3D data.

We acknowledge the providers of INSAT-3D data (MOSDAC), which was used in this study.

MATLAB tools have been used for developing necessary algorithms to obtain the data product.

### **References**

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