NATIONAL REMOTE SENSING CENTRE
REPORT / DOCUMENT CONTROL SHEET

1.	**Security Classification**	Unclassified		
2.	**Distribution**	Through soft and hard copies		
3.	**Report / Document version**	**(a) Issue no.:** 1.0	**(b) Revision & Date:** R01/ Jan 2016	
4.	**Report / Document Type**	Scientific Report		
5.	**Document Control Number**	NRSC-ECSA-ACSG-JAN-2016-TR-794		
6.	**Title**	Cloud Fraction retrieval using Indian Geo-stationary satellite (Kalpana-1/VHRR)		
7.	**Particulars of collation**	**Pages:** 04	**Figures:** 03	**References:** 06
8.	**Author (s)**	Shivali Verma, Hareef Baba Shaeb K. and P.V.N. Rao		
9.	**Affiliation of authors**	Atmospheric and Climate Sciences Group, ECSA, NRSC		
10.	**Scrutiny mechanism**	**Reviewed** DD (ECSA)	**Approved** DD (ECSA)	
11.	**Originating unit**	Atmospheric and Climate Sciences Group (ACSG), ECSA, NRSC		
12.	**Sponsor (s) / Name and Address**	NRSC, Balanagar, Hyderabad		
13.	**Date of Initiation**	October, 2015		
14.	**Date of Publication**	February, 2016		
15.	**Abstract:** Cloud Fraction is derived from the cloud mask 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 Kaplana-1. 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). Currently cloud fraction products have been generated for December, 2015. This methodology will be applied to generate cloud fraction for one year (2015) and eventually for Kalpana-1 and INSAT-3D. **Key Words:** Cloud Mask, Cloud Fraction, Kalpana-1, Very High Resolution Radiometer			

Cloud Fraction retrieval using Indian Geo-stationary Satellite (Kalpana-1/VHRR)

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

Abstract

Cloud Fraction is derived from the cloud mask 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 Kaplana-1. 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). Currently cloud fraction products have been generated for December, 2015. This methodology will be applied to generate cloud fraction for one year (2015) and eventually for Kalpana-1 and INSAT-3D.

Keywords: Cloud Mask, Cloud Fraction, Kalpana-1, 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 IPCC 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.

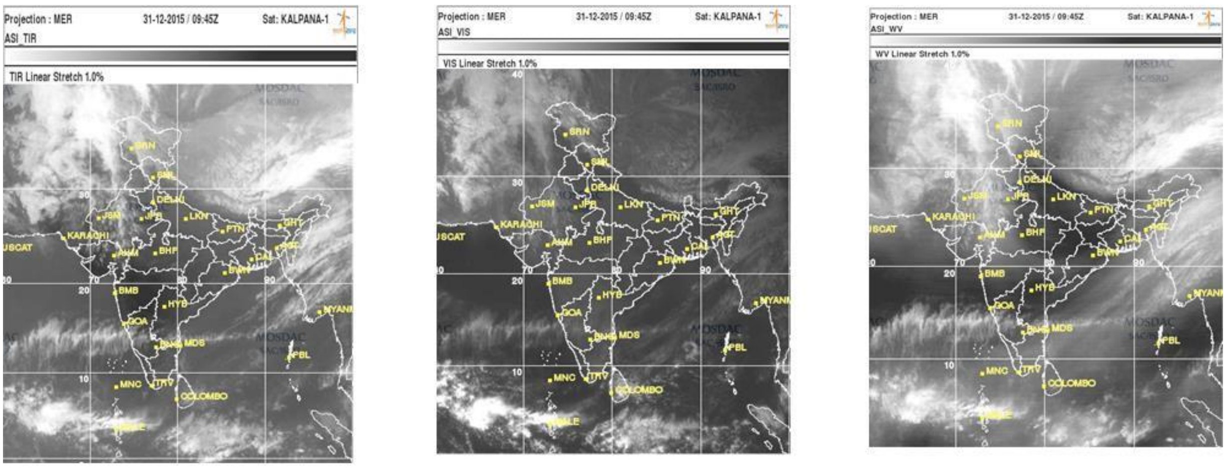
Data and Methodology

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 Kalpana-1, 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) in three channels, namely, TIR (10.5-12.5 µm) at 8km resolution, VIS (0.55-0.75 µm) at 2km resolution and WV (5.7-7.1 µm) at 8km resolution.

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 mask for a given scene. Following this, Cloud fraction is estimated over the Indian region at a spatial resolution of 0.25°×0.25°.

Results and Discussion

Cloud fraction is generated over Indian region [-10°N to 44.5°N and 45.5°E to 105.5°E], using the methodology described above. 48 products, on a daily basis, at half-hourly interval each have been generated for the month of Dec, 2015. Figure 1(a), (b) and (c) shows the TIR, VIS and WV channels respectively. Figure 3(a) and (b) shows the cloud mask and cloud fraction respectively, generated by implementing the methodology.



(a) (b) (c)

Figure 1: (a) thermal channel, (b) visible channel, (c) water vapour channel from MOSDAC (31st Dec, 2015 at 0945 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 mask and cloud fraction.

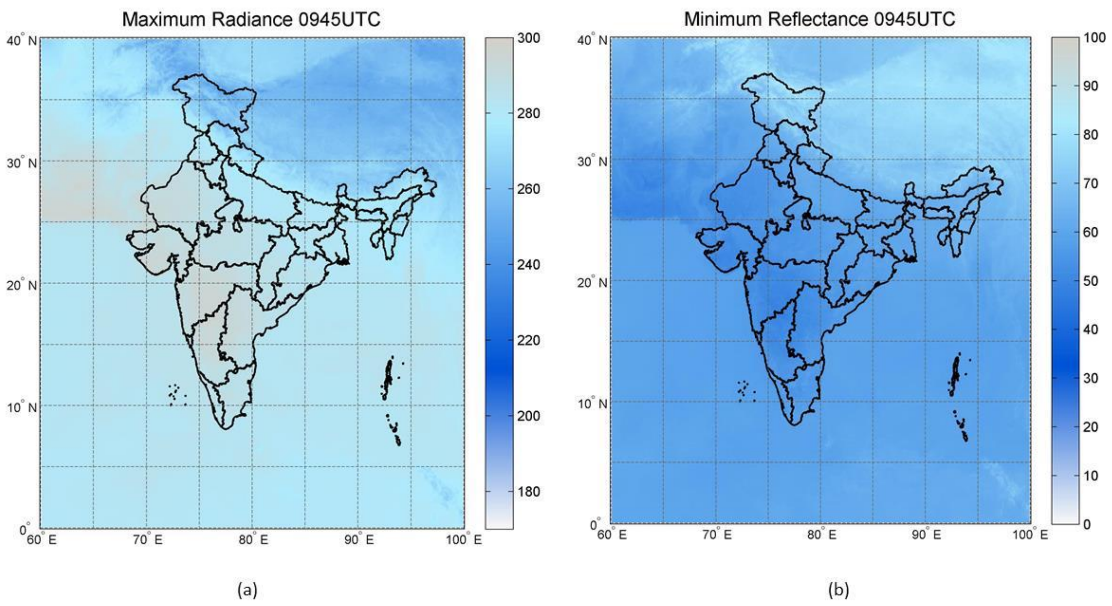


Figure 2: (a) maximum radiance and (b) minimum reflectance for 30 days at 0945UTC

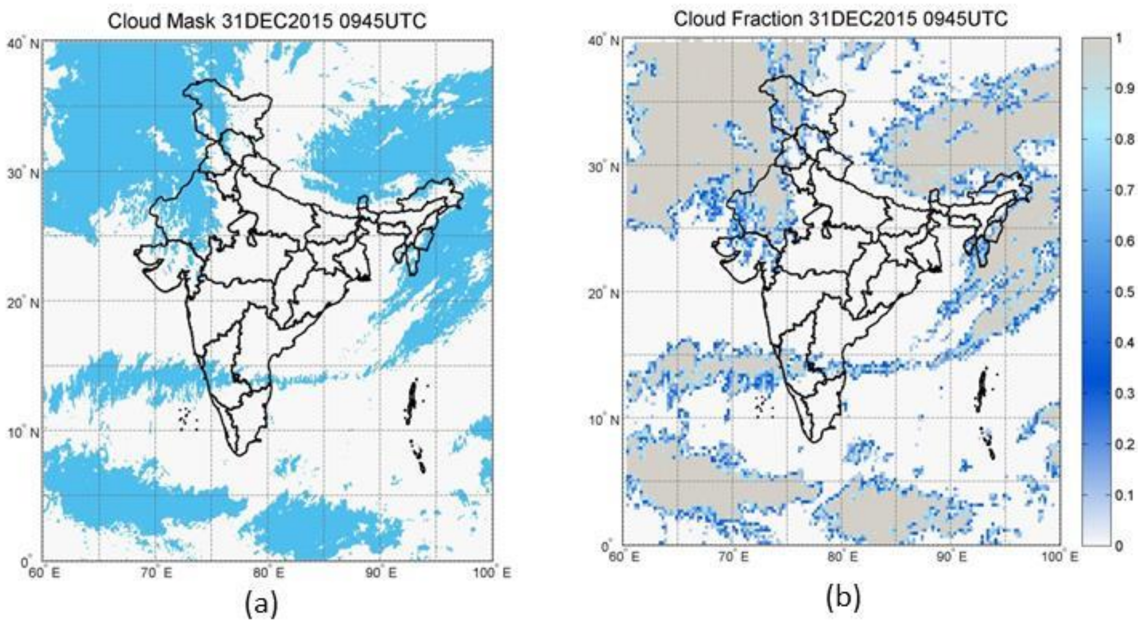


Figure 3: (a) cloud mask and (b) cloud fraction for 31st Dec, 2015 at 0945 UTC

Conclusion

Cloud Fraction is retrieved from cloud mask 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 for the year 2015. Efforts will be made to improve the algorithm after validation.

Description of Data

FileName (Daily)	:XXXX_ZZZ_L3_PP_VVV1.0 _DYYYYMMDD_HHMM (X- Sensor, Z-Satellite, L-Level3, P-Product name, V-version, D-Date, Y-Year, M-Month, D-Date, H-Hour, M-Minute)
Geographic Coverage	: -10°N -45.5°N; 44.5°E-105.5°E
Unit	:meter^2/meter^2
Spatial Resolution	:0.25°×0.25°
Temporal Resolution	:Half-hourly
File Format (Data)	:NetCDF
File Format (Image)	:TIFF

Acknowledgement

We are grateful to Dr. V.K. Dadhwal, Director NRSC for his support and motivation in accomplishing this work. We would also like to thank Mr. Prajesh T., Dr. S.S. Prijith, Mr. Devesh Maurya and Mr. S.V.S. Sai Krishna for their support.

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 data.

We acknowledge the providers of Kalpana-1 data (MOSDAC), which was used in this study.

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

References

S. Schadlich, F. M. Gottsche and F. –S. Olesen (2001), Influence of Land Surface Parameters and atmosphere on METEOSAT brightness temperatures and generation of Land Surface Temperature maps by temporally and spatially interpolating atmospheric correction, Remote Sens. Environ. 75:39-46.

William B. Rossow and Leonid C. Garder, 1993: Cloud Detection Using Satellite Measurements of Infrared and Visible Radiances for ISCCP. J. Climate, **6**, 2341–2369

Coakley Jr., J. A., and F. P. Bretherton (1982), Cloud cover from high-resolution scanner data: Detecting and allowing for partially filled fields of view, J. Geophys. Res., 87(C7), 4917–4932.

Hartmann, D. L., V. Ramanathan, A. Berroi, and G. E. Hunt, 1986: Earth radiation budget data and climate research. Rev. Geophys., 24, 439-468.

Lorenz, E. N., 1967. The Nature and Theory of General Circulation of the Atmosphere. WMO-No. 218. TP. 115. World Meteorological Organization, 161 pp.

Peixoto, J. P., and A. H. Oort, 1992: Physics of Climate. American Institute of Physics, 520pp.