High Resolution Passive Microwave Sounder Observation on South Indian Region Using Megha-Tropiques Payload

M. P. Vasudha and G. Raju

Abstract

Emission techniques are generally useful over the majority of the Earth's surface. Low-frequency channels are better suited to measure the emission due to liquid associated with rain, most techniques to date rely on high-frequency, scattering-based schemes. The passive microwave satellite based data used includes the Special Sensor Microwave Imagers, SSMI Sounder, SAPHIR (Sondeur Atmosph rique du Profil d Humidit Intertropicale par Radiom trie), Advanced Microwave Sounding Units (AMSU), and Microwave Humidity Sounder (MHS), along with land surface model emissivity estimates. The analysis of SAPHIR sounder data brightness temperature data relating to selected vegetated land with different surface obtained for continuous period of 3 years from 2014 to 2016 was achieved. From our study SAPHIR sounder data is found useful for retrieving surface emissivity. This study relates 183.31 ± 11.0 GHz emissivity values, retrieved from a radiative transfer model using collocated SAPHIR sounder brightness temperature measurements. This examination is noteworthy for microwave sounder assimilation in climate conjecture models and for the usage of the information from passive microwave sensors on-board the Indo-French satellite "Megha-Tropiques," which is committed to tropical environmental studies.

Keywords

SAPHIR • Brightness temperature • Land surface emissivity • Soil moisture

1 Introduction

Measurement of land related applications on surface emissivity is useful to determine variation in i. Surface heat fluxes; ii. Soil moisture content; iii. Vegetation and vi. Climatic condition. Land surface emissivity study can be classified into bare soil emissivity, canopy emissivity (vegetation canopy) and snow emissivity. Bare soil emissivity with no or sparse vegetation of candidate study area on temporal and seasonal scale has been selected as a parameter for our observation. Observations of land surface emissivity using infrared and/or microwave images obtained by sounder onboard satellites provide most of the information relating to the surface emissivity [1, 2]. Among the various satellite missions involved in the retrieval of land surface emmissivity, brightness temperature data obtained from AMSU [3] sensor onboard NOAA and SAPHIR sensor onboard Megha-Tropiques satellite mission were selected for our study purpose [4].

The primary data used for our analysis is in the form of brightness temperature measurement of microwave sounders. The values of brightness temperature measurement for 6-layer averaged values from 0 to 12 km from the surface were processed using numerical/statistical algorithms to determine the emissivity properties [5]. The main objective of the present study was to get an estimation of microwave emissivity from satellite observations and characterization of emissivity over the Indian subcontinent and examination of its seasonality. Further an attempt was made to demonstrate the advantages of SAPHIR data related to land applications for monitoring seasonal variation, geographical variations of vegetation conditions, moisture content etc. over selected regions of South India.

2 Methodology

Emissivity is a measure of how strongly a body radiates at a given wavelength. Land Surface Emissivity (LSE) is defined as the emissivity of an element on the surface of the Earth

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H. M. El-Askary et al. (eds.), *Advances in Remote Sensing and Geo Informatics Applications*, Advances in Science, Technology & Innovation, https://doi.org/10.1007/978-3-030-01440-7_79

and includes the emissivity of the surface and land surface temperature (LST). SAPHIR TB (Brightness Temperature) data were obtained from microwave sounder for all 6 channels with a 10 km resolution at nadir and 22.9 km at edge spatial resolution. Using SAPHIR microwave TB, the estimation of land surface emissivity by any of the three popular methods which are (i) Direct observation method, (ii) Physical retrieval and (iii) Dense media radiative transfer [6] would be as follows:

(i) Direct Observation Method: estimation of LSE by using SAPHIR satellite TB observation over the vegetated land and dense forest as input parameters. The microwave radiative transfer formulation under clear cloud sky for satellite observed brightness temperature $T_B(p,f)$ is

$$T_B(p,f) = \varepsilon(p,f)T_{skin}\Gamma + (1-\varepsilon(p,f))T_{\downarrow}(f)\Gamma + T_{\uparrow}(f) \quad (1)$$

where $\varepsilon(p,f)$ is the surface emissivity at a frequency f for the polarization p,

$\Gamma = e^{-\tau(0,h)\sec(\theta)}$ where h is the height of the satellite and θ = incident angle. Thus, Land emissivity is expressed as

$$\varepsilon(p,f) = \frac{T_B(p,f) - T_{\uparrow}(f) - T_{\downarrow}(f)\Gamma}{\left(T_{skin} - T_{\downarrow}(f)\right)\Gamma} \quad (2)$$

and estimated by

$$\varepsilon(p,f) = \frac{T_B(p,f)}{T_{skin}} \quad (3)$$

where T_{skin}—Skin temperature, T_B (p,f)—satellite observed brightness temperature, Γ is net atmospheric transmissivity. $T_{\uparrow}(f)$—Upwelling brightness temperatures, $T_{\downarrow}(f)$—downwelling brightness temperatures. Land surface emissivity (ε) is processed through Eq. (3). Climatic profiles of temperature, humidity, and water vapor are taken from the Japan Meteorological Agency Reanalysis (JRA).

(ii) Physical retrieval method: based on the principle of satellite observations with physical consistency among the received parameters.

(iii) Dense media radiative transfer theory with surface parameter (soil type) as input parameters.

3 Observation and Analysis

The variation of climatological seasonal changes in terms of brightness temperature variation is shown in Fig. 1 is shown to be in accordance with the gradation represented in accompanying color barcode i.e., min 220 K and max 280 K. In Fig. 1 column right to left shows the observations form SAPHIR during the year 2014, 2015, 2016. First row shows observations for the winter season on 14th Jan 2014 to 2016, second row depicts observations during the summer season 14-04-2014 to 14-04-2016, third row displays

Fig. 1 Shows Seasonal variation of BT in middle and south India (2014–2016)

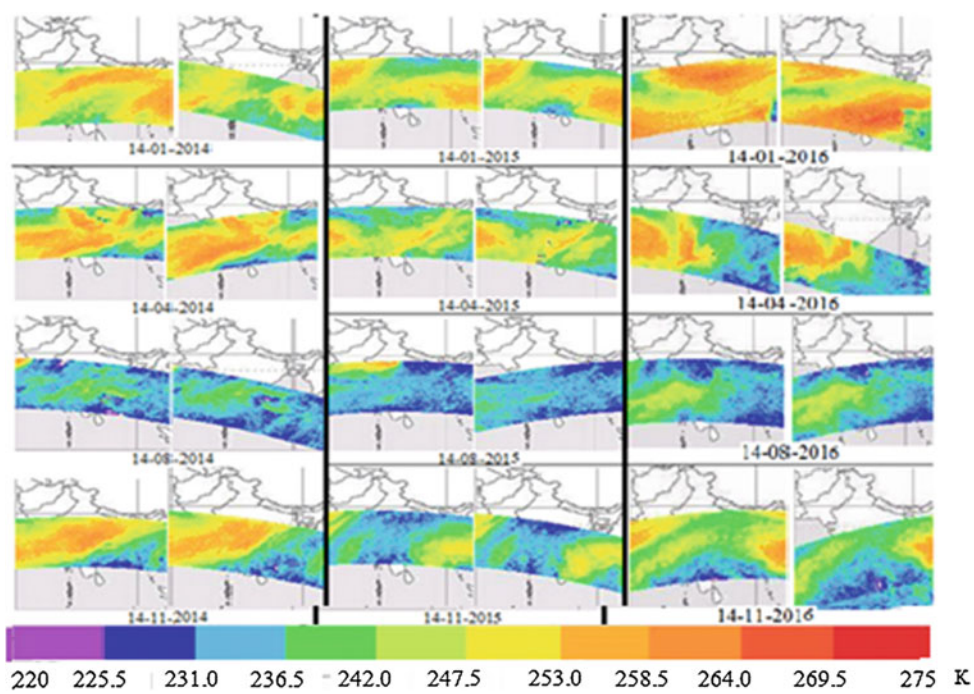

Table 1 Shows the variation of brightness temperature measured by SAPHIR (MT)

	Year: 2014		Year: 2015		Year: 2016	
Date	Middle Indian region (K)	South Indian region (K)	Middle Indian region (K)	South Indian region (K)	Middle Indian region (K)	South Indian region (K)
14th Jan	242–258.5	242–253	236.5–253	231–247.5	275.5–260	247.5–264
14th Apr	253–264	247–264	242–253	236–258.5	231–242	236.5–255
14th Aug	225.5–236.5	225.5–242	231–258.5	225.5–237	228–236.5	228–236.5
14 Nov	253–258.5	231–247.5	225.5–236.5	225.5–236.5	236.5–248	228–240

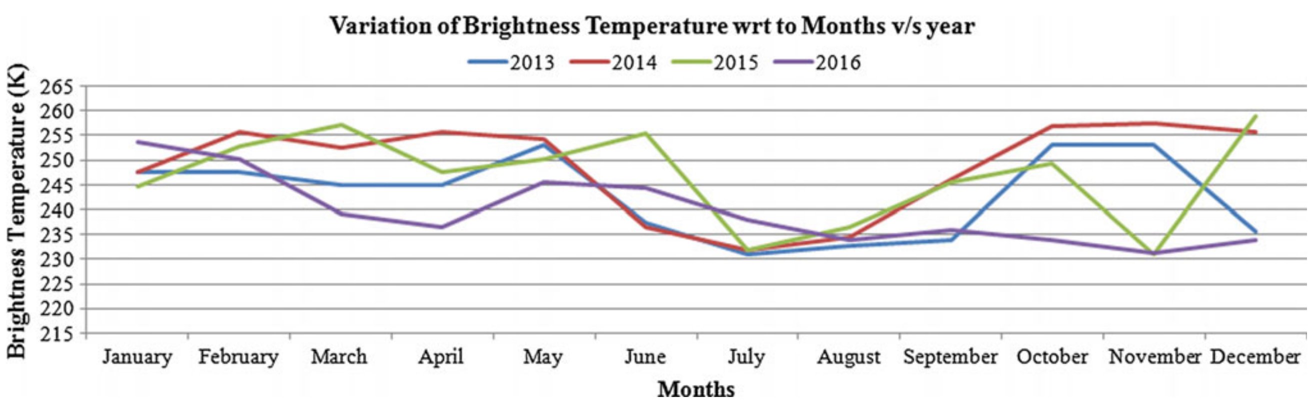

Fig. 2 Variation of TB over land from Jan 2013 to Dec 2016 by SAPHIR

observations during the monsoon/rainy season on 14th Aug 2014 to 2016 and last row is for observations during the autumn season.

The seasonal variation of brightness temperature in terms of kelvin is tabulated in Table 1. The brightness temperature variation from Jan 2013 to Dec 2016 measured by SAPHIR in South Indian region of every month was plotted as shown in Fig. 2. During the monsoon season which starts in mid of June and ends mid August of every year we can observe the lower temperature i.e., 225 K compared to the other seasons. In Fig. 2 the lower TB observed during June to Aug month might be due to the effects of rainfall and change in mean observed values of moisture content of the surface.

4 Conclusion

The observations of bare soil emissivity using microwave sounder images on seasonal and temporal scale were performed. The main objective of these observations were to find out the capabilities of MWS images to provide sufficient, frequent and accurate information regarding the parameters stated above. A study of the efficiency of the sensors clarified that MWS Images are more useful because they can be obtained in all atmospheric conditions when compared to IR Sounder images. They give the impression that the effect of precipitation upon the emissivities in the light-to-direct vegetated zone is most perceptible after direct substantial rain occasions (surpassing 10 mm in the earlier day). The LSM and physical emissivity strategies can be utilized to examine how the extent and time size of the related decrease in surface emissivity, during and after precipitation occasions.

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