Analysis of the diurnal cycle of vegetation using active and passive microwave satellite

l'Observatoire de Paris — LERMA
Laboratoire d'Études du Rayonnement et de la Matière en Astrophysique et Atmosphères

Dinh Thi Lan Anh, Catherine Prigent - LERMA, Observatoire de Paris

Objectives

By using data from Global Pricipication Measurement (GPM) at a global scale, this project will analysis:

1. Diurnal cycle of the backscattering coefficient (active mode)
2. Diurnal cycle of the emissivity (passive mode)
3. Comparison to other studies
4. The realtion between active and passive microwave signals

Introduction

Along with the development of remote sensing techniques, microwave observations are very useful for vegetation analysis due to its large frequency range (1 GHz to 300 GHz). They are less affected by the clouds than visible and infrared observations. They can also operate both day and night. This project aims to study the potential of using these satellite observations in evaluating the diurnal cycle of vegetation.

Datasets

Global Precipitation Measurement - GPM which was launched in 2014 provides the backscattering coefficient σ_0 and emissivity e. It is composed of 2 instruments:

- Active mode: Dual-frequency Precipitation Radar (DPR) including the Ka-band PR at 35.5 GHz and Ku-band PR at 13.6 GHz.
- Passive mode: GPM Microwave Imager (GMI) with 13 channels from 10.65 to 183 GHz, in V-H polarizations.

Methods

Firstly, the data need to be filtered by neglecting the high frequency emissivities (about 100 GHz) due to the water vapor contamination.
Secondly, the data are gridded using a 0.25° by 0.25°, converted to local time, and averaged for every 3 hours over one month and three months.
Then, the backscattering coefficient σ_0 and the emissivity e are calculated as the equations:

$$\sigma_0 = \sigma_{Surface}$$
$$T_b = T_s \times e$$

General analysis

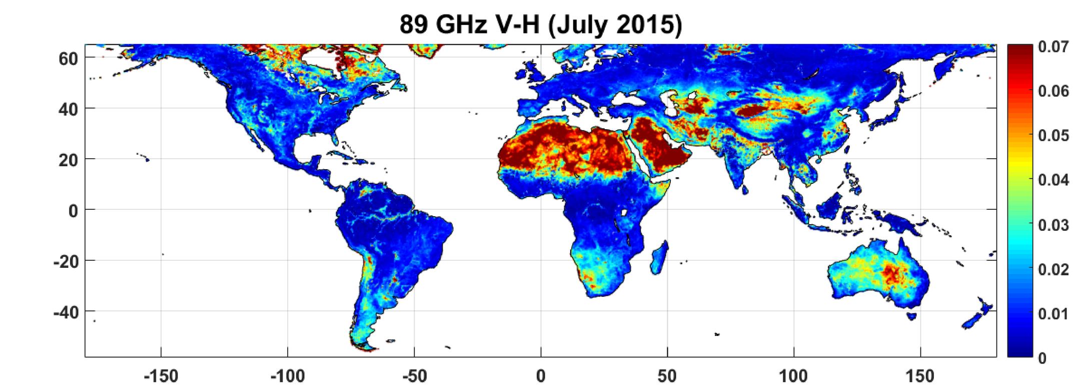

Figure 1: Monthly averaged map of emissivities at 89 GHz, July 2015 (V-H polarization difference)

The global maps of emissivity also show distinct structures of the surface. Indeed, the emissivity depends on the dielectric properties of the components of the material, as well as on the surface roughness. Generally, water has a very low emissivity in the microwave, on the contrary, soil shows the high emissivity. Also, the V-H polarization difference is larger in flat areas than in roughness areas. In addition, surfaces can look rougher at 85 GHz than at 18 GHz because of the smaller wavelength.

In general, for the small incident angle, the desert areas show a higher value of backscattering coefficients than the dense vegetation areas. In contrast, for the large incident angle for Ku band ($\theta_{Inc} = 16° - 18°$), backscattering coefficient at the soil interface is very small since σ^0 is directly influenced by the surface roughness. Also, the backscattering coefficient increases with decreasing vegetation for incident angle near nadir ($\theta_{Inc} < 8°$).

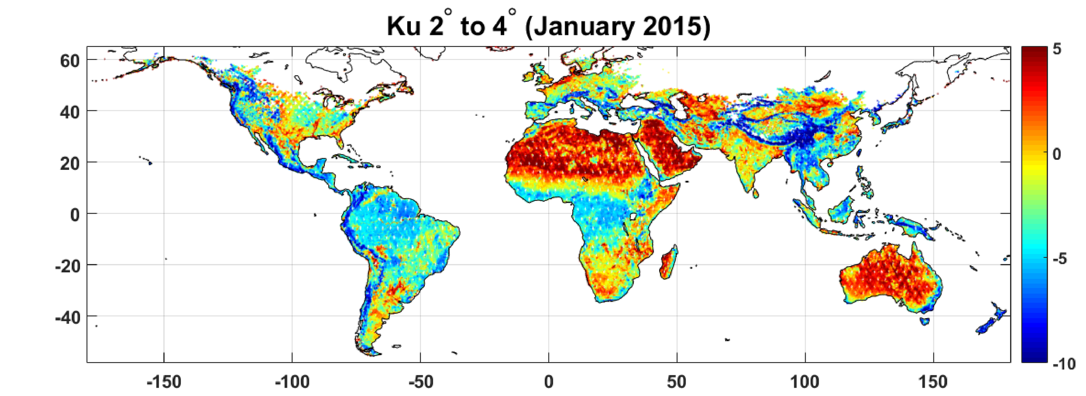

Figure 2: Monthly averaged map of backscattering coefficients at Ku band, January 2015

Analysis of the diurnal cycle

The diurnal analysis will be conducted for six different vegetation types extracted from the International Geosphere Biosphere Programme (IGBP) land cover.

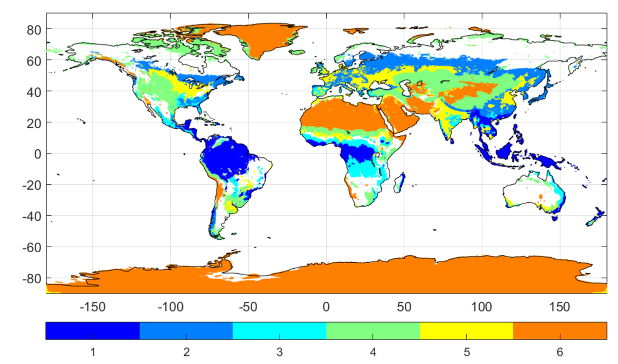

Figure 3: IGBP map

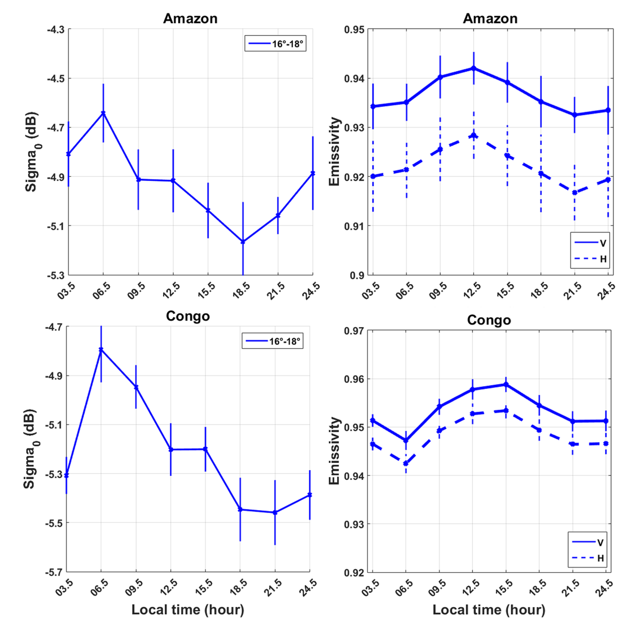

Figure 4: The backscattering coefficient and emissivity in SON of the Amazon and Congo rainforests.

- The study verified the systematic statically diurnal differences in both active and passive modes of the GPM data across the globe.
- Considering the evergreen broadleaf forests (Amazon, Congo), there is the remarkable difference between morning and evening overpasses at the global scale, with a magnitude of 0.5-1 dB. The σ^0 in wet seasons is higher than in dry seasons.
- For the emissivities response, the mean emissivity is lower in the wet seasons than in the dry seasons. The maximum value is found at mid-day and the minimum value is shown in the early morning for Amazon and Congo.

References

[1] S. C. Steele-Dunne, J. Friesen, and N. van de Giesen. Using diurnal variation in backscatter to detect vegetation water stress. *IEEE Transactions on Geoscience and Remote Sensing*, 50(7):2618–2629, July 2012.

[2] M. Satake and H. Hanado. Diurnal change of amazon rain forest sigma;0 observed by ku-band spaceborne radar. *IEEE Transactions on Geoscience and Remote Sensing*, 42(6):1127–1134, June 2004.

Conclusions & Persepectives

The study pointed out the diurnal cycle, as well as the vegetation dependence of the backscattering coefficient and emissivity. The results are also in agreement with with previous studies. There are several reasons could lead to this diurnal change such as change of vegetation, the moisture in the atmosphere or the surface temperature.
For future research, we will extend the datasets to analysis the inter-annual cycle. Also, other datasets such as NDVI, Fluorescence (GOME) will be studied to understand the link between the active and passive microwave signals.

Contact Information

Email dinhlananh2808@gmail.com
Phone +33 (0)6 99 40 13 41