- International TOVS Study Conference XVIII, Toulouse, France, 21-27 March 2012 -

Land surface VIS/NIR BRDF module for RTTOV-11: Model and Validation against SEVIRI Land SAF Albedo product

Jérôme Vidot[1] and Eva Borbas[2]
[1]Centre de Météorologie Spatiale, DP/Météo-France, Lannion, France
[2]SSEC/CIMSS, Madison, Wisconsin, USA

Introduction and methodology

Introduction

In the next version of RTTOV (version 11) there will be a possibility for the users to simulate clear-sky satellite observations in the visible and in the near infrared spectral regions. In clear-sky situations over land, the major contribution to the signal simulated at the top of atmosphere comes from the surface. As for thermal or microwave spectral regions, the surface optical properties exhibit strong spectral signatures based on the surface type. Furthermore, in the visible and near infrared spectral regions, the surface optical properties also exhibit a strong geometrical dependency, which depends on the solar and on the satellite directions. To describe the spectral and the geometrical dependences of the surface, the surface optical properties are represented by the Bidirectional Reflectance Distribution Function (BRDF). Additionally, the surface optical properties of vegetation-covered area present a non-negligible seasonal dependency. This poster describes the scientific approach of the RTTOV-11 BRDF model that provides a global (at a spatial resolution of 0.1°) and monthly mean land surface BRDF and quality index for any instrument with spectral response function between 0.4 and 2.5 µm. A preliminary validation of the model is shown by comparison with the SEVIRI Land SAF Black-Sky Albedo (or Directional Hemispherical Reflectance) product at 0.6 µm (Channel 1), 0.8 µm (Channel 2) and 1.6 µm (channel 3).

BRDF model

The BRDF is calculated by using the semi empirical linear model of Ross-Li (Ref. 1) that is given by:

$$BRDF(\theta_{sat},\theta_{sol},\Delta\phi,\lambda) = f_{iso}(\lambda) + f_{vol}(\lambda)K_{vol}(\theta_S,\theta_V,\Delta\phi) + f_{geo}(\lambda)K_{geo}(\theta_S,\theta_V,\Delta\phi)$$

where θ_{sol}, θ_{sat} and $\Delta\phi$ are the solar zenith angle, the satellite zenith angle and the azimuth difference between satellite and solar directions, respectively. λ is the wavelength. The three BRDF kernel model parameters f_{iso}, f_{vol} and f_{geo} are basically related to isotropic scattering, to leaf canopies and to shadowing effect, respectively.

Methodology

The methodology is similar with the UWiremis infrared land surface emissivity module developed for RTTOV (Ref. 2):

⇒ The first Principal Components (PCs or eigenvectors) of 126 selected laboratory reflectance spectra from the USGS database (Ref. 3) between 0.4 and 2.5 microns with wavelength resolution of 0.01 µm (Figure 1), were regressed against 7 hinge points corresponding to the central wavelength of MODIS channels (at 0.470 µm, 0.555 µm, 0.659 µm, 0.865 µm, 1.24 µm, 1.64 µm and 2.13 µm). The number of 6 PCs was found to be most optimal by giving the best agreement between the original laboratory measurements and reconstructed spectra.

⇒ Monthly means global BRDF kernel model parameters f were extracted from MODIS MCD43C1 product that allow to constrain the reconstruction of a BRDF spectra, which are used next to interpolate the BRDF of any instrument.

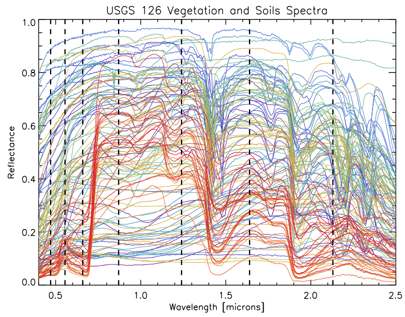


Figure 1. Reflectance spectra of the 126 selected USGS soils and vegetations surfaces. Dotted lines represent the MODIS channel central wavelengths.

BRDF validation with SEVIRI Land SAF Albedo product

For any given location (in latitude and longitude), month, geometry and instruments channel, the RTTOV-11 BRDF module provides the BRDF and a quality index that is extracted from the original MODIS quality flags.

For the validation of the RTTOV BRDF module, we used SEVIRI Land SAF product for the 25th August 2011 averaged at 0.1° spatial resolution from the SEVIRI original spatial resolution. We were not able to validate directly the BRDF since the BRDF is not an operational product from the Land SAF. We used the SEVIRI Land SAF Directional Hemispherical Reflectance or Black-Sky Albedo (BSA) product. The RTTOV BSA is calculated from the BRDF kernel model parameters (Ref. 1).

On Figure 2 is depicted the Land SAF BSA in channel 1 (at 0.6 µm, left), the RTTOV BSA in channel 1 (middle) and the RTTOV quality index for August 2011 (right).

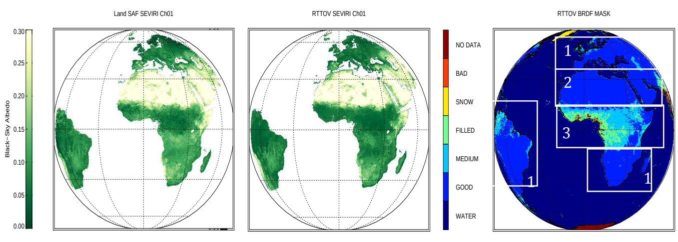


Figure 2. Left: SEVIRI Land SAF Black-Sky Albedo product for the 25th August 2011 in channel 1 at 0.6 µm. Middle: RTTOV Black-Sky Albedo. Right: RTTOV BRDF quality index.

The quality index reveal an area in Central Africa where the quality of the MODIS BRDF retrieval is reduced by the presence of aerosols and/or persistent clouds. For the interpretation of the results, we then separated the SEVIRI full disk into three parts (represented on Fig. 2):

1) Vegetated areas in Europe, South Africa and South America with good quality index.

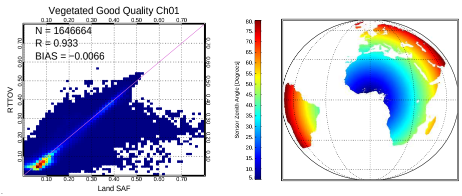
2) Desert areas in Northern Africa and Middle-East with good quality index.

3) Vegetated areas in Central Africa with mainly medium and filled quality index.

Effect of the SEVIRI geometrical observation subsampling

The scatterplot between RTTOV BSA and Land SAF BSA from Fig. 2 depicted in Fig. 3 show a lot of outliers. These outliers are explained by geometrical subsampling of the SEVIRI observations at the edge of the disk. By removing data for satellite zenith angle greater than 60°, the outliers are removed (compare with Fig. 4, top-left).

Figure 3. Left: Scatterplot between RTTOV and Land SAF BSA for SEVIRI channel 1 on area 1. Right: Satellite zenith angle.



Results

⇒ Good agreement in all areas with R>0.9

⇒ For vegetated areas:

If quality index is good, no bias in channel 2, RTTOV lower by ~0.01 in channels 1 and 3.

If quality index is medium or filled, RTTOV lower by 0.01–0.03 (Fig. 4 bottom)

⇒ For desert areas, no bias in channel 1 and 2 and RTTOV lower by ~0.02 in channel 3.

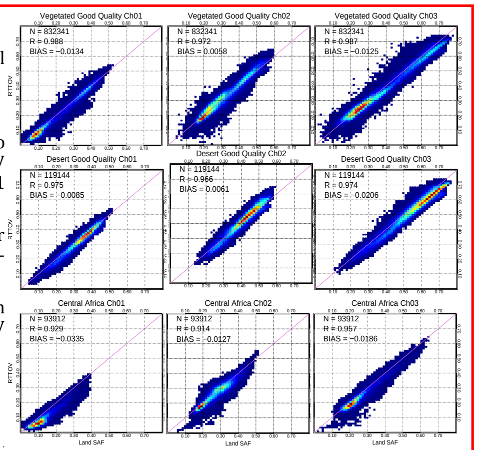


Figure 4. Scatterplots between RTTOV and Land SAF BSA for channels 1 to 3 and for the three areas.

Conclusion and perspectives

A BRDF model for land surfaces has been developed for RTTOV-11. It is based on a combination of USGS laboratory hyperspectral measurements of soil and vegetation surfaces and the MODIS BRDF kernel parameters products. This model allows the calculation of the BRDF for any instrument with channels between 0.4 and 2.5 µm. The model provides a global and monthly mean BRDF at 0.1° spatial resolution. It also provides a quality index of the BRDF. Comparison with one global SEVIRI Land SAF product show a good consistency between black-sky albedo, and better for desert surfaces. It is found that RTTOV-11 BRDF model tends to slightly underestimate the albedo, especially in areas where the presence of aerosols and/or persistent clouds reduce the quality of the MODIS BRDF retrieval. A standard deviation of the BRDF will be implemented in the model and seasonal variability will be investigated.

References:

(1) Lucht W., Schaaf C. B. and Strahler A. H., 2000: An Algorithm for the retrieval of albedo from space using semiempirical BRDF models, IEEE Transactions on Geoscience and Remote Sensing, Vol. 38, no. 2, pp. 977-998.

(2) Borbas, E. A. and Ruston B. C., 2010: The RTTOV UWiremis IR land surface emissivity module, Report NWPSAF-MO-VS-042, 24 p.

(3) Clark R. N., Swayze G. A., Wise R., Livo E., Hoefen T., Kokaly R. and Sutley S. J., 2007: USGS digital spectral library splib06a, U.S. Geological Survey, Digital Data Series 231. Available at http://speclab.cr.usgs.gov/spectral.lib06/ds231/.