DETERMINATION OF LAND SURFACE TEMPERATURE FROM AMSR-E DATA FOR BARE SURFACES

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Land surface temperature (LST) plays an important role when studying the balance of energy exchange of the earth. In many Earth science disciplines, it is a key input parameter for modeling applications, such as global change model, climate prediction model, and other land processes models. LST is a top issue in the earth science for a long time, and with the development of remote sensing technology, it becomes possible to retrieve and monitor LST in a large scale. How to efficiently and accurately retrieve LST from remote sensing data has been a major concern. Besides the atmospheric effects existed in the high frequency, the main problem in retrieving LST from passive microwave data is that the number of unknowns to be retrieved is always one more than that of the channel measurements, making the retrieval unstable and no unique. It is therefore necessary to develop some additional constrains at least one constrain to make the retrieval stable and reliable. Up to now, many retrieval models have been developed and can be classified into two types. One is semi-empirical model. This type of model has been generally developed by directly relating LST to the combination of brightness temperatures measured at satellite or ground levels at different frequencies and different polarizations for some specific conditions [1-3]. Since this type of model is less physical basis, it can not be used universally and always needs to be adjusted if applied to other conditions. Another type of the model is physics-based model. Compared with the former one, physical models have explicit physical meanings and are universal to a certain extent. However, physical models are generally much more complex than semi-empirical models, and need many input parameters which are difficult to be obtained in practice. These hamper the application and accuracy of physical models [4, 5].

This paper will focus on the estimation of LST from passive microwave data (AMSR-E) for bare surfaces. For bare surfaces, the brightness temperature T_{Bp} measured at satellite level in a p polarization mode (p=V, H are vertical and horizontal polarizations respectively) can be written as:

$$T_{B_p} = e_p \cdot T_e \cdot \exp(-\tau_a) + \exp(-\tau_a) \cdot \left[T_{ad} + T_{sky} \cdot \exp(-\tau_a) \right] \cdot (1 - e_p) + T_{au} \tag{1}$$

where e_p is surface effective emissivity in p polarization mode, T_e is land surface effective temperature, τ_a is the atmospheric opacity, T_{sky} is cosmic background emission ($T_{sky} \approx 2.7$ K), T_{au} and T_{ad} are the upwelling and downwelling atmospheric emissions.

Supposing that the relationship between different polarization emissivities at the same frequency can be express as

$$e_V = a \cdot e_H + b \tag{2}$$

the surface effective temperature can therefore be retrieved from:

$$T_e = \frac{T_{B_V} - a \cdot T_{B_H} - (1 - b - a) \cdot \exp(-\tau_a) \cdot \left[T_{ad} + T_{sky} \cdot \exp(-\tau_a) \right] - T_{au} \cdot (1 - a)}{\exp(-\tau_a) \cdot b} \tag{3}$$

if the atmospheric quantities (τ_a, T_{au} and T_{ad}) can be estimated using atmospheric radiative transfer model with the atmospheric profiles or estimated from other sources.

In order to check whether Eq. (2) is valid, a simulated surface emission database has been established with AIEM model [6] for the configuration of AMSR-E instrument, i.e. 6.925, 10.65, 18.7, 23.8, 36.5 and 89 GHz at vertical and horizontal polarizations with incident angle of 55 degrees. In the simulation, volumetric soil moisture varied from 2% to 44% at a step of 2%, and surface roughness parameters including root-mean-square height from 0.25cm to 3.0cm at 0.25cm interval, and correlation length from 5cm to 30cm at a step of 2.5cm. By analyzing, we found that a good linear relationship between vertical polarization and horizontal polarization emissivities at same frequency existed and was valid only for a given soil moisture, namely:

$$e_V = a(sm) \cdot e_H + b(sm) \tag{4}$$

where the coefficients a and b are independent of surface roughness parameters and only dependent on the volumetric soil moisture (sm). (see Figure.1)

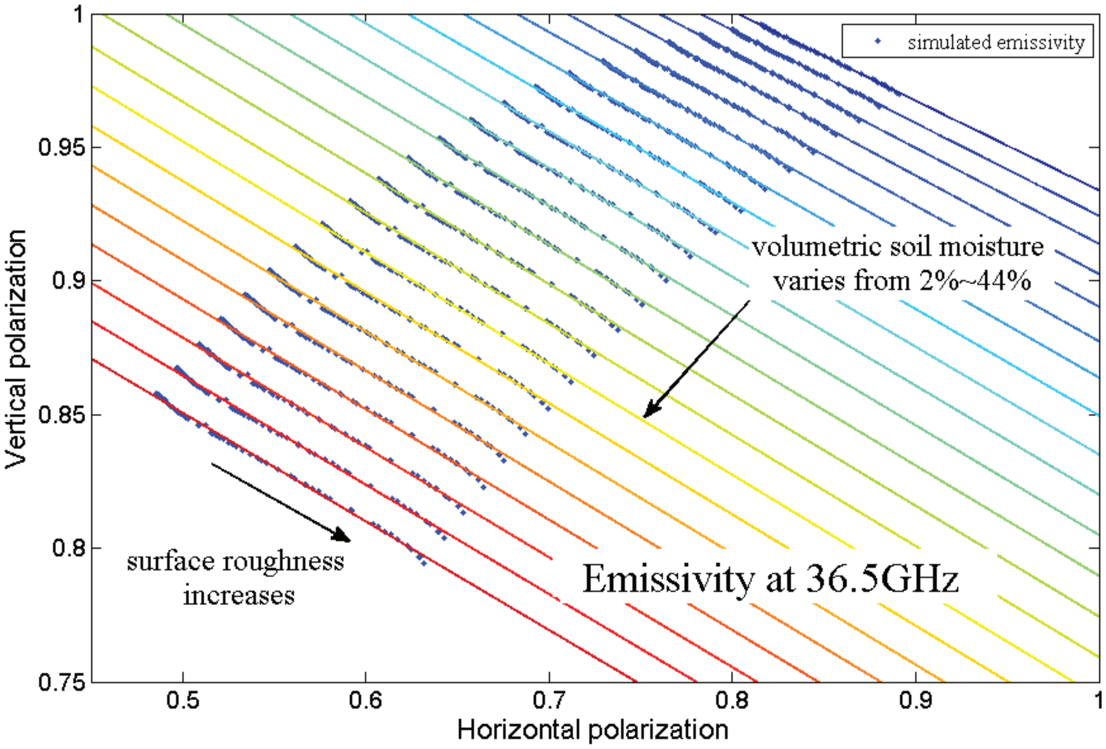

Figure.1. Linear relationship between simulated vertical polarization emissivity and horizontal polarization emissivity at 36.5GHz

In order to evaluate the accuracy of the LST retrieved from AMSR-data using equation (3) for a given soil moisture content, both simulated AMSR-E brightness temperature data and actual AMSR-E brightness temperature data were used. The simulated database was generated using the modified microwave radiative transfer model (MWMOD) [7] combined with AIEM model for different atmospheric conditions and different surface conditions. The results showed that an accuracy of 2K can be obtained if the instrument NE△T is less than 1K. As for the processing of the actual AMSR-E data, the AE_Land3 data (AMSR-E/Aqua Daily L3 Surface Soil Moisture) and meteorological re-analyses atmospheric profiles (ECMWF) were used respectively to select the correct coefficients a and b in equations (4) and (3) and to estimate the atmospheric quantities (τ_a, T_{au} and T_{ad}) with MWMOD. Compared with MODIS/AQUA derived LST for clear sky pixel over desert region, equations (3) and (4) can give promising results for AMSR-E data.

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