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The construction and application of the AMSR-E global microwave emissivity database

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Abstract. Land surface microwave emissivity is an important parameter to describe the characteristics of terrestrial microwave radiation, and is the necessary input amount for inversion various geophysical parameters. We use brightness temperature of the Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) and synchronous land surface temperature and atmospheric temperature-humidity profile data obtained from the MODIS which aboard on satellite AQUA the same as AMSR-E, to retrieved microwave emissivity under clear sky conditions. After quality control, evaluation and design, the global microwave emissivity database of AMSR-E under clear sky conditions is established. This database include 2002-2011 years, different regions, different surface coverage, dual-polarized, 6.9,10.65, 18.7, 23.8, 36.5 and 89GHz, ascending and descending orbit, spatial resolution 25km, global 0.05 degrees, instantaneous and half-month averaged emissivity data. The database can provide the underlying surface information for precipitation algorithm, water-vapor algorithm, and long-resolution mode model (General Circulation Model (GCM) etc.). It also provides underlying surface information for the satellite simulator, and provides basic prior knowledge of land surface radiation for future satellite sensors design. The emissivity database or the fast emissivity obtained can get ready for climate model, energy balance, data assimilation, geophysical model simulation, inversion and estimates of the physical parameters under the cloud cover conditions.

1. Introduction

Passive microwave emissivity is the key factor in the land surface physical properties retrieval, which is also essential underlying surface characteristics in the atmosphere parameters estimation, such as the water vapor, cloud liquid water. Because microwave land surface emissivities are not readily modeled by parametric physical approaches[1], retrieval algorithm developed by satellite brightness temperature is a common way to get the emissivity. Microwave land surface emissivities have been estimated from the Special Sensor Microwave/Imager(SSM/I)[2], Advanced Microwave Sounding Unit (AMSU)[3], AMSR-E[4] observation. Microwave emissivity database is important to analyze new instrument concepts, for assimilation schemes, and for precipitation algorithm, water vapor

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algorithm and so on. But so far microwave emissivity database of different land surface cover have been little studied. In this study, we discussed the effects of emissivity database and developed an emissivity operational system. The emissivity database could be as the basic data for retrieving geophysical characteristic parameter and monitoring drought and vegetation.

2. Data and Methodology

AMSR-E and MODIS aboard on the same satellite AQUA, which can provide microwave radiation data, land surface temperature data, the layered atmosphere temperature, humidity and pressure profiles data at the same time. Then instantaneous microwave emissivity under clear sky conditions can be retrieved by radiative transfer equation[4].

All the data needed to estimate emissivity include (1) AMSR-E L2A, The brightness temperature from 2002 to 2011;(2) MODIS land surface temperature(LST) to mask out the cloudy and rainy pixels;(3) Atmosphere temperature humidity and pressure profiles data from MODIS. Ancillary data include (1) Water body data to mask out the inland water body and ocean >80%;(2) Gtopo30 DEM to consider the atmosphere thickness.

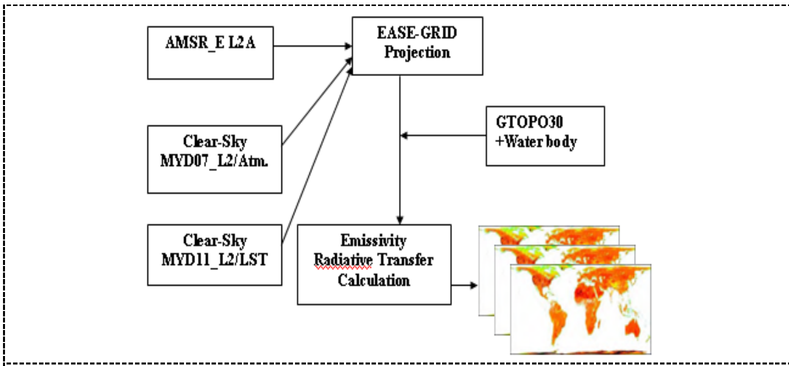

Figure 1. Steps involved in the emissivity estimation

Over a flat lossy surface, the integrated radiative transfer equation (RTE) in the Rayleigh-Jeans approximation for a non-scattering plane-parallel atmosphere can be written as:

$$T_{bp}(v,\theta)=e_{s,p}(v,\theta)*T_s*\Gamma(v,\theta)+T_{atm\uparrow}(v,\theta)\ +T_{atm\downarrow}(v,\theta)*(1-e_{s,p}(v,\theta))*\Gamma(v,\theta)$$

$$+T_{CB}(1-e_{s,p}(v,\theta))*\Gamma^2(v,\theta) \tag{1}$$

Equation (1) can be rewritten as [4]:

$$e_{s,p}(v,\theta)=\frac{T_{bp}(v,\theta)-T_{atm\uparrow}(v,\theta)-T_{CB}*\Gamma^2(v,\theta)}{T_s*\Gamma(v,\theta)-T_{atm\downarrow}(v,\theta)*\Gamma(v,\theta)-T_{CB}*\Gamma^2(v,\theta)} \tag{2}$$

In equation (1) and (2),

$$\Gamma(\nu,\theta)=e^{-\tau(\nu,0,\infty)\sec\theta} \tag{3}$$

$$T_{atm\uparrow}(\nu,\theta)=\sec\theta\int_0^\infty \gamma_{abs}(z',\nu)T(z')e^{-\tau(0,z',\nu)\sec\theta}dz' \tag{4}$$

$$T_{atm\downarrow}(\nu,\theta)=\sec\theta\int_0^\infty \gamma_{abs}(z',\nu)T(z')e^{-\tau(z',\infty,\nu)\sec\theta}dz' \tag{5}$$

Where T_{bp} is the brightness temperature. The ν and p are frequency and polarization, θ is sensor viewing angle, $e_{s,p}(\nu,\theta)$ is the surface emissivity , T_s is land surface temperature, $\Gamma(\nu,\theta)$ is the atmosphere transmissivity, $T_{atm\uparrow}(\nu,\theta)$ and $T_{atm\downarrow}(\nu,\theta)$ are the up-welling/down-welling contribution of the atmosphere, and is T_{CB} the cosmic background.
The result of half-month averaged emissivity and emissivity polarization difference in summer and winter has been showed in Figure 2 and Figure 3.

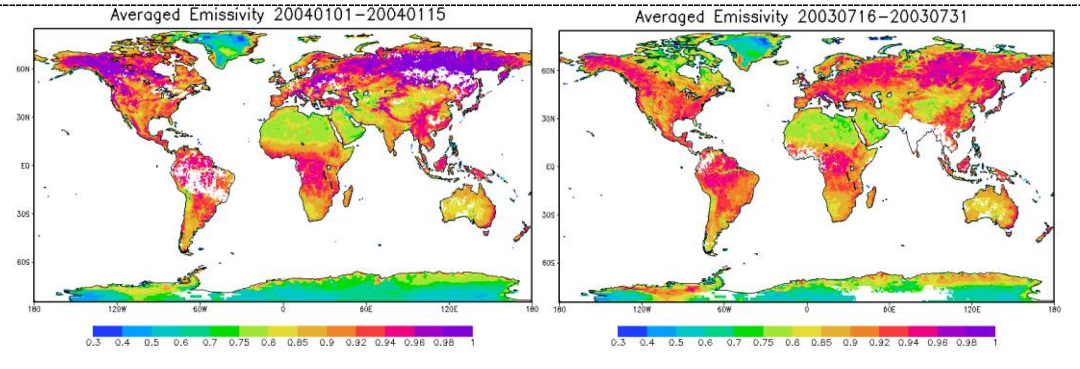

Figure 2. Global emissivity maps in winter and summer at 10.7GHz, H Polarization

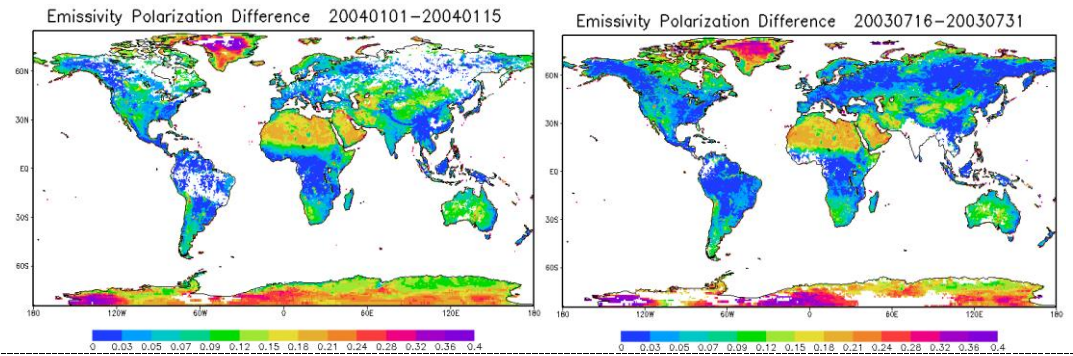

Figure 3. Global emissivity polarization difference maps in winter and summer at 10.7GHz

3. Operational microwave emissivity algorithm

The Operational Global Emissivity Production System consists of three subsystems. The first part is the products online publishing system which provides users the way to get, inquiry, and download the products. Global emissivity product database management system is the second part of this system, which mainly provides raw material for production system and products for publishing system. The last part is Global emissivity product system, which gets raw material from database (parts of management system) and product for the database. The three subsystems can also be classified as three layers, user interaction layer standing for publishing system, data access layer standing for database management system and product manufacturing layer for global emissivity product system. Note that neither the raw material stored in the management system nor the product system can be visited by users. The whole system maintained by the system administrator. Figure 4 shows the relationship between the three subsystems.

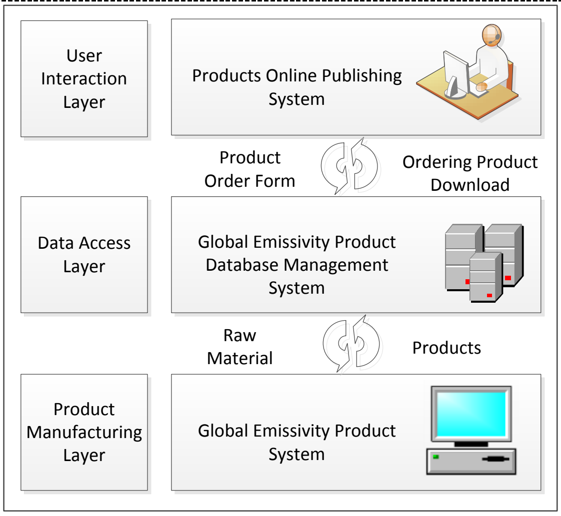

Figure 4. The microwave emissivity operational system

4. The functions of microwave emissivity database

The ten years emissivity database not only plays its review of the historical data, but also plays guiding significance for the follow-up instrument and subsequent inversion algorithms. AMSR-E may not be continuous in time and space, but this emissivity algorithm can be easily extended to other radiometer to complement the AMSR-E. On the one hand, AMSR-E emissivity database provides the changing characteristics of the terrestrial radiation of the earth surface in the past 9 years, and is the basic data for the microwave theory and parameter inversion. The database can provide the underlying surface information for precipitation algorithm, water vapor algorithm, and long-resolution mode model (General Circulation Model (GCM) etc.). It also provides underlying surface information for the satellite simulator and assimilation schemes, and provides basic prior knowledge of land surface radiation for future satellite sensors design. Based on the auxiliary IGBP global classification data (Figure 5), as well as the Food and Agriculture Organization (FAO) soil classification data (Figure 6), we have established emissivity characteristic dataset under different land cover. Then we will search and extract global pure pixels (coverage fraction>85%) at different land cover to have emissivity characteristic statistical analysis, and our aim is searching for parameterized or statistical ways to get microwave emissivity easily. The creation of the microwave emissivity database unified the understanding of theoretical simulation and the actual estimate. And the emissivity database or the fast emissivity obtained can get ready for climate model, the energy balance, data assimilation, the geophysical model simulation, inversion and estimates of the physical parameters under the cloud cover conditions. Finally, the emissivity database should be evaluated by the theoretical microwave emission model over the typical land covers.

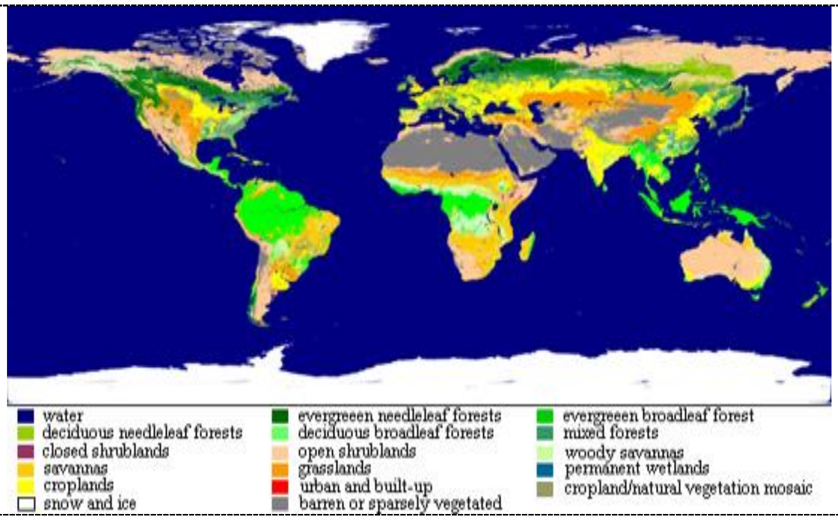

Figure 5. IGBP global classification map

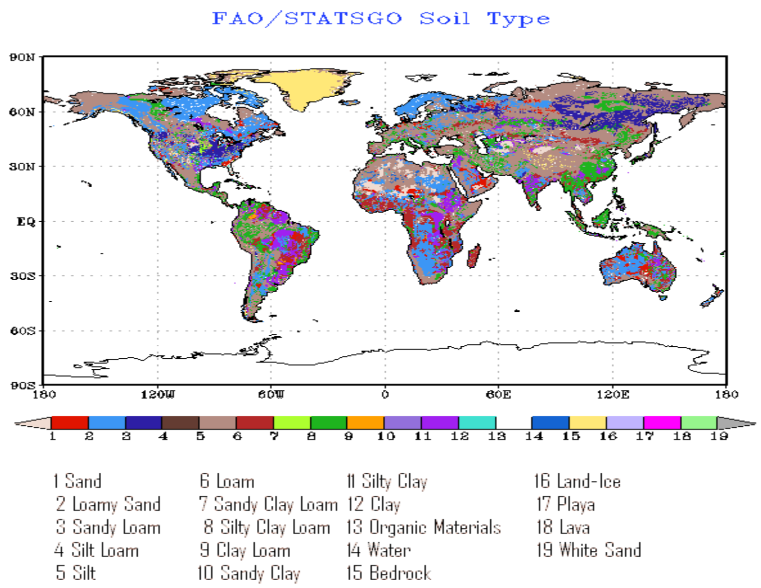

Figure 6. Texture Description of FAO

5. Conclusion

AMSR-E land surface microwave emissivity database has been introduced and established in this study. We discussed on the function, effects and composition of the database. It is the underlying surface database for the microwave theory application and atmosphere parameter inversion. Microwave emissivity operational system can provide emissivity quickly and automatically, which can be used to monitor agriculture and meteorological disaster such as drought and flood.

6. Acknowledgement

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7. References

[1] John F Galantowicz, Pan Liang, Jean-Luc Moncet 2006 *Geoscience and Remote Sensing Symposium* 3203-3206
[2] Prigent C, Rossow W B, Matthews E 1997 *Journal of Geophysical Research* **102(D18):** 21867-21890
[3] Karbou, Prigent C.，Eymard L 2005 *IEEE Transactions on Geoscience and Remote Sensing* **43(5)** 948-959
[4] Qiu Y B, Shi J C, Hallikainen M T 2008 *IEEE International Geoscience and Remote Sensing Symposium* **2** 749 -752