AMSR soil moisture algorithm development and validation

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Microwave remote sensing can directly measure the dielectric properties which are strongly dependent on the liquid water content. The longer wavelength is one of the advantages of microwaves. It is long enough to reduce the scattering effect of cloud particles and to make microwave sensors useful all-weather ones. The wavelength in the microwave region has sensitivity to the scattering effect of leaves. Microwave remote sensing has potential of the measurement of water content of vegetation. The independence of sun as a source of illumination is also one of the important reasons for using microwaves. We can obtain the data even in night. This advantage is more important in the case of non-sunsynchronous observation.

Advanced Microwave Scanning Radiaometer (AMSR) is a passive microwave radiometer with frequency ranges from 6.9 GHz to 89 GHz. It will be flown on-board of the United States Earth Observation System (EOS) PM-1, "AQUA", by National Aeronautics and Space Administration (NASA) of the United States and the Advanced Earth Observing Satellite-II (ADEOS-II) by National Space Development Agency (NASDA) of Japan. With a large antenna, AMSR will provide the best spatial resolution of multi-frequency radiometer from space. The spatial resolution of the ADEOS-II AMSR varies from approximately 50km at 6.9 GHz to 5 km at 89 GHz. The AQUA AMSR-E has slightly coarser spatial resolution due to its 1.6m antenna aperture instead of the 2m one for ADEOS-II AMSR. The antenna beams scan by continuous rotation along a conical surface, which intersects the earth's surface at an angle of 55 degree.

Currently, NASDA is developing an AMSR standard algorithm for soil moisture. The proposed algorithms by the selected principle investigators (PIs) are now being carefully tested and evaluated using the SMMR and SMM/I data. There are basically four candidate algorithms. At the time of the test, all algorithms are still under development and subject to changes. Jackson proposes two types of regression algorithms in addition to his basic one. Paloscia adopts two ways for estimation of one parameter, a simple liner regression method and vegetation biomass classification one based on the polarization information. Njoke proposes both empirical and physically- based algorithms.

The match-up data between SMMR and in-situ soil moisture at 79 Former Soviet Union (FSU) agricultural fields were provided by NASDA Earth Observation Research Center (EORC). The soil moisture measurements were conducted at 8th, 18th, and 28th of each month. The algorithm inter-comparison was implemented under the three typical vegetation conditions, which are indicated by the histograms of NDVI distribution in the area corresponding to the SMMR foot print. Paloscia's algorithm works well in three cases due to the effect of regression adjustment. In the case of not so dense vegetation with heterogeneity, the estimated values by Njoke's and Koike's algorithms scatter around the observed ones. Under the uniform and dense vegetation, those two show under estimation or scatter and Jackson's algorithm can not retrieve soil moisture. To evaluate algorithm performance, it is necessary to obtain ground truth data in uniform areas or spatially distributed information in heterogeneous areas.

Heterogeneity is one of the critical issues of passive microwave remote sensing of soil moisture due to large foot print of microwave radiometers, especially at low frequency. A ground-based microwave radiometer (GBMR) was deployed in the SGP99 to respond this scientific requirement.

The GBMR with three frequencies and dual polarization was operated during the SGP99 to provide well controlled observations to enhance algorithm development and aircraft and satellite data validation. Every morning, the radiometer was calibrated by using liquid nitrogen and the ambient hot load just before the operation. It was kept working until the end of operation of the day. Incident angle was 55 degree. 100 samples were taken at each rotation angle by rotating the antenna from –10 degree to + 10 degree with 5 degree interval. Total number of samples is 500 at each point. After ground surface measurement, sky reference was also collected. The gravimetric soil moisture samples of 0 – 2.5cm and 2.5 – 5.0 cm layers were collected at three points which correspond to the centers of foot prints at the rotation angle, -10, 0 and +10 degree at each site. The horizontal soil moisture measurement at 1.0cm, 2.5cm and 5.0cm in depth and the vertical measurement were carried out by using the TDR system at the same points. The infrared thermometer was used for the measurement of surface temperature at the points where the soil samples were collected. The soil temperature profiles were measured at 1.0cm, 5.0cm and 10.0cm in depth at the same points. A spectrometer which covers from 380nm – 2500nm with 1 nm sample interval was used. Seven samples were collected along the soil measurement course in addition to three white board measurements. Two portable surface roughness indicators were used. Two samples, one along north-south direction and the other along east-west, were collected at each site.

The observation shows that the apparent emissivity, Tb/Ts at 6.9 GHz increases as soil moisture increases. It is considered that the soil temperature gradient affect the observed brightness temperature significantly in the dry soil cases. The soil temperature difference between the observed values and the estimated effective values decreases as soil moisture increases. By the simple numerical simulation, the effect of scattering extinction under dry condition causes the brightness temperature increase as soil moisture increase. This means that temperature gradient should be considered in dry case.