Algorithm Development and Validation Using PALS for Future Soil Moisture Missions

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Currently, there will be several possibilities of satellite's L-band microwave instruments to be available in a few years. They include PALSAR on ALOS (active, Japan, 2004), SMOS (passive, ESA, 2006), and HYDROS (active/passive, proposed to ESSP). Airborne sensors – PALS and AIRSAR provide an unique tool to develop, validate and improve the algorithms, and test some new ideas quickly.

During past years, investigations have demonstrated the capability of both active and passive in soil moisture mapping. However, natural variability and the complexity of the vegetation canopy and surface roughness significantly affect the sensitivity of backscattering and brightness temperature to soil moisture. This study shows the techniques to estimate surface soil moisture with passive and active/passive L-band dual-polarization measurements. For passive, it uses a combined V and H measurements to estimate surface soil moisture with the minimization of the surface roughness effect for bare surfaces. For vegetated surfaces, we estimate surface soil moisture with the repeat-pass measurements to minimize the vegetation effects.

In order to do so, we first established a model simulated database for the random rough surface emissivities with a wide range of soil moisture and roughness condition using IEM model. Through analyses, we evaluated the characteristics the effects of the surface roughness on emissivity at different polarizations and the ratio between two measurements that have a same surface roughness but different moisture under change detection concept. A semi-empirical model for bare surface emission was established. This model separates the emissivity to two parts: one depends only on the flat surface reflectivity and the other depends only on the surface roughness. The surface roughness functions differ at V and H polarizations but they are highly correlated. This makes it possible to minimize the surface roughness effects and directly estimate soil moisture. Using the semi-empirical model, we developed an algorithm to estimate soil moisture with surface emissivity measurements for bare surface. We will show the validation of this algorithm with ground soil moisture and radiometer measurements.

Both backscattering coefficient and emission from vegetated areas are a function of water content and its spatial distribution as determined by vegetation structure and underlying surface conditions. It is clear that vegetation cover will cause an under-estimation of soil moisture and an over-estimation of surface roughness when we apply the algorithm for bare surface to vegetation covered regions. Due to complexity of natural surface and vegetation structure (unknowns are more than measurements), however, it is quite difficult to develop a quantitative algorithm to estimate soil moisture in vegetated areas.

One advantage of the microwave satellite's measurements such as SMOS and HYDROS is the short repeat-time. They are capable to revisit or measure surface conditions within a few days. Considering temporal variability of nature surfaces – the properties that affect the emission and backscattering signals, some variables such as surface roughness and vegetation can be considered as a constant between two or three data acquisitions. The changes between the data acquisitions will be mainly resulted from surface soil moisture change. These characteristics make it possible to develop a technique to estimate surface soil moisture with vegetated surfaces. We will show the validation of this technique with the airborne PALS measurements.