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Estimation of Soil Moisture change with PALS's L-band Radiometer

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Abstract – This study demonstrates the capability of estimating the relative soil moisture change using repeat-pass L-band radiometer. It shows 1) evaluation of the effects of the surface roughness and vegetation in the repeat-pass measurements, 2) development of a technique to estimate the relative soil moisture change, and 3) validation with the ground soil moisture measurements from SGP99 experiment.

I. INTRODUCTION

It is understood that the emission from vegetated areas is a function of water content and its spatial distribution as determined by vegetation structure and underlying surface conditions – roughness and soil moisture. Even through these effects can be modeled if the ground measurements are available, it is quite difficult to take into account these effects in the inversion process for soil moisture estimation.

One of the advantages in the satellite passive microwave measurements is the quick repeat-time. They are capable to re-visit or measure surface conditions within a few days. The general characteristics of temporal variability of nature surfaces – the properties that affect the emission signals are:

Surface soil moisture varies constantly over the time and has a significant diurnal circle during a day until it reaches a very dry condition.

Vegetation water content has also diurnal variability but it may have no significant change at the same time during a day unless there is a precipitation event. Most of vegetation growth or microstructure in terms of scatter size, shape, and orientation has a longer time scale (days – week) to be considered having a significant change.

Surface roughness, in general, can be considered as a constant for a long time period (weeks) except some man-made or weather events such as rainfall and agriculture activities.

Therefore, 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 change with vegetated surfaces.

In this study, we evaluate the effect of the surface roughness and vegetation cover on estimating the relative soil moisture change. Based on these characteristics, we demonstrate a technique that uses L-band radiometer to estimate the relative soil moisture change from repeat-pass measurements and its validation of PALS instrument derived soil moisture change with the ground measurements from SGP99 experiment.

II. EFFECTS OF THE SURFACE ROUGHNESS IN REPEAT-PASS MEASUREMENTS

To evaluate the effect of the surface roughness on estimating the relative soil moisture change, we first simulated a bare surface emissivity database at 1.41 GHz. This database covers the most possible soil moisture and roughness conditions and the incidence angle from 20° to 70°. Then, we developed a simplified model using this database. It is written as:

$$R_p^e = 1 - E_p = A_p \cdot r_p^{B_p} \qquad (1)$$

where E_p is emissivity and p indicates the polarization. R^e is the effective reflectance that includes the effect of the surface roughness. A_p and B_p are the roughness parameters depending on the polarization, incidence angle, surface RMS height, correlation length and the type of the correlation function. They represent an overall effect of the surface roughness. r_p is the flat surface reflectivity.

Under change detection concept, the relationships in terms of the ratio between any two measurements are evaluated with assumption of no surface roughness change. The signal change between two measurements is resulted only from surface soil moisture change. By varying all possible combination of soil moistures, we simulated the effective reflectivity ratio. That is:

$$R_{p2}^e \Big/ R_{p1}^e = (1 - E_{p2}) \Big/ (1 - E_{p1}) \qquad (2)$$

V. SUMMARY

One advantage of the passive microwave sensors is the quick repeat-time within a few days. Except soil moisture, most of natural surface characteristics, such as surface roughness and vegetation properties, can be reasonable assumed that there is no-change between the repeat measurements (same time during a day) between the data acquisitions. Based on this concept, we demonstrated the relative soil moisture change in terms of the ratio can be directly estimated from the repeat-pass measurements for both bare and vegetated surfaces when the small albedo assumption is valid. The advantage of this technique is that it does not require the surface information – we do not need to know if the pixel is a bare, vegetated, or fractionally vegetated, and vegetation information as long as the small albedo assumption is valid.