Soil Moisture Retrieval from Multi-polarization and Multi-frequency PolSAR Data

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Soil moisture studies are important in various fields such as hydrologic modelling, meteorology, agriculture, weather forecasting, flood and drought monitoring and other water and energy cycle applications. Dynamics of soil moisture content is well recognized by remote sensing datasets over a larger spatial extent as well as local scale. Recognizing the advantages of microwave systems over other Earth observation sensors, microwave remote sensing techniques are aptly used for soil moisture mapping at large scale. In this study, two parameters are defined and verified to improve the soil moisture (M_v in volumetric unit) retrieval from multi-frequency (L-band and C-band) and multi-polarization airborne SAR (E-SAR) data over the vegetated and bare field conditions, obtained during AgriSAR 2006 campaign held at DEMMIN test site in Germany, funded by European Space Agency. The major crops grown in the test site were winter wheat, winter barley and winter rape during the campaign.

A semi-empirical Water Cloud Model (WCM) proposed by Attema and Ulaby [1] is used for vegetation – soil system modeling (Eq. (1)) followed by appropriate inversion algorithm. In this model, total backscatter intensity ($\sigma°$) is represented as the incoherent sum of backscatter from the vegetation and the underlying soil surface.

$$\sigma^0 = AV_1\cos\theta\left[1-\exp\left(-\frac{2BV_2}{\cos\theta}\right)\right] + (CM_v + D) * \exp\left(-\frac{2BV_2}{\cos\theta}\right) \tag{1}$$

Where, A, B, C and D are the coefficients, V1, and V2 are vegetation descriptors, and look angle is θ. Model calibration followed by the model inversion (Look Up Table approach) results in the retrieval of soil moisture over vegetated field. In model calibration, the parameters (A, B, C and D) of Eq. (1) are estimated initially by trial and error and a priori knowledge from previous studies. Later on, the use of Genetic Algorithm for the parameter estimation was tested, verified and implemented.
The effect of various vegetation descriptors (V1 and V2) such as Leaf Area Index (LAI), wet biomass, vegetation water content and Radar Vegetation Index (RVI) (estimated from quad-pol L-band and dual-pol C-band data) on the WCM inversion was tested. The results showed that, in the case of winter wheat and winter barley, the implementation of RVI as the vegetation descriptors gives better soil moisture retrieval than the other vegetation descriptors, with RMSE of 7%-8% volumetric soil moisture. Dual polarization (VV-VH) C- band RVI shows similar results as that of RVI calculated from L-band.
The soil moisture retrieval in the bare field condition (LAI<2) was carried out by using linear regression between soil moisture and radar polarization index ((($\sigma°_{HH}$ -$\sigma°_{VV}$) / ($\sigma°_{HH}$ +$\sigma°_{VV}$)) *100) which yielded RMSE of 8%. The effect of vegetation and surface roughness on the accuracy of soil moisture estimation was taken in to account by using radar vegetation index and radar polarization index in the retrieval algorithm. The details of the study and results will be discussed during the presentation.

References

[1] E. P. W. A ttema, Fawwaz T. Ulaby, "Vegetation modeled as a water cloud," *Radio Science,* vol. 13, no. 2, pp. 357-364, March-April 1978.