ALOS PALSAR DATA EMPLOYED FOR SOIL MOISTURE ESTIMATION IN THE BO-PIKETBERG AREA, SOUTH AFRICA

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1.ABSTRACT

Information about the distribution of surface soil moisture is important for a number of applications including the precision management of agriculture and natural resources, as well as for understanding land-atmosphere interactions. It is often difficult and impractical to map soil moisture in the field over large regions. Due to the high spatial and temporal variability and, consequently, the cost of direct monitoring by means of field observations, as well as the extended time scales involved, a means of remote monitoring of soil moisture variability would be ideal for long-term soil moisture status assessment. Images of radar backscatter from orbiting satellites have been used extensively in an attempt to map surface soil moisture. The aim of this study was to test soil moisture retrieval algorithms for its ability to derive a quantitative measure of soil moisture content using single and multiple polarization radar data.

The study area, situated in the Bo-Piketberg area in the Western Cape Province of South Africa, was the topic of a study in which the quantification of surface and ground water use was studied using a variety of remote sensing and GIS modelling approaches. To obtain data for the quantification of the soil moisture component, a proposal was submitted to the European Space Agency with the aim of qualifying for the category-1 use of Envisat ASAR and ALOS PALSAR data. Through the proposal access was granted to four Envisat ASAR Alternating Polarization and four ALOS PALSAR Polarimetric scenes. Images were processed using SAR Polarimetry Workstation and ERDAS imagine software.

Envisat ASAR data was captured in alternating polarization mode with digital numbers representing units of amplitude. The data was converted to radar backscatter in decibel scale with the aim of reducing the dynamic range of the pixel data whilst making the data suitable for use in simple linear regression models for soil moisture quantification. When using the linear regression models for soil moisture estimation, one assumes a linear relationship between radar backscattering coefficient and volumetric soil moisture content. Ground-based soil moisture measurements in the form of neutron probe measurements were available for one of the farms in the area. These measurements could be used as input for linear regression analysis. The result of the application of the linear regression models depicted soil moisture values in volumetric percent. The limited distribution of initial ground-based estimates of soil moisture content implied that a sufficient accuracy assessment could not be performed. However, visual inspection of the result indicated a fairly obvious flaw in using radar data for soil moisture quantification in the specific study area. The side-looking geometry of the radar sensor causes mountainous regions to show severe image distortions known as layover and foreshortening. In particular, anomalously high backscatter values were recorded on the ridges of mountains, which is not necessarily a true reflection of the backscatter values for the particular land surface. Consequently, these areas should be masked out of algorithms aiming to quantify soil moisture content in mountainous regions.

Linear regression models provide a simple means for extracting soil moisture content estimates since it does not require additional estimates of surface parameters such as vegetation descriptors and surface roughness. However, initial measures of soil moisture are needed for the derivation of slope and intercept coefficients used as input into the models. Additionally, surface roughness and vegetation descriptors are assumed to be constant, not only time, but also between various agricultural fields making it possible to consider that radar backscattering coefficient is linearly related to soil moisture. Numerous researchers have shown that, in reality, radar backscatter is influenced by both vegetation conditions as well as surface roughness both of which remains unaccounted for in linear regression models.

To overcome the limitations associated with linear regression models for soil moisture quantification, researchers propose the use of multiple-frequency, multiple-polarization data to achieve more accurate soil moisture quantification algorithms. These models are designed to remove the need for priori information on surface parameters such as roughness. In order to employ multiple polarization models, fully polarimetric ALOS PALSAR scenes were acquired and processed from units of amplitude to a representation of radar backscatter in a linear scale. The Dubois model was applied to the scenes in an effort to extract information on soil moisture content. The results are consistent with rainfall patterns and evapotranspiration patterns over the same time period. However, distributed ground-based measurements were unavailable for the surface coverage of the scene making accuracy assessment difficult at the current point in time. Visual inspection of the results once again indicates some areas in which topographic distortions may be influencing the results. In addition, the Dubois model was developed for wavelengths between 20.5 cm and 2.8 cm whilst the ALOS PALSAR data operates at a wavelength of 23.6 cm. Distributed ground-based measurements will be needed to validate the accuracy of the results in this study area. Additionally, the valid local incidence angle range for implementing the Dubois model is between 30 and 65 degrees. The local incidence

angles for the particular scenes are below the 30 degree lower threshold. These factors combine to produce a large uncertainty with regards to the reliability of the results.

The follow-up phase of the project will concentrate on obtaining an ALOS PALSAR scene covering the area for which ground-truth data is available with the aim of validating the results obtained through using the Dubois model for soil moisture quantification. Additionally, Oh’s model for soil moisture quantification will be tested for its ability to derive quantitative measures of soil moisture content.