Geophysical Research Abstracts
Vol. 12, EGU2010-10010, 2010
EGU General Assembly 2010

Spatial and Temporal Distribution of Soil Moisture Estimation from ENVISAT ASAR Wide Swath Data for Grassland in Ireland

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Soil moisture (SM) is an important parameter for hydrological research. Estimation of SM over large areas using remote sensing data is now possible. Using ENVISAT data together with in situ measured SM data, we developed a model for simulating soil moisture dynamics of a 1200 km^2 grassland catchment in Ireland. We then compare the modeled output with SM from the physically based hydrological model GEOTOP. Some algorithms exist to derive surface soil moisture estimates from remote sensing data. For the ASAR data from the ERS mission, an existing method has been widely used, and was shown to be reliable. The method simulates the relationship between the dielectric constant and the backscattering coefficient for different land cover types, and the relationship can be described as

$$\varepsilon = a + b * dB + c * dB^2 \quad (1)$$

where ε is the dielectric constant of the soil surface, and dB is the backscattering coefficient from the ASAR data. ENVISAT/ASAR provides multiple acquisition modes, and the medium-resolution Wide Swath Mode (WSM) is used in this study with a spatial resolution of 150 m. Thirty-three WSM datasets at different times of year 2006 was received from the European Space Agency. The WSM data are firstly, geometric corrected using Digital Elevation Model (DEM) data of Ireland, and then using the BEST (Basic ENVISAT SAR Toolbox) software, the DN (Digital Number) value of the original remote sensing data are transformed to a backscattering coefficient.

Field measurements of SM at 30 minute intervals were acquired for a grassland area (51˚59′12?N, 8˚45′6?W), in the south part of Ireland. The dielectric constant of the soil surface can be calculated from ground measured soil moisture data with the following empirical equation:

$$\varepsilon = (a_0 + a_1 * S + a_2 * C) + (b_0 + b_1 * S + b_2 * c)m_v + (c_0 + c_1 * S + c_2 * C) * m_v^2 \quad (2)$$

S and C are the percentage of sand and clay, (39% and 17% respectively), $m_v$is the volumetric surface soil water content, and a, b, c are experiential coefficients depending on the sensor of the remote sensing data. The surface soil moisture data for the certain time are selected from the ground measured soil moisture database, corresponding to the remote sensing orbit time, and dielectric constants are calculated with Eq. 2. The data pairs (dB,ε) are fitted to Eq. 1, and the parameters for grassland (a, b and c in Eq. 1) are derived. The final model for our grassland catchment is:

$$\varepsilon = 1.8151 - 9.6471 * dB - 0.7404 * dB^2 \quad (3)$$

and the coefficient of determination (R^2) is 0.8198. In order to estimate soil moisture, we use dB from remote sensing data with Eq. 3 to firstly estimateε,and then use Eq. 2 inversely estimate soil moisture. Comparisons of remotely sensed soil moisture with output from GEOTOP reveal details of the spatial and temporal SM profile not possible before now.