Géosciences pour une Terre durable

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Near real time mapping of soil moisture using SAR images

ABSTRACT

Soil moisture plays a crucial role in the continental water cycle, more specifically on the distribution of precipitation between surface runoff and infiltration, which is the main driver behind most hydrological and geomorphologic processes. A better knowledge of the initial conditions of soil moisture could reinforce the early warning capacities of flooding. The main goal is to assess the soil moisture with a spatial accuracy and a temporal repetivity in adequacy with the requirement of the hydrological modelling. The French pilot basin of the Touch was selected because it is representative of Mediterranean type flash floods.

Works conducted in 2004-2005 have allowed assessing the behaviour of radar signal as a function of soil moisture. Results have shown that for a better estimate of soil moisture when using SAR data, it is necessary to use a radar configuration that minimizes the effects of surface roughness. The estimation of soil moisture is optimal at low and medium radar incidence angles (<35°). SAR images acquired at both low and high incidence angles (20° and 40°) makes it possible to eliminate the effects of roughness and thus to improve the accuracy on the estimation of soil moisture. The root mean square error on the estimation of soil moisture decreases by about 6% with one radar incidence (current SAR sensors) to 3.5% with two incidences.

The optimum configuration for soil moisture mapping with only one incidence can be attained by uniquely using the European ASAR sensor, 5 to 7 times per month on a study site in Europe. The arrival of new sensors (ALOS, RADARSAT-2 and Terra SAR-X, SENTINEL-1) should improve this periodicity. These results are tested face to the requirements of hydrological model and appear promising for the development of simplified operational algorithms for retrieving soil moisture from SAR data, and for monitoring multi-temporal moisture changes.

DATA BASE DESCRIPTION

• Study site: Touch River catchment basin near Toulouse, France (latitude 43° 27` N, longitude 01° 02` E). It is selected as reference basin for official authorities of flood forecasting and prevention (DIREN and SCHAPI).

• Radar imagery: the image data were acquired by ASAR and ERS-2 (C-band).

• Simultaneously with the radar acquisition, ground truth measurements including soil moisture and surface roughness were performed on several test fields. Soil moisture content was measured using gravimetric and TDR methods (upper 0-5 cm soil layer, 10 to 20 locations within each test field). The volumetric soil moistures range from 5.4% to 47.3%.

• It is composed mainly of agricultural fields intended for growing wheat and corn, forest stands, and urban areas.

DATA ANALYSIS

Strategy

• For a near real time mapping of soil moisture over the Touch basin**,** robust empirical relationships were obtained between the radar signal and the soil moisture using a large database acquired between 1998 and 2004 from several study sites. The database consists of C-band SAR data (ERS-2, RADARSAT-1, and ASAR) and measurements of soil moisture over bare soils.

• Next, these relationships are applied to ASAR images acquired in 2005 over the Touch basin.

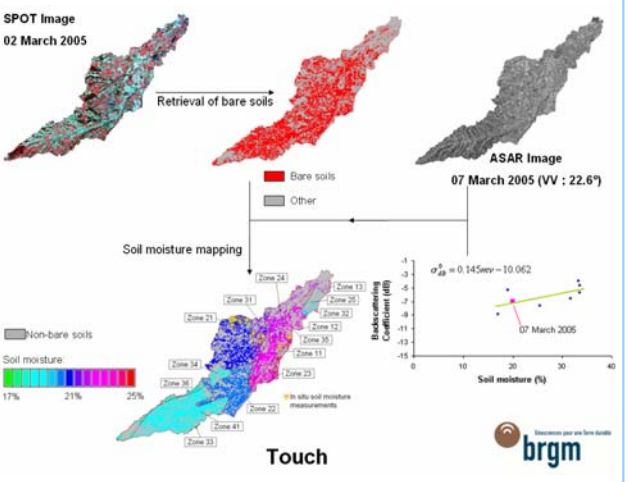
Results

• Results obtained in the validation phase with one incidence and one polarization show inversion errors in the estimation of *mv* of about 6% for incidence angles < 35°.

• Large errors in the retrieved soil moisture are observed for incidences of 40°-43° (RMSE of 9%). This is due to the fact that the radar signal is much more sensitive to surface roughness at high incidence angles.

• The use of both two polarizations does not improve on the inversion results obtained from a single polarization (about 1%).

• Good agreement was obtained when two incidence angles (one low and one high) were used. The RMSE of the comparison was found to be about 3.5%.



Results of the soil moisture mapping over the Touch basin. The SPOT-5 image was used to map bare soils and the ASAR image at 23° (07 March 2005) for mapping soil moisture over bare soils. The class denominated "other" includes forests, soils covered with vegetation, etc.

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