AIRBORNE MICROWAVE RADIOMETRIC MEASUREMENTS OF SOIL MOISTURE AND COMPARISON WITH SAR DATA

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Soil moisture (SMC) is a key state variable that influences both global water and energy budgets by controlling the redistribution of rainfall into infiltration, runoff, percolation in soil, and evapotranspiration. Due to these characteristics and to the great effect on the surface energy exchange, soil moisture content may have a strong impact on climate change dynamics and it is, therefore, a very important parameter for all hydrological applications, such as floods and drought monitoring, weather forecast, water and agriculture management.

A quantitative and accurate estimate of soil moisture on a global scale is always tricky, since local measurements of soil moisture content are strongly affected by spatial variability, besides being time-consuming and expensive. Moreover, the use of hydrological models for estimating SMC and extending the forecast of moisture distribution over larger areas is not straightforward, and it depends on the homogeneity of the selected areas and the information available on them (soil hydraulic characteristics and permeability, meteorological and climatological data, etc.).

The possibility of measuring SMC on a large scale from satellite sensors, with complete and frequent coverage of the Earth's surface, is, therefore, extremely attractive. Research activities carried out worldwide in the past have demonstrated that sensors operating in the low frequency portion of the microwave spectrum (P- to L-band) are able to measure the moisture of a soil layer, the depth of which depends on soil characteristics and moisture profile.

In general, the retrieval of soil parameters from microwave measurements is a typically ill-posed problem, because, in general, more than one combination of soil parameters (soil moisture, roughness, vegetation cover, etc.) has the same electromagnetic response. Multi-sensor techniques have a certain potential in discriminating between different contributions of the soil features to the global system response: in fact, by using sensors at different frequencies, polarizations and incidence angles, it is possible to improve the extraction of information and the classification accuracy. However, the availability of multi-frequency and multi-angle sensors on satellite platforms actually operating is limited, thus reducing the applicability of this approach.

An experiment with the aim of improving the generation of soil moisture and vegetation biomass maps by using both active and passive sensors was carried out in Northern Italy. The site selected for performing the experiments was a flat agricultural area close to Alessandria, in northern Italy (central coordinates: 45° N - 8.50 E). It is a flat alluvial plain measuring about 300 Km^2 and situated close to the confluence of the Scrivia and Po rivers. This area is characterized by large, homogeneous agricultural fields of wheat, alfalfa, fodder crops, corn, and sugarbeet.
An airborne campaign with multifrequency microwave radiometers at L, C and X bands was carried out on this area at the beginning of October 2008 in order to perform measurements of soil moisture and vegetation biomass and to compare these data with SAR images collected at the same time.

The microwave instruments were self-calibrating, dual polarized, digital radiometers with an internal calibrator based on two loads at different temperatures (250 K ± 0.2 K and 370 K ± 0.2 K). The beamwidth of the corrugated conical horns was 20° at -3 dB and 56° at -20 dB for all frequencies and polarizations. The cross polarization was lower than -30 dB. Calibration checks in the 30 K-300 K range were carried out before and after the field experiments by means of absorbing panels of known emissivity and temperature (Eccosorb AN74 and VHP8), and by observing clear sky with a calibrated noise source coupled to the antenna. The measurement accuracy (repeatability) was better than ±1K, with an integration time of 1 sec. A thermal infrared radiometer (8-14 μm) was also installed on the same boresight of the microwave radiometers.

Aircrafts were ultralight types able to fly at very low altitude. They crossed the area covering most of the agricultural fields. Ground measurements of vegetation biomass and soil moisture content (SMC) data were collected simultaneously with remote sensing measurements. SMC was measured by using a TDR (Time Domain Reflectometry) probe in different parts of the fields, and subsequently averaged. Also soil surface roughness was measured by using a needle profilometer. The statistical parameters of the surface were extracted from the processing of the profile pictures. Many fields at this time were bare and ploughed with high values of roughness and dry surface. Other fields were covered by senescent corn ready to be harvested or by corn stubbles.

Microwave experimental data have been compared with ground measurements and with simulations obtained with the Advanced Integral Equation Model (AIEM) and used for generating soil moisture and vegetation biomass maps of the area. These maps have been compared with ENVISAT/ASAR data.

A model able to relate emissivity to backscattering in the general case is not yet available. However, a simple formula exists for the case of an infinite half medium of isotropic scatterers. Thus, plotting measured emissivity versus backscattering and comparing experimental points with this model it has been possible to evaluate the deviation of the experimental points representing different surface types from the ideal case of isotopic model.

Experimental data have also been used to validate an algorithm based on an Artificial Neural Network and emission data at different frequencies in both polarizations for estimating regional soil moisture content. This algorithm will be applied within the framework of an operative project (PROSA) for the forecast of flooding funded by the Department of Civil Protection in Italy.