THE USE OF GNSS SIGNALS FOR ESTIMATING SOIL MOISTURE: THE LEIMON EXPERIMENT

M. Brogioni[1], M. Caparrini[2], A. Egido[2], E. Farres[2], N. Floury[3], L. Guerriero [4], E. Motte[2], E.Palchetti[1], S.Paloscia[1], P.Pampaloni[1], N. Pierdicca[5], E.Santi[1]

[1]IFAC-CNR, Florence, Italy, [2]STARLAB,Barcelona, Spain, [3]ESA/ESTEC,Noordwijk, Netherlands, [4]University of Tor Vergata, Rome Italy, [5] Sapienza University, Rome, Italy

The use of microwave radar and radiometer in estimating soil moisture and vegetation parameters of land has shown a good potential. However, both experimental activities and theoretical results seem to indicate that important limitations to the actual use of monostatic radar exist. They are: in soil moisture applications the simultaneous disturbing effects of soil roughness and vegetation cover; in vegetation monitoring, the early saturation of its response with respect to plant biomass. As far as radiometric measurements are concerned, the ground resolution required in many applications remains a challenging issue.

Global Navigation Satellite System are another possible source for bistatic radar observations of the Earth's surface. Indeed, preliminary investigations have demonstrated the capability of GPS scatterometers to sense small changes in land surface reflectivity and then in soil moisture [e.g.1-2]. Nevertheless, in order to obtain precise soil moisture estimates there are several phenomena that need to be taken into consideration, mainly the effects of diffuse scattering over the soil surface due to surface roughness and vegetation canopy [3].

In order to investigate the potentialities of GNSS signals for quantitative land bio-geophysical parameters remote sensing, and their future possible applications from spaceborne platforms a project has been promoted and funded by ESA. As a part of this project, a long term experimental campaign was foreseen in order to catch the natural variability of the geophysical parameters over a growing season and to accumulate enough observations. The campaign was carried on an agricultural area, kindly made available by the farm “La Salamandria”, located in Italy close to Florence along the Pesa River. Bare soil was first worked with several types of surface roughness, then half of the area was seeded with sunflowers.

A Starlab GNSS instrument was installed on a hydraulic platform, at a height of 20 meter above soil. The instrument features an up-looking GPS L1 RHCP antenna, for the reception of the direct signal, and two down-looking LHCP and RHCP antennas for the reception of the two polarization components of the reflected signal [4]. Both down-looking antennas share a common receiving channel, therefore the operative antenna is selected at each time by a radio-frequency switch. In addition to the GPS Antenna sections, two logical separated sections comprise the instrument: the Radio Frequency and the Digital Signal Processing section. The former comprises the calibration chain, which is a main part in the scatterometric instrument design, and the GPS front-ends, where the signal is down-converted to intermediate frequency, and digitized in a successive stage. In the Digital Signal Processing section the digitized signal is parallelized and sent to the instrument's software receiver, where the correlation of the signal with the clean replica is performed in order to finally produce the complex waveforms. The instruments records direct and reflected complex waveforms, and time series of the waveforms peaks from which the basic soil bio-geophysical observables are obtained.

Ground truth data, collected on the area at the same time as the GNSS measurements, comprised the most significant vegetation and soil parameters (plant density, leaf and stalk dimensions, number of leaves per plant, plant water content and moisture, volumetric and gravimetric soil moisture, surface height standard deviation and correlation length). Soil moisture of the first (10 cm) soil layer was continuously measured (24h/day) using 6 FDR (Frequency Domain Reflection) probes. Additional measurements were carried out with a portable TDR probe once a week. Gravimetric soil moisture was also measured collecting and weighting samples of soil before and after drying. These measurements were used for checking the calibration of FDR/TDR probes. Some meteorological parameters (i.e. air temperature, humidity, rainfall, etc.) were also measured on site. Vegetation parameters were measured by using conventional methods. Surface roughness measurements were obtained by using needle and laser profilometers. Soil temperature was monitored with a thermal infrared sensors and a PT 100 probe placed 10 cm below surface.

Soil moisture was also monitored on a restricted portion of the area with a ground based IFAC L-band radiometer [5] observing continuously 24 h/day at 50 degrees incidence angle.

The campaign lasted from early March to early September 2009 and made it possible to collect a significant amount of data in various surface and meteorological conditions. Comparison of GNSS radiometric and ground truth data have made it possible to estimate the sensitivity of GNSS signal to soil and vegetation conditions, and to perform a first estimate of the potentialities of the method in agricultural and hydrological applications.

Subsequently, experimental data have been used to validate physical models of bistatic scattering

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