Microwave remote sensing techniques for the analysis of land surface parameters

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Physical soil characteristics play an essential role in the functioning of continental water and carbon cycles. Over the last three decades, various different remote sensing techniques based on the use of microwave backscattering have demonstrated considerable potential for the estimation of soil and vegetation parameters, and several instrumental studies, making use of theoretical and experimental inversion techniques, have been developed for the retrieval of land surface parameters. Three techniques are discussed in this presentation: radar, passive microwave and GNSS-R remote sensing.

Active microwave remote sensing (radar) is well adapted to the characterization of soil surface conditions in agricultural fields, and has the advantage of remaining unaffected by meteorological and lighting conditions (cloud cover, day/night…). Radar relies on the use of microwave frequencies (wavelengths between 1 mm to 1 m) that are very sensitive to the geometric and dielectric properties of the measured medium, which are themselves dependent on surface parameters such as roughness, soil moisture, soil composition, and vegetation cover. Radar signals also depend on different instrumental parameters, such as polarization, incidence angle, and wavelength. In the case of covered soils, the radar signals scattered back to the sensor combine signals from the soil and from the vegetation. Most studies were carried out in the L-band (wavelength ~22 cm), C-band (wavelength ~6 cm), and more recently, in the X-band (wavelength ~3 cm).

Over the last three decades, passive microwave measurements have also demonstrated their strong potential for the estimation of soil moisture and other surface parameters. When compared to (active) radar measurements, passive microwave techniques should be less strongly affected by geometrical structures, in particular by soil roughness. Various experimental campaigns have been carried out using *in situ* towers or airborne measurements, in order to retrieve surface parameters (moisture, roughness, optical thickness of vegetation etc) from brightness temperature measurements. Simultaneously, the scientific community has made significant contributions to the development of radiative transfer models (empirical, semi-empirical or physical), in an effort to simulate and understand the behavior of microwave emissions produced by bare soils and various types of vegetation cover.

Global Navigation Satellite System reflectometry (GNSS-R) is a remote sensing technique that makes use of GNSS signals transmitted by navigation constellations, such as the Global Positioning System (GPS), following their reflection from the Earth’s surface. These signals are transmitted (and thus acquired) in the L band. GNSS-R remote sensing has several potential advantages when compared to classical remote sensing satellites. The first of these is the continuity (under all weather conditions) and global coverage provided by GNSS satellites. Secondly, the use of GNSS-R does not require the use of large, expensive receivers. Thirdly, the circular polarization of the signals makes them sensitive to the characteristics of the Earth's surface. In recent years, different experimental and theoretical studies have been proposed, in order to analyze the potential of this new technique.