Soil Moisture Monitoring Using GNSS-R Signals; First Experimental Results with the SAM Sensor

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ABSTRACT

Observing the Earth surface with Global Navigation Satellite Systems (GNSS) reflected signals has become a noteworthy remote sensing technique for the scientific community. The growing interest in GNSS as a remote sensing tool is due to its global availability and the carrier frequencies used. In fact, L-band, in which all current and next-future Global Navigation Satellite Systems emit, is a portion of the electromagnetic spectrum that highly interacts with the natural medium and for this reason, the possible applications exploiting these signals are numerous. In addition, the large number of GNSS signals in space, and their steadily increasing quantity and quality predicts a promising future for this remote sensing technique.

Among a wide variety of applications, soil moisture (SM) monitoring represents an important niche for GNSS-R. SM is a prime parameter for the surface hydrologic cycle since it drives the evapotranspiration and the heat storage capability of the soil, as well as determines the possibility of surface runoff after rainfalls. Despite the recognised environmental and commercial relevance of SM, providing such parameter over global and large scales remains a significant challenge. Sensors based on GNSS-R offer a suitable and efficient solution to this issue.

The basis for the retrieval of SM with GNSS-R systems lays in the variability of the ground dielectric properties associated to water content. The higher the concentration of water in the soil, the higher the dielectric constant and reflectivity, which affects signals that reflect from the Earth surface by increasing their peak power. Previous investigations, [1,2] demonstrated the capability of GPS bistatic scatterometers to sense small changes in surface reflectivity, becoming a precedent for this promising research line.

GNSS-R present various advantages with respect to others methods currently used to retrieve soil moisture. Firstly, as already mentioned, GNSS signals lie in L band, which is the most sensitive band to soil volumetric water content, i.e. soil moisture. Secondly, variations on thermal background do not contaminate GNSS-R signals as they do for other remote sensing techniques, such as radiometry. Finally, GNSS scatterometry from space has a potential higher spatial resolution than microwave radiometry, due to the highly stable carrier and code modulations of the incident signals which enables the use of Delay Doppler Mapping. However, in order to be able to obtain accurate SM estimates there are several effects that need to be taken into consideration. Some of those are mainly due to diffuse scattering effects over the soil surface, for instance effects due to surface roughness, vegetation canopy, and noise.

This paper reviews the theoretical approach for SM retrieval using GNSS-R, and focuses on the description of the development of an innovative GNSS-R system for soil moisture retrieval (named SAM). The validation campaigns performed with the SAM sensor, together with the results obtained are presented in the paper, which is finalized with the conclusions achieved and the ideas for future work on GNSS-R based sensors.

opment in the framework of the GSTP program, and Tragsatec for their collaboration in the acquisition of ground truth data and satellite imagery processing used for the SAM instrument validation.

REFERENCES

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