Determining complex permittivity from Fresnel coefficients in GNSS- reflectometry

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Global Navigation Satellite System Reflectometry (GNSS-R) is a microwave remote sensing technique which has been used in the last twenty years to derive information about the composition or the properties of ground surfaces [1,2]. The received power of the GPS signals reflected by the ground is proportional to the modulus of the perpendicular and parallel polarization Fresnel coefficients (see Fig.1). These coefficients depend on the incidence angle θ, and on the ground's permittivity ε, which is a complex quantity. The knowledge of ε is important for determining the soil moisture conditions and other characteristics of the surface (e.g., salinity, freeze-thaw transitions).

We are therefore interested in solving the inverse problem, consisting of finding the value of the permittivity from the knowledge of the measured values of the Fresnel reflection coefficients.

So far to our knowledge the real and the imaginary part of ε have been determined only with empirical models or numerically. In some cases (e.g., for non-dispersive soils), the imaginary part of ε can be neglected, and a real value of is ε sought. In this case, we have given explicit formulas for the determination of the real part of ε in [3,4].

In this work, we present explicit, analytical formulas for both the real and imaginary parts of the permittivity that should be used when the imaginary part cannot be neglected (e.g., wet soils or salinity determination).

These formulas are derived analytically and determine ε as an explicit function of the incident angle θ, and of the magnitude of the linearly polarized Fresnel reflection coefficients defined at the interface air-soil (see Fig.1). The results indicate that ε can only be determined in certain ranges of the incident angle θ. On the other hand, for $\theta = \pi/4$, there is a continuous range of values of ε. The analytical formulas were verified against know values of the complex permittivity obtained with numerical tests.

Most GNSS-R measurement systems are based on left and right circularly polarized antennas; in this case the linear reflection coefficients must be converted with suitable formulas to a combination of left and right circular polarizations.

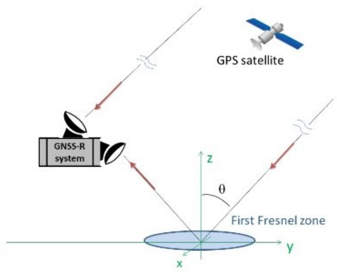

Figure 1. GNSS-R measurements system.

References

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