Using ground-based GPS to quantify surface moisture

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Motivation

Within the data evaluation process of global satellite navigation systems (e.g. GPS), one has to handle all existing factors with care in order to guarantee a highly precise and accurate determination of position points. These factors, which are affecting GPS positioning, are considered classified as satellite-related, atmospheric, and site-specific. The most important and most critical limiting site-specific factors are external antenna modelling and multipath effects.

Site-specific factors can be mitigated on the one hand by means of a correct and complete functional and geometrical modelling within the data evaluation process (e.g. receiver antenna modelling), but on the other hand it can be very difficult to model the effects caused by an inappropriate location (e.g. multipath reflections).

The choice of an appropriate method results from the reflections of the GPS signals consisting of an electrical and an optical magnetic component, on surfaces situated in the vicinity of the GPS antenna. GPS signals are polarized and thus the reflections are polarizations. The reflected signals interact with the direct, unreflected signals and determine the signal quality resp. the signal strength. As a measure of the signal quality the so-called signal-to-noise ratio (SNR) is referenced.

The framework of a cooperation between the Geodetic Institute, the Institute for Meteorology and Climate Research of the University of Karlsruhe (TH) and the Department of Electrical Engineering of the University of Applied Sciences Mannheim facilitates the feasibility of using ground-reflected signals of standard two-frequency passive GPS instrumentation as sensors for remote and in situ test investigations to conduct.

Fundamental Idea & First Experiment

This existence of a significant contribution between the soil-slip, surface moisture and the penetration depth of the received, ground-reflected GPS signals (considered as reflections) can be carried out not assuming the usability of GPS as a soil-slip, surface moisture sensor by means of analyzing the signal strength of the received GPS signals.

It is assumed that the position of the GPS antennas does not change within the experiment, and it is also assumed that the characteristics of the collector is only affected by variations of surface moisture, thus one is able to determine soil signal strength differences. Assuming additionally that the surface moisture is the only varied parameter (e.g. neglecting atmospheric variations due to temperature or humidity), signal strength variations could be correlated with moisture variations.

SNR values are depending on the manufacturer as well as on the satellite (Measurements Units (MU)/Amplitude Unit (AU)). In case of unachieved completeness of the used instrumentation precise minimum values of 972 dB (L1 frequency) 2.8 dB are characterised by a precise quality, therefore they are not taken into account in the data evaluation.

As an example the sky plots of the SNR values of the L1 signal at DOY 188 (of the reference antenna) and tilted antenna (bottom) are presented. The larger values of the unreflected reference antennas are clearly visible.

The MESMERISE data evaluation was carried out under the assumption that situations have an identical and constant correlation to each other. Therefore the geometrical situation defined by satellite positions, reflection surfaces and GPS antennas was repeated on a daily basis

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Data resolution (μAU): 0.25 μAU; important due to little SNR differences

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