Measuring snow seasonal variations in Antarctica with GPS

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Global Navigation Satellite Systems (GNSS) include GPS (USA), GLONASS (Russia), BeiDou (China) and Galileo (EU). GNSS systems are heavily used in everyday life for positioning, atmospheric monitoring, and timing. For these applications, reflected signals represent a detriment, reducing the achievable results accuracy. Conversely, when GNSS is used as remote sensing tool, reflected signals are beneficial and investigated to retrieve information on the near-surface antenna surroundings, such as soil moisture or snow depth [1,2].

In the past years, GNSS Interferometric Reflectometry (GNSS-IR) has become a well-established technique that uses signal-to-noise ratio (SNR) measurements to sense the antenna near field environment. The SNR oscillatory pattern arises from the interference between the direct and reflected signal components. Because of the antenna gain pattern, designed to suppress multipath effects, these interferences can only be seen at low satellite elevation angles, when satellites rise or set. The frequency of the SNR interference sinusoidal pattern depends on the vertical distance between the phase center of the GNSS antenna and the reflecting surface, and on the signal wavelength. In this study, only GPS satellites are considered, using the civilian frequency L1 available on all satellites.

GPS-IR applied to antennas in Antarctica allows to retrieve snow height variations, and to study snow precipitation/ablation in a meteorological sense. We used the homemade software ROB-IONO and Atomium to assess the snow height variations. The first antenna considered was deployed by the Royal Observatory of Belgium on the Derwael Ice Rise, in the coastal Dronning Maud land. This station provided continuous data from late 2012 to early 2016. At the beginning, the marker of the antenna was buried 1.85 m in the firn and the antenna positioned on a mast of 1.6 m from the ground. Every year the mast was extended using a roughly 1.6 m long rod, to avoid the complete sink of the antenna in the snow.This effect is mainly due to the vertical movements (1.3 my^{-1}) of the antenna towards the geocenter, caused by ice convective movements. Taking the antenna subsidence into account, we highlighted an annual variation of snow accumulation in April-May (~30-50 cm) and ablation during spring/summer period. The ultimate goal is to apply the method to GNSS stations from the POLENET network covering also the West Antarctic area to build a map of snow accumulation/ablation seasonal variations in Antarctica.

References

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