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Doppler shift estimation for GNSS reflectometry using a land topography adapted reflection model

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A GNSS setup with a receiver capable for reflectometry is operated by GFZ at Kongsfjorden (Spitsbergen), 78°54'14"N, 11°52'37"E, 512 m above ellipsoid (WGS-84). This permanent station at the Zeppelin mountain outpost, operated by the Norwegian Polar Institute (NPI), accumulates data since Summer 2013 observing reflections over the fjord and the adjacent land surface. Especially the presence of sea ice over the fjord and snow cover over land are of interest for reflectometry to investigate altimetry and remote sensing applications. The setup contains a GORS (GNSS Occultation Reflectometry Scatterometry) two-frontend receiver, which is based on commercial JAVAD hardware. The receiver is connected to one up-looking and one horizon-looking patch antenna with right-handed and left-handed circular polarization, respectively. Both antennas are installed on the same mount approximately 475 m above the fjord mean sea level. Reflections are observed at low transmitter elevation angles (between 10 and 2°). For these geometries the relative Doppler shift (sea surface reflected relative to direct signal) is almost constant 0.5 to 0.6 Hz and can be calculated with an established reflection model. Rather easily, sea surface reflections are identified in the data and the corresponding reflection points are located. About 55 daily recurring reflection events over the fjord are observed. They form a fan-shaped swath with 3 to 13 km distance around the receiver, corresponding to elevations of 10° to 2°. Also signatures of potential land reflections are found in the data. About 13 daily recurring events extend mainly over land. The potential land signatures have a rather variable Doppler shift between 0.2 to 1Hz. The significant topography of the mountainous surrounding, which varies between sea level and 900 m altitude, prevents the use of established reflection models. A topography adapted reflection model, which considers sloped surface facets, is developed. It incorporates a digital elevation model of the Kongsfjorden area, provided by NPI. This model solution is presented identifying the land reflection signatures and locating the corresponding reflection points. A relation between changes of the reflected signal power and the snow cover during the year 2014 was found. Further steps are planned to study the influence of the snow liquid water content, which is known to affect the snow reflectivity at GNSS wavelengths. Further efforts are required to correct considerable deviations in Doppler shift ($\sim$0.1 Hz) that still occur between the land reflection model and observed signatures.