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GNSS as a sea ice sensor - detecting coastal freeze states with ground-based GNSS-R

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Based on the idea of using freely available signals for remote sensing, ground-based GNSS-reflectometry (GNSS-R) has found more and more applications in hydrology, oceanography, agriculture and other Earth sciences. GNSS-R is based on analysing the elevation dependent SNR patterns of GNSS signals, and traditionally only the oscillation frequency and phase have been studied to retrieve parameters from the reflecting surfaces.
However, recently Strandberg et al. (2016) developed an inversion algorithm that has changed the paradigms of ground-based GNSS-R as it enables direct access to the radiometric properties of the reflector. Using the signal envelope and the rate at which the magnitude of the SNR oscillations are damped w.r.t. satellite elevation, the algorithm retrieves the roughness of the reflector surface amongst other parameters. Based on this idea, we demonstrate for the first time that a GNSS installation situated close to the coastline can detect the presence of sea-ice unambiguously. Using data from the GTGU antenna at the Onsala Space Observatory, Sweden, the time series of the derived damping parameter clearly matches the occurrence of ice in the bay where the antenna is situated. Our results were validated against visual inspection logs as well as with the help of ice charts from the Swedish Meteorological and Hydrological Institute. Our method is even sensitive to partial and intermediate ice formation stages, with clear difference in response between frazil ice and both open and solidly frozen water surfaces. As the GTGU installation is entirely built with standard geodetic equipment, the method can be applied directly to any coastal GNSS site, allowing analysis of both new and historical data. One can use the method as an automatic way of retrieving independent ground truth data for ice extent measurements for use in hydrology, cryosphere studies, and even societal interest fields such as sea transportation. Finally, the new method opens up for further studies in the response of GNSS-R to ice-related parameters, as periods of ice can easily be detected in both historical and new GNSS data.

Strandberg J., T. Hobiger, and Rüdiger Haas (2016), Improving GNSS-R sea level determination through inverse modeling of SNR data, Radio Science, 51(8), 1286–1296, doi:10.1002/2016RS006057.