SnowScat's Tomographic Profiling Mode: A Time Series Acquired During The ESA SnowLab Campaign 2015/2016

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SnowScat is a terrestrial stepped-frequency continuous-wave (SFCW) scatterometer which supports fully-polarimetric measurements within a frequency band from 9.2 to 17.8 GHz. Designed originally to support the investigation and validation of snow water equivalent (SWE) retrieval algorithms in the context of the CoReH20 candidate Earth Explorer 7 mission the SnowScat hardware has meanwhile been enhanced by adding a tomographic profiling mode. When operated in tomographic profiling mode the SnowScat device is additionally moved along a rail in elevation direction such that a synthetic aperture can be formed along this dimension. The advantage of this technique is that a high spatial resolution is obtained not only in direction of propagation but also along elevation by employing adequate signal processing techniques. In such a way, high-resolution two-dimensional vertical profiles of a snowpack can be obtained. More specifically, using the SnowScat device in tomographic profiling mode, it is possible to non-destructively retrieve high-resolution information on the spatial variation of radar backscatter, co-polar phase difference, interferometric phase and coherence; observables that (potentially) vary with spatially and temporally changing properties of the snowpack.

In winter 2014/2015, a first test campaign at a test site hosted by the WSL Institute for Snow and Avalanche Research (SLF), in Davos, Switzerland was carried out yielding a successful proof of concept of the enhanced hardware, the tomographic measurement, and a basic processing concept. A comparison of a tomographic profile with an in-situ snow profile indicated that the most prominent melt-freeze crusts/ice layers present within the snowpack could be identified. Within the scope of the more recent ESA SnowLab project a first time-series of tomographic profiles was acquired at the test site Gerstenegg, close to the Grimsel pass, in Switzerland, in winter 2015/2016.

In this paper, we will show the detailed tomographic measurement concept and we will present and discuss this comprehensive time series of two-dimensional tomographic profiles of a snowpack based on observed parameters such as 1) variation of radar backscatter, 2) co-polar (HH-VV) phase difference and 3) differential (temporal) coherence between tomographic profiles along the time series. Comparisons with various in-situ measurements are performed.