Polarimetric Sensitivity of Multi-Frequency Airborne SAR Measurements to the Ice Zones of Greenland

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Polarimetric SAR data are well known to provide a better characterization of a scattering scene compared to single-polarization measurements. In order to further extend the observation space, multi-frequency (polarimetric) measurements can be considered. The joint use of different wavelengths allows to gain sensitivity about scatterers at different size scale and at different depth (in case of volumes) due to the different penetration depths. For the study of ice masses, multi-frequency Pol-SAR data are expected to be sensitive to different subsurface layers. For instance, X-band is more suitable to investigate the shallow snow cover as well as surface features while L-band allows to sense the underlying firn and ice layers. Therefore, such a dataset can potentially provide a significant contribution to the identification and characterization of different ice zones which, in turn, is needed for more accurate mass balance estimation.

Because of the large number of factors determining the subsurface structure of glaciers and ice sheets, the exploitation of PolSAR data still plays a secondary role in the study of snow and ice properties. Early studies addressed the identification of ice zones focusing on the analysis of backscattering coefficients in single [1] and multi-polarization configurations [2]. Recent studies have shown that also the coherent nature of the polarimetric signature is essential. For instance, it has been shown that polarimetric phase differences between the HH and VV channels can reveal details of the microstructure of snow and firn layers [3].

In this study, a multi-frequency analysis of polarimetric signatures over the different ice zones of the Greenland ice sheet is presented. A set of descriptors is employed to extract and interpret the polarimetric information from the data, which includes backscattering coefficients, the scattering entropy, the mean alpha angle, polarimetric ratios and phase differences. The study is based on a multi-frequency (L-, C- and X- band) airborne Pol-SAR dataset acquired in May 2015, during the ARCTIC15 campaign, over a 200 km long (and 5 km wide) transect in West Greenland. Preliminary results show that, X- and C-band signatures are dominated by the ice surface features (e.g. roughness), which can generate complex (volume-like) scattering at such short wavelengths even in the bare ice (ablation) zone. Over the firn (accumulation) zone, the polarimetric signatures are saturated due to strong volume scattering occurring within the firn layers. In contrast, L-band measurements show a pronounced change of polarimetric signatures over the area of transition between two zones, pointing out a clear variation of scattering mechanisms according to the different subsurface structure.

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