Temporal Variations of X-Band PolInSAR coherence over Glaciers

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In recent years there has been increased interest in using synthetic aperture radar (SAR) to study and monitor ice and snow properties for glaciological and climate change research. Many studies exploited the polarimetric or interferometric information of SAR acquisitions, while the combination of both, Polarimetric SAR Interferometry (PolInSAR) was not yet extensively addressed. Particularly in forest applications, this technique is today a well-established SAR remote sensing discipline with unique and powerful applications related to the estimation of vertical structure of volume scatterers, e.g. forest height or biomass, promising a huge potential for snow and ice applications.

The use of different wave polarizations (SAR polarimetry), in fact, provides information on the scattering processes, which occur on the snow/ice surface and subsurface, while the coherent observation of the scene from slightly different angles (SAR interferometry), provides further information on the vertical location of the aforementioned scattering mechanisms [1]. This, combined with the penetration capability of radar waves - even at higher frequencies (e.g. X-band) - into ice and snow combined with the weather and sunlight illumination independent imaging capabilities make PolInSAR an ideal technique to study and monitor glaciers and ice sheets for glaciological and climate change research. A first remarkable success was the robust estimation of the scattering extinction of ice volumes at different frequencies (L- and P-band) [2]. The extinction coefficient is a key parameter linked to the dielectric properties of the ice volume as well as to its vertical structure.

The complex interferometric coherence at a given polarization depends on system and acquisition parameters as well as on physical parameters of the scatterer. After the compensation of system and geometry induced decorrelation effects the PolInSAR coherence is comprised of temporal, volume, and noise decorrelation. Temporal decorrelation can be avoided by using the simultaneous interferometric acquisitions of TanDEM-X. Further assuming negligible noise contribution, the volume decorrelation can be exploited for geophysical parameter estimation. Additionally, two dual pol time series of TanDEM-X over the Aletsch glacier, Switzerland and Helheim glacier, Greenland, provide an ideal test bed for the investigation of temporal PolInSAR signatures, with the goal to relate these to the temporal variation of snow and ice parameters like snow cover wetness, ice structure and density or grain size.

First analyses on the Aletsch glacier exhibit different temporal variations of the polarimetric interferometric complex coherence with indications of a dependency on glacier facies. For summer acquisitions indications for an increase in temporal variation with height can be observed. The temporal dual pol TanDEM-X PolInSAR signatures will be presented and further research directions highlighted