COMBINATION OF INTERFEROMETRIC AND POLARIMETRIC SAR MEASUREMENTS FOR SNOW WATER EQUIVALENT RETRIEVAL

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Globally, more than 16% of the human population rely on snow melt for their supply of fresh water. However, increasing temperatures due to climate change have an effect on the amount and timing of snow melt and runoff, thus influencing the ability of fresh water in many regions [1]. A variable which can be used to characterize the amount of liquid water in the snow pack is the Snow Water Equivalent (SWE). SWE combines the information on snow depth and density in one parameter and is an essential model input required for the description of water and energy cycles on the globe [2].
Remote sensing using Synthetic Aperture Radars (SARs) offers the possibility to monitor snow covered areas with a high spatial resolution independent from weather and illumination conditions [3]. In particular the ability of SAR to penetrate into the snowpack allows to be sensitive to snow parameters [4].
In dry snow, radar waves are refracted in the snow pack, because snow has different dielectric properties than air. This refraction can be measured in terms of an interferometric phase between two repeat pass SAR measurements (DInSAR) if a SWE change occurred between the measurements [5], [6]. However, due to the 2π interval of the interferometric phase, only a limited range of SWE changes can be retrieved unambiguously. The interval, outside where phase wraps occur, has a strong dependence on the wavelength of the radar wave and is larger for longer wavelengths. First results have shown that the phase wraps of the interferometric phase, especially for short wavelengths (e.g. X- and C-band), are one of the main limitations of using interferometric measurements for the SWE change retrieval.
Other methods rely on polarimetric SAR measurements for the retrieval of snow properties [7], [8]. It was shown, that the Copolar Phase Difference (CPD) between the VV and HH channel can be used two invert the snow depth. Between two SAR acquisitions, the depth of fresh snow can thus be inverted assuming a snow anisotropy and density and then be translated into a SWE change.
The objective of this study is to combine these two approaches and exploit the information given by the interferometric and polarimetric variables. For this purpose, we assess different SAR datasets. For the airborne case, SAR measurements acquired over the Great Aletsch Glacier in Switzerland with the airborne radar systems F-SAR are investigated. A time series of full polarimetric measurements were performed in X-, C- and L-band accompanied by ground measurements of snow parameters. For the investigation of spaceborne measurements, dual polarized data in the VV and HH channel acquired by TanDEM-X over a test-site in Svalbard are utilized.
First results indicate that the additional information on snow depth inverted from the CPD can provide valuable information for the interferometric SWE retrieval. The CPD allows to detect the amounts of phase wraps in almost all cases, which is validated with in-situ measurements. However, the performance of this method is limited as, depending on the temporal resolution of the SAR acquisitions, the snow microstructure of the fresh snow can change due to temperature gradients, affecting the anisotropy of the snow pack and therefore the measured CPD.
Up to now, the SWE retrieval with interferometric SAR and the fresh snow detection with polarimetric CPD measurements were applied separately and combined afterwards to estimate the amount of interferometric phase wraps. Our aim is to further refine the method, to have additional information on the snow structure change between the measurements. Changes in fresh snow depth and anisotropic snow structure, which influence the CPD measurements have also an influence on the interferometric DInSAR phase in the VV and HH channel. Therefore, it seems promising to treat both methods as a combined Polarimetric Interferometric SAR (PolInSAR) technique. This should increase the observation space with the overall goal to obtain a more robust SWE estimation concerning phase wraps and snow structure changes.

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