Topography and Displacement of Polar Glaciers from Multi-Temporal SAR Interferograms: Potentials and Error Analysis

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The capability of SAR interferometry in terms of deformation monitoring and topographic mapping has been proven by various case studies during last decades. In recent years, the focus of investigations has changed towards a detailed analysis of potential error sources, such as temporal decorrelation, atmospheric path delay, surface penetration, and orbit uncertainties. The analysis of stable targets, so called persistent scatterers, identified from a number of interferograms enables to minimize the effect of temporal decorrelation and to remove the influence of the atmospheric path delay. Based on this technique, DEMs with meter accuracy and millimeter terrain motion detection can be derived. However, due to the lack of stable targets, this method can not be applied for the analysis of polar glaciers, which is a well known application of InSAR. Thus, the evaluation of possible error sources is still a challenging problem in glacier monitoring.

This paper describes a new technique to simultaneously estimate topography and motion of polar glaciers from multi-temporal SAR interferograms. The approach combines several SAR interferograms in a least-squares adjustment based on the Gauss-Markov model. In order to connect the multi-temporal data sets, a spatio-temporal model is proposed that describes the properties of the surface and its temporal evolution. The parameterization of the model can be adapted considering the properties of the object under investigation. The redundancy in the equation system allows attaching all estimated unknowns with accuracy and robustness measures. The rigorous mathematical modeling of functional and stochastic relations allows for a systematic description of the processing chain. It is an optimal tool to parameterize the statistics of every individual processing step and the propagation of errors into the results. Schemes for analyzing the accuracy and robustness of the approach enable to estimate the theoretical standard deviations of the unknowns, the robustness of the results and the influence of possible unmodeled error sources in advance. Therefore, the approach is a useful tool for project planning.

The paper outlines the major features of the approach. Based on theoretical data, the potential of the approach with regard to the application of glacier monitoring is analyzed. Theoretical standard deviations of the unknowns are calculated depending on the number and the geometric configuration of the data sets. The influence of gross errors as well as the effect of non-modeled error sources on the unknowns is analyzed. A concluding case study demonstrates the feasibility of this approach in real-life situations.