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Glacier monitoring by spaceborne SAR data

Glaciers, one considerable part of the global cryosphere, sensitively interact with climate fluctuations and therefore they become very important climate indicators. Presently, they are the dominant cryospheric contributor to the sea-level rise although they only account for a very small part of the total volume of ice locked up on land. Whether glaciers are growing or decaying, and at what rate, will have some crucial influences in terms of water resources, economical development and risk management in the surrounding regions. Thus, there is an urgent need to study and monitor properties of glaciers and ice sheets, including glacier dynamics, mass balance, glacier surface area and furthermore the volume. In situ observations in the field can be used for part of the monitoring by various glaciological, hydrological or geodetic methods, but spaceborne and airborne remote sensing can provide comparable cost-effective and area-effective data.

Optical sensors have been extensively used to study ice covered areas, but the limitations are their dependence on weather conditions, which cannot always provide timely information of the target area. However, SAR, due to its all day, all weather imaging capabilities, can reliably collect data with a predefined temporal interval over long periods of time with a spatial resolution compatible with the application of glacier monitoring.

Recently, much work has been done to study the mass balance and surface area changes of glaciers using SAR techniques: most of the work is based on interferometric information or polarimetric data. But, the use of interferometry is frequently not possible due to the rapid movement and change of ice-surface conditions especially at most of the outlet glaciers, and the polarimetric data is only available in special areas and periods making it impossible for providing timely information. In this work, a method for glacier monitoring using multi-temporal and multi-angle high resolution TerraSAR-X data sets aiming to reduce the ‘data holes’ caused by radar shadowing and specular backscattering of smooth ground surface is proposed. Based on this, the glacier motion rates, one control parameter determining the mass balance, are firstly generated. The velocity will then be used to contribute to the glacier area detemination based on contextual classification and geophysical model concerning the glacier kinematics.

Moreover, the glacier thickness and volume are known for only less than 0.1% of the estimated global population of more than 200,000 glaciers. Volume estimation, however, is one of the most crucial and difficult tasks in the whole monitoring work. Therefore, it is intended to exploit an accurately determined glacier surface in order to generate rough estimates of the corresponding glacier volume based on geophysical models (volume-area scaling model). The estimation of glacier surface and volumes is expected to help the mapping and further investigation of two- and three-dimensional glacier changes.