XMAS - Determination of the Mass Balance of Alpine Glaciers with TerraSAR-X data

Volker Hochschild, Felix Bachofer, Jan Kropacek (Geographisches Institut, Universität Tübingen)
Rudolf Sailer, Hans Stötter (Institut für Geographie, Universität Innsbruck)
Andrea Fischer (Institut für Meteorologie und Geophysik, Universität Innsbruck)

Introduction

Glacier monitoring is becoming increasingly important due to global climate change and its impacts on glacier volume. The rapid retreat or advance of glaciers is a potential economic and environmental threat to the mountainous areas of Europe. So accurate and up-to-date information of the characteristics and the current trend of these changes, provided by modern satellite systems like TerraSAR-X, are needed in resource management, environmental protection as well as in global change studies. Glaciers are remote objects which have been observed and monitored over a long period (recently also with remote sensing data). The main interest in glacier monitoring has not only been the areal extent of the glacier, but also the glacier topography, thus allowing estimates of the glacier volume and the classification of the accumulation zone. The multipolarimetric design of TerraSAR-X is especially suitable for mapping of the accumulation area.

Methodology

The methodological approach of the XMAS-project is threefold:

1. With its fast repetition cycle of 11 days TerraSAR-X data will enable multitemporal change detection applications to observe the transition periods in autumn (snow accumulation) and spring (snow melt) with a higher time resolution as ERS and ENVISAT (35 days). This multitemporal quantification of the areal extent and height variations is of tremendous importance for the estimation of mass balance alterations and ice dynamics.

2. The signal intensity and the polarimetric information content are key issues in the determination of snow and firn in the accumulation area of the glaciers, since optical data is unsuitable over there due to missing surface texture. Nevertheless data fusion techniques will be applied to combine TerraSAR-X data with high resolution optical and laser scanner data.

3. Apart from these multisensoral evaluations also new object oriented classification approaches should be developed for applications in glaciology as well as a comparison of the different spatial acquisition modes of TerraSAR-X, to determine the highest potential for future glaciological applications.

Objectives

The main objective of the XMAS-project is the evaluation of the potential of TerraSAR X-band data to map different glacier surfaces in relation to the determination of mass balance parameters. TerraSAR-X data will be used in combination with other remote sensing sensors by applying data fusion techniques. This synergistic remote sensing analysis comprises object oriented detection and classification of TerraSAR-X data with the major advantages of the high spatial resolution, the fast repetition cycle and the full-polarimetric capabilities in combination with high resolution optical data (QuickBird, etc.) and laser scanner data (DEMs and intensity values), available for the test site on Hintereisferner in Austria.

TerraSAR-X Data

The following acquisition dates of TerraSAR-X data were selected for the test site Hintereisferner (Oetztal Alps, Tyrolia, Austria) during the summer 2008 ablation period.

- Simultaneously two laser scanning flights were acquired on the 7th of August and on the 9th of September 2008 by the TOPSCAN company by order of the cooperating ALS-X group of the University of Innsbruck (Geography Department, Prof. Stötter, Dr. Sailer).
- Additionally also digital optical images were acquired during these overflights by a Rollei Camera. Meteorologists of the University of Innsbruck (A. Fischer et al.) at the same time sampled field measurements of surface roughness, snow moisture, snow depth and provided web cam images of the upper Hintereisferner and are helping with local knowledge about the glacier by the interpretation of the TerraSAR-X images.

Results

Although there are no final results available yet, the preliminary interpretations show a general dependence of the TerraSAR-X images on surface roughness, distinguishing a smooth snow covered accumulation zone and a rough snow free glacier tongue on the StripMap mode images. On the higher resolution StripMap mode images single features like the position of the equilibrium line, crevasses, shattered glacier rims with wet snow covered crevasses, as well as rain gauges close to the glacier are visible and are subject to further interpretations.

Outlook

The TerraSAR-X acquisitions will continue during the summer period 2009, especially during the spring melting season from May on. Another laser scanning flight will be acquired simultaneously in order to exactly reference the TerraSAR-X data to the elevation data of the glacier. This will enable estimations of the mass balance of the glacier.