Mapping glacial and periglacial environments with optical and radar data

At all latitudes, field research in glacial and periglacial regions encounters limitations in terms of accessibility, expenses and repeatability. Remote sensing techniques represent a valuable additional dimension for feature monitoring. They • operate at global scales • use globally uniform data sets and methods • provide long-term, comparable measurements.

The Reintal in southern Germany and Austfonna on Svalbard are considered here (Fig. 1). Located at similar longitudes, they represent two extremes in terms of (peri-)glacial environments: a high alpine, steep rugged valley versus a smooth ice cap with low optical contrast.

Two independent methods are assessed to handle the gradients involved with respect to topography and climate: A. an object-oriented approach for alpine landform detection B. a combination of optical and radar data for subpolar mapping across large areas.

In the segmentation on four levels (Fig. 2), the small scale parameter conveys the spectral ground information of the Reintal (L1, Fig. 2) and the mask of three altitudinal subsystems (L4) requires a high scale parameter

A. an intermediate level serves as final level L2 (for details, see Schneevoigt et al., 2008).

In a second, separate step, classification is done on level L1, L4 and L3 individually. All information then merges into the final classification on L2, mostly based on fuzzy membership functions.

Level L1 classification renders ground land cover, level L4 the strata mask, level L3 eastern and western walls of cirques and hanging valleys (see Schneevoigt & Schrott, 2006).

This leads to a sound L2 landform classification (Fig. 3): a kappa coefficient of 0.915 in eCognition confirms the good fit of the results to ground truth.

The result of approach A coherently shows the geomorphic process units in the entire valley up to its inaccessible upper regions, which had not been mapped before.

In the visible spectral range, interpretations appear quite straightforward, because optical data depict the ground as it is perceived by the human eye. This helps understanding and represents an asset for methods to be widely spread.

For further information on the optical, object-oriented remote sensing applications and for geomorphologic details, see Schneevoigt et al. (2006, 2008).

Conversely, SAR imagery delivers information beyond the visible, backscatter, polarisation and interferometric phase coherence permit inferences on and below the surface, concerning roughness, melting conditions and snow facies amongst others.

Juxtaposing the two approaches A and B shows that the combination of these two distinct data sources is advantageous. The incorporation of radar data into an object-oriented classification scheme could result in a further yield of information.

References


Acknowledgments

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Fig. 1: Study areas in the Bavarian Alps (Reintal valley) and on Svalbard (Austfonna ice cap). Source: Google Earth

Fig. 2: Object-oriented classification. Top: Input data: an ASTER satellite scene (29.03.2001, 15m resolution), a digital elevation model (DEM; 5m resolution) generated in Topogrid. Segmentation on four hierarchical levels L1 to L4. Bottom right: workflow in object-oriented classification.

Fig. 3: Study area in Austfonna: Svalbard, Norway. Representative object-oriented classification result (17 km², relative relief of 1700 m).

Fig. 4: InSAR principles. Left: coloured fringes with 2m wavelength and phase difference (π) between the two passes. Right: eSAR geometry. “Flat Earth” removal to obtain clear topography signals and the effect of movements.

Fig. 5: Austfonna ice cap: (a) SAR amplitude image. (b) Interferograms of 7.8.1995: amplitude image in the background. Fringe structures from “Flat Earth” topology and movement. (c) Interferogram of 7.8.1995: “Flat Earth” corrected. Remaining fringes from topography and movements. (d) Unwrapped interferograms: where the fringes represent coherence values instead of moduli. 2π. Marked areas indicate fringe deformation due to movement influence.

Fig. 6: Landscape composite of Austfonna (10.07.2001) in RGB 540, shown in RGB 321 in the poster background.