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Remote sensing for mapping glacial and periglacial mountain environments. Examples from geomorphic landforms in the Bavarian Alps and from Norwegian glaciers

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At all latitudes, field research in glacial and periglacial regions encounters limitations in terms of accessibility, expenses and repeatability. Remote sensing techniques hence represent a valuable additional dimension for feature monitoring: they allow for operating at global scales with uniform data sets and measuring methods, thus providing continuous and comparable series of measurements. However, mountain environments imply difficult terrain conditions. Extreme altitudinal differences may occur within small horizontal intervals and result in offsets of many pixels or hundreds of meters if scanned at disadvantageous angles. Illumination and brightness often vary strongly because of relief influences, leading to shadows and shading. To handle those impediments, two independent approaches are assessed, the object-oriented approach for alpine landform detection on the one hand and the combination of optical and radar data for subpolar glacier mapping on the other.

Using the object-oriented approach comprising four spatial levels of differentiation, geomorphological landforms are mapped in a valley of the Bavarian Alps. A satellite scene from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and a digital elevation model (DEM) are classified predominantly with fuzzy membership functions. The result coherently shows the present-day pattern of geomorphological process units in the entire valley up to its inaccessible upper regions, whilst previously only the valley floor could be mapped in situ. When thus working 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 important asset for methods to be widely disseminated.

Conversely, synthetic aperture radar (SAR) imagery delivers a wide range of information beyond the mere visible. For example, backscatter, polarisation and interferometric phase coherence permit inferences on and even below the surface, concerning roughness, ground humidity and ice melting amongst others. The spectral analysis of combined optical and SAR data apllied to glaciers utilises that the spectral mass balance correlates with the volumetric glacier mass balance. This is demonstrated at the example of Norwegian glaciers and indicates that the combination of these two distinct data sources leads to an increased gain of information: optical and radar analyses can complement one another with their respective strengths. Further research is however needed to confirm these first results.