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Author(s):
Li, Shiyi; Huang, Lanqing; Bernhard, Philipp; Hajnsek, Irena

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Wet Snow Mapping in the Karakoram using SAR and Topographic Data

Shiyi Li[1], Lanqing Huang[1], Philipp Bernhard[1], and Irena Hajnsek[1,2]
[1]ETH Zurich, Institute of Environmental Engineering, Dept. of Civil, Environmental and Geomatic Engineering, Zurich, Switzerland (shiyi.li@ifu.baug.ethz.ch)
[2]2Microwaves and Radar Institute, DLR, Germany

Wet snow is a critical component of the cryosphere, and its spatial and temporal distribution has important implications for water resources, natural hazards, and the regional climate. However, mapping wet snow in alpine regions such as the Karakoram is challenging due to complex topography, harsh weather conditions, and limited in-situ observations.

Previous studies have shown that synthetic aperture radar (SAR) can effectively detect wet snow surfaces using the backscattering ratio between the current and reference images (e.g. the average of summer acquisitions). However, its regional application on a large-scale and complex terrain is hampered, as the ratio value is easily affected by the land cover, local topography, surface roughness, and snow wetness.

In this study, we present a new approach for mapping wet snow in the Karakoram using a combination of SAR data and topographic information. The SAR data used in the analysis were obtained from Sentinel-1, and the topographic data included a digital elevation model (DEM), slope angle, and slope aspect ratio. We first used a Gaussian Mixture Model to classify the ratio image of Sentinel-1 into wet snow (WS) and non-wet snow (NWS) classes, then transformed the two classes into a logistic function to characterize the probability of WS based on the backscattering ratio. Secondly, we categorized the image based on the topography and calculated the likelihood of WS for each topographic bin using the WS probability. The joint WS likelihood map was finally obtained by multiplying the WS probability on the backscattering ratio with the WS likelihood on topography, and a binary WS map was generated by setting a threshold on the joint likelihood map.

The proposed method was validated using snow maps generated from Sentinel-2 images. Compared with the traditional method of using only the SAR backscattering ratio, our method significantly reduced false negative detections and preserved the high true positive rate, indicating an improvement of robustness and accuracy by combining SAR and topographic data for regional wet snow mapping.

This study demonstrates a practical method of merging SAR backscattering features and topographic information for robust regional wet snow mapping in complex mountain ranges. It

also provides new insights into the incorporation of different datasets using a probabilistic framework. With the proposed method, the operational monitoring of wet snow distribution in the Karakoram using SAR becomes feasible and reliable.