Mapping Snow Mass in the European Alps Using Sentinel-1 Radar Observations

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ABSTRACT

Seasonal snow packs provide the water supply for more than one-sixth of the world’s population and have major impacts on climate. However, the spatio-temporal variability of snow is still poorly understood, particularly in mountainous areas, owing to a lack of high-resolution satellite observations and robust snow retrieval algorithms. We demonstrate the ability of the Sentinel-1 mission to monitor snow water equivalent (SWE) at 1-km resolution over the European Alps for 2015-2017. The SWE retrievals rely on a change detection algorithm using the cross-polarization ratio, or the ratio of cross-polarization to co-polarization backscatter. We show that this ratio is sensitive to SWE throughout winter. For dry snow conditions, Sentinel-1 SWE retrievals and in situ measurements from 588 sites across the Alps correlate to 0.8 over time and 0.68 over space, with a root-mean-square difference (RMSD) of 0.06 m. The SWE retrievals outperform globally available 9-km model simulations, which have a spatial correlation of only 0.28 vs. in situ measurements. The Sentinel-1 SWE retrievals also match regional, 1-km resolution snow model simulations over Austria and Switzerland, with correlations of 0.81 in time and up to 0.91 in space. Correlations are slightly lower over densely forested areas and somewhat lower over high-elevation areas with high simulated SWE during wet snow conditions. The results highlight the potential of Sentinel-1 observations to provide regional snow estimates at an unprecedented (1-km) resolution in mountainous areas.

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