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Exploitation of X-band SAR images and ground data for SWE retrieval through a machine learning technique

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Snow cover is a critical geophysical parameter for Earth climate and hydrological systems. It contributes to regulate the Earth surface temperature and represents an important water storage that is slowly released during the melting season and contributes to the river discharge.

The parameter that characterizes the hydrological importance of snow cover is the snow water equivalent (SWE). An accurate estimation of the spatial and temporal distribution of SWE in mountain environments is still a relevant challenge for the scientific community, due to the complex topography that causes a high spatial heterogeneity in snow distribution, by reducing the representativeness of traditional pointwise in situ measurements.

Several efforts have been done to develop new methods for estimating snow-related parameters. In particular, the large-scale monitoring of the Earth's surface from space-borne sensors has proven to be very effective, by improving the spatialization of land surface parameters. In the last decades, scientists have extensively investigated the potential of Synthetic Aperture Radar (SAR) data for deriving SWE. Unlikely to visible sensors, microwave sensors do not depend on the presence of sunlight and are not affected by the presence of clouds.

In this context, the main objective of this work is to exploit the already demonstrated sensitivity of the X-band SAR to snow [1] for estimating the SWE in the mountainous area of South Tyrol, in north-eastern Italy. For this purpose, the information derived from X-band SAR imagery acquired by the Italian Space Agency (ASI)'s COSMO-SkyMed constellation in StripMap HIMAGE mode at 3 m ground resolution is exploited together with ground measurements of SWE, which have been chosen by selecting the dates corresponding to the satellite acquisitions in the study period (2013-2015). In order to increase the training dataset, further backscattering coefficients have been simulated by using an implementation of the Dense Media Radiative Transfer (DMRT) theory, based on the Quasi-Crystalline Approximation (QCA) of Mie scattering of densely packed Sticky spheres [2]. Moreover, to optimize the satellite acquisition and use as much corresponding SWE data as possible, we integrated the ground dataset with other SWE values obtained as explained in [3] by means of a data fusion approach involving the snow model AMUNDSEN.

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