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Integration of a hydroclimatological model and remote sensing products for improving snow cover mapping in mountain areas

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Snow plays an important role in the hydrological cycle in mountain areas and it actually monitored by using different techniques. Remote sensing techniques can provide a significant added value, due to its synoptic view with respect to conventional methods. Optical sensors are limited in the applicability due to cloud presence, forest, and shadows.

Employing numerical models is an alternative approach for gaining information about a snowpack. However, also in well-equipped areas, these models maybe be subjected to uncertainties in spatially distributed applications, as they rely on meteorological forcing which need to be regionalized from point observations to the regional scale.

Consequently, the jointly use of remote sensing and physically-based models has received an increased attention in the past years. The detailed spatial representation, typical of remote sensing, makes it suitable for the extension in ungauged regions where models fail due to the lack of input data.

The aim of this paper is the introduction of a new concept of decision fusion by exploiting physical model simulations and remotely sensed products. The innovative aspect is that the fusion, carried out through a Support Vector Machine (SVM) classifier, involves the final products of both remote sensing and model outcomes, differing from all approaches where remote sensing is only used for model tuning and/or calibration.

The study considers the hydro-climatological model AMUNDSEN [1] and MODIS snow cover maps [2], both at 250 m ground resolution. Higher resolution images (Sentinel 2 and Landsat 8 products) have been used to derive reference datasets. The fusion aims at improving the snow estimation in areas where the satellite product and the model disagree.

Results obtained for two test sites (Matscher Tal and Rofental) are promising, hence the fusion method has been extended to the entire area of Tyrol, South Tyrol and Trentino. The training and test dataset has been selected by randomly selecting dates during the test period (October 2012 – July 2016) to have a representative sample set.

Once selected the dates, disagreement points have been extracted from the snow maps and randomly divided in training and test dataset. Then, in correspondence of selected points, through a visual interpretation, reference points are manually extracted from RGB of Sentinel-2 and Landsat-8 images.

On the test samples, the proposed approach shows an overall accuracy equal 89%, with respect to the 44% and 66% of MODIS and model products respectively.

[1] Strasser, U. 2008. Die Modellierung der Gebirgsschneedecke im Nationalpark Berchtesgaden. Modelling of the mountain snow cover in the Berchtesgaden National Park, Berchtesgaden National Park research report, Nr. 55, Berchtesgaden.

[2] Notarnicola, C. et al (2013a) Snow cover maps from MODIS images at 250 m resolution, Part 1: Algorithm description. Remote Sens 5:110–126