



## **Webcam images for validating and improving snow cover maps from high resolution Sentinel-1 & -2 data**

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In the Alpine region, snow cover variability is a high socio-economic aspect not only as local water resource and storage but also as a climate-related hazard and winter tourism. To quantify the effect of climate change on snow variation and the annual and inter-annual snow dynamics required by local stakeholders, continuous reliable measurement of the temporal and spatial variability of snow cover is needed. For monitoring snow cover variability, we aim to investigate the feasibility of using outdoor webcam images, like those provided by ski resorts for deriving weather information, as a source of reference for increasing the spatial and temporal resolution and accuracy of snow cover maps derived from Sentinel-1 and Sentinel-2 data. We use freely available images from webcam networks distributed over the Alpine region, which have high temporal (daily ~ every 15 minutes) and spatial (<10 m) resolution. To obtain snow cover maps from webcam images the two-step process are the georeferencing and the snow detection. We implemented a semi-automatic approach 1) to solve the orientation of the webcam images, which requires a high-resolution digital elevation model and an approximation of the webcam's position and 2) to classify the image pixels as snow-covered and snow-free. The accuracy of the automatic binary classification is assessed by means of manual snow classification. The snow-classified pixels of webcam images in the real-world coordinates are then compared with the snow cover maps derived from the Sentinel data. The approach to derive snow cover maps from webcam images is applied in different study areas located in Austria and Switzerland, selected according to the topography (i.e. elevation and slope), forest coverage and the availability of the Sentinel data. Furthermore, we use different webcam providers, which differ from the quality and type of the webcam device (e.g. single frame and panorama images). Despite the low image resolution and quality of some webcams, our results show that these images represent a rich data source to improve satellite-derived snow information, and furthermore to complement this information in cloudy conditions, steep mountainous terrain and in shadowed areas. By extending our approach to all available network of webcams in the alpine region, a synergistic usage of time series webcam images and Sentinel data should be considered in an operational context for deriving high spatial and temporal resolution snow cover mapping. The work is part of the WebSnow project (project number 866033) funded by the Austrian Research Promotion Agency (FFG).