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Analysis of short-term trends in snow cover variability in the European Alps - based on subpixel snow cover mapping with NOAA AVHRR data

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In alpine regions such as the European Alps, snow is a predominant environmental factor. High accurate snow monitoring in the Alpine Region is of great importance as temporal and spatial variations in snow coverage have far-reaching consequences on the natural and the socio-economic systems. It is required for various purposes such as meteorological modelling, climate studies, snow mapping, estimation of stored water equivalent or snowmelt runoff prediction. In contrast to conventional in situ snow observations, remote sensing data regularly provide spatial snow cover information which can be used for climate induced studies on snow cover variability. The main objectives of this study are to assess the accuracy of chronological sequences derived from fractional snow cover maps as well as to detect and analyze temporal and spatial variability patterns within the Alpine Region based on different statistical applications.

NOAA AVHRR has been employed for over 20 years and consequently offers a unique data archive for long-term studies. An additional advantage is the high temporal resolution of NOAA AVHRR, whereas its medium spatial resolution (1.1 km at nadir) means a challenge in rugged terrain. The used data set includes daily scenes from the platforms NOAA-16 (2001 - 2002) and NOAA-17 (2002 - 2007). The preprocessing includes calibration, georeferencing, atmospheric correction and orthorectification. For mapping snow, the widely used linear spectral unmixture algorithm is implemented to estimate snow cover at subpixel scale. Principal component analysis,

including the reflective part of AVHRR channel 3, is used to quantify fractions of 'snow' and 'no snow' within a pixel. Substantially, this algorithm improves the possibility to detect differences concerning snow distribution over complex topography for operational and near-realtime applications.

Time series of 7 years (2001 - 2007) are used to derive spatial and temporal snow cover dynamics. The input data is evaluated implicating difficulties in merging the data sets from different sensors. Statistical performance within the developed framework over the NOAA AVHRR data suggests an accurate caption of snow related variables. High spatial variability at lower elevation zones and the most persistent snow cover located at high elevations in the central Alps are found. The duration for snow persistence varies in different elevation ranges and generally becomes longer with increases in the terrain elevation. A slight decreasing trend in overall snow cover area is found during the investigation period.

Additionally, the resulting snow cover curve is compared to ground based temperature data and to particular meteorological events for further verification. Temperature is found to explain about 90% of the snow cover extent. These high correlations support the assumption of a reliable accuracy of the snow cover derived from fractional snow cover maps and can be implemented in the estimation of the dimensions of future scenarios in a warmer climate.

The results presented in this study are based on a short-term analysis and give an overview of possible methods to assess climatic change impact on snow dynamics in the recent years. Further studies aim to homogenize data derived from different sensors in order to compile a longer time series. The understanding of past, ongoing and future snow cover dynamics under the presumptions of the anticipated climatic change is crucial and can provide potential information to support the adaptation process of i.e. tourism industry, natural hazard management and water power industry.