Regional pattern of annual snow cover duration in the Greater Alpine Region (2000 – 2018)

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This study analyses regional differences in annual snow cover duration as quantified by the annual number of days with snow cover (DSc) and investigates differences in sensitivity of DSc to climatic variability across the Greater Alpine Region over the 2000-2018 period. MODIS snow cover data were used to estimate DSc based on the Regional Snowline Elevation (RSLE) method, a spatial filter technique for large-scale cloud cover reduction.

DSc over the study period closely follows the relief, with a mean DSc of ~10–60 days at elevations of 500 m that increase to about 100–150 days at 1500m. South of the main alpine ridge, DSc is, at the same elevation, consistently lower than north of it with differences of ΔDSc ~25–50 days. Similarly, the eastern part of the study region experiences longer snow cover duration than the western part. This difference is particularly pronounced at elevations below 1500m where ΔDSc ~25 days. Throughout the study period, a general upward shift of the RSLE was observed for most parts of the Greater Alpine Region. This upward shift, characterized by later onset of snow accumulation (ΔDstart ~14–30 d) and earlier melt-out at the end of the snow season (ΔDemd ~10–20 d), translates into reductions of the annual number of snow-covered days by up to ΔDSc = -46 days over the study period. The data suggest that, in particular, low-elevation (<600m a.s.l.) regions in the northeastern part of the Greater Alpine Region, as well as elevations between 1400 and 2000 m in the north-western part of the study region experienced the most pronounced reductions of DSc, whereas ΔDSc remained very limited south of the main alpine ridge. The spatially integrated MODIS-derived estimates of DSc correspond well with DSc estimates derived from longer-term point-scale observations at >500 ground station observations across the region. In the majority of regions, the temporal evolution of DSc over the 2000-2018 study period also reflects the longer-term DSc trends as estimated from these point-scale observations (1970-2014). This provides supporting evidence that the widespread decline of DSc across the Greater Alpine Region as estimated based on MODIS data is largely not caused by isolated short-term climatic variability but coincides with multi-decadal fluctuations. A comparison of the sensitivities of DSc to climatic variability indicates that neither mean winter temperatures Tw nor annual solid precipitation totals Ps are consistent first order controls on DSc across elevations and regions. Rather, the data highlight the importance of
the interaction between the two variables: depending on the respective sensitivities of $D_{sc}$ to changes in either variable, $T_w$ or $P_s$, respectively, the interplay between them can reinforce or largely off-set potential effects on $D_{sc}$ in different regions in the Greater Alpine Region. The regional differences in $\Delta D_{sc}$ with a less pronounced decline south of the main Alpine ridge are largely a consequence of this interplay: while $T_w$ evolved similarly North and South of the Alpine ridge, many southern regions, unlike the northern regions, experienced an increase in $P_s$ that offsets the effects of positive temperature trends.