DURATION OF SNOW COVER OF THE EUROPEAN ALPS

L.-M. Wielke
Department of Meteorology and Geophysics, University of Vienna
Althanstrasse 14, A-1090 Vienna, *lucia.wielke@univie.ac.at*

The relation between the observed duration of snow cover, temperature and station height has been studied quantitatively. The records of more than 250 stations in the Alpine region of Austria, France, Germany, Italy, Slovenia and Switzerland have been used for the years 1961 to 2000 in order to estimate the sensitivity of the snow cover duration to possible climate changes. The basic idea is that the interannual snow cover fluctuations would be an estimate for a snow cover trend in case of a possible future European temperature trend.

At intermediate levels, where e.g. many skiing areas are located, the sensitivity is relatively large. Our analyses concerning Austria, HANTEL et al. (2000), and Switzerland, WIELKE et al. (2004), have shown that a rise in the European temperature by 1 K may reduce the duration of snow cover in the elevations of maximum sensitivity by 4 weeks during winter.

In addition to our former investigations the sensitivity experiments distinguish between the different seasons and regions: the Alps as a whole, the Northern and Southern Alps and the Alpine countries respectively. Moreover the threshold for the calculation of the number of snow days per season through the parameter snow height was varied from 1cm, 5cm, 10cm, 15cm to 30cm.

The climate sensitivity shall be defined as $s = \partial n(H,T)/\partial T$, which is the derivative of the relative snow cover duration n with respect to temperature T for constant station height H. It is negative everywhere and adopts its minimum s_0 for $n = 0.5$. This extreme slope measures the sensitivity of the snow-temperature relationship. This governing parameter s_0 has to be fitted to the data, which can be done for one single station (local fit, Fig. 1) or for an entire region with a combined dataset (global fit, Tab. 1).

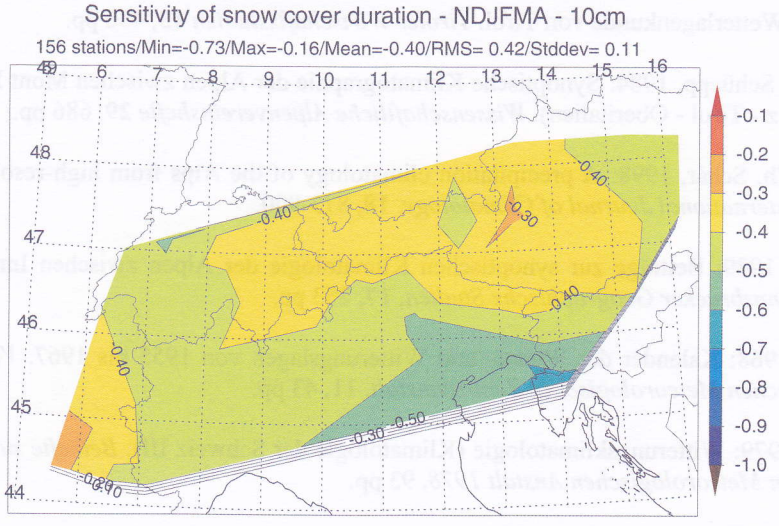

Figure 1: Map of local sensitivities s_0 for the months NDJFMA. Snow height of 10 cm is used as threshold for a snow day.

By interpreting our results in the way that a climate shift of 1 K would be within the natural seasonal fluctuations, they imply that a rise in the European temperature by 1 K has the potential to reduce the duration of snow cover in elevations of extreme sensitivities depending on the region

	DJF	NDJFMA
region	s_0 [1/K] ±0.10	
Alps	-0.39	-0.52
N-Alps	-0.34	-0.43
S-Alps	-0.39	-0.50
Austria	-0.39	-0.44
France	-0.30	-0.21
Germany	-0.37	-0.34
Italy	-0.31	-0.45
Slovenia	-0.32	-0.46
Switzerland	-0.31	-0.47

Table 1: Global sensitivity s_0 for the different regions in winter defined first through the months DJF and second through NDJFMA. Threshold 10 cm.

by 30 % to 39 % (4 or 5 weeks) in the winter season DJF and 21 % to 52 % (5 to 14 weeks) in the hydrological winter season NDJFMA. The value e.g. $s_0 = -0.39$ K^{-1} can be interpretated as a reduction of the duration of snow cover of 39% which is corresponding to 5 weeks (100% $\approx$ 12 weeks in DJF). Away from these elevations the sensitivity is getting gradually smaller.

Generally spoken the sensitivities in NDJFMA are higher than in the winter season DJF which can be explained as follows: In the winter season DJF the snow pack usually is already accumulated and stable against small shifts in temperature as the temperature itself is rather cold throughout these months. The period NDJFMA describes the whole development of the snow pack including the melting processes which makes the snow cover more sensitive to shifts than compared to the situation in DJF.

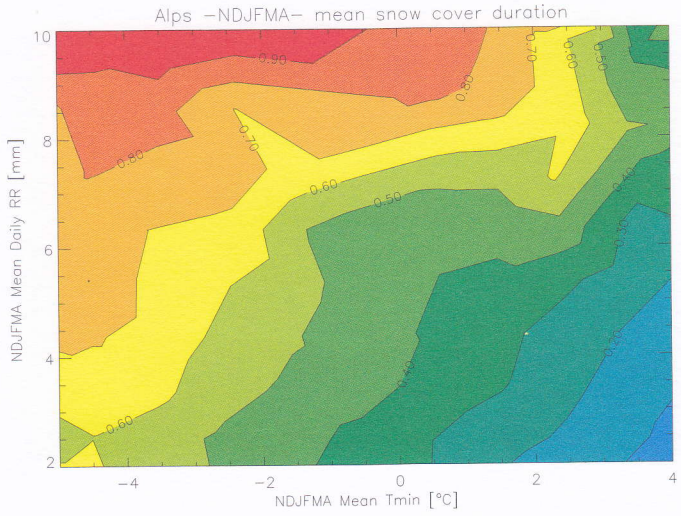

Figure 2: 2-D contour surfaces of mean snow cover duration as a function of winter (NDJFMA) minimum temperature and precipitation for all stations.

In addition to our former investigations this study takes precipitation as a second parameter into account. BENISTON (2003) showed that the relationship between the mean DJF minimum temperature, precipitation and snow duration can be graphically summarized in the two-dimensional plot for 18 Swiss stations. The same was done for all the climatologically stations mentioned above in Fig. 2, where the abscissa is the NDJFMA mean minimum temperature and

the ordinate NDJFMA mean daily precipitation. The 2-D surface represents the snow cover duration with a contour interval of 10 %. It shows that the precipitation has a significant impact on the snow cover duration especially for small shifts in high-precipitation regimes. This kind of diagram can be used empirically to estimate the changes in mean snow duration that may occur under shifting climatic conditions.

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