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Climatological reference data of a newly established long-term monitoring program in the central Alps

Christian Newesely[1] & Ulrike Tappeiner[1,2]

[1] Institute of Ecology, University of Innsbruck
[2] Institute for Alpine Environment, EURAC research, Bozen

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Summary

Above the alpine treeline, life conditions are controlled by topography and type of plant cover (Cernusca 1976, Tappeiner & Cernusca 1996, Körner 2003). Weather stations are thus, unable to capture the actual life conditions of plants, animals and microbes in high elevation, treeless terrain. The seasonal mean temperature in alpine surface soils (where most alpine plants have their shoot meristems and where both animal and microbe activity is highest) has been shown to vary across short horizontal geographical distances by more than air temperature does across 2000 m of altitude (Scherrer & Körner 2009). The topography driven mosaic of habitat temperatures offers alpine organisms short distance habitat alternatives in times of rapid climatic change. This is why alpine regions have always been organismic refugia during periods of climate change. Such short distance contrasts in life conditions also provide opportunities to study the biological effect of steep thermal gradients (and their co-variables such as snow depth and snow duration as well as soil moisture and evaporative forcing). A long-term monitoring program has been launched in the central Alps that capitalizes on such 'experiments by nature' across sharp snow melt gradients (see contribution by Körner, this volume).

Here we present the first climatological data for this large-scale, comparative undertaking. These basic data permit comparing sites and positions within sites, and they allow positioning the test areas in a wider European context (Körner et al. 2003). Single channel, automatic temperature loggers have been deployed across four different test regions (three in the Hohe Tauern National Park in Kärnten, Tirol and Salzburg, one region in the Swiss central Alps). Installed 3-4 cm below soil surface in typical alpine vegetation, ca. 200-300 m above the natural climatic treeline, the data collected by these devices currently cover 12 month (August 2016 - August 2017), and permit characterizing the test sites. At each site, transects (3-6 per site) had been established on the flanks of so-called snow-beds that cover both the most least favourable ('pessimal') as well as the most favourable ('optimal') locations over distances of less than 10 m.

The data for 20 transects now permit a ranking of all transects with respect to snow duration, winter and summer extremes, season length and seasonal temperature regimes. For sites that had no climate station at close distance, we also measured air temperature at 1.8 m height as a reference and as a means to link our observations to the weather service network. These data also permit to quantify the contrast between atmospheric conditions and the actual thermal life conditions along our transects.

We show that soil temperatures in winter differ greatly across otherwise similar ecological settings, with some sites experiencing soil frost down to -15°C, while others experience a constant 0°C situation under a thick, insulating snow cover. The date of snow-melt at the ‘pessimal’ edge of our transects is, on average, 5 to 30 days later than at the optimal edge, with the growing season defined by a weekly mean temperature of 5°C, varying in length from 86 to 143 days across the 20 transects, if we assemble the records for 2016 and 2017 into one 12 month series (Fig. 1).
After snow melt the soil temperatures are very similar at all points of the transects (Fig. 2). We arrive at a seasonal mean temperature for the lower and upper end of our transects between 8.9°C and 12.3°C (Tab. 1).

Overall these data illustrate the thermal matrix into which this long term monitoring program is embedded. Given the regional differences among the transects temperature conditions, we can rank the transects by certain temperature criteria, which offers an additional dimension for testing hypothesis and explaining biodiversity and ecosystem processes in a climate change context. The coming years will add a year to year time component to these data.

	Untersulzbach	Innergschlöss	Seebachtal	Furka
yearly mean air temp. [°C]	1.4°C	1.6°C		
season mean soil temp 'optimal' [°C]	11.8°C (138)	11.7°C (123)	10.5°C (143)	12.3°C (135)
season mean soil temp 'pessimal' [°C]	11.5°C (127)	8.9°C (86)	9.6°C (111)	11.7°C (88)

Table 1: Yearly air temperature and season mean soil temperature on the "optimal" and the "pessimal" point of the transects and number of days (xx) where the weekly mean of the soil temperatures was above 5°C.

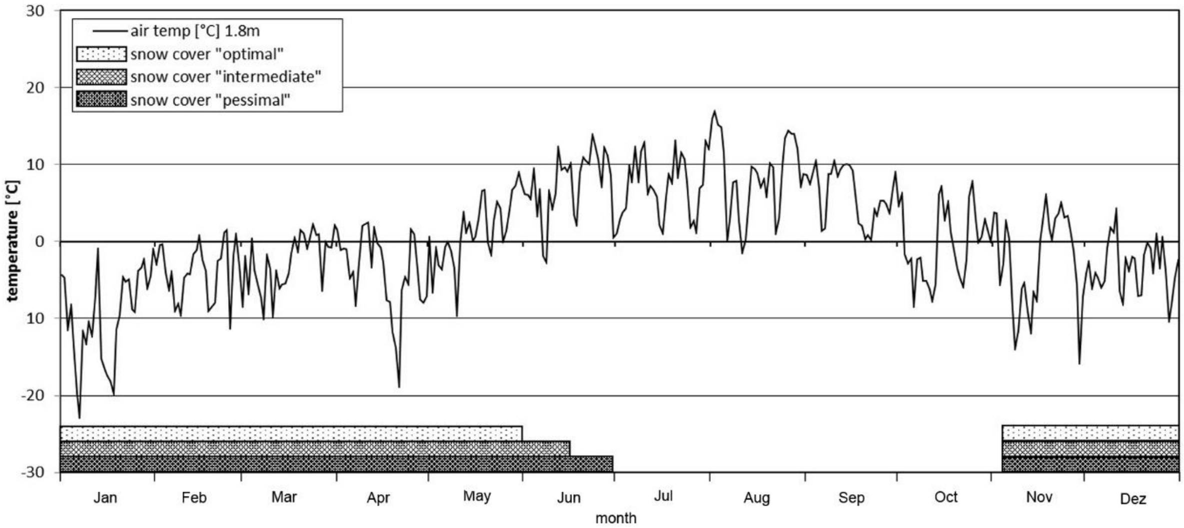

Figure. 1: Daily mean air temperature at a transect in Innergschlöss for the period August 2016 to August 2017 and the duration of the snow cover (strips) at the 'optimal', 'intermediate' and 'pessimal' point of the transect. A time lag of one month in snow cover duration at the beginning of the vegetation period can be seen between the 'optimal' and 'pessimal' point of the transect.

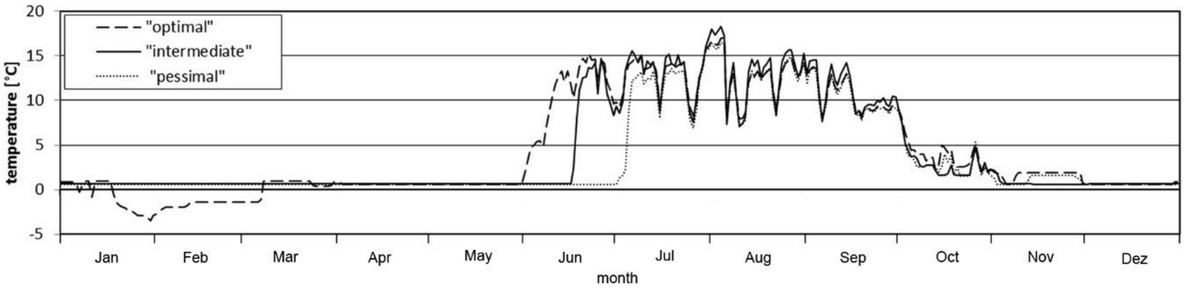

Figure. 2: Daily mean soil temperature at a transect in Innergschlöss for the period August 2016 to August 2017. The soil temperatures were recorded at 3-4 cm depth and show values from the 'optimal', 'intermediate' and 'pessimal' point of the transect. Soil temperatures well below 0°C indicate snow-free periods during winter and at snow melt, they increase rapidly above the freezing level. After snow melting no significant different can be seen.

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Contact

Christian Newesely
Christian.Newesely@uibk.ac.at
University of Innsbruck
Institute of Ecology
Sternwartestrasse 15
6020 Innsbruck
Austria

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