Topographic Effects on Shallow Ground Temperatures: Measurements at the PACE-Permafrost Monitoring Site Stockhorn Plateau, Matter Valley, Swiss Alps.

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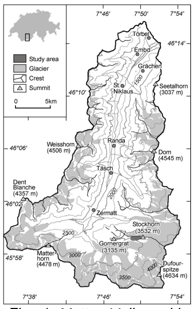

Fig. 1: Matter Valley with the indicated research area.

The complex topography of high mountain environments causes a wide variability of solar radiation and snow cover characteristics. Therefore, the pronounced relief is one main factor controlling the near surface ground temperatures. The quantitative knowledge of the complex ground heat transfer processes induced by differences in topography is still fragmentary.

In order to contribute to their quantification, ground temperature regimes within the upper part of the active layer are currently recorded at Stockhorn plateau (3410 m a. s. l.) in the southern part of the Matter Valley / Switzerland (*Fig. 1*). Data clearly demonstrate that the complex topography induces big variations in the ground thermal regime.

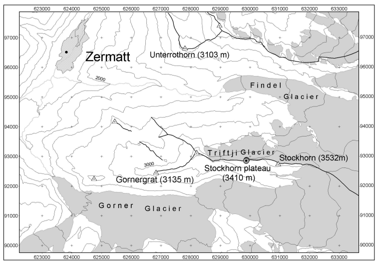

Fig. 2: The location of Stockhorn plateau within the Zermatt area.

Test Site

At the study site the east-west running crest between Gornergrat (3135 m a. s. l.) and Stockhorn (3532 m a. s. l.) (***Fig. 2***) extends to a small plateau that is gently inclined to the south, separating the glaciated north face from the non-glaciated southern face. The surface of the plateau consists of a thin debris cover with some spots of mosses and lichens (***Fig. 3***). The annual precipitation at Stockhorn is estimated to be 1500 mm, the mean annual air temperature (1961-1990) between -5 and -6 °C (KING 1990).

Data Collection

Measurements has started in September 2003. Six UTL-Loggers, have been arranged in a N-S transect of 50 m length (***Fig. 3***), recording ground surface temperatures in a hourly interval. More detailed data are available since August 2004: Five-channel-data-loggers have been installed in twelve vertical profiles.

Fig.3: Research area with the indicated UTL-measurement points Stock1 to Stock6. In the area in the foreground of the picture the five-channel-loggers were installed in August 2004.

The sites differ in topography and aspect in order to quantify their effects on the thermal regime. Ground temperatures are registered hourly in different sensor depths down to max. 100 cm. The test area incorporates a permafrost monitoring site with two boreholes (100 and 30 m deep), which have been drilled in July 2000 within the framework of the EU-project "Permafrost and Climate in Europe" (PACE). Even though the shallow borehole is located only 28 m more south, the temperature profiles show considerable differences (***Fig. 4***) confirming the fact that complex topography induces a high variability of ground temperatures. In June 2002 a meteorological station was installed close to the deep borehole by the University of Zurich providing data on air temperature, snow cover height, relative humidity, wind direction, wind speed, short-wave and long-wave radiation.

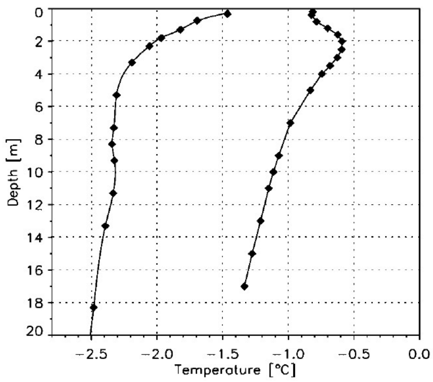

Fig. 4: Mean temperature profiles of the deep (left graph) and the shallow borehole (right graph), GRUBER et al 2004.

Results

When looking at the daily means of the ground surface temperatures measured by the UTLs between 1st Oct. 2003 and 31th July 2004, the influence of aspect becomes obvious. Due to more solar radiation the snow cover starts to melt earlier at the southern profile (*Stock6*). Consequently, the period of zero curtain begins almost two months earlier ***(Fig. 5)***, but is less pronounced than at the northern spot (*Stock1*). This is probably caused by a thinner snow cover combined with faster snow melt due to a higher amount of solar radiation.

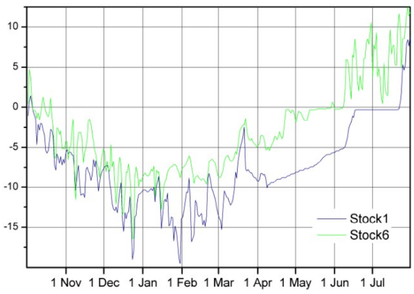

Fig. 5: Daily means of ground surface temperatures in °C at Stock1 and Stock6 (1st Oct. 2003 - 31th July 2004).

The exposed location of *Stock6* inhibits the formation of a deep snow cover, whereas *Stock5* – situated in a local depression – is covered by snow from the beginning of October on and becomes snow free again in the middle of July (***Fig. 6***).

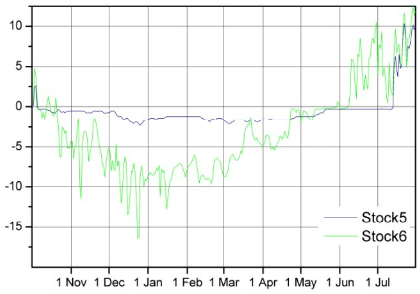

Fig. 6: Daily means of ground surface temperatures in °C at Stock5 and Stock6 (1st Oct. 2003 - 31th July 2004).

Table 1 summarizes the thermal differences between the spots by showing the minimum, the maximum and the mean temperatures between 1st Oct. 2003 and 31th July 2004.

Tab. 1: Maximum, minimum and mean of ground surface temperatures in °C (1st Oct. 2003 - 31th July 2004).

Locations from N to S	Stock1	Stock2	Stock3	Stock4	Stock5	Stock6
Max	8.86	11.39	12.89	12.79	10.32	12.50
Min	-19.53	-8.45	-9.46	-11.37	-2.31	-16.41
Mean	-7.46	-3.69	-2.83	-3.23	-0.53	-2.96

Conclusions

Data clearly demonstrate that local site characteristics induce massive differences in the thermal regime of the ground. Therefore, accurate knowledge of the local distribution of ground temperatures is needed to better understand the effects of the pronounced topography in high mountain environments.

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Acknowledgements

The the studies were supported by the Deutsche Forschungsgemeinschaft (DFG, project Ki 261/14-1). Meteorological data were provided by the University of Zurich. Without the generous logistical support of the Brig-Visp-Zermatt-Bahnen (BVZ) and the Gornergrat-Monte Rosa-Bahnen (GGB) during numerous field campaigns, this research would not have been possible.