Palaeoglaciology of the Central European Uplands – a link between the former ice masses over the Alps and Scandinavia

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INTRODUCTION

The Central European Upland is a horseshoe shaped range of mountains, containing the Bavarian Forest Mountains, the Fichtel Mountains, the Erz Mountains and the Giant Mountains. With altitudes up to 1600 m a.s.l. and the location in between the former ice cap of the Alps and the Scandinavian ice sheet this area is a key region for understanding Pleistocene climate and glacial development. Though the investigation of glacial traces in these areas started already 100 years ago, an all-European synopsis is still missing, last but not least because of the former political situation in Eastern Europe. As there are no unambiguous evidence for glaciers in the Fichtel and the Erz Mountains, this study focus on the Bavarian Forest Mountains and the Giant Mountains.

The aim of this study is to present previous reconstructions of glaciers in the Bavarian Forest Mountains and Giant Mountains. Furthermore, we use this data to compare the reconstructed glacial extent to results of a climate driven high resolution mass balance model.

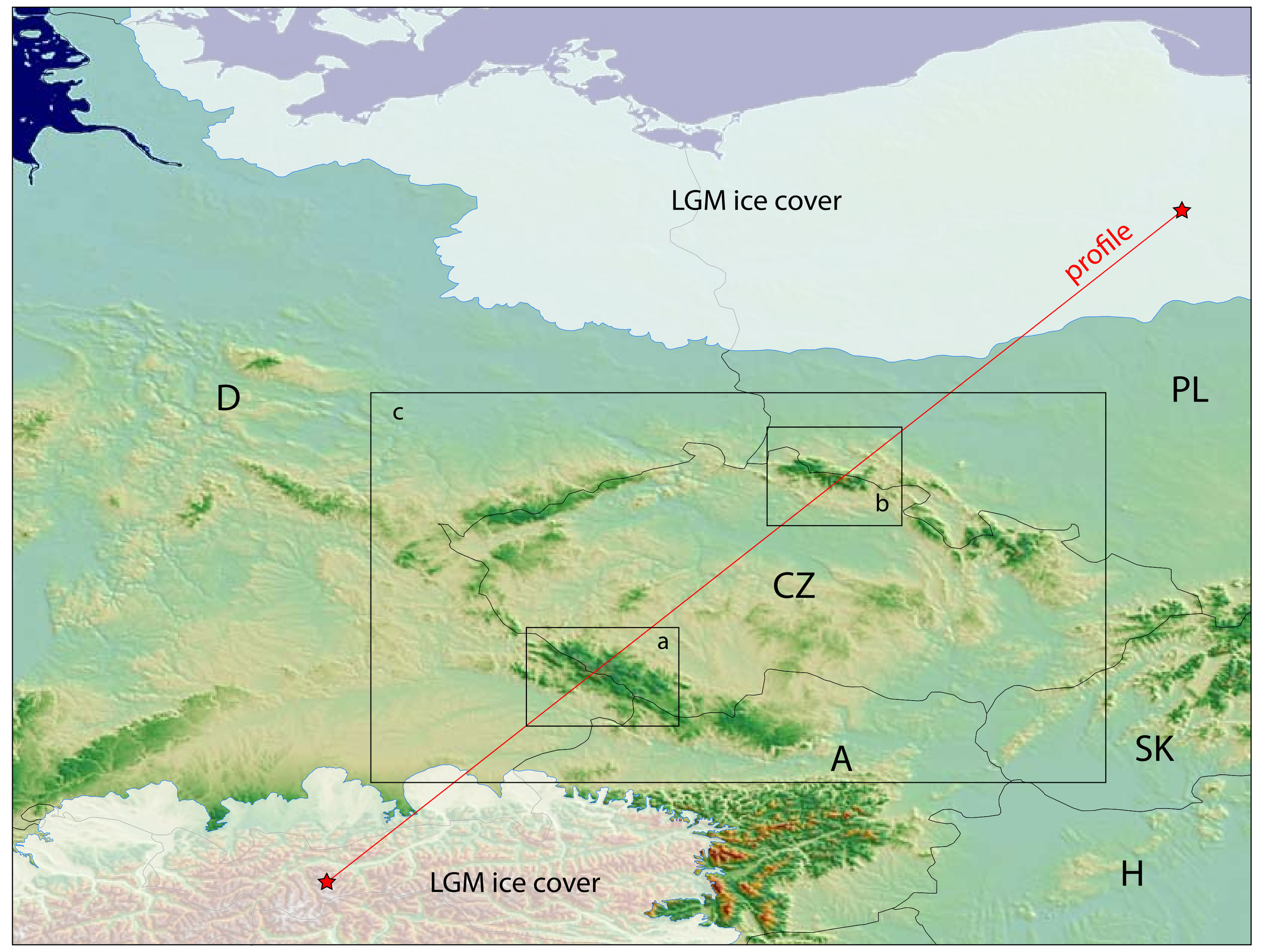


Fig.1: DEM of Central Europe with the study areas (a: Bavarian Forest; b: Giant Mountains, c: Central European upland) and the former extent of the Nordic and Alpine glaciation at the last glacial maximum.

GLACIAL RECONSTRUCTIONS

For the Giant Mountains a glacial reconstruction was presented by Partsch (1894) and this reconstruction was later supported by Chmal and Traczyk (1999). For the Bavarian Forest Mountains a glacial reconstruction along the Czech border from the Arber Mt. (1456 m a.s.l.) to the Plöckenstein Mt. (1378 m a.s.l.) was presented by Ergenzinger (1967). We use these reconstructions to test the climate shifts needed to generate glaciers in the two regions.

MASS BALANCE MODEL

We use a positive degree day (PDD) model with monthly mean temperature and precipitation (ca. 1 sq.km resolution) from the WorldClim database (Hijmans et al. 2006) as input and a degree day factor of 4.1 mm/degree/day for calculating the ablation (cf. Braithwaite 2008).
To test the model, present-day climate was used to model present-day glaciers in Switzerland. To generate positive mass balance in the Central European Mountains, the temperature and precipitation (based on the temperature/relative humidity relationship) were decreased. For all these PDD model runs, we compare the area of positive mass balance with the expected glacier area.

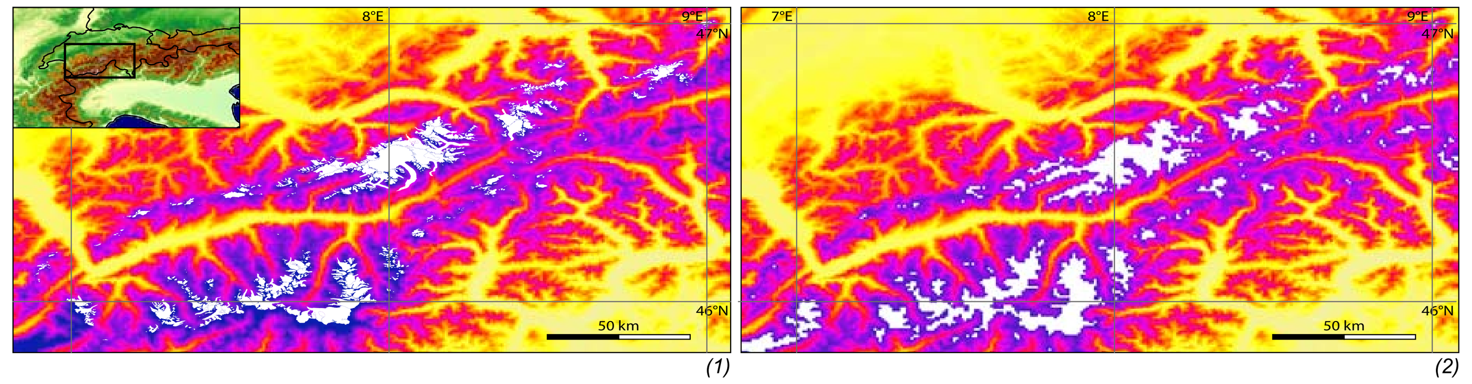


Fig.2: Area in the Swiss Alps where the mass balance model (2) is tested against present-day glaciers (1).

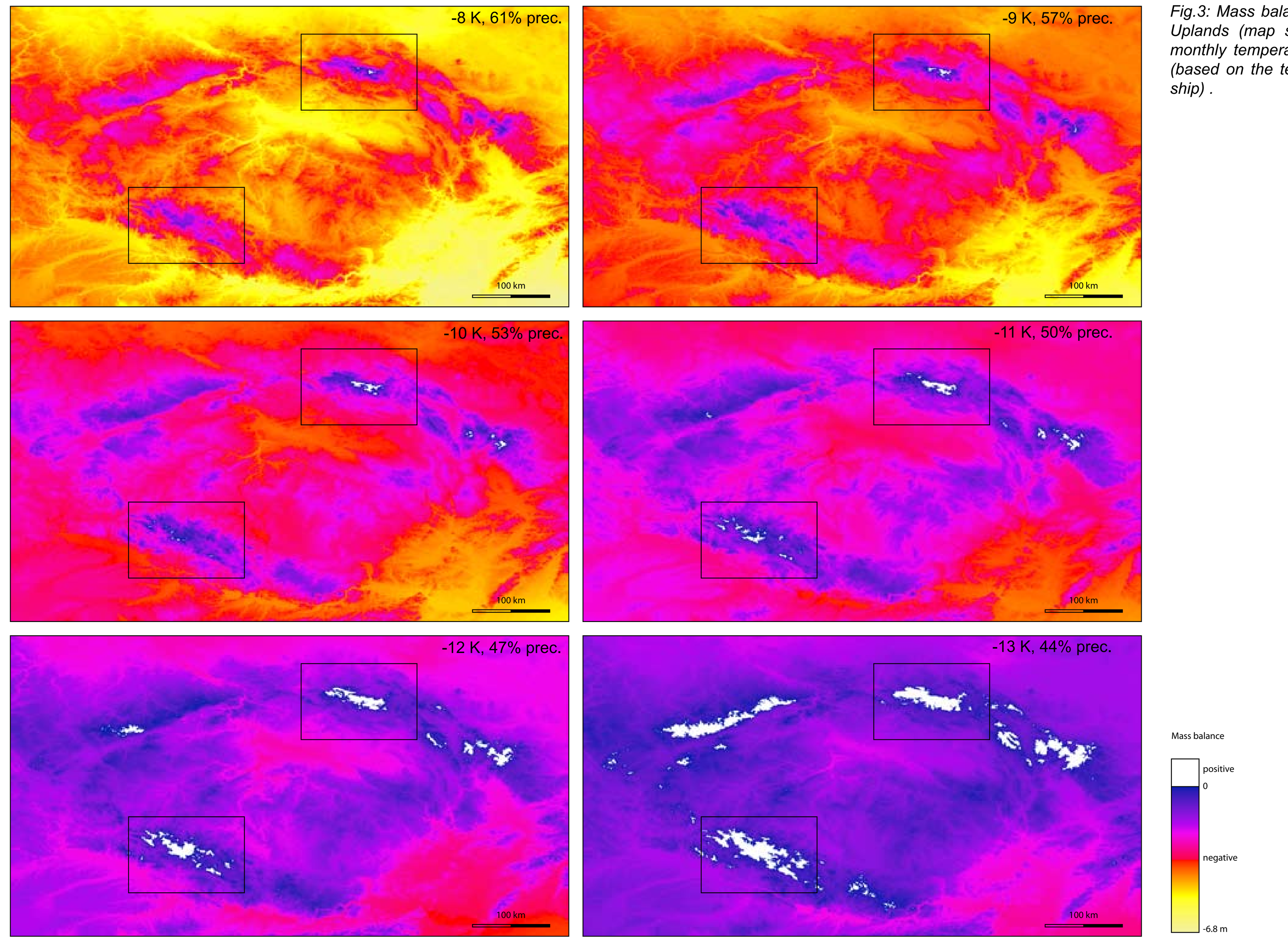


Fig.3: Mass balance model for the Central European Uplands (map section c) by decreasing the mean monthly temperatures and reducing the precipitation (based on the temperature/relative humidity relationship) .

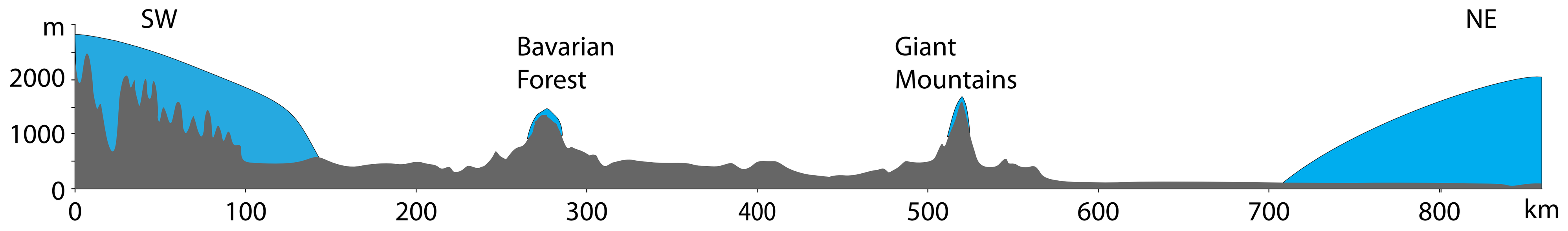
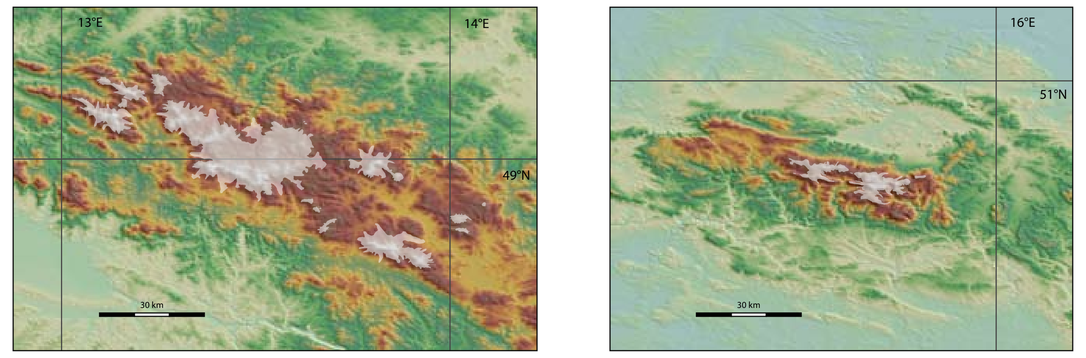


Fig.4: Profile (for location see Fig. 1) between the Alps (SW) and the North German Plain, (NE) showing the significant rise of the Central European Upland in between the two former big ice masses.



A) Bavarian Forest Mountain glaciation based on Ergenzinger (1967)

B) Giant Mountain glaciation based on Partsch (1894)

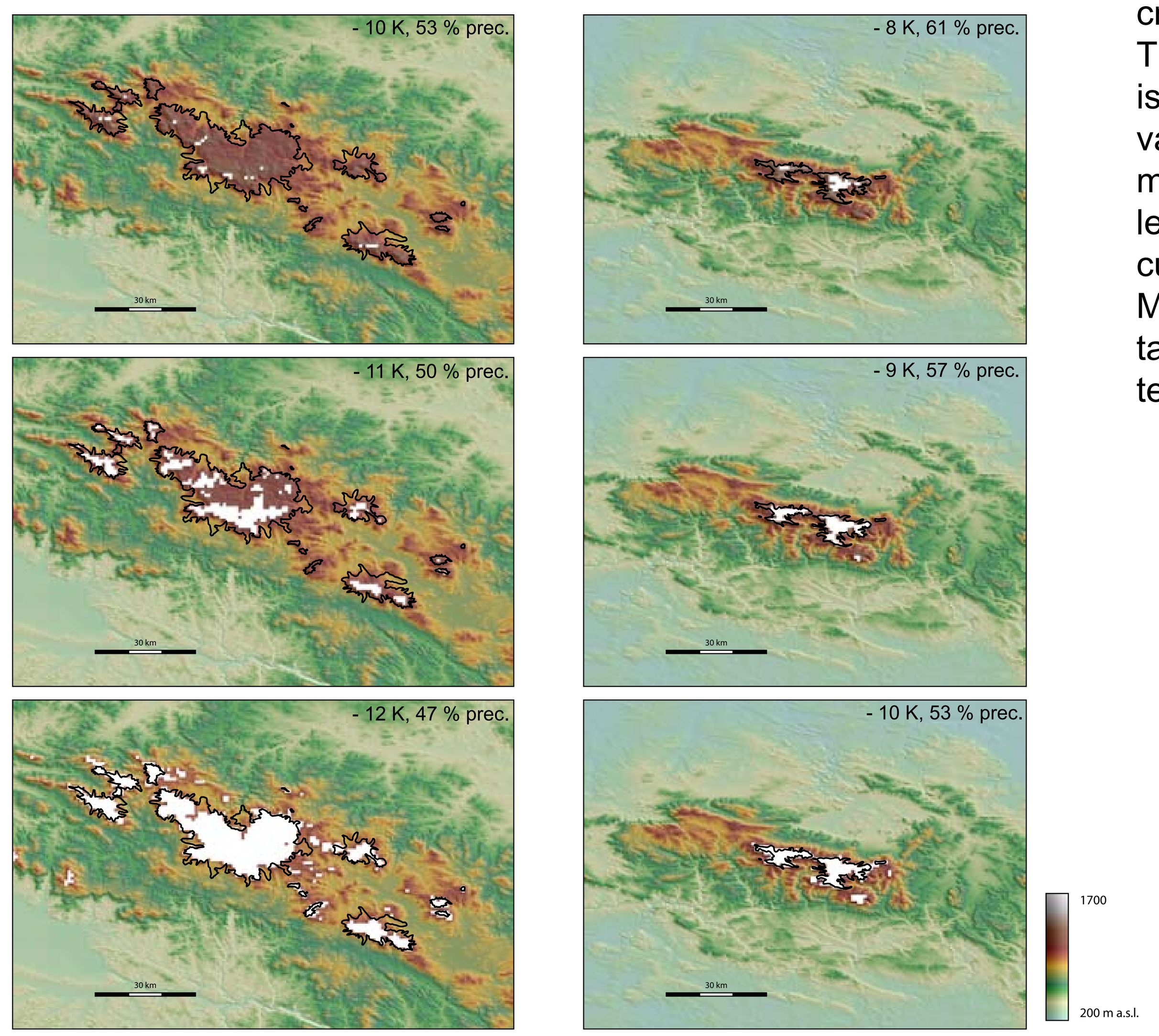


Fig.5: Mass balance model decreasing the temperature in three steps for the Bavarian Forest Mountains (left, 10 K / 11 K / 12 K) and for the Giant Mountains (right, 8 K / 9 K / 10 K). The black line marks the glacial reconstructions of Ergenzinger (1967) and Partsch (1894) as presented in fig 5A and 5B.

RESULTS

The test-model for the Swiss Alps reproduces present-day accumulation areas well, supporting the value of the basic mass balance model employed (fig. 2). For the Bavarian Forest Mountains, reasonable accumulation areas are generated when decreasing the mean annual temperature 11-12 K (fig. 5A) while for the Giant Mountains a temperature decrease of 9 K is enough (fig. 5B). Thus, glaciation in the Giant Mountains is more easily triggered than in the Bavarian Forest Mountains. Using our model, a temperature decrease of at least 10 K is necessary to show any accumulation in the Bavarian Forest Mountains whereas in the Giants Mountains accumulation occurs already at a temperature lowering of 8 K.

DISCUSSION

The temperature shifts needed for the model to yield accumulation areas in agreement with previous reconstructions are in broad agreement with climate reconstructions for the last glacial maximum. An interesting result is that the threshold for initiating positive mass balance and glaciation is reached more easily in the more northerly and more continentally located Giant Mountain area. This could possibly be an indication for more intense glaciation of the Giant Mountains. A more complete model should consider climate feedbacks of the Alpine and Scandinavian ice masses on the thresholds for central European glacial inception.

REFERENCES

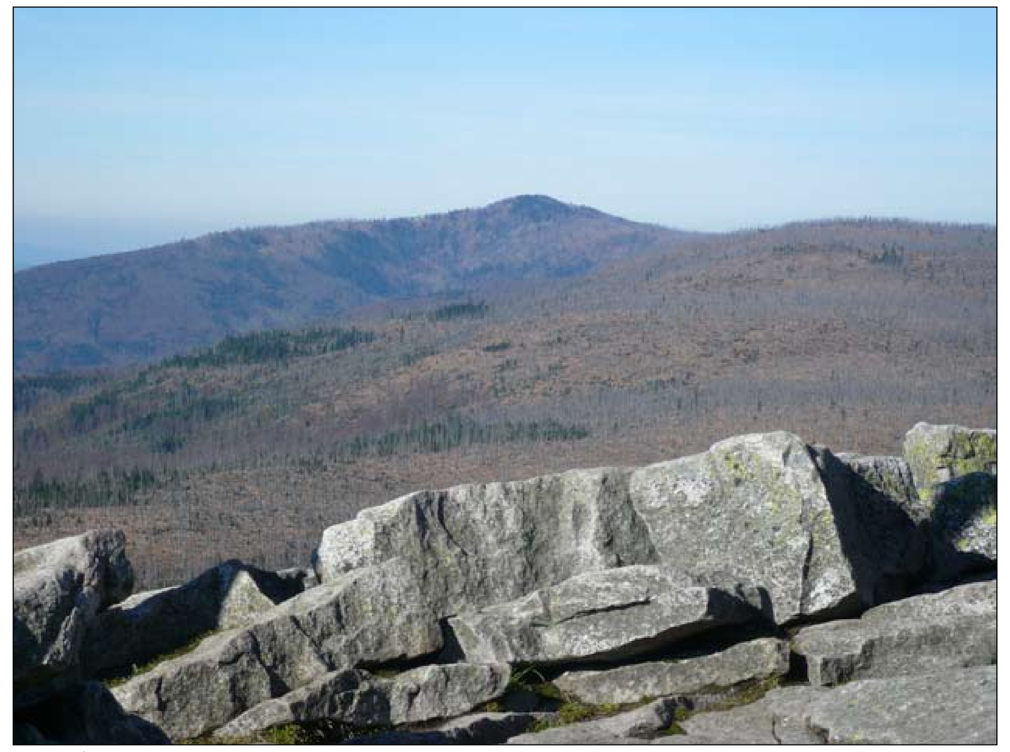
Braithwaite RJ. 2008: Temperature and precipitation climate at the equilibrium-line altitude of glaciers expressed by the degree-day factor for melting snow. Journal of Glaciology, 54, 437-444.

Chmal,H. and Traczyk,A. 1999: Die Vergletscherung des Riesengebirges. Zeitschrift für Geomorphologie N.F., Suppl.-Bd. 113:11-17.

Ergenzinger, P. 1967: Die eiszeitliche Vergletscherung des Bayerischen Waldes. Eiszeitalter und Gegenwart, 18: 152-168.

Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A. 2005: Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology, 25, 1965-1978.

Partsch, J. 1894: Die Vergletscherung des Riesengebirges zur Eiszeit [Glaciation of Giant Mountains in Ice Age]. Forsch. Deutsch. Landes- und Volkskunde, VIII/2: 103-194.



View from Lusen in the Bavarian Forest Mountains towards the Rachel cirques (photo: B. Hauzenberger).