Verifying modelling approaches: high mountain permafrost and its environment

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INTRODUCTION

The Ankogel Mountains are a highly glacierized area in the easternmost part of the Hohe Tauern Range in Carinthia (Fig. 1). The test site encloses 98 km^2 including the main peaks of the Ankogel (3246 m) and the Hochalmspitze (3360 m). Glaciers cover an area of 12.1 km^2 and shows wide retreat zones.

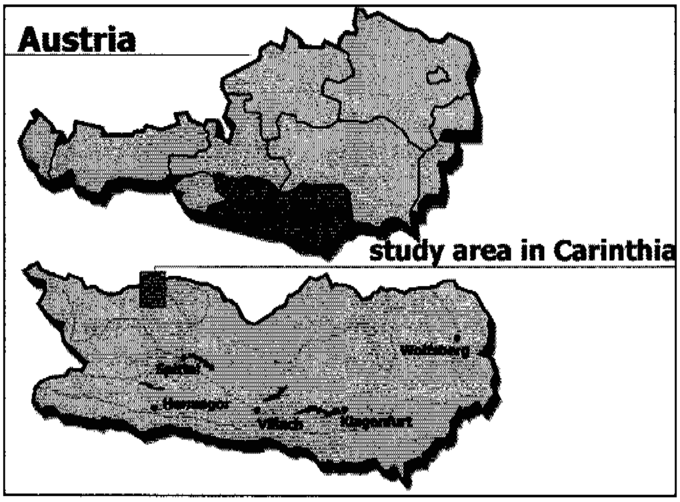

Figure 1. Location of the study area in Austria.

METHODOLOGY

The distribution of permafrost was modelled by an adaptation of the programme PERMAKART, using the GIS Arc-Info (Haeberli et al. 1996). The main point is to receive information about slope, aspect and elevation. The result is a supposed distribution of permafrost in the study area with the classes "permafrost probable", "permafrost possible" and "no permafrost". The modelling of potential incoming short wave radiation (PSWR) was done by using the programme ERDAS-Imagine. Shadows that are cast by topographic features on the surrounding surface were not calculated.

Remote sensing data are the basis for the mapping of the distribution of snow patches, vegetation and rock glaciers. Snow patches were mapped by using colour orthophotographs (as at: August 1998), Keller (1994) shows an investigation, in which a significant correlation between 493 snow patches and the occurrence of permafrost was detected. Infrared orthophotographs are a common data set for investigating vegetation. A useful classification in connection with the investigation of permafrost could only be carried out by visual interpretation. In connection with their percentage of soil cover, three classes of vegetation were used: uniform vegetation (over 90%,), transition vegetation (20 to 90%,), and island vegetation (below 20%). The background is the assumption that a solid cover of vegetation excludes permafrost in the underground. The occurrence of active rock glaciers is an obvious sign for permafrost.

RESULTS

As the distribution of exposition is homogenous it is a good basis for further analysis. The modelled classes of the distribution of permafrost were renamed for the reason of empirical results in the Hohe Tauern Range (Lieb 1998) from "permafrost possible" to "potential sporadic permafrost (PSP)" and from "permafrost probable" to "potential discontinous permafrost (PDP)" (see Tab. 1). The model of the PSWR shows a satisfying overall view and a good correspondence of areas with a PSWR under 53 kJ/m^2a and PDP.

The main part of the study is to compare the results of the modelling with the information received from the study area. 684 snow patches with an area of altogether 108 ha were counted in the study area (average altitude: 2635m). At first sight there is no significant relation between PDP and the occurrence of snow patches (Tab. 2), but a closer look shows that nearly all snow patches which are not situated in potential permafrost areas, occur in direct neighborhood with PDP and PSP.

29.3% of the study area are covered with vegetation, the relation between potential permafrost and vegetation provides a clear result: although there is a high percentage of soil cover with vegetation in this high mountain area, only a marginal zone of overlapping with PDP in an area of 0.9 hectares and 0.06% can be seen (Table 3). Rock glaciers can only be found in the southern part of the study area. Seven are active, one is inactive and eight are fossile. The model shows a good correlation with the catchment area of blocks, but does not mainly correspond with the lobes of the rock glaciers.

Table 1. Areas of generated permafrost classes.

	area in km²	area in %
no permafrost	58.3	59.7
PSD	15.3	15.7
PDP	24.0	24.6
sum	97.6	100.0

Table 2. Snow patches according to potential permafrost areas.

	area in km²	area in %
no permafrost	0.37	34.5
PSD	0.37	34.0
PDP	0.34	31.5
sum	1.08	100.0

Table 3. Areas of vegetation classes and overlapping with potential permafrost areas.

	area in km²	area in %	Overlapping %	
			PDP	PSP
uniform veg.	17.9	62.3	0.05	1.33
transition veg	8.6	30.1	0.12	9.86
island veg.	2.1	7.6	2.30	19.06
sum	28.6	100.0		

The final step is to generate a most probable lower borderline for permafrost including all results with a last visual interpretation of the geological situation (coarse debris). The adaptation uses the modelling of potential permafrost areas as a basis, the results of the distribution of vegetation correct the limit as well as the distribution of snow patches. A visual interpretation of the orthophotographs includes areas of coarse debris in the neighborhood of potential permafrost areas. The modelling of PSWR is only a check in a higher scale. The final result is an area of 35.16 km², that are 36% of the study area, which can be seen as potential permafrost areas. In April 2002 BTS-measurements were carried out in two small test sites in the south east of the study area. The results correspond very well with the most likely lower borderline for permafrost.

CONCLUSION

The model of the distribution of permafrost provides wide areas of potential permafrost, including almost the entire glacier areas. All the relations can be summarised as follows:

1. Although there is a superficial discrepancy between the assumption and mapping results of snow patches, a closer look provides valuable improvement.
2. Closed vegetation cover excludes potential permafrost in the study area with a probability of 99,96%.
3. All catchment areas of active rock glaciers are situated in potential permafrost areas.
4. The result of modelling the potential incoming short wave radiation shows a good connection to potential permafrost.

Crosschecking of results shows good correlations between the modelling results and the results from mapping for the Eastern part of the Alps. Valuable improvements can be derived in using the distribution of snow patches and geological patterns.

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