Conference Volume	4th Symposium of the Hohe Tauern National Park for Research in Protected Areas September 17th to 19th, 2009, Castle of Kaprun	pages 237-242

Surface characteristics of alpine cirques and valley heads in Central Austria with respect to permafrost distribution

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Summary

Surface characteristics (e.g. bedrock, scree slope, vegetated terrain) influence the thermal behavior and hence permafrost distribution in alpine environments. Consequently, global warming will not change evenly the permafrost distribution pattern in such environments. In this study different types of surface covers have been mapped at seven alpine study sites in central Austria (three of them are located within the Hohe Tauern National Park) based on true-color and color infrared orthophotographs. An interpretation key was developed for the requirements of the project ALPCHANGE. This ALPCHANGE Interpretation Key is comparable to the HABITALP-Interpretation-Key and consists of four hierarchical levels. Results of all study sites in the Hohe Tauern National Park show that *debris*, *glacier* and *rock* are the dominant surface coverages. Regarding *debris*, *coarse debris* dominates all three study sites (69-71%), followed by *fine debris* (14-22%), *coarse debris with vegetation less than 60%* (5-11%), and *fine debris with vegetation less than 60%* (2-3%). As a consecutive step, these data will be combined with temperature measurement data and other topographic information from the same study sites in order to calculate the present permafrost distribution.

Keywords

ALPCHANGE, surface interpretation key, Hohe Tauern National Park, Dösen Valley, Pasterze Glacier area, Gössnitz Valley

Background and objectives

Permafrost – as a thermal phenomenon is defined as ground where temperatures remain below 0°C for a period of at least two consecutive years. Amongst others surface characteristics strongly influence the thermal behavior and hence permafrost distribution in alpine environments. Mountain permafrost – in the Alps mostly discontinuous permafrost defined on the amount of spatial coverage – can be found in altitudes above 2500 m a.s.l. depending on topoclimatic conditions (Barsch 1996). Temperatures in coarse-grained scree slopes for instance are significantly lower than temperatures in similar slopes that consist of fine grained material or bedrock (Kellerer-Pirklbauer & Kühnast 2009). Therefore, global warming does not change the permafrost distribution in high mountain environments uniformly.

In this study an surface interpretation key was developed similar to the HABITALP Interpretation Key (Demel et al. 2006) thereby considering the specific requirements of the project ALPCHANGE (for more information see Kellerer-Pirklbauer et al., in this volume; or www.alpchange.at), These requirements are mainly studying the effects of different surface characteristics on global warming by combining point temperature data derived from continuous ground surface and near ground surface temperature measurements by miniature temperature data sensors (MTD) with the areal data (slope, aspect, elevation and surface characteristics).

Different types of surface cover were mapped at seven alpine study sites within ALPCHANGE in central Austria: Central Schober Mountains (Gössnitz Valley), Hintereggen Valley, Fallbichl-Schareck, Pasterze Glacier area, and Dösen Valley within the Hohe Tauern Range, and Reichart Cirque as well as Höll Valley in the Reichart area within the Niedere Tauern Range. Three of seven sites are located within the Hohe Tauern National Park (Fig. 1 and Table 1). Results of all seven study sites are presented here.

Study sites and data base

The mapped area at each study site varied between 0.9 km^2 and 30.2 km^2. The main optical data used for the analysis were true color (TC) or near infrared (NIR) orthophotographs, acquired between 1983 and 2003 (Table 1). In addition analysis in Dösen Valley used very high resolution satellite data (QuickBird).

Table 1: Location, areal extent and used data for surface mapping of the seven study sites.

Mountain Range	**Study site**	**Mapped area in [km^2]**	**Mapped elevation range in [m]**	**Used data**
Hohe Tauern Range	Gössnitz Valley (CSM: Central Schober Mountains)	8.2	2360 – 3250 890 m	TC, 0,5 m, 2003
	Hintereggen Valley (HEV)	2.4	2050 – 2774 724 m	TC, 0,5 m, 2003
	Pasterze Glacier Area (PAG)	30.2	2050 – 3798 1748 m	TC, 0,5 m, NIR, 2003 Orthophotos, 1983
	Fallbichl-Schareck (FAS)	0.9	2050 – 2570 520 m	TC, 0,5 m, NIR, 2003
	Dösen Valley (DOE)	4.3	2265 – 3086 821 m	TC, 0,5 m, 2003; QuickBird 2003; TC,1,2 m, 1997 TC, 1983
Niedere Tauern Range	Hochreichart cirque (REI)	1.9	1750 – 2380 630 m	TC, 0,5 m, NIR, 2003
	Höll Valley (HOV)	2.9	1700 - 2390 690 m	TC, 0,5 m, NIR, 2003

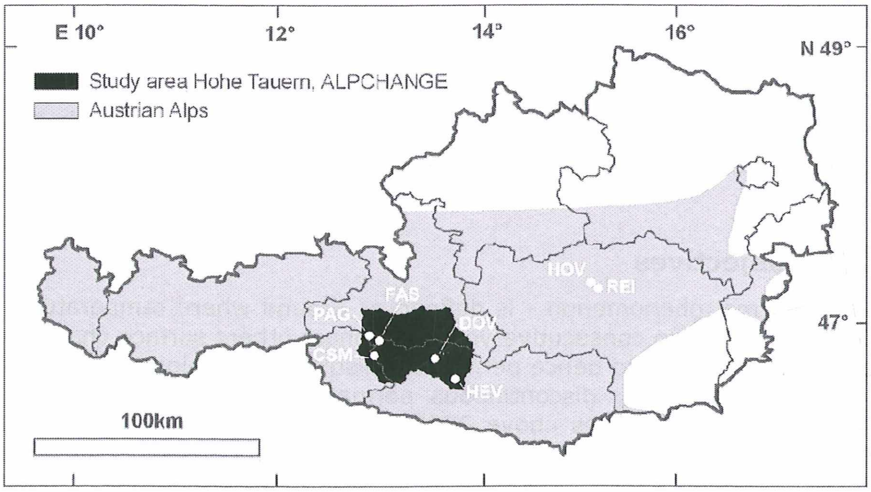

Figure 1: Location of the seven study sites of ALPCHANGE within the Austrian Alps. For abbreviations refer to Table 1.

The ALPCHANGE Interpretation Key and mapping rules

The ALPCHANGE Interpretation Key (AIK) consists of four levels (Table 2). The first and second level of the AIK is built-on hierarchically (digits 1 and 2 in the code). In the third and fourth level the character and the degree of the coverage are considered (digit 3: character and digit 4: degree). The first level contains the dominant surface characteristic such as *rock*, *debris*, *vegetation* or *glacier*. The second reveals more details such as *coarse* or *fine debris with or without vegetation*. In the third level the second-dominant surface cover is described (e.g. *alpine meadow*). Finally, the fourth level shows the degree of coverage of the different units (e.g. *alpine meadow* 10-40%)(Fig. 2).

Table. 2: The ALPCHANGE surface interpretation key

Digit 1: Level 1	Digit 2: Level 2	Digit 3: mixed with ...	Digit 4: Degree of coverage
1... Rock	11.. Rock 12.. Rock with vegetation	..1. Rock ..2. Coarse debris > 1 m ..3. Fine debris < 1 m ..4. Alpine meadow ..5. Dwarf shrub heath ..6. Mountain dwarf pine ..7. Green alder	...1 0 – 10 % ...2 10 – 40 % ...3 40 – 60 %
2... Debris	21.. Coarse debris > 1 m 22.. Coarse debris > 1 m with vegetation 23.. Fine debris < 1 m 24.. Fine debris < 1 m with vegetation	..1. Rock ..2. Coarse debris > 1 m ..3. Fine debris < 1 m ..4. Alpine meadow ..5. Dwarf shrub heath ..6. Mountain dwarf pine ..7. Green alder	...1 0 – 10 % ...2 10 – 40 % ...3 40 – 60 %
3... Vegetation	31.. Alpine meadow 32.. Dwarf shrub heath 33.. Mountain dwarf pine 34.. Green alder	..1. Rock ..2. Coarse debris > 1 m ..3. Fine debris < 1 m ..4. Alpine meadow ..5. Dwarf shrub heath ..6. Mountain dwarf pine ..7. Green alder	...1 0 – 10 % ...2 10 – 40 % ...3 40 – 60 %
4... Ice / Snow	4100 Glacier, not debris-covered 4200 Glacier, debris-covered 4300 Glacier, firn-covered 4400 Snowpatch		
5... Water	5100 Waterbody 5200 Creek		
6... Shadow	6100 probably rock 6200 probably debris 6300 probably vegetation		
7... Buildings	7100 Building 7200 Road 7300 Path 7400 Other	7110 Hut / House 7410 Avalanche barriers ..20 Dam	

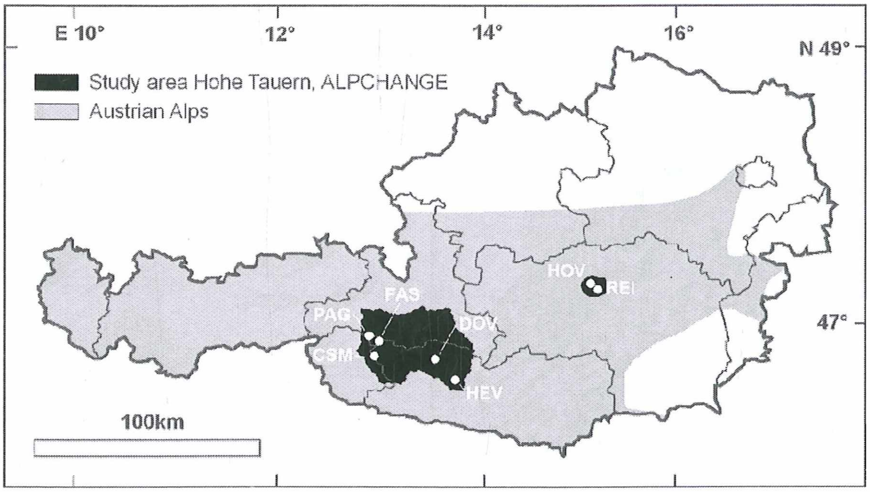

Figure 2: Exemplary detail of the Hochreichart area - Class 2442: *Fine debris with vegetation*: *alpine meadow* 10–40 %

The mapping is based on monoscopic orthophoto-interpretation with the directive that all polygons were created area-wide and do not overlap. One polygon had to define one particular homogeneous area and was assigned to a class by determining the dominant surface cover (principle of dominance) (DEMEL et al. 2006). The minimum-width was defined with 2 m, the minimum area with 100 m², and the minimum-mapping-unit with 10x10 m. The mapping was performed at a scale of 1:1,500.

For the separation of the class "*debris*" in "*coarse debris*" and "*fine debris*" boulders of 1 m were defined as border between the two classes. Dominant geomorphologic phenomena such as moraines, rockglaciers or mudflow-accumulations were considered priorily.

Results and discussion

This analysis only presents mapped classes which are essential for the ALPCHANGE project: *rock*, *rock with vegetation*, *coarse debris*, *coarse debris with vegetation*, *fine debris*, *fine debris with vegetation*, *vegetation* and *glacier* (Fig. 3, 4).

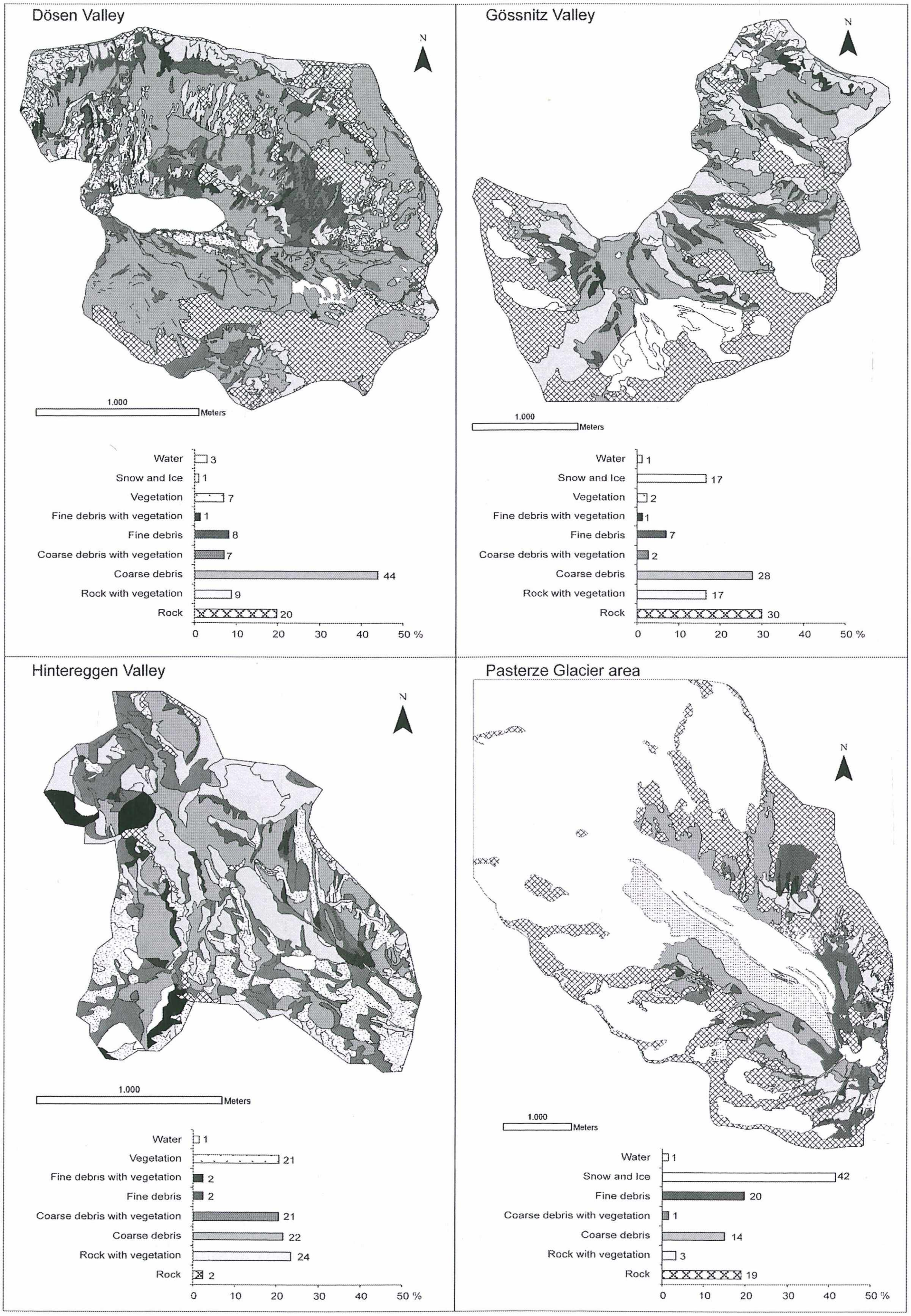

Figure 3: Mapping results and coverage percentages of *rock* and *debris* at first and second level and *vegetation* at first level for the study sites Dösen Valley, Gössnitz Valley, Hintereggen Valley and Pasterze Glacier (for map key see Fig. 5)

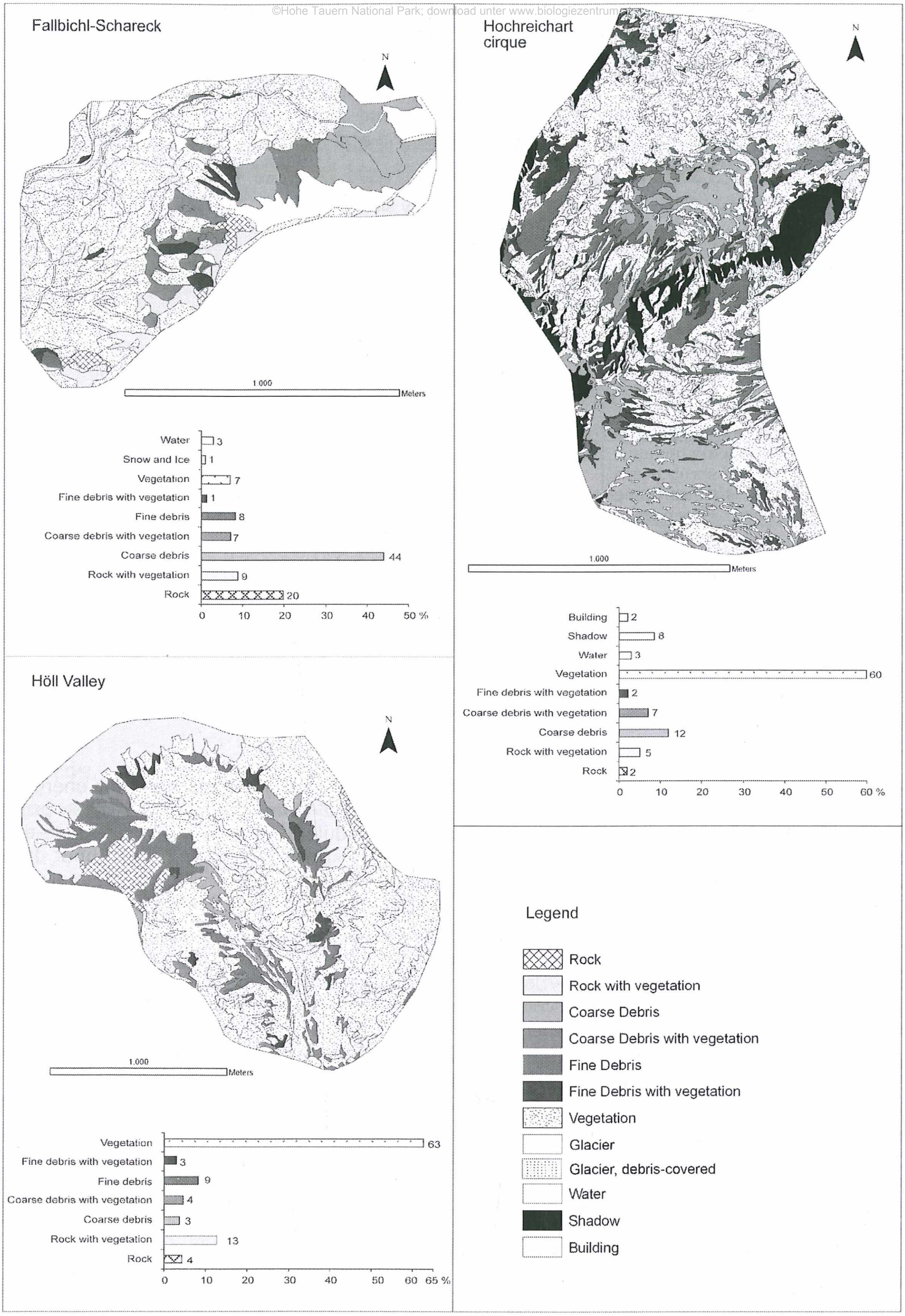

Figure 4: Mapping results and coverage percentages of *rock* and *debris* at first and second level and *vegetation* at first level for the study sites Fallbichl-Schareck, Reichart Cirque and the Höll Valley

Results of the study sites in the Hohe Tauern Range show that *debris*, *glacier* and *rock* are the dominant surface coverages. Especially the type *coarse debris* can be addressed as a crucial factor for supporting permafrost formation in the study sites. Dösen Valley shows a notably amount of *coarse debris* (45% + 7% *debris with vegetation less than 60%)* followed by Gössnitz Valley (25% + 2% *with vegetation < 60%*), Hintereggen Valley (22% + 21 *with vegetation < 60%*) and

Pasterze area (14% + 2% *with vegetation <60%*). In the Pasterze area the classes *glacier* and *debris-covered glacier* are predominant with 54% and 5%, respectively. Thus, permafrost is only probable in 16% of debris and 26% of rock covered area.

The two study sites in the Niedere Tauern Range are dominated by vegetated areas due to lower elevation. These are mainly *alpine meadow* (21-33 %) and *dwarf shrub* (13-32 %). Only between 18% and 44% of the mapped area is covered with *debris* and *vegetation < 60%* and are therefore adequate for permafrost occurrence (Table 3).

Table 3: Percentage of the surface cover-types in the six study sites at level 2.

CODE: Level 2	Hohe Tauern Range					Nieder Tauern Range	
	Dösen Valley	Gössnitz Valley	Pasterze area	Hinter-eggen Valley	Fallbichl-Schareck	Hoch-reichart Cirque	Höll Valley
11.. Rock	19	33	22	2	2		4
12.. Rock with vegetation	9	18	4	23	5	14	13
21.. Coarse debris	45	25	7	22	13	2	3
22.. Coarse debris with vegetation	7	2	1	21	7	8	4
23.. Fine debris	8	8	4	2		6	9
24.. Fine debris with vegetation	1	1		2	2	28	2
31.. Alpine meadow	7	2		21	33	22	24
32.. Dwarf shrub heath					32	13	28
33.. Mountain dwarf pine						1	13
34.. Green alder							
4100 Glacier		11	54				
4200 Glacier, debris-covered			5				
4300 Glacier, firn-covered							
4400 Snowpatch	1		1				
5100 Waterbody	3		1	1	1		
5200 Creek			1		1		
6100 probably rock				2		2	
6200 probably debris				3		4	
6300 probably vegetation							

Outlook

In a following step the data generated in this surface-cover analysis are the basis for energy-flux-modeling which yields to modeled ground temperature and consecutively to a most probable permafrost distribution. The approach comprises a two-module system with a (i) surface-energy flux model and a (ii) thermal-offset model (*PERMABAL*; STOCKER-MITTAZ et al. 2002). Input data for (i) are surface characteristics (e.g. albedo, roughness) and meteorological data (*e.g.* air temperature) modeling the surface temperature, for (ii) temperature differences (*e.g.* gravel size, snow cover thickness) to model the ground temperature.

References

BARSCH D. (1996): Rock glaciers. Indicators for the former and the present geoecology in high mountain environements. Springer, Berlin, 331 S.

DEMEL W., KIAS U. & HAUENSTEIN P. (2006): Interpretation Method – Development of an alpine interpretation key and common mapping guidelines for the description and delimination of land cover types – WP6. In: LOTZ, A. (Ed.), Alpine Habitat Diversity – HABITALP – Project Report 2002-2006. EU Community Initiative INTERREG III B Alpine Space Programme. NP Berchtesgaden, S. 52-66.

KELLERER-PIRKLBAUER A. & KÜHNAST B. (2009): Permafrost at its limits: The most easterly evidence of existing permafrost in the European Alps as indicated by ground temperature and geoelectrical measurements. Geophysical Research Abstracts 11: EGU2009-2779.

STOCKER-MITTAZ C., HOELZLE M. & HAEBERLI W. (2002): Modelling Alpine Permafrost Distribution Based on Energy Balance Data: a First Step. Permafrost and Perigacial Processes, 13: 271-282.

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Zeitschrift/Journal: Nationalpark Hohe Tauern - Conference Volume

Jahr/Year: 2009

Band/Volume: 4

Autor(en)/Author(s): Nutz Michaela, Avian Michael, Kellerer-Pirklbauer Andreas

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