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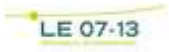

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The project "ALPCHANGE – Climate Change and Impacts in Southern Austrian Alpine Regions" with research results from the study area Schober Mountains, Hohe Tauern Range

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Summary

ALPCHANGE is a project on climate change and its impacts on the alpine environment in southern Austria with an – originally – three years running period from June 2006 to May 2009 (extended to November 2009). The project is mainly carried out by two universities in Graz (University of Graz and Graz University of Technology) and is funded by the Austrian Science Fund (FWF). The main objective of ALPCHANGE is to quantify landscape dynamics in alpine regions caused by climate change in past and present by combining two basic approaches: (1) investigation of the interaction of present climatic conditions and high mountain processes by use of a monitoring network established during the project period, and (2) analysis of signals from various dynamic landscape parameters – permafrost, geomorphodynamics, glaciers, and snow – for the ongoing climate change by a series of methods. Field research within ALPCHANGE is carried out at seven study sites in the Hohe and Niedere Tauern Ranges; three thereof within the boundaries of the Hohe Tauern National Park. In this paper we summarise research results from the study area in the central part of the Schober Mountains, focussing on the Größnitzkees Glacier, the Weissen Cirque (housing a rock glacier) the Kögele Cirque (housing a debris-covered glacier remnant) and the Hinteres Langtal Cirque (housing a rock glacier).

Keywords

ALPCHANGE, climate change and impacts, permafrost, glacier, snow, geomorphodynamics, Hohe Tauern National Park

The project ALPCHANGE and its objectives

The project "ALPCHANGE – Climate Change and Impacts in Southern Austrian Alpine Regions" is a project studying climate change and its impacts on the alpine environment in southern Austria with an originally three years running period from June 2006 to June 2009 (now extended to November 2009). The project is mainly carried out by the University of Graz and Graz University of Technology and is funded by the Austrian Science Fund (FWF). The authors form the core team of ALPCHANGE. Furthermore, G.K. Lieb and V. Kaufmann are involved since more than a decade in research activities in the Schober Mountains (e.g. LIEB 1996).

The main objective of ALPCHANGE is to quantify landscape dynamics in alpine regions caused by climate change in past and present. ALPCHANGE combines two basic approaches: (1) investigation of the interaction of present climatic conditions and high mountain processes by use of an upgraded monitoring network established for the very first time in southern Austria, and (2) analysis of signals from various dynamic landscape parameters – permafrost, geomorphodynamics, glaciers, and snow – for the ongoing climate change by a series of different methods.

The four landscape parameters react in differing time scales to climate change and therefore provide different information: snow cover instantly, glaciers within years to decades (depending on size), geomorphic features within years to decades and permafrost within decades to centuries. The interdisciplinarity of the project required usage of different methods and made the co-operation of a number of researchers with different backgrounds necessary.

Field research within ALPCHANGE was carried out at seven study sites in the Hohe and Niedere Tauern Ranges, four thereof (CSM, DOV, PAG and SON) within the boundaries of the Hohe Tauern

National Park (Fig. 1). For further information on the project please visit www.alpchange.at. In objective of this paper is to summarise research results from the study area in the central Schober Mountains (CSM).

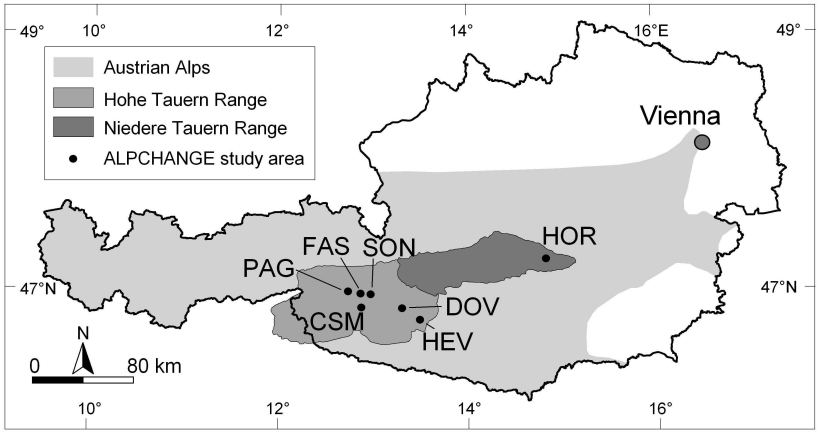

Figure 1: Locations of the seven ALPCHANGE study areas within the Hohe and Niedere Tauern Ranges. Abbreviations of study areas:

CSM=Central Schober Mountains*
DOV=Dösen Valley*
FAS=Fallbichl-Schareck
HEV=Hintereggen Valley
HOR=Hochreichart area
PAG=Pasterze Glacier*
SON=Sonnblick*

*located within the Hohe Tauern National Park

The study area Central Schober Mountains and the studied landforms

The Schober Mountains are characterized by crystalline rocks and a continental climate (1500 mm at 2000 m a.s.l., 0°C mean annual air temperature at 2300 m a.s.l.) causing minor glaciation and large areas affected by permafrost. The permafrost favourable conditions are indicated by the high number of rock glaciers (*n*=126), underlining the fact that the Schober Mountains provide suitable topoclimatic and geological conditions for rock glacier formation (LIEB 1996). Within the CSM our research activities at a local scale focus primarily on the following four landforms: the Gößnitzkees Glacier, the Weissen Cirque (housing an active rock glacier) the Kögele Cirque (housing a debris-covered glacier remnant) and the Hinteres Langtal Cirque (housing a highly active rock glacier) (Fig. 2).

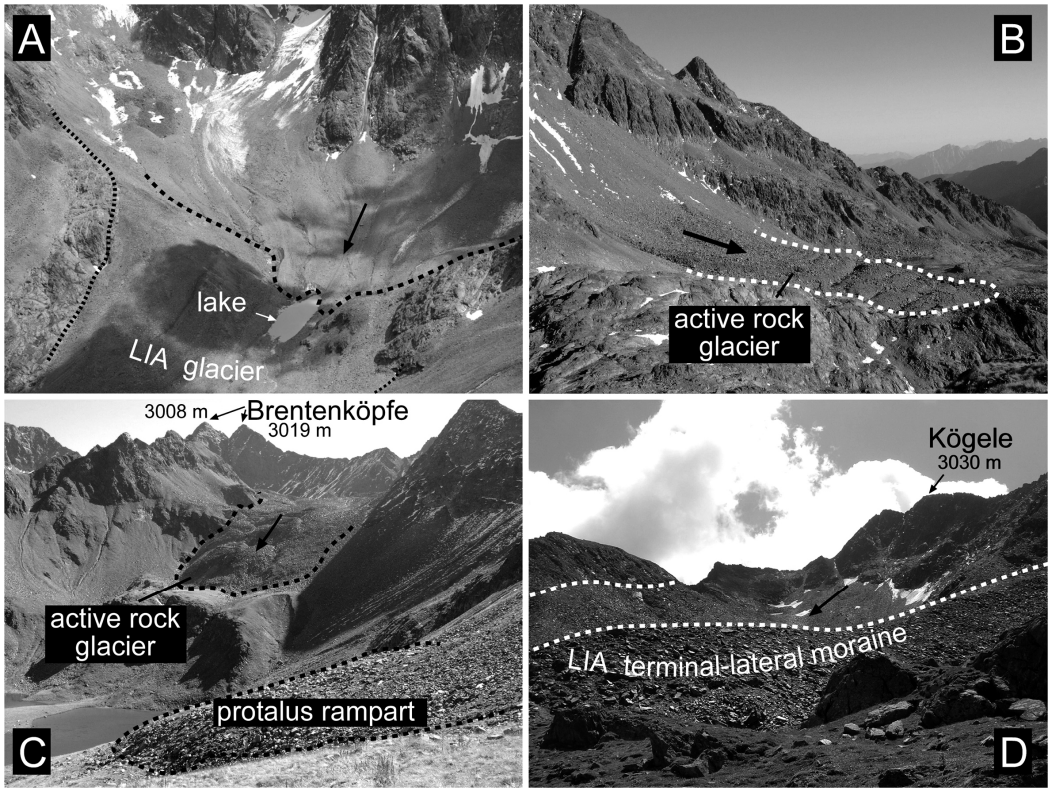

Figure 2: Terrestrial photographs of the four relevant landforms in the study area Central Schober Mountains (CSM): (A) Gößnitzkees Glacier, (B) Weissen Cirque and (C) Hinteres Langtal Cirque - both housing a rock glacier, (D) Kögele Cirque - housing a debris-covered degrading glacier remnant; LIA=Little Ice Age (ca. 1850 AD); black arrow indicates flow line of glacier/rock glacier; photographs by M. Avian and A. Kellerer-Pirklbauer.

Applied methods

Table 1 summarises the applied methods at each of the four studied landforms in the study area CSM that are briefly introduced and depicted in Chapter 2.

Table 1: Applied methods at the four studied landforms Gößnitzkees Glacier, Weissen Cirque, Hinteres Langtal Cirque and Kögele Cirque. Abbreviations: LiDAR=Light detection and ranging or Laserscanning (airborne and/or terrestrial); GS=geodetic survey; PG=photogrammetry (aerial and/or terrestrial); MTD=ground surface temperature and near ground surface temperature measurements (e.g. shallow boreholes) by use of miniature temperature dataloggers; AGE=age dating of rock glacier surfaces; MET=meteorological station; GEOM=geomorphic mapping and observations; RDC=monitoring of cirque processes with automatic remote digital cameras.

Studied landform	LiDAR	GS	PG	MTD	AGE	MET	GEOM	RDC
Gößnitzkees Glacier	X	X	X				X	
Weissen Cirque	X	X	X	X	X		X	
Hinteres Langtal Cirque	X	X	X	X		X	X	X
Kögele Cirque	X		X	X			X	

Research Results

Gössnitzkees Glacier

Gößnitzkees Glacier is located in the central part of the Schober Mountains at the valley head of the Gößnitz valley. "Kees" is the regional term for glacier. The unfavourable climatic (see above) and topographic (steep rock faces, narrow crests, lack of flat surfaces at high elevations above the regional equilibrium line altitude/ELA) conditions of the Schober Mountains for glaciation are the reasons that Gößnitzkees Glacier with its 0.59 km² in 2006 (KAUFMANN & LADSTÄDTER 2008c) is the largest glacier in this area. A distinct accumulation area is missing and avalanches from couloirs of the headwalls nourish the glacier with snow, ice and rocks. Therefore, more than 60% of the glacier is covered by a continuous supraglacial debris mantle with variable thickness (KELLERER-PIRKLBAUER et al. 2005). The glacier flow velocity is low and ranges between 20 and 50 cm a^{-1} as derived from ten velocity markers. Assuming a similar glacier retreat pattern as during the last decades, this glacier will be gone by ca. 2030 (KAUFMANN & LADSTÄDTER 2008c).

ALPCHANGE research at this landform (Table 1) is carried out by using LiDAR (initiated in 2000 on an annual to biannual basis; KELLERER-PIRKLBAUER et al. 2005), by geodetic survey (annually since 1996; KIENAST & KAUFMANN 2004), by aerial and terrestrial photogrammetry (aerial since 1954, terrestrial since 1988; e.g. KAUFMANN & LIEB 2002, KAUFMANN & LADSTÄDTER 2004, 2008c and 2008b) and geomorphic mapping and observations. Published research results supported by ALPCHANGE are found in KAUFMANN & LADSTÄDTER (2008b).

Weissen Cirque

The Weissen Cirque is located less than a kilometre south of Gössnitzkees Glacier facing to the west. The cirque is dominated by the tongue-shaped Weissenkar Rock Glacier which is fed by active scree slopes. The rock glacier consists of an active upper lobe overriding an inactive lower lobe. The landform is characterized by well developed furrows and ridges at its lower half, a lower limit at 2615 m a.s.l., a length of 500 m and a surface area of 0.11 km².

ALPCHANGE research at this landform (Table 1) is carried out by geodetic survey (initiated in 1997, annually), by aerial photogrammetry (since 1974; KAUFMANN et al. 2006), by ground surface temperature and near ground surface temperature measurements using UTL and Geoprecision dataloggers (initiated in 1997, extended in 2007; KELLERER-PIRKLBAUER et al. 2008c), by rock glacier dating (KELLERER-PIRKLBAUER 2008a) and by geomorphic mapping and observations. Published research results supported by ALPCHANGE are found in DELALOYE et al. (2008), KELLERER-PIRKLBAUER (2008a) and KELLERER-PIRKLBAUER et al. (2008c).

Research at the Hinteres Langtal Cirque

The Hinteres Langtal Cirque as well as the neighbouring Kögele Cirque (see below) are both orientated towards W-NW each with comparable high crests and mountain summits slightly exceeding 3000 m a.s.l. to the S and E. The first mentioned cirque is dominated by the Hinteres Langtalkar Rock Glacier indicating at its front the local lower limit of discontinuous permafrost at 2450m a.s.l. The rock glacier is approx. 850 m long and 200 to 350 m wide. Its frontal part is heavily influenced by disintegration through active sliding processes since 1994 (e.g. AVIAN et al. 2005 and 2008a, ROER et al. 2008).

ALPCHANGE research activities at the Hinteres Langtal Cirque (Table 1) are the most comprehensive ones of all four landforms studied in the CSM. At this site, we apply LiDAR (initiated in 2000; e.g. AVIAN et al. 2008a), geodetic survey (initiated in 1999, annually), aerial photogrammetry (since 1954; KAUFMANN & LADSTÄDTER 2008a), ground surface temperature and near ground surface temperature monitoring using Geoprecision dataloggers (network installed in 2006; e.g. KELLERER-PIRKLBAUER et al. 2008b), meteorological measurements through a comprehensive climate station (installed in 2006), geomorphic mapping and observations (since 1999; KELLERER-PIRKLBAUER & KAUFMANN 2007, KELLERER-PIRKLBAUER 2008b) and continuous monitoring of cirque processes by using an automatic remote digital camera/RDC (installed in 2006) delivering daily images of geomorphic and snow cover processes (KELLERER-PIRKLBAUER et al. 2008a).

Published research results supported by ALPCHANGE are found in Avian et al. (2008a and "in press"), DELALOYE et al. (2008), KAUFMANN & LADSTÄDTER (2008a), KELLERER-PIRKLBAUER (2008b), KELLERER-PIRKLBAUER & MATSUOKA (2009), KELLERER-PIRKLBAUER & ROUBAL (2009), KELLERER-PIRKLBAUER et al. (2008a, b and d) and ROER et al. (2008). Figure 4 presents for instance results of the long-term monitoring of the morphodynamics of the Hinteres Langtalkar Rock Glacier based on aerial photographs (1954-2006) and geodetic measurements (1999-2007). This graph clearly depicts for instance the extremely high horizontal displacement values in 2003-2004 caused by the exceptional warm summer 2003.

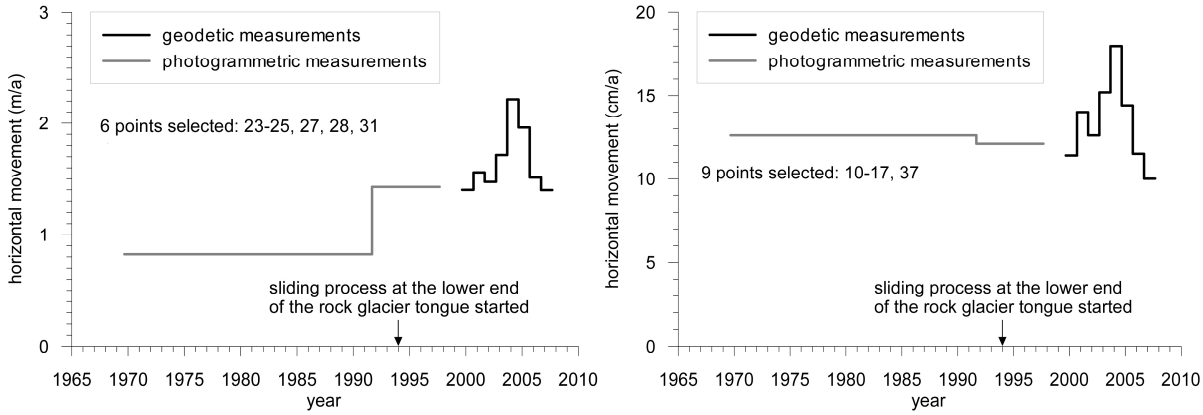

Figure 3: Mean annual horizontal displacement (in m a^{-1}) of the Hinteres Langtalkar Rock Glacier depicted for the faster lower part (left) and the substantially slower upper part (right) of the rock glacier (*cf.* Kaufmann & Ladstädter 2008a).

Kögele Cirque

The Kögele Cirque is located some 50 m higher compared to the neighbouring Hinteres Langtal Cirque. In contrast, this cirque lacks a rock glacier but houses a glacier remnant that is still slowly creeping down-valley thereby deforming its widespread supraglacial debris mantle. This debris layer is dominantly structured as small-scaled tongue-shaped landforms (STLs) that have a bended appearance proving the ongoing down-valley movement (see Fig. 3 in KELLERER-PIRKLBAUER & KAUFMANN 2007)

ALPCHANGE research activities at the Kögele Cirque (Table 1) are carried out by applying aerial photogrammetry (since 1969; KELLERER-PIRKLBAUER & KAUFMANN 2007), ground surface temperature and near ground surface temperature monitoring using Geoprecision dataloggers (network installed in 2006; KELLERER-PIRKLBAUER 2008b) and geomorphic mapping and observations (since 2006; KELLERER-PIRKLBAUER & KAUFMANN 2007, KELLERER-PIRKLBAUER 2008b). Published research results by ALPCHANGE are found in KELLERER-PIRKLBAUER (2008b).

Considering the entire CSM

Finally ALPCHANGE research activities at CSM are also carried on a more regional scale, as for instance climate change analyses (TAUCHER et al. 2008 and 2009) or a comprehensive analysis of glacier changes of the Hohe Tauern Range comprising CSM (AVIAN et al. 2008b).

Final remarks and Outlook

This paper summarises a whole suite of research activities from one of the study areas of ALPCHANGE. Chapters 2, 3 and 4 briefly introduced the study area Central Schober Mountains and the studied landforms the methods and our research activities as well as published results. Most of the mentioned publications are available digitally and therefore please don't hesitate to contact one

of the authors of this short paper for more details on a given publication. Furthermore, a series of collected data from our research activities in the CSM are still being processed and are prepared for publication. Finally, please note that most of our research activities initiated during the ALPCHANGE project period will be continued to be carried out as e.g. within the project PermaNET (www.permanet-alpinespace.eu).

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References

AVIAN M., KAUFMANN V. & LIEB G.K. (2005): Recent and Holocene dynamics of a rock glacier system: The example of Hinteres Langtalkar (Central Alps, Austria). Norwegian Journal of Geography, 59, 149-156.

AVIAN M., KELLERER-PIRKLBAUER A. & BAUER A. (2008a): Remote Sensing Data for Monitoring Periglacial Processes in Permafrost Areas: Terrestrial Laser Scanning at the Hinteres Langtalkar Rock Glacier, Austria. Proceedings of the Ninth International Conference on Permafrost, University of Alaska, Fairbanks, USA, 1, 77-82.

AVIAN M., KELLERER-PIRKLBAUER A., MOSER L. & LAMBRECHT A. (2008b): Glaciation Changes in the Hohe Tauern Range (Austria) between 1969 and 2003 based on Optical Remote Imagery: First Results. Geophysical Research Abstracts 10: EGU2008-A-09222.

AVIAN M., KELLERER-PIRKLBAUER A. & BAUER A. (in press): LiDAR for Monitoring Mass Movements in Permafrost Environments at the Cirque Hinteres Langtal, Austria, between 2000 and 2008. Natural Hazards and Earth System Sciences, Special Issue: LIDAR and DEM techniques for landslides monitoring and characterization.

DELALOYE R., PERRUCHOUD E., AVIAN M., KAUFMANN V., BODIN X., HAUSMANN H., IKEDA A., KÄÄB A., KELLERER-PIRKLBAUER A., KRAINER K., LAMBIEL C., MIHAJLOVIC D., STAUB B., ROER I. & THIBERT E. (2008): Recent Interannual Variations of Rock Glacier Creep in the European Alps. Proceedings of the Ninth International Conference on Permafrost, University of Alaska, Fairbanks, USA, 1, 343-348.

KAUFMANN V. & LADSTÄDTER R. (2004): Documentation of the retreat of a small debris-covered cirque glacier Goessnitzkees, Austrian Alps by means of terrestrial photogrammetry. Proceedings of the 4th ICA Mountain Cartography Workshop, 30 September - 2 October 2004, Vall de Núria, Catalonia, Spain, Monografies tècniques 8, Institut Cartogràfic de Catalunya, Barcelona, 65-76.

KAUFMANN V. & LADSTÄDTER R. (2008a): Documentation and visualization of the morphodynamics of Hinteres Langtalkar rock glacier (Hohe Tauern Range, Austrian Alps) based on aerial photographs (1954-2006) and geodetic measurements (1999-2007). Proceedings of the 10th International Symposium on High Mountain Remote Sensing Cartography, Kathmandu, Nepal (in press).

KAUFMANN V. & LADSTÄDTER R. (2008b): Application of terrestrial photogrammetry for glacier monitoring in alpine environments. IAPRS, 37, B8, Proceedings of the 21st Congress of ISPRS, Beijing, China, July 2008, 813-818.

KAUFMANN V. & LADSTÄDTER R. (2008c): Documentation of the retreat of Gössnitzkees and Hornkees glaciers (Hohe Tauern Range, Austria) for the time period 1997-2006 by means of aerial photogrammetry. Proceedings of the 6th ICA Mountain Cartography Workshop, Lenk, Switzerland, 115-123.

KAUFMANN V. & LIEB G.K. (2002): Investigations on the retreat of two small cirque glaciers (Goessnitzkees and Hornkees) in the Austrian Alps, Europe. High-Mountain Remote Sensing Cartography 1998 - Proceedings of the 5th International Symposium of the Use of Remote Sensing Data in Mountain Cartography, Karlstad University Studies 2002:27, 75-82.

KAUFMANN V., LADSTÄDTER R. & LIEB G.K. (2006): Quantitative assessment of the creep process of Weissenkar rock glacier (Central Alps, Austria). Proceedings of the 8th International Symposium on High Mountain Remote Sensing Cartography (HMRSC-VIII), La Paz, Bolivia, 2005 (=Grazer Schriften der Geographie und Raumforschung: 41), 77-86.

KELLERER-PIRKLBAUER A. (2008a): The Schmidt-hammer as a Relative Age Dating Tool for Rock Glacier Surfaces: Examples from Northern and Central Europe. Proceedings of the Ninth International Conference on Permafrost, University of Alaska, Fairbanks, June 29 – July 3, 2008, 913-918.

KELLERER-PIRKLBAUER A. (2008b): Surface Ice and Snow Disappearance in Alpine Cirques and its possible Significance for Rock Glacier Formation: Some Observations from Central Austria. Extended Abstracts, Ninth International Conference on Permafrost, University of Alaska, Fairbanks, 129-130.

KELLERER-PIRKLBAUER A. & KAUFMANN V. (2007): Paraglacial talus instability in recently deglaciated cirques: Schober Group, Austria. Proceedings of the 9th International Symposium on High Mountain Remote Sensing Cartography (HMRSC-IX), Graz, Austria, September 14–22, 2006 (=Grazer Schriften der Geographie und Raumforschung: 43), 121–130.

KELLERER-PIRKLBAUER A. & MATSUOKA N. (2009): Thermal regime and freeze-thaw action in alpine rockwalls: A comparison of sites in the Austrian, Swiss and Japanese Alps during the period 2006-2008. Geophysical Research Abstracts 11: EGU2009-8333-2.

KELLERER-PIRKLBAUER A. & ROUBAL R. (2009): Towards using ground surface and air temperature data for assessing the thickness of winter snow covers. Geophysical Research Abstracts 11: EGU2009-8082.

KELLERER-PIRKLBAUER A., BAUER A. & PROSKE H. (2005): Terrestrial laser scanning for glacier monitoring: Glaciation changes of the Gößnitzkees glacier (Schober group, Austria) between 2000 and 2004. Proceedings of the 3rd Symposium of the Hohe Tauern National Park for Research in Protected Areas, Kaprun, 97-106.

KELLERER-PIRKLBAUER A., AVIAN M., LIEB G.K. & PILZ A. (2008a): Automatic Digital Photography for Monitoring Snow Cover Distribution, Redistribution and Duration in alpine Areas (Hinteres Langtal Cirque, Austria). Geophysical Research Abstracts 10: EGU2008-A-11359.

KELLERER-PIRKLBAUER A., AVIAN M., LIEB G.K. & RIECKH M. (2008b): Temperatures in Alpine Rockwalls during the Warm Winter 2006/2007 in Austria and their Significance for Mountain Permafrost: Preliminary Results. Extended Abstracts, Ninth International Conference on Permafrost, University of Alaska, Fairbanks, 131-132.

KELLERER-PIRKLBAUER A., KAUFMANN V., KROBATH M., LIEB G.K. & AVIAN M. (2008c): 10 Years of Monitoring the Rock Glacier Kinematic and Surface Temperature at Weissenkar Rock Glacier, Austria (1997-2007). Geophysical Research Abstracts 10: EGU2008-A-02061.

KELLERER-PIRKLBAUER A., RIECKH M., AVIAN M. & LIEB G.K. (2008d): The unusual warm winter 2006/2007 and its effects on permafrost and bedrock weathering by frost action in alpine rockwalls of Austria. Abstract at the 3rd Central European Conference on Geomorphology, University of Salzburg, Salzburg, Austria, 23rd – 28th September 2008, p 82.

KIENAST G. & KAUFMANN V. (2004): Geodetic measurements on glaciers and rock glaciers in the Hohe Tauern National Park (Austria). Proceedings of the 4th ICA Mountain Cartography Workshop, 30 September - 2 October 2004, Vall de Núria, Catalonia, Spain, Monografies tècniques 8, Institut Cartogràfic de Catalunya, Barcelona, 101-108.

LIEB G.K. (1996): Permafrost und Blockgletscher in den östlichen Österreichischen Alpen. Arbeiten aus dem Institut für Geographie, Universität Graz 33: 9–125.

ROER I., HAEBERLI W., AVIAN M., KAUFMANN V., DELALOYE R., LAMBIEL C., KÄÄB A. (2008): Observations and considerations on destabilizing active rockglaciers in the European Alps. Proceedings of the Ninth International Conference on Permafrost, University of Alaska, Fairbanks, 1, 1505-1510.

TAUCHER W., KELLERER-PIRKLBAUER A., LIEB G.K. & AVIAN M. (2008): Temperature Trends at high Mountain Sites of Central Austria during the Period 1961-2006. Geophysical Research Abstracts 10: EGU2008-A-09077.

TAUCHER W., KELLERER-PIRKLBAUER A., LIEB G.K. & AVIAN M. (2009): Climatic trends at high mountains sites of central Austria during the period 1961-2006. Geophysical Research Abstracts 11: EGU2009-8064.

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