Schloss Nymphenburg, Foto: Markus Weber

20th Alpine Glaciology Meeting AGM 2016 Munich 25/26 February 2016

Location:

Carl-Friedrich-von-Siemens-Stiftung, Südliches Schlossrondell 23, 80638 München

Building of the Carl-Friedrich-von-Siemens-Stiftung

Program and Book of Abstracts

Organized by:

Bayerische Akademie der Wissenschaften
Erdmessung und Glaziologie
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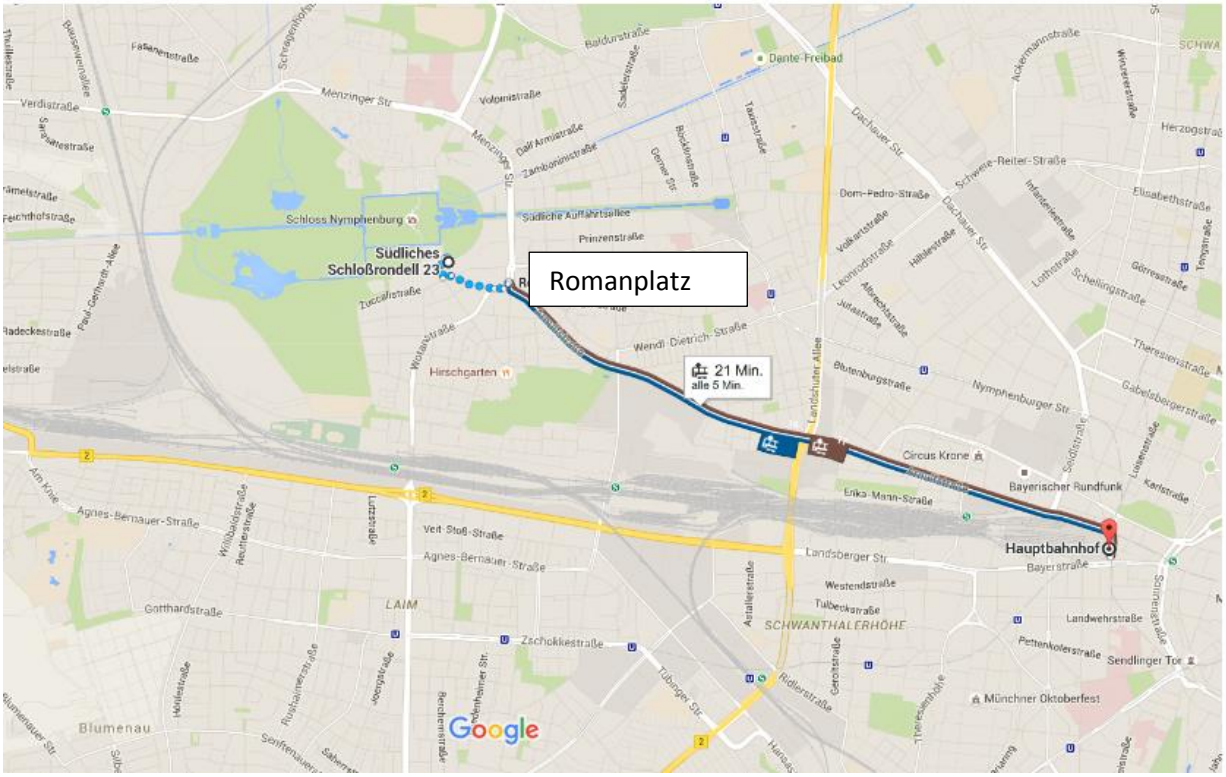
February 2016

Map of the AGM 2016 Location in Munich

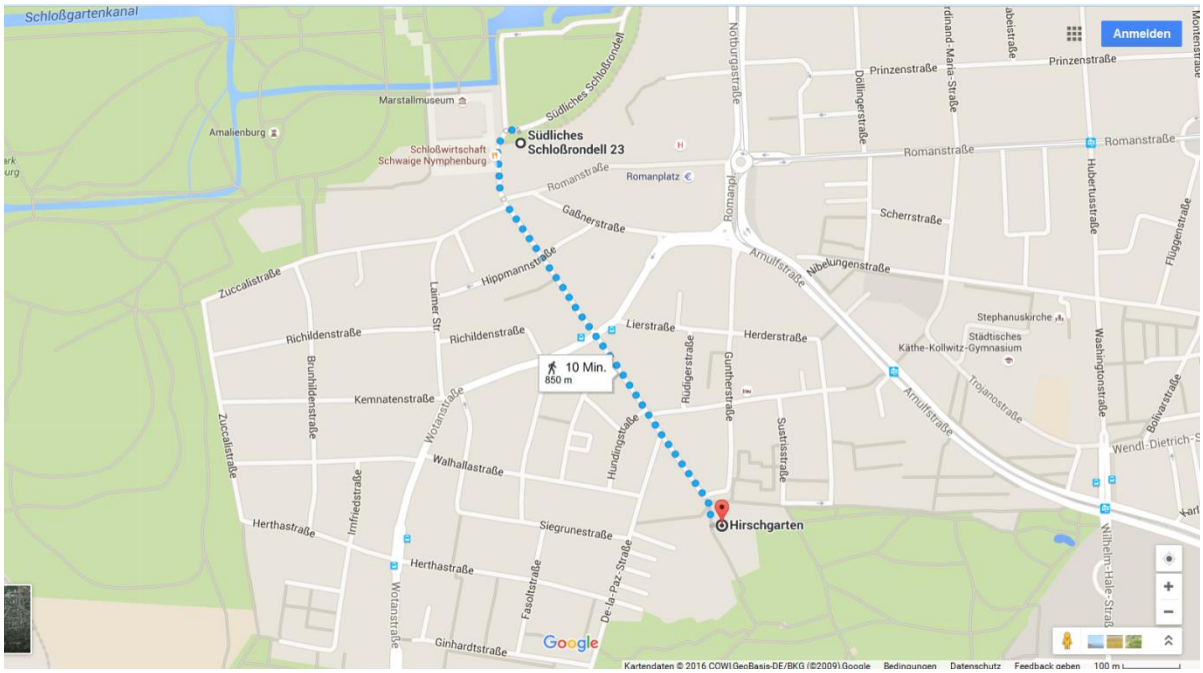
1. Location of the meeting: Carl-Friedrich-von-Siemens-Stiftung, Südliches Schloßrondell 23, 80638 Munich
2. Conference Dinner on 25 February 18.30 o'clock: Königlicher Hirschgarten, **Hirschgarten 1, 80639 München,** collective dinner



Connection from Munich Main Train Station (northern side of Hauptbahnhof): **Tram** Number **16** or **17** (every 5 Minutes) to Romanplatz / direction Amalienburgstrasse (21 min.); short distance = 2 units on the 10-unit stripe card (€ 13 : 5 = 2.60) or day pass (€ 6,40 per day in the City Center) or included in train ticket **Munich + City**; car parking at the south-eastern side of Nymphenburg Castle

Conferenz dinner at Hirschgarten:

Foot path on Hirschgartenallee from Meeting location to **Königlicher Hirschgarten** (**conference Dinner** on **25 February** 18.30 o'clock, 10 min. walk)



Option for using public transportation „stripe card": 10 stripes = € 13.-

1. Day: Main Train Station München – Romanplatz = 2 stripes
   Location of AGM – Restaurant: 10 min walk.
   Restaurant – Hotel: 2 stripes / Streifen
2. Day : Hotel – Location of AGM (Romanplatz) = 2 stripes
   Romanplatz – Main Train Station = 2 stripes

Program 20th Alpine Glaciology Meeting Munich Germany
25. Feb. 2016

09^{30} *Welcome: Christoph Mayer*
Introduction: Magnus M. Magnusson - The IGS at a crossroad:
the transition to Gold Open Access

Oral presentations

Session 1: Glacier Monitoring

10^{00}	**1.1**	Diolaiuti, G.	Present extent and features of the Italien glaciers: Results from the New Italian Glacier Inventory
10^{20}	**1.2**	Azzoni, R.	The dark side of the ice: New method to describe fine debris effects on the ice albedo and the composition of microbial communities on Alpine glaciers
10^{40}	**1.3**	Braun, L.	Half a century of direct glacier mass balances of Vernagtferner, Eastern Alps: how can they be interpreted?
11^{00}	*Coffee break*		
11^{30}	**1.4**	Gleisberg, E.	Calculation of the annual water balance components for the Vernagtferner basin between 1845 – 2013 using a conceptual runoff model
11^{50}	**1.5**	Fischer, A.	A decade of research on snow farming in glacier ski resorts: any ice left?
12^{10}	**1.6**	Covi, F.	Assessing potential reasons for different accumulation patterns on Mount Kenya and Kilimanjaro
12^{30}	**1.7**	Fugazza, D.	Areal and volumetric variations of the Lex Blanche Glacier (Mont Blanc Massif, Italy) from historical cartography and remote sensing sources
13^{00} – 14^{00}	*Lunch*		
14^{00}	**1.8**	Rankl, M.	Multi-mission satellite analysis of glaciers in High Asia
14^{20}	**1.9**	Thibert, E.	An analysis of extreme mass balance values recorded at Sarennes glacier over 7 decades
14^{40}	**1.10**	Paul, F.	Glacier mapping with Sentinel 2 MSI & Landsat 8 OLI: exciting perspectives and new challenges
15^{00} – 15^{30}	*Coffee break*		

Session 2: Geophysical Methods

15^{30}	**2.1**	Senese, A.	Ground thermal conditions at Punta Helbronner (Italian Alps) from a 2 year time series
15^{50}	**2.2**	Funk, M.	Monitoring glacier instabilities in the ice covered Weissmies northwest face
16^{10}	**2.3**	Steiner, J.	Traces of the Gorkha earthquake in April 2015 on Langtang's glaciers
16^{30}	**2.4**	Kappenberger, G.	The exceptional ice avalanche of Langtang Lirung released by the earthquake of April 25, 2015

Postersession

17^{00} - 18^{00} *Short presentations (max. 2 minutes scheduled for each poster, see special list) and afterwards poster exhibition*

18^{30} **Opportunity for collective dinner at Hirschgarten**
(*to be covered by each participant***)**

26. Feb. 2016

Session 3: Glacier and Climate

9^{30}	**3.1**	Vincent, Chr.	Sliding velocity fluctuations and subglacial hydrology over the last two decades on Argentière glacier, Mont Blanc area
9^{50}	**3.2**	Egli, P.	A dynamic energy balance model to compute supra glacial debris thickness using thermal satellite images on a glacier in Langtang valley, Nepal Himalaya
10^{10}	**3.3**	Kaser, G.	How do glaciers turn weather into a climate signal?
10^{30}	**3.4**	Pritchard, H.	Why do Asia's mountain glaciers matter?
10^{50}	**3.5**	Zolles, T.	Uncertainty estimation on energy balance models
11^{10}	**3.6**	Eisen, O.	Accumulation rates from central North Greenland during the past 700yr

11^{30} – 12^{30} *Lunch*

Session 4: Geodesy, glacier modelling

12^{30}	**4.1**	Gerlach, Chr.	Gravimetric observations at Svartisen, Norway
12^{50}	**4.2**	Nwachukwu, H.	Mass loss and mass distribution of alpine glaciers using terrestrial gravimetry
13^{10}	**4.3**	Heilig, A.	The temporal firn line evolution for glaciers in the Rofental, based on C- and X-band remote sensing SAR data
13^{30}	**4.4**	Buri, P.	3D-modelling of ice cliff evolution on a debris-covered glacier, Nepalese Himalayas
13^{50}	**4.5**	Groos, A.	Investigating mass balance processes for glaciers in the Karakoram based on enhanced degree day modelling

14^{10} *Closing remarks: Ludwig Braun*

14^{15} ***End of Meeting***

Poster Presentations

20th Alpine Glaciology Meeting Munich Germany
Postersession 25 Feb. 2016 17^{00} - 18^{00}

1	Azzoni, R.S.	Identification of recent glacier evolution and ice-related landforms of the Ararat/Ağri Dağı Mount (Eastern Turkey) through SPOT and PLEIADES images
2	Barandun, M.	Glacier-wide mass balance on four Kyrgyz glaciers from 2003 to 2015
3	Compostella, Ch.	Ice to water: the Forni glacier under investigation
4	Feiger, N.	Two new bedrock topographies for Gries- and Findelenglacier
5	Fischer, A.	The glacier survey of the Austrian Alpine Club: 125 years of citizen science
6	Hanzer, F.	Regional-scale model simulations of glacier snow cover and snow line altitude vs. satellite observations: uncertainty assessment in the Ötztal Alps (Austria)
7	Hartl, L.	Can a simple numerical model help to fine-tune the analysis of ground penetrating radar data? - Hochebenkar rock glacier as a case study
8	Krbcová, K.	Microtextural differences of glaciofluvial quartz grain from saalian and würm glaciation
9	Lambrecht, A.	Accumulation distribution in the upper Fedchenko Glacier, Pamir
10	Landmann, J.	Obstacles on the way to a consistent global glaciological database
11	Marke, T.	Past and potential future changes in the Austrian snow cover
12	McCarthy, M.	Using ground-penetrating radar to study debris-covered glaciers in the Himalaya
13	Naegeli, K.	Landsat based spectral albedo of glacier surfaces in the Western Swiss Alps
14	Prinz, R.	Scale effects impeding paleoclimate reconstructions from mountain glaciers: impacts on the vertical mass balance profile
15	Vezzola, L.	Assessing glacier features supporting supraglacial trees: the case study of the Miage debris-covered Glacier (Italian Alps)
16	Vijay, S.	Investigating seasonal and long-term glacier changes in Alaska and Western Himalaya (India) using multi-mission satellite data
17	Fürst, J.J.	Modelling present glacier dynamics on Svalbard - from inferring surface velocities to computing a flow-consistent bedrock map
18	Lindner, F.	Monitoring of outburst floods using seismology
19	Bollmann, E.	State-of-the art airborne photogrammetry for glacier monitoring

Abstracts in alphabetical order of the first author

Oral presentation = Vortrag (V); Poster (P)

Azzoni, Sergio Roberto (V)

The dark side of the ice. New methods to describe fine debris effects on the ice albedo and the composition of microbial communities on Alpine glaciers.

Roberto S. Azzoni[1], Antonella Senese[1*], Andrea Zerboni[1], Maurizio Maugeri[2], Roberto Ambrosini[3], Andrea Franzetti[3], Claudio Smiraglia[1] and Guglielmina A. Diolaiuti[1]

[1] Università degli Studi di Milano, Dipartimento di Scienze della Terra "A. Desio", Milan, Italy
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[3] Università degli Studi di Milano Bicocca, Department of Earth and Environmental Sciences, Milan, Italy

Abstract
The ongoing global warming has a primary effect on glaciers, not only intensifying the ice melt, but also increasing the magnitude and rates of debris accumulation at the glacier surfaces, especially if we consider the fine mineral and organic fractions (namely dust). Fine and sparse debris reduces ice albedo, enhancing the ablation, but also promoting colonization in the supraglacial habitats from bacterial communities and meiofauna. For better investigating the occurrence and composition of dust, we proposed a general protocol including integrated analyses of the supraglacial debris, recently established on the Forni Glacier, one of the most representative and paradigmatic Italian glaciers. Primarily, we proposed a novel method based on semi-automatic image analysis to quantify fine debris coverage on glacier ice and to investigate the variability of ice albedo, assessing also the impact of water (due to melt and rainfall).Then, we focused on the debris characterization, exploring the sedimentological composition and the origin of dust. Finally, we describe the microbial communities of cryoconite holes and proglacial areas. The estimated values for debris coverage obtained through image analysis were found in a significant linear relation with the natural logarithm of measured ice albedo: five sensitivity tests confirmed the robustness of this approach. We also found a fast surface variability with a debris coverage replacing of 6 g/m^2 per day (equal to 210 x 10^3 kg over a period of 1 month on the whole Forni tongue). The latter process is strongly dependent on the impact of water, which also as an important factor in turning albedo; in fact, water running at the glacier surface decreases the albedo due to its lower reflectivity, diversely rainfall are found causing a mean daily increase slightly higher than 20%. Sedimentological analyses suggest a local origin of debris and a high content of organic matter. Nevertheless, some cenospheres were found thus suggesting an anthropic contribution from long-distance sources to debris accumulation. Finally, also the cryoconite bacterial communities have a strong seasonal dynamic, with autotrophic populations dominating communities after snow melting and heterotrophic populations increasing in abundance later in the season. Moreover, the proglacial environment does not host bacterial communities similar to those found in the cryoconite holes, thus suggesting that this environment seem not to be the source of bacteria, but may provide inputs of organic matter.

Azzoni, Roberto Sergio (P)

Identification of recent glacier evolution and ice-related landforms of the Ararat/Ağri Dağı Mount (Eastern Turkey) through SPOT and PLEIADES images

Roberto S. Azzoni[1], Andrea Zerboni[1], Carlo Alberto Garzonio[2], Claudio Smiraglia[1], Manuela Pelfini[1] and Guglielmina A. Diolaiuti[1]
[1] Università degli Studi di Milano, Dipartimento di Scienze della Terra "A. Desio", Milan, Italy
[2] Università degli Studi di Firenze, Dipartimento di Scienze della Terra, Florence, Italy

Abstract
The Ağri Dağı Mount, also known as Ararat, is a volcanic complex located in eastern Anatolia (Turkey) near the borders to Iran, Armenia and Azerbaijan; it covers an area of c. 1100 km^2. The massif highest peaks, the Buyuk Ağrı (Greater Ararat) reaches an elevation of 5137 m a.s.l. Moreover, Ağri Dağı is the most important glacierized mountain in the Middle East, being the sole ice cap of the region. Notwithstanding that, only a few geomorphological and glaciological studies have been conducted there up to now. In this contribution, we investigate the present-day extent of the local glacial cover and the main ice-related landforms. Moreover, we focused our attention on the recent evolution of the ice cap. Geomorphological and glaciological mapping of the area was carried out by means of remote sensing study of the surface (employing LANDSAT, SPOT and PLEIADES imagery) and field control of evidence. The latter was performed during a scientific-alpinist expedition in the framework of the Central Scientific Committee of the Italian Alpine Club (CAI). The total glacier coverage is quantified in c. 6.23 km^2 (year 2014). A significant areal decrease of about -20% occurred since the '70s, when the glacierized surface was c. 7.98 km^2 (year 1976). Moreover, we identified three debris-covered glaciers. One of them, the Parrot Glacier, which is located in the North-Western flank of the volcano, reaches the lowest altitude and its snout is at c. 3500 m a.s.l. Based on remote sensing and field data, we elaborated the geomorphological map of the region, with a particular attention on ice-related landforms. In particular, we mapped the main moraine ridges along the volcanic complex and a wide relict glacier located in the North flank.

Barandun, Martina (P)

Glacier-wide mass balance on four Kyrgyz glaciers from 2003 to 2015 (P)

Martina Barandun (1), Ruslan Kenzhebaev (2), Marlene Kronenberg (1, 3) Matthias Huss (1, 4), Erlan Azisov (5), Leo Sold (1), Christian Kienholz (6), Ryskul Usubaliev (5), and Martin Hoelzle (1)

(1) Department of Geoscience, University of Fribourg, Fribourg, Switzerland (martina.barandun@unifr.ch),
(2) State Key Laboratory of Desert and Oasis Ecology, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi, China
(3) Meteodat GmbH, Zurich, Switzerland
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(5) Central Asian Institute of Applied Geosciences (CAIAG), Bishkek, Kyrgyzstan
(6) Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK, USA

Abstract
Direct mass balance observations are sparse and discontinuous in the Kyrgyz Tien Shan and Pamir Mountains. After the break-down of the Soviet Union, glacier monitoring was suspended for over a decade in Kyrgyzstan. In recent years, different projects (e.g. CATCOS, CAWa, CHARIS) aim at the re-establishment of a modern glacier monitoring network. In-situ measurements have been (re)-analysed and data gaps have been filled for Baytish Sook (Suyok Zapadniy), Glacier No. 354, Golubin and Abramov Glacier for the last decade.

In-situ measurements, however, are laborious and limited to a small sample of glaciers. According to the multi-level strategy for glacier monitoring, we aim at establishing a novel approach to combine local to regional glacier mass change observations. A recently elaborated methodology to derive sub-seasonal glacier mass balance based on remote snowline monitoring is applied to the above mentioned Kyrgyz glaciers for the period 2003 to 2015. The approach is based on the information content of short-term changes in snowline elevation detected on repeated remote sensing imagery (here: Landsat satellite images / oblique camera images), and has the potential to be applied on a large number of glaciers located in inaccessible areas.
A routine to automatically identify transient snowlines is employed on the orthorectified, projected camera images and compared to manually mapped snowline positions. Overexposure, fresh snowfall and cloud cover are critical. However, after a pre-selection of good-quality images the agreement is satisfying. Snowline position over the glacier areas are delineated with a semi-automatic procedure on Landsat scenes.
First results of the remotely derived glacier-wide mass balance show that a series of at least three successive sequences without fresh snow is necessary to reach reasonable results. The acquisition frequency and quality of the images is thus highly relevant. Preliminary results are promising for years with good data availability and agree well with mass balance series based on direct measurements and modelling.

Braun, Ludwig (V)

Half a century of direct glacier mass balances of Vernagtferner, Eastern Alps: how can they be interpreted?

Ludwig Braun and Christoph Mayer, Commission for Geodesy and Glaciology, Bavarian Academy of Sciences, Munich

Abstract

The monitoring of the seasonal and annual glacier mass balances of Vernagtferner, Austria, started in 1964 by the Commission of Glaciology, Bavarian Academy of Sciences. Detailed and continuous climate- and runoff measurements complement this mass balance series since 1974. The first photogrammetric survey was done by Sebastian Finsterwalder in 1889, which was followed by frequent topographic surveys, adding up to more than ten digital elevation models of the glacier until today. The 50 years of glacier mass balance and 40 years of water balance in the drainage basin are therefore embedded in a considerably longer period of glacier evolution, allowing an interpretation within an extended frame of climatology and ice dynamics. The direct mass balance observations cover not only the period of alpine-wide strong glacier mass loss since the beginning of the 1990s. The data also contain the glacier advances around 1900 and between 1970 and 1990. The combination of the observed surface mass exchange and the determined periodic volumetric changes allows a detailed analysis of the dynamic reaction of the glacier over the period of a century.

Buri, Pascal (V)

3D-modelling of ice cliff evolution on a debris-covered glacier, Nepalese Himalayas

Pascal Buri[1], Evan S. Miles[2], Jakob F. Steiner[1], Francesca Pellicciotti[1,3]

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[2]Scott Polar Research Institute, University of Cambridge, Cambridge, UK
[3]Department of Geography, Northumbria University, Newcastle upon Tyne, UK

Abstract
Supraglacial ice cliffs are typical features of debris-covered glaciers, and affect surface evolution, glacier downwasting and mass balance by providing a direct ice-atmosphere interface where melt rates can be very high. As a result, they might account for a significant amount of the total glacier mass loss, in contrast to ice covered by a continuous debris-layer, but their contribution has rarely been quantified through physically-based models.
We use a grid-based energy-balance model of 3D-cliff backwasting that includes changes in the geometry of the cliff due to progressive melt, effects of adjacent supraglacial ponds and the re-covering by surrounding debris.
We use the model to study the evolution of four cliffs over one melt season on Lirung Glacier, Nepal. Observations of changes in cliff geometry and volume, based on high resolution aerial and terrestrial photogrammetry, indicate a variety of processes, with some cliffs remaining constant, some growing and some shrinking substantially.
Model results suggest that melt due to energy fluxes at the cliff surface controls changes in the central and top sections of cliffs, and expansion of the upper portions in particular, but cannot explain the evolution of the lower and marginal sections. These are due to the subaqueous melt of the cliff portions in contact with a pond, which tends to maintain steep lower faces. Marginal parts that reach lower slope angles or tend to cut into adjacent debris ramps are covered again in debris. When cliffs become decoupled from lakes because of drainage, they tend to shrink substantially. This work sheds light on mechanisms of cliffs changes by quantifying them for the first time with a dynamic, physically-based model and a novel ground control dataset.

Compostella, Chiara (P)

Ice to water: the Forni glacier under investigation

C. Compostella (1), G. P. Verza (1), A. Senese (1), D. Bocchiola (2), C. Franzini (3), V. Mauro (3) and G. Diolaiuti (1)

1) University of Milano, Earth Science Department, via Mangiagalli 34, Milano, Italy
2) Politecnico of Milano, Milano, Italy
3) Stelvio National Park, Bormio (Sondrio, Italy).

Abstract
The Forni Glacier, in the Stelvio National Park (Ortles-Cevedale group, Central Italian Alps, 46° 23’ N 10° 35’ E), is the largest Italian valley glacier featuring three accumulation basins confluent into a single valley tongue. The glacier have been studied for several decades and, in the last few years, it has been equipped with two Automatic Weather Station, with additional specific sensors for energy exchange between atmosphere and soil and precise snow accumulation measurement. In 2005, the first permanent supraglacial Automatic Weather Station (AWS) of the Italian Alps was installed at the glacier tongue surface. The AWS was already included in the international meteorological network SHARE (Stations at High Altitude for Research on the Environment) and in the CEOP network (Coordinated Energy and Water Cycle Observation Project), the latter promoted by WCRP (World

Climate Research Program) within the framework of the GEWEX project (Global Energy and Water Cycle Experiment). Now it is also included into the CryoNet network (managed and promoted by World Meteorological Organization – WMO) as the unique Italian surface measurement station. Data recorded are the 7 standard WMO climatic parameters plus detailed albedo evaluation using a complex radiometer with short and long wave channel. More recently, in 2014, a second station was added to perform accurate snow deposition measurements, according to the SPICE (Solid Precipitation Intercomparison Experiment) international program, managed and promoted by WMO. Data are acquired continuously and recorded every 10 minutes by data loggers. Both weather stations are equipped with radio modem, allowing the daily remote data download by telemetry. The station stands have been specially developed to hold properly the sensors on ice and snow surface, they are steady, but not fixed on the glacier, allowing fast repositioning by hand for small shift or by helicopter if needed.
Moreover in 2009, Idrostelvio, a scientific survey program, has started. Idrostelvio is aimed at investigating the runoff of a selection of streams (mainly fed by snow and ice melt) within the Stelvio National Park. During the last five years, we installed 11 hydro-stations, equipped with data loggers and hydrometric sensors, powered by solar panels. Specifically, we installed 10 pressure sensors, while 1 ultrasonic sensor was placed above the outlet stream of the Forni glacier.
All these instruments make the Stelvio National Park the most monitored park of the Italian Alps. Using the data coming from these stations (both weather and hydrometric stations), we can model the energy balance of the Forni glacier, the derived melt amount, the water budget at basin scale and, finally, the water availability within the Park.

Covi, Federico (V)

Assessing potential reasons for different accumulation patterns on Mount Kenya and Kilimanjaro

Federico Covi, Alexander Gohm, and Georg Kaser

Institute of Atmospheric and Cryospheric Sciences, University of Innsbruck, Austria

Abstract
Accumulation patterns and glacier behavior differ considerably on Mount Kilimanjaro and Mount Kenya in tropical East Africa. The present study aims to investigate the most relevant driving mechanism of precipitation over the two neighboring mountains. The potential of atmospheric modeling in understanding atmosphere-glacier interactions will also be addressed.

Diolaiuti, Guglielmina Adele (V)

Present extent and Features of the italian glaciers: Results from the New Italian Glacier Inventory

Guglielmina Adele Diolaiuti[(1)], Roberto Sergio Azzoni[(1)] Carlo d'Agata[(1)], Davide Maragno[(1)], Davide Fugazza[(1)] and Claudio Smiraglia [(1)]

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Abstract
A glacier inventory is a fundamental tool for describing and managing the Alpine glacierized environment and evaluating the impacts of the ongoing climate change. After the 1959-1962 Italian glacier inventory published by the Italian Glaciological Committee (CGI) in cooperation with the National Research Council (CNR), only regional glacier lists have been developed in Italy, thus giving partial pictures of the evolution of the Italian glaciers. In this work, we summarized the main results

from the New Italian Glacier Inventory, a national glacier atlas recently completed and based on the analysis of high resolution color orthophotos which were acquired in the time frame 2005-2011. The choice to use as main source of data orthophotos acquired in a quite wide time window (2005-2011), is supported by the need of analyzing images affected by the smallest possible snow coverage: the orthophotos which covered the whole Italian territory in 2006 can cause large error due to the heavy snow coverage affecting many important glaciarized areas of the Italian Alps. In the New Italian Glacier Inventory 903 glaciers are described, covering a total area of 369.90 km2 ± 2%. The largest part of the glacier coverage is located in the Aosta Valley Autonomous Region (36.15 % of the total), followed by the Lombardy Region (23.71 %) and the Autonomous Province of Bolzano (23.01 %). The highest number of glaciers was found in Lombardy (230), then in the Autonomous Province of Bolzano (212), in the Aosta Valley Autonomous Region (192), and in the Autonomous Province of Trento (115). About 84 % of the census is composed by glaciers minor than 0.5 km2 covering only the 21% of the total area. Glaciers wider than 1 km^2 are 9.4 % of the whole number, but they cover 67.8 % of the total area. In the widest size class (>10 km^2), only three glaciers are found. Only 25 glaciers (2.8 % of the census) were classified as “valley glacier”, while the largest part (57.3%) was classified as “mountain glacier” and “glacieret” (40%), thus underlining that the Italian glaciers are spread into several small ice bodies with few larger glaciers. A first comparison between the total area reported in the New Italian Glacier Inventory and the value reported in the CGI –CNR Inventory (1959-1962) suggests an overall reduction of the glacier coverage of about 30% (from 526.88 km^2 in the Sixties to 369.90 km^2 in the present time). A second comparison was performed with the WGI (World Glacier Inventory) dataset which in the Eighties listed 1381 Italian glaciers covering a total area of 608.56 km^2. This comparison suggests a loss of 478 glaciers and an area reduction of 238.66 km^2 (-39 %).

Egli, Pascal (V)

A dynamic Energy Balance Model to compute supra glacial debris thickness using thermal satellite images on a glacier in Langtang valley, Nepal Himalaya

Pascal E. Egli[1], Francesca Pellicciotti[1,2], Álvaro Ayala[1], Pascal Buri[1]

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[2]Department of Geography, Northumbria University, Newcastle upon Tyne, UK

Abstract
A significant proportion of Himalayan glaciers is debris covered. Knowing the thickness of the debris cover is essential to obtain accurate estimates of melt rates. Due to the remoteness of these glaciers, collecting field measurements of debris thickness for a large number of glaciers is not realistic.
For this reason, previous studies have proposed an approach based on computing the energy balance at the debris surface using surface temperature from satellite imagery together with meteorological data and solving for debris thickness. These studies differ only in the way they account for the nonlinearity of debris temperature profiles and the heat stored in the debris layer.
In our study we aim to 1) assess the performance of three existing models, and 2) develop a new methodology for calculating the conductive heat flux within the debris, which accounts for the history of debris temperature profiles by solving the advection-diffusion equation of heat numerically. Additionally, we found that in the previous studies several input variables are considered as uniform and we improved this by using distributed representations.
As a study case we use Lirung glacier in Langtang valley, Nepal, and we work with Landsat satellite thermal images. Results are validated using measurements of debris thickness on the glacier from October 2012 and 2015.
In some cases the existing models yield realistic results. But there is very little consistency between results for different satellite images. In general, computed debris thickness is frequently too thin

compared to reality. Two of the existing models were able to accurately reproduce the extent of thin debris cover on the upper part of Lirung glacier. The mean debris thickness on Lirung obtained with the three existing models lies between 0.1 m and 0.3 m depending on the model used, whereby the upper value of 0.3 m corresponds best to the field measurements.
Preliminary results from our new model show a larger spatial variability of debris thickness on the glacier as compared to existing models. Mean debris thickness on Lirung glacier computed with the new model is 0.4 m and is therefore closer to the field measurements than with the existing models. All models are most sensitive to effective thermal conductivity, shortwave radiation and albedo. We conclude that there is a large potential for improvement in debris thickness modeling.

Eisen, Olaf (V)

Accumulation rates from central North Greenland during the past 700yr

Nanna B. Karlsson, Olaf Eisen, Lisbeth T. Nielsen, Sepp Kipfstuhl, Johannes Freitag, Anna Winter, Dorthe Dahl-Jensen
CIC, AWI

Abstract
A key variable when interpreting the evolution and mass loss from polar ice sheets is the input from the surface mass balance. While ice core records contain information on past accumulation rates, they always only provide information for a single location. Here, we present spatially distributed accumulation rates from central northern Greenland, specifically the area between the NEEM (North Greenland Eemian Drilling) and NGRIP (North Greenland Ice Core Project) ice core drill sites. The accumulation rates have been reconstructed using ice-penetrating radar, firn core measurements and inverse methods, and we are able to retrieve both spatial and temporal changes in the accumulation over an area spanning 300km by 300km. We investigate the stability of the accumulation pattern over the past several hundred years, and we address the question of how well the measured accumulation rates at the ice core sites capture the regional variations in accumulation. We find that while the accumulation rates at NEEM have been stable for the past 700 years, the NGRIP site has experienced fluctuations in accumulation rate. We interpret this as an indication of shifts in the dominating weather pattern or the ice divide in central North Greenland.

Feiger, Nadine (P)

Two new bedrock topographies for Gries- and Findelenglacier

Nadine Feiger1, Leo Sold2, Silvan Leinss3, Andreas Bauder4, and Daniel Farinotti5

1 Department of Environmental System Science, ETH Zurich, Zurich, Switzerland
2 Department of Geosciences, University of Fribourg, Fribourg, Switzerland
3 Institute of Environmental Engineering, ETH Zurich, Zurich, Switzerland
4 Laboratory of Hydraulics, Hydrology and Glaciology (VAW), ETH Zurich, Zurich, Switzerland
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Abstract
Knowledge of the ice thickness distribution of glacier is important for glaciological and hydrological applications. In this contribution, we present two new bedrock topographies and ice thickness

distributions for Gries- and Findelenglacier, Switzerland. The results are based on Ground Penetrating Radar (GPR) collected in spring 2015 and already existing data. The GPR data are analysed using ReflexW software and interpolated by using the ITEM model. ITEM calculates the thickness distribution by using principles of ice flow dynamics and characteristics of the glacier surface. The uncertainties deriving from both, signal interpretation and data interpolation, were quantified in a series of analyses. The results show a total glacier volume of 0.283 km3 and 0.987 km3 for Gries- and Findelengletscher, respectively; with corresponding average ice thicknesses of 56.3 m and 55.4 m.

Fischer, Andrea (P)

Institute of Interdisciplinary Mountain Research of the Austrian Academy of Sciences, Innsbruck, Austria

The glacier survey of the Austrian Alpine Club: 125 years of citizen science

Abstract

The glacier survey of the Austrian Alpine Club started to operate in 1891 after the publication of a call to participate in glacier length measurements in the Eastern Alps. During the next decades, a number of scientific investigations and expeditions were sponsored by the Alpine Club. The results were published in the journal of the club, but also in scientific book series (Wissenschaftliche Ergänzungshefte). Today, the annual length measurements on about 100 Austrian glaciers are still carried out by about 20 observers and their teams. These data illustrate the amount and pacing of the post LIA glacier retreat and the glacier advances of 1920s and 1980s. The rapid retreat and disintegration of glacier tongues is not only impressive, but also a challenge for the continuation of the surveys.

Fischer, Andrea (V)

A decade of research on snow farming in glacier ski resorts: Any ice left?

Andrea Fischer, Martin Stocker-Waldhuber, Bernd Seiser, Kay Helfricht

Abstract
In 2004, the first research project investigated the effects of glacier covers, densification and accumulation on four Tyrolean glacier ski resorts (Stubaier Gletscher, Sölden, Pitztaler Gletscher and Kaunertaler Gletscher). More than one decade of extreme glacier melt later, the decadal effect of the effort on glacier elevation change was investigated. Initially, less than 10% of the ski resort area and less than one per mille of the total glacier area in Austria were covered. Recently, snow production on glacier gained more importance. Investigations of surface mass balance and energy balance of covered glaciers showed a melt reduction of about 70%. Together with snow farming, locally positive mass balances were the result of glacier covers. Surveys in 2015 revisited the test sites of the early projects (2004-2009). Despite glacier dynamics, glacier surfaces with snow management show reduced decrease of surface elevation , both on piste and along lift tracks.

Fürst, Johannes (P)

Modelling present glacier dynamics on Svalbard - from inferring surface velocities to computing a flow-consistent bedrock map

Johannes J. Fürst[1] & Matthias H. Braun[1]

Institute of Geography, University of Erlangen-Nuremberg, Erlangen, Germany

Global surface temperatures have risen by ~0.7°C over the previous century. Due to an inherent amplification of climatic changes in high latitudes, warming has been more expressed in Polar Regions. One eminent consequence is the general retreat of Svalbard glaciers observed throughout the last century. In the last decades, southern Svalbard glaciers have even moved on to thin at dramatically increasing rates. This latest thinning trend is however not confirmed throughout the Arctic. The reason relies in the unique climatic conditions on Svalbard. Since warm ocean currents in the North Atlantic reach the southern tip of the archipelago, the climate is rather warm and variable for its latitudinal band. Evolution of Svalbard glaciers has therefore often been suggested to play a precursor role for the other Arctic regions. Within the Arctic, Svalbard is unique in another respect, as glacier extents and elevation changes are well characterised over several decades. However, the interpretation of these geometric changes in terms of the climatic evolution is inhibited, as they arise from both the climatic surface mass balance and from ice flow divergence. The latter depends on glacier geometry and dynamics, and is not necessarily directly controlled by changes in climatological parameters. Yet, observations on glacier thicknesses and velocities are sparse and temporally incoherent, which impedes to this day a reliable quantification of the dynamic control on Svalbard glacier changes. By extension, we have only a vague idea on how much volume is annually discharged by iceberg calving at the marine ice fronts. Ice discharge presumably explains a large portion in the total mass budget, as more than half of the ice-covered area drains through marine-terminated glaciers.

The aim of the research proposal is to expand the knowledge on the ice dynamic component of glacier evolution to the entire Svalbard archipelago. To this end, surface velocities are inferred from satellite remote sensing, which, in turn, serve to reconstruct the bedrock topography beneath all ice-covered areas. The reconstruction makes use of the mass conservation principle, provides therefore a flow-consistent thickness map and is already implemented in our ice flow model. Information on both ice velocities and ice thickness are a prerequisite to quantify the ice flow divergence that explains a, to this day, largely unknown portion of glacier changes. The reconstruction will therefore make it possible to better interpret recent geometric changes in the light of the observed atmospheric warming in the Arctic. Moreover, previous extrapolations for archipelago-wide estimates of ice volume and discharge can be improved on a physical basis. As the bedrock reconstruction is consistent with the observed ice flow, the map will facilitate the application of ice flow models on Svalbard. With our flow model, we aim at inferring the contribution of basal sliding to present glacier flow.

Fugazza, Davide (V)

Areal and volumetric variations of the Lex Blanche Glacier (Mont Blanc massif, Italy) from historical cartography and remote sensing sources

Davide Fugazza[1], Luca Benazzi [1], Carlo d'Agata[1], Roberto Azzoni[1], Claudio Smiraglia[1], Guglielmina Diolaiuti[1]
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Abstract
The Lex Blanche Glacier is a medium-sized ice body located on the Italian side of the Mont Blanc Massif. In this study, we used historical cartography from the Italian Military Geographic Institute (IGM), regional maps from Aosta Valley Autonomous Region (RAVA) , aerial orthophotos and satellite data from the SPOT 5 mission to determine the glacier terminus position, map the glacier boundaries and quantify its areal and volumetric variations in the timeframe 1882-2015.
Although historical maps can be of limited use to study changes in glacier volume in view of their scale, our analysis indicates that they offer precious information to describe frontal and area variations over several years, especially when combined with traditional measurements of terminus position. To analyze volumetric variations, we used regional maps to generate Digital Elevation Models (DEMs). We carried out a detailed accuracy assessment to identify the possible error sources in the original maps, and discuss how they affect our estimations.
Based on the combination of our data sources, the glacier seems to have undergone distinct advancing and retreating phases since the end of the Little Ice Age, with the latest advancing phase culminating in 1986. Since then, the glacier terminus has retreated by over 400 m and the eastern tongue has detached from the main glacier body. Between 1882 and 2009, we estimated an area loss of 28%.
We further investigated the relationship between the glacier evolution and climate fluctuations, by analyzing temperature and precipitation records from the Courmayeur meteorological station between 1933 and 1991 and the stations installed in Val Veny after 2002. This allowed us to identify different climate phases driving glacier changes.

Funk, Martin (V)

Monitoring glacier instabilities in the ice covered Weissmies northwest face

Martin Funk[1], Lukas E. Preiswerk[1], Fabian Walter[1] and Lorenz Meier[2]

[1]VAW
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Abstract
A large part of the glacierized northwest face of Weissmies mountain in the Saas valley (Switzerland) recently became unstable. The likely reasons for this new development are a climate-induced glacier thinning of the supporting Triftgletscher and a progressive warming from freezing to melting conditions at the ice-bed interface. Consequently, in summer 2014 a part of the glacierized face with 800,000 m^3 of ice switched to an "active phase" with high surface flow velocities. Such an active phase increases the likelihood of a major icefall.
In this case, an ice/snow avalanche may threaten the population and infrastructure of the Saas valley. A monitoring campaign was initiated to detect warning signals of dangerous break-off events to allow a timely evacuation of endangered areas. Interferometric and Doppler radar, seismic and acoustic sensors, optical imaging as well as GPS receivers were installed to provide real time

continuous surface displacement and ice fracture development data. A critical increase in surface velocities is a clear sign of an impending icefall. The rupture time can thus be predicted based on surface velocity data.
The surface velocities on the unstable part decreased from ~20 cm/d in October 2014 to 5 cm/d in February 2015. During July 2015, they decreased even more to 3 cm/d. This deceleration in the very hot July 2015 was completely unexpected, because meltwater at the ice/bed interface typically reduces basal resistance, promoting basal motion and the onset of instability. The likely reason for the unexpected low ice flow in July 2015 is a channelization of subglacial meltwater flow making the drainage system more efficient and thereby limiting basal motion.
Since the start of the monitoring program in October 2014, no large-scale velocity increase was observed. Nevertheless, several small-scale icefalls (a few thousand m^3 of ice) did take place. Some of them were recognized in advance based on the local surface velocity increase. In some cases, small events occurred without precursory acceleration. It is not yet completely clear why no warning signals could be recognized prior to these events.

Gerlach, Christian (V)

Gravimetric observations at Svartisen, Norway

Christian Gerlach(1,2), Siri Eikerol(2), Vegard Ophaug(2), Alexander Helland(2), Miriam Jackson(3), Björn Ragnvald Pettersen(2), Jon Glenn Gjevestad(2), Torsten Spohnholz(1)

(1) KEG, Bavarian Academy of Sciences and Humanities
(2) Norwegian University of Life and Environmental Sciences (NMBU)
(3) Norwegian Water and Energy Directorate (NVE)

Abstract
Absolute gravimetry is sensitive to various geophysical phenomena affecting either station height (like uplift or subsidence) or nearby mass variations (like changes in ground water table or melting of nearby glaciers). Absolute gravimeters of highest precision may be able to resolve gravity changes caused by melting of a 10cm thick ice layer. However, these instruments are not usable in the field, as they require stable temperature conditions at room temperature and must be place on solid ground. The subglacial lab at Svartisen, Norway, allows to place an absolute gravimeter right below the glacier masses. In 2014 first subglacial gravity values were observed in cooperation of the KEG, NVE and NMBU. Science case as well as conducted and planned field work are discussed.

Gleisberg, Eva (V)

Calculation of the annual water balance components for the Vernagtferner basin using a conceptual runoff model

Eva Gleisberg(2) , Braun, Ludwig(1) and Markus Weber

1 Commission for Geodesy and Glaciology, Bavarian Academy of Sciences, Munich
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Annual values of winter, summer and annual glacier mass balance have been measured at Vernagtferner, Ötztal Alps, Austria, for the period 1964/65 to 2014/15, and the results can be interpreted in the light of geodetically-obtained mass balances over more than 160 years and

hydrological measurements over 40 years. The application of a conceptual hydrological model between 1850 and 2011 shows that runoff from Vernagtferner in the time span 30 years after the end of the Little Ice Age was almost as high as today, and that the onset of the hydrological measurements in the fall of 1973 marked an absolute minimum in discharge due to positive mass balance years in the sixties and seventies. The rather cyclic behavior of glacier mass balance and runoff ended in the 1980s to give way to a consistent trend towards more and more negative mass balances and ever-increasing runoff. Due to the strong shrinkage of Vernagtferner the runoff values will diminish in the future.

Groos, Alexander (V)

Investigating mass balance processes for glaciers in the Karakoram based on enhanced degree day modelling

Alexander Groos1, Christoph Mayer2, Claudio Smiraglia3, Guglielmina Diolaiuti3

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2Commission for Geodesy and Glaciology, Bavarian Academy of Sciences and Humanities
3Dipartimento di Scienze della Terra A. Desio, University of Milan, Italy

Abstract
In contrast to many alpine glaciers across the Himalaya no extensive mass loss has been observed in the Karakoram during previous decades. The varying response of Karakoram glaciers to recentclimate change is supposed to be predominantly controlled by the presence of supraglacial debris, reduced summer temperatures and the influence of winter precipitation attributed to prevailing westerly cyclones. A new and enhanced degree-day model approach, which consists of basic statistical and more complex physical components, is presented in this study. The aim of the model is to analyse the sensitivity of accumulation and ablation processes in the Karakoram regarding present and future changes of various atmospheric and glaciological variables. To account for the impact of debris cover on glacial melt information on the debris thickness distribution were derived from Landsat thermal images applying a simple energy balance model and empirical relationships. Downscaled atmospheric data from the High Asia Refined analysis (HAR) were used as input for the model. Daily mean values of the Urdukas AWS (4,200 m a.s.l.) on the Baltoro glacier served for the validation. Despite considerable uncertainties in the amount and variability of accumulation a first estimation of annual snow accumulation and glacial ablation for the whole Karakoram was undertaken. The modelled outputs are in agreement with in-situ measurements from the Baltoro glacier in 2011 and 2013. Finally, transitional snow line altitudes were derived from the daily MODIS snow cover product to evaluate the spatio-temporal variability of the model outputs.

Hanzer, Florian (P)

Regional-scale model simulations of glacier snow cover and snow line altitude vs. satellite observations: uncertainty assessment in the Ötztal Alps (Austria)

Florian Hanzer1,2, Philipp Rastner3, Ulrich Strasser1, Rudolf Sailer1

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3 Department of Geography, University of Zurich, Switzerland

The cryosphere of mountain regions is rapidly changing in response to climate change. This is particularly evident in global-scale glacier retreat. Trends in snow cover, however, are more difficult to determine, as annual fluctuations can be very large. Snow is an important parameter in the energy and mass balance of glaciers. Satellite-based snow cover (SC) and SLA observations allow region-wide monitoring of glaciers and can be used for improved parameterization and validation of energy and mass balance models, which are frequently applied e.g. for climate change impact studies.
We present an automated tool to derive the SLA for large glacier samples from remote sensing data, using multi-temporal Landsat imagery (1972-2015), digital glacier outlines and a high-resolution DEM as input data. The derived SC maps and SLA values are used for the validation of the fully distributed, physically based hydroclimatological model AMUNDSEN which is applied to simulate the energy and mass balance of snow and ice surfaces in the highly glacierized region of the Ötztal Alps (Austria). While using both interpolated station recordings (taking into account the complex topography of the study site) as well as downscaled gridded fields from the nowcasting and analysis system INCA as meteorological input, model performance is evaluated over multiannual to multidecadal periods. First results indicate a generally good agreement between observed and simulated SLA, with a tendency of the model towards a slight underestimation of SLA. Our findings underline the potential of the presented SLA detection method for regional-scale glaciohydrological investigations.

Hartl, Lea (Poster)

Can a simple numerical model help to fine-tune the analysis of ground penetrating radar data? - Hochebenkar rock glacier as a case study

Lea Hartl, Andrea Fischer, Christoph Klug, Lindsey Nicholson

IGF - Institut für Interdisziplinäre Gebirgsforschung, Österreichische Akademie der Wissenschaften, Innsbruck

Abstract
Little is known about the thickness of active Alpine rock glaciers, yet they are important components of the local hydrology. We use GPR data to determine the depth of the bedrock of Äußeres Hochebenkar rock glacier (Austria). There is no detailed information available regarding density and composition of the rock glacier and assumptions about the signal propagation velocity have to be made when processing the GPR data. We use a simple creep model based on surface displacement and slope to calculate the thickness of the rock glacier along a flow line. We calculated bedrock profiles along the flow line for three different time periods, using input from multi-temporal digital elevation models. We improved the fit of the profiles by calibrating the values used for layer densities and considered the model valid where the modelled bedrock profiles are within error of each other. We then compared the modelled values with the GPR data to check whether our assumptions for the propagation velocity produced results that match the model. While the fit is good at the lower end of the rock glacier, the GPR data appear to overestimate depth in the upper

region. We adjusted the propagation velocity accordingly and find maximum thicknesses of over 50 m and a mean thickness of 30-40 m. The insights gained from the modelling approach thereby improved the fine-tuning of the GPR analysis.

Heilig, Achim (V)

The temporal firn line evolution for glaciers in the Rofental, based on C- and X-band remote sensing SAR data

Achim Heilig, Anna Wendleder, Andreas Schmitt and Christoph Mayer

Abstract
Remote sensing synthetic aperture radar (SAR) data can be used to differentiate between dry and wet snow zones. A wet snow snowpack strongly reduces the backscattered energy in comparison to dry snow or snow free conditions. We used this information to distinguish between dry snow, bare ice and wet snow areas on glaciers and thereby assessed the temporal evolution of the firn line for four different high Alpine glaciers within the Rofental in the Austrian Alps. The results were validated by time-lapse camera photography, data on the equilibrium line altitude (ELA) and LANDSAT 8 optical remote sensing data (if available). Radarsat (C-Band), Sentinel 1 (C-Band) and TerraSAR-X (X-Band) SAR data acquired during the glaciological years 2013/14 and 2014/15 could be used for this study. The two years were largely different in terms of mass balance values for all four glaciers. For the less negative mass balance year (2013/14), both, C- and X-band SAR data map the firn- and snowpack reduction during the summer months accurately. Results are insensitive to incidence angle, polarization, descending or ascending acquisition and acquisition time. However, for the strongly "negative" year (2014/15) with very strong ablation, the ice surface is covered with numerous supra-glacial meltwater streams and previous years' firn layers are affected by melt. Such conditions impede the monitoring of the temporal firn line evolution. Here, we gathered best agreement with validation data for cross-polarized, descending – early morning acquisitions for both C- and X-band SAR. In addition, date of SAR data acquisition is crucial to observe minimum accumulation area ratio during the mass balance year. Without information on precipitation and temperature during the ablation period, SAR data can easily be misinterpreted. Simple thresholding is impossible to distinguish between new snow, firn and winter accumulation.

Kappenberger, Giovanni (V)

The exceptional ice avalanche of Langtang Lirung released by the earthquake of April 25, 2015

Giovanni Kappenberger, CH-6654 Cavigliano, Switzerland

Abstract
The Gorka earthquake of April 25 2015 was the cause of a large number of events, such as rockfalls, landslides and avalanches in central Nepal and especially in the Langtang Valley. The most catastrophic desaster resulted from a huge and complex ice avalance, originating partly at the 7234 m high Langtang Lirung. This avalanche covered Langtang Village, leaving nearly 200 victims.
By comparing repeat-pictures and own observations of ice-cliffs in the Nepal Himalaya since 1978 until October 2015, it follows that an ice mass accumulated above about 6000 m during the recent decades. The ice-layers from monsoon precipitation became thicker after 1995, indicating an intensification of summer accumulation. At lower altitudes instead, the ice mass loss –as in the rest of the world- is increasing, due to climate warming and the total ice-mass balance is clearly negativ.

For the Langtang ice avalance it follows that, if an earth quake of similar magnitude than that of april 25 would have happened 20 years before, the release of total mass of ice would have been less. The consequences, including the widespread destruction would probably have been considerably smaller.

Kaser, Georg (V)

How do glaciers turn weather into a climate signal?

Georg Kaser, Prof. at the Institute of Atmospheric and Cryospheric Sciences, University of Innsbruck

No abstract available

Krbcova, Klara (P)

Microtextural differences of glaciofluvial quartz grain from saalian and würm glaciation

Klara Krbcova, Department of Physical Geography and Geoecology, Faculty of Science, Charles University in Prague, Prague, Czech Republic

Abstract
Weathering and diagenesis causes on quartz grains various microtextures, which reflect the age, diagenetic history and environmental condition. This paper deals with main microtextural, which distinguish saalian glaciofluvial quartz grains from Moravian Gate and würm glaciofluvial squartz grain from High Tatras.
Six samples (300 quartz grains) from three sand-quarries in Moravian Gate and six samples (300 quartz grains) from glaciofluvial outcrop in High Tatras were studied under electron microscope and results were statistically analysed with F-test to define the main microtextures which distinguish the samples from two glacial stages.
Saalian samples from Moravian Gate were characterized by rounded shape, low relief, straight steps, V-shaped pits, dish-shaped pits, straight grooves, adhering particles and solution features. Würm samples from High Tatras were characterized by sub-rounded shape, medium relief, straight grooves, fracture features, parallel grooves, edge abrasion, meandering ridges, adhering particles and solution features. On quartz grains, which were reshaped by older saalian glaciation, occur less glacial microtextures, whichare overlaid with microtextures of subsequent transport. On surfaces of würm quartz grains sampled from outcrops in High Tatras occur the relicts of glacial action. Based on the statistical analysis, quartz grains from saalian and würm stage are significantly distinguished by sub-angular and rounded shape, parallel grooves, edge abrasion, V-shaped and dish-shaped pits, grinding features and irregular chemical relief.
The study was funded by the Grant Agency of Charles University (GAUK 1314214).

Lambrecht, Astrid (P)

Accumulation distribution in the upper Fedchenko Glacier, Pamir

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2Institute for Environmental Physics, University of Heidelberg, Heidelberg

Abstract
Fedchenko Glacier in the Central Pamir, Tajikistan is one of the largest mountain glaciers of the world, covering a total length of 72 km. Despite the global trend of strong glacier recession, the area of Fedchenko Glaicer remained almost constant during the last 90 years. The glacier tongue, however, shows a considerable reduction of ice thickness of several tens of meters, while the situation in the accumulation area is not clear. Some observations from remote sensing data indicate a slight increase in surface elevation, but due to the unknown penetration depth of the microwave data, no clear conclusion could be drawn.
A new and extensive study of the accumulation conditions in the uppermost basin of the Fedchenko Glacier aims on revealing the spatial and the temporal distribution of accumulation in the feeding zone of this large glacier. Based on shallow ground penetrating radar investigations and firn core data, the accumulation history can be reconstructed for the last 15 years at least on a bi-annual basis. The spatial distribution reveals a strong gradient from the western basin margin towards the center. The investigations further show that melt conditions frequently occur in the basin up to 5200 m elevation and sometimes even higher.

Landmann, Johannes (P)

Obstacles on the way to a consistent global glaciological database

Johannes Landmann, Fabien Maussion
Institute of Atmospheric and Cryospheric Sciences, Innsbruck

The recent development of open access glaciological databases (glacier outlines, mass-balance, thickness...) allows important advances in the field of global scale glaciology. However, employing data from different sources can be challenging as the various datasets have different histories and standards. In the case of glacier inventories, for example, glacier coordinates might be outdated or have rounding errors and linking the databases becomes impossible without expert knowledge. In our work we implement a semi-automated tool to link the Randolph Glacier Inventory (RGI 5.0), the World Glacier Monitoring Service Fluctuation of Glaciers dataset (WGMS FoG 2014), Glacier Thickness Dataset (GlaThiDa 2014) and glacier length fluctuations compiled by P. Leclercq. The tool (developed in Python) and our results are made freely available

Lindner, Fabian (P)

Monitoring of Outburst Floods using Seismology

Fabian Lindner, Fabian Walter and Lukas Preiswerk
Laboratory of Hydraulics, Hydrology and Glaciology, ETH Zürich
In past years Glacier de la Plaine Morte, a plateau glacier in the Bernese Alps, showed hazardous potential due to the rapid drainage of Lac Des Faverges, an ice-dammed lake. Even though the glacier is located within the drainage basin of the Rhine River, parts of the meltwater can reach the

Rhone Valley through a carstic system. In addition to this complex drainage system, the lake volume is expected to increase in the future. This emphasizes the need for monitoring and investigation of the outburst floods. For this purpose, we use seismology, which in recent years has provided unprecedented insights into various glaciological processes. With respect to subglacial hydraulics, recent studies demonstrate that seismic signals can serve as a proxy for water flow through or under glaciers.
This summer we aim to investigate subglacial hydrualics of Glacier de la Plaine Morte by deploying an array of borehole seismometers close to Lac Des Faverges. Additional stations are available for a dense instrumentation at the glaciers surface. With this setup, we propose to (1) understand the initiation mechanism of the outburst flood, (2) track water through the drainage system, and (3) monitor time-dependent changes in the englacial and subglacial conduits. Furthermore, in an experimental setup, we propose to monitor material changes of the ice - such as crevasse opening or filling of existing crevasses with water - by means of seismic interferometry. For this innovative approach, Glacier de la Plaine Morte will serve as a testing laboratory. However, the method is potentially applicable to various scenarios in glaciology, e.g. to monitoring of unstable glaciers.

Magnússon, Magnús (V)

The IGS at a Crossroad: the transition to Gold Open Access

Magnús Már Magnússon,
International Glaciological Society, Scott Polar Research Institute, Cambridge, United Kingdom

Abstract
With the introduction of the requirement for scientific papers to be published as Open Access by funding agencies the IGS was put in a difficult predicament. As a 'not for profit' organisation and a registered charity we have in the past relied heavily on institutional and library subscriptions to subsidise several of our activities.
So as we moved towards full open access we have had to gradually change our 'business' model, a process we started a few years ago in anticipation of this becoming a reality. Luckily, we have been fairly successful at that and are in a reasonable financial standing.
And the time has come. As of the beginning of 2016 the Journal of Glaciology and the Annals of Glaciology have been published fully Gold Open Access. Authors will be expected to pay the compulsory 'Article Processing Charges' or APCs as they are commonly known and our scope for waivers will be reduced. We have now joined in partnership with Cambridge University Press to publish the Journal of Glaciology and the Annals of Glaciology.
In this brief presentation I will go over the status and the implications for our authors and what further changes we can expect.

Marke, Thomas (P)

Past and potential future changes in the Austrian snow cover

Marke, T.1), Hanzer, F. 1,2) und Strasser, U. 1,2)

1) Institute of Geography, University of Innsbruck, Austria
2) alpS, Innsbruck, Austria

Abstract
Snow depth and snow cover duration in the Alps are both characterized by a high spatial and temporal (interannual to decadal) variability, indicating a high sensitivity to climatic conditions. Knowledge of this natural variability and changes in snow conditions is essential for science and stakeholders not only to understand past and present snow conditions, but also for the interpretation of future snow scenarios. While instrumental time series of the relevant meteorological and snow cover variables are an important requisite for climate studies, generally only few long-term climate and snow observation time series are available, and their spatial representativity is mostly limited. Numerical models represent valuable tools to improve the spatial density of snow information as well as to assess potential changes in the snow cover induced by changing climatic conditions by means scenario simulations. The present study shows past changes in the Austrian snow cover derived from daily snow cover simulations with the hydroclimatological model AMUNDSEN on a 1x1 km2 grid for the period 1948–2009. Prior to the analysis of changes in the snow cover, the model is thoroughly validated using homogenized snow observations (point scale) as well as remotely sensed snow cover patterns. The results for past changes in snow conditions are supplemeted by potential future snow cover changes up to the year 2050 as derived from snow simulations forced by different realizations of the IPCC A1B scenario.

McCarthy, Mike (P)

Using ground-penetrating radar to study debris-covered glaciers in the Himalaya

Mike McCarthy,
Scott Polar Research Institute, British Antarctic Survey, Cambridge, UK

Abstract
The ablation areas of many glaciers in the Himalaya are mantled by extensive supraglacial debris. Supraglacial debris modulates energy transfer from the debris surface to sub-debris ice, affecting glacier evolution, melt rates, runoff, and mass balance, and facilitates the development of glacial features such as moraine-dammed lakes. We explore how ground-penetrating radar can be used to image the subsurface, and improve our understanding, of debris-covered glaciers in the Himalaya.

Nwachukwu, Henry (V)

Mass loss and mass distribution of alpine glaciers using terrestrial gravimetry

Henry Nwachukwu
University of Bremen

Abstract
Observation of mass balance of mountain glaciers is traditionally derived from glaciological or geodetic approaches. These methods measure changes of volume and transform them into mass

change using a density assumption. Alternatively gravimetric observations are directly sensitive to mass change. However, terrestrial gravimetry is not a standard tool in glaciology and requires a lot of field work. Besides its ability to track temporal mass changes, the method can also be applied for studies on glacier thickness, thus complementing radar or seismic campaigns. In recent years, several gravity campaigns have been run on Vernagtferner. Here we try to discuss the feasibility, advantages and disadvantages of the gravity method for observing mass balance and thickness of mountain glaciers.

Paul, Frank (V)

Glacier mapping with Sentinel 2 MSI & Landsat 8 OLI: Exciting perspectives and new challenges

Frank Paul

Department of Geography, University of Zurich, Switzerland

Abstract
The recently launched Sentinel 2 satellite with its sensor Multi Spectral Imager (MSI) offers unprecedented possibilities for automated and much more precise glacier mapping at global scales than ever before. With its 10 m spatial resolution in the VNIR bands (20 m in SWIR) and the large swath width of 290 km it will theoretically be possible to map all glaciers in a country such as Switzerland or Austria on one day. The higher repeat frequency (5 days with Sentinel 2a and b) also offers better chances for a cloud free acquisition in a comparably short end-of-summer time-window. As the spectral ranges of the VNIR and SWIR bands of MSI and the Operational Land Imager (OLI) on Landsat 8 are very similar, glaciers (clean ice and snow) can be mapped automatically with previously applied methods such as the TM3/5 (OLI4/6, MSI 4/11) band ratio.
In this study a Sentinel 2 precursor dataset (from the commissioning phase) acquired on August 29, 2015 over the Swiss Alps is used to map glaciers with the band ratio method mentioned above and compared to outlines derived from a Landsat 8 OLI scene of the same region acquired only 2 days later (on 31.8. 2015). Additional to the classic red/SWIR band ratio, the 15 m resolution panchromatic band of OLI instead of the 30 m red band is used to map glaciers at a two-times higher spatial resolution. All ratios were derived from the raw digital numbers and threshold values were manually selected.
First results show that the red/SWIR ratio for MSI required an additional threshold in the blue band for accurate mapping of snow and ice in shadow, whereas this was not required for both OLI ratios. In general, all outlines overlap within the geometric accuracy of the orthorectification, but the outlines from the 30 m OLI red/SWIR ratio were generally outside of the 15 and 10 m outlines. This is basically a consequence of the full consideration of mixed pixels when using the 30 m bands. For the same reason narrow debris bands (medial moraine) on glaciers are classified as glacier ice with 30 m OLI bands but not with the 15/10 m bands, thus requiring in a higher workload for manual editing. On the other hand, debris-covered parts are much better visible with the 10 m resolution MSI sensor and a higher accuracy and consistency for the manual mapping can be achieved.
A special near-future challenge will be the high repetition rate of the acquisitions, which might go down to one or two days at high latitudes with all three sensors. With the manual image selection and scene-by-scene processing that is currently applied, it will be impossible to process all suitable images. Hence, new methods of automated screening / selection / processing of archived images have to be developed to utilize the full potential of the new optical sensors for glacier mapping and monitoring.

Prinz, Rainer (P)

Scale effects impeding paleoclimate reconstructions from mountain glaciers: impacts on the vertical mass balance profile

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Abstract
Lewis Glacier on Mt. Kenya lost more than 80% of its area since its last stadial in the late 19th century (L19). Can we reconstruct climate conditions sustaining Lewis Glacier in its L19 extent? First, we optimized a physical based energy and mass balance model to the modern-day glacier extent with in situ observed climate observations. Second, from this record we constructed synthetic climate scenarios (based on coupled parameter perturbation applying a simple weather generator concept) as input for the mass balance model. These scenarios reflect the observed variability in precipitation and air temperature over recent decades, reproduce the observed mass balance variability for the modern-day glacier extent, and quantify the glacier's sensitivity to climate.
Using the mass balance model as optimized for the modern-day glacier on the L19 extent, driven by climate perturbations most favourable to glaciation, results in negative mass balances. This would traditionally be interpreted to mean that even the extremes of the present-day climate are incapable of reproducing the L19 conditions.
Alternatively or additionally, the modelling suggests that the L19 Lewis Glacier could be sustained if a favourable climate perturbation is applied in conjunction with a modification of the gradients used to extrapolate the climate observations over the glacier surface from those optimized for the very small modern-day glacier. Such a modification might be justifiable, where the modern-day glacier is so small that it is unlikely to generate significant microclimatological effects that would be expected for the larger L19 extent, when e.g. the glacier filled its cirque reducing long-wave emissions from surrounding terrain drastically. For this presentation the vertical mass balance profiles will be used to demonstrate the impact of these scale effects on the microclimatology and consequently on the energy and mass balance.
In a general sense this finding indicates that extracting proxy climate conditions from a particular glacier geometry, using a modelling system optimized on a dramatically different geometry, may invalidate the approach, particularly if changes in boundary layer dynamics are substantial and not resolved in the model. This issue might warrant further investigation given that paleoclimate reconstructions based on mountain glacier fluctuations inherently involve these scale contrasts; yet they are rarely considered in the tools used.

Pritchard, Hamish (V)

Why do Asia's mountain glaciers matter?

Hamish Pritchard,
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Abstract
Water from mountain glaciers is at its most important for downstream communities during drought summers. For most large river basins in an average year the melt contribution is modest, rarely more than a few percent of monthly water inputs. Typically in a drought though, the lack of precipitation reduces the spring snowmelt, rainfall runoff and groundwater flows, but not glacial melt – the

summer peak in glacial melt takes on a greater significance. Asia's high mountain glaciers feed water into basins that range from humid to arid, monsoonal to temperate. The water stress on their populations ranges from low to extremely high, and a highly-stressed nation could be pushed into crisis by drought. I have assessed to the first order the contribution of Asia's high mountain glaciers to the Indus, Ganges, Brahmaputra, Aral, Issyk Kul, Balkhash and Tarim river basins in an average year and in the driest years on record for each basin. I find that the glacial melt fraction of total water input is two to three times greater during drought summers and for the irrigation and hydropower dams in the Indus and Aral basins, the melt fraction can peak at one third and two thirds of supply respectively. In these basins, with extensive glaciation, relatively dry summers, and extremely high water stress, glaciers therefore act as an important buffer against the worst effects of drought.

Rankl, Melanie (V)

Multi-mission satellite analysis of glaciers in High Asia

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Abstract
Snow cover and glaciers in High Asia are important freshwater resources for many downriver communities as they provide water for irrigation and hydro power. A better understanding of current glacier changes is hence an important informational baseline. Glaciers across the Himalaya have been affected by mass loss and frontal recession. However, glaciers in the Karakoram have shown stable and positive glacier mass balances during recent years as well as stable and advancing termini. The Karakoram is also known for a large number of surge-type glaciers.
Here, we present a comprehensive glacier inventory for the Karakoram Region, including multitemporal surface flow as well as geodetic glacier elevation and mass changes. Special interest was put on the monitoring of temporal changes of surge-type glaciers. Glacier surface velocities were derived from intensity offset tracking algorithms applied to time-series of SAR imagery (1992-2013). Geodetic glacier elevation and mass changes were estimated from TanDEM-X and SRTM/X-SAR Digital Elevation Models between 2000 and 2012. Based on the glacier inventory for the Karakoram, we show elevation changes and glacier mass balances for glaciers with advancing and stable termini as well as surge-type glaciers separately.
Our findings show nearly balanced elevation changes of -0.09 ± 0.12 m a-1 on average or mass budgets of -0.01 ± 0.02 Gt a-1 (using a density of 850 kg m-3) for glaciers with stable or advancing termini in the Central Karakoram. The high resolution elevation changes revealed distinct patterns of mass relocation at glacier surfaces during active surge cycles. Our measurements are independent from varying penetration depths of the radar signal or temporal decorrelation between image acquisitions.
The present multi-sensor glacier monitoring was recently extended to the broader Himalaya Range (project TanDEM-ICE funded by DLR and BMWi). An overall goal is the interferometric processing of TanDEM-X DEMs in order to estimate large-scale glacier elevation changes. Further, the appropriate geometric sensor settings for interferometric processing in high mountain areas are going to be analyzed (e.g., short vs. long across-track baselines). For the purpose of calibrating TanDEM-X DEMs, field studies including precise DGPS measurements were carried out at glaciers in the Indian Himalaya. The bistatic TanDEM-X mission is highly suitable for interferometric processing due to high spatial resolutions and only 3 sec time lag between TanDEM-X and TerraSAR-X overpasses. We want to stress the enormous potential of the TanDEM-X mission to estimate geodetic glacier mass balances, in particular when compared to elevation data sets acquired in a similar frequency and comparable observation period.

Senese, Antonella (V)

Ground thermal conditions at Punta Helbronner (italian alps) from a 2 year time series

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Abstract
In this study, the thermal conditions of steep bedrock are analyzed by means of an Automatic Station (AS rock) set up by two shallow temperature profiles (facing toward North and West, respectively, and measuring rock temperatures at 0.5, 10, 30 and 43 cm of depth). The analyzed period is two hydrological years long, from 1st October 2008 to 30th September 2010. The chosen site is a granite outcrop located at Mount Flambo (Punta Helbronner, Italy, close to the Italian-France boundary), at an altitude of 3430 m a.s.l. at the top of Giant Glacier. AS rock was installed in 2008 in collaboration with the researchers of Insubria University (BST) with the aim at contributing to the knowledge of rock weathering in high mountain areas and its environmental effects by permanent field measurements of frequency and intensity of thermal cycles at different depths and exposures, and intensity of periglacial process and permafrost degradation. The importance of the comparison between two different aspects is due to microclimate differences: in general the northern face is colder and wetter than the western one, and it can give an example of cryogenic weathering at its peak intensity; instead the west-orientated face can represent an environment where frost shattering is moderately active.
The measured temperatures within both profiles (West and North) are labeled T1-T4 with increasing depth (e.g. T1 = 0.5 cm and T4 = 43 cm), in particular T1 refers to "rock-air" interface (i.e. GST = Ground Surface Temperature). The north-facing slope was found to be slightly warmer than the west-facing one: for the 56% of the analyzed period at least one of the northern thermistors recorded higher temperatures compared to the others sensors. On the other hand, during 61% of days lower temperatures were measured by one of western thermistors. In particular, the hottest dataset was recorded by T4W (33% of the entire period) followed by T1N (28%) and the coldest one was achieved by T1W (32%). From these results, a constant trend between exposures was not found. The thermal offset was found to be equal to +0.07°C (2008/2009) and -0.13°C (2009/2010) for the northern face and to +0.43°C (2008/2009) and +0.19 (2009/2010) for the west oriented wall. Isothermal conditions (i.e. min > -0.5°C and max < +0.5°C) and zero curtain conditions (i.e. min > -0.2°C and max < +0.2°C) were not found at the top of the profiles, but these conditions occurred only at the bottom (even if very rarely). At both aspects, the frozen days (D_F, i.e. min < -0.5°C and max < +0°C) were more frequent at higher depths. Instead, thawed conditions were found to be less present than the frozen ones. Days with freeze-thaw cycles (D_{F-T}, min < -0.5°C and max > +0.5°C) were found to be more frequent at the north-facing site and in general they were absent from December to February. May was the month characterized by the highest number of D_{F-T} for the northern aspect, instead for the other slope the months with the highest occurrence were May 2009 and April 2010. However, freeze-thaw cycles did not last for the entire month in any of these cases. In addition, we took into account thermal shock: it did not occur as temperature variations per minute were found to be lower than 0.09°C min^{-1}.
To better understand rock temperature trends, in addition to the thermistors some meteorological parameters were measured by a permanent Automatic Weather Station (AWS Monte Bianco-Osram, installed in collaboration with Ev-K2-CNR and supported by OSRAM SpA) far less than 50 m from AS rock, set up on Giant Glacier surface in winter 2007 (Diolaiuti et al., 2011; Senese et al., 2012b). In fact, it has been demonstrated that ground surface temperatures (GST) mainly vary in response to the energy balance (in particular to air temperature and shortwave radiation) and the snow cover. We found a very good correlation (r = 0.95) between air temperature and ground temperatures at all

depths. For this reason, we derived ground temperatures from air temperature with a maximum RMSE value of 2.63°C (at T4N). Comparing ground surface temperature with incoming solar radiation (SWin), higher values of GST were generally recorded immediately after the maximum radiation input (i.e. noon). As expected, the rock temperature follows the radiation trend: increases/decreases of shortwave radiation are followed by increases/decreases (respectively) of GST. In particular, the northern slope was found to be warmer in the first hours of the day while during the second part of the day the other rock face featured higher temperatures. Finally, the days characterized by snowfalls are analyzed considering daily albedo values higher than 0.90. As the outcrop is very steep (slope of 50°-80°), a correlation between GST and snowfalls was not found. In fact, the fallen snow slides along the rock faces and accumulates at the base, thus not influencing the upper part of the outcrop where the thermistors are installed.

Steiner, Jakob (V)

Traces of the Gorkha earthquake in April 2015 on Langtang's glaciers

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Abstract
The 7.8M earthquake that struck the Nepalese Himalaya in April 2015 left many observable marks on the landscape. The Langtang valley, where we have been working since 2012, was heavily affected and a debris-avalanche triggered by ice- and rock-fall events that destroyed the main village of the valley gained wide media and scientific attention.
Using high-resolution satellite imagery, field observations from before and after the earthquake, and data from the sensors that survived the massive pressure wave hitting our field sites, we provide an insight into how the earthquake has affected the cryosphere of the catchment.
We observe that the ice released from hanging glaciers was primarily released from the ridges of the main mountain chains pointing to topographic amplification in these regions. This could provide a hint which regions should be given special attention when it comes to dangerous ice-fall events.
Deposits on the glacier tongues were up to 50 m in thickness and resulted in increased melt hours and days after the earthquake, as evidenced by pressure transducers and the areal extent of the terminal lake.
From imagery just after the earthquake and then in October, following the monsoon, we can observe how debris cover redevelops after being significantly altered with co-seismic mass movements.

Thibert , Emmanuel (V)

An analysis of extreme mass balance values recorded at Sarennes glacier over 7 decades

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Abstract
Seasonal components of glacier mass balance can be seen as Annual Maxima Series (AMS) that should theoretically be distributed as Generalized Extreme Values (GEV). An analysis of extreme values of winter, summer and annual balance recorded at Sarennes glacier (French Alps) is conducted

through the extreme value theory. In search of extreme deficit annual balance occurrences and, admitting in a first approach stationary conditions for climate, low accumulation and high ablation values are well modelled by Weibull and Gumbel laws, respectively. The driest observed winter in 1976 has a very high (low-probability) return period of 400 years, and recent years (2011, 2003 and 2009) displaying high ablation values, are appointed as having more than a 30-year return level of occurrence. Nevertheless, these results suppose stationary random sequences which are not supported by the time-trend of the mass balance time series due to climate change. Taking into account the time structure of the data (increased mass loss since 1982), probability distribution of extreme ablations are significantly modified, as well as the rank and return periods of the most extreme ablation years (2003 and 1949). Crossing winter and summer distributions, annual balances are also well modelled by a GEV distribution. An application to water resources is discussed.

Vezzola, Laura (P)

Assessing glacier features supporting supraglacial trees: the case study of the Miage debris-covered Glacier (Italian Alps)

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Abstract
The number of debris-covered glaciers featuring supraglacial trees is increasing worldwide, as a response of high mountain environments to climate warming. Generally, their distribution on the glacier surface is not homogeneous, thus suggesting that some glacier parameters influence germination and growth of trees.
In this study, we focused our attention on the widest Italian debris-covered glacier, the Miage Glacier (Mont Blanc massif). We analyzed the ablation area in the range from 1730 m to 2400 m a.s.l. where continuous debris coverage is present and trees are found. Using data obtained by remote sensing investigations and field surveys we defined a record of glacier parameters to be analyzed with respect to the presence and abundance of trees.
We found that supraglacial trees are present at the Miage Glacier: i) whenever exceeding a debris thickness threshold (≥19 cm); ii) with a gentle slope (≤ 10°); iii) with a low glacier surface velocity (≤ 7.0 m/y); and iv) where the vertical changes due to glacier dynamics are positive (i.e. prevalent increase due to both slow debris accumulation and preservation of ice flow inputs that we found ranging between +7 m and +28 m over 28 years). The statistical analysis supports our findings.
The analysis of the same parameters might be conducted on other debris-covered glaciers featuring supraglacial trees, in order to evaluate if such conditions are local ones or if they are general factors driving germination and growth of trees.
By identifying the features supporting the presence and growth of trees in these environments, and their thresholds, a contribution is given for a better understanding of the importance of debris-covered glaciers and, in general, of debris-covered ice, as a refuge for trees during warm intervals of the Holocene.

Vijay, Saurabh (P)

Investigating seasonal and long-term glacier changes in Alaska and Western Himalaya (India) using multi-mission satellite data

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Abstract
In this study, we investigate the seasonal changes of Columbia Glacier, Alaska during 2011-2014. Columbia Glacier is a large tidewater glacier located in the south-central Alaska. The glacier has retreated significantly (~ 21 km) since the early 1980s and split it into two branches, – main branch and west branch, after 2010. We use time-series of TanDEM-X data (2011-2014) to monitor seasonal surface velocities, mass flux and frontal change of Columbia Glacier. We find distinct dynamic behavior of the branches after the split. At the main branch, we hypothesize that the seasonal surface velocity is driven by subglacial drainage hydrology. The terminus velocity and mass flux vary by a factor of 12 during the transition of inefficient to efficient subglacial drainage system to route the surface meltwater. The west branch retreated ~4 times faster in comparison to the main branch during 2011-2014. We observe a speedup and surface lowering at the west branch in consequence to frontal retreat.
In the second part of the study, we estimate the ice elevation change of the glaciers in Himachal Pradesh, Western Himalaya (India) by differencing TanDEM-X DEM of February, 2012 and SRTM-C DEM of February, 2000. We first correct the potential bias in elevation change measurements due to different radar frequencies (C band for SRTM-C DEM, X band for TanDEM-X DEM). We also test interferometrically derived SAR coherence (X-, C- and LBand) to delineate the debris covered glaciers in the region and compare them with existing glacier inventories (RGI 5.0). Consequently, we determine the volume and mass changes of the glaciers in the region during 2000-2012. The hypsometric analysis (25 m elevation bin) of thickness change of ~800 km2 of ice covered area reveals that the elevation change rate transits from -2.0 m yr-1 (4000-4200 m) to -2.7 m yr-1 at higher elevations (4200-4800 m). This rate steadily decreases upstream (>4800 m). We expect that the presence of possibly thick debris cover at lower elevations causes reduced rate of downwasting. At higher elevations (4200-4800 m), the surface, covered with comparable thinner and patchy debris, is exposed to more solar radiation leading to an increased rate. We investigate the mass changes of few benchmark glaciers of the region and potential driving factors for such changes.

Vincent, Christian (V)

Sliding velocity fluctuations and subglacial hydrology over the last two decades on Argentière glacier, Mont Blanc area

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Abstract
The subglacial observatory beneath the Argentière glacier provides a rare opportunity to study the interactions between glacier sliding velocity and subglacial runoff. The sliding velocity has been monitored in this cavity almost continuously since 1997 and the resulting data indicate a decrease in

annual sliding velocities over the last two decades. We found close relationships between annual surface velocity, sliding velocity and ice thickness. These relationships indicate that the ice flow velocity changes do not depend on subglacial water runoff changes at the annual time scale. The seasonal magnitudes of sliding also show a decrease over the last two decades. At the seasonal time scale, sliding velocity increases before or simultaneously with the large runoff increase in May, indicating a distributed drainage system. Conversely, at the end of the melt season, sliding velocity continues to decrease after the runoff returns to low winter values. The simultaneous increases of runoff and sliding velocity occur mainly before the spring transition. Later, sliding velocity generally appears not to be related to water inputs coming from the surface, except for some large accelerations after mid-August that are always associated with periods of rapidly increasing water inputs to the subglacial drainage system.

Zolles, Tobias (V)

Uncertainty Estimation on Energy Balance Models

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Abstract

In glaciological modelling energy balance models often contain many free Parameters. Those parameters are tuned to fit observed data. As a performance measure the Root-Mean-Square-Error (RMSD) or the Mean-Absolut-Error (MAE) are commonly taken. It had been addressed by Rye et al. that there might be a need for multi objective optimization, to address the features of the model and the available calibration data [1].

In this study we use the energy balance model presented by Thomas Mölg to simulate the distributed mass balance of two alpine glaciers for a period of three summers. A global sensitivity analysis (GSA) was performed to identify the key model parameters. We than conducted a Monto-Carlo optimization for the individual summer mass balances.

In total we defined five objective functions. We try to assess the uncertainty of the individual parameters over the space of optimal solutions in respect to the different parameters, as well as inter annual differences. Through cross validation we assessed the performance of the different single best solution for each other time period.

The whole process was done on two different glaciers within the Alps to further investigate probable overfitting of the parameters to local glacier micro climate.