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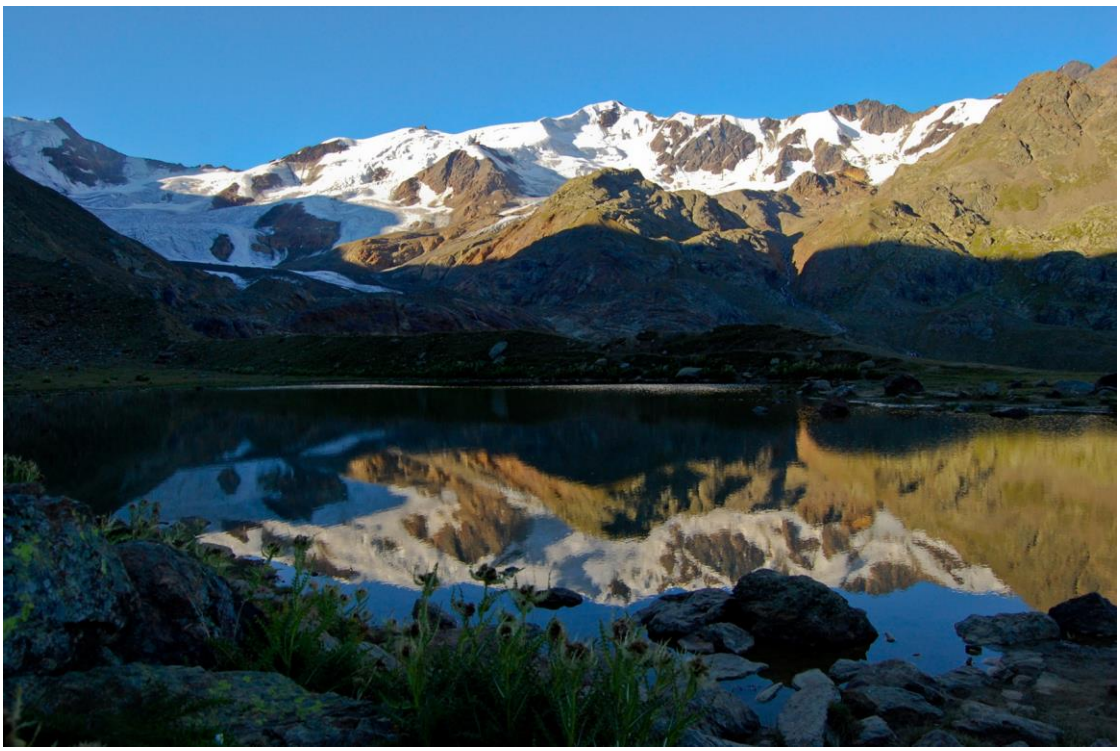
ABSTRACTS



Edited by

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Preface

We are very pleased and proud to host the 19th Alpine Glaciology Meeting in Milan. The period we chose, the first week of the Expo2015, surely makes Milan busy and a bit chaotic, but more interesting and full of opportunities to enjoy it, maybe also visiting the Expo2015 or the several side events.

The AGM has come to its 19th edition and, once again, it will give a precious opportunity for young, "enthusiastic" scientists to meet senior glaciologists in a friendly and warm environment. Here, research projects, ongoing activities and studies, preliminary or final results will be shared and discussed thus giving an actual exchange of ideas.

We are really indebted to all the people, who are working (in the past and now) to make the AGM events successful: Martin Funk (Zurich), Christian Vincent (Grenoble), Georg Kaser (Innsbruck), Ludwig Braun (Munich), and to all the others supporting the 19th AGM edition, especially my colleagues at the Dipartimento di Scienze della Terra "Ardito Desio" – Università degli Studi di Milano. Special thanks must be extended also to the Rector of the Università degli Studi di Milano, Gianluca Vago, who kindly allowed us to use this nice meeting room. Another special thank must be given to Levissima Water Company, which powered this event.

Last but not the least, I have to thank the Head of the Dipartimento di Scienze della Terra "Ardito Desio", Mauro Giudici, who supports as usual our research and projects.

We believe that the AGM in Milan will be unforgettable and we wish you a pleasant and fruitful meeting!

Claudio Smiraglia and the UniMi team

Abstracts

Contribution: Oral presentation

Seasonal dynamics of bacterial communities in cryoconite holes on the Forni Glacier (Italian Alps) and potential sources of bacteria from periglacial environments

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Ecologists currently consider glaciers as ecosystems, and the cryosphere, i.e. that part of earth where water is frozen either permanently or for long times (permafrost, glaciers and sea ice and snow), has been proposed as a biome in its own right. Ecological processes indeed occur on glaciers, particularly in cryoconite holes, which are considered the most biologically active environments on glaciers. Ecology of cryoconite holes in polar regions has been widely investigated, while that of cryoconite holes on mountain glaciers has been neglected. In this study we investigated the temporal dynamics of the microbial communities in cryoconite holes on the Forni Glacier (Italian Alps) along the ablation season and the contribution of eolian transport from periglacial environments to the microbial communities of cryoconite holes. We used Next-Generation Sequencing to assess the structure of bacterial communities, and estimated also photosynthesis and respiration rates of cryoconite holes with field measurements. We found a seasonal succession of bacterial communities, with autotrophic populations dominating communities after snow melting, and heterotrophic populations increasing in abundance later in the season. However, a net CO_2 production was observed in the large majority of cryoconite holes, thus indicating that communities at those environments are mainly heterotrophic. Surprisingly, we also observed similarity between communities at cryoconite holes within few tens of meters to one another. Conversely, none of the periglacial environments we investigated (moraines, proglacial plain, and the debris of probable endoglacial origin) hosted bacterial communities similar to those found in the cryoconite holes in any season. Hence, periglacial environments seem not to be the source of bacteria living in the cryoconite, but may provide inputs of organic matter to cryoconite necessary to sustain the heterotrophic communities of cryoconite holes even without affecting the structure of their microbial communities. We propose the following seasonal dynamics of cryoconite microbial

communities: 1) at the beginning of the ablation season, sediments, already present on glacier surface or delivered from external environments, allow the formation of cryoconite holes, 2) low organic carbon content, oligotrophic conditions and high solar radiation favor dominance of autotrophic cyanobacteria on bacterial communities, 3) with the progression of the ablation season, the increased concentration of organic matter both of endogenous and exogenous origin supports the increase of heterotrophic bacterial populations, 4) new-formed cryoconite holes are connected to older close ones by water flowing through the rotten ice so that bacterial communities follow a similar seasonal dynamics.

Contribution: Oral presentation

A coupled framework to process snow data at sub-daily time resolution and model seasonal snow mass dynamics at local scale

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In this contribution, we discuss how to limit instrumental noise in measurements of snow-related variables at sub-daily temporal resolution to use them in a parsimonious model of snow depth, density and water equivalent. When present on the ground, seasonal snow plays an important role in local hydrology, ecology and economy. In particular, it acts as a seasonal reservoir for water in the solid state, ruling runoff dynamics at the local scale, besides streamflow timing and amounts at the catchment scale. Given this important role, many efforts have been dedicated in the past to monitor the real-time presence and status of snow, and to predict the expected evolution of water storage in the form of snow. However, manual measurements of variables related with snow hydrology - such as snow depth, density and/or water equivalent - are labour and time consuming, while failures of automatic sensors in remote conditions are well known. Examples include oscillations of snow depth and SWE measurements by ultrasonic depth sensors and snow pillows due to temperature-based or wind-based effects, or rain gauges plugging and under-catch. These issues limit the reliability of measurements from remote areas, and make the use of sub-daily time-series in snow modeling very complicated. In particular, they make it difficult to define precipitation events (both liquid and solid), to reconstruct melting dynamics and to assess the beginning or the end of the snow season on the ground. To improve the use of fine-grained data-series in snow hydrology, we discuss here an automatic routine that processes hourly data of snow depth, SWE, precipitation and air temperature, and that makes them fit to force, calibrate and evaluate a parsimonious model of snow depth, density and SWE. The routine includes a mass-conservation approach to classify liquid and solid events, and a refined paradigm to reduce sub-daily oscillations in snow depth data. This last considers anomaly temperature conditions as a proxy of instrumental errors. The routine is coupled with a model to discern instrumental errors from mass inputs. In this work, we

introduce the routine, and we provide some examples of its use within western US automatic sensor network. Some additional examples of model use in Europe are also discussed.

Contribution: Oral presentation

A novel integrated method to describe fine debris over a melting glacier surface and to assess its effect on ice albedo: the case study of Forni Glacier, Italian Alps

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The characteristics of the sparse and fine debris coverage at the glacier melting surface and its relation to ice albedo were investigated. Despite the abundant literature related to dust and black carbon deposition on glacier accumulation areas, only few studies on the distribution and properties of fine debris in the ablation zone are available. Furthermore, guidelines are needed to standardize field samplings and lab analyses thus permitting comparisons among different glaciers. A novel integrated method to describe fine debris occurring at the ablation surface of debris-free glaciers and its impact on ice albedo was developed and a linear relation between the percentage of glacier area covered by fine debris and the natural logarithm of ice albedo was determined to exist. The percentage of glacier area covered by fine debris was quantified by using an innovative semi-automatic approach based on high-resolution image analysis. The robustness of this approach was analyzed through five sensitivity tests. Our procedure was tested on the surface of a wide Alpine valley glacier (the Forni Glacier, Italy), in summer 2011, 2012 and 2013. The mineral fraction was generally of local origin with high organic matter content. Nevertheless, some cenospheres were found thus suggesting an anthropic contribution. The effect of water (originating from ice melt and liquid precipitation) on albedo was also considered. Meltwater occurred mostly during the central hours of the day and a short lasting rain influence (from 1 to 4 days long).

Contribution: Poster presentation

The first complete analysis of an ice core from the eastern European Alps. Trace elements, major ions and black carbon profiles of the "Alto dell'Ortles" Glacier (3905 msl)

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Ice cores are an archive of a wide variety of climatic and environmental information from the past, retaining them for hundreds of thousands of years. Anthropogenic pollutants, trace elements, heavy metals and major ions, are preserved as well providing insights on the past atmospheric circulations and allowing evaluating the human impact on the environment. Several ice cores were drilled in glaciers at mid and low latitudes, as in the European Alps. The first ice cores drilled to bedrock in the Eastern Alps were retrieved during autumn 2011 on the *Alto dell'Ortles* glacier, the uppermost glacier of the Ortles massif (3905m, South Tirol, Italy). Despite the recent summer temperature increase this glacier still contain cold ice, being therefore a source of information about the climatic conditions over the last 400 years. This glacier is located close to densely populated and industrialized areas and can be used for reconstructing past and recent air pollution and human impact.

The innermost part of the core is under analysis by means of a new "Continuous Flow Analysis" system. This kind of analysis offers a high resolution in data profiles. The separation between the internal and the external parts of the core avoid any kind of contamination.

An aluminium melting head melts the core at about 2.5 cm min^{-1}. Water is then splitted into 4 fluxes by a manifold for the simultaneous analyses of conductivity, the dust concentration and size distribution from 63 nm to 50 μm (Abacus); trace elements with Inductive Coupled Plasma Mass Spectrometer (ICP-MS, Agilent 7500) and refractory black carbon (rBC) with the Single Particle Soot Photometer (SP2, Droplet Measurement Technologies, Boulder, Colorado). For analyses of organic and inorganic compounds a fraction of the melt water was collected by an auto sampler.

We will analyze Li, Na, Mg, Al, K, Ca, Ti, V, Mn, Fe, Ni, Cu, Zn, Rb, Ag, Cd, Sb, I, Ba, Pt, Tl, Pb and U. Trace elements concentrations in the Ortles snow were related to the emissions from the Po Valley, one of the most polluted region of Europe. Moreover during the 1st World War the Austrian army had a camp near to the top of the glacier and therefore it is likely to find some related contamination. Radioactive elements will be analyzed as well, reflecting the atmospheric nuclear weapons tests during the period covering the 50s and 70s.

rBC is one of the most important aerosol species affecting the climate system, and particularly the glaciers, by modifying the radiative energy balance. It is expected to find a significant increase of rBC concentration in the ice from the onset of the Industrial Revolution.

Contribution: Poster presentation

Grandes Jorasses Icefalls in September 2014. Monitoring and forecast

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Grandes Jorasses is an unbalanced cold hanging glacier located on the south face of the Mont Blanc Massif (Aosta Valley, IT). The glacier is subject to periodic icefalls that can entrain large volumes or trigger snow avalanches in winter. Since the valley below is a major touristic area, the glacier is monitored since 2008. Previous monitoring actions were carried out during a critical period when an important breaking-off event occurred in June 1998 and the ice avalanche reached the valley floor.

Monitoring is based on topographic measurements carried out by automatic total station located on the valley floor. Targets are installed on the ice surface, what represents a major effort due to the difficult access. The measurements are analyzed in order to detect an acceleration of the glacier or from parts of it. Based on such an accelerated ice motion, the time of breaking off can be estimated. Low-cost GNSS devices have also been developed and installed on the glacier. Moreover, 3 automatic cameras installed on the right side allow to observe morphological changes of the glacier.

A safety concept for the valley floor has been set up based on numerical avalanche simulations of different scenarios. The safety measures depend on the scenarios which take into account both ice volume and snowpack stability.Between 2012 and 2014, surface velocities didn't change much, ranging between 3 and 6 cm/d with seasonal oscillations. From mid July 2014, an acceleration was detected on 3 targets installed below the main crevasse that crosses the upper part of the glacier. A 4th target above the crevasse did not show any significant motion change. As this trend lasted for several days, an imminent breaking off event was diagnosed. By the end of August, velocity reached 10 cm/d, and a new crevasse in the upper part of the glacier was observed. Since the unstable ice volume was evaluated to be smaller than in 1998 and no snow cover was present on the slope below, no safety

measures were considered necessary for the valley. However, for climbers the situation was dangerous. An information campaign was set up through official media as well as mountain websites and social networks. By mid September velocity reached 25 cm/d and the crevasse enlarged more and more. As a safety measure for climbers, the Municipality closed the access to the "Boccalatte" hut, located on the slope below the glacier.

On September 23, after reaching 60 cm/d velocity, a first breaking-off event occurred. The ice volume was estimated by photogrammetric methods to be about 55.000 m^3. The remaining ice mass continued to accelerate and reached 120 cm/d before breaking off in the night between 28 and 29 September As forecasted, the ice avalanche stopped on the slope and did not reach the valley floor. The ice volume of this breaking off event was estimated to be 50.000 m^3 .A thorough monitoring program and an adequate communication allowed to manage this dangerous situation and to avoid damages.

Contribution: Oral presentation

A moonson-like behaviour for glaciers in Trentino (Italy)

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In occasion of the preparation of a new inventory for Trentino glaciers, all historically available data were digitized in a geographic information system (GIS) with the aim to reconstruct their evolution from the end of the Little Ice Age (LIA) up to date.

Through ground surveys, digital aerophotogrammetries, cartography studies and historical images the limits of moraines and glacial sediments, as well as those of active rock glaciers, deposited during the LIA were recorded. Through these limits the polygons of the glaciers at the maximum of the LIA (around 1850) were defined in GIS. At that time glaciers filled an area of about 110 km2 distributed in the mountain groups of Presanella, Cevedale, Brenta, Marmolada and Pale di San Martino, where many of them still remain albeit much reduced. In the early 1900s, however, some glaciers disappeared mainly because of the adverse conditions of altitude and/or orientation (for example on Rosengarten and Monzoni mountain groups).

Other digitized inventories were those dating back to 1958 (CGI, Italian Glaciological Committee), to 1987 (SAT, Mountaineering and Climbing Federation Trento), 2003 (PAT, Autonomous Province of Trento) and 2013 (PAT). The last one counts 120 glaciers with total area of about 28 km2.

The inventories of 1958 and 1987 were completed using location surveys and compilation of maps with scale 1:25 000; the other two were completed on the basis of LiDAR surveys from which the perimeters scale 1:1 000 and digital surface models (DSM) were adopted. Despite the different accuracy for the two inventory types, the total areas can be compared with sufficient reliability, assuming that measure errors cancel each other out.

The average annual losses of glacial surface (ΔSy, in %) were compared for each of the considered four time periods. We have noticed that these losses have grown exponentially.

With the three-dimensional analysis of the 2003 and 2013 inventories, the average annual reduction in

thickness (ΔHy, in mm water equivalent) was determined for the glaciers representative of the main mountain groups, and it has been observed to achieve values up to 4 000 mm.

These data, which have a strong seasonal connotation, are comparable to those of monsoon systems, almost as if they would like to witness the tropicalization of climate resulting in global warming.

Contribution: Poster presentation

Potential effects of future climate change in the water towers of Asia: the case study of the Dudh Kosi Basin, Nepal

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Rivers from the Himalayan glaciers are a lifeline for a population of billions, and yet their dynamics, water budgets, and response to global change are little studied, and poorly understood. It is expected that accelerated melting of glaciers from the water towers of Asia, in response to diffuse warming, and more erratic rainfall patterns, will provide more variable hydrological cycle, with larger floods in the melting season, and diffused droughts otherwise. However, while large literature worldwide provides conjectures of the potential state and fate of these mountains, experimental investigation and ground based know-how are lagging behind. The harsh environmental, and climatic conditions of these high mountains make field investigation logistically complex, and physically challenging, and scientists are struggling in the need for data. Here, under the umbrella of the project "Dudh Kosi Hydrology", funded by the EVK2CNR association, and carried out in cooperation with NAST, we investigated hydrology of the Dudh Kosi river catchment (450 to 8848 m asl, ca. 4000 km^2) in central Nepal, including the Khumbu glacier at Mt. Everest's toe. We used i) nivo-glaciological data from field investigations on the Khumbu, and Changri glaciers, ii) hydrological and weather data from high altitude stations of the EVK2CNR network, together with iv) ground data from DHM, and v) remote-sensing data, to provide realistic glaciological and hydrologic modeling of the Kosi basin. We modeled hydrological run-off processes with a semi-distributed hydrological model, including ice-flow dynamics. Validation against in stream discharges indicates accurate depiction of ice mass budget and ice flow, and of hydrological fluxes. Then, we used climate projections from the IPCC (until 2100) to answer the question whether future ice cover, and hydrological cycle will change significantly in the Dudh Kosi basin.

Contribution: Oral presentation

Heterogeneous mass changes of glaciers in the Karakoram 1975-2010 investigated based on remote sensing data

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Recently published results have revealed balanced budgets or slight mass gains in the Karakoram glaciers in the last decade. However, no long-term mass balance measurements exist for this region and information about irregular behaviour of glaciers in this region are based mainly on front variation measurements. Length changes show a delayed climatic signal and cannot be directly linked to climate and hydrology, particularly in regions with surge-type glaciers.

In this study, we investigate surface elevation changes and geodetic mass balances over a glacierized area of ~3600 km² in the Hunza Valley, Central Karakoram region, between ~1975 and ~2010. Digital terrain models (DTMs) were generated from two declassified stereo-pairs from the Hexagon program (~1975). In addition, we used available DTMs generated from ASTER stereo data (AST14DEM, 2008), DEM generated from SPOT and Cartosat-1 data (year ~2010) and the SRTM DTM acquired in February 2000.

Our results confirm that glacier change in Central Karakoram has a high spatial variability, and that surge activities occurred frequently in the period prior to 2000. We found probably balanced mass budgets for the 1973 – 1999 period (+0.04 ± 0.40 m w.e.$^{-1}$) and slightly positive values (+0.19 ± 0.35 m w.e. a^{-1}) thereafter. However, the differences are not significant. The largest uncertainties stem from the SRTM DEM, which is subject to penetration of the c-band radar beam into snow and ice, and from data voids and miscorrelations in the accumulation regions where low contrast due to bright snow is common on the utilised optical images.

Contribution: Poster presentation

Glacial geomorphosites and climate change: examples from the Central Italian Alps

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Glaciers have been recognized as one of the best example of geomorphosite in the high mountain environment. They are not only indicators of climate changes and archives of climatic and environmental data but also representative examples of active processes and landforms. The scientific value, and in particular the attributes of *model of geomorphological* and *paleogeomorphological evolution* may be considered the most relevant ones. Among the scientific features also the *educational value* and the *ecological value* can be meaningful and important for what concerns the global geomorphosite value The additional attributes like the cultural, socio-economic and aesthetic ones vary among the different glacial typology. The glacial landscape includes the three categories of geomorphosites, recently proposed according to the degree of landforms activity. Erosional and ancient moraines are examples of passive geomorphosites (PG), the runoff modeling characterizing the lateral moraines generate "calanchive" landforms that may be considered examples of evolving passive geomorphosites (ePG) while medial moraines well represent active geomorphosites (AG).

Examples of these three categories of sites will be outlined focusing on the Forni Valley (Valtellina, Central Italian Alps), outlining the methodology adopted in this area, to date and to quantify the rate of processes. The vegetation, in particular, demonstrated to be a useful tool to delineate the evolution of glacial landscape as a consequence of climate change, that, inducing a retreat of the Forni Glacier, allows the vegetation dynamics to track the glacier path, colonizing new areas left free from ice. Using biological and abiological indicators, to investigate and evaluate landscape changes, enhances both *ecological* and *educational values* of a complex geomorphosites as the Forni Glacier area may be defined.

Contribution: Poster presentation

A karst system in the Belvedere Glacier (VB)

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The Belvedere Glacier is a valley glacier located above Macugnaga (Piedmont, North-Western Italy). It lies at the base of the east face of Monte Rosa, the second-highest mountain of the Alps and Europe outside the Caucasus (Dufourspitze, 4,634 m). The glacier is fed by snow and ice on the east side of Monte Rosa and, particularly it collects seven minor, steep glaciers, few of them culminating above 4,500 metres. The true Belvedere Glacier, mostly covered by rocks, develops with moderate slope for almost three kilometres to its lowest point, at about 1,800 metres above sea level. Here, the Anza River forms, a 35-kilometres Alpine torrent which flows through the Valle Anzasca into the Toce River, of which it is a right tributary.

Within the Belvedere Glacier, several large underground rivers, many of which originate from the tributaries glaciers, form long ice caves, not necessarily at the ice/bedrock boundary. In the years 2009-2014, cavers from Novara and Biella explored about 20 caves, including the Tre Amici one (development 137 m, depth 69 m), the Zamboni system (development >500 m) and the Effimera (ephemeral) Cave (development > 587 m, depth 73 m). As far as we know, the latter is the largest ice cave so far explored and mapped in the Alps. These caves can be arranged into three groups:

1 *Moulins*. Few moulins has been recently discovered in the central zone of the Glacier. Only one of them has been explored, which turned out to be *ca.* 30 m deep.

2 *Subglacial caves*, that develop at the ice/bedrock boundary. They are usually quite straight, not so long, with large, squashed, gradually narrowing sections. Subglacial caves develop most often at the glacier terminus or at the junctions with minor, tributary glaciers (Fillar, Nordend, Tre Amici).

3 *Endoglacial caves.* These are active, meandering caves, often quite long, with vertically elongated sections. Many of them alternate parts completely excavated into the glacier to others developed at the ice/bedrock (or even at the ice/moraine) boundary. Sometimes, the caves walls show the marks of ancient river levels. The possibility to enter into these caves (Effimera, Locce, Zamboni) is largely a result of accidental phenomena. Their exploration is only possible with

significant water flow, possibly because the latter provides the heat to maintain accessible dimensions. Low temperatures and reduced flows shortly imply the significant reduction of the gallery section, due to the plastic behavior of the glacier ice. In the years 2002-2004 it was possible to trace the water of the Lago Effimero (ephemeral lake): the tests suggested the existence of a subglacial river flowing close to the western moraine. Currently, an important stream flows close to the oriental moraine, where it is partly accessible through the Zamboni system. Tracing tests showed that this stream is the underground emissary of the Locce Lake. Further tracing experiments on affluent streams point to the existence of one or more intermediate water reservoirs: it is even possible that the Locce cave allows the access to one of them. Short descriptions and topographic surveys are provided for the main caves, along with some discussion about their genesis.

Contribution: Oral presentation

Interaction between bacteria, rocks and pioneer plants in the recently deglaciated area of Matsch Valley, Italy

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Retreating glaciers offers a unique chance to study the role of bacterial communities in barren rock colonization processes and soil formation. Here we aimed to define the role and composition change of bacterial communities since deglaciation. We examined four transects in the moraine of the Weisskugel Glacier (2500 m a.s.l) in the Central Italian Alps at 5, 50, 150 and more than 150 years after deglaciation. Bacterial community structure and diversity analysis have been done by ARISA, pyrosequencing and MiSeq sequencing (> 20 million reads) of 16S rRNA gene and of *nifH* gene. Bioinformatic tools were used to assess the bacterial functionality (Picrust).

The estimated number of species in soils after 5 years and 50 years from deglaciation was significantly high (448±58 and 558±32 respectively). The genera prevailing in the soil after 5 years included *Ferrithrix*, *Micrococcus*, *Serratia*, and *Finegoldia*, while after 50 years *Stella*, *Kaistia*, *Luteolibacter*, and *Arenimonas*. Some of these genera were also predominant in varnish of surrounding rocks surfaces. We compared the most common floristic associations in soils of 150 and more than 150 years after deglaciation (*Cetrario Loiseleurenion, Nardion strictae, Festucetum halleri*) by total rhizobacterial DNA and RNA analysis in two different seasons. The total rhizobacterial communities were significantly different from the correspondent active communities both in structure and functionality. Within the total bacterial communities, each plot differed significantly according to the sampling season and soil age, whereas within the active bacterial communities plots clustered mainly according to the season. A marked shift in active Proteobacteria, Acidobacteria, Planctomycetes highlighted the difference between the vegetation plots, growing seasons, and soil age. Functional analysis of all the transects showed specific traits according to soil age with *Bradyrhizobium* as main bacterial genus in N-fixation.

A complex dynamical succession has been highlighted, where bacteria and floristic communities interact

together. The ultimate consequences of the interaction strongly depends to soil age, fertility and plant cover.

Contribution: Poster presentation

Glaciological and biological features of supraglacial debris on Changri-Nup and Khumbu Glaciers (Sagarmatha National Park, Nepal)

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Debris-covered glaciers (DCGs) represent an important fraction of glaciers, and their number are supposed to increase in the future due to more effective and frequent macrogelivation processes and rock degradation phenomena (linked to Climate Change). Supraglacial debris plays a fundamental role on mass budget and evolution of DCGs due its insulating properties (whenever a "critical" depth is exceeded). Furthermore, it represents an important habitat for many biological taxa, from bacteria to vascular plants and animals, which can take advantage of its peculiar microclimatic features, with important implication for high altitude biota response to climate.

Himalaya hosts an important fraction of debris-covered glaciers, which have been and still are the object of many studies. Here we present the preliminary results of a sampling expedition performed in October 2014 and aimed to collect data about ice melt rate and magnitude, abundance and characteristics of supraglacial debris and its biological features (microbiological communities and plant cover).

Two stake farms were installed on the Khumbu and Changri-Nup glaciers, consisting of 6 stakes with debris thickness of 0, 2, 5, 10, 20, 40 cm, respectively.

Ablation stakes positioned during previous expeditions were found, measured and replaced if necessary both on the debris covered and on the debris free parts of the glaciers. Samples of supraglacial debris were collected for microbiological, pH and organic matter analyses; each sample was associated with the recording of vegetation cover; plant specimens were collected and analyzed to perform an ecological characterization following the CSR model.

On Lobuche glacier, the same data were collected both on supraglacial debris and on five moraine ridges of increasing age.

Measurement of stake farms showed a very low ablation due to the cold weather conditions, but at the same time highlighted the role of debris for conditioning melting of underlying ice, particularly intense under debris 2 cm thick (thinner than the local "critical" value).

Plant cover could be observed on supraglacial debris of all the examined glaciers, even if with low cover values. A preliminary ecological characterization of the most frequent species showed a prevalent stress-tolerant strategy on undisturbed sites and a stress-tolerant ruderal one on debris and moraines, testifying an important role of physical disturbance.

Collected debris samples will be analyzed for grain size, pH, Organic matter content. Ablation data of ablation stakes and of stake farms will be associated to those collected in the previous expeditions to develop and improve the ablation models of the investigated glaciers. Microbiological analyses will be performed on debris and snow samples collected to that purpose.

Contribution: Poster presentation

Spatial and temporal variability at Talos Dome site (East-Antarctica)

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Five snow pits and five firn cores were sampled during the 2003/04 Italian Antarctic Campaign at Talos Dome (East Antarctica), and analysed in order to study the spatial and temporal variability of chemical markers and annual snow accumulation rate at Talos Dome site through an accurate dating of these records. All the samples were analyzed by two conductivity-suppressed Ion Chromatographs, for anion (F-, MSA, Cl-, NO3-, SO42-) and cation (Na+, NH4+, K+, Mg2+, Ca2+) determination.

Thanks to the marked seasonal pattern of selected paramters, it was possible to accomplish an accurate dating of the firn cores and snow pits. On the basis of this dating, the accumulation rate was calculated for each year at each sampling point, providing consistent results among the different samplings. Such an agreement is a confirmation of reliability of dating as well of the representativity of the different sampling points at Talos Dome site. In order to achieve an overview of the average chemical composition and load of particular ion species in snow layers at Talos Dome, an ion balance was calculated from the average value of each component in each stratigraphic record.

Primary (Na+, Cl-, partially SO42-) and secondary (non sea salt SO42-, MSA) marine sources are the major contributors to the chemical composition of the deposited aerosol at this site, together with nitrate/nitric acid.

All the snow pits and firn cores showed an evident acidic character. It was interesting to notice how ammonium accounted for a significant fraction of the cationic budget in the pits (23%), whereas it almost disappeared in the firn cores.

To study the distribution of concentration values in each records, percentile plots were used.

The different snow pits and cores showed a small variability of the median values regarding sea salt components (Na+, Cl- and Mg2+), Ca2+, K+, F-, NO3- and SO42-. As concerning MSA, it showed higher values in snow pits than in firn cores, very likely due to diffusion processes leading MSA to

move from the inner to the external part of ice cores. An analogous observation could be made for NH4+, which in firn cores it was almost missing, due to post-depositional losses of gas-phase ammonia.
As concerning the study of the accumulation rate variability at Talos Dome, average values were found to range between 70.3 to 85.4 mm w.e. (water equivalent) yr-1, and small differences from one point to another (e.g. 70 and 74 mm w.e. yr-1 in the N-NE part against 92 and 81 mm w.e. yr-1 in the S-SW part) of the site were found and interpreted in terms of ablation and accumulation areas
The substantial uniformity in ionic load, ion balance and accumulation rate between the different sampling points confirm the larger importance of the temporal variability rather than the spatial variability in terms of average composition and concentration of the chemical markers, supporting the reliability of Talos Dome site for paleo-environmental and paleo-climatic studies.

Contribution: Oral presentation

Bacterial diversity in an Alpine glacier summer ski resort as determined by culture-based and molecular approaches

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The glacier Madaccio, Ortles group, in National Park of Stelvio (Nationalpark Stilfser Joch) hosts in its upper part a ski area, principal operating in summer and fall seasons. Focus of the study was to analyze the microbial community and the eventual presence of pollutants in the glacier. Two areas of Madaccio glacier both at 3200m a.s.l. were considered one undisturbed and one close to ski resort active since 1930s: superficial ice core samples were collected and analyzed. The levels of pollutants detected in the area close to ski resort, up to 43 ng· L^{-1} for PCBs and up to 168 µg· L^{-1}, were higher than the pollutants level found in the undisturbed glacier. In two ice cores, Polyciclic Aromatic Hydrocarbons (PAHs) were three orders of magnitude higher than PCBs. Living bacteria ranged from $2.2 \cdot 10^3$ to $3.7 \cdot 10^4$ ufc· g^{-1}; a number or strains were also identified by sequencing of 16S rRNA. The most represented genus was *Sphingomonas* followed by *Pseudomonas, Arthrobacter, Afipia, Polaromonas, Cryobacterium* and *Janthinobacterium.* Culture independent technique, DGGE (Denaturing Gradient Gel Electrophoresis) was used to analyze the DNA of bacteria recovered from drilled ice. The most abundant phylum detected was Actinobacteria followed by Proteobacteria and Bacteroides. Firmicutes, Acidobacteria and Cyanobacteria were also identified in lower amounts. A relevant number of isolated strains were found phylogenetically related to known xenobiotic degrading species, thus supporting the possible role of polluted glacier as reservoirs of bacteria strains for bioremediation application in cold environments.

Contribution: Oral presentation

Impact of climate variability on Trentino Glaciers

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The glaciers are natural elements that characterize the environment of high altitude. These moving masses of snow and ice contribute to change the morphology of the high mountains, even leading to episodes of slope instability. Moreover, glaciers represent a key component in the local hydrological balance and represent an important drinking water resource, as significant resource for the energy, the tourism and hence the economic sphere. For all these reasons it is important to quantify the response of glaciers with reference to different climate change scenarios, as outlined in the course of this century.

The glaciers are considered good indicators of climate. The direct action of climate variability could be obtained through consideration on the annual mass balance, resulting from the difference between accumulation (winter snowfall) and ablation (water lost because of melting during the summer season at lower altitudes with respect to the equilibrium line). Changes in the mass balance lead to changes in the glacier profile or in the position of the glacier snout. However there is a delay in the resulting adaptation due to the slow response of the glacier to changes in the mass balance: the lag depends on size, morphology and exposure of the glacier.

The aim of this study is to describe the impact of climate change on the glaciers of Trentino region. By analyzing the data of the position of the glaciers snout, available since 1920, the standardized annual average of the snout fluctuation has been performed. The latter has been related to snowfall and summer precipitations, to average, minimum and maximum temperatures recorded by weather stations (distributed evenly throughout the region) of the Autonomous Province of Trento. The variables were correlated in order to grasp which parameter is more affecting variations of glaciers in Trentino, which months of the characteristic year are larger involved in and how is the delay that occur for the response of the glacier.

Contribution: Poster presentation

Evolution of the Arguerey and Breuil Glaciers since the end of the Little Ice Age (Graian Alps, Italy)

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This work aims to illustrate the evolution of the Arguerey and Breuil glaciers (La Thuile, Aosta Valley), from the end of the Little Ice Age (LIA) to the years 2000s.

Glacier extent for specific time steps (1850, 1929, 1961, 1975, 1999, 2000, 2005) has been derived from topographic maps, orthophotos, and from data collected by the Italian Glaciological Committee and by the Glariskalp Project. Acquired data were stored in a GIS, in order to allow a quantification of glaciers change over time.

At the end of the LIA the Arguerey Glacier had an areal extent of about 2.26 km^2: in 2005 this glacier appeared fragmented in two main bodies, covering a total area of about 0.44 km^2, with a reduction of 81% of the glaciated area over 150 years. At the end of the LIA the Breuil Glacier had an areal extent of about 3.39 km^2: in 2005 the glacier was subdivided in two bodies, for a total area of about 0.69 km^2, with a reduction of 80% of the glaciated area in 150 years. A detailed reconstruction of glacier change through time will be provided.

The above data will be completed with the most updated information gathered during the most recent glaciological surveys realized in the framework of the Italian Glaciological Committee activities.

The evolutionary framework of the glaciers will be completed with a climatic characterization of the area in order to know the main climate elements and the monthly or seasonal variability of these. This work, carried out in the framework of the NextData project, aims to contribute to the knowledge of recent glacier evolution in the northwestern Italian Alps, also in support of studies on the impacts of climate change on high-altitude environments and resources.

Contribution: Poster presentation

Chemical, physical and microbiological characterisation of water in an Alpine permafrost area (Istituto Mosso Lter site, NW Italian Alps)

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High altitude areas in the Alps are characterised by the permafrost environment, which reacts sensitively to climate change effects. During the last decades several studies on alpine permafrost-related hazards have been performed but few studies have focused on the geochemical content of the water that drains permafrost areas. For example, rock glaciers physically and chemically influence the water that passes through them and their discharge can be highly enriched in solutes. Unexpected high nickel and manganese concentrations exceeding the EU limits for drinking water have recently been reported in some studies investigating rock glacier discharges. The present study aims to evaluate rock glacier solute fluxes into a high altitude lake in the NW Italian Alps (Istituto Mosso LTER site, www.lteritalia.it/) in order to understand the impact of climate parameters on alpine permafrost, in particular the effects of permafrost ice melt on the water quality of mountain headwaters. This objective has been achieved through an integrated-multidisciplinary research programme involving climate analysis, rock glacier ground surface temperature investigation, water physiochemical and microbiological analyses. Nine automatic and three manned weather stations located in the surrounding areas of the rock glacier (2700 m a.s.l.; radius: 12 km) have been used to study the relationships between climatic parameters and permafrost dynamics. Moreover, meteorological data have been collected by installing portable instruments in situ, integrated in a Mini Automatic Weather Station. To investigate the correlations between physiochemical features of water and the thermal state of the rock glacier surface, the ground temperature monitoring has been conducted. Temperature dataloggers have been buried 5/10 cm into the ground, regularly distributed on the rockglacier surface and in few surrounding sites. Total Station was used to achieve position for each datalogger and differential GNSS was used to

acquire global geographic coordinates with centimetric precision in order to accurately interpolate ground temperature data grid. Water quality monitoring was conducted using a multiparameter probe. In particular, NO3-N, DOC, TOC and turbidity were analysed, and UV-visible absorbance spectra were recorded every three hours during summer and early autumn seasons. Water sampling in the rock glacier lake was conducted on weekly basis during the ice-free season; moreover, the ablation water of the Indren Glacier, 2 km far from the main study area, has been analysed in order to use it as reference data. Water samples have been analysed for anions, cations, trace elements, nutrient content, EC, Eh and pH. Finally, in order to assess microbial diversity and abundance of communities, functionally related to ecosystem nutrient dynamics, diversity and abundance of microbial communities were analysed. The fine material in the permafrost feature has been characterised through the determination of Ntot, Corg, N forms and heavy metals.

Contribution: Oral presentation

Glacial evolution in the Julian alps since the Little Ice Age (LIA) maximum

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First description of glaciers in the Julian Alps (Southeastern European Alps) dates back to 1880. Since then other geographers occasionally performed dedicated surveys, mainly concentrated in the Mt. Canin area, aiming to characterize the geometrical and altitudinal evolution of the glaciers. First surveys of the Montasio Occidentale glacier date back to 1921 while on the Triglav glacier, at present in the Slovenian side of the Julian Alps, glaciological surveys began in 1946. Overall, in the literature, seven glacial bodies are reported in the Italian side of the Julian Alps and one in the Slovenian side. Glaciers in the Alps attained their LIA maximum extents in the 14th, 17th, and 19th centuries, with most reaching their greatest LIA extent in the final 1850/1860 AD advance. Glacier reaction patterns under wetter and cooler conditions during the 19th century, compared with present climate, lead into widespread advance of valley glaciers around 1820 and in 1850. For many glaciers in the Western Alps, especially in the Italian sector, this phases represent the maximum LIA extents. In the Eastern Alps in 1820 glaciers were smaller than in 1850, with Pasterze glacier (the largest valley glacier of the Austrian eastern Alps) reaching its maximum in the 1850-60 phase. This evidence mainly referred to the largest valley glaciers in the Alps which have a higher response time if compared with small cirque glaciers. Therefore, under this circumstances, the first geographers of the Julian Alps likely saw the withdrawal phase of these glaciers soon after the advance occurred 30-40 years before. At present most of the glacial remnants of the Julian Alps are small *firn* and ice masses generally of indefinite shape, without or with poor evidence of flow structures, that develop in hollows or on protected slopes, often thanks to snow drift and avalanches. Such features belong to the categories of very small glaciers and ice patches. Here is set the first complete inventory of glacial evidence in this Alpine sector taking into account also a number of glacial bodies apparently of second order, so far disregarded. The estimated area reduction since the LIA maximum has been quantified from geomorphological evidence, LiDAR

analysis and aerial photograph observations. During the LIA maximum the total area covered by permanent ice bodies was equal to 2.22 km^2, while at present (2012) it has been set in 0.29 km^2. The largest shrinkage concerns the Canin and the Triglav glaciers. Using thickness and density assumptions, the volume and the mass changes has also been estimated, as well as the Equilibrium Line Altitude of the Canin glacier during the LIA maximum.

Contribution: Poster presentation

Glacio-hydrological modeling of the debris-covered Belvedere Glacier (VB), Italy

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It is presented here a preliminary approach to glacio-hydrological modeling of the Belvedere glacier, in the Monte Rosa group of the North-Eastern Italian Alps. The debris covered Belvedere glacier (9 km^2) is of large interest due to its potential for GLOFs, ad seen *e.g.* during 1999-2004, with formation of a large pro-glacial lake, subsequently drained. We use debris cover maps, weather data from an AWS station upon the glacier, ice melt data from an ablation stake network, meteorological data from a number of weather stations nearby, and snow cover maps from LANDSAT TM, to set up locally a degree day model for snow melt, and to originally tune the DEB-model, to mimic buried ice ablation under variable debris thickness. We then set up the *Poly-Hydro*, including flow routing into snow, ice, and ground reservoirs, for mimicking hydrological budget of the glacier, and surrounding area. Validation is carried out against hydrological data from downstream the Belvedere glacier. The model provides acceptable results, and will be used henceforth for testing sensitivity of the glacier under future climate change.

Contribution: Poster presentation

Hydrology of the Rio Maipo of Chile under future climate change

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Under the umbrella of the scientific collaboration project named "*Plan de Acciòn para la conservacion de glaciares ante el cambio climatico*", we present the assessment of potential climate change impacts upon the hydrologic regime of the snow and ice melt driven Maipo river basin, in the Santiago metropolitan region. In the central Andes, glaciers play the role of *water towers*, providing a large amount of melt water during the warm dry season, essential for populations downstream, for drinking, agriculture and hydropower production. In the last few decades, in response to global warming most of the glaciers have been retreating and loosing mass, and the permanent snow-line is considerably rising, with likely large consequences on the hydrological regime. Long term water resource availability of Rio Maipo under potential climate change is studied here. First, a hydrological model is tailored for the catchment that is able to explicitly include snow and ice melt, and simplified glaciers' dynamics to depict hydrological regime of this area. Both ground measured, and remote sensing data are used to feed the model, including in situ measured data, precipitation data from the Tropical Rainfall Measuring Mission (TRMM), and snow cover and temperature from the Moderate Resolution Imaging Spectroradiometer (MODIS). The climate-driven hydrological model is calibrated and validated via discharges measurements, and later forced by temperatures and precipitations change projections from ECHAM6 GCM, according to 3 different radiative forcing trajectories adopted by the IPCC for its AR5. The results show potential significant changes in the hydrological regime, with lower flows during melting season, in addition to prospectively reduced ice and snow covered areas.

Contribution: Poster presentation

The glaciers of the Dolomites in the last years

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Mountain glaciers are sensible indicators of climate change, reacting particularly to changes in summer temperatures and winter precipitation. Glaciers and glacierets in the Dolomites (Italian Eastern Alps), due to their limited extension, show very fast reactions to ongoing climatic changes.
In the past, ARPAV (Environmental Agency of Veneto Region) collected historical data about the area and the front variation of the Dolomites glaciers from the end of the 19th century to the present day. Since 1999, ARPAV carried out several glaciological survey campaigns, using orthophotos and other pictures, in order to create a detailed inventory of the glaciers with all their recent variations. In 2004 a GPS and GEORADAR survey was carried out over a few glaciers (Marmolada, Antelao Superiore and Fradusta), in order to create a digital terrain model (DTM) both of the surface and the bedrock, and to extract the glacial masses.
In September 2009 and 2014 (in the framework of the 3PClim Project), 75 Dolomites glaciers or glacierets were surveyed using airborne Lidar: the survey determined the surface and volume variation of all the glaciers and the mass balance of Fradusta, Antelao Superiore and Marmolada.

The inventory of Dolomites glaciers has been updated. The general retreat of the glacier slowed down in the last five years; taking into account the most important 27 glaciers in the Dolomites, the glaciered area increased in the last 5 years from 4.70 km^2 to 5.00 km^2 (Marmolada increased of 0.1 km^2), mainly due to the last snowy winters. The front variation reveals a slower retreat in some glaciers in 2013, while the Fradusta Glacier shows an advance (CGI dataset).
Volume and mass balance data are currently under analysis; while in the 2004/2009 period all glaciers lost consistent ice masses, in the last five years the mass loss appears to be weaker.

Contribution: Oral presentation

A hybrid system to support glacier monitoring activities on Italian Alps

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For over 100 years, the major glaciers in Italian Alps have been systematically monitored by a varied network of scientists, academics, volunteers and amateurs. Their efforts have produced one of the longest and most valuable collections of glaciological observations worldwide.

The format of the field observations and the instrumentation used by the operators have changed widely over the century and this evolution is still in progress. A great geographic variability of traditions and practices adds further heterogeneity to the collections, making extremely onerous both retrieving and consulting all the documents.

In this scenario some crucial requirements must be addressed:

- to preserve the existent collections and ensure that they will go on;
- to normalize and merge them, even enriching them with the scattered resources currently unused;
- to promote updated and optimized procedures for enhancing the collection of new observations;
- to make the information available for access and analysis.

These requirements are very hard to be addressed since they require funding, expertise and a unique reference framework.

Recent advancements in information technology let foresee scenarios in which mobile devices and sensors will easy the recording of field measurements, while web processes and applications will facilitate the automatic storage and display of data, while web standards and practices will supply interoperability and common data models. User friendly interfaces and interactive tools could then help amateurs to compile, map and handle additional glaciological information. Besides, the Citizen Science (CS) approach, which is living a flourish phase in the Earth Sciences realm, can help in involving new

volunteers in the monitoring activities and in better managing the informative content of their contributions, also known as Volunteered Geographic Information (VGI).

In the present work a system to properly collect and manage the most varied informative contents 19th on a multipurpose web platform is described. It gets its methodological design from the geo-web technological framework and from the CS/VGI approach. While addressing some main constrains that are affecting the Italian glacier monitoring, the proposed system supports spatial and temporal interpretation, and facilitate the collaboration among the different users. Moreover, the compliance to standard profiles and spatial web service guarantees for the effective sharing, re-use and maintenance of the collections over time.

This web platform facilitates both the management and the access to measurements, geographical data, images, textual documents, comments and communications. It allows web users to perform searches among data and metadata, to combine the data layers in customized views, to compile and submit new informative contributions. It also serve the coordinators as an administrative console, and help them in performing their supervision tasks.

Contribution: Poster presentation

Soil properties and soil-vegetation relationships in patterned groud on different parent material (NW Italian Alps)

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Cryogenic patterned ground represents an impressive characteristic of high latitude/altitude periglacial landscapes. On the Alps, large sorted/nonsorted patterned ground features generally occupy stable, exposed surfaces at high altitudes and represent a particularly harsh habitat for plants. Patterned grounds cover various morphological forms as decametric to metric polygons, stone circles or mud boils, frost mounds or hummocks, ground stripes on slopes. These landforms are strictly related with seasonal frost activity, with or without permafrost, and frost-susceptibility (microtopography, texture, water content, thermal conductivity) which could be influenced by the parent material characteristics. We analyzed soils across transects through typical active patterned ground features (sorted or nonsorted stone circle or stripe) on four common lithotypes (calcschists, serpentinite, gabbros and gneiss) in the Western Italian Alps, in order to investigate the small-scale lateral and depth variability in physico-chemical properties, and their association with cryoturbation, plant cover and species distribution. In these areas, climate conditions contribute to create a strong soil cryoturbation, leading to the formation of well-developed patterned ground features, sorted or nonsorted, based on the parent material liability to physical frost shattering and chemical weathering. These patterned ground features are characterized by strong edaphic gradients over small distances. In particular, low organic carbon, exchangeable bases and nutrients, and potentially toxic heavy metals are measured in the bare central sections, and higher concentration of the same substances are found on the more stable, better vegetated rims. Microbial populations as well as plant species and communities, show a clear concentric distribution, well correlated to soil C:N ratio, influenced by lithology of parent material and coherent with trends of soil physicochemical parameters.

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Contribution: Poster presentation

The Forni Glacier (Italy) and the SPICE project (WMO)

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At the Forni Glacier ablation tongue an AWS has been running from autumn 2005 thus providing meteorological and energy data and snow depth information. Forni Glacier is the largest Italian valley glacier (c. 11.36 km^2 of surface area in the Ortles-Cevedale group, Stelvio National Park, Central Italian Alps). Forni Glacier is included in the official "Geosites Inventory" of the Sondrio Province, Lombardy Region (Italy) and is located in areas identified as SICs (Sites of Community Importance) according to the 92/43/CEE. Moreover, it is inserted in the list of the glaciers monitored by the Italian Glaciological Committee (CGI) to evaluate its recent volume, area and length changes. The AWS here located (named AWS1 Forni) was installed on the lower sector of the glacier, at 800 m from the glacier terminus. The AWS1 Forni is already included in the international meteorological network SHARE (Stations at High Altitude for Research on the Environment) managed by the Ev-K2-CNR and in the former CEOP network (Coordinated Energy and Water Cycle Observation Project), promoted by the WCRP (World Climate Research Programme) within the framework of the online GEWEX project (Global Energy and Water Cycle Experiment). The long sequence of snow data also permitted the insertion of the AWS1 Forni into the SPICE (Solid Precipitation Intercomparison Experiment) project managed and promoted by the WMO (World Meteorological Organization). For this experiment, another station (named AWS Forni SPICE) was installed on 6th May 2014. The Forni Glacier is the unique Italian site inserted into the SPICE project and from 2015 also into the CryoNet program, this latter is one of the four components of the WIGOS (WMO Integrated Global Observing System).

The overall WMO-SPICE objective are: i) to recommend appropriate automated field reference system(s) for the unattended measurement of solid precipitation in a range of cold climates and seasons, and to provide guidance on the performance of modern automated systems for measuring total precipitation amount in cold climates for all seasons, especially when the precipitation is solid, snowfall (height of new fallen snow), and snow depth; ii) to investigate the measurement of precipitation amount

over various time periods (minutes, hours, days, season), as a function of precipitation phase (liquid, solid, mixed), and snow on the ground (snow depth); and iii) to prepare recommendations to WMO Members, WMO programs, manufacturers and the scientific community, on the ability to accurately measure solid precipitation, on the use of automatic instruments, and the improvements possible.

As field working reference systems for measuring snow on the ground, the Forni SPICE Components include: i) manual snow pits; ii) 4 graduated stakes at the corners of the automated snow depth sensor (a snow pillow); iii) hourly camera observations of the four graduated; and iv) Enel-Valtecne snow weighing. The instruments under test are: i) Campbell sonic ranger SR-50 (active since autumn 2005); ii) Sommer sonic ranger USH-8; iii) Park Mechanical snow pillow SS-6048 with a STS pressure transmitter ATM.1ST. Finally, the ancillary measurements (active since autumn 2005) are: i) precipitation occurrence/type; ii) station pressure; iii) air temperature; iv) relative humidity; v) wind speed/direction; and v) net radiation (SW and LW fluxes).

Contribution: Poster presentation

Water stable isotopes from Ortles ice cores compared to instrumental temperatures

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During autumn 2011 four ice cores were retrieved from the top part of the Alto dell'Ortles Glacier, at 3859 m a.s.l.; it was the first deep drilling of a cold glacier in the Eastern Alps. The Alto dell'Ortles mass balance in the upper part still largely positive, although the glacier appears to be currently transitioning from a cold to a temperate state due to increasing summer temperatures. Below the firn-ice transition, chemical and physical signals appeared to be well-preserved, and even the temperate firn portion seems to retain most of the seasonal oscillations. An automatic weather station (AWS) was installed contemporary to the drilling procedures, while nearby weather stations have been collecting temperature data since mid 1800s. Oxygen and hydrogen stable isotopes in ice cores have been widely used to reconstruct past temperatures, but the sensitivity of the isotope thermometer shows significant geographical variations, even within the Alpine region. Post-depositional processes, such as melting and refreezing, diffusion, evaporation and condensation, may alter the original isotope content of precipitation or partially erase the lighter winter deposition (wind ablation), biasing the seasonal signal and making it more difficult to reconstruct temperature variations. Modifications in annual accumulation and snow seasonality can also threaten the climatic interpretation of the isotopic signal. Using a preliminary timescale, a composite record of isotope data from the Ortles core #1 and #2 has been created for the last century, in order to increase the signal-to-noise ratio and compare oxygen-18 and deuterium profiles to instrumental temperatures.

Contribution: Poster presentation

The study of the Swedish glaciers using the GIS platform and the remote sensing technique

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Introduction and methods

This glaciological research uses the GIS platform and the Remote Sensing Technique. In particular the software *ArcGis 9.3* or *10* and with the use of *LANDSAT images*. The satellite images has been downloaded from the website "http://glovis.usgs.gov/" and they consisted in recent images (approximately of July-September 2012, it depends of their quality) and in older images (approximately every ~5 years from 1984 onwards). The first idea was to classify them with the use of "*ice and snow index*" (NDSI) in order to recognize better the snow and ice cover from other kind of objects which could be confused with (rocks, bright soil, etc.). The result was not what we have expected and we have realized that was sufficient implement them with some ArcGis command (Pan-sharpening, Mosaic, etc.). The place of our research was the group of the Swedish glaciers located in the north-west part of Kiruna, in the Abisko's region (where we can find the most significant glaciers in Sweden) and other places nearby.

Proceeding

The work has been divided in 3 parts. The first one consisted in choosing the best LANDSAT images of the study area and to download them. Furthermore, elaborating these images with the use of ArcGis and with the use of a Remote Sensing's software, ENVI. It has to remedy the problem of the cloud cover that was present in some images. The second part consisted in analyse the results obtained from the classification and to compare it with the one elaborated from the National Board and with the past's series LANDSAT images of the glaciers in order to observe their evolution.

The last part will include the conclusions and the obtained results.

Goals

One aim of the work is to map the glaciers of interest using the already explained instrument and to compare the results with the one obtained from the National Board.

In addition to the classification will be calculated the area of the glaciers and, in a second time, their lengths and the position of their front to reach another our goal, that is to quantify exactly how much and how these glaciers changed in the last 30 – 40 years. This will not only realized through by the resulting of the data or tables but also by the comparative view of the older and gradually more recent LANDASAT images.

The last goal could be to understand how the area of the glaciers is correlated with the variations of the lengths and with the position of the front of them.

Contribution: Poster presentation

The Miage Lake – Recent evolution from historic maps and pictures

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The Miage glacier is the third largest glacier in Italy (ca. 10 km^2) and one of the largest debris-covered glacier in the Alps. It lies on the south side of Mont Blanc and flows downvalley NW-SE, turning NE on the Valley bottom. Miage Glacier fluctuations during the Neoglacial (ca. 5000 ys BP) built up a wide morainic complex. This is made of several concentric moraines and hosts intra-morainic and ice-contacts lakes. Among them, the Miage Lake, located at the right side of the glacier, is very well known as a touristic attraction because of its amazing landscape and of calving processes causing ice blocks to fall down into water.

Miage Lake is subject to drawdown events that occurred several times during the last decades. The latest occurred in September 2004 and in late August-early September 2014 respectively, and allowed to observe the morphology of the bed of the lake, which is divided into 4 small basins.

Historic documents, such as old maps and photos or postcards, are available for the Miage Lake and Glacier, starting from the half XVIII century and the end of XIX century respectively. The analysis of such documents allows to reconstruct the recent history of the lake, the drawdown events, as well as the evolution of the ice-cliff bordering the north shore of the lake itself. Here a selection of both old and recent images is presented, showing the recent evolution of the lake.

Contribution: Poster presentation

Surface snow at Dome C (Antarctic plateau): chemical composition from long-term continuous records

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Antarctica is the most pristine and remote region in the world, far from pollution sources, completely surrounded by the ocean and with negligible anthropic inputs. Aerosol particles and atmospheric gases can be trapped in the snow layers by atmospheric scavenging processes, so the interpretation of chemical stratigraphies of ice cores drilled in such remote regions allows to obtain an excellent data set for paleoclimatic and environmental information.

All year-round snow samplings were carried on for several consecutive years at the inner French - Italian station Concordia in Dome C (75˚06' S, 123˚23' E), 1200 km far away from the Indian sector of Antarctic coast, on a 3300 m a.s.l. plateau, in parallel with aerosol measurements. This sampling programme main goal was to obtain information on the main natural sources, the tropospheric transformation processes and the prevailing long-range transport pathways of the atmospheric particulate matter and to understand what depositional and post-depositional processes can affect some chemical markers once they are deposed from atmosphere on the snow surface. Dome C is the same site where EPICA (European Project for Ice Coring in Antarctica) ice core (providing about 800.000 years of paleo data) was drilled in 2004.

Sea salt Sodium ($ssNa^+$), a well snow-preserved analyte, is used as sea spray chemical marker and its inter-annual trend, together with the study of oxidized sulfur compounds SO_4^{2-} and MSA (Metansulfonic Acid), can be related to the atmospheric circulation modes affecting the oceanic areas surrounding the Antarctic continent; $ssNa^+$ in ice cores is a common proxy for sea ice extention.

Sulfate, Nitrate and Chloride are the main ionic components in Dome C snow. They show different seasonal trends: while Sulfate and Nitrate are characterized by summer maxima (especially Nitrate, with very sharp summer peaks), Chloride follows Sodium seasonal trend, with winter maximum concentration values. Despite common trends for Sodium and Chloride, their stoichiometric ratio is

not 1:1 as in NaCl, but there's a Chloride depletion due to the general acidity of Dome C snow. This fact brings to a loss of volatile acids, such as HCl, from snow layers.

Calcium (Ca^{2+}) is a typical crustal marker that provides the background level of continental contribution (mainly from South America and, to a lesser extent, from Oceania), from erosion and long range transport processes, to the Antarctic Plateau.

Contribution: Oral presentation

UAV-based high-resolution mapping of glacier features at the forni Glacier, Central Italian Alps

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Fast, reliable and accurate methods for glacier mapping are necessary for understanding their dynamics and assess their response to climate change. With the aid of remotely-sensed imagery, mapping has been carried out either via semi-automatic approaches, based on medium-resolution satellite images, or via manual delineation using aerial orthophoto. Although faster, medium-resolution based approaches can cause significant loss of accuracy when analyzing small glaciers, which are predominant in the Alps.

In this study, we present a semi-automatic segmentation approach based on very high-resolution visible RGB orthophoto acquired from a low-cost UAV (Unmanned Aerial Vehicle) survey of the Forni Glacier (Stelvio National Park, Central Italian Alps) using an off-the-shelf digital camera. The approach we applied showed the ability to map large-scale morphological features, i.e. bare ice and medial moraines, with better accuracy than methods relying on medium-resolution satellite imagery that use a combination of optical and thermal information. Slight misclassification occurs mainly at the margins of the medial moraines. By using segmentation, we also mapped small-scale morphologies not discernible on satellite images, including epiglacial lakes and snow patches, in a semi-automatic way. On a small portion of the eastern ablation tongue, featuring homogeneous illumination conditions, we investigated in higher detail the occurrence of fine and sparse debris and tested a texture filter technique for mapping crevasses, which showed promising results.

Our analyses confirm that the glacier is undergoing intense dynamic processes, including darkening of the ablation tongue and increased surface instability, and show the potential of UAVs to revolutionize glaciological studies. The main issue that we found limiting the ability to extract information from UAV surveys is the illumination geometry, and a lack of standard procedures to correct for such issue. Nevertheless, we suggest that by using a combination of different payloads (e.g. thermocamera or near

infrared sensors), mapping of glacier features via UAVs could reach high levels of accuracy and speed, making them effective tools for glacier inventories.

Contribution: Oral presentation

Spatial distribution of albedo at the Forni Glacier, Central Italian Alps, derived from Landsat satellite images

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The albedo is a fundamental component of the surface energy balance of glaciers, determining the amount of net solar radiation available for melt. However, its temporal and spatial distribution on the glacier surface is often overlooked and in melt models constant values of ice and snow albedo are assumed for the whole glacier, leading to inaccurate estimations of ice melt.

In this study, we retrieve the albedo on the surface of the Forni Glacier, Stelvio National Park, Central Italian Alps, using satellite images from the Landsat TM and ETM+ sensors at 30 m resolution, and investigate its spatial distribution and temporal evolution between 2 different years, 2011 and 2013.

The retrieval method includes correction steps for all the processes that influence the relationship between the satellite signal and the albedo: radiometric calibration, atmospheric correction using the 6S radiative transfer code, correction for local topographic effects and for the anisotropy of the reflected radiation over the hemisphere.

In spite of the uncertainties introduced by each of these steps, the modelled albedo values have a good correspondence with field measurements from the Automatic Weather Station (AWS) located on the eastern part of the ablation tongue. The albedo values for the ablation tongue are typical for debris-rich ice, confirming the ongoing darkening phenomena previously observed in literature. We expect that by extending the record of modelled albedo measurements back into the past 10 years, we will be able to better determine the extent of this darkening process and obtain more accurate estimations of ice melt.

Contribution: Poster presentation

Measuring glacier surface development based on multi-temporal TLS-data

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Glaciers respond to climate change, which influences the glacier`s behavior by causes changes in mass balances and in runoff characteristics. These changes have effects on both the natural environment and economic interests. Therefore the analysis of glacier development has particular importance in order to integrate the acquired data and the knowledge in future climate models. In this scientific study the summer glacier changes are recorded employing a terrestrial laserscanner (TLS). With this geodetic method the aim is to generate a summer balance with the following aspects:

- temporal measurement of the glacier surface
- calculation of changes in volume
- comparison of the results from the direct glaciological method with those from the geodetic method.

The main research question in which way terrestrial laserscanning is suitable for the determination of mass changes during the ablation period and to analyze pros and cons of the method. This is evaluated through comparison of TLS-geodetic measurements with glaciological measurements of mass balance. Thus we compare the surface change recorded by the TLS with surface change recorded at a number of stakes drilled in the glacier. The area of interest is the Hochjochferner in the southern Ötztal Alps.

The work is carried out as part of the "hiSNOW" project, which is a collaboration between the Institute of Geography of the University of Innsbruck , the Institute for Meteorology and Geophysic (Innsbruck) and EURAC (Bolzano). The overall aim of this research project is getting information and understanding of snow and ice melt contribution to runoff for a different defined spatial and temporal scales of modeling. The research is based on using glaciological and geodetic methods of determining mass balances and runoff from snowmelt at a range of temporal scales.

Both the detailed evaluation of the acquired data of the volume changes and the selective comparison of the height between the data of the selected stake with the according laserscanning data is currently in progress. The volume change on the basis of the TLS data is calculated exemplarily using the first

measured and the last measured data during the ablation period. For the height comparison it is important to use data which are gathered within a narrow time frame in order to get realistic comparisons.

Contribution: Poster presentation

Firn and ice thicknesses determined by radio echo sounding on two cirque glaciers in Lombardy

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Radio echo soundings using dual-frequency 200 and 600 MHz antennas were applied on Suretta glacier (0.16 km², Valle Spluga) and Lupo glacier (0.22 km², Alpi Orobie) to investigate glacier thicknesses and firn stratification. On two days in October 2014, tracks of a total length of 2.4 km (Suretta) and 3.1 km (Lupo) were recorded. The post-processing was conducted using the Reflexw software package and consisted of a dewow filtering, bandpass filters, removal of horizontal constant noise and a topography migration together with a compensation for divergence losses. The observed thicknesses along the tracks (mean horizontal resolution of 20 cm) were inter- and extrapolated to the entire glacier areas. Mean and maximum glacier thickness is 11.2 m and 38.8 m at Suretta glacier. For Lupo glacier, the corresponding values are 14.9 m and 44.2 m.

Together with trends of geodetic mass balances, which were derived from historic topographic maps, these results will help to improve predictions of the future behaviour of small glaciers on the southern flank of the Alps.

Contribution: Poster presentation

Glacier evolution of the last decades in the Nepal Himalaya, from repeat pictures and from own glaciological observations

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After 50 years, a series of repeat photographs of glaciers were made in the Khumbu region Nepal in October 2006. The early photographs were taken mainly in 1956 by glaciologist Fritz Müller who was a scientific member of the Swiss Everest Expedition. The qualitative results show that very often the main valley glaciers did not change much in length nor in shape at the front, due to a substantial coverage of debris. Considerable thinning of glaciers was found at higher elevations of the valley glaciers. This could be recognized also by the strong destabilization of the moraines due to the absence of ice back-pressure to the morainial flanks. Several small glaciers without mass gain from high elevations have disappeared. Steep small glaciers with an accumulation area reaching to high elevations have not changed much in shape. This is probably due to higher snowfall amounts at high altitudes during monsoon seasons since the early 1990s. This increase in monsoon-precipitation has also been observed analyzing firn stratigraphy on glacier cliffs, in regions more to the west: in Lang Tang (2011) and Annapurna region (2012), as well as in Garwhal (2014). This little mass gain observed above 6000m compensate only to some degree the general ice loss of the glaciers of the mentioned regions of Central Himalaya, due to climate warming with an increase in the equilibrium line altitude (ELA).

Contribution: Poster presentation

Snow precipitation measured by raingauges: systematic errors estimation and data series correction

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Precipitation measured by raingauges are usually affected by a systematic underestimation of the real water volumes that reach the ground and which can be larger in case of snowfall. The wind, disturbing the trajectory of the falling water droplets or snowflakes above the rain gauge, is the major source of error, but using tipping bucket recording gauges also the induced evaporation due to the heating device must be taken into account. In Valtellina and Vallecamonica Alps, manual measurements of fresh snow water equivalent (SWE) have been compared with melted snow measured by rain gauges with manual recording and by mechanical and electronic heated tipping-bucket recording gauges without any wind-shield: all these gauges underestimates the SWE, in a range between 15% and 66%. In some innovative monitoring sites, instead, electronic weighing storage gauges with Alter wind-shield are coupled with snow pillows data: daily SWE measurements from these instruments are in good agreement. To reconstruct historical data series of precipitation affected by systematic errors in snow precipitation measurements, we tried out a simple model that applies a correction factor as a function of air temperature as an index of precipitation phase transition. The threshold air temperature were estimated from a statistical analysis of snow fields observations. A correction based on wind speed would be less effective, due to limited availability of wind data. The correction model applied with daily resolution lead to 5-37% total annual precipitation increments, which grow with altitude above sea level and wind exposure.

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Contribution: Oral presentation

Tree-ring stable isotopes for reconstructing glacio-hydrological changes in glacier forefields: the study case of the Forni Glacier, Italian Alps

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Hydrological changes in high-mountain catchments are one of the prominent factors that will affect water availability in the European Alps and surrounding areas in the next future. The predicted increase of glacier ablation rates will cause higher water discharge into Alpine streams and rivers, however, in general, a constant declining trend in glacier stocks is foreseen for the next decades and a decline in melting waters is therefore expected.

Recent researches have demonstrated that it is possible to detect the glacier meltwater signature in the tree-ring $\delta^{18}O$, thus opening new opportunities for spatio-temporal reconstructions of environmental changes: tree-ring stable isotopes variations are strictly linked to the physiological state of the trees and therefore by analyzing the cellulose produced in a certain year it is possible to date past changes occurred in the environment where trees are growing. In particular, trees fed by glacier meltwaters (typically depleted in $\delta^{18}O$ with respect to the normal precipitation signature) produce a ^{18}O-depleted wood cellulose: the study of tree-ring stable isotopes in the context of environmental reconstructions in glacial environments is an approach that was firstly applied in a recent study at the Miage Glacier (Leonelli et al., 2014).

Based on this finding, with the aim reconstructing past glacio-hydrological changes occurred in the Forni Glacier forefield, trees along the Frodolfo glacier stream and trees in a nearby control site where they are mostly fed by precipitation, were sampled in the Forni Glacier forefield (Sondrio, Italy).

Results evidence that over the analyzed period 1980-2010 CE, $\delta^{13}C$ values at the two sites do not significantly differ. Also $\delta^{18}O$ values are similar up to 2000, but since 2001 at the glacier stream site trees always show a more depleted cellulose than at the control site, with values reaching mean values of about 32‰ vs. 34‰ at the control site. A ^{18}O-depleted cellulose of tree rings since 2001, and local minimum values in 2001 and 2009, may be interpreted as induced by higher discharges in the glacier stream as well as particularly ^{18}O-depleted glacier meltwaters.

Overall, this study confirms what already found at Miage Glacier, thus opening new challenges and possibilities of deriving glacio-hydrological information from tree-ring stable isotopes both in living and subfossil woods from proglacial areas.

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Contribution: Oral presentation

Supplementing ice core time series at a small scale Alpine glacier with a 3D full stokes ice flow model using Elmer/Ice

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The cold glacier saddle Colle Gnifetti (CG) is the unique drilling site in the European Alps offering ice core records substantially exceeding the instrumental period. In spite of an ice thickness not much exceeding 100 m, CG provides long-term ice core records due to its low net accumulation and rapid layer thinning. However, net accumulation at CG is characterised by strong spatio-temporal variability causing depositional noise and, combined with a complex flow regime, upstream-effects. These intricate glaciological settings hamper the full exploitation of the unique potential for long-term ice core records of this site. Here we present first results from developing a new model attempt, i.e. full stokes with consideration of firn rheology, specifically tailored to the complex CG settings, and utilizing the 3D finite element model Elmer/Ice in combination with existing CG ice core as well as geophysical data. A major objective is to map source trajectories of existing ice core sites in order to evaluate potential upstream effects. Since dating the CG ice cores becomes a challenge already after the last 100 years or so, an

additional focus is to assist in finding a reliable age scale, especially targeting depths where annual layers can no more be counted. This includes the calculation of isochronous surfaces for

intercomparison of different drilling sites within the CG multi core array.

A considerable amount of empirical data has been collected at CG over the last few decades, allowing the model to be established on a solid empirical base. Some of these quantities are used as model input, others for validation. Input quantities comprise density and temperature profiles measured at the ice core sites, GPS surface topography and GPR based bedrock topography. The GPR derived ice thickness comprises an uncertainty of typically 15% and thereby limits the model accuracy. Additional limitations arise from other model parameters, that are not directly constrained by measurement, for

example the mechanical stress on the glacier boundaries. To achieve better constraints, the model input quantities are iteratively adjusted to provide the best fit between model derived and directly measured quantities. Here we present first results in our latest attempt to reconstruct some of these insufficiently constrained model parameters – e.g. the bedrock topography. We also show first steps regarding the model validation based on comparison with empirical data, using for this purpose the measured surface velocities and net snow accumulation.

Finally we discuss the next steps in building our model approach, which include comparing model results with ice core derived depth-dependent information like e.g. the observed layer thinning or the measured vertical age distribution as well as to couple the mechanical model with a thermodynamical one.

Contribution: Poster presentation

Inferring snow cover duration from the measurement of soil temperature in the Alpine tundra (NW-Italy, LTER site "Istituto Mosso")

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The alpine tundra occurs across a very large range of latitudes and geological settings, and their environments are correspondingly diverse. Here the soils are perennially cold and often snow-covered and plants show a high degree of specialization in order to survive in such extreme conditions. Snow cover duration and redistribution by wind action is critical to microclimate in this environment, affecting soil temperature, soil moisture, organic matter accumulation, and fluxes of trace gases such as CO_2, N_2O and CH_4. At high altitude, the different aspect and the relief control the effect of prevailing winds on snow distribution, originating areas characterized by a different number of snow cover days. Little snow cover duration (SCD) means extremely wind-blown area, while high snow cover duration means late melting snow bank. Snow cover distribution and duration is considered critical to the development of mountain soils because of its direct effect on soil temperature, soil moisture and duration of the growing season, which in turn control nutrient availability in the alpine environment. The depth and duration of snow cover, for example, regulates soil temperature with stable values close to 0°C when the snow depth is enough to ensure thermal insulation.

Snow cover can reduce the amplitude of the daily soil surface temperature. During the snow-covered period the amplitude of daily soil surface temperature is reduced to lower than 2°C, most of the time even less than 1°C. The sharp change in the amplitude of the daily soil temperature can be used to detect the first and last day of snow on the ground and consequently the snow cover duration. Danby and Hik (2007) suggested a threshold of 1°C.

In the LTER site Istituto Mosso (Alagna Valsesia (VC)) soil temperature (5 cm depth) was measured since 2005 at elevations ranging between 2500 and 2900 m asl. A nivometeorological station,

belonging to the network managed by the Comando Truppe Alpine-Servizio Meteomont (Italian Army), allowed the snow depth measurement in correspondence to the soil temperature measured at 2901 m asl. By comparison of the snow cover duration detected by the daily soil temperature amplitude (<1°C implies the presence of snow on the ground) and the ultrasonic snow depth sensor, it resulted that about 25 cm of snow are still on the ground when the daily temperature amplitude was larger than 1°C. Normally the complete melting of the snowpack occurs the following day or in the two next days.

On the basis of the soil temperature daily amplitude, at 2901 m asl, in the time span 2005-2014, the mean SCD was equal to 264 days, with a minimum of 235 days in water year 2006-2007 (warm spring of 2007) and a maximum of 299 days in water year 2013-2014. Considering the other study plots in the LTER site, at 2840 m asl the mean SCD was equal to 260 days and at 2525 m asl was 229 days, indicating a significant increase of snow cover duration with altitude. Significant differences in soil temperature occurred between the two plots. During the snow-free season the mean soil temperature at 2525 m asl resulted 5°C (s=0.87) higher than at 2840 m asl, corresponding to a rate of 1.59°C/100 m, while during the snow covered season the soil temperature resulted equal to 0°C at both sites. The highest mean soil temperature difference between the two study sites occurred on July 2009 and 2010, with an average value of 6.8°C, and on June 2011 and 2012, with an average value of 7.3°C.

In these sites, characterized generally by a thick long-lasting snow cover (pattern 1 according to Ishikawa, 2003), through the soil temperature measurement it is possible to derive snow cover duration. This could be slightly underestimated, however, because the daily soil temperature amplitude was greater than the selected threshold (1°C) even if about 25 cm of snow are still on the ground. Even if it could be affected by this uncertainty, long-term soil surface temperature monitoring can provide a cost-effective method for detecting changes of snow cover duration, a key parameter for soil development and soil nutrient cycling in the alpine tundra.

Acknowledgments:

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Contribution: Oral presentation

The IGS at a crossroads: the transition to gold open access

M. Magnusson

IGS – International Glaciology Society

With the introduction of the requirement for scientific papers to be published as Open Access by the 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 move towards full open access we have to gradually change our 'business' model, a process we started a few years 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 will be fully open access. Authors will be expected to pay the compulsory 'Author Processing Charges' or APCs as they are commonly known and our scope for waivers will be severely reduced.

In this brief presentation I will go over the status and the implications for our authors and what further changes we can expect.

Contribution: Poster presentation

Simulation of future glacier retreat at Freya Glacier (NE Greenland)

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The mass balance of the Greenland Ice Sheet is a key-topic in climate research, because of a series of highly relevant impacts on the Earth climate and marine system (e.g. sea level, thermohaline circulation). Recent studies have shown that it is not only the mass change of the Greenland Ice Sheet itself but also that of numerous smaller marginal glaciers and ice-caps located around the Greenland Ice Sheet which is of relevance for the total mass loss from Greenland and related freshwater input to the Arctic sea.

To estimate glacier retreat and meltwater influx into the sea for Freya Glacier, a small valley glacier in NE-Greenland, the physically based snow/ice model AMUNDSEN has been extended by a pragmatic glacier flow model. The latter approach is often referred to as the Δh parameterization (Huss et al. 2010) and allows estimates of distributed ice thickness change from an empirical function (describing ice thickness change as a function of elevation) in combination with mass balance changes simulated with an energy balance snow/ice model. In the present study this model chain is forced by scenario data generated with a stochastic climate generator that rearranges weekly slices of observed meteorological conditions following a predescribed temperature trend for a considered region (here:
5.8 °C/100 years as described in the IPCC Fifth Assessment Report for the representative concentration pathway „RCP 8.5"). The presented poster shows the results for this first application of the described model chain indicating a severe decrease of ice thickness and extent of Freya Glacier up to the year 2050. The results shown here represent a first feasibility study and will be complemented by consideration of further statistically downscaled climate change scenarios in future studies.

Contribution: Oral presentation

Long term reaction of Baltoro Glacier, Pakistan

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Baltoro Glacier is one of the largest valley glaciers in the world and a prominent representative of large debris covered glaciers in the Karakoram. Observations on this glacier have a long history, dating back to the first scientific visit during an Italian expedition to the Karakoram in 1909. Since then the glacier was repeatedly visited by researchers and after 2004 a more focused investigation started. Especially two scientific questions are investigated on this glacier: i) what is the effect of extensive supra-glacial debris cover on the ablation conditions and ii) is it possible to determine the high elevation accumulation in the Karakoram? Beginning in 2004, extensive ablation observations have been carried out across the lower 35 km of Baltoro glacier in combination with investigations of ice dynamic changes. The terminus position of Baltoro Glacier has been more or less stable during the last 100 years. However, surface profiles show that the surface elevation in the ablation zone has decreased considerably during this period. Model calculations demonstrate that the debris cover in the lower parts of the glacier effectively protects the ice body and mitigates the influence of high melt rates on the glacier mass balance. Mass balance calculations, on the other hand are complicated due to a general lack of information about the accumulation conditions in the entire mountain region. A series of new measurements now allows us to fill this gap and characterise the mass input to the ablation zone.

Contribution: Oral presentation

The state of the glaciers in the Central Karakoram National Park, Northern Pakistan

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The glaciers of the Karakoram Range represent an essential source of water for the Indus River and for Pakistani people. Here we focus on the extensive area of the Central Karakoram National Park (CKNP), in the north of Pakistan. A complete, up-to-date glacier inventory of the park was performed for the years 2001 ad 2010. Glacier boundaries were drawn manually using FCC Landsat ETM+ and TM images for the years 2001 and 2010. The CKNP hosts more than 700 glaciers, covering an area of 4,600 km^2. The glacier area change occurred during 2001–2010 was then investigated. Not surprisingly, no significant change is seen, similarly to what observed in other areas of the Karakoram Range in the same period.

As most of the glaciers here are covered by debris, supraglacial debris was also mapped by means of a supervised classification. This could permit a better understanding of the ice melt processes, as supraglacial debris mitigates the melting rates, depending on its thickness. To this end, we calculated the supraglacial debris thickness from surface temperature data derived from the Landsat thermal band. Indeed, surface temperatures and debris thickness are linked by a power law, which we calibrated with field data collected on the Baltoro glacier in 2011. Knowledge of the supraglacial debris thickness will improve ice melt modeling on debris-covered glaciers in this area.

Finally, the area is known for housing surge-type glaciers. We identified eight surging events occurred in the study period. The identification was based primarily on the magnitude of the advance, but also the presence of looped moraines and by comparison with the existing literature. Distinguishing the surging events from the normal glacier advances is essential to link the climate change to glacier evolution in this area, and to shine a light on the actual processes controlling the Karakoram Anomaly.

Contribution: Poster presentation

Revision of the glacier inventory of the Afghani Hindu Kush

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The Afghani Hindu Kush hosts several glaciers, but little is known about their dynamics, and contribution to water resources of Afghani rivers. Here we used the latest Randolph Glacier Inventory (RGI, version 4.0, 1 December 2014) as the basis for updating the outlines of the glaciers within the Afghanistan borders. According to the RGI, 1229 glaciers are present in these territories. Outlines are provided, but referencing to acquisition date is specified rarely, and evolution of the glaciers cannot be investigated. Glaciers here are smaller than those in the neighbor Karakoram on average, so they are likely more vulnerable to climate change. Thus, a multi-temporal analysis on their areal changes will provide precious information on their status, as smaller glaciers respond faster to climate variation. This could only be possible if information on the date when the outlines are drawn is provided.

We therefore started an activity aimed at updating the RGI inventory in the Afghani Hindu Kush including such information. We used the most suitable and recent Landsat OLI images. Five scenes were used to cover the entire study area. The original outlines have been modified at the glaciers' snouts, and elsewhere to adjust the glacier boundaries to the present limits. High resolution images (*i.e.* Google Earth TM) were used for a final check. We also innovatively provided a debris mask for the glaciers, now lacking, and extremely important in controlling ice melt, most notably in the Hindu Kush. The mask was produced by means of a supervised classification on the pixels of the false color composite Landast images (RGB = 654). At present, 77 glacier outlines (for a total area of 734 km^2) were updated, accounting for 33% of the total ice area according to the RGI, and including all the largest glaciers (>20 km^2). The supraglacial debris covered more than half of the total surface of our sample. The present work is updating (and completing) the Afghani Hindu Kush glacier inventory, and providing information of debris cover to aid improvement of analysis, and modeling of glaciers' evolution in this area.

Contribution: Oral presentation

A GIS – minimal glacier model on the Rutor Glacier (Western Italian Alps)

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Introduction

Mountains are sentinels of climate change, for their rapid response to environmental modifications (UN A/Res/62/196). In high-altitude environments, mountain glaciers are rapidly retreating in most of the world (Nesje and Dahl, 2000).

To obtain estimates of future glacier conditions, quantitative descriptions of glacier dynamics are adopted. The more complex models provide a detailed description of glacier dynamics, but also require a larger amount of input data. In case such information is not available, as it is often the case for most mountain glaciers, it could be safer to resort to simplified descriptions that make best use of the data.

In this work, we adopt the minimal model (MGM) approach (Oerlemans, 2011), improved by an intensive use of Geographic Information System (GIS) to investigate the dynamics of the Rutor Glacier (Aosta Valley).

The Rutor glacier is one of the largest glaciers in the Italian Alps, with a surface area of 8.5km^2, and it displays a rather regular and lively dynamics. Variations in the surface area of Rutor glacier were studied from its maximum expansion in the Little Ice Age to the present, through a combination of ground surveys, digital techniques and pre-existing data time series (Villa and others, 2007).

GIS-based minimal model

The MGM are a simple but effective way of estimating glacier response to climate change. In such approach, the main state variable is glacier length, L, while the other variables such as the mean ice thickness are expressed as a function of L using a perfect plasticity assumption. The evolution of the glacier length is obtained from an integrated continuity equation driven by the mass balance.

On Rutor we calculated the volumetric mass balance by Digitial Elevation Models, we traced the glacier limit around its surface and we reconstructed its evolution with a multi-temporal analysis, drawing the flow lines that follow the accumulation-ablation dynamics, along which the model is applied. The GIS

algorithms were developed to extrapolate from DEMs all the features needed to calibrate the MGM. These parameters are useful to start the iterative process and to calibrate the results on real values. Moreover, we validated the simulated results by comparing the numerical outputs with the flow line length values from past measurements. Then, the GIS analysis of glacier flow line could increase the accuracy of MGM.

Climate drivers

The Rutor mass balance has been measured since 2004, too short for the purpose of the present work. Thus, we verified whether we can use an average mass balance record obtained by averaging over a set of glaciers in the western Alps.

After comparing the model results with the available data, we estimated the future behavior of the Rutor glacier by using climatic drivers on mass balance, provided by a set of General Circulation Model (GCMs) participating in the Climate Model Intercomparison Project 5 effort (CMIP5) (Knutti and others, 2013, Taylor and others, 2012).

Contribution: Oral presentation

The contribution of geomatics to the TEMATIC project: new potentials and challenges in glaciers monitoring

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The TEMATIC (TEsting Methods And Techniques for Investigating the Cryosphere) project has been proposed by the Research Group in Glaciology at the Department of Earth Science "A. Desio" - University of Milan (Milan, Italy) in order to contribute at the knowledge of the present state of the Alpine cryosphere, and of its possible future evolution in dependence of different scenarios of the climate change, through the development of new monitoring techniques and methodologies for the acquired data analysis.

In this frame, it is under activation a cooperation between the mentioned Research Group in Glaciology, the no-profit Association MacroMicro (Rome, Italy) and the Geodesy and Geomatics Division at the University of Rome "La Sapienza" (Rome, Italy) and the Italian Government, which manifested high interest for this research proposal.

The contribution to the TEMATIC project of the Geodesy and Geomatics Division at the University of Rome "La Sapienza" is focused to apply new techniques and data processing methodology to the glaciers monitoring, mainly focusing on their morphological evolution and volume variation and on their surface velocities.

As regard the first goal, the morphological evolution will be monitored comparing glaciers Digital Surface Models (DSMs) realized on the basis of optical and Synthetic Aperture Radar (SAR) imagery acquired at different epochs, applying new image processing techniques developed in photogrammetry/computer vision and radargrammetry, whereas the second goal will be realized through SAR imagery time series, applying standard and new image correlation strategies.

Both for the first and the second goal, imagery will concern other glaciers than Alpine ones, just for the presently larger data availability; anyway, the methodological conclusions of the investigation can be

applied to Alpine glaciers in the next future, possibly overtaking the encountered problems.

In details, the first goal will be pursued both considering optical terrestrial and satellite imagery and SAR satellite imagery. The investigation on the terrestrial imagery will consider recent imagery acquired by the professional photographer Fabiano Ventura (president of the no-profit Association MacroMicro) during his recent repeat photography expeditions in Karakorum (2009), Caucaso (2011) and Alaska (2013), together with historical imagery acquired in the past (up to one century ago) during famous expeditions to the same glaciers, benefiting from the fact that recent imagery were taken from the same locations of the past ones. A particular care will be put in the preliminary evaluation the photogrammetric potential of such imagery, obviously acquired just for documentation purposes. An important outcome of this preliminary investigation will be the definition of an effective field strategy to follow in the future repeat photography expeditions (Alps, Himalaya) in order to acquire imagery certainly useful for photogrammetric purposes too. Moreover, as regards the satellite imagery, a detailed search is ongoing in order to identify the (possibly free) available stereopairs, both for optical and SAR imagery, on the mentioned glaciers, in order to generate glacier DSMs through photogrammetric and radargrammetric techniques. A significant role could be preferably played by the free imagery from the new ESA (European Space Agency) satellite SAR mission Sentinel-1, now operational for more than 1 year, and by the imagery from the ASI (Italian Space Agency) satellite SAR mission COSMO-SkyMed, operational from about 8 years, now available for free in a limited amount (100 imagery) within the Open Call for the usage of COSMO-SkyMed quite recently opened by ASI.

Concerning the second goal, it will be pursued considering both the Sentinel-1 and the COSMO-SkyMed SAR satellite imagery time series, possibly focusing on different ground resolution imagery in order to assess the impact of this crucial parameter on the accuracy of the glacier surface velocities retrieval. In this respect, it is important to underline that, if it will be demonstrated that Sentinel-1 imagery are suited for the velocity determination, there will be the possibility to design and establish a worldwide service for glaciers surface velocities monitoring.

Finally, a crucial role will be played by positioning techniques based on the Global Navigation Satellite Systems, now mainly the GPS and, in the next future, Galileo too. In fact, the recent availability of low-cost single frequency receivers, will enable both an easier and cheap determination of control points for the photogrammetric image processing, and the establishment of low-cost monitoring geodetic networks, able to assess pointwise the displacements determined by SAR satellite imagery time series.

Contribution: Oral presentation

Breaking the ice with the media

J. Pasotti

Scientific journalist

Communicating through the media can be tricky, but can be effective too. Acquiring skills to dialogue with the media is the way to benefit from media exposure. I will show a successful case of dialogue between glaciologists and the media, present 3 pitfalls scientists should be aware of when contacted from the media, and provide 5 tips to improve communication via the media.

Contribution: Poster presentation

The participatory approach promoted by the Italian Glaciological Committee for monitoring supraglacial vegetation in the Italian Alps: call for the 2015 campaign

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Field data was collected by the authors and by the following persons that are here acknowledged: R.S. Azzoni, V. Bertoglio, M. Bettio, I. Bollati, A. Franchino, A. Fusinaz, V. Garavaglia, G. Gilli, M. Gilli, C. Iulita, G., Losapio, G. Mortara, E. Motta, M. Motta, M. Pecci, S. Scapinello, R. Serandrei, Barbero, A. Théodule, E. Tosatto, M. Vagliasindi, G. Vergnano, D. Zannetti

Since summer 2011 the Italian Glaciological Committee -CGI- together with researchers of the University of Milan has launched a census of supraglacial vegetation (i.e. vegetation growing on the glacier bodies) in the Italian Alps.

In the first three years of monitoring, the 27 observed glaciers have allowed to collect new information for those glaciers where supraglacial vegetation was already known or studied (Miage, Brenva and Belvedere Glaciers) and to detect new glaciers presenting vegetation colonization.

For what concerns supraglacial debris, 13 glaciers presented an abundant debris coverage of the tongue, namely: Lana, Belvedere, Locce Nord, Miage, Brenva, Vedretta d'Amola, Verra Grande, Aurona, Lys, Valle del Vento, Chérillon, Forni and Calderone.

Herbaceous supraglacial vegetation was reported for the Miage Glacier (that presents an abundant coverage), the Brenva (detached lower tongue of dead ice) and the Locce Nord glaciers that present a minor vegetation density (diffused cover). The Miage Glacier presents also an abundant colonization of both shrubs and also well developed trees (about 3-4 m height) while the Brenva Glacier presents a 'diffused' shrub and tree cover.

First stages of herbaceous vegetation cover are reported for the Calderone, Forni, Ciamousseretto, Capra, Vedretta d'Amola, Rosa dei Banchi, Lys and Belvedere glaciers (for the latter also sparse shrubs and trees are reported).

The relationship between glacier fluctuations and vegetation dynamics makes the vegetation system a precious archive of data for studying climate impacts on the Alpine environment and also for

assessing past glacier history. Following glacier tongues retreat, the expanding proglacial areas are undergoing vegetation recolonization dynamics, however it is especially debris covered glaciers and glaciers with medial moraines that are involved, especially when they located at an altitude below the vegetation potential limit, where the superficial velocity is low and the debris has a sufficient thickness.

The supraglacial vegetation is also an indicator of the abiologic systems dynamics, is a valuable proxy for climate impacts reconstructions and for assessing recent variations of debris covered glaciers.

All people interested of Glaciology and hikers who frequent the Alpine glaciers can help in gathering information for the 2015 campaign, filling the form that can be downloaded from http://www.glaciologia.it/en/vegetazione-epiglaciale/?lang=en and taking photos. Both the form and the photos should then be sent via e-mail to: glacioveg.unimi@gmail.com.

Bibliographic reference
Pelfini M., Leonelli G. (2014) First results of the participatory approach for monitoring supraglacial vegetation in Italy. Geografia Fisica e Dinamica Quaternaria 37: 23-27.

Web Resources:
Location of the glaciers for which supraglacial vegetation has been reported: http://www.glaciologia.it/wp-content/uploads/vari/SupraglacialVegetation_2013.zip

Contribution: Poster presentation

Dye tracing test at Morteratsch Glacier (CH) to investigate englacial drainage flowpaths and to evaluate possible GLOF risk

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With an area of about 16 km^2 and a lenght of 7 km, the Morteratsch Glacier (Graubünden, CH) is the largest glacier in the Central Alps and the longest in the Bernina Massif. It is a typical valley glacier, built up by the confluence of Vadret da Morteratsch and Vadret da Pers. Both tongues contain well developed en-glacial caves systems and big sub-glacial caves exist (or have been existing till 2010) at the snout.

The glacier morphology let us infer the possibility that "steps" in the bedrock could be responsible for the formation of en- or sub-glacial lakes, which could create a high GLOF (Glacial Lake Outburst Flow) risk.

In the upper ice fragile horizon (150-200 m deep), water moves through en-glacial conduits, so that hydrodynamic inside a temperate glacier is similar to karst water circulation: it can thus be investigated with hydrogeological methods normally used in karst systems.

In September 2012 a dye tracing test was organized, with the aim to evaluate GLOF risk for the Morteratsch Glacier. Two different dyes (Uranine and Aminorhodamine G) have been injected simultaneously into two different sinkholes, in the Vadret da Morteratsch and in the Vadret da Pers. The use of a fluorometer with data logger in the outlet at the snout allowed a detailed and continuous restitution graph to be obtained, which allowed to estimate both the development and efficiency of the en-glacial karst drainage system and the possibility of en- and sub-glacial lakes or storage basins to exist inside or below the glacier.

The restitution graphs are significantly different in the two cases:

- the Vadret da Morteratsch en-glacial flow path exhibits a first arrival of the dye through a well developed caves system, and two minor later peaks probably due to less efficient secondary caves flow paths;
- the Vadret da Pers en-glacial flow path exhibits a similar first arrival peak through a quite well developed caves system, but most dye arrives later, as pointed out by a second wide peak, which indicates a high dye retention, together with dilution and homogenization processes which are well compatible with the existence of an en- or sub-glacial basin or lake, where the dye is temporarily stopped and dispersed. This result is compatible with other Authors' investigations (Cook & Swift, 2012), who infer the probability of bedrock overdeepening and related sub-glacial basins to exist in Morteratsch Glacier.

A dye tracing test alone cannot distinguish between en- or sub-glacial basins (GLOF risk being much higher in the former case), but this method surely enables to highlight a potentially risky situation. In the studied case of the Morteratsch Glacier, a GLOF risk is therefore quite low, or null, in the Vadret da Morteratsch tongue, but rather higher in the Vadret da Pers tongue.

Dye tracing tests could therefore be an efficient, quick and easy method to evaluate possible GLOF risk, especially in the present retreat phase.

Contribution: Poster presentation

Glacier surface classification with multi-temporal terrestrial laser scanning-data: comparison of in situ snow density measurements and backscattered signal at Hochjochferner, Ötztal Alps

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Seasonal snow is a crucial factor in the water budget and thus a focus for hydrological monitoring and modelling of high Alpine catchments. While mapping the extend and duration of seasonal snow and estimates of its depth have improved over the last decades, the amount of water stored in the snow pack is still an open question applying remote sensing techniques.

Within the hiSNOW project (high resolution monitoring and modelling under climate changing conditions), which focuses on the effects of the ongoing climate change on the mass balance of an alpine glacier and the snow cover distribution. We use a combination of airborne and terrestrial high-resolution remote sensing methods, satellite data and direct glaciological methods to correlate snow surface properties detected by TLS backscattered signals (also termed intensity or amplitude) to in-situ measured snow densities. As test site we defined the Hochjochferner (HJF) in the Ötztal Alps, Italy. Which is an easy and permanently accessible research area. HJF has a suitable shape and size and is barely debris covered. Snow pit analyses show a homogenous density distribution over the snow-covered areas of the glacier throughout the entire observation period (17.7.2014 to 03.10.2014). Preliminary results of the TLS data show that the intensities decrease with the age of the snow. In addition it can be stated that the intensity values are lowest at the bare ice of the glacier tongue. Hence, training areas for ice, snow and firn are used for the classification of the intensity values of the entire glacier. Photos of the field work and georeferenced color values of the scanner intern camera are used to validate the training areas. Finally, intensity values and concurrent density measurements are correlated to establish a tool for possible automated snow age and snow density classification from TLS.

Contribution: Oral presentation

Thermofluidodynamic modelling of the Adamello Glacier in the current climate

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A thermofluidodynamic model was applied to the study case of the Adamello glacier (17,24 km^2, after ASTER 2003 data), located in the Central Alps. The behaviour of the glacier between 1996 and 2007 was simulated in the current climate conditions. Using the open source finite element code Elmer (http://www.csc.fi/elmer) the dynamic and mass continuity equations were solved for the velocity field and the free surface elevation. The glacier was modelled with a 3D mesh composed by 28050 nodes and subdivided into 10 vertical layers. Elevation of the free surface and bedrock recorded in 1991 and in 1996 were used as boundary and initial conditions. For each simulated year a top surface temperature of -7.5 °C was considered for the winter semester (no-slip condition prevailing); in the ablation season the glacier's temperature was set to 0°C. During melting a fixed bottom velocity was applied to simulate the slip behaviour. As a Neumann boundary condition on the glacier's top surface the mean -1.4 m a^{-1} mass balance estimated from the energy-balance over the 1995-2009 period was assumed. The reliability of the energy balance was verified with point measurement at ablation stakes over two ablation seasons, with runoff data and remote sensing. The maximum simulated surface velocities of the order of 10^2 m a^{-1}, a value consistent with observations of speed of some ablation stakes. In order to assess the validity of the results, the change in the thickness of the glacier observed between 1998 and 2007 (DEM difference) was compared to the simulated change in the free surface elevation. Another useful application of the modeling result is the identification of the ice divide of 5 glaciological units in the Sarca and Oglio subbasins, separated from a hydrological point of view, which is not a trivial task to be performed in the field. The modeling framework is intended to be applied to simulate the evolution of the glacier's morphology under climate change scenarios which set a severe threat to the possibility the Adamello glacier will survive in the next century.

Contribution: Poster presentation

International glacier-caving camp 2014 - Gorner Glacier (Switzerland)

A. Romeo

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The importance of the exploration of endoglacial cavities in the glaciers has recently opened new challenge for scientific research. The first "International Glacier–Caving Camp" was organized by Alessio Romeo and Fracesco Sauro for to open the endoglacial world to multi-disciplinary researchers interested in glacial environment.

The International Camp was located on the top of the central moraine of the Gorner Glacier (CH), at almost 2450 m, from 17th to 27th October. In ten days, 46 persons, composed of cavers and scientists from different European countries, have participated.

Scientific studies:

-*Geomorphology and Hydrology* - Niccolò Segreto

Overview of the evolution of Gorner glacier in the last 20 years, in terms of geomorphology and hydrology, to monitoring the endoglacial caves position in the ablation area. With the help of Alessio Romeo he will compare also the old positions of the moulins (data are mainly in Alessio Romeo's Geology Bachelor Thesis " Aspetti morfologici ed evolutivi delle cavità endoglaciali del Ghiacciaio Gorner (CH)", 2001) with the new positions for a study on the variations of cave entrances compared with the morphological evolutions of the glacier (width, length and thickness). The glacier front retreating will be also analysed.

-*Biology* - Alain Couté and Catherine Perrette

Biologists at the Historical Natural Science Museum of Paris specialized in micro-algae and extremophile organisms. They had proposed a primary biological study of Alpine cryoconites. During the 25th and 26th October 4 different cryoconites were sampled on the main tongue of Gorner glacier not far from the Base Camp.

-*Microbiology* - Stefan Leuko

Alessio Romeo had also tacked sediment's samples of the same crioconites for the Astro-Biologist

Stefan Leuko of the German Aerospace Center in Cologne. He will analyse the samples looking for extremophile bacteria like Archea.

-*Nano-particles* - Roberta Brayner

She works for the Diderot University of Paris ad she has a special competence in nano-particles and chemistry. A additional step for a more complete knowledge of cryoconites.

-*Drone mapping and 3D photos* - Tommaso Santagata

With a radio-controlled Drone he had realized a photographic documentation in 3D and with an infrared camera of some parts of the ablation area and different moulin's entrances.

The complete results of the International Camp will be published as soon is possible. We are confident that these documentations will be interesting for future researches and explorations.

Contribution: Oral presentation

New systems for monitoring glacier moulins

Santagata T. and A. Romeo

La Venta Esplorazioni Geografiche – Via Priamo Tron, 35/F – 31100 Treviso (TV)

The fast spread of new unmanned aerial vehicle technology that is taking place in recent years is helping to improve many scientific research activities, especially for the study of glaciers and ice caves (moulins).

In October 2014, as part of the project "Inside the Glaciers 2014" was held the first International camp of speleo-glaciology on the Gornergletscher (SW Switzerland), attended by cavers and scientists from different nationalities with the aim to explore and carry out several research activities on glacier moulins.

This glacier is one of the most interesting alpine for its supraglacial and glacial pseudo karst formations. It has been explored since 1985 by scientists and speleologists that have mapped more than 40 glacier moulins and some marginal tunnels.

During this first international explorations field we used a drone equipped with a camera and GPS system with which was possible to perform photogrammetric surveys and obtain detailed mapping of some parts of this glacier (especially on two of the largest moulins) carrying out different three-dimensional reconstructions and surface analysis with very high detail.

With the data acquired from aerial photographs we realized different geo-referenced orthophotos and digital surface models that were used to calculate contour lines and make comparisons with the coordinate positions of the moulins detected during last expeditions.

The three-dimensional reconstructions of the areas detected have allowed to obtain many important information about the surface of this glacier that can be use for cartographic, morphometric and structural analysis.

Actually we are still working on this material, and for the next expeditions it could be interesting to do further tests to make new comparisons.

Moreover, during this field were carried out some tests with a camera modified with an infrared filter shooting to the entrance of some moulins. The data obtained seem interesting, but also from this

point of view it will be necessary to make other comparisons in future.

The aim of this contribution is to share the results obtained and demonstrate how UAV's could help scientists to better understand the morphological evolutions of ice caves and get detailed information about glaciers.

Contribution: Oral presentation

Improved isotope hydrograph separation in a high-elevation catchment (Rofen Valley, Austrian Alps)

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Seasonal snowcover and glaciers are important water storages of high mountain regions. For water resources management it is important to know about the timing and amount of water released by these storages, especially in downstream regions where the water is needed (e.g. for hydropower or drinking water) or where it represents potential risk (e.g. through droughts or floods). Seasonal water availability is strongly dependent on cryospheric processes and becomes even more relevant in a changing climate.

Isotopic tracers are useful tools in the assessment of water resources and provide information about the sources of water contributing to streamflow at the catchment scale. Previously, little effort has been invested into high-frequency tracer studies in seasonally snow covered and glacierized catchments characterized by temperate climates. However, high-frequency tracer studies with spatially distributed sampling points provide important information on water origin and help to better understand the hydroclimatological processes in remote regions.

The objectives of this study are to quantify the spatio-temporal variability of the snowmelt isotopic content and its impact on isotopic hydrograph separation. Therefore subdaily water samples from snow, snowmelt, surface runoff and streamflow were taken in the Rofen valley (Austrian Alps) during two snowmelt events in spring 2014 and analyzed for isotopic content with cavity-ring-down spectroscopy. Snowmelt results from a distributed energy balance model were used to weigh the measured isotopic content of north- and south-facing plots and spatially distribute it to the catchment scale. $\delta^{18}O$ values showed distinct inter- and intra-event variations, as well as marked differences between north- and south-facing slopes. Potential elevation effects were not considered. Two-component isotope hydrograph separation revealed snowmelt contributions of 36±3 % and 76±13 % for the early melt and peak melt period, respectively.

The proposed contribution describes the experimental setup and discusses first results of this improved

approach of hydrograph separation. Moreover, insights into future work in the Rofen valley will be provided as carried out in the ÖAW project HydroGem3. In this project additional tracer will be applied to separate the hydrograph into three components (rain, snowmelt and icemelt). Furthermore a seasonal and annual timescale will be implemented in the research design.

Contribution: Oral presentation

Post-LIA glacier changes along a climatic transect in the Central Italian Alps

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The variability of glacier response to atmospheric temperature rise in different topo-climatic settings is still matter of debate. To address this question in the central Italian Alps we compile a post-LIA (Little Ice Age) multitemporal glacier inventory (1860-1954-1990-2003-2007) along a latitudinal transect that originates north of the continental divide in the Livigno mountains, and extends south through the Disgrazia and Orobie ranges, encompassing continental-to-maritime climatic settings. In these sub-regions we examine area change of 111 glaciers. Overall, total glacierized area has declined from 34.1 to 10.1 km^2, with a substantial increase in the number of small glaciers due to fragmentation. Average annual decrease (AAD) in glacier area has risen of about an order of magnitude from 1860-1990 (Livigno: 0.45; Orobie: 0.42; and Disgrazia: 0.39 % a^{-1}) to 1990-2007 (Livigno: 3.08; Orobie: 2.44; and Disgrazia: 2.27 % a^{-1}). This ranking changes when considering glaciers < 0.5 km^2 only (i.e., we remove the confounding caused by large glaciers in Disgrazia), so that post-1990 AAD follows the latitudinal gradient and Orobie glaciers stand out (Livigno: 4.07; Disgrazia: 3.57; and Orobie: 2.47 % a^{-1}). More recent (2007-2013) field-based mass balances in three selected small glaciers confirm post-1990 trends showing consistent highest retreat in continental Livigno and minimal area loss in maritime Orobie, with Disgrazia displaying a transitional behaviour. We argue that the recent resilience of glaciers in Orobie is a consequence of their decoupling from synoptic atmospheric temperature trends. A decoupling that arises from the combination of local topographic configuration (i.e., deep, north-facing cirques) and high winter precipitation, which ensures high snow-avalanche supply, as well as high summer shading and sheltering. Our hypothesis is further supported by the lack of correlations between glacier change and glacier attributes in Orobie, as well by the higher variability in ELA_0 positioning, post-LIA glacier change, and inter-annual mass balances, as we move southward along the transect.

Contribution: Oral presentation

Evolution at the top: new fungal taxa from rocky heights of the Calderone Glacier, Gran Sasso D'italia

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Extreme and border environments are elective for studying microbial endemism since environmental pressure is likely to influence the degree of adaptive radiation and speciation. Polar and Alpine environments, therefore, may host a selection of peculiar and very adapted species. Yet, one of the consequences of the global warming concerns the moving throughout the Poles, or through higher altitudes, of some habitats with a consequent disappearance of the pre-existing border ecosystems and associated species that can be easily replaced by more competitive ones coming from lower altitudes. Therefore, studies on this threatened biodiversity are urgent, before some species become extinct. Despite their irreplaceable role in maintaining stability of all ecosystems, fungi are among the less studied organisms; they may be cosmopolitan or adapted to harsh environments, even precluded to other life-forms. They also show a bewildering metabolic diversity with wide implications for their biotechnological and medical potential.

Black meristematic rock inhabiting fungi (RIF) are among the most stress- resistant organisms known, being able to tolerate wide ranges of temperatures, irradiation, osmotic stress and even Space conditions; they thrive on natural rocks both in cold and hot deserts, and wherever the conditions prevent the establishment of cosmopolitan, fast-growing fungi.

Until recently, RIF remained familiar to only few researchers, when their potentialities in many research areas such as microbial ecophysiology, evolution and adaptation to extremes, as well as in applied research, such as human pathogenicity, bioremediation, biodeterioration and exobiology, became apparent. New, genotypically peculiar taxa have been found and described in the rocks of the Antarctic desert, but even in extremely cold locations of mountain tops in the Alps, Andes and Himalaya.

The Gran Sasso d'Italia is the highest mountain top of the Italian Apennines, hosting the southernmost European glacier named Calderone, with a typical Alpine environment. Due to the ongoing global-

warming, it had a significant reduction during the 20th century and is considered a vanishing ice body. A number of mycological studies have been conducted in this area focusing mainly on yeast biodiversity; this is the first study concerning isolation of RIF from this location. Sampling was made along an altitudinal transect from 2000 to 2914 m asl. Twenty-nine fungi have been isolated and were studied with molecular approach. Molecular phylogeny revealed the presence of 5 new genera and 8 new species that are being described. The high number of new entities found in this study, with respect the few isolates, confirms that rock surfaces in Alpine locations are still an underexplored habitat and RIF species richness still remains woefully underestimated.

Contribution: Poster presentation

Parameterization of radiative components and air temperature driving ablation at the Forni Glacier (Italian Alps)

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We focus here on modelling the spatial distribution of the meteorological parameters most influencing snow/ice melting over the Forni Glacier (Italian Alps). Specifically, we consider longwave and shortwave downward radiation, and air temperature. In fact, in energy balance models the radiative components are the most important driving factors, while the air temperature is considered a proxy of ablation in T-index approaches. We set up and test a methodology for their accurate distribution, for mass budget modeling upon glaciers in the absence of supraglacial automatic weather stations (AWSs), or direct complete (i.e.: both up and down and both long and short wave fluxes) radiation measurements. First, we distribute the incoming solar radiation by taking into account actual atmospheric conditions, glacier topography and shading. Then, we model the incoming longwave radiation considering cloud-cover and air temperature. Third, we investigate a local lapse rate to depict the yearly variability of the vertical temperature gradient, to assess the actual thermal conditions at different elevations. Finally, we compare the modelled values against observed data. The results display that i) our approach provides an acceptable depiction of the distributed solar radiation and of the incoming infrared radiation, and ii) the application of a local lapse rate provides a good distribution of temperature at the glacier surface. In addition, the present study provides some information concerning errors in modelling these three parameters, useful for quantifying glacier melt rate. Moreover, it turned out that unlike solar radiation and air temperature, the longwave radiation can be considered constant over a glacier surface. Finally, for estimating these parameters, we suggest that a supraglacial weather station measuring all meteorological data is not strictly necessary. In fact, air temperature can be modelled from data acquired far away the site (up to 20 km from the glacier). The unique parameters that should be measured directly over the glacier surface seem the vapor pressure, considered in this study for estimating the clear-sky

emissivity in the infrared model, and the shortwave radiation. Hence, it seems enough a minimal configuration for a supraglacial weather station, equipped with a pyranometer measuring the incoming global solar radiation, and a thermo-hygrometer, for modelling of the three most important parameters driving the ice/snow melting.

Contribution: Oral presentation

A simple model to evaluate ice melt over the ablation area of glaciers in the Central Karakoram National Park, Pakistan

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This study provides an estimate of freshwater derived from ice melt for the ablation areas of glaciers in the Central Karakoram National Park (CKNP, Pakistan), a protected area located in one of the most glacierized regions in the world. In the CKNP there are about 700 glaciers, covering ca. 4600 km^2, with large debris cover (518 km^2). To assess meltwater volume we applied a distributed model able to describe both buried- and bare-ice ablation. The daily ice melting at each pixel with bare-ice was estimated by applying an enhanced T-index model. The buried-ice melt model based on estimating the conductive heat flux through the debris layer and, consequently, the ablation rate, assuming a linear temperature gradient from the top of the debris layer to the ice surface for mean daily conditions. Model inputs are: i) glacier boundaries (updated to 2010); ii) a supraglacial debris cover map (updated to 2011); iii) a Digital Elevation Model; iv) daily mean meteorological and energy data from automatic weather stations (AWSs) located in the CNKP area. The melting models were calibrated using data collected in the field in the CNKP area and validated by comparison with ablation data collected in the field, and independent from those used to build the model. Models for distributing the input meteorological variables (i.e. air temperature and incoming solar radiation estimated by dataset acquired at Askole) were validated through those measured at Urdukas in 2011 and at Concordia in 2012. During 23rd July - 9th August 2011 mean estimated ablation in the CKNP was 0.024 m day^{-1} in buried-ice areas and 0.037 m day^{-1} in bare-ice areas. The model displayed a good performance to estimate buried- and bare-ice melt. In particular, we found a mean error of -0.01 m w.e. (corresponding to 2%) and a root mean square error value equal to 0.09 m w.e. (17%). According to our model, the ablation areas of all

the glaciers in the CKNP have produced a water volume of 1.96 km^3 during the study period. The model is very sensitive to air temperature variations (±1°C), ice albedo (±10%), and incoming shortwave radiation (±10%), giving a change in melt amount of ±7%, ±5%, and ±5%, respectively. Moreover, debris thickness variations (±10%, ±50%, and + 100%) have less impact on total ice melt amount (up to ±4%), but their impact becomes stronger when considering melt amounts from buried-ice only (up to 34%).

Contribution: Oral presentation

The new Italian glacier inventory: a contribution to a better understanding of the Alpine glaciation

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A new Glacier Inventory is an indispensable scientific and practical requirement in Italy due to the importance of evaluating the present glacier coverage and the recent changes driven by climate. The first Italian Glacier Inventory dates back to 1959-1962. It was compiled by the Italian Glaciological Committee (CGI) in cooperation with the National Research Council (CNR) and describes 835 ice bodies which altogether were covering 518 km^2. Moreover in the Eighties a new inventory was compiled to insert Italian data into the World Glacier Inventory (WGI). During the last decade the largest part of the Italian Alpine Regions have produced regional and local glacier inventories, moreover the actual need is an unique homogeneous glacier database. The new Italian glacier inventory includes the main fundamental parameters and features, such as glacier name, national inventory code, former WGI code, coordinates, surface area (minimum size 0.01 km^2), glacier type and aspect (following the guidelines of the World Glacier Monitoring Service summarized by Paul et al., 2010). The identification of the Italian glacier bodies and the evaluation of glacier area and main features have been performed by analyzing aerial orthophotos acquired in the time frame 2005-2011 (pixel size 0.5 m X 0.5 m) and processing high resolution satellite images.

The whole Italian glaciation consists in 903 ice bodies covering a surface area of 369.9 km^2. Considering the glacier surface, the Italian region featuring the widest ice coverage is Valle d'Aosta (133.7 km^2). Moreover, the highest number of glaciers per region is found in Lombardy (230 ice bodies). Excluding the two glacieret split from Calderone glacier in the Apennines, the Italian glaciation is located on the Alps and mainly consists in small ice bodies (mean glacier area of 0.4 km^2) classified as Glacieret or Mountain Glacier. The dominant aspect is North and only a very small number of wide glaciers is still present (i.e. 3 glaciers >10 km^2) resembling the ancient huge Alpine glaciation.

Contribution: Poster presentation

Widening rate of glacier forelands: the case study of the Forni Valley (Stelvio National Park, Italian Alps)

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Alpine glacier shrinkage is accompanied by a progressive expansion of deglaciated areas, both on the valley slope and in the bottom valley. Glacier retreat provides new habitats for plants and animals, that can colonize the glacier foreland. Chrono-sequences and ecesis have been already studied in order to assess the biological response to climate change in glacial environments, but the expansion of proglacial areas and their evolution over time are also topics of great interest in the context of global change.

The aim of this study is to evaluate the expansion of the proglacial area of the Forni Glacier due to the glacial fluctuations occurred since the Little Ice Age (LIA). This research was conducted in the Forni Valley (Stelvio National Park, Italy), where the Forni Glacier past fluctuations are well documented by at least four moraine ridges, from the LIA until the last advance occurred in the end of the 1970s. Using aerial images, orthophotos and field data, the moraine ridges have been georeferenced, and the expansion rate has been estimated in GIS environment for each time interval defined by the dated moraines.

Assuming an expansion of 100% of glacier foreland between the end of the LIA and the current position of the glacier, our results show that 24,1% of the glacier foreland expanded between 1859 and 1914; 6,7% between 1914 and 1926; 47,3% between 1926 and 1981; 21,9% between 1981 and nowadays. The velocity of expansion was 11.000 m^2/year between 1859 and 1914; 14.300 m^2/year between 1914 and 1926; 21.700 m^2/year between 1926 and 1981; 19.200 m^2/year between 1981 and nowadays.

The results obtained in this study show that i) the mean velocity of area expansion of the glacier foreland during the last 88 years was nearly double than the mean velocity during the 1859-1926 time interval, thus featuring an ongoing phase of acceleration starting from the beginning of the last

century; ii) the linear glacial retreat (measured by the operators of the Italian Glaciological Committee), instead, calculated for the same four time intervals shows a remarkable acceleration only starting from 1981.

The increasing rate of expansion of the glacier foreland needs to be taken into account not only for a better understanding of the dynamics of biological forms in newly formed proglacial areas, but also for the evaluation of the physical processes involved in the landscape changes, related for instance to the action of melting water on unconsolidated debris.

Future perspective of the research aims at analyzing and comparing different trends of expansion of glacier foreland at the regional scale.

Contribution: Oral presentation

Effects of future climate change upon the water towers of Asia: a case study from the Upper Indus Basin

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The mountains of the Hindu Kush, Karakoram and Himalaya (HKKH) are the "third pole" of our planet, and rivers from therein are a life lines for billions. Recent dynamics of glaciers in the Karakoram is not clearly assessed hitherto, and in the last decade substantially unchanged ice cover area was seen, against noticeable area loss worldwide, i.e. the so called "Karakoram anomaly". Assessment of future water resources and hydrological variability under climate change in this area is utmost needed, but the hydrology of these high altitude catchments is still poorly studied and little understood. Our study is carried out under the umbrella of the SHARE-Paprika project, aiming at evaluating the impact of climate change upon hydrology of the upper Indus river. This study focuses upon a particular watershed, the Shigar river closed at Shigar (about 7000 km2), nested within the Upper Indus Basin (UIB) and fed by seasonal melt from two major glaciers (Baltoro and Biafo). Hydrological, meteorological, and glaciological data gathered during three years of field campaigns (2011-2013) that represent a unique dataset are used with topographic information, historical climate data and remote sensing data of ice and snow cover to set up a semi-distributed hydrological model, providing acceptable depiction of in stream flows and snow and ice cover dynamics. The model is used to assess changes of the hydrological cycle until 2100, using in input the climate projections of precipitation and temperature (locally adjusted using downscaling) provided by three state-of-the-art Global Climate Models used in the recent IPCC AR5 (EC-Earth, CCSM4 and EcHam6) under the RCP2.6, RCP4.5 and RCP8.5 emission scenarios. The projected flow duration curves, some selected flow descriptors, and the significance of modified flow regimes in the Shigar river are then evaluated. Under all RCPs future flows are predicted to increase until half century, and then to decrease, but remaining mostly higher than control run values. Snow melt is projected to occur earlier, while ice melt component is expected to increase, with ice thinning considerably, and even disappearing below 4000 m.a.s.l. until 2100. The "anomaly" condition does not seem to persist in the second half of the century with relevant impacts on the amount of water stored in the area.

Contribution: Oral presentation

Cryoconite in Italian Alps and Karakoram hosts different microbial communities

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Cryoconite holes are small depressions which form on glacier surface when dark airborne sediment (cryoconite) lay down and, heated by solar radiation, enhances ice melting. These habitats are particularly interesting because they represent hot spots of biodiversity in the glacier ecosystem. While the microbial communities of these habitats in polar regions are well characterized, few information is present in the literature about microbial communities in holes of mountain glaciers.

We analyzed microbial communities in cryoconite holes on Forni (Italy) and Baltoro (Pakistan) Glaciers and described their taxonomic biodiversity. The comparison of these communities allowed defining whether the microbial communities of cryoconite holes on mountain glaciers from different areas of the world are similar or if each glacier hosts different communities. The molecular characterization was carried out by quantitative PCR, sequencing of 16S rRNA gene and Whole Metagenomic sequencing.

We collected and analyzed 111 cryoconite samples: 30 collected on the Baltoro Glacier in July 2013, 21 on Forni Glacier in July 2012, 60 collected on Forni glacier in July-September 2013. Morphological data of cryoconite holes were recorded (major axis, minor axis, perimeter, depth and orientation) as well as some chemical and physical parameters (temperature, pH, oxygen saturation, conductivity and organic matter). Finally, we measured, with the dark-light bottle experiment, the rates of net productivity, primary productivity and respiration in the cryoconite.

By comparing our morphological data with those reported in the literature, we observed that cryoconite holes on mountain glaciers were smaller than those measured on Antarctic glaciers, but larger than those on Artic ones. Cryoconite holes in Forni Glacier have a slightly acid pH (6.43±0.13)

and oxygen saturation of 84.3±0.98. Values on the Baltoro Glacier were significantly different: mean pH was 8.66±0.09 and oxygen saturation was 97.5±0.4. The amount of organic matter in the cryoconite of Forni Glacier varied between 0 and 115 mg per g of dry sediment while in samples from Baltoro varied between 52 and 117 mg per g. The rates of respiration and photosynthesis were higher on Baltoro than on Forni glacier, but the balance between them always indicated a net heterotrophy of cryoconite communities. Quantitative molecular analyses conducted on 16S rRNA gene confirmed that cryoconite holes host a significant amount of bacteria, with number of copies ranging between 10^9-10^{10} per g of sediment. Both the phylogenetic and the functional molecular analysis showed that the communities observed on Baltoro glacier were completely different from those on Forni glacier. The first ones were rich in heterotrophic bacteria belonging to the genus *Limnohabitans* (Order *Burkholderiales*), while the second ones had more developed autotrophic populations dominated by Cyanobacteria. This indicates that microbial communities in cryoconite holes may largely differ between glaciers in different areas of the world.

Contribution: Poster presentation

GPR surveys on Forni and Fellaria Glaciers aimed at evaluating ice and snow thickness

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In August 2013 and August 2014 respectively, two GPS-assisted Ground Penetrating Radar surveying campaigns were performed on Forni glacier (eastern part of Valtellina, Central Italian Alps), thanks to the work of several SGL volunteers.

The lower area of the glacier was surveyed during the first campaign (August 2013), using a low frequency (40 MHz) antenna and a GSSI SIR3000 acquisition unit. The three accumulation basins were investigated with the same equipment in August 2014. Moreover, snow depth measurements were carried out by using a 200 MHz antenna. Helicopter was used for transporting people and equipment; surveys were carried out by moving the antenna directly on the glacier surface in order to limit signal loss due to attenuation.

A snow depth survey was also performed on Fellaria glacier (Val Malenco, Central Italian Alps) in August 2014.

More than 6 km of radar profiles were surveyed on Forni Glacier, providing a clear view of the glacier bed morphology. A maximum ice thickness of about 120m was measured. We obtained a good distribution of data, notwithstanding the constraints in safely walking on the glacier surface with surveying equipment.

Good data were also recorded by the 200MHz antenna, which allowed to measure snow depth both on Forni and Fellaria glaciers. Such measurements were calibrated by comparison with manual snow depth measure at the same sites; the calibration allowed to estimate the propagation velocity of radar wave in the medium.

Thanks to the availability of helicopter, during August 2014 GPR campaign a high definition photogrammetric survey was also performed on Forni glacier snout. The photogrammetric model is currently being georeferenced by comparing it with a georeferenced terrestrial laser scanner model of the same area produced in late September 2014.

Contribution: Oral presentation

Flora and fauna of debris-covered glaciers and rock glaciers

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Recent papers highlighted that debris-covered glaciers and rock glaciers host habitats that can support life, but the ecological features on this landforms are known yet. The present research aims to study plant and arthropod communities on alpine debris-covered glaciers and rock glaciers, together with their microclimatic regime and the physical and chemical parameters of the soil, comparing them with those of the surrounding landforms. We selected a debris-covered glacier in the Monte Rosa Massif (Western Italian Alps: Belvedere glacier), two active rock glaciers in the Ortles-Cevedale Massif with contrasting lithology (Central-Eastern Italian Alps: Lago Lungo and Vedrettino) and another one in the Adamello-Presanella Massifs (Central-Eastern Italian Alps: Amola). The study was performed in order to test two hypothesis: 1) debris-covered glaciers and rock glaciers differ from the adjacent moraines and scree slopes, respectively, for the presence of cold-adapted species; 2) debris-covered glaciers and rock glaciers can host cold-adapted species below their normal altitudinal distribution (i.e. down to the elevation of subalpine woods or alpine grasslands).

Preliminary results showed that the supraglacial debris of Belvedere glacier, unlike the adjacent moraine, hosted high alpine plant species (e.g. *Poa laxa* and *Cerastium pedunculatum*) below their normal altitudinal distribution, down to the elevation of subalpine larch woods. The glacier hosted also a relatively rich community of spiders (9 species) including some cold-adapted species (e.g. *Pardosa nigra* and *P. saturatior*), even though with no differences with respect to the moraine. The rock glaciers of Ortles-Cevedale Massif differ from the surrounding scree slopes for the presence of plants adapted to

low temperatures and long-lasting snow cover (*Luzula alpino-pilosa* and *Doronicum clusii* on silicate debris, *Arabis caerulea* and *Saxifraga oppositifolia* on carbonate debris). The arthropod communities of rock glaciers and scree slopes were similar each other on both the substrates, including cold-adapted spiders (e.g. *Pardosa nigra*) and cold-adapted carabid beetles (e.g. *Oreonebria castanea*). The rock glacier of Adamello-Presanella showed high frequencies of mosses linked to long-lasting snow cover (e.g. *Polytrichastrum alpinum*) and cold-adapted carabid beetles characterized by endogean life style (*Trechus tristiculus*, *Nebria germari* and *Oreonebria angustata*).

In the light of the obtained results, we advance the hypothesis that debris-covered glaciers and rock glaciers may act as warm-stage refugia for cold-adapted species as consequence of their microclimate features and thermal inertia due to ice presence and debris cover.

Contribution: Poster contribution

Ecological features of a derbis-covered glacier: an example of multidisciplinary approach to the study of Alpine landforms

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Several studies about geomorphological, botanical and zoological features of glacial landforms were performed on the Alps. However, the ecological features on these landforms can be understood only through multidisciplinary approaches able to merge biotic and abiotic information. In the present study, we adopted a sampling design that integrates the collection of glaciological and biological data on Belvedere debris-covered glacier (Western Italian Alps) and the surrounding landforms. Our aim is to analyze how plant and arthropod species change in relation to the environmental variables, both within and between the investigated landforms.

We selected three landforms, corresponding to different ecological conditions: i) stable slopes (soils without permafrost evidence that are supposed to have the potentiality for climax vegetation and related fauna), ii) moraine ridges (morphologies without an ice core, located outside the actual glacier area), iii) supraglacial debris (rock debris covering glacier ice thus giving buried ice conditions). Glaciological investigations were performed on the glacier surface to evaluate magnitude and rate of buried ice melt, surface albedo and debris thickness. We also recorded air temperature and humidity at ground level with data-loggers protected from direct sunlight and soil/debris physical and chemical features (particle size distribution, organic matter content and pH). For each landform, we surveyed plant communities with 15 plot of 25 m^2 and arthropod communities (ground beetles and spiders as key taxa) with 15 pitfall traps. Through this sampling design, we are going to test the following hypotheses: 1) the supraglacial debris differs from the till of the adjacent moraine ridges for the occurrence of cold-adapted species, 2) the glacier hosts such species below their normal altitudinal distribution (i.e. down to the

elevation of subalpine woods and shrublands), thus suggesting these sites to act as refugia for these species during unfavorable (warm) climatic conditions.

Mean ablation (from the 4th July to 28th September 2014) varied from -0.1 cm w.e./day (2120 m a.s.l., with a debris layer 40 cm deep) up to -2.5 cm w.e./day (2060 m a.s.l., with a debris layer 8 cm deep). The mean surface albedo was 0.12. The mean ice flow during the summer timeframe resulted higher in the upper part of the ablation tongue (more than 3.5 cm/day) and lower at the glacier snout (about 1.1 cm/day). The mean debris thickness was 20.9 cm.

Cold-adapted plants (e.g. Cerastium pedunculatum and Poa laxa) were observed on the supraglacial debris, below their normal altitudinal distribution (down to 1890 m a.s.l., at altitudes where stable slopes are dominated by larch woods and subalpine shrublands). These species did not occur on iceless moraine and stable slope. Two cold-adapted spiders were found on the glacier: Pardosa saturatior and Pardosa nigra, but the latter were frequently found also on the moraine ridge. Ground beetles were found on the moraine, but not on the glacier surface. Our hypotheses are thus differently supported depending on the considered taxa. Further studies about the ecological reasons of such differences are presently ongoing. In the matter of that, the abiotic variables may explain the distribution of the biotic components, endorsing the importance of a multidisciplinary approach.

Contribution: Oral presentation

The role of glacial lakes in glacio-hydrological studies: an outcomes from Stelvio (Alps) and Sagarmatha (Himalaya) National Park

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High altitude ecosystems are especially vulnerable to climate change. Glacial lake evolution and their surface area change is a highly visible and easily measurable signal of the impact of climate change in such ecosystems. Here we share our experience and learning from the research activities in the Stelvio (Alps) and Sagarmatha (Mt. Everest) National Park (NP; Himalaya) on evolution of the glacial lakes. In these sites, we developed inventories of all the glacial lakes and further, analysed their evolution over the last 50 years using space-borne aerial photography and satellite data. We analysed more than 100 lakes (1954–2007) in Stelvio and more than 600 lakes (1962–2013) in the Sagarmath NP. In general, three types of glacial lakes are identified: *supra, pro, and unconnected*.

In Stelvio NP, almost all the lakes are unconnected lakes. At low elevation, ponds are disappearing or subject to an area reduction since the 1980s due to increased evaporation/precipitation ratio. At high elevation new ponds are appearing or increasing their size since the 1950s due to the glaciers' shrinkage and retreatment. The upwards shift of Alpine lakes are as a response of increasing average temperatures.

In the Himalaya, supraglacial lakes were dominating in number. We found that decreasing precipitation together with an increasing temperature is influencing to evolution of these lakes. Both number and surface area of supraglacial lakes has continuously increased (number +109.7 %; area +13.3 %) with an accelerated rate in the last decade due to increase in the glacier melting. Proglacial lakes are more or less constant in both numbers and size, while the surface area of unconnected lakes has increased from 1960s–1990s (+4.3 %) and decreased from early 1990s afterward (-10.9 %). Trends in the surface area change of unconnected lakes are following the precipitation trends that we observed increased from 1960s to 1990s and significantly decreasing afterwards. Unconnected lakes are good indicator of precipitation. The decrease in the precipitation is not only impacting to lakes, but also significantly impacting to the glaciers in the Himalaya.

Furthermore, we point out that different types of lakes have potential to explain glaciological and climatic conditions of the region. We underline a clear need to extend this analysis at broader area to gain regional perspective. The findings of this study make it possible to interpret by climate change in these environments, in terms of alteration of the variations created their ecological role and the loss of ecosystem services.

Contribution: Poster presentation

Glaciers of Lombardy region (Central Italian Alps), 2014 field survey results

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Servizio Glaciologico Lombardo

We present the results of the 2013/14 glaciological field surveys in the Lombardy region (Central Italian Alps) conduct by Servizio Glaciologico Lombardo onlus (SGL). The 62 volunteers surveyed 160 glaciers (95% of the region glaciers' surface) with terrestrial pictures and 27 glaciers with terminus variations measurement. The Equilibrium Line Altitude was estimated with field surveys and terrestrial pictures and was useful to provide a "qualitative mass balance index" of 75 glaciers based on the Accumulation Area Ratio 0.67 concept.

At the end of ablation season most of the Lombardy glaciers were still covered by a thick and extensive snow cover similar to the season 2000/01 (the last year with extensive positive balances).

The terminus fluctuations showed a 70% of retreating glaciers compared to 2013, while 22% remained stable and 7,5% advanced. The percentage of retreating terminus is lower compared to the previous years due to the presence of small and fast reacting glaciers. Some target points for terminus surveys were buried by snow and for this reason some measures could not be done.

Thanks to an exceptionally snowy winter and a cold and wet summer the overall mass balance index was positive for 51% of the glaciers, stable for 31% and still negative for only 17% of the 75 investigated glaciers.

The most favourable situation has been found in Orobic Alps where glaciers are mainly low elevated, avalanche fed and snow accumulation is usually much stronger than in the rest of the region. In this sub-region almost the 100% of the glacier surface was snow covered until the end of the summer providing very positive mass balances. Elsewhere in the region and noticeably in the most continental sub-regions like Livigno and Ortles-Cevedale the final balance is more dependent of summer temperatures and the final mass balances where less positive or slightly negative.

Contribution: Poster presentation

Role of glacial caves in the evolution of glaciers: examples on the Forni Glacier (Valtellina, I), Morteratsch and Aletsch Glaciers (Ch)

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All the Alpine glaciers are presently affected by huge ice mass losses, with great reduction in volume and retreating of the glacier snouts. Ice mass reduction goes together with changing in morphology, stress distribution and subsequent jointing. Constant monitoring and observations through time of glacial caves point out as recent glacier changing is affecting also on the evolution of en-glacial caves systems and on the formation of contact caves.

It is in fact well demonstrated that glacial caves strictly depend on the distribution of stress through the ice mass and on air and water flow entering the caves: every change in one of these factors causes a change in the morphology of caves.

On the other hand, the existence of glacial caves has a control on the evolution of the glaciers themselves, by breakdown and collapse of caves causing sometimes huge losses of ice mass, and by a more criptic process of "erosion" under ice by sublimation and melting processes inside caves.

Formation and evolution of glacial caves can also control some peculiar features on the glaciers surface, such as sinkholes and collapse dolines, unroofed canyons, englacial deposits causing the formation of glaciers cones, etc…

Some examples of what is happening on Forni Glacier (Valfurva, Northern Italy) and on Morteratsch Glacier (Southern Switzerland) show the important role glacial caves may have in the evolution of a glacier, mainly in the snout zone. On these two big glaciers it has been observed the way the evolution of very large contact caves is leading to the collapse of large areas at the snout during the last few years: thanks to the breakdown of large glacial galleries, at the snout huge ice masses are suddenly lost, together with a considerable reduction in length. The collapse of large sub-glacial caves thus

dramatically and suddenly changes glacier morphology at the snout.

Examples on Morteratsch, Aletsch and Forni Glaciers also show the role sub- and en-glacial sublimation and melting processes play in ice mass loss.

Glacial caves therefore play a significant role in the evolution of alpine temperate glaciers, being responsible for rapid and spectacular retreats and for considerable ice loss: information given by the study of en-and sub-glacial caves may thus help in forecasting glacier evolution in the very next future.

Contribution: Oral presentation

Highlights on past sea ice changes and solar activity from Talos Dome site (East Antarctica)

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Talos Dome site, located in Northern Victoria Land (East Antarctica, 159° E 72° S, 2316 m a.s.l.), revealed to be able to yield relevant information on past environmental and climatic variability on different timescales (from the last decades to the last glacial cycle) due to favourable glaciological and geographical characteristics. Among these, the relatively high accumulation rate, allowing the preservation of reversibly deposited chemical species, and the strategic location, making it representative of the atmospheric transport processes occurring on the regional to global scale, play a key role.

Here we show the potentiality of the two different chemical records, sea salt Na^+ ($ssNa^+$) and nitrate, retrieved at Talos Dome, in providing information on past sea ice variability and solar activity.

Sea ice is a key component of the polar climate system representing at the same time a visible sign and a feedback on the Earth's climate change. Since a direct knowledge of Antarctic sea ice variability is limited to the satellite monitoring era (past 40 yr), for earlier times one has to rely on proxy data. $ssNa^+$ record from ice cores has been long proposed as such a proxy but, in order to reliably use proxy records, a validation with the available direct data for current times is mandatory. At this purpose, $ssNa^+$ record from Talos Dome firn cores was compared with satellite data of Sea Ice Extent (SIE) in the whole Antarctic ocean and in different oceanic sectors for the 1978-2003 time period. A good agreement was observed especially considering the Ross Sea and Indian Ocean sector, which appear to control $ssNa^+$ concentration in the marine aerosol reaching Talos Dome during selected periods.

As concerning solar activity, a better knowledge of its long-term variability is crucial for solar physics,

as well for environmental and climate sciences. Since continuous direct records of solar variability are limited to the past four centuries, for longer timescales one has to rely on indirect proxies, such as cosmogenic nuclides ^{14}C and ^{10}Be, stored in natural archives (tree rings and ice cores). Nonetheless, a difficulty in such a reconstruction by using cosmogenic isotopes is due to the complex signal they provide, containing information on the production rate and also on geochemical system effects. Moreover, ^{14}C and ^{10}Be exhibit significant discrepancies on millennial time scales, hindering the knowledge of solar activity at this time scale.

At this regard, a significant positive correlation between nitrate content in TALDICE ice core and the flux of galactic cosmic rays, as reconstructed from radiocarbon INTCAL 14C and GRIP ^{10}Be records, was found along the Holocene on long (multi-centennial, millennial) timescales. Moreover, Schwabe (11 yr) and Gleissberg (55-100 yr) solar cycles are shown to be present in the last two centuries of nitrate dataset. These evidences support TALDICE nitrate record as a potential new proxy of past solar activity.

Contribution: Oral presentation

Diversity and ecology of psychrophilic and psychrotolerant yeasts isolated from Alpine habitats

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Worldwide glaciers (including those occurring in Alpine habitats) are strongly retreating due to ongoing climate change. Accordingly, studies of cold-adapted microorganisms (including psychrophilic and psychrotolerant yeasts) sharing glacier habitats may acquire increasing scientific interest, because they could give additional information on the mechanisms of physiological adaptation to cold conditions.

Samplings have been carried out in the summers from 2003 to 2010 in the Ortles-Cevedale complex (Italian Alps) and Mount Blanc complex (French Alps). Some Kg/year of superficial and deep debris and a few L/year of melt waters (originating from sub-glacial flow exiting underneath the glaciers) were aseptically collected. Besides, some Kg/year of snow and ice cores (diameter = 8 cm) were drilled in proximity of the sediments. Debris, ice cores, snow and melt waters were analyzed for dry weight, pH, organic C, N and P by using standard methods. Isolation of culturable yeasts was carried out using RB + tetracycline, DG18 and DRB + chloramphenicol media after incubation at 4°C and 20°C for 12 or 3 weeks respectively. All yeast isolates are deposited in the Industrial Yeasts Collection DBVPG of the University of Perugia (Italy) (www.dbvpg.unipg.it). Over 1,100 yeast cultures were isolated and the strains were identified by sequencing of the D1/D2 domain of 26S rRNA gene and ITS 1 & 2 and by comparing the sequences obtained in GenBank database (BLASTN freeware from www.ncbi.nlm.nih.gov/BLAST).

The yeast and yeast-like isolates belonged to over 50 species of 17 different genera (*Aureobasidium*, *Bulleromyces*, *Candida*, *Cystofilobasidium*, *Cryptococcus*, *Dioszegia*, *Erythrobasidium*, *Exophiala*, *Guehomyces*, *Holtermanniella*, *Leucosporidium*, *Mastigobasidium*, *Mrakia*, *Mrakiella*, *Rhodotorula* and *Sporobolomyces*). A few new yeast species were also described: *Glaciozyma martinii*, *Glaciozyma watsonii*, *Mrakia robertii*, *Cryptococcus vaughanmartiniae* and *Cryptococcus onofrii* and the description of few others is still in progress. On the whole, yeast species diversity found in Alpine glaciers was comparable with what previously observed in other worldwide glaciers. A habitat-specific

distribution of the different species was observed. Principal component analysis revealed that organic C, N and P are apparently mostly related to culturable yeast abundance and diversity, thus postulating that the frequency of isolation of certain species may be correlated with some organic nutrients (with special emphasis for organic P).

Contribution: Poster presentation

Novel indicators of environmental change from trees in the debris-covered glacier foreland: the case study of the Miage Glacier (Mont Blanc Massif, Italian Alps)

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Supraglacial trees are a useful source of data for reconstructing past glacier surface movements and debris-coverage instability. Proglacial trees also represent a useful tool for the identification and dating of changes in the glacial stream discharge and wide-spreading of melting water. Dendroglaciology is currently applied not only for reconstructing glacier fluctuations but also for investigating glacier surface dynamics at decadal scale. Trees and dated tree-ring characteristics such as scars, growth rate and reaction wood may provide information about glacier movements, discharge and hydrology.

The Miage Glacier in the Mont Blanc Massif (Italy), represents a unique situation in the southern side of the Alps, due to the presence of abundant supraglacial vegetation. The density and distribution of trees is strictly linked to glacier surface velocity, thickness of debris-coverage, ablation rate, grain size distribution, slope and ice thickness, as documented by the results obtained during field surveys, data analysis and remote sensing techniques.

The most recent studies show that supraglacial trees can also be considered environmental and climatic stress indicators. Leaf VOC (Volatile Organic Compounds) emissions and tree-ring carbon and oxygen stable isotopes show significant differences in trees located on the supraglacial debris with respect to trees on the lateral moraine, and these results suggest the possibility to apply these techniques in the identification of areas affected by glacio-geomorphological and climatic stress.

Tree-ring characteristics may also be analyzed in order to reconstruct the past hydrology of debris-covered glaciers with annual resolution. In particular, trees fed by glacial meltwater of the Lago Verde (Miage Glacier) show that tree-ring cellulose is more depleted in $\delta^{18}O$ compared to trees fed by other water sources and, moreover, tree-ring width is narrower in trees affected by lake-level fluctuations.

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Contribution: Oral presentation

Glacier features influencing the presence and abundance of supraglacial trees: the case study of the Miage debris-covered Glacier (Mont Blanc Massif, Italian Alps)

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The number of debris-covered glaciers featuring supraglacial tree vegetation is increasing worldwide, as a response of high mountain environments to the current climate warming. At the debris-covered surface of these glaciers, trees can be found thus giving peculiar landscape and ecosystems. Their distribution is not homogeneous, thus suggesting that some glacier parameters influence germination and growth of trees.

This study was performed on the widest Italian debris-covered glacier, the Miage Glacier in the Mont Blanc massif, where herbaceous and tree vegetation is present at the surface of the glacier tongue. We analyzed the ablation area in the range from 1730 m to 2400 m a.s.l., where a quite continuous debris coverage is present and colonized by trees (mainly *Larix decidua* Mill. and *Picea abies* Karst), also reaching an age of 60 years close to the terminus. By remote sensing investigations and through field surveys we obtained a record of glacier parameters (debris thickness, debris-surface temperature, slope, aspect, elevation, ablation rate, surface velocity, debris-NDMI, variation in ice thickness over several years) to be analyzed with respect to the presence and abundance of trees in 15 plots (plot size: 15 m x 15 m).

Our results show that supraglacial trees are present at the Miage Glacier: 1) whenever exceeding a debris thickness threshold (≥19 cm), 2) with a quite gentle slope (≤ 22°), 3) with a low glacier surface velocity (≤ 7.0 m/year), 4) where the ice thinning due to surface ablation is moderate (ranging between -1.8 m/year and -0.7 m/year) and 5) where the vertical changes due to glacier dynamics are positive (i.e. prevalent increase due to both slow debris accumulation and then preservation of ice flow inputs that we found ranging from +7 m and +28 m over a period 28 years long).

The analysis of the same parameters, conducted on other debris-covered glaciers featuring supraglacial trees, may provide new data in order to evaluate if such conditions are local ones or if they are actual and general factors driving germination and growth of trees.

Contribution: Poster presentation

An integrated approach to the morphodynamics of glacier-glacier lake systems in the Italian Alps

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Climate change affects glaciated and recently deglaciated areas in high mountain regions and can enhance the formation of new glacier lakes and/or the expansion of existing ones. The importance of glacier lakes either in the natural and human systems is due to several reasons: 1) their potential economic value (for hydropower production and tourism); 2) their environmental role for high mountain ecosystems; 3) the related natural hazards (outburst and consequent flood); 4) their strong dependence by glacier dynamics.

The Italian cryosphere is experiencing new glacier lakes formations: very important phenomena to be monitored, as it has been done in many other regions of the world, for better understanding present-day dynamics of the glacial environments and delineate evolutionary scenarios of the geomorphological landscape. In this framework, a cooperative research project and a phD position have been established in 2014 at the University of Torino to study glaciers and glacier lakes of the Italian Alps by using a multiscale (regional and local), multitemporal (past, present and future) and multidisciplinary (geomatics, geomorphology and geography) approach.

The first step of the research is the identification and the characterization of present and historic glacier lakes in the Italian Alps in order to improve the knowledge of the phenomenon at the present time and at the regional scale. As suggested by scientific literature, further remote sensing investigations (semi-automatic analysis of optical satellite images, e.g. Landsat 8, ASTER) offers updated information on large alpine areas. Data validation and integration is performed by analyses of aerial ortophotos and reports of the annual glaciological surveys. It is expected to offer a general overview of the geographical and geomorphological characteristics of detected glacier lakes.

A second step in the research is related to the assessment of future glacier lakes formation in the Italian Alps. A selection of methods applied in other high mountain regions such as the Himalayas and

the Swiss Alps, will be tested on glaciated regions of Italy. They are based on the analysis, in a GIS environment, of glaciers surface topography through Digital Elevation Model (DEM) in order to identify glacier bed over-deepenings. In these sites, if glaciers will continue to retreat and may be disappear, water can accumulate forming new lakes.

Regional scale results will be then verified on few case studies that have experienced the formation of new glacier lakes recently in the past. At the local scale, it is expected to reconstruct evolutionary stages of glacier-glacier lake systems by using historical data (maps, photos), aerial photos, optical satellite images and field surveys. A first proposed test site for detailed studies is the Rutor Glacier (Aosta Valley): it has a well known history of glacier lake outburst floods and recently new glacier lakes have appeared in the proglacial zone.

Contribution: Oral presentation

Mechanisms of subglacial cavity filling in Tête Rousse Glacier

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The deadliest outburst flood from an englacial cavity occurred in the Mont Blanc area (French Alps) on Tête Rousse glacier in 1892. A subglacial reservoir was discovered in the same glacier in 2010 and drained artificially in 2010, 2011 and 2012 to protect the 3000 inhabitants downstream. The mechanism leading to the spontaneous refilling of the cavity following these pumping operations has been analyzed. For this, the subglacial water volume changes between 2010 and 2013 were reconstructed. The size of the cavity following the pumping was found to have decreased from 53500 m^3 in 2010 to 12750 m^3 in 2013. Creep and the partial collapse of the roof of the cavity explain a large part of the volume loss. Analysis of cavity filling showed a strong relationship between measured surface melting and the filling rate with a time delay of 4-6 hours. A permanent input of 15 m^3/day, not depending on surface melt, was also found. The meltwater and rain from the surface is conveyed to bedrock through crevasses and probably through a permeable layer of rock debris at the glacier bed. The drainage pathway permeability was estimated as 0.054 m/s from water discharge measurements and dye tracing experiments

Contribution: Oral presentation

Impact of topography change on the cumulative curve of the specific glacier mass balance

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The local mass change at a glacier surface is controlled by the energy and mass exchange with the atmosphere through climate variables such as precipitation, air temperature, radiation and air humidity, and is, therefore, elevation dependent. The individual specific mass balance is also a function of topographic parameters of the glacier surface, such as the area-elevation distribution and slope and aspect. As a result, series of glacier mass balance do reflect not only trends in climate parameters, but also changes in the surface topography of the glacier. These changes are the result not only of the mass changes at the surface, but also of ice mass movements due to glacier flow. In this context, the dynamics of ice need not necessarily be linked directly to the climate-induced mass changes.

As a result, the cumulative mass balance curves diverge clearly even from those of neighboring glaciers. This fact is usually attributed to differing reaction times of the glaciers with respect to climatic changes, which corresponds to the concept of low-pass filtering. Analyses of measured yearly glacier mass balances at three neighboring glaciers (Hintereisferner, Vernagtferner and Kesselwandferner in the Oetztal valley, Austria) have shown, however, that the climate signal characteristic for that region can be isolated only to a slight degree using filtering techniques.

More promising is the concept of the superposition of the individual parts stemming from climate change and changes in topography. For over 150 years the topographic part has been determined quantitatively using the numerous mappings of the three glaciers over time since 1884 when calculating specific mass balances under constant climatic boundary conditions. The resulting variation of mass balance is compared to the empirically determined one, which also includes climate-induced changes. The results even when using a simple modelling approach show that the topographically induced signal is most dominant when the glacier tongue reaches farthest down into the valley. A glacier surge, as observed at Vernagtferner around 1900, may even reverse the climatic trend in the glacier mass balance. A more detailed modelling study of Vernagtferner using the HBV3-ETH9 runoff

model additionally shows the impact of the equilibrium line altitude (ELA) apart from the influence of topography. With a low-lying ELA the impact of area changes, typically occurring in the lowest parts of the glacier, increases in relation to the total glacier.

In summary, the study shows that until the mid-20th century the trends in specific mass balances of Vernagtferner were controlled primarily by topographic changes due to ice-dynamical processes (fast advances, rapid meltback of the tongue). The study also reveals that it was not until recent decades that the climate change signal has become dominant in controlling glacier mass balance, stemming from the loss of glacier tongues, the almost complete halt in glacier movement, and the rising of the ELA to the uppermost parts of the glacier.

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Contribution: Poster presentation

The fingerprint of glaciers. Glaciological notes on the Alpe Veglia thematic trail: an example of scientific dissemination

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The book, created as part of the Interreg Project Italy-Switzerland called "SITINET: geological and archaeological sites in the Insubria Region", wants to illustrate the importance of the study of glaciers, of the landscape forms related to their current and past presence, and of the climate changes in order to make it more readable and understandable the geological landscape that surrounds us.
The publication is divided into two sections. The first, entitled "Why study a glacier" illustrates simply the basics of glaciology, starting from the basics on the definitions of the glacier, the dynamics and the methods of study and research, and then offer some reflections about the importance of glaciers as climate archives, addressing the issue of glaciation in the Alps. The second section details the points of interest along the glaciological route in Alpe Veglia and in the Alpe Veglia and Alpe Devero Natural Park, providing descriptions of geological, geomorphological and natural interests without neglecting information on historic and ethnographic issues. Accompanying texts, numerous photos, graphic reconstructions and drawings showing the geology of the area and the formation of the different morphologies related to the action of the glaciers.