Gemeinsame Tagung des AK Hochgebirge und der ARGE in Heidelberg

Abstracts

Three different glacier surges at a spot: What satellites observe and what not

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In the Karakoram, dozens of glacier surges occurred in the past two decades, making the region one of the global hotspots. Detailed analyses of dense time series from available optical and radar satellite images revealed a wide range of surge behaviours: from slow advances with slow ice flow over periods longer than a decade to short, pulse-like advances with high velocites over a few months. In this study, we present an analysis of three glaciers that are currently surging in the same region of the central Karakoram: North Chongtar, South Chongtar and an unnamed glacier referred to as NN9. Various optical (e.g. Landsat, Sentinel-2, Planet) and SAR (Sentinel-1, TerraSAR-X) satellite sensors combined with DEMs from different points in time (e.g. SRTM, SPOT, HMA DEM) are used to (1) obtain comprehensive information about the evolution of the three surges between 2000 and 2021 and (2) to compare and evaluate capabilities and limitations of the different satellite sensors to observe surges of comparably small glaciers in steep terrain. We found a contrasting evolution of advance rates and flow velocities for the three glaciers, while the elevation change patterns are more similar. Advance rates >10 km y-1, velocities up to 30 m d-1 and surface elevations raised by 200 m are derived for South Chongtar and a slow, almost-linear increase of advance rates (up to 500 m y-1), flow velocities below 1 m d-1 and elevation increases of up to 100 m for the three times smaller North Chongtar Glacier. The even smaller glacier NN9 shows a mixture of the surge behaviour of the two other glaciers. It seems that different surge mechanisms are at play in this region and that the mechanism can change within a single surge. We also found that sensor performance is dependent on glacier characteristics (size, flow velocity, amplitude of changes). Flow velocities could not be derived from Sentinel-1 for any of the glaciers. All considered DEMs have sufficient accuracy to detect the mass transfer during the surges and elevations from ICESat-2 ATL03 data bridge a data gap and fit neatly.

Zunehmender Schneefall in den Hochlagen: eine mögliche Erklärung für die “Karakorum-Anomalie”?

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Der Karakorum ist ein stark vergletschertes Gebirge im Westen Hochasiens und stellt eine essenzielle Süßwasserquelle für Millionen von Menschen im Indus-Becken dar. Im Gegensatz zu fast allen anderen Gebirgsregionen weltweit ist im Karakorum bisher kein ausgeprägter Gletscherschwund zu beobachten. Abnehmende Sommertemperaturen und zunehmende Winterniederschläge werden als mögliche

Ursachen für die Gletscher-Anomalie diskutiert. Fehlende meteorologische Langzeitmessungen und Studien zur Schneeakkumulation oberhalb von 3.000 m ü.d.M. erschweren jedoch die Verifikation dieser Hypothese. Um die räumliche und zeitliche Variabilität der Schneeakkumulation im zentralen Karakorum zu untersuchen und das Potenzial der Firnbecken als Klimaarchiv zu erkunden, haben wir uns auf die Spur einer kanadischen Forschungsexpedition aus dem Jahr 1986 zum „Snow Lake“ im zentralen Karakorum begeben. Im Sommer 2019, über 30 Jahre später, haben wir an den acht Standorten zwischen ca. 4.400 und 5.200 m ü.d.M. die Experimente der historischen Expedition wiederholt. In jedem Schneeschacht wurden Dichtemessungen bis zum Sommerhorizont des Vorjahres durchgeführt, um die höhenabhängige Veränderung des jährlich akkumulierten Schnees zu quantifizieren. Darüber hinaus wurden an drei ausgewählten Standorten Schneeproben für die Analyse von Seltenen Erden und stabilen Wasserisotopen entnommen, wodurch sich der Zeitraum und Ursprung des abgelagerten Schnees prinzipiell rekonstruieren lässt. Zuletzt wurden die neuen Messungen mit den 30 Jahre alten Ergebnissen der kanadischen Forschungsexpedition sowie mit unabhängigen meteorologischen Reanalyse-Daten verglichen, um Langzeittrends im Niederschlag in den Hochlagen des Karakorums festzustellen. Im Rahmen des Vortrags werden die Ergebnisse der Untersuchungen vorgestellt und im Kontext der Anomalie diskutiert.

Aufeis in Ladakh - Spatial and temporal dynamics in the Tso Moriri basin

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Aufeis is a common phenomenon in cold regions of the northern hemisphere that develops during winter by successive water overflow and freezing on ice-covered surfaces. Most studies on *aufeis* occurrence focus on regions in North America and Siberia, while research in High Mountain Asia (HMA) is still in an exploratory phase. This study investigates the extent and dynamics of icing processes and *aufeis* in the Tso Moriri basin, eastern Ladakh, India. Based on a combination of 235 Landsat 5 TM / 8 OLI and Sentinel-2 imagery from 2008 to 2021 the occurrence of icing and *aufeis* was classified using a Random Forest classifier. A total of 27 frequently occurring *aufeis* fields with an average maximum extent of 9 km² were identified, located at a mean elevation of 4700 m a.s.l. Temporal patterns show a distinct accumulation phase (icing) between November and April, and a melting phase lasting from May until July. Icing is characterized by high seasonal and inter-annual variability. Successive water overflow mainly occurs between January and March and seems to be related to diurnal freeze-thaw-cycles, whereas higher day-time temperature result in larger icing areas. *Aufeis* feeding sources are often located within or in close vicinity to wetland areas, while vegetation is largely absent on surfaces with frequent *aufeis* formation. These interactions require more attention in future research. Besides, this study shows the high potential of a machine learning approach to monitor icing processes and *aufeis*, which can be transferred to other regions.

Langfristige Variationen der Oberflächenhöhe des Fedtschenkogletschers, Pamir, aus terrestrischen und satellitenbasierten Beobachtungen

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Der Fedtschenkogletscher im Pamir ist einer der größten Gletscher Hochasiens und dominiert die vergletscherten Gebiete im zentralen Pamir. Der Gletscher wurde schon zu Beginn des 20. Jahrhunderts detailliert vermessen, so dass eine einzigartige Basis für Langzeitbeobachtungen der Gletscheränderungen existiert. Auf der Basis von mehreren Feldkampagnen und mit Hilfe von

optischen und Radar-Satelliteninformationen konnte die langfristige Entwicklung des Gletschers, sowie detaillierte Höhenänderungen der letzten zwei Dekaden untersucht werden. Ziel dieser Untersuchung ist es die widersprüchlichen Aussagen zur Stabilität der Gletscher im zentralen Pamir mit Hilfe neuer Daten neu zu bewerten. Zudem werden diese Beobachtungen in Bezug zu verfügbaren meteorologischen Informationen gesetzt. Die Analysen deuten darauf hin, dass die geringeren Massenverluste um die Jahrtausendwende vermutlich durch eine Anomalie in der langfristigen Niederschlagsentwicklung verursacht wurden.

Reconstruction of the climate, vegetation and fire history of the Sanetti Plateau, Ethiopia. Teil 1: The B4-archive

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We report on Last Glacial environmental fluctuations in about 4000 m asl on the Sanetti Pateau in the Bale Mountains, based on biogeochemical and palynological analyses of laminated lacustrine sediments. After deglaciation at about 18 cal kyr BP, a steppe like herb-rich grassland with maximum Chenopodiaceae/Amaranthaceae and Plantago existed. Between 16.6 and 15.7 cal kyr BP, conditions were dry with a desiccation layer at ~16.3 cal kyr BP documenting a short phase of maximum aridity on the plateau. While that local event lasted for only a few decades, concentrations of various elements (e.g. Zr, HF, Nb, Nd and Na) started to increase and reached a maximum at 15.7 cal kyr BP. We interpret those elements to reflect allochthonous, eolian dust input via dry northerly winds and increasingly more arid conditions in the lowlands. We suggest an abrupt versus delayed response at high and low altitudes, respectively, in response to Northern Hemispheric cooling events (the Heinrich Event 1). The delayed response at low altitudes might be caused by slow negative vegetation and monsoon feedbacks that make the ecosystem somewhat resilient. At ~15.7 cal kyr BP, our record shows an abrupt onset of the African Humid Period, almost 1000 years before the onset of the Bølling–Allerød warming in the North-Atlantic region, and about 300 years earlier than in Lake Tana region. Erica pollen increased significantly between 14.4 and 13.6 cal kyr BP in agreement with periodically wet and regionally warm conditions. Similarly, intense fire events, documented by increased Black Carbon contents, correlate with wet and warm environmental conditions that promote the growth of Erica shrubs. This allows to conclude that biomass and thus fuel availability is one important factor controlling fire events in the Bale Mountains.

Rekonstruktion der Klima-, Vegetation- und Feuer-Geschichte des Sanetti Plateaus, Äthiopien. Teil 2: Wulfsee-Sedimente

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Der Wulfsee liegt wie das B4-Archiv auf dem Sanetti Plateau im Bale Nationalpark in 4000 m asl. Im Gegensatz zum B4-Archiv hat es ein deutliches Einzugsgebiet und war während der letzten Vergletscherung von einem Kargletscher bedeckt. Seine Sedimente konnten bis 480 cm beprobt werden, der holozäne Teil in hoher Auflösung. Über dem dichten, zermürbten Basalt an der Basis folgen ca. 250 cm mächtige, braune, tonige Sedimente, abgelagert zwischen ca. 16,2-12 ka BP. Die jüngeren Sedimente oberhalb 160 cm sind dunkelgrau und laminiert. Die 14C-Daten zeigen, dass der Gletscher im Wulfsee-Becken um ca. 16,2 ka BP abschmolz. Unter vermutlich relativ trockenen Bedingungen (Heinrich Event 1) wurden bis 15,7 ka BP humusarme Sedimente, reich an vulkanischen Mineralen, abgelagert. Anschließend steigen die Humusgehalte deutlich an, was auf günstige Bedingungen für Biomasse-Produktion bzw. Biomasse-Eintrag hinweist, vermutlich im Zusammenhang mit der African Humid Period. Zwei Humus-Maxima um ca. 12,5 und ca. 8,5 ka BP interpretieren wir als Versumpfungszonen während der Younger Dryas und während trockener Phasen um 8,5 ka BP. Die bisher vorliegenden Alkan-Daten bestätigen für den unteren Teil der Sedimente zunächst trockene Bedingungen (H1), gefolgt von humiden Verhältnissen (AHP), dann eine deutliche Austrocknung während der Younger Dryas, sowie um 8,5 ka BP und ab ca. 4 ka BP. Die Black Carbon-Gehalte weisen ein Maximum von ca 9 g kg^{-1} um ca 15 ka BP auf, während der Beitrag von Black Carbon zum Humus um 16 ka BP am höchsten ist (ca 25%).

Do trees make forests? The alpine Anthropocene in the Bale Mts (SE Ethiopia): Pending questions of the DFG-FOR 2358

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Single trees and isolated tree-groves in treeless environments witness detrimental climatic changes or human-induced depletion of forests. The case-study of Erica trees in afroalpine heathlands of the Bale Mts in SE Ethiopia shares the uncertainties to understand (1) tree-growth and treelines in the ecotonal Ericaceous Belt of the East African mountains, and (2) the age of the alpine Anthropocene:

- Erica trimera changes from tree-growth of 20 m in 3000 m to dwarf-shrub of 20 cm in 4270 m, and from forests and thickets to isolated trees and dwarf-shrubs between the slope and the plateau of the Bale Mts.
- Burning, fire-wood extraction and browsing has reduced the Erica-cover, documented since the 1970s, but presumed since 41 ka BP with the occupation of Middle Stone Age hunters.
- Erica groves, thickets and dwarf-shrubs are prevalently but not exclusively bound rocky slopes, protected from fire and access.
- Erica flowers abundantly, but seedlings are only common in the lower Ericaceous Belt and absent in afroalpine heathlands except of ‘kindergarden’-patches next to mother trees.

The pattern of isolated trees in afroalpine heathlands and the absence of seedlings remains enigmatic.

Fortlaufende Arbeiten zur Rekonstruktion von Mensch-Klima-Umwelt Geschichte anhand von Biomarkern und Stabilisotopen im Fotschertal, Stubaier Alpen, und in Äthiopien

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Im Rahmen von zwei kürzlich beendeten bzw. fortlaufenden DFG Projekten realisiert die AG Zech an der TU Dresden Biomarker- und Stabilisotopenanalysen. Ziel ist es, Beiträge zur Mensch-Klima-Umwelt Rekonstruktion in den Alpen und in den äthiopischen Bale- sowie Arsi-Mountains zu leisten. So lieferten die Untersuchung von Pflanzenwachs-bürtigen Alkanbiomarkern und fraktionsspezifische 14C-Datierungen am mesolithischen Fundplatz Ullafelsen im Fotschertal nahe Innsbruck wertvolle neue Erkenntnisse über die pedogenetische Entstehung des Fundplatzes (Zech et al., 2021). Die Konzentration und Muster von Benzolpolycarbonsäuren belegen den menschlichen Einfluss durch Feuer während des Mesolithikums. Dagegen lässt sich der Eintrag menschlicher Fäkalien anhand von Biomarkern nicht nachweisen (Lerch et al., 2022). Vielmehr belegen die Fäkalbiomarkermuster zusammen mit den stark erhöhten 15N Gehalten eine sehr starke anthropo-zoologische Beeinflussung durch Schafe und Kühe. Fortlaufende und geplante Arbeiten konzentrieren sich auf eine zeitliche höhere Auflösung der Mensch-Umwelt-Klima Rekonstruktion im Fotschertal anhand von Moorarchiven. Im Äthiopienprojekt stand gemeinsam mit der Forschergruppe DFG 2358 „The Mountain Exile Hypothesis“ unter anderem die Untersuchung der Seesedimente des Garba Guracha in 3950 m üNN in den Bale Bergen im Fokus. Aus methodischer Sicht konnten beispielsweise sedimentäre Zucker als aquatische Biomarker (Bittner et al., 2022) und der sog. „Paläohygrometer-Ansatz“ basierend auf der Kopplung von δ2H-δ18O Isotopenergebnissen (Lemma et al., 2021) validiert werden. Fortlaufende Arbeiten zielen insbesondere auf eine zeitlich höher aufgelöste Klimarekonstruktion für siedlungsgeschichtlich besonders relevante Zeitabschnitte ab.

Referenzen

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The potential of boulder-dominated periglacial and related landforms as palaeoclimatic and morphodynamic indicators in selected areas of South Norway

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Boulder-dominated periglacial, paraglacial and related landforms are important elements which can help to improve our knowledge about past climatic conditions and morphodynamic processes. As the formation and stabilization of these landforms can be associated to cold or transitioning climatic conditions from cold to warm, putting them on a solid temporal basis is vital to connect their evolution to

changing climatic conditions throughout the Holocene. In this study, Schmidt-hammer exposure-age dating (SHD) was performed at different landforms including sorted polygons, rock-slope failure deposits and a blockfield in and around Breheimen and Rondane, South Norway. By obtaining an old and a young control point, it is possible to calculate a calibration curve, from which the respective landform ages were estimated. SHD age estimates from Breheimen ranged from 8.02 ± 0.72 to 3.45 ± 0.70 ka showing their relict character. The sorted polygon ages of 6.55 ± 0.68 and 4.76 ± 0.63 ka point to a stabilization within and towards the Holocene Thermal Maximum (HTM; ~8.0–5.0 ka) and considerably younger than comparable landforms from Jotunheimen. Whereas the ages of the investigated rock-slope failures from 8.02 ± 0.72 to 3.45 ± 0.70 ka can be divided in two groups. The first group consists of two rock-slope failures with overlapping ages with a mean age of ~7.6 ka. This timing can be related to the onset of the HTM characterized by warmer temperatures possibly leading to slope weakening due to a variety of factors, such as permafrost degradation and increasing cleft-water pressure. Ages of the second group, with three rock-slope failures, cluster around ~3.7 ka, shortly after a cold climatic period between 4.75–3.85 ka. Therefore, we assume that the occurrences of these rock-slope failures could have been climatically induced by warmer temperatures. The blockfield age of 5.24 ± 0.79 ka is significantly younger than other dated blockfields in South Norway, e.g. in Rondane and indicates longer activity of the boulders at the blockfield surface. Surface exposure ages from boulder-dominated landforms stress that these landforms can be valuable elements in improving our knowledge about landform evolution and palaeoclimatic fluctuations within the Holocene in South Norway.

How does spatial heterogeneity affect inter- and intraspecific growth patterns in tundra shrubs?

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Arctic and alpine ecosystems are strongly affected by rapidly changing environmental conditions, resulting in profound vegetation shifts, which are highly heterogeneous and hard to predict, yet have strong global impacts. Shrubs have been identified as a key driver of these shifts. In this study, we aim to improve the understanding of how such broad-scale vegetation changes are locally impacted by inter- and intraspecific plasticity and topographically driven heterogeneity in microsite conditions. We assessed continuous stem diameter variation of three dominant tundra shrub species at daily resolution during 5 years, using high-precision dendrometers, thus bridging the gap between classical dendroecology and plant physiology. From this data, we identified distinct growth patterns which we linked to microsite environmental drivers. The observed patterns appeared highly variable depending on site and species, strongly influenced by the characteristics of the individual plant. As the main driver of this variability, we identified fine-scale topographic complexity, causing the sampled specimens to adjust locally by developing distinct growth strategies. We found these strategies strongly related to snow-cover variation and associated freezing and thawing. Predicted changes in winter conditions and associated snow regimes will therefore have strong effects on shrub growth and community structure, yet, these effects are highly complex and not uniform in direction. The ability to adapt in a heterogeneous environment appeared highly differentiated between species and closely connected to intraspecific plasticity. Here, we identified spatial variability related to local topography as a main indicator for potential future redistribution and niche shifts in response to environmental change.

Season length – not temperature – explains inverse Bergmann's clines in the common alpine tundra ground beetle *Amara alpina* (Paykull 1790)

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Alpine tundra ecosystems are projected to be severely impacted by global climatic changes. This concerns invertebrates especially, which play a key role in arctic-alpine food webs. Adaptations of body size are considered a universal response to climatic changes. Body size, in turn, governs the overall fitness of an individuum, as it influences the accessibility of food resources as well as mobility and reproductive success. Gradient-based approaches reveal that there is no universal pattern of body size clines. Moreover, it seems that mobility and life history facilitate the development of physiological adaptions. Especially less mobile species, such as the widespread alpine tundra carabid *Amara alpina* (Paykull, 1790), seem to display a decrease of body size along elevational gradients. This provokes the question which climatic drivers govern the decrease in body size. To find an answer, we measured 900 specimens of *Amara alpina* from all over Norway. We tried to explain the observed patterns with a random Forest approach using climatic data from the Senorge.no service in a 1x1 km resolution. Our results reveal a) the existence of two distinct morphological groups, and b) season length to be the primary driver of these patterns. The thermal parameters we tested did not serve well as explanatory variables. Here, we interpret these findings, which address different aspects of life history and its feedbacks to snow cover patterns in the alpine tundra.

A conceptual framework for mountain ecology

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At the risk of beating a strawman, I will recall a few basic principles and concepts that I feel are imperative for high elevation ecological research. It starts from a consistent, agreed upon, definition of mountains and their bioclimatic belts, and the trivial fact that organisms and entire ecosystems do not respond to meters of elevation but to the climate they actually experience. Hence appropriate climatology and microclimatology is key. I will explain why the agronomic concepts of stress and limitation must fail in a natural setting. When it comes to abiotic and resource limitation of plant growth, all evidence we have, indicates that carbon is not a rate limiting resource. Irrespective of resource supply, actual growth activity is under strong developmental (genetic) control with ecotypic, that is, evolutionary settings. This will limit responses of biomass production to rapid climatic change. The key to predict future vegetation change in high mountains is (a) a mechanistic concept of what we call a 'growing season', (b) to account for microtopography effects, and (c) to account for stochasticity (extreme events, disturbances). I will close by referring to the first five years of results of a multidisciplinary long-term monitoring program in the Alps along micro-snowmelt gradients (Austrian Hohe Tauern, S-Tyrol, Swiss Furka region). I will conclude that the alpine belt will shrink by the upslope advance of treeline, a loss that will be hardly balanced by novel terrain released by glaciers. However, alpine biota presumably are the most robust world-wide in terms of species losses should warming continue. This is so, because thermal habitat diversity provides short distance escapes as they do exist nowhere else. So, I suggest, the ongoing vulnerability debate better focusses to where it belongs to: the safety of people and their infrastructure in mountains.

Suggested reading:
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Folgenabschätzung für einen Gletscherseeausbruch in Bhutan

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Der aktuelle Gletscherschwund lässt vielerorts neue proglaziale Seen entstehen oder vergrößert bereits bestehende. Dadurch erhöht sich das Gefahrenpotenzial für Gletscherseeausbrüche (GLOFs). Mit Hilfe des hydrodynamischen Modells HEC-RAS wurde der Ausbruch eines potenziell gefährlichen Sees in Bhutan simuliert. Weil sowohl das genaue Ausbruchsvolumen als auch die Gerinnerauigkeit unbekannt sind, wurden verschiedene Ausbruchsszenarien erstellt. Auf einem digitalen Geländemodell mit 5 m Auflösung wurden sowohl die Fließgeschwindigkeiten als auch die Überflutungsflächen und –tiefen berechnet. Für das Fallbeispiel des Mo Chu Einzugsgebiets zeigt sich, dass selbst beim ungünstigsten Szenario nur wenig Schäden an Wohngebäuden zu erwarten sind. Trotzdem würde ein Ausbruch dieser Größenordnung vermutlich Infrastruktur und ackerbauliche Nutzflächen zerstören und könnte sich sogar noch 120 km flussabwärts der Ausbruchsstelle auf den Betrieb eines Wasserkraftwerks auswirken. Die Modellierung hat außerdem gezeigt, dass bei Verwendung eines gröberen Geländemodells (30 m) die Flutwelle deutlich überschätzt wird, was den Einsatz hochauflösender Daten für diese Zwecke dringend nahelegt. Die Ergebnisse beinhalten wichtige Informationen für den lokalen Katastrophenschutz und stellen wertvolle Grundlagen für Planungen zur Risikominimierung dar.

Water conflicts in the Upper Huasco Valley, Chile – a hydrosocial perspective

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In arid mountain regions such as north-central Chile, limited water availability and water quality are influenced by climatic variability and associated droughts, agricultural land-use change and mining activities. The stress on the scarce resource, which is highly dependent on the Andean cryosphere, exacerbates conflicts between different water users, such as agricultural producers, mining companies, and local communities across the region. Based on an integrated perspective on human-water-relations, our case study assesses changing water demands and associated conflicts in the Huasco valley. The study choses a multi-method approach. Empirical research combines interviews, remote sensing and water sampling to shed light on the complex hydrosocial entanglements in the valley. We analyse land-use change and assess uneven power relations of actors on multiple scales that are key for an improved understanding of the changing waterscape. The area has witnessed conflicts over water governance ever since the Pascua Lama gold mine became a focus of resistance for the controversial extraction of mineral resources in the Andean Main Cordillera and received increasing media attention. Environmental impacts of mining activities on glaciers and regional water availability have been in the foreground in this conflict. At the same time, competing water demands are fuelled by the intensification of export-oriented agriculture. The results show the expansion of water intensive agricultural land-use, cryosphere change and the impact of mining, and relate these processes to the discourses on water scarcity. The analysis further indicates the competing interests of actors with uneven power relations and the different meanings attributed to water and glaciers. The case study stresses that such integrative hydrosocial assessments of water conflicts are needed for a better understanding of water scarcity and related conflicts and as a base for more equitable water governance.

Ecological restoration in the high Andes of Colombia: the challenges of community-based initiatives

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Land degradation is increasingly recognised as a serious problem in the high Andes, in particular in the context of the hydrological functions of mountain forests and páramos. In Colombia, initiatives to counteract this problem and restore ecosystem functions vary in scale from national political

commitments to local community-based, private and academic actions. While in the past monocultures of exotic tree species were widely promoted, nowadays native species have become priority restoration material in many of the actions (whereby "native" is variably defined). Some of these actions have capacitated and strengthened local communities and greatly enhanced biodiversity and soil functions, while others have difficulties in getting off the ground or have been discontinued before significant improvements were achieved. In addition, most initiatives lack monitoring plans that would allow the actors to analyse the outcomes of their actions and to adapt to the dynamic conditions of the mountains in which the restoration is carried out. In our research project we aim to understand the institutional and governance structures behind community-based restoration initiatives and their effects on social and ecological outcomes of these projects. We will present some first observations on the functioning of community-based restoration projects in the Colombian high Andes and the factors that have allowed or have hampered the sustainability of these projects. We welcome discussion on conceptual and methodological approaches to this complex but highly interesting topic.

High nature value of abandoned alpine pastures – safeguarding biodiversity and multiple ecosystem services by regrazing

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European grasslands have evolved under centuries of extensive human use and harbor much of the biodiversity of the Eurasian continent. In particular, high-altitude alpine pastures have characterized the European Alps for centuries. However, they have been increasingly abandoned since the 1950s, while intensification of use has taken place in the valleys. The abandonment of traditional alpine farming on mountain pastures is the strongest land use change in the European leading to undesired changes in soil functions as well as loss of biodiversity. Recently, climate change is facilitating faster woody encroachment into abandoned Alms and finally, reforestation. Without grazing, the exceptionally species- and flower-rich mountain pastures performing multiple provisioning, regulating and supporting ecosystem services (maintaining biodiversity and beauty, providing biomass and fodder, storing carbon, and nutrients, protecting water bodies against nutrient pollution, regulating soil erosion and avalanches, supporting flower resources to pollinators and thus maintaining trophic networks) undergo succession to grass-dominated plant communities. Re-grazing of abandoned alpine pastures is a practicable measure to preserve the high nature value. Here, we report scientific findings from a unique re-grazing project performed by an association of alpine farmers, scientists, representatives of agricultural and nature conservation authorities as well as nature conservation associations. We synthesize the first results after five years of extensive re-grazing, monitoring multiple ecosystem parameters related to soil functions, to primary production as well as to the biodiversity of different species groups (e.g. plants, insects, birds) and highlighting the important and unique aspects of the local biodiversity in the Northern Limestone Alps. In 2018, after 63 years of abandonment, we started to revitalize the Brunnenkopfalm in the Ammergauer Alps (Bavaria, Southern Germany), an alpine biodiversity hotspot harboring about 250 plants species. Soil biochemical cycles and freshwater quality remained unchanged so far, although we expect long term changes. This new and long-term regrazing experiment aims at analyzing efficient conservation strategies for ecosystems of high nature value and important service provisioning.

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