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Collection of abstracts

Geographical patterns of the fits between modelled and observed alpine treelines and upper forest limits globally

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The climatic upper limit to tree growth, the alpine treeline, is thought to be predictable on a global scale. We validated the most recent formal prediction, which was based on a model using growing season length and temperature plus water availability (Paulsen & Körner 2014) applied globally based on CHELSA climate data (Karger et al. 2019). Although the oroginal publications reported a very good global fit, our geographically diferentiated evaluation with a larger set of validation points (1245 points globally) showed very interesting geographical patterns in the model bias. Most interestingly, we found that in some regions the model predicted climatic treelines below observed forest limits, i.e. forest growing above treeline, which is, by definition, not possible. Such situations were found in very wet regions and those with very low annual thermal seasonality (Patagonia, the Canadian Coast Mountains, the Altiplano) and still await an explanation.
We corrected the treeline predictions for these biases, since we were interested in mapping how far actual upper forest limits are removed from this potential, climatic treeline, as an indication of the conservation status of global mountian areas. We determined the vertical distance of all current upper forest limits to this corrected climatic treeline, at a 1-km^2 resolution. We found that the vast majority of upper forest limits were located well below the potential treeline, with a median of about 500 m at temperate and between 750 and 1000 m at tropical and subtropical latitudes. These deviations are partly natural, but the largest are very likely caused by millenia of high-elevation land-use. The maps porduced can inform conservation and management decisions, although local contexts should always be considered, and provide a baseline for interpreting and predicting the responses of treeline ecotones and other upper forest limtis to climatic change.

A multiyear study on sensitivity and response of the treeline ecotone to climate warming in Rolwaling Himal, Nepal

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Alpine treelines will shift upslope in the course of climate change, at least in the long term, unless not prevented by non-thermal site factors. Most empirical studies in mountains of the world found treelines to be advancing, but quite a few assessed a distinct persistence of treeline elevations. In order to explain inconsistent response patterns, many-faceted interactions between climate warming as a global/regional input variable and modulating factors at local scales (the complexes of abiotic and biotic site factors as well as site history and anthropogenic influences) and their interrelationships have to be analysed. These analyses were integrated into a multiyear study on sensitivity and response of the treeline ecotone to climate warming in Rolwaling Himal, Nepal. In Rolwaling, upper subalpine forests of tall, upright growing *Abies spectabilis* and *Betula utilis* give way at the treeline to *Rhododendron campanulatum* krummholz at 3900-4000 m. The treeline position in Rolwaling is lagging behind climatic changes. Lag factors, non-thermal drivers, and feedback processes are largely related to the dense krummholz zone, acting as an effective barrier for upslope migration of other tree species. Feedback processes in the self-sustaining *Rhododendron* krummholz create site conditions such as nutrient deficiency, reduced light availability, and lower soil temperatures, that severely restrict the competitiveness of other tree species, further constrained by allelopathic effects of *Rhododendron*. Tree growth-climate relationships show that climate warming-induced moisture deficits during pre-monsoon seasons have adversely affected radial tree growth of *Abies spectabilis* and *Betula utilis* over recent decades, also playing a role in retarded treeline dynamics. Regardless of stand densification and high levels of recruitment, even above the krummholz zone, a treeline shift to higher elevation is only to be expected in the medium to long term (decades to centuries).

Studying treeline ecotones at the northern face of the central Alborz Mountains, North Iran

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Mountains contain several ecotones between different vegetation types under steep climatic gradients. The importance of ecotones in mountains is often noted when treeline ecotones are discussed since climatic warming might cause an upslope ascent of alpine treelines. Though, the spatial patterns of treeline ecotones (abrupt or gradual) are determined by particular combinations of climatic conditions, the topographic template, species composition and disturbance history. The origin and the process of a treeline pattern, whether abrupt or gradual, remains only loosely defined.

The Alborz Mountains are located in the north of Iran, at the southern shore of the Caspian Sea. Temperate climate and high amounts of precipitation (between 500 and 1500 mm per year) allow the presence of closed Hyrcanian forests on north-facing slopes, a form of temperate deciduous broad-leaved forest dominated mainly by Fagus orientalis. The upper limit of these forests is dominated by Quercus macranthera, which marks the transition zone to current alpine vegetation. Although the thermal life conditions above the Quercus macranthera zone (2400-2850 m a.s.l.) are suitable for tree growth, trees are absent. The reasons for the absence of trees are still not clear. In this regard, we intended to test the hypotheses related to climate, edaphic conditions and seedling establishment to analyze the dynamics and the underlying processes of treeline spatial patterns in the Alborz. We

collected data on vegetation, soil, topography, and other site conditions along three elevational transects from closed forests in the subalpine belt across the treeline ecotone to the alpine vegetation above the uppermost tree individuals. From the data collected, the special pattern of the treeline (with a focus on seedling establishment) and the possible explanations for the absence of trees above the current Quercus macranthera limit will be discussed.

Forest Expansion in the Nepal Himalaya

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In the 1970s and 1980s, predictions of near-complete deforestation of the Nepal Himalaya by the turn of the Millennium culminated in the Theory of Himalayan Environmental Degradation which identified agricultural expansion due to population growth as the main cause of deforestation and forest degradation. 50 years later, processes of deforestation and forest degradation in Himalaya have not only slowed down but have, in some cases and regions, even been reversed. The forest cover of Nepal has almost doubledbetween 1992 and 2016 with most of the forest gain in the Mid Hills of Nepal. Change of cropland to forest now outweighs change of forest to cropland. These changes, to all appearances and appear to be driven to a large extent by community forestry and by abandonment of agricultural land. Community forestry was introduced to Nepal already in the 1970s and has been highly successful in terms of increasing forest cover and improving forest quality. Agricultural land abandonment has many causes but is mainlydriven by the outmigration of young farmers to international labor markets. While the international response to this development is overall positive, acase study from Sindhupalchok and Kavrepalankchok Districts has shown that the local response can be quite different and that for at least some farmers, the risks and hazards associated with regenerating forest, e.g. human-wildlife conflicts,outweigh the potential benefits of this process.The presentationdraws on the work of a team of researchers from Singapore, Nepal, Finland and Germany, andintroducesa recently initiated project to study vegetation regeneration processes on abandoned farmland, the implications of these changes for the livelihoods of local people, and forestry as well as agroforestry options for optimizing benefits and mitigating risks.

Der Belvedere Gletscher, Monte Rosa: Veränderungsdetektion seit der Kleinen Eiszeit

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Infolge des Klimawandels ist ein rasanter Gletscherrückgang in den Alpen zu beobachten. Neben diesem starken Rückgang ist auch eine Zunahme der Schuttbedeckung und damit eine deutliche Vergrößerung der schuttbedeckten Flächenanteile auf Gletschern zu verzeichnen. Am Beispiel des Belvedere-Gletschers, der sich an der Ostabdachung des Monte Rosa Massivs in den westlichen Italienischen Alpen befindet, werden die Gletscherveränderungen mit kombinierten Methoden analysiert. Der Gletscher stellt einen der wenigen Gletscher in den Alpen dar, der durch ein surge-Ereignis gekennzeichnet ist. Auf Basis von historischem Bild- und Kartenmaterial kann die Gletscherentwicklung wie auch die Schuttbedeckung bis in das frühe 19. Jahrhundert visualisiert und rekonstruiert werden. So hat bereits Schlagintweit 1851 eine erste Kartierung des Gletschers und seiner Schuttbedeckung vorgenommen. Mit aus stereoskopischen Luft- und Drohnenbildern generierten digitalen Geländemodellen können Volumenveränderungen detailliert erfasst werden und damit zugleich der Einfluss von Schmelzbahnen und Wasserkörpern auf dem Gletscher untersucht werden. Die Untersuchungen werden in einer Forschungskooperation 4EU+ zwischen den Universitäten Prag, Milano und Heidelberg durchgeführt.

Estimating mean depth and volume of glacial lakes in the upper Indus, Ganga and Brahmaputra basin, Hindu-kush-Himalayas

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Glacial lakes are vital component of high-mountain landscape across the world. Glacial lakes serves several purposes such as providing freshwater for domestic and industrial uses, providing habitat for local flora and fauna, navigation, tourism, etc. However, due to rapid melting of glaciers in the high mountainous systems across the world, glacial lakes are expanding at an unforeseen rates. This rapid expansion of glacial lake have several unfavorable outcomes as well. Increase in Glacial Lake Outburst Floods (GLOFs) risk, contributing to the faster melting of parent glaciers, and greater absorption of the solar radiation are few of them. Therefore, continues monitoring of glacial lakes is of immense importance.

In the present study, we attempted to estimate the mean depth of glacial lakes and volume of glacial lakes in the three major basin of South Asia, namely Indus, Ganga and Brahmaputra. We developed eight empirical equations based on the existing dataset to estimate the mean depth and volume of glacial lakes in the upper Indus, Ganga and Brahmaputra (IGB) basins. The mean estimated depth of glacial lakes in the upper IGB basin was estimated to be 11.47 m, whereas the average estimated volume of glacial lakes was 1.63*106 m3. Furthermore, we found, that shape of the glacial lakes plays a crucial role in determining the relationship between area of glacial lakes and mean depth, and area and volume.

The present study, provides vital insights about the mean depth and volume of glacial lakes in the upper IGB basin, which will help future researchers and policy makers in identifying potentially hazardous glacial lakes and developing robust policies to mitigate the impact of future GLOF events.

Gya revisited: Entwicklung eines proglazialen Sees im Trans-Himalaya von Ladakh

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Im Jahr 2014 kam es zu einem Gletscherseeausbruch (GLOF) in Gya, einem Tal mit gleichnamiger Siedlung im Süden von Ladakh. Im Vortrag wird die Entwicklung des auf 5400 m gelegenen und zumeist eisbedeckten Gletschersees auf Grundlage multitemporaler Fernerkundungsdaten mit hoher zeitlicher und räumlicher Auflösung und wiederholten Geländebegehungen (Oktober 2014, August 2019, September 2023, Januar 2024) mit standortgenauen Wiederholungsaufnahmen aufgezeigt. Die lokale Fallstudie wird in ein regionales Inventar der Gletscherseen im Trans-Himalaya von Ladakh eingebunden, um das potenzielle Risiko künftiger GLOFs zu bewerten. Die Fallstudie veranschaulicht das Problem, dass potenziell ausbruchsgefährdete Seen in Inventaren übersehen werden. Erforderlich ist ein verbessertes Verständnis unterschiedlicher Ausbruchsmechanismen, das zu einer genaueren Bewertung der Gefährdung durch GLOFs beitragen kann.

Uncovering the secrets of dirty glaciers with UAV-based infrared thermography

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Dirty glaciers – those covered with rocky debris – occur in many mountain ranges and play animportant role in the regional hydrological cycle. However, modelling the surface mass balance, runoff contribution and future evolution of debris-covered glaciers is fraught with uncertainty because accurate observations of small-scale variations in debris thickness and sub-debris ice melt rates are available for only a few locations worldwide. Here we present the results of an experiment on the Kanderfirn in the Swiss Alps where we combined in-situ measurements, UAV-based infrared thermography and numerical modelling to uncover spatial variations in supraglacial debris thickness and trace sub-debris ice melt during the 2023 ablation season. The detailed mapping revealed typical small-scale debris features and debris thickness patterns that are not spatially resolved by the thermal infrared sensors of current-generation satellites. Accounting for sub-debris ice melt processes and for the high

spatial variabilty of debris thickness in glacier models is essential to reliably predict the surface mass balance, meltwater contribution and evolution of dirty glaciers.

A Late Glacial and Holocene paleoclimate record from Africa's largest afro-alpine ecosystem, the Bale Mountains in South Eastern Ethiopia

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Understanding past climate variabilities and extremes and their influence on hydrological dynamics is of paramount importance for successfully forecasting and mitigating future climate challenges. Afro-alpine ecosystems offer pristine climate archives mainly due to their remoteness from modern anthropogenic influences. The Bale Mountains in the Southeastern Ethiopian Highlands are the largest and most contagious afro-alpine ecosystem in Africa. They are also situated in close proximity to the East African rift which is the home of many early hominins. The juxtaposition of rift and alpine systems coupled with complex climate dynamics offer a unique perspective to understand pre-industrial climate –human interaction.

During a field campaign in 2017, sediment cores from up to 4.8 m depth were retrieved from the shorelines of Central Lake on the Sanetti Plateau in the Bale Mountains. 12 radiocarbon dates were used to establish a 17 ka chronostratigraphy. In our contribution, we present preliminary results from a multi-proxy approach (cf. Bittner et al., 2022a,b) focusing on this archive. This includes stable isotope records established using sugar and n-alkane biomarkers as well as temperature and lake water chemistry reconstructions using branched glycerol dialkyl glycerol tetraethers (GDGTs). Despite physiographic differences, microclimate systems and the influence of several climate forcings, our record mostly agrees with records from the low land and rift as well as to some degree with global deep sea and ice records.

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How straightforward is δ18O derived from alpine peat archives as paleoclimate proxy? A case study from the Fotsch Valley in the Stubai Alps, Austria

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The stable oxygen isotopic composition δ18O serves as invaluable proxy for reconstructing climate history from many archives including peat archives. However, recent research has increasingly emphasized the role of other potentially influencing factors than climate such as plant physiology for shaping (hemi-)cellulose-derived δ18O signals. The Fotsch Valley in the Stubai Alps, Austria, has been the subject of geoarchaeological and paleoenvironmental investigations for many years (e.g. Zech et al., 2021). Recently, Lerch et al. (2023) presented a first Holocene δ18O record established for hemicellulose-derived sugar biomarkers from the so-called „Potsdamer Hütte Mire“(1970 m a.s.l.) and tentatively interpreted the record in terms of dry versus humid climatic variability. Currently, we extend the δ18O dataset and additionally study modern vegetation on its δ18O signal. In our contribution, we will present the respective preliminary results and scrutinize the potential impact of changing plant communities on the (hemi-)cellulose-derived δ18O records of the peat archives in the Fotsch Valley as well as as in general.

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Zur Vegetationsgeschichte des Riß/Würm-Interglazials in den Allgäuer Alpen

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Aus dem südlich von Imberg bzw. unweit von Sonthofen gelegenen Kiendelsbachtobel wird ein rund 11 mächtiges Komposit-Pollenprofil vorgestellt, das im Hangenden von würmeiszeitlichem Vorstoßschotter überlagert wird, der von schluffig-kiesiger Moräne mit Blöcken abgelöst wird. Im Liegenden der teils limnischen, vorwiegend tonigen Ablagerungen mit zwei zwischengeschalteten Schieferkohlelagen stehen zuerst konglomerierte Schotter mit eingeschalteten Bänderschluffen an, die von mächtigen Bänderschluffen und schließlich rißzeitlicher Grundmoräne unterlagert werden. Nach geologischen Kriterien datieren also die (See)Tone mit den eingeschalteten Schieferkohlelagen entweder in die letzte Warmzeit, das Riß/Würm-Interglazial, oder aber in eine Erwärmungsphase bzw. ein Interstadial des Frühwürm. Um diese Frage zu klären wurden die aus dem Aufschluss stammenden Proben mit dem Ziel einer möglichst genauen Datierung pollenanalytisch untersucht.

Erstmalig konnte mit dem Pollenprofil Kiendelsbachtobel ein Eem-Profil aus höherer Lage am Rand der nördlichen Kalkalpen untersucht werden. Das aufgeschlossene Profil liegt auf fast 1000 m Meereshöhe, also in der Montanstufe und deutlich höher als alle anderen süddeutschen Eem-Stratigraphien. Da die Schieferkohlen auf Erlenbruchwaldtorfe zurückgehen, ist die Pollenführung wechselhaft und die Pollenerhaltung mäßig. Dennoch ist die Sequenz von der protokratischen bis zur telokratischen Phase des Interglazials fast vollständig und zeichnet trotz der teils stark erhöhten Alnus-Anteile ein relativ klares Bild des waldgeschichtlichen Ablaufs nach. Picea spielt eine größere Rolle als in tiefer-gelegenen Profilen, auch im Vergleich zu Abies, und Carpinus eine viel geringere. Zudem sind die zeitweilig häufigen Nachweise von Ilex aquifolium bemerkenswert. Die Nachweise von diesem Taxon verweisen auf ein wintermildes Klima zu jener Zeit. Der obere Teil des Profils (Pollenzone 9 und 10) lässt sich nicht eindeutig biostratigraphisch einstufen. Entweder ist noch das ausgehende Riß/Würm-Interglazial erfasst oder aber schon das Frühwürm mit dem 1. Stadial und gegebenenfalls auch einem fragmentarischen 1. Frühwürm-Interstadial repräsentiert.

Flower colour communities across elevation - a case study on calcareous vs silicious bedrock from the European Alps

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Flower colour plays an important role in structuring plant communities and is under selection by pollinators. Recently, the significant discrepancy between flower colour vision by humans versus pollinators has been discussed, which must be taken into account when considering the role of flower colour in communication with pollinators. Since bedrock and soI've oil conditions are known to affect plant community composition, and can also affect

flower colour directly, studies on flower colour composition of a community should include bedrock as an environmental variable. Elevational gradients in high mountain ranges are particularly suitable to study patterns and drivers of plant community diversity, including plant functional trait distribution relevant for trophic interactions.

We measured flower colour spectra within six highly diverse grasslands on both calcareous and silicious bedrock across an elevational gradient in the European Alps: Hohe Leite (500 m asl), Brunnenkopfalm (1500 m), Obergurgl (2500 m), Kaserstattalm Stubai (1850 m), Arnspitze (1700 m) and Furkapass (2400 m). We collected flowers or petals of 315 locally occurring, insect-pollinated plants and measured their light reflectance property using ocean optics spectrophotometer. We used the 'bumblebee color vision model' to translate spectral data into "bee-colours" because bumblebees are representative insect pollinators from low to high elevation in the European Alps.

Our primary results suggest that for humans 'white' and yellow' flowers increase with higher elevation, whereas for bees 'blue' and 'green' flowers increase. Our data shows that calcareous grasslands have a higher color diversity than siliceous grasslands based on human vison, but higher number of blue and bluegreen flowers based on hymenopteran vision. Subalpine area shows a higher color diversity based on human vision, despite alpine regions harboring a higher number of plant species. Based on pollinator vision, more species with blue and bluegreen flowers occur in the alpine than in the subalpine region.

Novel competitors to high elevation plant communities revealed by an upslope translocation experiment across the European Alps

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With advancing climate warming, cold-adapted alpine plant communities face immense challenges. The interactive effect of altered temperature, seasonality and changes in the precipitation regime is leading to climatic shifts, and ultimately the compression or expansion of mountain species distribution ranges. Consequently, new biotic interactions arise with the arrival of novel upwards migrating competitors. However, to date, only few studies have experimentally addressed effects of both, climate warming and drought-imposed water deficit for lowland, subalpine and alpine plants through experimental reciprocal translocations.

We conducted a five-year reciprocal translocation experiment of entire plant-soil turfs. Down-slope translocation simulates the expected future climate at higher elevation sites, while up-slope translocation simulates cooler and wetter conditions for lowland plant communities and colonizing species, which might potentially become competitors for alpine plants in the future.

In the lowland recipient site, we found that survival rates of alpine and subalpine communities were significantly lower than survival rates of lowland control communities.

Unexpectedly, in the subalpine and alpine recipient sites, survival rates of the lowland community were not different from survival rates of the respective alpine or subalpine control community. Moreover, we found significant patterns of variation of two community indicators computed from bio-climatic realized niches of the original species: Drought- and thermos-tolerance. Downslope translocated alpine and subalpine communities shifted toward more drought-tolerant and thermo-tolerant community composition. In contrast, lowland communities translocated upslope shifted significantly towards more cold-tolerant community composition only in the subalpine recipient site, and not in the alpine.

Our study demonstrates that both alpine and subalpine plant communities suffered under warmer and drier climatic conditions, while many lowland species could continue to thrive under colder conditions at higher elevations across several years, although some of them were placed out of their niche.Thus, alpine plant species may not be able to sustain current community structure within their current habitat in the long term but will face climate change, novel biotic interactions and reshuffling. This is posing them at risk of being displaced by colonizing species from lower elevations.

Ein neuer Ansatz zur digitalen Fels- und Reliefdarstellung

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A new approach for the digital representation of rocks and reliefs is presented. A prerequisite for the method was its applicability for diferent scales and thus diferent resolutions of the underlying terrain models. A further requirement was its suitability for diferent rock types. It must also take into account the rock surfaces that have become ice-free due to glacier retreat and be easy to integrate into the map in the event of an update. The relief representation follows the principle that the terrain should be reproduced as naturally as possible to provide the map user with the best possible orientation in the terrain. The approach requires a very good knowledge of the terrain as well as a certain artistic talent to achieve an appealing, natural color scheme. Through the process of color manipulation from the four-color set, it is also possible, in addition to the summer representation from the data collected with remote sensing methods, to generate winter representations for e.g. ski tourers. The use of established, automatic procedures considerably reduces the workload for the cartographer and also enables simple integration of corrections and changes to the landscape, e.g. due to glacial retreat and landslides, and can be applied to large map series due to its reproducibility

Es wird ein neuer Ansatz für die digitale Fels- und Reliefdarstellung vorgestellt. Voraussetzung für die Methode war ihre Anwendbarkeit für verschiedene Maßstäbe und damit unterschiedliche Aufösungen der zugrunde liegenden Geländemodelle. Eine weitere Anforderung war die Eignung für unterschiedliche Gesteinsarten. Sie muss auch die durch Gletscherrückgang eisfrei gewordenen Felsfächen berücksichtigen und im Falle einer Aktualisierung leicht in die Karte zu integrieren sein. Die Reliefdarstellung folgt dem Grundsatz, dass das Gelände so natürlich wie möglich nachgebildet werden soll, um dem

Kartennutzer die bestmögliche Orientierung im Gelände zu ermöglichen. Der Ansatz erfordert eine sehr gute Kenntnis des Geländes sowie eine gewisse künstlerische Begabung. Durch den Prozess der Farbmanipulation aus dem Vierfarbsatz ist es möglich, neben der Sommerdarstellung aus den mit Fernerkundungsmethoden erhobenen Daten auch Winterdarstellungen für z.B. Skitourengeher zu erzeugen. Durch die Verwendung etablierter, automatischer Verfahren wird der Arbeitsaufwand für den Kartographen erheblich reduziert und ermöglicht zudem eine einfache Integration von Korrekturen und Veränderungen der Landschaft z.B. durch Gletscherrückgang und Massenbewegungen und ist durch seine Reproduzierbarkeit auf große Kartenwerke anwendbar.

Untersuchungen zu Vegetation, Flora und Fauna der Griese in den Ammergauer Alpen

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Als Griese werden Schutt- und Schwemmfächer definiert, die von temporären oder permanenten Wildbächen durchzogen werden. Die Wildbäche der Alpen transportieren große Mengen an fein- bis grobkörnigem Schutt und lagern einen Teil davon im Talbereich ab. Diese Lebensräume sind geprägt von gewässermorphologischen Veränderungen und einem räumlichen Nebeneinander unterschiedlicher Sukzessionsstufen der Vegetation. Die hohe Dynamik und die häufigen Störungen führen dazu, dass eine speziell an diese Bedingungen angepasste Vegetation, Flora und Fauna vorzufinden ist. Durch den immer häufigeren Verbau von Wildflüssen, Kiesentnahme, Energiegewinnung, Flussbegradigungen und den Ausbau von Infrastruktur, sind diese besonderen Lebensräume bedroht oder sind in großen Teilen bereits verloren gegangen, was zu einem dramatischen Rückgang ihrer typischen Pflanzen- und Tierarten beigetragen hat.
Die eng aneinandergrenzende Lebensräume mit unterschiedlichen dynamischen Einflußfaktoren, sorgen für eine außergewöhnlich hohe Biodiversität an typischen Arten und Pflanzengesellschaften. Neben stark bedrohten Tierarten, wie der rotflügeligen Schnarrschrecke (Psophus stridulus), kommt eine Vielzahl an seltenen, für den Alpenraum typischen, Pflanzenarten vor. Beispielsweise verschiedene Enzian-(Gentianaceae) und Orchideenarten (Orchidaceae). Das Arten- und Lebensraumspektrum der Griese ist bisher nur wenig untersucht und es fehlen aktuelle Kartierungen. Unser laufendes Monitoring an ausgewählten Griesabschnitten der Ammergauer Alpen dokumentiert die Standortsvielfalt, Sukzessionstadien und die floristischen und faunistischen Besonderheiten.

Alpine Vegetation Dynamics in Response to Natural and Anthropogenic Environmental Changes in Finnish Lapland – A Preliminary Survey

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The vegetation above treeline in subarctic regions and of high mountains share similarities in flora, natural environments, and the dynamics in response to climate shifts. This study aims

to elucidate alpine plant diversity and vegetation patterns in different elevations and climatic zones. The research question is how alpine plants and vegetation patterns respond to environmental changes along an elevational gradient in subarctic mountain regions. Here, I conducted a preliminary survey in Kilpisjärvi, Finnish Lapland from 29th of June to 5th of July, 2023. I observed altitudinal vegetation zones on Mt. Saana, Mt. Korkea Jehkas, Mt. Pikku-Malla, and around Mt. Iso-Malla and examined plant species growing around mountain trails on the mountains and the state of flowering. A result in accordance with earlier studies is that the treeline of mountain birch (Betula pubescens) in Kilpisjärvi is approximately 600m in altitude. There is similarity in flora among the mountains, including Vaccinium uliginosum, Vaccinium myrtillus, Phyllodoce caerulea, Trollius europaeus, and Cornus suecica. Silene acaulis and Dryas octopetala were distributed on Mt. Saana and Mt. Korkea Jehkas, whereas they were not observed around the mountain trails on Mt. Pikku-Malla, Mt. Iso-Malla. Earlier studies indicate that not only natural conditions, such as the snowpack, but also reindeer grazing impacts on the vegetation, for example, species composition and species richness, in mountain birch, yet the impacts in alpine zones are still in underrepresentation. In this context, this study will attain three objectives: (1) to examine the lines among actual altitudinal vegetation zones, (2) to investigate the shifts in spatial alpine vegetation patterns, focusing on the species composition, the species richness, and distributions of endangered species, (3) to identify essential vegetation-environment interrelationship that results in the vegetation transition, analysing both natural and anthropogenic site factors.

Past, present, and future glacier evolution in the Tropical Andes

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Glaciers and ice caps outside the polar ice sheets are strongly affected by climate change, and various observables are defined as essential climate variables. Glacier shrinkage has local to regional-scale impacts on hydrology, ecosystems, and society. In the Tropical Andes, the glaciers pose an important water resource and significantly contribute to the local and regional water supply, especially during the dry season and drought periods. Moreover, glacier retreat increases the risk of glacier lake outburst floods putting downstream communities at risk. To improve future water management and risk assessment as well as to evaluate the impact of climate variations, region-wide and detailed information on the past, present, and future glacier evolution in the Tropical Andes is required. Current glacier mass change estimates have spatiotemporal limitations and often considerable uncertainties, while regional projections, carried out within global analyses, show partly ambiguous trends. This project aims to overcome these deficiencies by comprehensively analyzing the Tropical Andes' past, present, and future glacier evolution. An improved regional assessment of current and future glacier changes will be conducted based on an innovative combination of multi-mission remote sensing data, in-situ measurements, and glacier and hydrological modeling. In combination with data on past glacier changes, which are obtained by exploiting unique remote sensing archives, the evaluation of the long-term trend and its

relation with climate change will be facilitated. By assimilating the new remote sensing products and in-situ observations into an ice-dynamic model inversion, highly improved ice volume distribution information will be generated. Projections of glacier evolution for the Tropical Andes until 2100 using mass balance modeling, optimized for the tropics, and fully 3-dimensional glacier modeling will be conducted to overcome the shortcomings of existing global estimates. Those activities will facilitate the subsequent study of the glacier lakes evolution and the glacier meltwater contribution to catchment runoff.