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Achim A. Beylich and Katja Laute

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Front photo:

View of the Mediterranean landscape of the Calpe region in eastern Spain (Photo: K. Laute)

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Second Workshop of the IAG Working Group on

Denudation and Environmental Changes in Different Morphoclimatic Zones

(DENUCHANGE)

http://www.geomorph.org/denuchange-working-group/

12-14 September 2019, Calpe, Spain

Volume of Abstracts

Editors:

Achim A. Beylich and Katja Laute

Workshop venue

Suitopia Hotel, Avda. Europa, 2, 03710 Calpe, Spain

Preface

During the 9th IAG International Conference on Geomorphology in New Delhi, India, 6-11 November 2017, the IAG Working Group on *Denudation and Environmental Changes in Different Morphoclimatic Zones (DENUCHANGE)* was approved for a four-year period (2017-2021). There is general agreement that global environmental changes will have significant effects on Earth surface systems. The question how global environmental changes will affect our landscapes and the way we interact with it is therefore of highest importance.

Denudation, including both chemical and mechanical processes, is of high relevance for terrestrial Earth surface and landscape development and the transfers of solutes and sediments from headwater systems through main stem of drainage basin systems to the world oceans. Denudation is controlled by a range of environmental drivers and can be significantly affected by human activities. A systematic compilation and comparison of contemporary denudation rates quantified for clearly defined drainage basin systems in different defined climatic regions, combined with a coordinated geomorphological analysis and compilation of the respective key controls of denudation that is presently occurring in the different selected morphoclimatic regions, is still largely missing, and IAG DENUCHANGE is helping to close this still existing gap. The Working Group shall contribute to an improved understanding of the possible effects of ongoing and accelerated global environmental changes on contemporary terrestrial Earth surface systems.

The First Workshop of this new IAG Working Group was held in Storkowo-Szczecinek, Poland, 25-27 September 2018. It was identified that DENUCHANGE shall focus on morphoclimatic regions that react particularly sensitive to ongoing and accelerated environmental changes. The key focus of DENUCHANGE is therefore on (i) cold regions (including glacierized, glaciated and unglaciated cold climate environments), (ii) temperate regions, (iii) arid / semi-arid regions, and (iv) tropical regions. The different morphoclimatic regions are defined by morphometric characteristics/signatures detected in the various regions.

We kindly welcome you to the Second Workshop of IAG DENUCHANGE held in the Mediterranean environment of the Calpe region in eastern Spain, 12-14 September 2019, and we are looking forward to a fruitful scientific exchange of ideas and to valuable in-depth discussions on denudation in a range of different morphoclimatic settings. The main goal of this workshop is to develop further the Working Group activities as defined in the DENUCHANGE Working Group Objective (http://www.geomorph.org/denuchange-working-group/).

On behalf of the IAG DENUCHANGE Steering Committee,

Achim A. Beylich, Katja Laute and Marina Renner Jorro

Workshop Organizers

Content

1. Workshop program

11 September 2019

20:00: Informal workshop welcome meeting in Calpe

12 September 2019

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09:00-09:30: Opening of the workshop and welcome of participants (Achim A. Beylich)

09:30-10:00: Achim A. Beylich and the DENUCHANGE Team: The IAG Working Group on Denudation and Environmental Changes in Different Morphoclimatic Zones (DENUCHANGE, 2017-2021): Working group objective, key research questions, overview of activities and planned outcomes

10:00-10:45: Discussion on further steps and definition of goals of the workshop

10:45-11:15: Coffee and tea break

11:15-13:15: First oral session (*Chair*: Ana Navas)

11:15-11:45: Waldemar Kociuba: Quantification of slope-channel coupling in a proglacial river with terrestrial laser scanning

11:45-12:15: Georgi Rachev, Rossitza Kenderova, Ahinora Baltakova, Alexander Sarafov, Sonya Stoyanova, Petko Bozhkov: Geomorphological and climatological studies in the area of Bulgarian Antarctic base (Livingston island, South Shetlands archipelago)

12:15-12:45: Katja Laute, Achim A. Beylich: Potential effects of recent glacier changes and the formation of new proglacial lakes on sediment delivery and sediment yields at the Jostedalsbreen ice cap in south-western Norway

12:45-13:15: Andreas Mayr, Clemens Geitner, Martin Rutzinger, Michael Tobias Löbmann, Rita Tonin, Stefan Zerbe, Camilla Wellstein, Charlotte Gild, Abraham Mejia-Aguilar, Ruth Sonnenschein: Erosion in subalpine grasslands of the Alps – State-of-the-art, remaining questions and current research

13:30-14:45: Lunch

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15:30-16:00: Eliza Płaczkowska, Kazimierz Krzemień: Bedload transport in headwaters (Western Tatras, Poland)

16:00-16:30: Zbigniew Zwoliński, Marcin Winowski, Andrzej Kostrzewski: Denudational processes of the cliff coast, Wolin Island, 2013-2019

16:30-17:00: Coffee and tea break

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17:00-17:30: Valeriu Stoilov-Linu, Mihai Niculiţă, Dan Dumitriu, Necula Nicusor: The sediment fluxes from Bistricioara catchment (Eastern Carpathians, Romania)

17:30-18:00: Olimpiu Pop, Mihai Niculiţă, Mircea Alexe, Ionela-Georgiana Răchită: Mining sediment transfer and morphological changes related to anthropogenic and hydrogeomorphic activities in a temperate-mountain environment (Călimani Mountains, Eastern Carpathians, Romania)

18:00-18:30: Leticia Gaspar, Ivan Lizaga, William H. Blake, Borja Latorre, Laura Quijano, Ana Navas: Tracking changes of soil contribution and processes of an agroforestry catchment during a flood event

18:30-19:00: Ivan Lizaga, Leticia Gaspar, William H. Blake, Borja Latorre, Ana Navas: Could channel bed sediments explain the soil responses to exceptional rainfall events?

20:30: Joint workshop dinner in Calpe

13 September 2019

09:30-10:30: Poster session (*Chair*: Małgorzata Mazurek)

Achim A. Beylich and the DENUCHANGE Team: The IAG DENUCHANGE (Denudation and Environmental Changes in Different Morphoclimatic Zones) program

Sonya Stoyanova, Georgi Rachev, Rossitza Kenderova, Ahinora Baltakova, Dimitar Krenchev, Petko Bozhkov: Freeze-thaw activity in the high mountain area of Pirin Mountains, SW Bulgaria

María Concepción Ramos, Ivan Lizaga, Leticia Gaspar, Laura Quijano, Ana Navas: Nutrient losses by erosion in soils under different land use/land cover using simulated rainfall with increasing intensities

Achim A. Beylich, Katja Laute: Drivers and rates of fluvial processes and source-to-sink fluxes under changing climate and anthropogenic impacts in Mediterranean catchment systems in eastern Spain

Achim A. Beylich, Katja Laute: Morphoclimate and contemporary denudation in the upper Driva drainage basin in central Norway

Katja Laute, Achim A. Beylich: Denudational hillslope processes in selected mountain environments in western Norway and eastern Spain

Jasper Knight, Stefan W. Grab, Helene Burningham: Basalt pseudokarst in the Lesotho Highlands, southern Africa

Jasper Knight, Helene Burningham: Morphological zonation of weathering along a rocky shore platform in South Africa

10:30-10:45: Discussion: Preparation of group works (*Chair*: Achim A. Beylich)

10:45-11:15: Coffee and tea break

11:15-12:15: Group works

12:15-13:15: Summary of group works and synthesis. Planning of further steps (*Chair*: Achim A. Beylich)

13:30-14:45: Lunch

15:00-19:00: Field trip to Calpe and the surrounding Mediterranean landscape
(*Field guides*: Achim A. Beylich, Katja Laute)

20:30: Joint workshop dinner in Calpe

14 September 2019

Departure of workshop participants

2. IAG DENUCHANGE Working Group Objective

The defined key question of the IAG Working Group DENUCHANGE (2017-2021) (http://www.geomorph.org/denuchange-working-group/) **is:**

What are the contemporary chemical and mechanical denudation rates in different morphoclimatic zones on the Earth?

Denudation, including both chemical and mechanical processes, is of high relevance for Earth surface and landscape development and the transfer of solutes and sediments from headwater systems through main stem of drainage basin systems to the world oceans. Denudation is controlled by a range of environmental drivers and can be significantly affected by anthropogenic activities.

The better understanding of possible effects of ongoing and accelerated environmental changes on present-day denudation requires systematic and quantitative studies (environmental monitoring) on the actual drivers of denudational processes. Only if we have an improved knowledge of drivers and quantitative rates of contemporary denudational hillslope and fluvial processes as well as of the connectivity in landscapes and between hillslope and fluvial systems across a range of different selected climatic environments, possible effects of global environmental changes on denudation can be better assessed. Special focus will be given to selected morphoclimatic zones that are expected to react particularly sensitively to ongoing and accelerated environmental changes, and the key focus of DENUCHANGE will therefore be on (i) cold regions (including glacierized, glaciated and unglaciated cold climate environments), (ii) temperate regions, (iii) arid / semi-arid regions and (iv) tropical regions. The different morphoclimatic zones are defined by morphometric characteristics/signatures detected in the various zones.

DENUCHANGE will

- Provide a detailed compilation and comparison of contemporary chemical and mechanical (drainage-basin wide) denudation rates in selected and clearly defined drainage basin systems in selected cold regions, temperate regions, arid / semi-arid regions and tropical regions worldwide. As denudation is scale-dependent, the selected drainage basin systems will be of a defined and comparable size to allow direct comparisons between the drainage basin systems situated in the different morphoclimatic zones. The existing/available and compiled data on contemporary chemical and mechanical denudation must be based on comparable sampling periods, sampling frequencies, and on comparable monitoring methods and techniques applied.

- Provide a process-oriented, coordinated and integrated analysis and compilation of the respective key drivers of contemporary denudation occurring under the different present-day morphoclimates.
- Based on the previous two compilations: Address the key question how environmental changes are affecting contemporary denudation rates in different morphoclimates. This also includes human activities in different morphoclimatic zones, in the context of environmental changes in the Anthropocene.

3. DENUCHANGE Steering Committee, Core Members and Workshop Participants

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4. Accepted Scientific Abstracts

The IAG DENUCHANGE (Denudation and Environmental Changes in Different Morphoclimatic Zones) program

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There is a general agreement that global environmental changes will have significant effects on Earth surface systems. The question on how global environmental changes will affect our landscapes and the way we will interact with it is therefore of the highest importance. Denudation, driven by both chemical and mechanical processes, is of high relevance for Earth surface and landscape development and the transfer of solutes and sediments from headwater systems through main stem of drainage basin systems to the world oceans. Denudation is controlled by a range of environmental drivers and can be significantly affected by human activity.

A better understanding of possible effects of ongoing and accelerated environmental changes on present-day denudation systems requires systematic and quantitative studies (including monitoring) on the actual drivers of denudational processes in differentiated landscape controls. Only if we improve our current knowledge of drivers, mechanisms and rates of contemporary denudational processes as well as of the connectivity in landscapes and between hillslope and fluvial systems across a range of different selected climatic environments, possible effects of global environmental changes on denudation can be better assessed. Special focus must be given to selected morphoclimatic zones that react particularly sensitive to ongoing climatic changes and human activities, and the key focus of IAG DENUCHANGE will therefore be on (i) cold regions (including glacierized, glaciated and unglaciated cold climate environments), (ii) temperate regions, (iii) arid / semi-arid regions,

and (iv) tropical regions. The different morphoclimatic zones are defined by morphometric characteristics/signatures detected in the various zones.

A systematic quantitative compilation and geomorphologic comparison of present-day denudation rates in selected and clearly defined drainage basin systems of different defined climatic zones, combined with a coordinated analysis and compilation of the respective key controls of denudation that is presently occurring in the different selected morphoclimatic settings, is still largely missing and urgently needed. The IAG Working Group on *Denudation and Environmental Changes in Different Morphoclimatic Zones (DENUCHANGE, 2017 – 2021)* is helping to close this still existing key knowledge gap and is contributing to a better understanding of the possible effects of global environmental changes on contemporary changes of the terrestrial Earth surface systems. Detailed information on IAG DENUCHANGE and the DENUCHANGE Working Group Objective is found on the IAG DENUCHANGE website at http://www.geomorph.org/denuchange-working-group/.

Drivers and rates of fluvial processes and source-to-sink fluxes under changing climate and anthropogenic impacts in Mediterranean catchment systems in eastern Spain

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Climate change, human activities and other perturbations (like, e.g., fires, earthquakes) are likely to influence existing patterns of weathering, erosion, transport and deposition of material across defined landscape components and units. While it is still a challenge to develop an improved understanding of how such changes interact and affect slope and fluvial processes, the connectivity within landscapes and between slope and fluvial systems, as well as contemporary denudation rates, source-to-sink fluxes, and sedimentary budgets, this kind of quantitative analyses promise to be an efficient framework to assess the impact of environmental changes and disturbances to sediment dynamics and to evaluate landscape sensitivity. The current knowledge on drivers and rates of contemporary sediment dynamics and denudation forms the basis for understanding and predicting the consequences of ongoing and accelerated environmental changes.

Ongoing GFL research activities on drivers and quantitative rates of contemporary sediment dynamics and chemical and mechanical slope and fluvial denudation in selected catchment systems in eastern Spain are presented. The Pou Roig and Quisi catchment systems in the Calpe region in eastern Spain are located in a Mediterranean, partly mountainous and/or anthropogenically affected environment. Sediment transfers, runoff and fluvial transport are almost entirely controlled by pluvial events. Our investigations include detailed geological and geomorphological mapping combined with statistical analyses of existing meteorological high-resolution data and the observation and monitoring of meteorological and runoff events, and of sediment transfers on slopes and in stream channels using a combination of different automatic and manual observation, monitoring and sampling techniques. Our

results on controls and the spatiotemporal variability of chemical and mechanical denudation, storage and sedimentary budgets within the two catchment systems contribute to an advanced understanding of key drivers and rates of contemporary sediment and solute dynamics and denudation in this Mediterranean environment, and provide the basis for improved predictions of possible effects of climate change and anthropogenic impacts on contemporary denudation rates in this morphoclimatic region.

Morphoclimate and contemporary denudation in the upper Driva drainage basin in central Norway

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Ongoing GFL research activities on the current morphoclimate and on contemporary chemical and mechanical denudation rates in selected tributary systems of the upper Driva drainage basin in central Norway are presented. The upper Driva drainage basin (located south of Oppdal in central Norway) is situated in a cold-climate and mountainous environment, has year-round discharge with a predominantly nival runoff regime, and the temporal variability of solute and sediment transfers, runoff and fluvial transport is largely controlled by thermally and/or pluvially determined events.

Our investigations include detailed geological, geomorphological and permafrost mapping combined with the detailed statistical analysis of high-resolution meteorological data and the continuous observation and year-round monitoring of sediment transfers, runoff and fluvial transport using a range of different techniques in the different selected tributary systems. The detected spatial variability of chemical and mechanical denudation rates in the upper Driva drainage basin is largely explained by varying tributary characteristics, with tributary valley morphometry and sediment availability being the most important environmental controls. The detailed statistical analysis of the current morphoclimate allows quantitative statements on effects of ongoing and accelerated environmental changes on chemical and mechanical denudation rates in this cold-climate environment.

Tracking changes of soil contribution and processes of an agroforestry catchment during a flood event

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Sediment export rates are sensitive to changes in land use, human impact and climate but the response of the landscape to such changes is difficult to interpret. In the Mediterranean region, floods are expected to increase as a result of climate change, and knowledge of soil erosion hot spots during exceptional rainfalls is required to support mitigation measures. This study reports the response of the main sediment sources during an exceptional rainfall event in 2012 (235 mm) at the outlet of an agroforestry catchment located in NE Spain. For this purpose valued suspended sediment samples and rainfall records were collected during the flood event. We used fingerprinting methodology and applied the FingerPro unmixing model to estimate the contribution from main sources.

The time-integrated suspended sediment samples revealed changes in source contribution during the 2-hour sampling sequence. There were relatively high contributions from rangeland, agriculture and subsoil at the beginning of the sampling, representing 30, 40 and 35% of the total source contributions, respectively. Our records captured the delivery of pulses of eroded surface soil transported by runoff with direct connectivity to the stream. The sequence was followed by a sharp increase in channel bank contribution (up to 90%) in comparison to the other sources, reflecting streambank erosion and landslide occurrence, which manifested during the flood. The different characteristics of the study catchment, in terms of distribution of land uses and structural connectivity of the landscape, played a key

role in controlling sediment availability and the prominence of the contributing source. The rainfall event activated the entire catchment. Sediment from sources that during regular flood events remain disconnected was transported and surpassed the linear elements that typically interrupt the connectivity of the landscape. The lowest suspended sediment concentrations (SSC) and the highest soil organic carbon contents (SOC) support topsoil erosion from rangeland, agricultural and subsoil occurring at the beginning of the exceptional event, while later peaks of SSC and high contributions of channel bank suggest a shift to the predominance of streambank erosion. Our results support the use of fingerprinting techniques to determine variations in source contribution and sediment provenance during flood events, as extreme rainfalls are main drivers of sediment mobilization and key factors in changing landscapes. This is essential in identifying vulnerable hot spots, in which early-stage interventions are needed, and for helping policy makers with management of soil and water resources.

Basalt pseudokarst in the Lesotho Highlands, southern Africa

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Physical, chemical and biological weathering processes are significant contributors to landscape development in mountain blocks worldwide, and over long time scales, but the interplay between different weathering processes is uncertain. Jurassic-age basalt lava flows underlie the Drakensberg mountain range of eastern Lesotho, southern Africa (summits 3200-3400 m asl), and weathered bedrock is commonly exposed on flat plateau surfaces. Subaerial weathering throughout the Quaternary and Holocene has resulted in a range of weathering forms, some of which exploit pre-existing cooling fractures within the basalts, and some of which are independent of geological control. These forms include pseudokarst-style potholes, karren and other microforms. The geometry, chemistry of water contained within the potholes, seasonal presence of ice, sediment and organic residues all suggest that physical, chemical and biological weathering processes are significant at different times and in different ways in subaerial weathering. Moreover, it is also likely that these process-types show pronounced seasonal variability that means that the interplay between different processes is subtle. It is also likely that subaerial weathering has been significantly underestimated as a landscape-shaping process in many mountain blocks worldwide.

Morphological zonation of weathering along a rocky shore platform in South Africa

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Shore platforms found along bedrock coasts worldwide are often interpreted as due to wave abrasion acting on uniform bedrock surfaces. Whilst this viewpoint may apply at the macroscale, there are complex feedbacks between bedrock properties (rock type, mineralogy, rock structures), weathering and erosion processes and rates, and microtopography at the meso- to microscale. In turn, these influence wave runup, backwash processes, and extent of wavesplash and physical, chemical and biological weathering processes that result. This study investigates the relationships between bedrock properties, microtopography and shore platform weathering and erosion processes from a site on the Indian Ocean-facing coast of South Africa. Three shore-normal transects (45–57 m in length) were surveyed across the sandstone platform using a differential GPS. These data were integrated with rock surface hardness measurements taken using a Proceq Equotip instrument. Results show that platform morphology and hardness values vary considerably, corresponding to the most dominant weathering and erosion processes that are found at different positions in the tidal frame. The lowest hardness values (most extensive rock weathering) are found on the landward third of the platform but away from the land margin. The highest hardness values and the greatest variability of values are found on bedrock highs immediately above highest astronomical tide level, in the lower third of the profile. This position suggests a dominant role of wave-splash and wetting/drying. Variations in hardness values and microtopography through the transects were used to develop an evolutionary model linking rock hardness values to specific processes of weathering and erosion of rocky shore platforms.

Quantification of slope-channel coupling in a proglacial river with terrestrial laser scanning

Waldemar Kociuba

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Braided rivers are part of dynamic and complex environments shaped by the interaction of flow and sedimentary regimes. The relation between the supply and transport of sediments determines their morphological evolution. The aim of this study is the analysis of the dynamics of sediment supply from slopes to the valley floor, the incorporation of sediments into the river channel and their influence on the dynamics of erosion and deposition processes along the river course (Scott River, SE Svalbard). The Scott River is a typical gravel-bed river of the High-Arctic Region with a glacial-nival regime, in which the dominant source of water is the proglacial water discharged to the fjord through the erosional valley. The upper part of the catchment (40%) is occupied by an alpine glacier (Scott Glacier) 3.1 km long and 1.1-1.8 km wide. The highest part of the glacier rises to 502 m a.s.l., and its snout (in 2012-2013) raised from 85 to 92.5 m a.s.l. The study of the dynamics of geomorphic processes at the slope-valley-channel interface was conducted in the context of a short (3 years) and very short (3 weeks) time scale using terrestrial laser scanner (TLS) positioned by GNSS RTK system. Field survey and post-processing analyses were performed for the lower gorge section of the valley bottom at the interval of three average melt seasons and in the melt season of 2013 before and after the largest flood event occurring within more than 25 years. The differences between two DEMs revealed significant spatial differentiation of erosion and deposition events in the analysed area, demonstrating the significant role of small debris flows and mass movements on slopes as sources for direct and indirect sediment supplies to the Scott riverbed.

Potential effects of recent glacier changes and the formation of new proglacial lakes on sediment delivery and sediment yields at the Jostedalsbreen ice cap in south-western Norway

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Presently, glaciated mountain environments are amongst the most dynamic geomorphic systems as they are exposed to various climatic and environmental changes. Climate-induced widespread glacier retreat and thinning lead to a gradual enlargement of formerly glaciated terrain.

The glacial landscape of the Jostedalsbreen ice cap in south-western Norway is currently undergoing significant changes reflected by progressing glacier length changes of the outlet glaciers and the formation of new glacial lakes within the recently exposed glacier forefields. For the period from 1952-1985 to 2017/2018 the entire glacier area of the Jostdalsbreen ice cap experienced a loss of 79 km^2. A glacier area reduction of 10 km^2 occurred since 1999-2006. Two percent of the recently exposed surface area (since 1952-1985) is currently covered with newly developed lakes.

Proglacial lakes play a geomorphic key role with respect to sediment connectivity and the sedimentary budgets of proglacial areas. The formation of proglacial lakes significantly reduces sediment delivery from glaciated mountain drainage basins to the downstream valley sections by trapping efficiently coarse- and partly suspended sediment loads. However, proglacial lakes can also change from a sink to a temporal sediment source in specific weather conditions. In addition, a completely filled up lake can develop into a new source of erodible sediments. Hence, the sediment delivery from the Jostedalsbreen outlet glaciers will most likely be altered in the near future with consequences for, e.g., stream hydrology and ecology as well as hydropower production. However, it is likely that a

recognizable share of the future suspended sediment load from the retreating glaciers will probably be buffered by newly formed proglacial lakes.

Due to the predicted increase in summer temperatures for western Norway until the end of this century, it is very likely that the current trend of an accelerated mass loss of Norwegian glaciers will continue and further new lakes will emerge within the newly exposed terrain. Especially in mainland Norway, where glaciers and glacier-fed streams have a high importance for hydropower production, tourism and climate research it is essential to better understand how proglacial lakes affect the sediment delivery from the Jostedalsbreen ice cap and what are the regional and global socio-economic implications arising from these newly emerging landscape features.

Denudational hillslope processes in selected mountain environments in western Norway and eastern Spain

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We present ongoing GFL research activities focussing on environmental drivers of rockwall retreat, and denudational hillslope processes in a cold climate mountain environment (western Norway) and in a Mediterranean mountain setting (eastern Spain). In detail, we explore the influence of (i) lithological and structural characteristics, (ii) the rockwall temperature regime, and (iii) the connected relative importance of physical-, chemical- and biological processes on weathering and resultant morphologies under these two contrasting climates. Special focus is on possible effects of ongoing and accelerated climate change and on the question how these effects differ under the two distinct climates.

Our research is conducted on selected hillslope systems within two tributary valleys (max. elevation 2083 m a.s.l.) located on the western side of the Jostedalsbreen ice cap in the fjord landscape of western Norway. The lithology consists primarily of Precambrian granitic orthogneisses. The climate (slightly above sea level) is cool temperate oceanic with a mean annual air temperature of ca. 6°C and an annual precipitation sum of 1100 mm. January and February are the coldest months with mean monthly air temperatures below 0°C. Higher elevations are characterized by a distinct winter frost regime and a several months lasting closed snow cover. Maximum summer temperatures (June, July) are rarely exceeding 25°C but rockwalls having a favourable exposition can receive rather high solar radiation. The selected hillslope systems in eastern Spain (Calpe) are located within the Sierra de Bernia mountains (max. elevation 1126 m a.s.l.) which consist of glauconitic and bioclastic marine limestones with alterations of marl. The area is characterized by a mild Mediterranean climate with a mean annual air temperature of ca. 18°C and an annual precipitation sum around 400 mm (slightly above sea level). During the coldest months (January, February) it

can be comparably cold even with frost and snow in the mountains although they are situated close to the coast. In contrast, maximum summer temperatures (July, August) can easily exceed 30°C and south-facing rockwalls are exposed to high solar radiation.

Our investigations encompass detailed geological and geomorphologial mapping, the identification and monitoring of the most relevant hillslope processes in combination with detailed statistical analysis of high-resolution meteorological data. Our monitoring programme includes installed nets for collecting newly accumulated rockfall debris, installed tracer lines and remote time-laps cameras for monitoring various mass transfers as well as near-surface and surface rockwall temperature sensors for monitoring the thermal rockwall regime.

An improved and more comprehensive understanding of how different environmental factors interact and control hillslope processes under two contrasting and changing climates is expected to be essential for predicting possible effects of ongoing climate change in sensitive mountain environments.

Could channel bed sediments explain the soil responses to exceptional rainfall events?

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One of the principal soil degradation problems affecting mountainous landscapes is the loss of topsoil by water erosion. Soil detachment highly increases during exceptional storm events that remove topsoil, especially from unprotected soil surfaces. Soil particles are further transported by runoff with indirect impacts on water storage capacity and quality of water bodies. To evaluate the soil response to these exceptional events, source samples were collected in a 23km^2 catchment that was mostly cultivated at the beginning of the last century but was shifting to rangeland and forest areas in the last decades. To monitor the effect of land cover in sediment mobilization, the source samples were distributed over the five main land use/land covers (LU/LC). The main LU/LC are agricultural land, pine afforestation, Mediterranean forest, bare soil and channel bank areas. Furthermore, to monitor the effect of severe storm events 20 channel bed sediment samples were collected along the main streams before and after an exceptional storm event. Source apportionments were calculated using the FingerPro R package to understand the impact of these exceptional events in activating sources supplying sediment to the streams besides modifying connectivity and transforming the landscapes.

The unmixing outputs displayed a large variation of source apportionments from the upper part to the lower part of the catchment and from pre- to post- event sediments. After the event, a decrease of more than 70% of the fine fraction and its associated elements and SOC along with a rise in contents of elements associated with the coarse fraction was recorded in the channel bed sediments. Overall, the results show substantial contributions from bare soil, agriculture and channel banks. However, the low contribution from soil located inside

forest areas underlines the benefits of vegetation to prevent soil loss. Our findings highlight the hazards of exceptional storm events on modifying sediment source contribution and exporting fine sediment to the streams along with the importance of protecting natural covers to prevent export of fine sediment to the hydrological systems.

Erosion in subalpine grasslands of the Alps - State-of-the-art, remaining questions and current research

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In many regions of the Alps grassland in the subalpine elevation zone is affected by shallow erosion. This group of mechanical denudation processes includes shallow landslides and abrasion by snow gliding and avalanches, which are displacing patches of turf and regolith. The resulting bare earth areas and the dislocated material are susceptible to secondary erosion and further particle transport by water or wind.

On the one hand, several studies report an increasing occurrence of such eroded areas over several years to decades. They partly attribute this to agricultural extensification or abandonment and related vegetation changes, and a few studies also suggest a possible link to climate change. On the other hand, periods of accelerated and reduced erosion, respectively, have been observed to alternate irregularly and, for some areas and time periods, the recovery of eroded areas by vegetation succession seems to counterbalance the development of new eroded areas.

The complexity of these spatio-temporal erosion dynamics is likely an effect of the manifold, interacting factors that are controlling erosion activity. Some of these factors are highly variable in space and/or time at various, often multiple scales. This concerns for instance (i) the small-structured spatial patterns of the natural predisposition for erosion (depending

amongst others on slope morphology and geology), (ii) variable natural and anthropogenic influencing factors (such as land use and vegetation) and (iii) the spatial and temporal occurence of different triggers for erosion activity (e.g. precipitation events or snow conditions). Hence, an identification of trends and patterns of erosion and succession or a reliable estimate of erosion rates is challenging, both at the hillslope scale and regionally.

In the first part, this contribution seeks to summarize the current knowledge on the main geomorphological processes for Alpine grassland erosion as well as on estimated process rates and to point to the most important unanswered questions. The dependence of erosion on various natural and anthropogenic factors, such as geology, slope morphology, agricultural land use and climate is discussed. Case studies at different test sites in the Alps indicate that abrasion by snow gliding and avalanches must be rated as the main process for initial development of shallow eroded areas. We argue that a systematic monitoring is needed (i) in order to localize and quantify the areas that are affected by erosion, (ii) to improve the understanding of opposing erosion and stabilization processes and (iii) to progress towards estimating rates of shallow erosion in Alpine grasslands at various spatial and temporal scales. Hence, we suggest detailed process-oriented analyses at the hillslope and at the plot scale, but also spatio-temporal analyses at catchment to regional scale, to evaluate robustly how the process activity depends on (changing) land use and climate.

In the second part, we provide an overview of our current interdisciplinary research activities, which are systematically addressing some of the issues outlined above. In several study areas in North Tyrol (Austria) and South Tyrol (Italy), we pursue an approach that combines remote sensing and field work at plot scale to catchment scale. These investigations comprise for instance the stability of the regolith depending on its components and properties (including plant roots), or the mechanisms and dynamics of vegetation succession on eroded areas. Moreover, spatio-temporal dynamics of erosion are mapped and quantified, and identified patterns are analyzed considering also small-structured patterns of potential drivers, such as historic and contemporary land use.

Source-to-mainstream: Hydrochemical changes of water in channel head of headwater stream in the lowland area (West Pomerania, Poland)

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The main factor responsible for the initiation of a channel, the flow of dissolved material in a catchment, and its supply to river channels is the nature of runoff generation. In the humid temperate zone, in low-lying areas where permeable rocks with high water-holding capacity and a slow water-cycle rate predominate in the substratum, the infiltration excess overland flow, or Hortonian runoff, is uncommon. The excess of rain- or melt-water usually infiltrates into the soil and thus nourishes the groundwater, which is then drained by outflows. In such areas, groundwater seepage erosion can be the primary mechanism that controls channel initiation and the development of a headwater streams. As a result of erosion processes a headwater alcove (=channel head) develops around groundwater outflows.

In areas with good hydraulic connections between groundwater and streams, the groundwater controls a steady runoff and the chemistry of stream water. In the postglacial zone of West Pomerania, steady groundwater outflows create favourable conditions for the concentration of water, which leads to the formation of first-order streams with discharges ranging from several to tens of dm^3s^{-1} and, as a result, to the development of channel processes.

The aim of this study is to present variations in sources supplying solutes and to identify the conditions of affecting ion outflows in the headwater stream based on the recognition of physicochemical properties of waters in the channel head. The present study focuses on the channel head Żarnowo located at the southern slope of the upper Parsęta valley (West Pomerania). Field studies were conducted at the channel head consists of three niches,

developing in the sand and gravel glaciofluvial plain and erosive-accumulative alluvial terrace made of river sands, gravels and silt. Each of the niches is drained by rivulets - the largest ones reach discharge volumes ranging from several up to 45 $dm^3 \cdot s^{-1}$. Niches are connected by a common stream outflow with its length of 300 m. The discharge volume from the entire set of niches in 2000-2005 amounted to 72.3 $dm^3 \cdot s^{-1}$.

Water samples were taken from the sites located at the places of outflow of groundwater at the footslope zone of the studied niches, at the hyporheic zone and flows at individual niches and rivulet which drains the channel head. Measured in the field were water temperature, pH, and electrical conductivity. The concentrations of chemical components: K^+, Ca^{2+}, Mg^{2+}, Na^+, $Fe^{2+/3+}$, Mn^{2+}, HCO_3^-, Cl^-. NO_3^-, PO_4^{3-}, SO_4^{2-} and SiO_2 were determined in the hydrochemical laboratory.

The chemical composition of waters within the emerging headwater stream depends on the performance of individual sources of niche supplies. The presence of geogenic components such as HCO_3^-, K^+, Ca^{2+}, Mg^{2+}, Na^+ in the rivulet waters is the result of chemical weathering and leaching of its products. The intensity and nature of these natural processes depend on the environmental parameters of the zero-order catchment, water migration rates and lithological variability of the niche aquifer and bottom. Geogenic ions are dominant in the chemical composition of the channel head waters and show low temporal variability and small differences within the headwater alcoves. In turn, the hydrochemical measurements display a mosaic pattern of spatial and temporal differences in concentration of biogenic components and heavy metals. Nitrates belong to the group of components with the highest spatial variability of concentrations in the studied niches. Their concentration is significantly reduced in the hyporheic zone. This is the effect on biogeochemical processes connected with a change in the degree of oxidation of nitrogen in interstitial waters.

Water chemistry in headwater stream reflects not only the properties of groundwater nourishing the channel head, but also changes it undergoes in the hyporheic zone and within a channel head during the organisation of runoff. The transformation of the chemical composition of water in the hyporheic zone of the headwater alcoves under study can be an effect of:

1. the outflowing groundwater attaining a physico-chemical equilibrium in response to current atmospheric conditions,

2. precipitation, ion-exchange sorption, oxidation and reduction of some chemical components (e.g. $Fe^{2+/3+}$, Mn^{2+}, NO_3^-, PO_4^{3-}, SO_4^{2-}), and

3. retention of nutrients (including K^+, Ca^{2+}, NO_3^-, PO_4^{3-}, SO_4^{2-}) by communities of water- and moisture-loving plants in the growing season (biological sorption) and their release in the autumn. It should be emphasised that in the eutrophic environment of a channel head the seasonality of concentrations of biogenic components in water is less distinct.

Headwater streams play a critical role in determining downstream water quality and, in turn, groundwater discharge areas may play an important role in determining both the chemistry and hydrology of headwater streams.

Bedload transport in headwaters (Western Tatras, Poland)

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Bedload transport is an important component of mechanical denudation in a catchment. Even if its fraction in the total sediment fluxes from the catchment is insignificant, it causes the largest morphological transformation and destruction during extreme events e.g., floods, debris flows. Small mountain streams are characterized by a very quick response to meteorological events, and hydrological processes are directly reflected in the activation of morphogenetic processes. The aim of this study is to discover the mechanism of bedload transport in 19 headwater catchments with an area <2 km^2 in the Western Tatras. This objective is achieved by determining:

(a) bedload transport mechanism depending on the size and type of flood,

(b) bedload transport in the longitudinal profile of stream channels,

(c) dynamics differences of the tested process in the alpine and montane areas.

The study was carried out in tributaries of the Chochołowski Stream catchment in the Western Tatras. Two catchment groups were distinguished in the study area, which represent areas with different natural environment conditions and various activities of morphogenetic processes: alpine and montane catchments. Alpine catchments (N=11) are located within crystalline bedrock (granitoids, metamorphic shists). A significant part of their area (more than 50%) is located above the upper tree line and the slopes are transformed mainly by snow avalanches, nivation, solifluction, gelideflation, and debris flows. While montane catchments (N=8) are located within sedimentary bedrock (limestones, dolomites),

in the montane forest zone. Slopes are mainly transformed by mass movements (e.g. landslides, creep) and linear erosion.

The bedload transport measurements were carried out with intervals over a period of 40 years, using the painted stone method. At every gauging site, depending on the width of the channel, from 30 to 400 particles of different sizes (0.5–50 cm) occurring in a given section of the channel were traced. Streamwater levels and flows were measured in 5 hydrometric profiles.

During large floods observed in the main Chochołowski Stream (Q>5 m^3s^{-1}), usually associated with prolonged rainfall or a combination of snowmelt and rainfall, it can be expected that bedload will also be activated in its tributaries. Such floods occur in study area 1-2 times per year. If the flow in the main stream equalled Q<5 m^3 s^{-1}, then the transport of bedload associated with small local and short-term floods could occur in the channels of its tributaries. Floods of this type are caused by either very local rainfall or snowmelt, which occur in different parts of the catchment at different moments: in the subalpine and alpine zones in May, and in the montane zone in April. Thus, there is not always a strong connection between discharge in a tributary and discharge in the main stream. During small local floods, the role of the local channel structure is important. Channel topography can slow down the transported bedload, which is particularly visible within alluvial fans. On the other hand, during high-energy events, this effect disappears, and the distance of transported bedload increases down the channel. In the slope subsystem represented by the colluvial channel, bedload displacement distances are the smallest in the longitudinal profile of the channel irrespective of the size of the flood, both in alpine and montane channels. These distances are significantly shorter than in the fluvial subsystem, especially in its middle section (semi-alluvial channel). In alpine channels, bedload transport occurs on a much smaller scale over the entire length of the longitudinal profile than in the montane channels. Both the distance of the bedload transport, its size, and the frequency of occurrence of geomorphologically-active floods is smaller in alpine catchments than in montane ones.

Mining sediment transfer and morphological changes related to anthropogenic and hydrogeomorphic activities in a temperate-mountain environment (Călimani Mountains, Eastern Carpathians, Romania)

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During the period between 1970 and 1997, the mining activities for sulfur-rich ore extraction and processing in Călimani Mountains (Eastern Carpathians, Romania) resulted in significant changes of the hillslope and channel morphology. An open-pit quarry was progressively created on the flanks of the Negoiul Românesc stratocone, as well as several spoil heaps on its western and northern slopes. Sediments originating from the spoil heap talus area have been reworked by hydrogeomorphic processes and redeposited mainly along stream channels. Trees in the riparian area have been and still are heavily disturbed by hydrogeomorphic process activity (burial of tree stems and roots) and by the hydro-geochemical pollution. Previous studies of this area have attempted to investigate only at a local scale the morphological changes and to reconstruct the spatial and temporal pattern of hydrogeomorphic activity, without regards of the morphological changes and sediment transfer across the catchment. This study is aiming (i) at assessing the geomorphic changes related to mining activities and contemporary geomorphic process activity, and (ii) at reconstructing the spatial and temporal variability of hydrogeomorphic activity on the anthropogenically-influenced slopes and stream channels. Topographic data acquired from successive topographic surveys using total station measurements and drone-based photogrammetry, have been combined with data resulted from remote sensing imagery (orthophotoplans) and GIS analysis, in order to construct multi-temporal Digital Elevation Models (DEMs), which served to derive, by DEM-differencing methods and Geomorphic Change Detection (GCD), the volumetric changes in various sectors of the catchment area

affected by the mining activity. Dendrogeomorphic methods were also applied, in the attempt to improve the knowledge about the past occurrence of extreme hydrogeomorphic events and to analyse their effects on trees disturbed along the flow paths in these mining areas. Results indicate that the sediments originating from the mining deposits combined with those from the anthropogenically-undisturbed areas are transported mainly during extreme hydrogeomorphic events, leading to an accelerated aggradation of the stream channels. This coupling system of natural and human-disturbed environment amplifies the erosional and transport capacity of floods, hyperconcentrated flows and debris flows along the stream channels. This also has direct implications for the sedimentation rate along the stream channels or within the sediment retention reservoirs and threatens the dam stability of the tailing pond constructed in the upland catchment. Our approach presented herein can significantly improve the understanding of the morphological changes and the riparian forest dynamics over historical time periods and has potential for supporting land managers and their decisions regarding the reclamation of these mining areas.

Geomorphological and climatological studies in the area of Bulgarian Antarctic base (Livingston island, South Shetlands Archipelago)

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The Bulgarian Antarctic Base "St. Kliment Ohridski" (S 62º38'31.6"; W 60º21'41.2", 12.45 m a.s.l.) is situated at the South Bay of the Livingston Island, part of the South Shetlands archipelago. Free of ice territory in the BAB's area differs from 3 to 5 km^2 in the observed seasons. The accessible coastal forms, rock outcrops and moraine ridges are parallel to the coast line, with 5 km total length and with height above sea level from 0 to 208 m. The rock outcrops in the area belong to the Miers Bluff Formation of metasedimentary complex, to volcanogenic-sedimentary complex of the Bowles Formation, to complex of the batholith of Antarctic Peninsula and to multiple dyke complex and Quaternary tholeiitic and alkaline lava of Inot Point formation (Smellie et al., 1995, Stoykova et al., 2002, Pimpirev et al., 2000, 2002, 2003, Krastev et. al, 2006). Their destruction depends mainly from their exposure to weather phenomena and especially to daily freeze-thaw cycle in the summer season.

The Bulgarian geomorphological study in the Bulgarian Antarctic Base (BAB) area was part of a wider project for complex geological, geochemical, geophysical and ecosystem analyzes. Its specific object was characteristics and monitoring of contemporary landforms dynamics in the free of ice territories in the BAB area. The field work on this project has been taken during five summer campaigns from 2004/ 2005 to 2009/ 2010. During the field seasons we have established and observed key sites for weathering, slope, coast and glacial processes;

we described different forms and observed their change for five summer seasons; characterized different deposits by grain size and petrographic composition.

During the 2018/ 2019 field season the investigations were extended and related to measurements and installing equipment in order to characterize the sediment transfer in the area of the Bulgarian Antarctic base (BAB) in the context of climate change. Data loggers in rock outcrops with different exposure and a meteorological station were set; and the physical weathering using Schmidt Hammer (Rock Type N) were studied.

Nutrient losses by erosion in soils under different land use/land cover using simulated rainfall with increasing intensities

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Intensive farming and land use changes including land abandonment can favour soil degradation by hydric erosion, giving rise to important soil and nutrient losses and to a decrease of organic matter content, which make the soils less fertile and productive. A particular example of these land characteristics is seen over a large area located at the southern part of the Pyrenees in the Pre-Pyrenean region (Aragón, Spain), in which after several decades of intensive rainfed farming, lands were abandoned (Navas et al., 2017). The aim of this research was to evaluate the relative contribution of different land uses/land covers to nutrient detachment and exportation by runoff, and what could be the effect of increasing rainfall intensities which may be recorded more and more frequently under climate change. The research was carried out using simulated rainfall in the laboratory, using plots prepared with soils collected in areas with different land use/land cover (forest, scrub, afforested areas, agricultural soil and barren land).Three rainfall intensities (22, 50 and 65 mmh^{-1}) were used, which were recorded in the area with different return periods. The simulations were maintained for 30 minutes in which runoff rates and soil losses were evaluated for each land use. Sediment concentration and nutrients (N: N-nitrate+N-organic and P: particulate+ dissolved) were analysed using different aliquots in the runoff samples. The results showed that for low intensities, the highest runoff rates were observed in barren land followed by the agricultural soils, being in agricultural soils near 3xtimes higher than in

the soils under forest, scrubs or afforested areas. For higher intensities runoff rates increased in all land uses, reaching values of about 3 and 8 times higher in agricultural soil, 4 and 7 times higher in scrubs and about 3 and 4 times higher in afforested areas, respectively for intensities of 50 and 65 mmh^{-1}. Under low intensities, there were only significant soil losses in agricultural and barren lands (25 and 128 gm^{-2}, respectively), which increased with rainfall intensity (up to 80 and 570 gm^{-2}, respectively, under I= 65mmh^{-1}). Among the rest of land uses the afforested areas were the ones that recorded lower soil losses (5 and 10 gm-2, under rainfall intensities of 50 and 65 mmh-1) , followed by scrubs and forest in which soil losses were between 3 and 4 times higher). The observed results obtained under laboratory conditions were compared with soil losses estimated in the field using the ^{137}Cs technique (Lizaga et al., 2018), and it was observed quite good agreement in the ratios in which the different land uses contribute to the total soil losses, with the poorer agreement in the case of the forest likely due to more difficult reproducibility of soil cover in lab conditions.

Nutrient losses due to erosion were higher in agricultural soils than in the rest of land uses. Nitrogen losses in runoff were mainly in organic form, and the maximum amounts recorded under the highest analysed intensity varied between 0.67 gm^{-2} in agricultural lands and 0.025 gm^{-2} in afforested areas. The differences in the contribution of the different land uses to N are in accordance to results found by other authors (Gao et al., 2004; Otero et al., 2011).

Regarding phosphorous, agricultural soils contributed to the highest losses, with values of 0.8, 3.2 and 8 gm^{-2}, respectively under rainfall intensities of 22, 50 and 65 mmh^{-1}. In forest soils, P losses varied between 1.9 and 5 gm^{-2} for intensities of 50 and 65 mmh^{-1}, while in the scrubs varied between 1.4 and 2.8 gm^{-2} and in the afforested areas P losses were below 0.2 gm^{-2}. However, despite being barred land the soils in which higher soil losses were produced, its contribution to nutrient losses were lower than in other land uses. The result agree with the observed by Meng et al. (2008) and FarKas et al. (2013) Thus, the results confirmed the agricultural lands as the most important non pollution source of both nutrients.

References

Farkas, C., Beldring, S., Bechmann, M., Deelstra, J., 2013. Soil erosion and phosphorus losses under variable land use as simulated by the INCA-P model. Soil Use Manage. 29(SUPPL.1), 124-137.

Gao, C., Zhu, J.G., Zhu, J.Y., Gao, X., Dou, Y.J., Hosen, Y., 2004. Nitrogen export from an agriculture watershed in the Taihu Lake area, China Environmental Geochemistry and Health 26(2), 199-207.

Lizaga, I., Quijano, L., Leticia Gaspar, L., Navas, A. 2018. Estimating soil redistribution patterns with ^{137}Cs measurements in a Mediterranean mountain catchment affected by land abandonment. Land Degradation & Development, 29: 105-117. DOI: 10.1002/ldr.2843

Meng, Q., Fu, B.,Tang, X. 2008. Effects of land use on phosphorus loss in the hilly area of the Loess Plateau, China. Environmental Monitoring and Assessment 139(1-3), 195-204.

Navas, A., Quine,T.A., Walling, D.E., Gaspar,L., Quijano, L., Lizaga , I. 2017. Relating intensity of soil redistribution to land use changes in abandoned Pyrenean fields using fallout caesium-137. Land degradation & development, 2017-2029.

Otero, J.D., Figueroa, A., Muñoz, F.A., Peña, M.R. 2011. Loss of soil and nutrients by surface runoff in two agro-ecosystems within an Andean paramo area. Ecological Engineering 37 (12), 2035-2043.

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The sediment fluxes from Bistricioara catchment (Eastern Carpathians, Romania)

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The Bistricioara Basin is located in the central part of the Eastern Carpathians, occupying 781 km^2, it spills into Izvorul Muntelui reservoir, and is a mountainous gravel bed river. In order to characterize the sediment flows in this hydrographic basin, data on liquid and solid flows from three hydrometric stations in the basin: Bilbor, Tulgheş and Bistricioara were analysed. Periods with hydrometric data are between 1953 and 2017, but continuous data for the three hydrometer stations exist only since 1977. The Bilbor hydrometer station lacks liquid flow data, which is obtained by correlation with the other two stations. Liquid and solid flow data were expanded and normalized for the period 1961-2017, for which the precipitation data from ECA & D, ROCADA and WORDCLIM data was also extracted. An empirical model based on the correlation between precipitation, leakage and effluent sediment was developed to model the flow of water and sediment in the Bistricioara sub-basins.

The exported sediment yield is only a part of the hillslope-channel cascade, that is why we coupled the sediment yield analysis with topographic with UAV surveys, creating high resolution models of channel topography for several channel reaches and for the most important confluences of Bistricioara river with its tributaries. These surveys were used to characterize the hydraulic setting of water and sediment flow.

Daily water stage and 20-40 channel elevations acquired per year from discharge measurements were used to assess the vertical dynamic of the river channel.

Beside these quantitative data we also used cartographic material to assess the river channel migration. Topographic maps covering the period 1890-1984 and aerial imagery data covering 1984-2012 period were used to map the Bistricioara channel for six periods (1890, 1920, 1960, 1984, 2005, 2012). Remote sensing images from the Google Earth database

were used to assess changes with a higher temporal accuracy for the period between 2005 and 2018. A photogrammetric DEM at 5 m resolution was used to map the valley and terrace extension, in order to evaluate the BRT classification (Rinaldi et al., 2013, 2016) of laterally confined and partly confined typology.

The results show that: (i) channel migration, especially after 1960 was limited by the anthropic intervention along the channel, by imposing confinement through stabilizing walls especially for road embankment protection, (ii) before 1960 there was extended use of water force for mills and wood, along the main channel or through water deviation along anthrophic channels, (iii) the Bistricioara channel was assessed as alluvial single-thread type 7 (cobble-gravel material and riffle-pool morphology) with sectors of wandering (type 11) and pseudo-meandering (type 12), (iv) channel bed elevation trends show degradation upstream of the confluence with Putna river, and aggradation downstream, (v) Izvorul Muntelui reservoir water level probably influenced the aggradation which should be monitored, since in a mountainous area the space of channel migration is limited and this can have huge social implications, and (vi) suspended load vs. discharge analysis show sediment limited supply upstream of Putna confluence and limited capacity transport downstream.

The present study is of great importance for the water and local administration because it draws the general framework of sediment fluxes along the river channel and it opens the road for a topographic monitoring of sediment fluxes.

Freeze-thaw activity in the high mountain area of Pirin Mountains, SW Bulgaria

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This work presents results from the ground surface temperature measurements, which are most informative for localization of frozen ground during the winter season. Three sites were monitored with different slope aspect – Kazanite Cirque (Banderitsa Valley, N-NE aspect), Begovitsa Cirque (Begovitsa Valley, S-SW aspect) and Sinanitsa Cirque (Sinanitsa Valley, W-NW aspect) on the same elevation – above 2200 m, defined as the Alpine boundary in the Bulgarian mountains. Thermometer loggers were installed in shallow soil cover at 2-3 cm depth and programmed to record hourly data.

Seasonally frozen ground has been established in the Pirin Mountains. Our measurements showed 5 to 7 months freezing period in the observed sites. It has strong relation with the exposure and the altitude. There are indications for seasonally frozen ground appearance above 2200 m on the west-southwest macroslope of the Pirin Mountains. Duration of the frozen period is greatest in the northern exposition and lowest in the southern.

A geomorphological study has also been conducted in the same sites, regarding establishment of relation between soil temperature variation and slope processes activity. Our observations confirmed that the exposure factor determines the type and the speed of the slope processes. The ground surface temperature data allowed us to define three periods of activity of the slope processes: the cold period (December-February), the warm period (July-September) and the transitions between the two main periods. The highest rate of slope processes is established at the transition between the cold and the warm period (March-June).

Denudational processes of the cliff coast, Wolin Island, 2013-2019

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Contemporary processes of cliff formation and development result from the denudation system, and are driven mainly by the climate, which continuously varies over time and is spatially differentiated. The primary factors in the functioning of the denudation system of Wolin Island's cliff-coast are weather conditions, which change according to seasonal, annual and multiyear cycles, geological settings, landform, land cover, and diverse forms of human activity.

Cliff-coasts play a crucial role in the contemporary morphosystem of Wolin Island. The Wolin cliffs, 15 km long, constitute a section of a nearly 50-kilometre cliff zone on the Polish seaside. The Wolin terminal moraine, the most important landform in the northern part of the island, is undercut from the sea side with steep cliffs. The authors confirmed the glaciotectonic character of the Wolin moraine ridge. In terms of the geological structure of the Wolin cliffs, two series of till can be distinguished. Grey till linked with Warta glaciation occurs in the bottom part of the cliff. Its maximum thickness reaches 40 m. The grey till is directly overlain by the Vistulian brown till of lesser thickness, up to a few meters, which can be found only in some sections of the cliff. On the presented moraine till beds there are deposits of fluvioglacial sand as thick as 40 m in many places. Over the top part of the fluvioglacial sands there are aeolian cover sands with a thickness of 2 to 15 m.

Systematic fieldwork has been conducted since 1973 to identify and define the morphological variability and developmental tendencies of Wolin's cliff-coast. A verified, thematic database of cliff top recession has been compiled, based on a series of long-term observations at five research sections. It contains the annual rate of Wolin Island's cliff top recession in selected test sections in the years 1984–2019. The database served as a

comparison resource for this study. Systematic monitoring of cliff top recession indicated the rate of coastal cliff destruction, which is caused mainly by sea abrasion, mass movements and water erosion. It should be mentioned here that the findings of ongoing studies of individual landform evolution, sets of forms and the types of landforms on the Wolin cliffs, aimed at creating a detailed geomorphological map of the cliff-coast, provide an important supplement to the presented documentation. The main goal of this work is to use laser-scanning materials (TLS) gathered in the years 2013-2019 and current diagnostic studies to present quantitative and qualitative tendencies in the morphodynamic changes on the cliff-coast of Wolin Island.

In the course of carrying out the proposed research task, current studies were conducted of the abrasion processes occurring on Wolin Island in selected test sections with different morphodynamics of the coast east of Międzyzdroje located in the Pomeranian Bay (Southern Baltic). This area was divided into three test sections, differentiated by the morphology, lithology and exposition of the coast. The first section, 380 m long and 20-25 m high, is made up of bottom till layer deposits and sandy layers (upper layers). The second section is the most diverse both in terms of lithology and morphology. At the length of 342 m there is both a clayey cliff and a sandy cliff. The height of this coast varies between 35 and 55 m. The third section, 380 m long and 55-60 m high, is built entirely of fluvioglacial sands.

The study consisted of laser-scanning of the morphological face of cliff-wall at one year intervals. Scanning results provide a solid basis for a comparative study of the abrasion processes present in the South Baltic Sea cliff-coast. Quantitative determination of denudative processes was possible using a Leica ScanStation c10 laser scanner. Thanks to the use of modern technology, whose measurement accuracy reaches up to 1-2 cm, it is possible to accurately quantify the sediment balance within the cliff. As a result of the measurements, it was possible to obtain digital elevation models and, on their basis, to conduct differential analyzes leading to the identification of the morphodynamic zones of the cliff and quantification of the sediment balance.

Thanks to the conducted research, it was possible to obtain a quantitative illustration of denudative processes taking place on three sections of the cliff coast. The largest loss of material was recorded on the second test section and it amounted to 14 180 m^3. A slightly

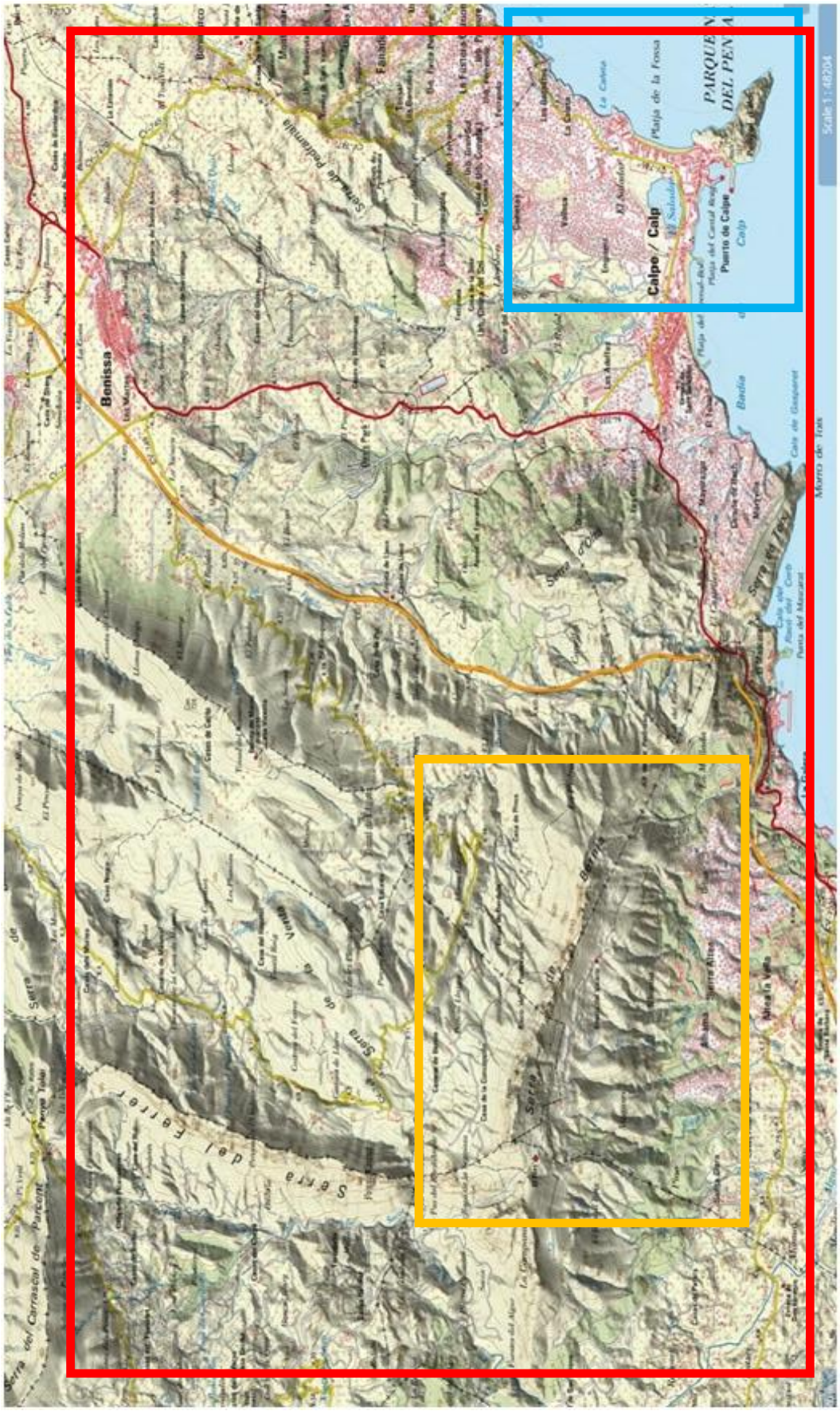
smaller loss was registered on the third section 13 991 m^3. At the same time, it should be noted that this balance relates to the shorter time span (2017-2019) than is the case for the other two sections (2013-2019). The lowest loss of material was recorded in the first section. In the measurement period of 2013-2019 it amounted to 9 329 m^3. The values given are absolute values that show the total sediment balance. To determine the dynamics of the cliff in quantitative analyzes, it is necessary to include at least such characteristics as the surface of the analyzed cliff. The surface of the cliff is a function of its length and height. In quantitative analyzes of denudative processes occurring on sea cliffs, it is often overlooked to take into account the height of the cliff, and this may draw an erroneous picture of the activity of the slope. In this study, the authors decided to characterize the cliff activity using the m^3 m^{-2} indicator, in which the material balance is converted to the surface of the analyzed area. Using this approach, it should be noted, that the most active section is the third section (0.66 m^3 m^{-2}), the first section (0.31 m^3 m^{-2}) and the second segment (0.21 m^3 m^{-2}) is the least active. If the measurement period is taken into account, which in this case is not the same for all sections, then the results look as follows: the first section - 0.051 m^3 m^{-2} yr^{-1}, second section - 0.035 m^3 m^{-2} yr^{-1}, and third section - 0.033 m^3 m^{-2} yr^{-1}.

The conducted research has shown that the most dynamic zone is the foot of the cliff because erosion and accumulation processes occur most often there. During periods of storm surges, this zone, as a result of abrasion processes, moves towards the land, while in spring and summer periods when the processes of depositing colluvial materials dominate, they move towards the sea. Thanks to this, the base of the cliff is exposed to the destructive activity of the waves, which in turn leads to its rapid degradation.

5. Field trip information and views of Calpe and the surrounding Mediterranean landscape

Views of Calpe and the surrounding Mediterranean landscape (Photos: K. Laute)

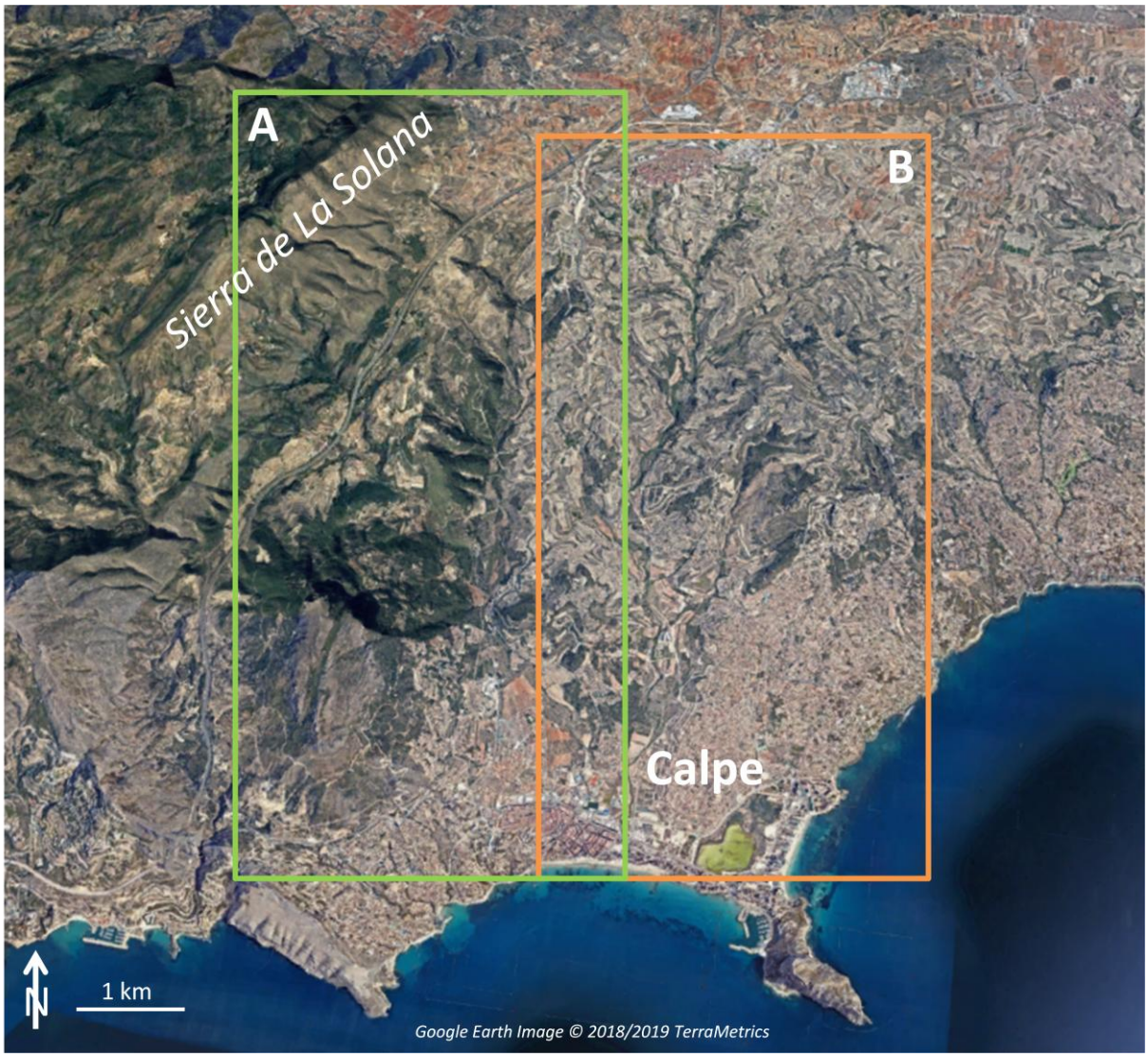
Topographical map of the entire study area (red frame) and views of the city Calpe (blue frame) and the Sierra de Bernia mountains (yellow frame) from the air plane (Map source: CNIG, http://centrodedescargas.cnig.es/CentroDescargas)



View of Calpe with the Peñón de Ifach, les Salinas and surrounding areas (Photo: K. Laute)

View of the Sierra de Bernia mountains (Photo: A.A. Beylich)

Overview of the Pou Roig (A) and Quisi (B) catchment systems



Impressions of the Pou Roig catchment (Photos: K. Laute)

Impressions of the Quisi catchment (Photos: K. Laute)

Overview of the hillslope systems in the Sierra de La Solana and Sierra de Bernia mountains

Impressions of the Sierra de La Solana (Photo left: K. Laute, Photo right: A.A. Beylich)

Impressions of the Sierra de Bernia (Photos: K. Laute)

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