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## The uniqueness and complexity of Danube Delta landscapes

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Deltas are among the most dynamic and complex systems of nature, their genesis and evolution being largely subsumed by sequences of processes that govern the occurrence of specific landscapes (from their formation to the present days and, implicitly, from their initiation under natural conditions to the most recent anthropogenic remodeling).

Given the vastness of the Danube Delta and its relatively low degree of anthropization compared to other deltaic systems, a series of landscapes can be observed, which together generate the unique design/physiognomy/expression of this deltaic system (both in terms of geomorphological features and specific biodiversity). The specific landscape is particularly diverse, integrating (i) the river delta (landscapes generated by fluvial processes), (ii) the maritime delta (landscapes generated by wind, wave, and currents action) and (iii) the tectonically controlled delta (southern compartment - landscapes influenced by neotectonic processes).

Ten distinct landscape types harmonize within the macro-landscapes of fluvial, maritime and tectonically controlled deltaic compartments: (1) numerous lakes, channels and levees blended into a labyrinthic landscape specific to the fluvial delta, (2) main-branches landscapes with wide channels and extensive levees, (3) secondary delta landscapes, (4) beach-ridge plain landscapes with large dunefields and deciduous forests, dominated by oak, (5) beach-ridge plains with low sand dune ridges, (6) labyrinthic landscapes with large lakes developed between beach ridges, (7) extensive reed marsh cushion landscapes (8) erosive, accumulative, stable low-lying deltaic shoreline landscapes, (9) large lagoons superimposing former beach ridge plains and (10) truncated beach ridge plains.

These landscapes have a specific sensitivity to present-day external factors (current climate change and accelerated sea-level rise, together with the increasing anthropogenic pressure), deltaic systems being particularly susceptible to environmental change. A comprehensive understanding of the deltaic geomorphological processes that govern the Danube Delta is necessary to design the best conservation plan of this Europe's unique bio-morphosystem.

KEYWORDS Danube Delta, deltaic systems, landscapes

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## **Rockfall hazard assessment in active geomorphosites: a case study using dendrogeomorphic approach**

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Rockfalls are known as detachment, fall, rolling, and bouncing of rock fragments and represent a hazardous geomorphic process widely spread in mountain ranges, coastal cliffs, volcanoes, riverbanks, etc., some of them occurring in geomorphosite areas visited by tourists. Related or not to climate change, rockfalls negatively impact tourists and local communities of the affected areas. Taking into consideration the importance of natural risk in tourism development, several research surveys were made by academics and practitioners to mitigate and manage rockfall hazards and associated risks. The risk derived from rockfalls became a subject in the contemporary research in geomorphology and tourism analysis, and these studies, besides the theoretical approach, have been focused on infrastructure and elements into and towards tourist destinations with historical buildings or natural attractions flanked by cliffs that generate rockfalls. Various research methods, techniques and instruments are employed for rockfall monitoring, e.g., terrestrial laser scanning, LiDAR, total station survey, rock joint sensors, and other remote sensing imagery or photogrammetry. Most of these studies were focused on the present stage of the critical areas, but for a better understanding of the geomorphic hazard history and a better prediction, the dendrogeomorphic method was used in the past decades. So far, little research has been done on the frequency and magnitude of the rockfalls. Dendrogeomorphic reconstruction of rockfall activity was used to investigate and model different geomorphosites in the Alps. In the Carpathians, despite the presence of various active rockfall sites, the dendrogeomorphic investigations were not applied to assess rockfall hazards. In this study, we tested the potential of growth rings of Norway spruce (*Picea abies* L. Karst.) trees to record past rockfall activity. The Detunata Goală active geomorphosite (Apuseni Mts., Romania) was chosen as a study site to test the dendrogeomorphic methods to reconstruct rockfall activity. Trees with visible disturbances related to the mechanical impact produced by rockfalls, e.g., apex loss, stem wounding and tilting, have been sampled. Additionally, undisturbed trees growing outside the area reached by fallen rocks have also been sampled, and their growth chronologies served to build a local reference chronology. Growth anomalies (scars and traumatic resin ducts, compression wood and growth suppression sequences) found within the annual rings of disturbed trees were used to reconstruct rockfall events' time and spatial extent. Despite some inherent limitations of dendrogeomorphic methods, tree rings proved to be a reliable source of information on rockfall activity, clearly revealing the existence of the rockfall hazard within the geomorphosite area. Regarding hazard management, this information on past rockfall activity may further be helpful for decision-maker policies oriented to reduce the rockfall hazard exposure of tourists in the active geomorphosite investigated.

**KEYWORDS** geomorphosites, rockfalls, Detunata Goală

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# Geomorphological and hydrogeological analysis of the karst systems in the central-western part of the Metaliferi Mountains

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This study is the first step of a broader project aiming to extend future research to other karst areas in the Metaliferi Mountains. Thus, the object of this scientific endeavour is represented by the karst areas located in the central-western part of the aforementioned unit. These karstic areas are characterized by a notable spatial fragmentation, taking the form of calcareous klipfes in which karst systems with a certain geomorphological and hydrogeological complexity have emerged. One of the edifying aspects regarding the configuration of the karst in the analysed area is the limited karstifiable rock volume, along with its dispersion in the form of the analysed perimeters within the Metaliferi Mountains. This configuration is reflected in the differences regarding the distribution of landforms, along with the regime and characteristics of the water agent, existing between the karstic and non-karstic domains (in the case of the areas from Boiu de Sus or Deleni). On this basis, through the research carried out, the intent is to highlight the existing relations between the two previously mentioned domains, each of them being subjected to a distinct morphogenesis, which generated, in the case of the karst domain, surfaces with higher altitudes in relation to the adjacent space, thus contributing to their relative isolation. The influence of the karst environment extends beyond the surface topography, affecting the hydrographic network by reorganizing it, while concurrently inducing changes in the chemical composition of water, in the sense of increasing alkalinity following the dissolution of  $\text{CaCO}_3$ . In this sense, it is highlighted how the specifics of surface drainage change as it infiltrates the karst system, by outlining the spatial distribution of the drainages, capitalizing on the tracer method. This involved the use of a saline solution at the insurgency points, followed by the collection of water samples upstream and downstream of the karst system at certain time intervals after the placement of the saline solution. These samples were analysed in the laboratory to establish the existence of links between the points of water entry into the karst and subsequent resurgences. Furthermore, the analyses highlighted how the karst environment influences the physical and chemical characteristics of the water agent.

KEYWORDS karst system, Metaliferi Mountains, hydrogeology, Boiu de Sus, Deleni, tracers

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## **Preliminary results for determining the age of the 3<sup>rd</sup> fluvial terrace deposits in Transylvanian basin using optically stimulated luminescence method**

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For determining the absolute age of the terrace deposits, a geomorphosite was selected, located on the left side of Someşul Mare River, southeast of Rebrîşoara, which includes a fragment of the tread of the 3<sup>rd</sup> terrace (20 m relative altitude) and the cuesta slope, facing north, of the Făgetului Hills. Since the beginning of the 20<sup>th</sup> century, the question of the fluvial terraces age has been long debated in Romanian geomorphological literature. A large number of geomorphologists have carried out studies where the question of the age of the terraces both inside the Carpathian curvature and outside, was raised. Most of the studies carried out for the terraces on the rivers of the Transylvanian Basin indicated the age of the 3<sup>rd</sup> terrace as Wurmian (Brătescu, 1941; Dragoman, 1955; Posea, 1961; Fuchs and Konya, 1967; Jakab and Sipos, 1970). Moreover (Savu, Mac and Tudoran, 1970 states that the 3<sup>rd</sup> terrace was formed in the Middle Weichselian (Würm II). Until recently, most assumptions related to the age of the terraces were based on the correlation between them and/or by dating the paleontological fossils discovered in the terrace deposits. Recent studies, on the other hand, use high-precision methods to determine the ages of terrace formations. Researchers as: Bălescu, 2003, Necea et al., 2013, Armaş, 2018, use methods as the Infrared-stimulated luminescence dating (IRSL) and SAR-OSL (Optically Stimulated Luminescence). The present study focuses on the attempt to determine the age of the 3<sup>rd</sup> terrace in the corridor of the Someşul Mare River. In the alluvial formations of this terrace, two geologic drilling operations were carried out from where several samples were collected. They were subjected to OSL analysis at the Luminescence Dating Laboratory, Department of Geoinformatics, Physical and Environmental Geography, University of Szeged, Hungary. The results showed an older age of 3<sup>rd</sup> terrace than was believed until now.

**KEYWORDS** optically stimulated luminescence, 3<sup>rd</sup> terrace, fluvial terrace deposits, Transylvanian Basin

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## **Electrical resistivity tomography measurements and its benefits in geomorphology and geoarchaeology**

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Geophysics measuring methods are widely used in geomorphological studies. This paper focuses on the ERT geophysics ground penetrating method and its purposes in geomorphological and geoarchaeological surveys. The sites where the measurements took place are Detunata Goală, a low altitude permafrost rock glacier deposit, Chiselet archaeological site and near the seaside cliffs of "2 Mai Sea Life Reservation" located between 2 Mai and Vama Veche villages along the Romanian coast. The aim of the study is to show how to use and the benefits of using the ERT method in geomorphology by obtaining topographic profiles of soil stratigraphy, detecting low-elevation ice and permafrost lenses, the stratigraphy of a Neolithic human settlement and possible buried walls or artifacts, and the stratigraphy of the Romanian coastal zone and the contact between loess and limestone on the seashore cliffs.

**KEYWORDS** ERT, geomorphology, geoarchaeology, coastal sediments, low altitude permafrost

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## **Present day morphological state of the Someșul Mic, Someșul Mare and Someș Rivers, Romania**

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In the context of the increased interest on integrating the complex spatial and temporal response of fluvial systems to human impacts into the process of assessing the ecological state of the rivers and in promoting a sustainable river management, European countries have developed a multi-scalar, hierarchical, process-based hydro-morphological framework focused on understanding the river functioning and evolution as a basis for interpreting current conditions. The evaluation of stream morphological quality was preceded by a phase of river segmentation, consisting of an initial division of the network into river reaches with homogeneous morphological characteristics. The evaluation procedure consists of a set of 28 indicators, which were defined to assess longitudinal and lateral continuity, channel pattern, cross section configuration, bed structure and substrate, and vegetation in the riparian corridor. These characteristics are analyzed in terms of geomorphological functionality, artificiality, and channel adjustments (MQI). The Morphological Quality Index (MQI) was calculated for 17 distinct channel reaches on Someșul Mic Rivers, 18 channel reaches on Someșul Mare River and 17 on Someș River.

**KEYWORDS** reference conditions, channel adjustments, geomorphological functionality, river morphological state

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## **Estimating sediment budget and transport in the Râul Mare watershed for managing the Râul Mare-Retezat hydropower system**

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So far, the estimation of sediment quantities in hydrographic basins has been carried out both in international research and at the national level based on the USLE (Universal Soil Loss Equation) model proposed by Wischmeier & Smith, 1978. Furthermore, the evaluation of the transport capacity of eroded materials through topography can be modeled based on the Connectivity Index (IC) proposed by Borselli et al., 2008 and modified by Cavalli et al., 2013, this being a new GIS methodology, not previously used in geomorphological studies in Romania. Modeling these data allows the identification of areas with active erosion, as well as areas where the specific process is that of material accumulation, thus making it possible to estimate quantitatively the sediment budget of a certain study area, as well as a prediction of its trajectory. Through this study, the estimation of both the sediment budget production and its transport capacity towards the Gura Apelor lake was performed, as well as the spatial modeling of these data using the previously mentioned GIS methodology, in order to correlate it with the potential of sedimentation of the reservoir. According to the results, in the reception basin of Gura Apelor lake, a potential average soil erosion rate of 4.97 t/ha/year was estimated, this value falling into the low erodibility class, the total amount of eroded material in the studied basin each year being approximately 118,395 tons. Half of the area has insignificant erodibility values, up to 3 t/ha/year, while high and very high values represent only 3.67% or 867.23 ha of the basin. Additionally, based on the identification of sediment traps through the Connectivity Index, it was concluded that only 17.6% of the estimated material has the capacity to fill the reservoir, namely 20,875 tons. These data, along with the results of other similar studies, can be easily validated by solid discharge data measured at hydrometric stations, the need for this data being essential for a complete and complex sediment dynamics and production assessment.

KEYWORDS RUSLE; connectivity index; erosion; Gura Apelor; sediment flux

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# The morphogenetic complexity of landslides in the Vrancea seismic region (Romania): insights from two recent high-impact slope instability events

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In landslide-prone environments, the determination of rainfall triggering thresholds represents a key issue in developing reliable hazard scenarios. Estimation of the return periods of precipitation amounts causing the failure of different landslide types with various magnitudes is a valuable support in developing proactive measures for effective risk mitigation. The Vrancea Seismic Region (VSR) of Romania, overlapping the Curvature sector of the SE Carpathians, is a representative geomorphic region, severely affected by a wide range of hydro-meteorological-induced hazards, which frequently evolve in multi-hazards. Within the existing natural hazard inventories for VSR, landslides have a consistent share in the total number of slope process records, with an associated large damage toll. The complex landslide typology and the lack of a clear common occurrence pattern of landslide events are the main causes of uncertainty in landslide susceptibility modelling, which makes the hazard scenarios development still very challenging. This paper aims to provide a consolidated view on the morphogenetic complexity of landslides in the VSR by examining the hydro-climatic preparing and triggering pre-conditions for two recent long-term impact landslide events occurred in 2014 and 2015. The results of a detailed analysis of the conditioning factors, with a focus on the climatic preparing/triggering ones, outlined the importance of precipitation triggering thresholds, including those assigned under below-average conditions, in building optimal hazard scenarios, especially in the landslide-prone areas, where anthropic slope instability factors (i.e. building slope overload, inadequate construction codes) play a critical role in slope failures.

KEYWORDS landslides, Vrancea seismic region, Curvature Subcarpathians, slope overload

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## **Detection and characterization of marine fronts in the Western Black Sea basin using observation data**

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Mapping and characterization of marine fronts are essential aspects of physical oceanography due to their significant impact on local dynamics, ecology, and climate. Also, these areas are generally associated with increased production through multiple trophic levels, thus are essential for fisheries management. Better detection and (potential) prediction of marine fronts can lead to the proper implementation of sustainable growth initiatives in the Black Sea. We present our first analyses concerning fronts identification using Earth Observation data. The work was performed using two types of satellite derived products: Chlorophyll-a concentration (Chl) and Sea Surface Temperature (SST). Therefore, the detected marine fronts have a dual nature: thermal and primary production driven. The study area covers the Western Black Sea basin. Daily products delivered by the Copernicus Marine Service (CMEMS), in addition to a spatial resolution of 1 km, are used. These are Level 3 datasets, based entirely on observations. Thus, no gap-filled or modelled data are involved. In terms of methodology, a filter-based algorithm was chosen. It implies the use of a contextual median filter followed by a Sobel edge detection pass. The results are then post-processed in order to derive meaningful information concerning the dynamics of the identified marine fronts.

**KEYWORDS** marine fronts, Earth Observation, CMEMS, edge detection algorithm

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## **Assessment of territory's susceptibility to landslides and soil erosion in Sibiu county based on GIS spatial analysis models**

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The environmental component represents the support that sustains all anthropic activities, either in a favorable manner, by creating the necessary conditions for human society, or through restrictiveness, when certain processes and natural phenomena prevent the development of some anthropic activities. The natural risks that are the subject of this study, namely landslides and soil erosion, are part of the category of those that can impose various restrictions in terms of land use and management.

Landslides are geomorphological processes that affect the stability of slopes, causing significant material and environmental damage and affecting residential and transport infrastructures. Together with soil erosion processes, these are the main factors that have major implications regarding the management of agricultural lands and the economic development of the affected areas. The present study first purpose is assessment of territory's susceptibility to landslides using the classic methodology in force in Romania (H.G. 447/2003) and the identification of hot spot areas which will become extremely useful to prioritize the actions of combating the occurrence of these natural slope processes and reducing the medium- and long-term effects.

The second purpose of this study is identifying the land's susceptibility to soil erosion, which has a particular importance to design the most useful intervention measures and reduce the negative effects on the natural and anthropogenic environment induced by them. The estimation of soil losses at the level of Romania is carried out using different models and analysis scales, but the ROMSEM Model (Romanian Soil Erosion Model) is unanimously accepted.

By using GIS based analysis for mapping these two geomorphological processes in Sibiu County many implications on human society (e.g., material damage and risk induced to the population through material losses, difficulties related to transport, interruption of water and electricity supply, possibility of occurrence of landslides and the reactivation of existing ones) could be prevented.

**KEYWORDS** landslides, soil erosion, ROMSEM Model, Sibiu County

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## **Towards national active landslide inventory using EGMS datasets**

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Landslide inventories are the most basic and trivial tool required for more advanced investigations regarding susceptibility analysis, hazard and vulnerability assessment, and risk mitigation. Due to the limited resources used for landslide mapping, most inventories are geomorphological, including all the landslides within an investigated area regardless of their triggering factor or state of activity. At the national scale of Romania, there is not a harmonized dataset available for the entire territory, but only a few regional and local landslide inventories exist.

We aim to better this problem by starting to create an inventory of active landslides detected by remote sensing techniques. For this, we used the European Ground Motion Service (EGMS) products which provide millimeter-scale measurements of the annual velocity and displacement series. This data is provided by the ambitious project of the Copernicus Land Monitoring Service for the EU-participating countries and consists of processed Sentinel-1 Single Look Complex SAR images with the Multi-temporal Differential SAR Interferometry algorithms. Out of the different types of MT-InSAR measurements accessible for visualization and download from February 2015 to December 2021, the calibrated (Level 2B) ascending and descending data are the most relevant and supply the needs of most users.

In our case, we exploited such products to detect deformations related to slow-moving landslides. As a final goal, we started creating an active landslide database from a regional level to a national inventory, which can be improved further by harmonizing and including the regional geomorphological inventories. To succeed, we derive the 2D components from the InSAR measurements and evaluate them geomorphometrically to validate the landslide-induced deformations.

**KEYWORDS** landslide inventories, EGMS, slow-moving landslides

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## **Towards an up-to-date gully inventory from Moldavian Plateau of Eastern Romania**

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Worldwide, gully erosion is an important sign of land degradation, rendering slopes unfit for agriculture and forming an important source of sediments in a different range of environments. Gully erosion is recognized as a major environmental threat in the Moldavian Plateau from eastern Romania. Most of them were initiated by human activities, representing probably some of the most important case-scenarios of human impacts on land degradation through soil erosion in Europe. Till now, the only gully inventory map for the entire region was drafted by Rădoane et al. (1995). Using topographical maps scaled 1:25.000, they mapped over 9000 gullies and estimated an average gully density of 0.1-1.0 km/km<sup>2</sup>, with maximum values >3 km/km<sup>2</sup>.

Based on modern GIS techniques doubled by classical field monitoring campaigns we achieved a detailed up-to-date gully headcuts inventory comprising 43188 gully headcuts. The different source data (DEMs, including LIDAR datasets, different series of aerial photos, satellite images) were supplemented with field data obtained through classical topographical measurements (Topographical Total Station, GPS), as well as modern UAV techniques (SfM & LIDAR datasets). The density varies widely between 0-119 gully headcuts/sqkm, with an average value of 2.13 gully headcuts/sqkm.

Our comprehensive gully head inventory demonstrates an exclusive scientific importance, contributing to the better understanding of the gully spatial distribution and typology on the whole regional scale. It comes to complete and support the scientific results already obtained in the field on gully erosion within this part of Romania.

**KEYWORDS** gully erosion, gully headcuts inventory, GIS techniques, UAV SfM, LIDAR

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## **GLO-30 as a global DEM for geomorphological applications**

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Copernicus DEM is the new global dataset with the desired coverage and resolution to become the standard elevation dataset to replace SRTM. SRTM represents the Earth's terrain at the level of February 2000, with a spatial resolution of 1' and a feature resolution that can cover medium-scale landform features. The GLO-30 Copernicus DEM is based on the WorldDEM topographic data with an original resolution of 0.4", obtained from TerraSAR-X and TanDEM-X SAR interferometry data. The WorldDEM sources were acquired between December 2010 and January 2015, and every surface was acquired twice. GLO-30 dataset is resampled from 0.4" to 1". The global validation against ICESat data revealed a RMSE of 1.68 m, a standard deviation of 1.68 m, and an absolute vertical accuracy linear error at 90% confidence interval of 2.17 m.

In the present approach, LiDAR data at 0.5 and 1 m spatial resolution covering two regions over Eastern and Western Romania were used to evaluate the accuracy in landform representation of the GLO-30 Copernicus DEM. The results show that the deformations due to the RADAR acquisition (shortening and layover) are lower than for the SRTM dataset, but the number of voids is bigger, especially in the mountainous areas. The resolution of the geomorphic landforms is superior to SRTM data, with river channels, gullies, and landslides feature being very often recognizable in non-forested areas.

In conclusion, GLO-30 Copernicus DEM outperforms SRTM and can be used as a new source of global elevation data, but care is needed when certain types of landforms are targeted by the analysis, especially in forested areas. The most affected by the inconsistencies due to the RADAR acquisition technology are the hydrological features, especially in mountainous areas with forest cover.

KEYWORDS GLO-30 Copernicus DEM, global DEM

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## **The spatial reconstruction of rockfall activity by dendro-geomorphological methods in a forest stand in the Southern Carpathians**

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Rockfall is a common geomorphic process in steep mountain regions, which can cause considerable material and human damage. In order to mitigate the negative impacts of rockfall, it is essential to delineate hazard areas that require detailed reconstruction of past rockfall activity. Spatial analysis of rockfalls based on tree growth responses to impacts was carried out for the tourist geomorphosite "Stone Gate" at 1400 m (a.s.l.) in the Cozia Massif in the Southern Carpathians. The dendro-geomorphic reconstruction covers over 200 years of rockfall activity (1807-2022) and is based on the analysis of 100 cores and 70 discs taken at different stem heights from 40 *Picea Abies* (L.) Karst. The assessment allowed the dating of 1137 growth anomalies due to rockfall activities, of which 928 are different rockfall events, with an average recurrence interval of 5.4 years. The results of the study show the manifestation of processes with high frequency and low magnitude of rockfalls, without recording large-scale events, but most importantly the main direction of the release of rock fragments and the dynamics of the source area. Therefore, this work provides important information on the spatial patterns of rockfalls in the study area, which is very useful for the planning and design of the mountain terrain.

**KEYWORDS** dendrogeomorphology, growth rings anomalies, rockfalls, recurrence interval, spatial analysis avalanches, susceptibility, multicriteria analysis

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# Fluvial style changes during the Holocene in NW Romania

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Europe's river systems have a multi-millennial history of human impact. The depositional history of floodplain sediments along Western and Central European rivers reveals that during the Early Holocene most of the floodplains were drained by anastomosing channels evolving in the presence of extensive forests and with limited vertical aggradation. In contrast, during the middle and late Holocene, as land-use changes in watersheds became more important, rivers metamorphosed into meandering and braiding channel types, while floodplain sedimentation rates increased, especially during the last 2000-1000 years.

To extend the European model further to the east, in this study we review published and unpublished data on climate, vegetation and human impact of the Holocene in NW Romania in relation to local fluvial reconstructions in the Someş drainage basin.

The main objectives of this exercise are: 1) to establish the chronological framework for the Holocene fluvial history in the study area; 2) to investigate the sensitivity of the Someş drainage system to the main environmental changes in the last 11,700 years, and 3) to define the present-day patterns in channel and floodplain behaviors of this region.

Our findings point to five critical moments during which the Someş fluvial system changed definitively, without a return to the previous state: the Younger Dryas/Holocene Transition, ca. 10 ka BP, ca. 6-5 ka BP, ca. 3-2 ka BP and the AD 1970s. The combined effects of climate changes and associated vegetation dynamics (structure and composition) are found responsible for the first four transitory phases, while human impact is the main cause for the last one. We suggest that the years AD 1970's should be considered as reference interval of time for defining the start of the Anthropocene rivers in NW Romania, while the period of the last ca. 3000 - 2000 years should be considered as the appropriate "natural" reference state to approach for current fluvial behaviors and their future trajectories.

KEYWORDS NW Romania, Someş drainage basin, Holocene

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## **Anthropogenic impact on solute fluxes in a headwater catchment in Western Germany**

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Headwaters are a source of fresh water and material transported to the downstream sections of river channels. In most regions of Europe, the natural environment of headwaters has been significantly transformed by human activities, which is reflected in the quality of surface waters and the rate of solute fluxes. The aim of the study was to determine the anthropogenic impact on solute fluxes in a headwater catchment in Germany. The study area (Wüstebach experimental catchment) is located in the Eifel Mountains and is part of the TERENO (Terrestrial Environmental Observatories) network. The catchment is currently subject to the following anthropogenic pressures: the use of de-icing salts on the motorway running through the catchment and the logging of 22% of the forest area in 2013 by the National Park to promote the regeneration of near-natural beech forest. We used data from almost 13 years (June 2009-April 2022) of environmental monitoring in the Wüstebach catchment to calculate monthly and annual rates of solute fluxes. The concentrations of ions in stream water and precipitation were determined: Ca<sup>2+</sup>, Mg<sup>2+</sup>, Na<sup>+</sup>, K<sup>+</sup>, Al<sup>3+</sup>, Fetot, Mn<sup>2+</sup>, NH<sub>4</sub><sup>+</sup>, NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>-</sup>, and Cl<sup>-</sup>. Data from the Wüstebach catchment were compared with data from the control (untreated) catchment. The average annual rate of total dissolved solids in the Wüstebach catchment was 83 t/km<sup>2</sup>/a. Only the loads of four ions performed a significant difference after deforestation (SO<sub>4</sub><sup>-</sup>, NH<sub>4</sub><sup>+</sup>, Al<sup>3+</sup>, Fetot). However, total dissolved solids and loads of most of the ions did not show any significant differences after deforestation, which indicates a slight impact of logging on the chemical denudation. This resulted from the limited soil erosion that followed deforestation as the soil was well protected during logging works by covering harvester lanes with branches. However, there is a significant impact of road salting on the solute fluxes in the headwater catchment. Assuming that the control catchment is not affected by using de-icing salts, the road salting inputs in the Wüstebach catchment calculated based on the precipitation share for Na<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, K<sup>+</sup>, and Cl<sup>-</sup> ions were, on average, 88%, 53%, 18%, 53%, and 90%, respectively, of the original ion loads. The input with road salting was so large that elevated concentrations of Na<sup>+</sup> and Cl<sup>-</sup> were noted throughout the study period with slight seasonal fluctuations. This proves the subsurface build-up of salt due to the long-term application of de-icing salt. Without the input of de-icing salts, the average annual rate of chemical denudation in the catchment would be about 19 t/km<sup>2</sup>/a. Thus, on average, this ion storage effect in the soil has increased the total dissolved solids rate by 62%. In summary, it can be concluded that long-term intensive road salting in winter has a greater impact on the solute fluxes than the clear-cut of 22% of the catchment area.

**KEYWORDS** solute fluxes, Wüstebach experimental catchment, road salting

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## **Recent gully erosion intensity in an agricultural landscape underlain by fluvioglacial sediments (NE Czechia)**

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Gully erosion is a worldwide issue that is often caused or accelerated by inappropriate land management. This study comprehensively evaluates accelerated gully erosion in fluvioglacial sediments left by a Pleistocene ice sheet in northeastern Czechia. Geomorphic mapping of an area of approximately 2 km<sup>2</sup> revealed gullies up to 3.5 m wide and deep, with their heads starting at the boundaries of fields and pastures. One of the causes of accelerated gully erosion are considered to be anthropogenic interventions, mainly melioration measures, or natural piping that cause concentrated subsurface runoff. Dendrogeomorphic methods were used to determine the development of the gully system. Trees respond to erosion processes by changing the anatomy of the cells in the newly grown root rings. When we determine the time of anatomical change onset, we are able to identify the year of erosion processes. Microscopic analysis and dating of 102 cross-sections from 28 exposed tree roots revealed 18 years of gully incision since 1985, with increased activity from 2007 to 2014. The mean incision rates ranged between 1–20 cm/year but could reach 1 m during individual events. To determine predispositions of gully erosion a geophysical survey with the use of Ground Penetrating Radar (GPR) was carried out. A total of 17 GPR profiles were conducted in the agriculture field above the gully systems. The geophysical survey confirmed the presence of subsurface structures (possibly the melioration measures in the area) and their possible connectivity to the gully systems. The combination of concentrated subsurface and surface runoff is considered to have a significant effect on the expansion of gullies in the present.

**KEYWORDS** dendrogeomorphology, GPR survey, gully erosion, melioration measures, piping

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## **Tree-ring-based reconstruction of debris flow activity in mining areas of Călimani Mountains (Eastern Carpathians, Romania)**

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Mining activities for sulfur-rich ore extraction and processing resulted in significant morphological changes in Călimani Mountains (Eastern Carpathians, Romania). Hydrogeomorphic processes, i.e., debris flows originating in the spoil heap area produced in the last decades an increasing volume of sediments transferred along the stream channels. In this mining area, very limited information exists about the frequency and spatial extent of past debris flow activity. Dendrogeomorphic methods allow to document the spatial extent and temporal frequency of debris-flow activity with an annual or even a seasonal resolution. This dating method is based on the identification of growth anomalies (e.g., scars) recorded by the annual rings of trees disturbed by debris flows. The purpose of this study is to apply dendrogeomorphic methods to reconstruct debris flow chronology in mining area of Călimani Mts. To this end, trees exhibiting clear external signs of mechanical disturbances (stem wounding) related to past debris-flow activity were sampled. The analysis of growth anomalies, e.g., scars, identified within the annual rings of the disturbed trees allowed to precisely date the occurrence year and season of past debris-flows events. Reconstructed debris flow frequencies and return periods spanning the period 1970–2021 indicate an increase of debris flow activity over the last two decades. Reconstructed debris-flow history will further be coupled with the analysis of spatio-temporal patterns of precipitation in the attempt to identify debris-flows' triggering precipitation thresholds in the study area.

**KEYWORDS** debris-flows, Călimani Mountains, dendrogeomorphic methods

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## Multi-risk decision-support tools for sustainable urban development

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Multi-risk and multi-hazard evaluation has gained popularity among studies that aim to achieve a sustainable urban development. For the city chosen as a case study, Deva, Romania, geomorphological, hydrological, and technological risk processes were inventoried. Pre- and post-disaster analyses have thus been carried out, which become a priority if we want to reduce the negative impact on the population and the environment, as well as hotspot analyses, models that will allow us to prioritize actions in order to mitigate negative effects in risk-prone areas by identifying their causes and intervening to mitigate and even stop their effects. This phase is part of the risk assessment, allowing the spatial identification of the risk using GIS spatial analysis techniques, thus enabling numerical spatialization based on correlation and statistical analysis or geo-statistical functions of the elements at risk: number of people, number of buildings and economic value of housing and transport infrastructure. The data resulting from the multi-hazard analyses obtained is useful to local authorities for the elaboration of risk strategies and the preparation of land use plans in accordance with the law.

KEYWORDS multi-risk, landslide, flood, smart cities

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## **Siret Valley between Roman and Mărășești settlements – preliminary geomorphological approach**

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The Siret Valley is generally asymmetrical in the study area, with the left side being short and steep and the right side being long and gently sloping, on which the entire series of river terraces can be seen. In the current study, we attempted to determine which terrace of the Siret River is the highest in this area. This information could lead us to discern the paleogeomorphological evolution of the Pietricica Hill, the Zăbrăuți Platform, and the Tutova Hills, as well as the Siret Valley and the lower Troțușului Valley. Given that, the Pâncești Platform and the Zăbrăuți Platform are composed of Căndești gravels, which are not present in the Culmea Pietricica, being composed of Miocene conglomerates and abundant greschist, which suggests that the massive subcarpathian peak rose only recently (during the Quaternary; Brânduș first proposed this theory in 1979). According to the alluvial remains discovered, the highest terrace in Siret is located between 125 and 130 meters above sea level (east of Buchila village), and based on the morphology of the terrace bridges, at 170 – 190 m (Șomușca, Dalul Rusului, Dealul Teiuș – Răcăciuni, the interfluvium between the Orbeni and Drăgușani streams, etc.). By identifying the type of soil on each morphological landform and using radiometric and paleontological dating to determine the age of the alluvial and deluvial material, we are attempting to accurately date the age of the terraces of the Siret, Lower Bistrita, and Lower Troțușul rivers. For this preliminary communication, we used cartographic materials from Ms. Lecturer's doctoral thesis. Dr. Florina Tatu and the field observations carried out by the authors of the study on Valea Siretului and Valea Bistriței in January and March 2022, February, and March 2023.

**KEYWORDS** Siret Valley, paleogeomorphological evolution of the Pietricica Ridge, alluvial remains discovered

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## **Spatial modelling of land subsidence using LiDAR height resolution DEM and statistical methods. Sălcuța Plain as case study (Romania)**

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The present study aims to establish the risk to excess moisture by identifying the subsidence areas within the Sălcuța Plain and drawing up the risk map to this phenomenon. As a result of the chemical and mechanical subsidence of the loessoid deposits, 303 depressions were formed that affect agricultural lands. The surface drainage network around the depressions drains to these negative landforms constituting a temporary converging hydrographic network. The identification of both surface drainage network and excess moisture areas was achieved in semi-automatic mode in GIS environment, using the open-source software SAGA GIS based on a digital elevation model of the LiDAR type, with high spatial resolution of 5 meters. In the next step, the distribution map of areas affected by excess moisture was generated using basic geospatial information in raster format (topographic indices and soil maps). The evaluation results indicated that to the four classes of the topographic wetness index were corresponding significant surfaces, such as: low – 990 ha (4,5 %); moderate – 791 ha (3,6 %); high – 163 ha (0,7 %); very high – 21 ha (0,1 %). In order to restore the land affected to the agricultural activities, most of the subsidence areas were artificially drained by a network of draining channels. However, the method chosen by the authorities did not completely eliminate the stagnant footprint of the soils. In this regard, the research demonstrates the potential use of topographic data and GIS for assessing subsidence impacts through environmental condition and it is desired to raise an alarm signal regarding excess humidity in the study area in order to take the necessary measures by the stakeholders.

**KEYWORDS** subsidence, excess moisture, LiDAR, Sălcuța Plain

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## The influence of climatic and anthropogenic processes on more than one and a half century of Danube Delta coastline dynamics

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Shoreline evolution can vary significantly across various temporal and spatial scales. This dynamic behavior is primarily attributed to the rapid adjustments in form and processes that occur on sandy coasts. Low and high-energy wave conditions are typically associated with periods of accretion and erosion, but the extent of these changes can vary significantly depending on the specific local conditions and the temporal and spatial scales being considered. Through successive comparisons of historical maps (since mid-nineteenth century), satellite images, aerial photos, and GPS surveys, in relation to various forcing factors (storminess and river sediment discharge), we try to explain the influence of climatic and anthropogenic processes on Danube Delta coastline dynamics in the last 170 years on centennial to decadal timescales. We show that Danube Delta coastline experienced variable dynamics, depending on the factors and processes which had the leading role at different temporal and spatial scales. At centennial timescales, shoreline evolution was highly influenced by the threefold decrease of Danube sediment discharge in the last century (mainly after 1950, as a result of dams construction in the Danube watershed), especially along the accumulative sectors of secondary deltas. On multi-decadal scale, storminess (as a result of climate variability) was the driving factor for coastline changes.

Human influence superposed on the natural response of the coast to variability of climatic, hydrological, and hydrodynamic (marine) factors. All these changes resulted in different shoreline morphology and configuration along Danube Delta coast (e.g., the transition from fluvial- to wave-influenced morphology of the Chilia lobe; the shifting of the Sf. Gheorghe mouth from an asymmetric to a deflected wave-influenced delta morphology). The last three decades have been marked by the extension of erosional processes. Our results offer a general perspective of the processes driving Danube Delta coastline dynamics, overseeing the future trends of shoreline evolution in the next decades. This data can be crucial for coastal planners and managers in order to take informed decisions in the future Danube Delta management plans.

KEYWORDS coastal erosion/progradation, storminess, river sediment discharge

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## **Dendrogeomorphic research in subsidence areas caused by coal mining**

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Dendrogeomorphology is an established discipline that is commonly used to date natural hazards, including landslides, debris flows, rockfalls, snow avalanches, and flash floods, by examining tree-ring records. Anthropogenic impacts frequently alter the present landscape, resulting in changing frequencies or increased spatial extents of geomorphic processes, such as subsidence-induced landslides or rockfalls caused by mining activities. In such cases, dendrogeomorphic records from afforested sites may provide information where ground movement monitoring is lacking. Additionally, the temporal occurrence of subsidence can vary greatly, ranging from gradual to abrupt movements. While radar interferometry can currently measure subsidence rates, such data typically covers short time periods and are less precise in forested areas. Comparing tree-ring-based data with in situ monitoring may clarify the sensitivity and reliability of dating methods in these particular conditions of continuous ground movement. We conducted dendrogeomorphic analyses at various sites in the Czech Republic with geomorphic activity caused by past or current underground mining of black coal or ore. We discovered over 20 rockfall events in three stopes that emerged after medieval ore mining, with increased rockfall activity in the Eastern Sudetes since the 1980s. Furthermore, we obtained the years of exposures from ten roots, revealing ground subsidence and the opening of tension cracks, and even the lateral retreat of the flanks of minor depressions. We also employed dendrogeomorphic techniques to detect subsidence-induced surface displacements in the Upper Silesian Coal Basin, which has been affected by underground coal mining. Chronological data were compared with in-situ monitoring and among various sites with lower and higher subsidence rates. Most events occurred in the 1930s, 1970s, 1990s, and late 2000s, with a peak of activity in 1973 and other notable events in 1986, 1995-1997, and 2005-2011. Moreover, not only the timing of mining operations, but also site-specific factors such as soil, morphology, and precipitation events, are essential for characterizing surface displacements in the forested post-mining landscape.

**KEYWORDS** dendrogeomorphic records, ground subsidence, post-mining landscape

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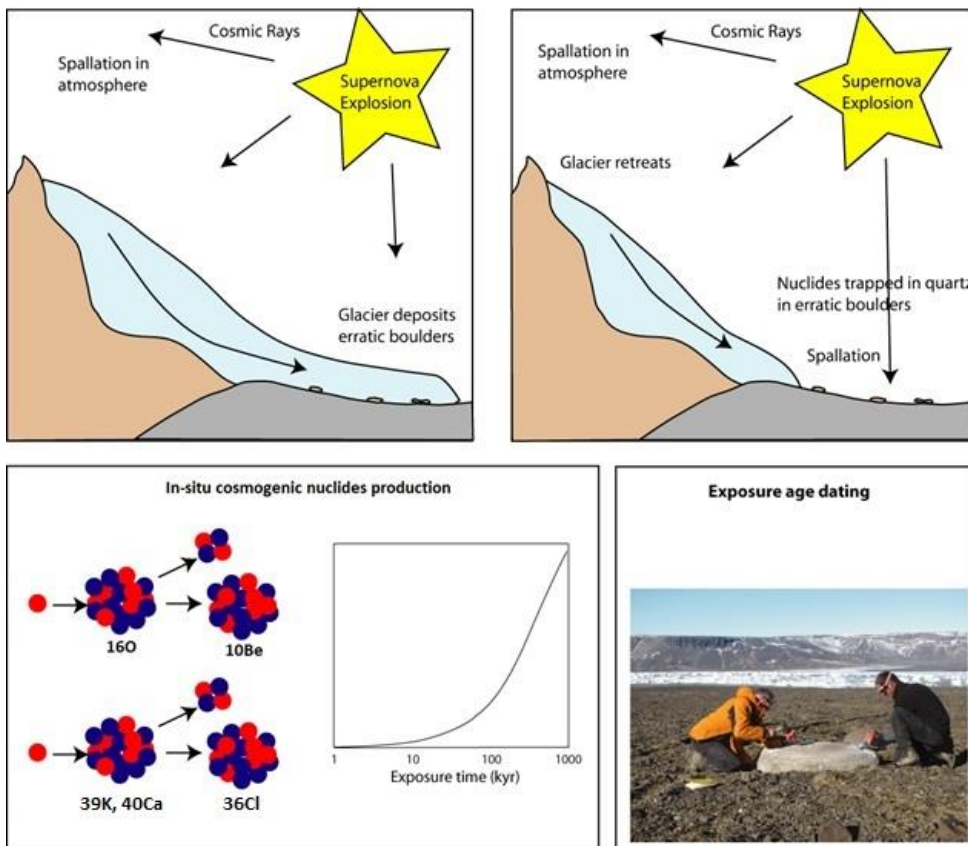
## Dating deglaciation with in-situ cosmogenic nuclides

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Surface exposure dating with in-situ produced cosmogenic nuclides is routinely used in developing palaeo-ice sheet and palaeo-glacier retreat chronologies. This technique offers direct numerical dating of glacial landforms, using mineral targets in stable erratic boulders resting at the ground surface and/or in bedrock surface. The advantage of this method for glacial geochronology is that moraines and/or ice-moulded bedrock can be directly dated, instead of their age being constrained by radiocarbon dating of organic material and/or luminescence dating of sandy deposits intercalated between morainic sediments or overlaid glacially eroded rocks. In-situ cosmogenic nuclides were successfully used in constructing chronologies for both Pleistocene and Holocene palaeo-ice sheets and palaeo-glaciers.



Modified from: *AntarcticGlaciers.org*

In my talk, I will focus on recent results constraining the timing and dynamics of the last deglaciation in the area of the last Scandinavian Ice Sheet's southern sector in Poland and in the area of the present mountainous glaciation in the arctic Norway. The results from the northern Poland are  $^{10}\text{Be}$  surface exposure ages of large erratic boulders resting in-situ on moraines located in the vicinity of the last ice sheet's maximum extent (the



local LGM limit). They indicate asynchronicity of the last Scandinavian Ice Sheet's maximum extent across the northern Poland. The results from Norway are  $^{36}\text{Cl}$  surface exposure ages of moraine erratics deposited by one of the mountainous glaciers in the Lyngen Alps region. The results show the history of the Steindalen valley deglaciation from the Late Pleistocene through the Holocene to the Little Ice Age.

KEYWORDS cosmogenic nuclides, last deglaciation

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## **Sociogeomorphology and ethnogeomorphology: two new directions in geomorphology in recent decades**

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In contemporary times, geomorphology is open to the trend of modernizing its ideological discourse and adopting increasingly technical approaches to its object of study, the relief. At the same time, our science is increasingly open to interdisciplinary approaches in response to the challenges that modern society, which is increasingly dynamic, is throwing at the scientific community, given not only the transformations of the terrestrial environment but also the often fragile relations between society and the natural processes, of which geomorphological ones are not few. Based on these considerations, our focus turns to two paradigms: sociogeomorphology and ethnogeomorphology, which represent emerging scientific fields explored between two already existing disciplinary domains.

Sociogeomorphology, defined as a branch at the intersection of geomorphology and sociology, offers a new and appropriate vision for understanding and explaining the relationships between society and geomorphological phenomena. It relies on a holistic approach to landforms and geomorphological processes proportional to their impact on the social and societal levels. This new branch of geomorphology is also essential for appropriately addressing geomorphological issues that affect society. From a sociogeomorphological perspective, the physical and human components are seen as part of a socio-natural system rather than isolated entities. Anthropogenic and natural processes, as well as the interactions between them, can either promote or inhibit, for example, the regulation of the evolution of a river system.

Ethnogeomorphology provides a non-relativistic response to the multiple connections between humans and landscapes, reflecting and advocating for the establishment of conscious relationships with places. It aims to develop a vision called "ethnogeomorphic," where landscapes are seen as both natural and living cultural entities. Ethnogeomorphology involves thinking about traditional approaches to humans and their relationships with the natural framework as a whole and the bio-physical components within, from, and towards the landscape. Prospectively, ethnogeomorphology offers a new perspective based on communication pathways that promote and enhance synergies between human geography and physical geography. A critical-objective approach that leads to a creative realignment among diverse cultures and physical geography moves towards a new understanding of the geographic landscape as a complex spatial structure where the simultaneity of geomorphological and cultural entities is a tangible and lasting reality.

**KEYWORDS** geomorphology, sociogeomorphology, ethnogeomorphology

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## **Towards automatic segmentation of landslides. Preliminary results for Sibiu county**

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Landslides belong to the category of geomorphological hazards that affect the stability of slopes causing significant material and environmental damage as they affect housing and transport infrastructures. At the county level of Sibiu, most of the area (34,001 hectares), representing 62.87% of the whole territory, has a high probability of landslides, the medium-high probability class characterizes 26.12 % of the area, 997 hectares (1.84% of the territory) have a very high probability of landslides according to H.G. 447/2003 Methodology. The advancement of precise predictive models in this setting is mostly hindered by the lack of the lack of large datasets which are indeed costly to be annotated for semantic segmentation problems. In this work, we aim at the automatic identification and segmentation of landslide using a few-shot approach based on remote sensing, starting from satellite data from the visible spectrum. Our method is based on the use of the recently released Segment Anything Model (SAM) by Kirillov et al., 2023, combined with a semi-supervised method. By providing few labeled points belonging to regions associated with landslides, we train a classifier for automatically segmented regions by a given zero-shot pretrained model. By carefully manually reviewing the results of our model, we also aim at the construction of a relevant dataset, which could be used to compare the performance of different methods available in the literature for the automatic segmentation of landslides, both zero/few-shots and ad-hoc models. The identification of hot spot areas will be extremely useful in prioritizing actions to combat the occurrence of these natural slope processes and in reducing the effects in the medium and long term.

**KEYWORDS** landslide detection, machine learning, semantic segmentation

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## **Assessing the influence of mountain climate variability on permafrost and frost processes in Central and S-E European mountain ranges**

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Evolution of discontinuous mountain permafrost presently preserved in high-altitude Central and SE European mountain ranges can be regarded as an indicator of climate warming. In the frame of recent climate projections, these areas are prone to become the expression of the transition from inactive to relict landforms, potentially impacting mountain hydrologic regimes and related hazards intensity. The last two decades document permafrost existence and ground thermal regime in rock glaciers and rockwalls in the highest massifs of the Carpathians and the Balkan mts., while other studies also focus on ground temperature response to both warming and snow regime changes in periglacial areas from the Eastern Alps. The objective of this research is to evaluate multidecadal patterns of temperature and precipitation indices relevant for possible impacts on mountain periglacial landforms in Central and S-E European ranges. Available continuous climate data were used from meteorological stations situated above 2000 m altitude in: a) Tatra Mts. (Chopok, 2007 m; Lomnický štít, 2635 m); b) Julian Alps (Sonnblick, 3111 m; Kredarica, 2515 m); c) the Southern Carpathians (Vf. Omu, 2505 m) and d) Rila Mts. (Musala, 2927 m). We addressed similarities between trends at regional scale and validated inferred influences through in-situ ground temperature dataseries. Specifically, in-situ measurements of permafrost and freezing ground indicators from rock glaciers and rockwalls in the Romanian Carpathians were used to give an estimate of permafrost condition and duration of seasonal frost in comparison to thermal and pluvial variability. Freezing index (Fi) during the autumn cold snow-free interval was considered a particularly important index and was reconstructed at multi-decadal timescale using air temperature and precipitation data from the Southern Carpathians, Tatra and Rila Mountains. Our preliminary results show that mean annual air temperatures values are increasing in all locations with similar mean rates (approx. 0.032 °C/yr). Both warm and cold seasons thermal regimes contribute to this trend, with only slight inter-site differences. The variability of solid and liquid annual precipitations and the monthly multiannual analysis of data highlights distinct pluvial patterns in respect to local topo-climatic characteristics of each mountain range. The rain/snow ratio apparently expresses a direct impact on permafrost and frozen ground by reducing the snow cover period and increasing the warm snow free interval, which enables thermal supplementary exchanges between ground and warm atmosphere and potentially disturbs the thermal balance of ground-preserved ice. Specifically, Fi values are shown to be recently reducing, which equals with a lowering ground cooling degree before the onset of the isolating snow cover. This is also reflected by other changing cold season features, i.e. duration of snow-free and zero-curtain intervals, snow-cover thickness and seasonal frost duration. In such changing conditions, periglacial landforms in the mountain ranges from Central and S-E Europe would potentially be exposed to inactivation, which questions the medium- to long-term permafrost.

KEYWORDS mountain climate, permafrost, seasonal frost, Central and SE Europe mountains

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# The application of cost-effective UAV systems and GIS spatial analysis in cadastral and construction surveying for building planning

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Architects and civil engineers struggle with building planning, construction, and maintenance uncertainty. Topography connects architecture and landscape, thus design and planning projects rely on monitoring, surveying, and field data. Unmanned aerial vehicles with digital cameras and structure from motion software are increasingly used in several sectors to build high-resolution digital elevation models. Despite its widespread use, most surveying projects believe that this technology produces inferior topographic representations due to legislation, environment, and weather constraints. While UAV systems have several drawbacks, their ability to acquire data from a different angle and provide outputs could revolutionize the construction business. Budget UAV systems can be used to construct a civil engineering survey approach. Thus, a supplemental UAV survey with spatial analysis in a geographic information system was built to enhance the deliverables. These include orthophoto maps, larger-scale and denser topographic representations, digital surface and terrain models, slope, aspect, and solar radiation maps that will aid building planning. The technique includes two case studies with varying terrain and vegetation constraints, an accuracy assessment, and a UAV implementation benefits discussion.

**KEYWORDS** land survey, mapping, UAV, photogrammetry, GIS, digital terrain model (DTM), construction planning

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