Polar Amplification: What are our current climate models missing?

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KEYWORDS: climate change, polar amplification, climate models

Past climate episodes with higher-than-today greenhouse gas concentrations show evidence of strong polar warming (polar amplification), and this trend can also be observed in recent years in the Arctic. Future polar warming will strongly affect the Greenland and Antarctic ice sheets, permafrost and the large stores of carbon it could release, and the northern (and potentially southern) hemisphere storm tracks, hence future weather in many countries.
Climate models generally underestimate polar amplification, both when simulating past warm climates and present-day warming. This might be due to missing processes, such as stratospheric processes that are not resolved in state-of-the-art climate models. Previous studies hypothesised that wintertime polar stratospheric clouds may have played an important role in polar warming through greenhouse forcing. Here, we examine these factors using a high-top atmospheric model with interactive chemistry. We find that the lower orography in Central Asia, Greenland at the North America at the early Eocene weakens the stratospheric circulation which, in combination with sufficiently high methane concentrations, leads to a substantial increase in polar stratospheric clouds in the Arctic winter. Furthermore, an increase in early Eocene polar stratospheric clouds due to a 16- to 64-fold higher than pre-industrial methane concentration would have a radiative forcing larger than the direct greenhouse effect from the methane itself. This polar stratospheric cloud-induced radiative forcing could cause up to 7.4˚C of polar surface warming.

Grasslands, climate change and disturbances

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KEYWORDS: grassland, forest-steppe, climate change, disturbances, CE Europe

Grass-dominated ecosystems (grasslands and forest-steppe) in central and eastern Europe play a critical role in biodiversity, climate, and livelihoods and offer many ecosystem services. In terms of their ecology, these systems differ significantly from forests and face different threats. They often do not conform to standard biodiversity concepts such as naturalness and the concept of climax vegetation. Therefore, the reforestation of grass-dominated ecosystems is still actively promoted to mitigate climate change through enhanced carbon fixation. I will show how multiproxy palaeoecological records and information from archaeological, archaeozoological, and paleontological databases can elucidate past dynamics, the drivers that maintain them, and their diversity. This complex understanding is essential to mitigate future impacts from climate consumers, advance their scientific recognition, and improve conservation strategies.

Understanding lacustrine delta sedimentary records of environmental changes and natural hazards in formerly glaciated active mountain ranges

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KEYWORDS: lacustrine sediments, natural hazards, acoustic mapping

European mountain ranges where both shaped by environmental changes related with Quaternary glaciations and active faults triggering earthquakes and landslides. During the last glacial cycle, climate warming and deglaciation formed large valley lakes and also numerous small lakes in altitude since the Late Glacial period in the French Alps and Pyrenees. During the Holocene these lakes where also exposed to human activities (mining, agriculture, urbanization, industry), to extreme climate events (tributary floods) and potentially tsunamigenic earthquakes. This presentation will illustrate how acoustic mapping technics combining seismic profiles, sediment cores and multibeam bathymetric data in glacial lakes can help understanding dominating sedimentary processes shaping tributary deltas in either large valley lakes or small altitude lakes. Ongoing studies focusing on natural hazards associated with the instabilities of lacustrine deltas will also be presented.

The Holocene climatic and environmental changes in the forest-steppe and steppe belts of Ukraine and their impact on ancient cultures

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KEYWORDS: forest-steppe, Holocene climatic, environmental changes, Ukraine

The study of pollen and soil successions from 35 archaeological sites (from Chalcolithic to the Iron Age) in the forest-steppe and steppe of Ukraine has shown drastic climatic and environmental changes, which significantly affected material cultures in these areas. The Neolithic developed first (after 8200 BP) in the area of the present-day steppe, which had then a benign environment: broad-leaved woodland on Phaeozems and mesophytic steppe on Chernozems (Bezus'ko et al., 2011). The Chalcolithic Trypillia culture appeared first (7400 BP) in the west of the modern forest-steppe, covered then by forests, with highly mesophilic *Carpinus betulus* and *Tilia platyphyllos*. The apex of the Trypillia culture (at the beginning of the IV millennium BC) corresponded to the spread of these forests from the River Dniester to the River Dnipro under more oceanic climate. *Carpinus betulus* grew then even in the east of the northern steppe (nowadays it does not occur anywhere in the steppe). The settlements of the Trypillia culture and the Chalcolithic cultures of the steppe and eastern forest-steppe were located both on plateaus and in the valleys. The cattle strongly dominated the herds everywhere, but *Cerealia* was cultivated mainly in the forest-steppe.
After 5500 BP, aridification and cooling led to the reduction of woodland (and disappearance of *Carpinus*), replacement of forest pedogenic processes by humus accumulation, and the spread of steppe northwards (Gerasimenko, 2015). The settlements were located mainly near rivers and gullies; sheep and goats, or horses dominated in the herds of the Late Chalcolithic tribes. The final decline of the Trypillia agriculturalists happened at the end of this arid phase.
After 4900 cal BP, the climate became cooler and wetter. High floods, the spread both of woodland and mesophytic steppe to the south, development of forest soils (in the steppe belt they occurred on slopes and in the valleys), and domination of boreal trees in the woodlands took place. The Early Bronze Age settlements existed on plateaus and near rivers, cattle was abundant in the herds, *Cerealia* was cultivated in the valleys, and woodworking appeared.
The strongest drought occurred 4400-4000 cal BP. Steppe penetrated to the west of the modern forest-steppe, and a dry steppe, dominated by *Artemisia*, spread far north within the area of modern mesophytic steppe. Kashtanozems formed in the place of the former Chernozems, and Chernozems in the place of the former Phaeozems. Desiccation fissures and loess-like sediments occurred in the south. Only temporary camps of the Middle Bronze cattle breeders existed in a large part of the modern Chernozem grassland.
During the wet phase of the Late Bronze 4000-3400 cal BP, forest-steppe and mesophytic steppe spread south, and broad-leaved woodlands occupies the valleys in the modern southern steppe. Mesophilic *Carpinus betulus* occurred in the forest-steppe and in the low reaches of the Dnieper River. The entire steppe was mesophytic, and sedentary settlements existed under humid climate. In the western and southern steppe, the Sabatynivka farming economy flourished, with dense net of settlements in the areas, which are now too dry for farming.

During the arid phases of 3400-2700 cal BP, xeric steppe, with weak humus accumulation, occupied a large part of the modern grassland with its well-developed Chernozems. Forested areas were strongly reduced in the forest-steppe, and the boreal trees dominated over broad-leaved taxa in the forest composition. Only temporary camps of cattle breeders occurred in steppe plains, though in the lower reaches of the Dnieper and Southern Bug Rivers, the Bilozerka farming culture (the Final Bronze Age) persisted.

The wet phase of 2700-2200 BP supported the mesophytic steppe of the Scythians, the plant farming of Greek colonies on the Black Sea shores, and the dominance of woodland in the northern part of the forest-steppe. This time was marked by the largest increase in humus content in the Chernozems (Ivanov, Chendev, 2015). Woods for the last time occupied large areas in the steppe valleys. The Greek colonists in the south and the Scythian tribes in the northern steppe cultivated crops. Warmth-loving walnut have been introduced in the southern steppe. During the warm arid phase of 2200-1600 BP, grassland spread far to the north within the modern forest-steppe. Xeric steppe occupied the large area in the south of Ukraine. The Sarmatian nomadic tribes invaded the steppe and southern part of the forest-steppe during these times. Nevertheless, at the northern and western parts of the forest-steppe, warmth and precipitation were sufficient for an acme of broad-leaved trees and an increase in Phaeozem soils fertility. The density of agriculturalists' settlements of the Zarubintsi and Chernyakhivska culture grew there at that time. In the steppe, Chernyakhivska culture spread only along the Dnieper valley and at the Black Sea shore. The short periods of wetter climate, with a slight spread of forest-steppe and mesophytic steppe to the south, occurred 1600-1400 BP and 1200-1000 BP. During the first interval, people of the Pen'kiv culture were able to practice farming in the river valleys of the northern steppe; during the second interval, the settlement of Saltiv culture appeared near the river valleys in the eastern steppe of Ukraine. Under the benign climate of 1100-800 BP, the Kiev Rus' state existed in the northern part of the forest-steppe, a part of steppe nomadic tribes got sedentary in the central forest-steppe, and the Byzantine colonies, whose inhabitants practiced farming, appeared on the Black Sea shores. Nevertheless, the huge areas of the steppe were crossed by successive waves of nomads, and the xeric steppe occupied even the larger areas, particularly after 800 BP. The economies of the Bronze and Early Age cultures were strongly controlled by climatic changes, but the increase in human impact after 2000 BP hampers palaeoclimatic reconstruction. The environments of Ukraine during the Holocene climatic phases are reconstructed on the vegetation and soil maps.

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Advancing insights into climatic variability in Eastern Europe based on multiparameter tree ring chronologies

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The Carpathian Mountains, pivotal to Central and Eastern Europe's ecosystems, face escalating conservation concerns due to deforestation and climate change impacts. These pressures have triggered floods, landslides, and alterations in species distribution. The analysis of paleoclimatic proxy archives unveils the impact of distinct climatic periods in the region over recent millennia.

The Medieval Climate Anomaly (MCA) exhibited evolving moisture patterns, with the early phase being wetter, followed by a drying trend, alongside a subtle overall warming trend. Varied timing of these shifts occurred across the northern and southern Romanian Carpathians. The Little Ice Age (LIA) presented unpredictable conditions linked to volcanic eruptions and solar activity, featuring dry spells interspersed with heavy rain episodes. While winters cooled between AD 1500 and 1750, available proxies suggest slightly elevated summer temperatures, reaching their coldest in the early 19th century. Subsequently, the Current Warm Period (CWP) saw escalating temperatures after 1970, adversely affecting agriculture and hydrology. Despite positive precipitation anomalies in the 19th and early 20th centuries, post-1970 witnessed diminished precipitation and heightened incidence of extreme climatic events.

Amid these observations, high-resolution studies examining climatic and environmental conditions spanning the past millennium, considering ongoing anthropogenic influence, are lacking. Further research is needed to address debates and gaps regarding climate change patterns in the Carpathians and regional responses to atmospheric dynamics, focusing on extended, locally-calibrated reconstructions. In this sense, our current effort involves developing reliable and high-quality temperature records spanning about 300-400 years at four locations in the Carpathians: N Romania, Slovakia, Ukraine, and S Romania. These temperature reconstructions are based on living Norway Spruce (*Picea abies*) chronologies of tree-ring width (RW) corrected for disturbance, Blue Intensity (BI), and color bias-free surface intensity (SIB) from scanned and microscope-based high-resolution images, as well as traditional and surface-based quantitative wood anatomy (QWA/sQWA).

We have conducted a Principal Component Analysis (PCA) to identify the primary forcing in the variation of tree growth identified in our preliminary temperature reconstruction based on ~18,000 tree ring width (RW) and ~1,000 Blue Intensity (BI) series. The results suggest

that 56% of the tree growth variability can be explained by April-September temperatures. Although BI responds strongly to this broader seasonal window, the RW response is also significant but generally weaker and mostly restricted to a narrower (June-July) season.

An ongoing detailed evaluation spans the AD 1901-2010 period, representing the full calibration period overlapping with the instrumental temperature dataset, and includes a comprehensive evaluation of Carpathian-wide and sub-regional reconstructions. The initial proxy outcomes, validated by meteorological station data, clearly depict a noticeable increasing temperature trend since 1980 across all four regions. This trend aligns with observations from other high-elevation European locations like the Alps, highlighting a consistent regional pattern. Additionally, the wavelet analysis of PC1+PC2 timeseries uncovers a robust multi-annual periodicity (2-7 years) between the early 20th century (~1910) and 1930 to 1940. Post-1950, however, our data reveal a prominent and continuous multidecadal periodicity (~20 years).

We expect that combining all available parameters will further strengthen the climate signal, providing records with reduced uncertainty that will help further explore the paleoclimate of the Carpathians. Incorporating novel data from underexplored regions using tree-ring-based climate reconstructions is a crucial advancement in enhancing our comprehension of the climatic dynamics operating at a European regional scale.

The Carpathians and Lower Danube as a barrier for the dispersal of steppe rodents in the Pleistocene and Holocene: Ground squirrels as a case study

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KEYWORDS: Subcarpathia, Late Pleistocene, Holocene, Ground squirrels

1 Introduction

The role of Carpathians as a driver of biodiversity is especially high for the steppe fauna, on the first place, for hibernating small mammals. For mole-rats, jerboas, ground squirrels, with their limited abilities to crossing geographical barriers, the Carpathians together with the lower flow of the Danube and Prut rivers and the forest zone north to the mountains are a part of an "Iron Curtain", effectively dividing the steppe ecosystems of the Eastern and the Western Europe and thus increasing their spatial heterogeneity.
Pleistocene environment provided more opportunities of faunal exchange compared to the present day, due to the strongly increased area of open landscapes. For ground squirrels, *Spermophilus*, however, the Carpathian-Low Danube barrier was a formidable challenge even during the Pleistocene. Starting from their first appearance in Europe 2.5 MY ago, ground squirrels of the Eastern and Western Europe always belong to different species. The only exception consists of larger ground squirrels of the subgenus Colobotis, which was represented by the only species *S.* (C.) *superciliosus* throughout their huge range, but by several well-defined subspecies. Here we will not consider this subgenus.

2 Carpathian-Low Danube barrier: the way around

Pleistocene ground squirrel species of Subcarpathia (Ukraine, Moldova) are closely related to that of the area north to the Carpathians. Namely, there were closely related sister-species pairs: *S. praecox* and *S. polonicus* in the Early Pleistocene (Popova et al., 2021); *S. odessanus* (=36-chromosome *S. suslicus* west to the Dnipro (Zagorodniuk et al., 2008)) and extinct *S. citelloides* in the Middle and Late Pleistocene (Kowalski, 2001). This suggests the Middle and Upper Dniester valley to have provided a steppe corridor between the Northern Black Sea area and uplands of southern Poland, where the landscape allowed open habitats to exist during cold epochs of the Pleistocene (Popova et al., 2021). On the other hand, the species level of the differentiation between Central European and Subcarpathian ground squirrels is evidence that this corridor must have been opened only for short time, under certain conditions. For the last time such event took place when the Lublin isolate of *S. odessanus* appeared. The event must be very recent because there are no Holocene findings of *S. odessanus* in Poland (Kowalski, 2001) and must have been a result of agricultural changes of landscape, which caused both the increase of suitable open areas and food resources for ground squirrels.

3 Carpathian-Low Danube barrier: the possibility of the breakthrough?

Circumstances of the occurrence of the European ground squirrel *S. citellus* east from the Carpathians, on the first sight, look similar to that for Polish *S. odessanus*: there were no evidence of *S. citellus* in any of the Holocene or Pleistocene localities (Krokhmal and Rekovets, 2010); its appearance is believed to be very recent (Gromov and Erbaeva, 1995).
Primarily (during the Pleistocene), *S. citellus*, an ancient, to some extent archaic and rather termophilous species, was restricted to southern Europe. Early Holocene warming allowed the spread of *S. citellus* northward, where this species replaced *S. citelloides* in the southern part of the range of this latter, while the northern part of the *S. citelloides* range turned out to be occupied by forests, unsuitable for ground squirrels. As a result, *S. citelloides* went extinct and *S. citellus* stayed the only ground squirrels of Western Europe. Later on (c. 5 ky) (Ramos-Lara et al., 2014), the agricultural transformation of landscape caused the expansion of the species further to the north, as far as Germany and Southern Poland. However, *S. citellus* had been unable to cross the Carpathian-Low Danube barrier for a long time. What is important, that, in contrast to *S. odessanus*, *S. citellus* definitely did not use the Dniester corridor. The recent Polish population of *S. citellus* (now extinct) were restricted to Silesia and a large distance separated it from Subcarpathia.
Thus, the appearance of *S. citellus* in Subcarpathia seems to be triggered by a factor other than the above triggers of expansion. The Early Holocene warming, which was the cause of expansion for *S. citellus* from its primary Pleistocene range, does not correspond in time. Landscape changes (both climatic, Pleistocene, and agricultural, Late Holocene), which favoured the faunal exchange through the Dniester corridor, do not fit spatially (no spatial connection with populations that could have been ancestral). Agricultural transformation of landscapes, which caused further (Late Holocene) expansion of *S. citellus* north (virtually, in the forest zone) cannot be excluded to play a role here, but looks unlikely as a main trigger. A rare random event is the most likely explanation.
New palaeontological data may shed more light on certain drivers of the faunal exchanges.

4 Results

Ground squirrel fossils of from three localities of the Dniester area were studied: 1) Tadirka Cave, Khmelnytskyi oblast', Early Holocene (Ridush, 2022); 2) Zeleniv, Chernivtsi Oblast', Last Glacial Maximum (Ridush et al., 2021; Popiuk, Ridush, 2022); 3) Korman' 9, Chernivtsi Oblast', Epigravettian site, 22 cal BP (Kulakowska et al., 2021).
Ground squirrels are represented by *S. odessanus* only in each locality. In such a way, our new data support the barrier role of the Carpathians and the Low Danube for the dispersal of ground squirrel species and, generally, the history of occurrence of ground squirrel species in Subcarpathia outlined above.

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Do palaeo July temperatures obtained from the loess gastropods (Serbia) support the European Middle Pleistocene "missing" glaciations?

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KEYWORDS: Loess gastropods, malaco-thermometer, Serbia, MIS 8, MIS 10

In this study, we present the malacological results from the loess-palaeosol sequences Stari Slankamen, Veliki Surduk and Požarevac which are situated in Serbia. These are the well-investigated profiles, having the oldest continuous records of loess in the southern Carpathian basin, together temporarily covering the last nine glacial-interglacial cycles. The loess samples were sieved, after which the gastropod shells were manually picked up and determined. The used methodology for July temperature reconstruction relies on the fact that several environmental conditions need to be fulfilled for all found gastropod species to survive: minimum temperature, humidity, and vegetation. These were defined in previous studies; thus, it was possible to estimate July temperature which allowed the existence of found assemblage. In these profiles, 11 terrestrial gastropod species were used to estimate the July palaeotemperatures of each glacial in Serbia from MIS (Marine Isotope Stage) 24 until MIS 2. Results show that the summers of MIS 8 and MIS 10 were warmer compared to other glacial periods (July temperatures were only 3°C lower than today). According to the loess stratigraphy in the Middle Danube basin, the MIS 14 loess is not preserved and was incorporated into the pedocomplex which developed from MIS 15 until MIS 13. In previous studies, the mentioned periods: MIS 8, MIS 10 and MIS 14 are called the "missing" glaciations in Europe, as the colder periods which occurred after them eroded the evidence of the glaciers' extent. Our results support the warm summer scenario which is possibly reducing the chance of snow accumulation and glacier expansion in the surrounding mountains. The future improvement of the results would be: (1) determining the absolute elevation of the previous terrain at which the loess was accumulating, which would allow calculation of temperature gradient from the location of the profiles to the mountain tops which were glaciated, (2) dating the shells and not loess sediments, and finally (3) determining the minimal abundance of shells necessary for obtaining reliable results, as the abundances of shells are varying throughout the past nine glacial-interglacial cycles.

Climate variability in the Bukovynian Carpathians and foreland at the turn of the 20th century

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KEYWORDS: climatic variability, Bukovynian Carpathians, meteorological observations, long-term Climate Data, spatial distribution

This research addresses the historical climate patterns of the Bukovynian Carpathians and its surrounding regions in the late 19th and early 20th centuries based on an extensive network of meteorological observations that commenced in the 1860s within the Austrian Monarchy. Climate data, including average annual and monthly air temperatures, as well as atmospheric precipitation, were analyzed, with a focus on the city of Chernivtsi, which boasts the longest series of observations since 1852. The study reveals that the century-long climatic trends align with broader patterns observed throughout the Eastern Carpathians. Moreover, it highlights the pronounced continentality exhibited by this region. The research elucidates the cold decades in Chernivtsi in the latter half of the 19th century as a continuation of the Eastern Carpathians' coldest period dating back to 1720–1850, spanning six centuries. Spatial distributions of average monthly temperatures during this period exhibit distinct orographic and steplike isotherm patterns. Temperature variations, particularly during the summer months, reveal inversion characteristics in valleys and internal lowlands, accompanied by decreased atmospheric precipitation in the dry spring and autumn months. The study also assesses spatial patterns of multi-year average air temperatures and precipitation at the turn of the 20th and 21st centuries, observing similarities in their distribution, albeit with notable differences monthly, particularly in the summer and mountainous regions. This comparison indicates a 1°C increase in average July monthly temperatures in the southernmost mountain massifs, while foothill areas experience an increase of no more than 0.5°C. In the annual context, changes are less conspicuous. The study also highlights the need for precise interpolation techniques and downscaling to account for local climatic variations, especially in constructing precipitation fields due to the absence of high-mountain weather stations in earlier centuries.

Landform Evolution of the Southern Yangtze River Deltaic Plain and its Driving Forces

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The morphological evolution of the southern part of the Yangtze River Delta has been a topic of significant debate due to the lack of absolute dating support from stratigraphic studies. To address this issue, this study collected five 25-30 m long drill cores (JD, HQ, JQ, ND, and YZ) from the southern part of the Yangtze River Delta and applied optically stimulated luminescence (OSL) dating. The key findings are as follows:
(1) The sedimentation rate in the drill cores exhibited a three-stage-change pattern over the Holocene period: fast (9.0-6.0 ka), slow (6.0-2.5 ka), and fast (2.5-0 ka). In the past 500 years, the sedimentation rate in the eastern region reached up to 5.2 cm/a.
(2) Rapid accumulation occurred in the western region during the early Holocene, which was a response to rapid sea-level rise. Slow accumulation in the middle Holocene was attributed to reduced sediment supply from the Yangtze River basin. In the late Holocene, rapid accumulation was associated with increased soil erosion caused by intensified human activities.
(3) Based on the dating results, the rate of shoreline advancement in the past 3 ka exhibited significant fluctuations (ranging from 2.7 to 80.2 m/a), with the slowest period of shoreline advancement occurring during 0.8-0.44 ka. Apart from changes in sediment supply influenced by climate change and human activities, the variations in shoreline advancement rate are also linked to changes in underwater accommodation space and shifts in sedimentation centers during different periods.
This study provides clarity on the chronological controversies surrounding shoreline changes in historical geographical research and contributes to a better understanding of the evolution of the Yangtze River Delta.

Bridging natural and social systems: An integrative model of national parks in the Carpathians

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KEYWORDS: national parks, Carpathians, paradigm shift, integrative model

In the face of increasing climate changes, a rapid decline in biodiversity as well as the increasing urbanization of countries and the reduction in the area of land that is undeveloped and not transformed by people, more and more attention is being paid to projects that can reduce the negative impact of human activity on the natural environment. The important role of protected areas is recognized as one of them. At present these areas are no longer treated as "islands" of protected nature that should be isolated from human influence. According to the modern paradigm, protected areas are seen as links in a complex ecological network, functionally connected with the socio-economic environment, which should provide model examples of solutions for combining conservation and development goals as well as generate economic benefits for local communities and strengthen local and national economies.
The "EU Biodiversity Strategy for 2030: Bringing nature back into our lives" was adopted in this spirit, as part of the European "Green Deal" policy. It assumes an increase in the surface of protected areas (including strictly protected areas) and strongly emphasizes the importance of nature conservation for people's lives and the economy. The issues of combining nature conservation with socio-economic development are particularly important in the Carpathian Mountains, a region unique in Europe in terms of nature and culture, but at the same time facing serious problems related to the progressive loss of biological and landscape diversity, impoverishment of cultural heritage, and social and economic problems. In order to ensure the protection of this unique region, and at the same time strengthen the local economy, increase the quality of life of the region's inhabitants and increase the activity of local communities, the Carpathian countries signed the Framework Convention on the Protection and Sustainable Development of the Carpathians (The Carpathian Convention). National parks, seen as instruments of protection and regional development, should play an important role in its implementation.
Taking into account the paradigm shift regarding protected areas and the important role that national parks should play in the Carpathian region, a study was conducted to establish a theoretical template for an integrative national park model and to assess the degree of the implementation of the model in national parks of the Carpathians. In addition, factors that may affect the implementation process of the model were identified. The theoretical pattern was built on the basis of expert evaluations expressed in the Delphi survey. The analysis of the degree of the implementation of the model and of the factors influencing the process was carried out on the basis of surveys conducted in national park directorates. The fuzzy set Qualitative Comparative Analysis (fsQCA) was used to assess the importance of the factors. Due to the current political situation in Ukraine, the research was limited to national parks located within the borders of the European Union.
The model of a national park that integrates nature conservation with socio-economic development was based on three pillars: integrated planning, participatory management and proactive operational strategy. Surveys carried out in park directorates have shown that many

of them implement an integrative model of operation, but none fully corresponds with the theoretical model. Analyzing the factors that determine the implementation of the model (related to supportive government policies and legal regulations, the scope of competence of the directorates, the attitudes of local authorities, the social environment), it was established that none of the conditions could be considered either necessary or sufficient for the implementation of the model. The model can be successfully implemented in various national, regional and local conditions. However, the implementation of the model should be based on a voluntary and bottom-up process, which is supported by state policy.

The evolution of the Caspian Sea over the last 20,000 years: mineralogical data

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KEYWORDS: mineralogical data, last deglaciation, the Caspian basin evolution

The Caspian Sea, similar to the Black Sea, belongs to the Ponto-Caspian region. These are remnants of the Eastern Paratethys that separated during the Pliocene (Varuschenko et al., 1987). The Caspian Sea is a closed intracontinental water reservoir (sometimes semi-closed in the past) that is highly sensitive to climate change. A large part of its catchment area is located in the Eastern European plain and, during the Quaternary, it was subject to major fluctuations in water level (over 100 m; *e.g.* Serebryanny, 1982; Varuschenko et al., 1987).
Grain size, clays, magnetic minerals and carbonates contents were analysed on sediments from the deep basins of the southern and central Caspian Sea. These measurements were done at the GEOPS laboratory (Paris-Saclay University, GEOPS/LSCE PANOPLY platform, Orsay, France). The results were compared with data from the two basins and from river terraces in the lower Volga which constitute the shallowest basin of the sea, now emerged, and with Black Sea sediments studied previously (Chalié et al., 1997; Jelinowska et al., 1998, 1999; Strechie et al., 2002; Strechie-Sliwinski, 2007; Tudryn et al., 2016, 2022; Lahijani et al., 2020).

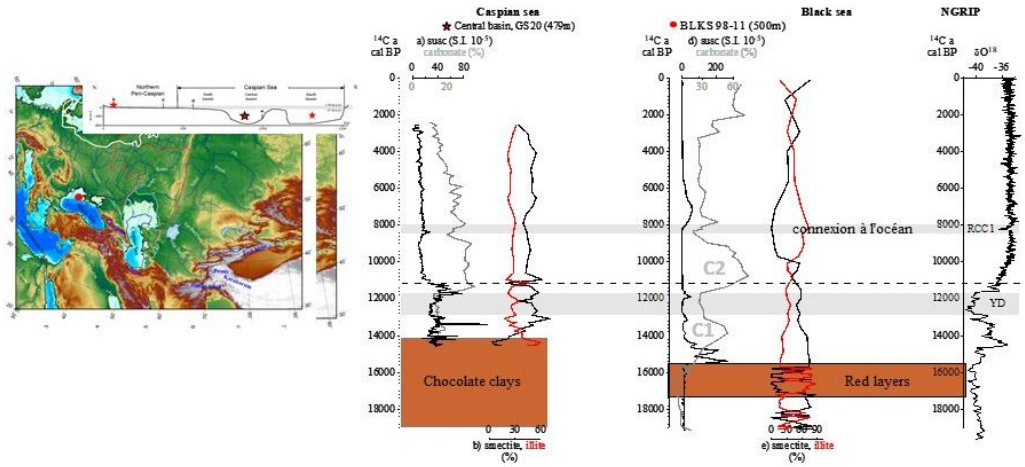

Figure 1 Location of studied sediments sediment cores, carbonate contents, magnetic susceptibility and dominant clay minerals from the Central basin of the Caspian Sea compared to the Black Sea and NGRIP 18O isotope curve.

Among other things, the results show that during the last deglaciation, the Caspian basin collected meltwater and fine-grained sediments from the southern margin of the Scandinavian

Ice Sheet (SIS) via the Volga. It induced the deposition of illite-rich sediments called chocolate-clays in the northern and middle Caspian basins. During the Holocene, fine grained sediments deposited in the middle and south basins are characterized by increased contents of carbonates and smectite. The presence of iron sulphides in several depths, highlights the sub-oxic bottom conditions while detrital iron oxides reveal well oxygenated waters. Similar processes were recorded in the Black Sea sediments, including deposition of illite-rich "red layers", material transported from south margin of the SIS by the Dniepr.

Geochemical analysis of aeolian and fluvial sediments at Danube fluvial terrace, Velika Vrbica (Serbia)

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KEYWORDS: loess, fluvial sediments, Wallachian basin, geochemistry, loess provenance

The Danube fluvial terrace in Velika Vrbica is situated at the westernmost edge of the Wallachian basin, Serbia. The profile is positioned in a gully valley with a base consisting of point bar sands interlayered with overbank clay deposits, which are together covered by loess sediments. The investigated loess-paleosol sequence (LPS) has a height of 11.15 m and has been sampled at 5 cm intervals for geochemical analysis using XRF. Fluvial sediments were sampled and analysed as well. Weathering indices such as Al/Sr, Rb/Sr and Zr/Sr for LPS clearly correlate with the first 5 MIS stages. Zr/Rb and Si/Al ratios were used as grain size proxies and they indicate that the largest sediment grain sizes correlate with the MIS 1 and MIS 2 stages. Chemistry of fluvial sediments was analysed in the context of loess provenance which was investigated using (Al/Ti)/(Fe/Ti) plot, principal components analysis, k-means clustering and discriminant analysis. Prior to analysing, the sediments were divided up in 5 groups: loess, paleosol, aeolian sand, point bar sands and overbank deposits. The results show that most of the chemical variability can be attributed to differences in grain size and different weathering intensities, which is furthermore illustrated by the fact that fluvial and aeolian sands are the groups which share the most similar chemical composition. Analysis showed that Zr concentrations are generally lower in fluvial sediments compared to aeolian, with loess containing more Zr than point bar sands which is contrary to what is expected, having in mind the properties of zircon (most abundant Zr-bearing mineral). This leads to a conclusion that Danube's alluvium is not the only source for loess at Velika Vrbica and that low Zr concentrations for aeolian sand illustrate that it mostly originates from point bar sands which experienced aeolian transport before being deposited.

Loess deposits in southern Tajikistan (Central Asia): Magnetic properties and paleoclimate

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The continental accumulation of dust during the Quaternary led to the formation of widespread loess deposits in southern Tajikistan. In this area, the accumulation of loess is commonly associated with the occurrence of dust storms and the widespread distribution of loess provides evidence of dust storms becoming more frequent in arid Central Asia at least since the Early Pleistocene. Southern Tajikistan represents one of the largest loess deposits in Central Asia. We conducted a thorough study on the magnetostratigraphy, grain size, and magnetic susceptibility of the Chashmanigar section to reconstruct the stratigraphy of loess deposits and paleoclimate of Tajikistan. Based on our new data, the lower boundary of the basal ages of the Olduvai and Reunion subchrons were established for the studied Chashmanigar section. Rock magnetic analyses showed that the predominant ferrimagnetic minerals are large pseudo-single domain grains of magnetite, including limited maghemite. Standard demagnetization techniques yielded a characteristic component of natural remanent magnetization, which was used to obtain a well-defined magnetostratigraphy. In southern Tajikistan, paleosols consistently exhibit finer grain size distribution and higher magnetic susceptibility than loess horizons, suggesting that the environment of the Chashmanigar section was colder, drier, and dustier during glacial periods than during interglacial periods. Through correlation with astronomically tuned oxygen isotope records, sophisticated dating of the loess-paleosol sequence at Chashmanigar could be achieved, and the global significance of the recorded paleoclimatic variations could be revealed. The resulting grain size, magnetic susceptibility, and correlation with astronomically tuned oxygen isotope clearly provide information about the climatic pattern during the Early Pleistocene.

The impact of local topoclimatic conditions (snowblow and avalanches) on ELA of paleoglaciers in the Eastern Carpathians

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KEYWORDS: ELA, palaeoglaciers, snowblow, avalanches, Last Glacial Maximum, Eastern Carpathians

The glacier reconstruction and their ELAs provides valuable information about climate elements such as mean summer temperature and annual precipitation. However, calculation of ELA position based on the hypsometric characteristics of past glaciers is strongly influenced by local topo-climatic factors, such as shading, snow drift from surrounding non-glaciated slopes, and snow avalanches, which can significantly affect the glacier mass balance. At the same time, calculating the ELA position without considering the influence of these factors significantly underestimates the regional ELA position, hence palaeoclimatic inferences based on the reconstruction of small glaciers may be subject to substantial errors.
The impact of these factors is particularly significant for small (<5 km^2) and very small (<0.5 km^2) cirque glaciers that dominated during the LGM in the Carpathians. This problem was analysed using the example of marginally glaciated massifs in the Eastern Carpathians, which were close to the threshold of glaciation during the LGM: the Călimani, Gurghiu, Maramureş Mountains in Romania and the Polonyna Rivna and Borzhava in Ukraine.
Our results indicate that in the Eastern Carpathians almost 30% of glaciers were entirely controlled by local topo-climatic conditions. The additional snow contribution area to the glaciers was multiple times (5-12) larger than the glacier surface area. Considering the additional snow contribution, the reconstructed ELA of individual glaciers was on average 25 to 150 meters higher, corresponding to 1.8 to 53% of the glacier elevation range (on average 17 ± 12%). An additional methodological aspect of our studies was that ELA calculation of small glaciers should be conducted with the inclusion of additional snow contribution area (snow contribution area ELA; scaELA), as opposed to the traditionally used AABR ELA method based solely on the hypsometry of the glacier surface.

Study of groundwater in rural settlements

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KEYWORDS: underground water, wells, geochemical monitoring

The chosen area for groundwater research is the territory of the village of Klishkivtsi (central part of the Khotyn Upland), where, as of 2022, there were 1344 wells. They became the points where research was conducted (Figure 1). Similar research was carried out in the village of Mlynky (northern slope of the Khotyn Upland), although with less detail.
The detailed study of wells has shown that they differ from each other in both qualitative and quantitative indicators, allowing for their classification into four categories as follows:
1. Landscape category – classified based on the landscape designation of the well. This category includes four classes: *watershed, sub-watershed, slope,* and *valley*. **2. Level category** – classified based on the average water level in the well. This category consists of three classes: *shallow* (up to 5 meters), *moderately deep* (from 5 to 20 meters), and *deep* (over 20 meters). **3. Category of use** – classified based on the well's usage for different purposes. It comprises three classes: *neutral, traditional,* and *donor*. **4. Water supply category** – classified based on the average water storage capacity in the well. It includes three classes: *weakly supplied* (up to 2 m^3), *adequately supplied* (from 2 to 4 m^3), and *well-supplied* (over 4 m^3).
The average dynamics of groundwater (GW) is directly proportional to the annual precipitation. The higher the amount of precipitation in a year, the higher the groundwater dynamics, and vice versa.
If the terrain is highly dissected, then GW levels usually tend to be deep. On the other hand, if the terrain is weakly dissected, GW levels will be at a shallow depth. However, these patterns are frequently disrupted. In the first case, when we have a highly dissected terrain, the GW levels can be relatively shallow due to local water tables. In the second case, in relatively homogeneous relief, GW levels can be at a significant depth due to the geological structure of the area, primarily influenced by the depth of the impermeable layer.
The GW level in river valleys, ravines, and gullies fluctuates between 2 to 10 meters. On the slopes of watersheds, the depth of the water table does not exceed 17 meters. At the actual watersheds, the depth can reach up to 25 meters. There are cases where, on certain sections of river valleys, the GW level is at a significant depth – around 10 to 15 meters, while on the watersheds, on the contrary, there are areas with relatively shallow water-bearing horizons (2–3 meters). The main reason for these variations is the lithological structure of the Khotyn Upland.
Thanks to drilling activities in the territory of the Khotyn Upland, the following types of aquifers have been identified: local aquifers, overlapped aquifers, and continuous (translandscape) aquifers. Local aquifers are small water-bearing horizons that are not connected to other aquifers. They are isolated, and there exists a so-called «dead zone» around them where GW is absent.
Local aquifers in the territory of the Khotyn Upland tend to dry up during dry periods since their recharge solely depends on precipitation. The thickness of these aquifers does not exceed 2 meters in wet periods and decreases to 20-40 centimeters in dry periods. Local aquifers are

associated with watershed landscape complexes, but there are cases where they can be found in isolated slope and even valley areas. Continuous (translandscape) aquifers cover vast areas and can extend over multiple populated areas with their surrounding territories. Local aquifers appear as isolated islands amidst the translandscape aquifers. The main groundwater regime and the regime of small rivers depend on continuous aquifers. They act as major reservoirs of atmospheric moisture and serve as the primary objects for the migration of groundwater masses and dissolved chemical elements. In wet periods, the thickness of continuous aquifers can reach up to 2.5 meters, while in dry periods, it decreases to 80 centimeters. These aquifers are widespread in all landscape complexes of the territory. Overlapping aquifers are rare and are mostly found in areas with old significant landslides or abrupt transitions from watershed areas to slopes (in such cases, the confinement of aquifers may occur at the intersection of two types of relief).

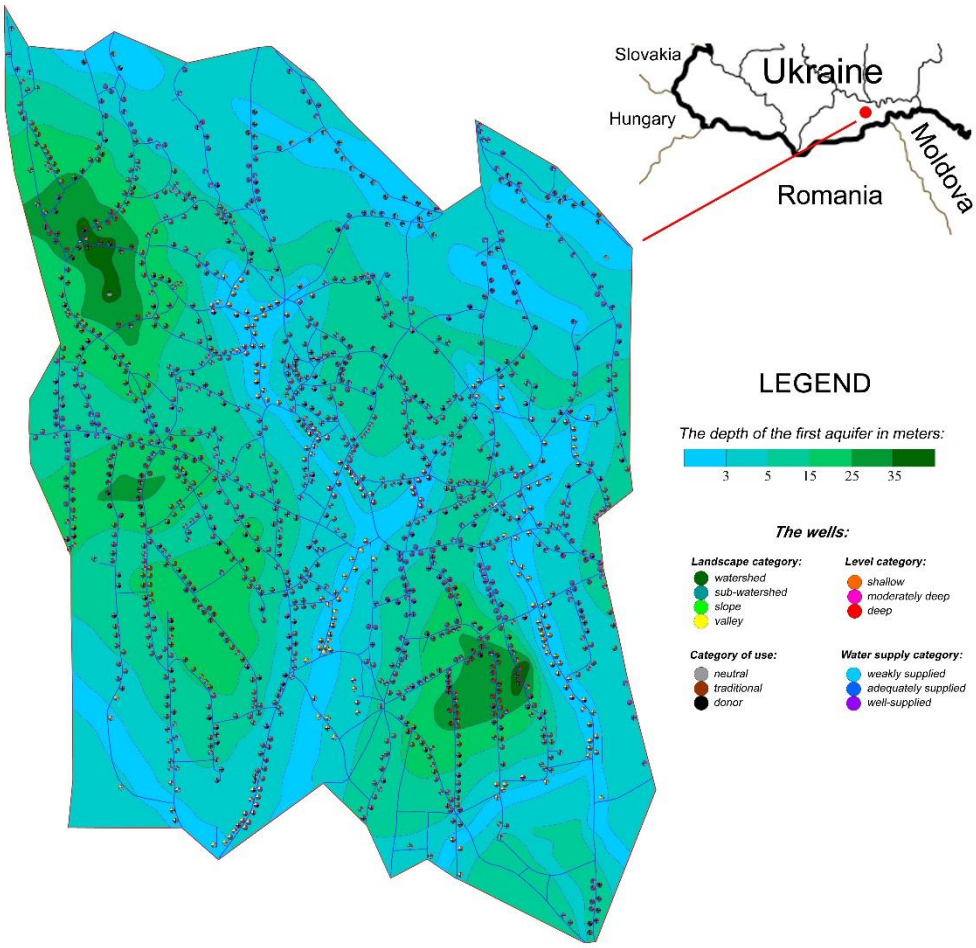

Figure 1 Groundwater of Klishkivtsi village.

Groundwater horizons are predominantly located within the thickness of anthropogenic deposits, mostly eluvial deposits (on watersheds and sub-watersheds), as well as alluvial deposits (in river valleys, floodplains, and lower terraces). However, in some cases, water-bearing horizons can be situated at the contact zone between bedrock and anthropogenic deposits.

Water-bearing and formative rocks include (within the thickness of anthropogenic deposits) loess-like loams, heavy brown loams, brown sandy loams, and pebble-gravel-sandy deposits.

Within the thickness of bedrock, they include clayey, silty, sandy, and stony loams of the Neogene and Sarmatian formations, among others.

The «dead zones», mentioned earlier, occur where water-bearing horizons lie on bedrock formations. The absence of aquifers in certain sections of the bedrock layers is due to their oblique monocline deposition, which causes water to flow towards interlayer waters.

Throughout the year 2022, the most stable groundwater level was observed during the winter period. This can be explained by the fact that water input from precipitation was almost negligible. Additionally, the water consumption by the population also decreased due to the inactivity of pumping stations.

The sharp increase in the groundwater level in spring was caused by snow melting and the beginning of rainwater recharge. During the summer period, the groundwater level reached its lowest point, with several short-term peaks associated with intense rainfall events.

Chemical monitoring provides valuable and sufficient information about the qualitative state of groundwater, enabling the assessment and prediction of geochemical processes occurring in groundwater. It helps identify the degree of contamination and the quality of groundwater, find sources of pollution, methods of their elimination, and rational water use in various activities. Certain components of the ionic set exceed the maximum permissible concentrations (MPC) by one or more orders of magnitude. The pH ranges from 7.1 to 7.8, indicating neutral to slightly alkaline water. The overall water hardness varies from 10.2 mg-eq/l (hard water) to 22.2 mg-eq/l (very hard water), and the degree of mineralization ranges from 0.54 g/l to 1.76 g/l. NH_4 and NO_2 are present in relatively small amounts. The prevailing water types in the northwestern parts of the territory are hydrocarbonate-magnesium-calcium, while in the southeastern parts, they are hydrocarbonate-calcium. In some cases, Cl^- and SO_4^{2-} slightly exceed MPC levels.

Trends in land cover/land use of the Republic of Moldova for the period 2000-2019

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KEYWORDS: land use, land cover, productivity, degradation

Moldova has a total land area of approximately 33,846 square kilometers. The country is characterized by rolling plains and hilly landscapes, with the highest point being Bălăneşti Hill at 429 meters above sea level. The landscape is predominantly agricultural, with fertile soil suitable for farming.
For this study in the analysis process, UNCCD Default Data, Trends.Earth Land Productivity Dynamics were used, due to the insufficiency of national cartographic data that would cover all stages of the analysis.
The data show that in the period 2001-2019, at the national level, there is an increase in the land area against the background of a 5% reduction in the areas covered by water, a situation related to the accelerated disappearance of reservoirs due to clogging (Tab. 1).

Table 1. National estimates of total land area, area covered by water bodies and total country area

Year	Land area (km^2)	Water bodies (km^2)	Total country area (km^2)	Real country area (km^2)
2001	32878	330	33208	33846
2005	32879	329	33208	33846
2010	32875	333	33208	33846
2015	32883	325	33208	33846
2019	32894	314	33208	33846

Table 2. National estimates of land cover (km^2)

Year	Tree-covered areas	Grasslands	Croplands	Wetlands	Artificial surfaces	Other Lands	Water bodies
2000	-	-	-	-	-	-	-
2001	2510	124	28897	49	1297	0	331
2002	2513	124	28641	49	1551	0	330
2003	2514	124	28388	49	1803	0	330
2004	2516	123	28115	49	2075	0	330
2005	2516	123	28115	49	2075	0	330
2006	2513	123	28111	49	2075	0	336
2007	2515	123	28110	51	2076	0	335
2008	2524	123	28081	51	2094	0	335
2009	2524	123	28082	52	2095	0	333
2010	2527	123	28077	52	2095	0	333
2011	2529	123	28075	52	2096	0	333
2012	2530	123	28074	54	2101	0	327
2013	2530	123	28072	54	2103	0	326

Year	Tree-covered areas	Grasslands	Croplands	Wetlands	Artificial surfaces	Other Lands	Water bodies
2014	2535	123	28064	54	2105	0	326
2015	2535	123	28063	54	2107	0	326
2016	2548	123	28054	55	2107	0	321
2017	2559	123	28046	56	2107	0	318
2018	2564	123	28042	57	2107	0	316
2019	2568	122	28039	57	2108	0	314
2020	-	-	-	-	-	-	-

As for degradation processes, urbanization is found to be a key process, thus registering a conversion of agricultural land into built-up areas.
In the interval 2001-2019, the areas with forested lands are increased, as well as wetlands and artificial surfaces to the detriment of croplands (from 87% to 84%) and water bodies (Tab. 2). The area of grasslands has also been reduced.

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Influence of environmental factors on children's health and adaptation

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KEYWORDS: external environment, pollution, cardiovascular system, adolescents, rural and urban environment

The experimental data related to the ecological factors that have an impact on the adaptation of children and adolescents are presented. As ecological factors were selected the state of air and water in the areas of educational institutions are investigated. The presence of the correlation between the degree of pollution of the external environment and the cardiovascular indices of adolescents was established. A greater number of children in the ecologically favourable aria, 87.5% - HR over one minutes after exercise is within the normal range, this index being a smaller number of children in the polluted area -only 70%. HR over five minutes after exercise is not restored to normal in 60% of children in the polluted area and 37.5% of children in the ecologically favourable area. The studies of the economy of blood circulation showed that in the schools in most students KEK increased, which indicates the stress of the state of the cardiovascular system. KEK was increased in 62% of students living in a less polluted zone, and 50% of teenagers from a more polluted area. Thus, for the students from the institutions located in the more polluted areas, the indices of heart economy and the restoration of the frequency of heart contractions after physical effort are lower compared to the values of the students in the high schools from the less polluted areas. Therefore, cardiovascular parameters are influenced by ecological factors, in particularly, the composition of air.

A comparison between flash-floods and river(basin) floods in Moldova river basin

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KEYWORDS: flash floods, flood elements

There are two types of floods: flash floods and river or basin floods. Between these there are differences and similarities, and this is what we want to show in this paper, especially because flash floods are aiming to be dominant and much more frequent in the last years. Flash floods occur when runoff from excessive rainfall causes a rapid rise in the water height (stage) of a stream or normally-dry channel. According to the Ministry of Environment, Water and Forests, a flash flood is a flood which occurs in a basin with an area smaller than 200 sq km, in less than 6 hours concentration time, and is usually generated by a rainfall which lasts less than 3 hours, or shorter than the time of concentration. Basin floods are generated by a more general rain, usually on the whole basin, not necessarily heavy rain but which can last more than one day, or/and snow melt. We could find similarities in the way they are generated, because they are both generated by rain (convective or front rain) and in the objectives affected and differences in the total or increase time, form coefficients, volume of runoff, and even on the surfaces the runoff is produced. In this respect we have chosen to analyse the Moldova river and its tributaries peak discharge floods as general floods compared to the flash floods which have occurred in the last years, calculating the flood elements, seeing their appearance probability, as well as presenting reports of what has been affected.
The conclusion of the analyses is what could we expect in the future, how can we adapt at living with flash floods, and possible and sustainable ways to reduce their impact on society.

Weather-related disasters over the past centuries in the Eastern Carpathians based on documentary evidence

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KEYWORDS: documentary evidence, Eastern Carpathians, extreme events, HISTCLIMCARP project

Weather-related disasters are known as extreme events, being some of the most destructive natural disasters. On a global level, historical studies on the relationship between climate and society cover a relatively short period, they are only from the Middle and Late Holocene period. However, in the Eastern Carpathian region, documentary evidence of weather-related disasters has been recorded since the last two millennia. A novelty in the investigation of extreme events of the past is the application of several new techniques and methods, because they provide a clear picture of the intensity and magnitude of the events and the impacts produced by them. The aim of this project (HISTorical CLimate variability and IMpact on human society and agriculture in the CARPathian regions – HISTCLIMCARP) is to reconstruct the climate variability of the last 500 years inferred from historical documents, natural archives and integrated paleo reanalysis in the Carpathian region (Romania) and to determine the impact of on agriculture and human society and to study the possible mechanism by which these three are interlinked. The preliminary results indicate differences between intra and extra Carpathian regions of dry and wet periods during the last 500 years. Moreover, our preliminary results indicate not only a strong impact of natural climatic factors on human society, but also show how important it is to focus paleoclimate reconstructions on a regional scale.

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Central Andes climate sensitivity since the early 20th century

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KEYWORDS: Andes, climate changes, sedimentology, geochemistry

In this presentation we show results of an initiative of the FAO/IAEA-UN interregional project INT5153, entitled "Assessing the Impact of Climate Change and its Effects on Soil and Water Resources on Polar and Mountainous Region" whose main objective is to improve our understanding of how modern climate changes may threaten the water availability of communities living in high mountains and the impacts at their natural environment, at a global scale.
The presentation is focused on recent studies conducted at Western Huayna Potosi/Bolivia where we combined a detailed lacustrine paleoclimate record, with the regional glacier's retreats, local meteorological data and remote sensing. This region at Central Andes has been experiencing a severe drought regime since 1990 that is well recorded not only by climate indexes but also by the regional dendrochronological and glacial information. One sediment core sampled at Lake Tuni, 4458 m a.s.l., at Western Bolivia associated to the Nevado Huayna Potosí, 6,088 m, spanning from 1865 to 2017, clearly indicated a reduction in the natural erosive patterns by the reduction in the input of terrigenous materials and mineral grains magnetic susceptibility as a response to significant regional glaciers retreat and melting water runoff decrease. The time scale of the observed hydrological changes seems to be closely related to changes at both the Amazon hydrological climate regime characterized by a trend in the duration extension of the dry season and deforestation and the Central Pacific El Nino Index that exhibited a progressive positive change in the same period.

How similar are Chinese and Serbian loess?

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KEYWORDS: Paleoclimate, loess-paleosol sequences, Early Pleistocene, Vojvodina region

Loess-paleosol sequences (LPS) in the Vojvodina region, the northern province of Serbia, are among the oldest and most complete LPS in Europe to date. These thick LPS contain a detailed paleoclimatic and paleoenvironmental record since the late Early Pleistocene. Variations in magnetic properties, dust accumulation rates, and the intensity of pedogenesis demonstrate evidence for a Middle Pleistocene climatic and environmental transition. The onset of loess deposition in Vojvodina also indicates a direct link between dust generation in Europe and that in the interior of Eurasia since the Early Pleistocene. The youngest part of the Early Pleistocene LPS and oldest part of the Middle Pleistocene LPS is characterized by relatively uniform dust accumulation and soil formation rates as well as relatively high magnetic susceptibility values. In contrast, the last five interglacial-glacial cycles are characterized by sharp environmental differences between high dust accumulation rates during the glacials and low rates observed during soil development. The data presented in this study demonstrate the great potential of Chinese and Serbian loess archives for accurate reconstruction of continental Eurasian Pleistocene climatic and environmental evolution. The main similarity between these two distant loess records on the opposite sides of the huge Eurasian continent comes from similar variations in magnetic proxies based on similarities in pedogenesis intensity dynamics. On the other hand, the main differences of these loess records are consequences of discrepancies in responsible air circulations and availability of source area clearly visible in different patterns of grain size composition.

Developments of Carpathian forests from Holocene to Anthropocene

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KEYWORDS: Carpathian forests, Holocene, climate change, anthropogenic impact, tree species

The review study surveys the historical evolution of the Carpathian forests, spanning from Holocene to Anthropocene, in response to climate fluctuations and anthropogenic influences. This study is underpinned by the literature search conducted within the Web of Science and Scopus databases, yielding 253 pertinent articles published from 1999 to March 2023. The focus of this investigation resides in the dynamics of prevailing Carpathian tree species, namely the European beech (Fagus sylvatica), Norway spruce (Picea abies), oaks (Quercus robur, Quercus petraea), and silver fir (Abies alba). The interplay between these species' trajectories and concurrent environmental shifts across the region is highlighted. Holocene deglaciation is marked as a pivotal phase in the Carpathian forests expansion, driven by rising air temperatures and facilitating the upward movement of glacial refugee species such as the Scots pine (Pinus sylvestris) and larch (Larix decidua Mill.). This upward shift was accompanied by the spread of mixed oak stands in the foothills. During the Preboreal and Atlantic phases, early coniferous and broadleaf species were progressively replaced by Norway spruce, silver fir, European beech, and hornbeam, facilitated by the competitive edge of shade-tolerant species. The evolutionary trajectory of mixed stands favoured the European beech over the Norway spruce, leading to European beech-dominated forests expanding into the mid altitudes. Human activity has shaped the forest's trajectory since the Bronze Age. Timber use contributed to the decline of the treeline, while lower elevations experienced intensive oak logging due to agricultural expansion. The Late Bronze and Early Iron Age witnessed the expansion of European beech and silver fir populations, with the latter benefiting from fire-related activities for colonization of burnt areas. Anthropogenic impacts remained influential, even as forest management evolved through the Late Iron and the Roman Ages. The broad-scale colonization and related mining activities in the Carpathians led to the significant area reduction of mountain forests in the late Middle Ages. Intensive forest exploitation persisted into the Austro-Hungarian Monarchy era, resulting in the biggest forest cover decline. Efforts to enhance timber yields favored Norway spruce resulted in monodominant planted forests and subsequent severe disturbances (windstorms and bark beetle outbreaks), exacerbated by extreme cold spells during the late Little Ice Period. The 20th century saw forest area stabilization and an increase between the two World Wars, marked by diverse reforestation efforts following land abandonment amid changing socio-political landscapes at the Anthropocene onset.

Relationship between fire and mining activities during the late Holocene in a peat core sequence in the northern Carpathians, Romania

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KEYWORDS: fire regime, late Holocene, PCA, Lăpuş Mountains, mining activities

The relationship between fire and mining activities has consequences such as deforestation and mining, which overlap climate change and can cause changes in fire regimes and potentially increase the risk of fires, threatening vulnerable landscapes. The reconstruction of a long-term wildfire regime is possible by analyzing the abundance of carbonaceous vegetation fragments (e.g., charcoal) preserved in sediments accumulated in different depositional environments (e.g., lakes and peatlands). The sedimentary charcoal is used for reconstructing regional changes in fire regime and anthropogenic effects of historical mining and local soil and bedrock erosion was also reconstructed using elemental geochemistry, magnetic mineral properties, and particle size analysis. Was analyzed sedimentary macroscopic charcoal morphology on sediments from the Tăul Mare peat bog, in the Lăpuş Mountains, northern Romania. Principal component analysis (PCA) was used to compare intensity in fire regime, charcoal accumulation rate (CHAR), geochemistry, magnetic mineral properties, and particle size using PAST4.11 software. In the late Holocene, the proxy may be interpreted as reflecting climate change caused by anthropogenic activity in special mining having consequences in landscapes with changes in fire regime. The main results of PCA converge to conclude the following: fire activity increased following anthropogenic activities in the study area; increases in wildfire have generally been accompanied by episodes of increased landscape openness and expanded pastoral activities; the study area followed the mid-altitude mountains and proximity to landscape resources, pasture, and mining. Temporally variation in fire severity may reflect climate changes (as shown by published regional palaeoclimate reconstructions) for example, warmer and drier conditions. In conclusion, our results show a direct connection statistically significant between fire severity and heavy metal concentration and a direct link between fires and erosion (regardless of severity). This study offers information about previously unstudied environmental history in the mid-altitude mountain, of the northern Carpathians and emphasizes the importance of studies that can improve our understanding of the fire regime caused by mining activities.

Periglacial tors in the Curvature Carpathians - identification, spatial distribution and appearance, changing environments and touristic potential

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KEYWORDS: ruiniform relief, periglacial tors, Curvature Carpathians, spatial distribution, terrestrial inventories on tors, changing environments, touristic potential

The alpine mountain landscape in the Curvature of Carpathians is characterized by the wide spread of the areas occupied by ruiniform relief and periglacial tors, of which the most famous ones are in Ciucaș Massif. Periglacial tors have been defined as a part of a residual mass of bedrock produced below the surface, originating in selective deep weathering and subsequent removal of regolith. During field observations periglacial tors have been identified at altitudes above 1700 m asl. Although tors had been known for centuries, there are few recent studies in the Curvature Carpathians focusing on their spatial distribution, appearance and touristic potential. The area located in the Ciucas Massif is very important due to its geomorphological characteristics and is suitable for the inventory of periglacial tors. The study focuses on the analysis of periglacial tors using old maps and GIS tools for an updated inventory of these landforms, GPS tools for on site identification and telemeter for measurements. The identified periglacial tors have been manually extracted from old maps and several new sites were added, scattered throughout the Curvature Carpathians. Several fieldtrips conducted in specific parts of the study area provide data about their shapes, location and height, allowing for the addition of GPS and morphometrical data. The data has been processed using ArcGIS software, resulting in spatial distribution and density maps for specific areas.

Discovering past and present nature of remote Ukrainian mountains: Bukovynian Carpathians within the National Nature Park Cheremoskyi

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KEYWORDS: Ukrainian Carpathians, Chornyi Dil, National Nature Park Cheremoskyi, geological diversity, Cheremosh River

The Chornyi Dil Ridge, situated in the Ukrainian Carpathians within the historical region of Bukovyna, is a geological and ecological treasure trove. While extensive research has been conducted on the crystalline structures of the Maramarosh Mountains in this region since the 19th century, the midaltitude massif of Chornyi Dil Ridge, with its highest point at 1483 m a. s. l., remains relatively unexplored. This ridge, preserved within the National Nature Park Cheremoskyi since 2009, offers a unique blend of natural and cultural features, geological monuments, and biodiversity, thanks to its remote location in the southernmost part of the Ukrainian Carpathians.

The Chornyi Dil Ridge showcases a rich diversity of rocks in terms of age, lithological and facies composition. Some of the oldest metamorphic formations in the crystalline massif include chlorite-muscovite, quartz-feldspar, and biotite schists belonging to the Bilopototska Series (Upper Proterozoic). Additionally, schists, quartzites, and Late Proterozoic intrusive formations, characterized by biotite and muscovite granite-gneisses, contribute to the geological complexity of the area. The southern part of the ridge predominantly comprises conglomerates, sandstones, and gravels of the Soymulian beds of Cretaceous, while basalt conglomerates, sandstones, carbonate mudstones, and siltstones of the Rudarnenska Series, along with colourful sandstones, mudstones, jasper, marbled limestones, and conglomerates of the Boltagulian (Jurassic), add further geological intrigue. Notably, gastropods and brachiopods are found in the basal layers of some formations, providing insight into the region's paleontological history.

The geological structure and lithology of the rocks in the Maramarosh, Rakhiv, and Chornohora (Magur) Series influence the hydrographic network of the region, particularly the Upper White Cheremosh valley and its tributaries. The river's course is impacted by several tectonic zones, leading to a convex deformation of its longitudinal profile. As the river approaches the transverse monolithic massif of the Grebenyshche Ridge, it changes direction and follows the fault zone upstream. This hydrographical configuration is a result of the intricate geological history of the Chornyi Dil Ridge.

The Chornyi Dil Ridge is known for its unique climate, which has been documented since the Austrian rule times. This region is characterized by colder temperatures compared to its adjacent areas, often experiencing a lack of meteorological summer and heightened precipitation during the spring and autumn months. The Chornyi Dil Ridge is home to indigenous communities of cedar and spruce forests, some of which are listed in the Green Book of Ukraine. These relict associations are notable for the presence of cedar pine, a species listed in the Red Book of Ukraine, making this ridge the sole habitat for this species in the

Bukovinian Carpathians. Furthermore, the ridge hosts rare plant species, including bitter root (*Saussurea discolor*), the Eastern Carpathian endemic yellow monkshood *(Aconitum jacquinii Rchb*), the South-Eastern Carpathian endemic silene zawadzkii (*Elisanthe zawadzkii*), and the iconic edelweiss (*Leontopodium alpinum*).

The Chornyi Dil Ridge is a region of immense geological and ecological significance within the Ukrainian Carpathians. Its diverse geological formations, complex hydrographical patterns, unique climate, and exceptional biodiversity make it a subject ripe for further research and exploration. Uncovering the geological history and ecological importance of this remote area promises to yield valuable insights into the past, present, and future of mountain development in the region.

Tracing human activities over the past eight millennia in SE Europe using multi-proxy approaches from lake sediment records

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KEYWORDS: lake sediments, human activities, SE Europe, ANCLE

For millennia, humans have shaped the environments, modifying natural vegetation cover and aquatic ecosystems, and changing the biogeochemical cycles. However, significant, and prolonged changes in the environment only began with the emergence of Neolithic farming practices, about 7,500 years ago in south-eastern Europe. A novelty in investigating the past environmental changes is the application of an integrative approach combining conventional (geochemical, physical) and novel paleolimnological techniques (biogeochemical) as it offers an unprecented opportunity to investigate the extent, driving forces and impacts of climatic vs anthropogenic processes transforming the environment over longer time scales.
This project (Changing environments - The past ANthropogenic and CLimatic dimension of Environmental changes in SE Europe - ANCLE) aims to provide a novel perspective on the Holocene environmental changes in a historically rich, though unexplored area (Romania, SE Europe) in relation with past climatic changes and human activity. In this project we apply integrative biogeochemical approaches (biomarkerks, fecal sterols and sedDNA) to lake sedimentary archives collected from mid and low elevation sites. The preliminary results from faecal sterols and sedDNA (plants and mammals) from Lake Ighiel (W Romania) show a continuous human presence, though with a variable intensity, over the past 5000 years. Such work will provide an unprecedented picture of environmental changes in this unmapped region of Europe and will pave the way for exciting future applications in different disciplines.

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The Virtual Palaeoscience (ViPs) Project: resources for online learning and their potential for more inclusive Environmental Education

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KEYWORDS: Environmental change; Equity, Diversity and Inclusion (EDI); online resources; Digital Visualisation Tools (DVTs); Community of practice

The Virtual Palaeoscience (ViPs) Project (Virtual Palaeoscience) was created as a response to the COVID-19 pandemic's curtailment of field and lab work in environmental disciplines, including Quaternary Science, where these activities are crucial to student learning outcomes. The initiative aimed to collect, collate and develop digital resources to support virtual field and lab-based teaching supported by the international palaeoscience community.
Project membership grew quickly, especially in 2020 when teaching activities were most restricted, and remains over 200. Hosted on-line as a searchable database, the project has accrued > 600 digital resources that can be accessed for free, used directly or as exemplars modified for local application. The project was steered by a small coordinating group, but the project aims were led by the wider community as a result of workshop-based discussions via a subset of working groups. The development of the ViPs project has been set out by Hutchinson et al. (2022). Here we consider the future potential of this approach.
While widespread restrictions impacting educational activities are now largely over, the potential of the virtual dimension to teaching, making activities such as field and lab work more accessible and inclusive remains as a positive legacy of ViPs. For example, virtual fieldtrips can help address challenges associated with accessibility; virtual lab work can improve students' preparedness for practical sessions instilling confidence and digital learning resources allows more opportunities for more varied teaching/learning styles which can support accessibility and inclusion.
ViPs was supported by the UK's Quaternary Research Association (QRA) but has the potential to support the use of digital tools for EDI and Access worldwide. The principal focus of the project has been the collection and collation of digital resources, rather than their development, which was one of the initial aims. However, the potential of this approach, and the expertise and experience garnered by the core ViPs Project team, is reflected in recent funding by the UK's Natural Environment Research Council (NERC) of two EDI and Digital Technology focussed projects CULTIVATE and More Inclusive Fieldwork, and EU funding for the Digilego project creating Open Educational Resources (OERs).

Reconstructing 6000 years of lake level variation in central Transylvania, Romania

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Lake level variations are used as key tools in hydroclimate reconstructions, due to their strong link to past climate changes. Apart from climatic controls, lake levels can also fluctuate due to land-cover and land-use changes, as these affect surface properties and hydrological characteristics of the lake catchment, ultimately leading to changes in evapotranspiration. Understanding the relative contributions of natural vs. anthropogenic factors in the Holocene lake level changes across Europe still remains a challenge, as there are very few lake-level records in the lowlands, particularly in Eastern Europe.

Here, we provide the first lake level reconstruction in the lowlands of Transylvania (Romania), based on the geochemical and geophysical analysis of sediments extracted from the Țaga Mare lacustrine archive that spans the last 6200 years. Potential drivers of lake level change are further explored within a comparison with published regional palaeoclimate and palaeovegetation records.

Results indicate a complex succession of lake level phases during the last 6200 years. Prior to 4000 cal yr BP, physical and geochemical proxies suggest moderate to low lake levels, against the background of high erosion and more turbulent sedimentation. Significant decreases in lake levels occured in the intervals 3800-3600, 3150-2800, 2500-2300, 2200-1900, 1600, 1450-1350, 1200 cal yr BP, separated by phases of higher water level. Particularly interesting is an episodic transition from lake to a wetland with fen peat between 2000 – 2200 cal yr BP, when water level was likely below 1m. This transformation occurred as a result of warm and dry climatic conditions, based on published palaeoclimate reconstructions. The increase in water level and subsequent recovery of the lacustrine environment at 2000 cal yr BP took place under colder and wetter climatic conditions, with increased fluvial activity and erosion. As for the last 1000 years, the sediment chronology and geochemical properties indicate an increase in water levels, as well as a massive sediment reworking that started ca. 800 years ago, paralleled by the development of human activities inside the lake catchment.

Based on the obtained results, we can conclude that lake levels in this area are vulnerable to changes in both climate and anthropogenic pressure, which should be considered when assessing and managing water resources under a climate warming scenario.

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The historical evolution of the environmental conditions in the Lake Bolătău-Feredeu area within the Bukovina region

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KEYWORDS: lake sediments; Bukovina; paleoenvironmental reconstruction

1 Introduction

Lake sediments serve as repositories of environmental changes within the lake-catchment system, with preserved pollen grains offering insights on a larger scale. The productivity within the lake and the surrounding catchment area continually mirrors environmental fluctuations and potential disturbances due to human influences. To ensure a comprehensive and accurate interpretation of lacustrine sediment data, one must have a profound understanding of the current state of the lake and its catchment area, as well as meticulous documentation of the site-specific processes and conditions, (Wan et al., 2019).
Organic geochemical methods, especially n-alkanes, prove to be excellent tracers of changes in vegetation composition, (Meyers, 2003). In addition to organic methods, understanding mainly inorganic parameters, including mineralogical analyses, stable isotopes, weathering indices, elemental composition, and particle size distribution, with low sample requirements, also contributes valuable information for reconstructing the environment and paleoclimate. These parameters enable the detection of changes in the catchment area, such as temperature, rainfall, and human impact, especially those affecting lake input conditions.
The primary objective of this research was to conduct a geological and geochemical study of the lake sediment and catchment of Lake Bolătău-Feredeu, primarily focusing on paleoenvironmental and paleoclimatic reconstruction. The ultimate goal was to document a comprehensive paleoenvironmental narrative spanning the entire analysed time frame.

2 Study site

The selected research area (Lake Bolătău-Feredeu) is situated in the Eastern Romanian Carpathians in the Bukovina region, covering the catchment area of the Sadova River. Lake Bolătău-Feredeu, located at 1134 meters above sea level and adjacent to a Natura 2000 protected site, is one of the three Millenial Lakes of Bukovina. The sediment from these lakes is stratified and provides insights into the past 1000 years. The catchment area spans approximately 30 hectares, while the lake's surface covers 0.3 hectares. At the time of sampling, the water depth measured 5.2 meters, as documented by Mîndrescu et al. in 2013 and 2016.

3 Methods

Sampling from the bedrock was conducted based on preliminary data, such as geological maps, and field observations coinciding with soil sampling. During these field observations,

careful consideration was given to topographical conditions and plant cover. For rock samples, we created an average sample, ground it for uniform particle size, and then analyzed subsamples after dusting and homogenization. We used X-ray powder diffractometry and X-ray fluorescence analysis to calculate weathering indices.
Soil samples, collected from the same locations as rock samples, were homogenized, and subsamples were derived for testing. Laser diffraction determined particle size distribution. We also used X-ray powder diffraction and X-ray fluorescence analysis to identify mineral phases and calculate chemical composition for weathering indices.
Lake sediment study involved various methods like optical microscopy, cathodoluminescence microscopy, infrared spectroscopy (FTIR-ATR), and micro-Raman spectroscopy. Stable isotope measurements on two sediment cores, along with C%, N%, and C/O atomic ratio, helped identify organic matter sources and assess productivity. We conducted high-resolution sampling on 1-cm average samples from cores LB-G-01 and LB-G-02. For LB-G-02, C% values guided n-alkane analysis using gas chromatography, and index calculations were based on peak intensities (TAR_{HC}, P_{aq}, P_{wax}, P_{hw}). In LB-G-01, subsamples with prior age determination underwent stable isotope measurements, mineralogical composition determination using X-ray diffraction (XRD), and elemental analysis via X-ray fluorescence spectrometry (WD-XRF) on pastilled samples. We independently interpreted the data and calculated weathering indices, while laser diffraction analyzed particle size distribution for insights into changing application conditions (Karlik M, 2022).

4 Conclusion

Main events in the lake catchment area of the last 500 yrs.:
i. 1500 A.D. – 1620 A.D. – Distribution of Herbaceous Plants in the Catchment Area: According to the data, herbaceous vegetation was observed scattered within the previously dense forested vegetation during this period (Karlik M, 2022).
ii. 1620 A.D. – 1700 A.D. – Cold Period in the Catchment Area: The region experienced decreased productivity due to a drop in temperatures. As herbaceous vegetation diminished, the filtering effect on the lake's shoreline also decreased, allowing larger particle-sized materials to reach the lake more easily (Karlik M, 2022).
iii. 1700 A.D. – 1780 A.D. – Nearly Stable Period: This period exhibited relative environmental stability, characterized by short-term events within the catchment area that generated no significant differences (Karlik M, 2022).
iv. 1780 A.D. – 1860 A.D. – Cold Period and Deforestation in the Catchment Area: During this cold period, deforestation occurred as an anthropogenic influence. I found that deforestation primarily affected the Lake Iezer catchment area and only reached the Lake Bolătău-Feredeu catchment area around 1811 A.D. (Karlik M, 2022).
v. 1860 A.D. – 2010 A.D. – Modern Landscape Change in the Catchment Area: In the wake of earlier deforestation, there was a noticeable decrease in woody vegetation in favor of herbaceous plants during this period (Karlik M, 2022).

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The development of gypsum karst in Northern Bukovyna in Late Pleistocene – Holocene

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KEYWORDS: gypsum, karst, Holocene, cave, Chornyi Valley, Balamutivka village

1 Introduction

According to the karst-speleological zoning, the Northern Bukovyna and its northern part, situated in the Middle Dniester area, belongs to the Podillia-Bukovynian karst region. Several dozen natural caves have been explored in this area. Some of the caves were developed in Cretaceous and Neogenic carbonate rocks, but their dimensions are not more than tens of meters (Ridush and Kuprich, 2003). However, most of the biggest caves in the area, like Optymistychna, Ozerna, Mlynky, Kryshtaleva and others, were developed in a gypsum layer (Low Badenian, Miocene), bedded deeply under the surface, and they are mostly of hypogenic genesis (Klimchouk and Andreychouk, 2017). The sulphate rocks are outcropped or bedded close to the surface at the northern part of Northern Bukovyna, close to the Dniester River valley. In the Bukovynian part of the gypsum area, only one relatively small maze-cave is known (Skytska (Hostri Hovdy)) (Tab. 1). The geological age of this cave is still unclear, but it is undoubtedly older than the Late Pleistocene. However, on some gypsum areas, the classic epigenic karstogenesis, with a minimal contribution of the previous hypogenic stage, is developed. Until now, caves of this type were only briefly mentioned in the karstological literature, especially regarding their geological age.

2 Methods

The speleomorphogenetic method was used for the study of karst formation, lithology and hydrological conditions, which provided information about: 1. Lithology recondition for karst development, 2. Type of water exchange system, 3. The succession of karst systems stages (Klimchouk and Andreychouk, 2017). We also constantly provided the monitoring of active karst processes in this area (Ridush and Kostiuk, 2019). In addition, paleontological and paleogeographical studies of caves sediments are conducted (Kononenko et al., 2022).

3 Results

The features of epigenic karst development are under the influence of surface water and rocks' natural porosity and fissures. The numerous caves of epigenic origin are known in the northern part of Northern Bukovyna (Table 1).
Due to the high solubility of gypsum, the karst process in the area is still active and evidently visible. For example, during the last few decades (since 1980), the new karst ditch appeared in the Chornyi Potik Valley, between the caves Nezabudka and Troitska. Because of anthropogenic activity, the new ponors appeared (caves Orange River and Red Ponor), and the older caves-ponors became inactive (Selenitovyi Ponor) in the same valley.

Table 1. Caves at the northern part of Northern Bukovyna (according to the materials of the Ukrainian cadastre of caves)

№	Name	Length, m	Amplitude, m	Prevailing genesis	Age
1.	Skytska (Hostri Hovdy)	3550	14	hypogenic	Pleistocene
2.	Chornopototska	970	6	epigenic	Holocene
3.	Pionerka	600	13	epigenic	Holocene
4.	Nezabudka-Troitska	375	5	epigenic	Holocene
5.	Balamutivska	263	8	epigenic	Holocene
6.	Fushteika	219	14	epigenic	Holocene
7.	Kremenevyh Vidschchepiv	210	14	epigenic	Holocene
8.	Elefantyna	200	4	hypogenic	Pleistocene
9.	Panska Skelia	180	12	epigenic	Holocene
10.	Ducha	144	5	epigenic	Holocene
11.	Dovhyi Yar-1	100	4	epigenic	Holocene
12.	Selenitovyi Ponor	80	5	epigenic	Holocene
13.	Martynivka	80	5	hypogenic	Pleistocene
14.	Pidlianka	75	6,5	epigenic	Holocene
15.	Orange River	70	5	epigenic	Holocene
16.	Dovhyi Yar-2 (Malecha)	40	4	epigenic	Holocene
17.	Red Ponor	23	2	epigenic	Holocene
18.	Lianka	22	8	epigenic	Holocene
29.	Voronka	20	0	epigenic	Holocene
20.	Koziachi Nizhky	17	14	epigenic	Holocene

Due to the high solubility of gypsum, the karst process in the area is still active and evidently visible. For example, during the last few decades (since 1980), the new karst ditch appeared in the Chornyi Potik Valley, between the caves Nezabudka and Troitska. Because of anthropogenic activity, the new ponors appeared (caves Orange River and Red Ponor), and the older caves-ponors became inactive (Selenitovyi Ponor) in the same valley.

To the northeast of the Chornyi Potik Valley, the karst ditch Dovhyi Yar is located, there are several caves (Pionerka, Dovhyi Yar-1, Dovhyi Yar-2) were explored. Now it functions as a blind karst valley because it collects the surface runoff from the surrounding territory. Pionerka Cave is the largest cave in this microregion, with signs of hypogenic speleogenesis on the upper floor. Because of periodical flooding with rain and snow-melting runoff, its internal configuration is constantly changing. So, at the modern stage, the cave continues to develop in epigenic conditions. The lower gallery, with a periodical waterflow, contains loose, loamy flood sediments that we consider to be of Holocene age. Meanwhile, the hypogenic stage should be much older due to the geomorphological position of the territory; no ancient sediments were recorded in the cave.

Several active caves containing the Late Palaeolithic artefacts in the cave sediments are known near Balamutivka Village. But as it was evidently shown, the flints and few bone remains were washed into these caves through the ponors from the loess strata, bedded on the ancient river terrace above the gypsum strata (Kononenko, Ridush and Popiuk, 2022). Moreover, gypsum lithology in this cave undergoes intensive frost weathering in the area of daily and seasonal temperature fluctuations, which caused the relatively quick destruction of the entrance grotto of the Balamutivska Cave (Ridush, 2000; Kochergan and Ridush, 2011).

Meanwhile, the sediments containing palaeogeographical records were explored in a few caves. In the Martynivka cave, except for the Medieval cultural layers, the fauna of rodents, dated to LGM was found (Ridush et al., 2021). In the entrance grotto of the Balamutivska Cave, the Mesolithic drawings and carvings on the walls were found yet in 1951 by (Chernysh,

1959). Nevertheless, the Mesolithic age of the Rock art in this cave was discussed, and the explanation of what way the drawings could survive since the Early Holocene was given (Ridush, 2000).

Moreover, the few small dead-end galleries adjacent to the main chamber contain slender-thick (up to 1.0m) deposits of light-yellow loess-like loam with the remains of Chiroptera, Lepus sp., Vulpes sp., Rodents, Aves, Reptiles, Amphibia, Pisces, Mollusca, and Diptera puparium. The species and radiocarbon age should be determined (Ridush, 2022).

4 Conclusions

Karst development in the northern part of Northern Bukovyna is controlled by lithology, geology, and tectonic settings, as well as cycles of chemically active water. We can determine the signs of karst development by the morphology of the cave passages, as well as by the available cave deposits (paleogeographic sights). Also, karst development is influenced by human economic activity, which has been started in this region at least since the Neolithic.

The development of epigenic karst and karst denudation is still active in the territory, but its history in Late Pleistocene and Holocene should be traced after the karst sediments research. At present, it is enhanced by anthropogenic factors, in particular, economic development of the territory (ploughing, reduction of forests cove, runoff regulation etc.).

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Using GIS tools in the study of paleovalley in the Verchny Prut basin

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KEYWORDS: GIS, SRTM, paleogeomorphological analysis, paleovalleys, Chornyy Cheremosh, Chorna Tysa, Lyuchka, Oslava

1 Introduction

The use of new, modern methods of digital mapping and geoinformation tools in research allows us to take a fresh look at the seemingly already known and defined problematic issues of clarity of the stages of origin and formation of the basins of the river systems of the Ukrainian Carpathians and their gradual stabilization within the current boundaries. The long-standing and clearly defined position of leading specialists, Ukrainian geomorphologists (Andreychuk, 2012; Bayrak, 2008; Klapchuk, 1994) and hydrologists (Kostenyuk and Smyrnova, 2010), thanks to the use of new geographic information technologies and access to modern software, opens up new opportunities for its revision and clarification. An important aspect of studying basin systems in mountainous regions, such as the Ukrainian Carpathians, is the use of not just a cartographic research method with the corresponding results of visualization, zoning, or creation of appropriate mapping schemes, but also the use of system analysis. That is, thanks to GIS applications (TIN interpolation qgis), when creating appropriate models, we can reveal in more detail the complex issues of the reformation of ancient drainage valleys and their modern reflection in the relief of this territory. The complex and not fully disclosed issue of the reformation of ancient drainage valleys in the Pliocene-Pleistocene period is extremely important for understanding modern channel processes in the rivers of the Upper Prut basin, as it still significantly affects the perception of the current pattern of the hydrosystem of the study basin and the inherited nature of channel macroforms in some of its sections.

2 Methods

It is the ambiguous conclusions and results of previous researchers that prompt the use of new, more advanced methods that will better substantiate and determine the course of the processes of restructuring the river network of the southeastern macro-slope of the Ukrainian Carpathians, as well as identify the factors that caused these changes. First of all, it is important to take into account and rely on the changes in the configuration of the Upper Prut hydrosystem at different stages of its functioning and development. One of the methods for studying the peculiarities of river basin hydrosystem formation is geomorphological analysis (Karabinyuk, Hnatyak, Buryanyk, Hostyuk and Karabinyuk, 2021). The pattern of the hydrographic network is a reliable indicator of the morphology and genesis of the modern relief, tectonics and neotectonics, and the type and intensity of surface runoff (Bayrak, 2008).

3 Results

The Upper Prut basin is quite interesting in this regard, as it is known to have several "special" sections of the valley and channel network, which indicate significant reformation, so-called

interceptions, and changes in flow at different stages of orogeny of the Carpathian mountain-fold structure. From the hydrological and channel studies point of view, the study of the hydrographic network of the Upper Prut is quite important, since changes in the number and length of tributaries cause changes in the magnitude of the main factors of channel formation: water and sediment flow, and the availability of data on ancient flow valleys will determine the nature and boundary conditions of river channel formation (Kostenyuk and Smyrnova, 2010). Let's take a closer look at the study area. As can be seen from Figure 1, the orographic connection between the Black Tisza-Prut-Black Cheremosh river valleys is clearly traced, with only the direction of flow through this ancient valley remaining open. It should be noted that many researchers attributed to this ancient form a southeastern direction through the Suceava River basin to the upper reaches of the Moldova River (a right tributary of the Siret River, which flows within Romania), while others (Klapchuk, 1994) consider the direction of flow through this valley to be radically opposite: from the upper reaches of the White Cheremosh from the Marmarosh massif, through Verkhovyna-Vorokhta to the village of Delyatyn.

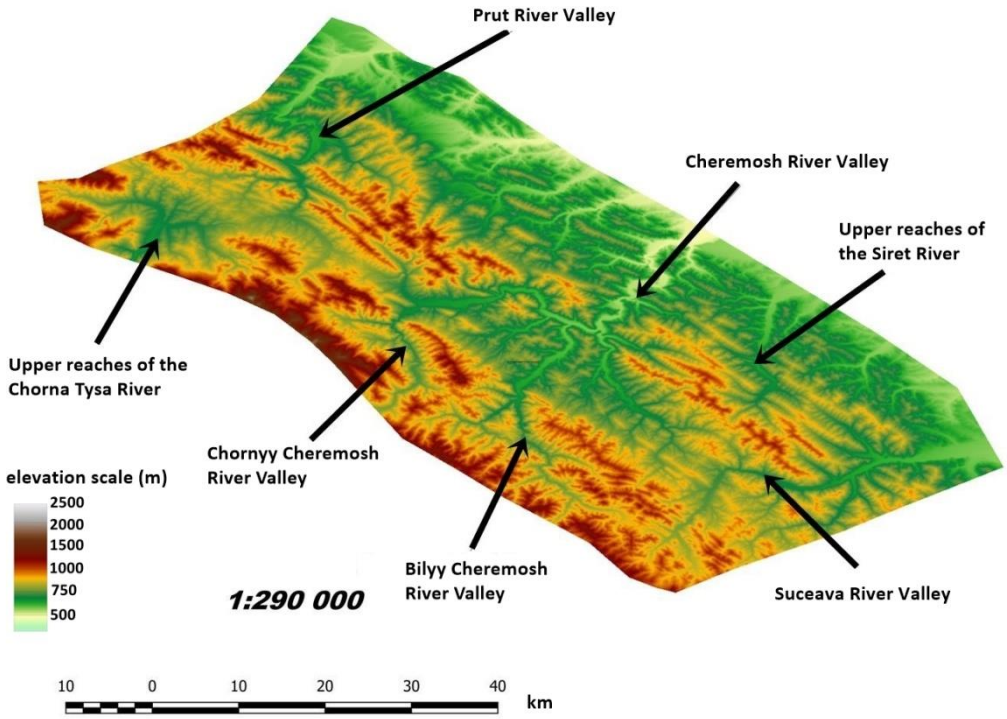

Figure 1 Hypsometric map based on the digital relief model (DRM) of the mountainous part of the Verchny Prut basin and the adjacent territory.

As we can see, the question of the Vorokhto-Putyla lowlands and depressions in the Suceava River valley remains open, since V. M. Klapchuk's theory does not provide a clear answer to the question of the formation of this area under the northwestern direction of flow. The correct answer to this dilemma will be found only during thorough research of alluvial deposits of terraced levels, which are preserved in fragments, and a comprehensive analysis of the results obtained by paleogeomorphologists and hydrologists in joint work in the future. Today, the issue of re-shaping the hydrological network of the Ukrainian Carpathians and Upper Prut rivers (in particular, intercepting their main tributaries and changing the direction of flow) remains insufficiently studied and substantiated, despite the enormous work of well-known specialists, geomorphologists and hydrologists who have devoted a lot of time and effort to

solving it (Burshtyns'ka, Babushka and Halochkin, 2020). However, there are still many nuances that require more detailed study and clarification, as well as a possible rethinking of digital modeling using the latest GIS technologies. After all, these complex problematic issues, supplemented by field research, may be able to be looked at from a new, more practical perspective.

4 Conclusions

The formation of the modern hydrosystem of the Upper Prut basin was a complex process. At different stages of the study of this basin system, various theories of possible reformation of both the main channel streams and minor tributaries were proposed. At the same time, we are talking not only about their configuration but also about the periodic increase or decrease in the area of the entire catchment basin, which is known to significantly affect the total flow module. The reasons for these transformations are currently considered to be periodic upward movements and subsidence in various local areas, which is reflected in the change in the erosion base and, accordingly, the reconfiguration of the river system to new conditions.

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Neotectonic movements in the Romanian Plain (the Călmăţui Basin) and their influences on the demography of prehistoric human settlements

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KEYWORDS: Eneolithic, tell, paleoevolution, Buzau hydrographical network

Knowing the impact that the natural elements characteristic for a certain territory have on human communities is a mandatory stage for the evaluation of the structure and functional character of those communities. Located at the contact of the Carpathian and the Romanian Plain, the area of Wallachia's Subcarpathians is individualized through a complex natural potential due to the dynamics of phenomena and processes present throughout history, as well as the existence of important mineral resources (salt, limestones, chalk, amber). Landscape geodiversity guaranteed a diversified offer for the humanization process, with significantly higher accessibility than adjacent areas, so that, in socio-cultural terms, this environment, located at the interference of multiple cultural spaces, creates regional identities or synthesis facies, by combining elements that are specific to different cultural traditions.

In the Eneolithic epoch settlements in this area present certain particularities, the existence not only of settlements with complex stratigraphy, vertically developed, similar to tell-like settlements from the Danube Valley and the wider Balkan region, but also of some that are developing mostly in the horizontal plane. Tell-like settlements with amplitudes between 1.5-4 m and a diameter of 40-80 m, easily identifiable in the plain area by surface research, are easily confused with natural forms of relief in the Subcarpathian zone.

Circumscribing the human, cultural and natural element in a multifunctional system involves applying an inter- and transdisciplinary approach which guarantees the detail analysis of the components that form the natural system subjected to scientific research, the inhibitory or amplifying role, and especially that of the activity of modelling the evolution of human component as part of a whole.

The evolution of the climatic water balance in Poland in the light of the progressing climate change

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KEYWORDS: precipitation, evaporation, climatic water balance, Poland

1 Introduction

Prior to the pronounced warming of the climate observed globally and in Poland since the 1980s (Jarraud, 2013; Wójcik and Miętus, 2014; Tomczyk and Bednorz, 2022), the water needs of crop plants were usually defined by the concept of optimal rainfall and the associated values of rainfall excesses and deficits (Hohendorf, 1948; Dzieżyc et al., 1987). Currently, due to the marked increase in air temperature, resulting in an increase in evapotranspiration, the concept of climatic water balance (CWB) is commonly used. In contrast to the increase in air temperature, the level of precipitation in Poland has not shown significant changes since 1980 (Żmudzka, 2002; Wibig, 2009). However, variation in precipitation in Poland is increasing; the value of the coefficient of variation increased from 10% to 16% in the period from 1861 to 1990, and to 19% in the years 2001–2018 (Kożuchowski, 1996, Ziernicka-Wojtaszek and Kopcińska, 2020). This causes an increase in the frequency of extreme precipitation phenomena – heavy rainfall as well as droughts. In this situation, the National Research Institute of Soil Science and Plant Cultivation (IUNG) in Puławy has been monitoring agricultural drought since 2009. In the Agricultural Drought Monitoring System, weather conditions causing drought are determined on the basis of the climatic water balance (Doroszewski et al., 2012). The system indicates areas at risk of drought 14 times during the growing season for 14 monitored agricultural crops in all communes of Poland. One of the most important syntheses of the phenomenon of drought in Poland is a study by Doroszewski et al. (2014), who described the spatial variation of drought for specific groups and species of plants and for soil categories in Poland in the 50-year period of 1961–2010, as well as the trend of drought occurrence and frequency in 10-year periods. In this situation, the aim of the present study is to present the evolution of changes in the values and spatial differentiation of the climatic water balance (CWB) in Poland in the successive periods of 1951–1980, 1971–2000, 1981–2010 and 1991–2020.

2 Data and methods

The data used for the analysis were average monthly air temperature values and monthly precipitation totals for all periods compared in the study, obtained from the National Research Institute of Meteorology and Water Management. The data were from 21 weather stations evenly distributed around Poland. Mountain areas were not included due to the insufficient number of weather stations. The climatic water balance was calculated as the difference between the precipitation total and the total potential evapotranspiration, determined according to Thornthwaite (1948). Water resources were calculated for the time interval from June to August, i.e. for the part of the growing season with the most intensive plant growth,

when water requirements for most crop plants are highest. Four climatic water balance regions were distinguished: wet > −60 mm, optimum water balance −60 to −90 mm, moderately dry −90 to −120 mm, and dry < −120 (Table 1, Fig. 1).

3 Results

The study period of 1951–2020 includes three official WMO climate normal periods, i.e., 1971–2000, 1981–2010 and 1991–2020, as well as the 30-year period of 1951–1980 preceding it, which was not an official normal period, but is a comparative base from before the marked increase in air temperature observed since the start of the 1980s. The 1971–2000 normal period is a transitional period when temperature changes were beginning to be noted, while the last two are periods of a pronounced and systematic increase. In general, wet areas and areas with optimal water balance decreased systematically over time in the successive 30-year periods, from 70% to 60% to 47% to 31% of the area of Poland, while moderately dry and dry areas increased during the 30-year periods, from 28% to 38% to 51% and finally to 67%, and thus two-thirds of the territory of Poland. Dry areas with a CWB value < −90 mm are always observed in the strip of central Poland running from west to east, which over time, i.e. as the air temperature increases, is gradually broadening northwards and southwards. The driest area, with CWB values < −120 mm, increased from a few percent of the total area of Poland in the previous periods to 22% in the final period of 1991–2020. It included the west-central part of the country, i.e., the southern part of the South Baltic Lake District and the northern part of the Central Polish Lowlands, except for their most eastern limits. A small fragment of this driest area also appeared in this period at the eastern border of central Poland in north-western Polesie.

Table 1. Area of the designated climate water balance regions for the periods 1951–1980, 1971–2000, 1981–2010, and 1991–2020 (given as % of the area of Poland). Source: self-reported data

Climatic water balance regions	Period			
	1951–1980	1971–2000	1981–2010	1991–2020
Wet > −60	33	20	16	3
Optimum water balance −60 to −90	37	40	31	28
Moderately dry −90 to −120	27	36	48	45
Dry < −120	1	2	3	22
Mountain areas not included in the analysis (black)	2	2	2	2

4 Conclusions

This study is a continuation of research on the effect of global warming on the decrease in water resources due to the increase in evapotranspiration, in the situation of progressive warming and the absence of clear tendencies in precipitation in Poland. These conditions cause the area of the water balance regions designated as dry to increase systematically in successive periods. The results of the study, as a current assessment of water resources in Poland with delimitation of regions, can be placed between the old, classical studies from 1881–1930 and 1931–1960 and projections of climate change for the end of the 21st century.

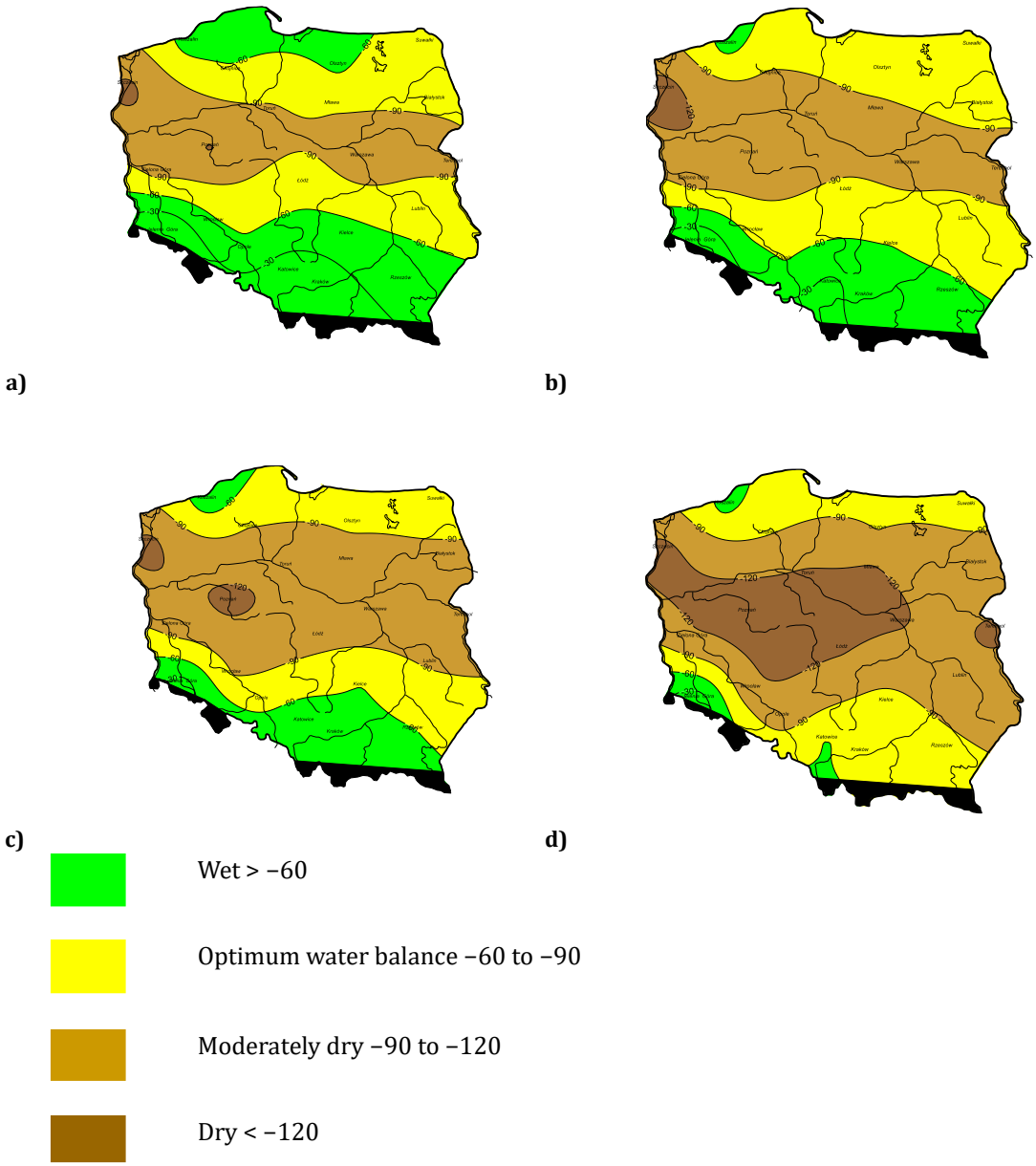

Figure 1 Climatic water balance regions in Poland during the years a) 1951–1980, b) 1971–2000, c) 1981–2010 and d) 1991–2020. Source: self-reported data.

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The hydrodynamic conditions of a mountain river reach: The Ochotnica River in the Polish Western Carpathians

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KEYWORDS: braided river, flow channel system, flood, hydrodynamic conditions, Ochotnica River

1 Introduction

The objective of this study was to analyze the impact of floods on the hydraulic conditions of a 150-m Ochotnica river reach. The interpretation of hydraulic conditions was based on measurements of basic hydraulic parameters such as shear velocity, shear stresses, Reynolds number, Froude number, and flow velocities under various discharge conditions and flow channel systems between 2000 and 2022.

2 Research object

The Ochotnica river, with a length of 22.7 km, drains an area of 107.6 km^2 in the Gorce Mountains (Polish Western Carpathians) [Starkel 1972] and flows into the Dunajec river as its left tributary at an altitude of 385 m a.s.l. in Tylmanowa. The study was undertaken in a 150-metre-long reach in the middle part of the Ochotnica river, located at 13.5 km of its course, at an altitude of 534 m a.s.l., with a catchment area of 58 km^2. The Ochotnica catchment is underlain by flysch sediments (alternating sandstone and shale layers) [Starkel 1972]. The upper course of Ochotnica river is carved out of solid rock with numerous shelves and rock outcrops. The middle and lower parts of the river channel are cut in sedimentary and solid rock, and comprise a gravel-bed, straight, single-threaded river with a braided system. The average slope for the entire channel is 3.61% and varies from 5.68% in the upper to 1.55% in the lower part.

3 Methods

Description of the hydrodynamic parameters has been grouped into four periods: 2000-2002, 2003, 2014-2015, and 2022. Field measurements of water velocity were carried out during different periods of a year under different discharge conditions (low flows, small floods, and average flow, just after a bigger flood) and were repeated four times each year.

Water velocities were measured using the Model 801 Electromagnetic Open Channel Flow Meter by Valeport. This device can measure water velocities ranging from 0.001 m · s-1 to 5 m

· s^{-1}. Measurements were done directly above the riverbed and were based on Jarrett's [1991] findings regarding taking velocity profiles in mountain stream cross-sections.
The methods of Gordon et al. [2007] and Bergeron and Abraham's [1992] were then applied to the field data, and shear velocity V_* values were calculated from the velocity profiles obtained near the riverbed. First, several instantaneous velocities were measured just above the bed of the stream, V [m · s^{-1}], and average velocity V_{av} [m · s^{-1}]. Then, the value of dynamic velocity and shear stress was calculated based on the knowledge of the velocity profile distribution in the river, which satisfies the equation of Von Karman-Prandtl [Bergeron and Abrahams 1992]:

$$V = \left(\frac{V_*}{\kappa}\right) \ln\left(\frac{z}{z_0}\right) \quad (1)$$

The dynamic velocity is obtained by plotting the regression line between the values of instantaneous velocities and the logarithmic values of the distance between the measurement from the riverbed. If the line is straight, then we can calculate the dynamic velocity from the slope [Gordon et al. 2007, Radecki-Pawlik 2011]:

$$V_* = \frac{a}{5.75}\ [m \cdot s^{-1}] \quad (2)$$

where:
a - coefficient of inclination of a straight $V = f(h)$ adopting the form of equation $y = ax + b$ (where x is the height above the river bed on which the velocity was measured; b is the intercept of the equation).
The calculated value of the dynamic velocity was used to determine the forces acting on the stream bed, i.e. shear stress, according to the formula [Gordon et al. 2007]:

$$\tau = \rho \cdot (V_*)^2\ [N \cdot m^{-2}] \quad (3)$$

where:
ρ - represents water density [kg · m^{-3}].
Then the Reynolds number for the measuring vertical section was determined [Graf 2001]:

$$Re = \frac{V \cdot h}{\nu}\ [-] \quad (4)$$

where:
V - velocity [m · s^{-1}]
h - water depth [m]
ν - kinematic viscosity coefficient [m^2 · s^{-1}]
In addition, the Froude number was determined [Graf 2001]:

$$Fr = \frac{V}{\sqrt{g \cdot h}} \quad (5)$$

where:
g - gravity [m · s^{-2}]
In addition, the water depth - h [m] was measured.

4 Results

From 2000 to 2002, six measurement series were made at low and medium-low flow Q = 0.36 - 0.49 m^3 · s^{-1} (Fig. 1). Water flowed fastest in the left channel, where the mainstream was observed. The speed here was up to 1.5 m · s^{-1}, with typical values between 0.31 and 0.75 m · s^{-1}. The water depth was higher than in the other channels, averaging from 0.11 to 0.25 m up to a maximum of 0.36 m. The Reynolds number indicated the presence of turbulent movement in the left and middle channels. Only in the right channel, where the water was often stagnant, laminar (Re < 500) or transient (Re = 500 – 2000) movement could often be observed. The Froude number was in the range of supercritical motion (Fr < 1). In one case, a subcritical movement occurred in the mainstream (Fr > 1). Analogously to the previously mentioned hydrodynamic parameters, the values of shear stresses can be measured. The highest values

were in the main current (left channel), and the lowest in the right bay because such a distribution is related to the bottom turbulence, which is greater in the left and middle bay than in the right one.

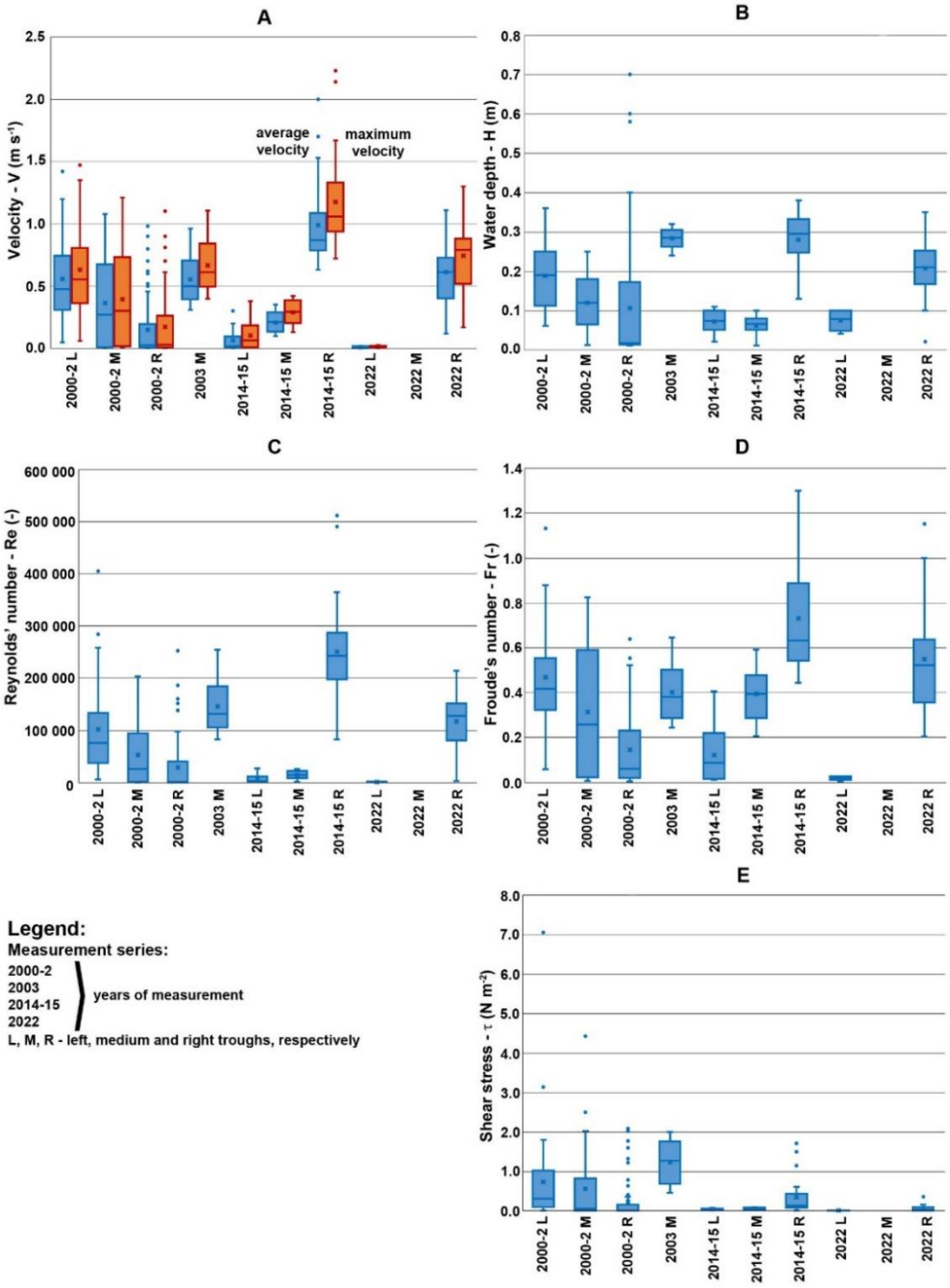

Figure 1 The values of hydrodynamic parameters (A: velocities, B: water depth, C: Reynolds' number, D: Froude's number, E: shear stresses), where: left, medium and right means to values of measurement into left, medium and right flow channel, respectively.

In 2003, the channel changed from multi-thread to single-thread. This change was accompanied by the passage of a flood wave with a flow of Q = 10.46 $m^3 \cdot s^{-1}$, which was 3-4

years of recurrence. All observed parameters at that time were close to the highest of all earlier and later measurements, despite the measurements being made during drought Q = 0.30 $m^3 \cdot s^{-1}$. Particularly noteworthy is the water depth, which was much higher than in the left braid during the 2000 to 2002 period, despite similar velocity values. This may indicate river incision [Plesiński and Radecki-Pawlik 2016]. The shear stress and turbulence were also much higher than in the previous series of measurements, which means that the material deposited in the channel was more easily activated and transported downstream [Wyżga et al. 2020].
The channel system returned to multi-threading in the next measurement period (2014-2015). During this period, in 2010, there was a large flood with a flow of Q = 15.90 $m^3 \cdot s^{-1}$. This layout has two differences compared to the layout (pattern) from 2000 to 2002: the mainstream was moved from the left braid to the right one, and the right channel cut into the alluvial bed with the mainstream. The lowering of the bottom is evidenced by high water depth values, with slightly higher velocities compared to the previous measurement series. This situation continues to this day (2022). Although the values of hydrodynamic parameters in 2022 are slightly lower than in 2014 and 2015, the measurements in 2022 were made at low levels (Q = 0.33 - 0.66 $m^3 \cdot s^{-1}$ in 2022 and Q = 0.99 - 1.22 $m^3 \cdot s^{-1}$ in 2014-2015). Thus, although several flood waves passed between 2015 and 2022, the largest of which had a flow of Q = 19.14 $m^3 \cdot s^{-1}$ in 2018, the channel did not return to its form of the period 2000-2002. In 2022, the channel is single-threaded again, but the left and middle braids are flooded only at medium levels (at Q = 0.81 $m^3 \cdot s^{-1}$). From 2000 to 2002, the flow to the flooding of the adjacent braids had to be at least Q = 0.36 $m^3 \cdot s^{-1}$. Thus, we have more than doubled the flow rate, which will spill water into the braided channels.

4 Conclusions

The values of hydrodynamic parameters unequivocally indicate river incision into the alluvial substrate, the lowering of its bottom and, consequently, the reduction in the frequency of flooding of the ephemeral flow channels.

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Pebbles in the architecture of the Podhale region

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KEYWORDS: pebbles, the Podhale region, traditional architecture, building material

In settlements of the Podhale region, you can easily see buildings with pebbles in their facades. They are a traditional building material that was used in every town in the Podhale region. The pebbles were an easily accessible material because they were deposited in the beds of the local rivers and streams. These places were also common exploitation fields from which the local community selected the needed stones. In this anthropogenic way, changes occurred in the beds of rivers and streams because many of them lost their natural armour. Rock rubble, obtained from the beds and backwaters of rivers and mountain streams, was used in local construction for many years.

The Podhale region is located in southern Poland, on the border with Slovakia. This area belongs to the Tatra and Nowy Targ counties, south of the Lesser Poland Voivodeship. The Podhale region is on the border of the Western Outer Carpathians and the Western Inner Carpathians. This area constitutes the majority of the catchment area of the upper Dunajec (the Vistula River basin), and waters from it are drained, apart from the Dunajec, by the Czarny Dunajec, the Biały Dunajec and the Białka Rivers. The southern borders of their catchment area are also the European watershed between the Baltic and the Black Seas.

The genesis of pebbles is related to the sculpture-forming activity of rivers and streams. The pebbles are formed during water transport of rock rubble, which undergoes further erosion processes by moving and rolling. The angular edges of the rubble are gradually sanded and rounded. The pace of this process depends on many factors, including the hardness of the rocks, the river's slope, the amount of flowing water and its strength, and the roughness of the watercourse bed. The lithological substrate of the Podhale is varied and contains both igneous and sedimentary rocks. The former includes granite, which builds the High Tatras. There are also sandstones in the Spisz-Gubałówka Foothills, the Gorce Mountains and the Żywiec Beskids. At the same time, limestones lie in the Pieniny Klippen Belt and the High Tatras, and the bottom of the Orawa-Nowy Targ Basin is covered with gravel. Due to the lithological diversity of the Podhale, the river valleys and the almost flat the Orawa-Nowy Targ Basin are filled with pebbles formed from various rocks.

The richness of rocks in the Podhale region favoured their economic use, and one of their uses was construction. This was also the case with pebbles, especially granite and sandstone, which, thanks to their hardness, worked well as a building material. They were used to erect objects of large and small architecture, among which there were both secular and sacral buildings. Private houses and public buildings were built of pebbles. These rock materials were, therefore, commonly used in construction in the second half of the 20th century, and today, they are a permanent element of the landscape of the Podhale settlement network. They give it a specific character and show the importance of pebbles in the Podhale architecture.

Pebbles were not only a cheap and readily available building material, but they were also used for architectural ornamentation and to accentuate specific details of the walls of buildings or other stone structures of small architecture. This was done in two ways - the pebbles' shape,

colour and size were properly attached to the wall facade, or fixed patterns were laid out of rock rubble, among which floral motifs were the most common. For this purpose, rocks of one type were used, and they were arranged in the facade according to the adopted scheme, or different types of rocks were combined, creating specific stone compositions. Different sizes of pebbles were used to decorate the walls. Larger boulders were used to decorate the facades of the walls, while small pebbles were used to decorate the frames of windows and doors and narrow strips at the edges of the stone facades. Decorating the walls with pebbles was a specific element of aesthetics in the architecture of the Podhale region, which was built with river rubble.

Temporal variation of rainfall in the Bâc hydrographic basin

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KEYWORDS: Bâc, variation, rainfall, trend, cycles

Climatologic series for monthly and annual rainfall, monthly and annual number of days with rainfall in the Bâc hydrographic basin (1890-2022, at weather station from Chisinau) were used to investigate the temporal variability of atmospheric rainfall. We tried to underline the following aspects: indices of variability; frequency of rainfall quantities; linear secular trend; cyclic components of series by means of moving averages, spectral analysis and autocorrelation function. The results confirm the general characteristics of the variability of rainfall series in this region. The general linear trend over more than 100 years is a positive one. Some cycles were outlined having periods of 2 years, 8-12 years, 30 and 42-45 years.

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Analysis of the contents of the National Curriculum from the perspective of climate change and the formation of climate resilience skills in students. Case study: Republic of Moldova

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In 2019, a new National School Curriculum was approved in the Republic of Moldova for the secondary and high school levels, focused on the formation of key competences and values. It is obvious that the traditional approach, the informational load and their internal sequence of school disciplines components could not remain in their current form, in the context where there is a referential system suggested by the key competences, educational purposes, competences in training, attitudes and promoted values. The national curriculum has come with a number of novel elements, in line with the latest achievements and trends in both the field of educational sciences and geosciences. Among the new elements, we will mention those of a content, the main emphasis being placed on the practical, applicative character of the contents studied, related to the needs and interests of the students. The contents were selected from the perspective of their role in the students' areas of functional knowledge, skills and attitudes for competence training. Therefore, in all classes where Geography is studied, new content units have been introduced, including geographical risk processes and phenomena, which involve the study of problem subjects and problem-situations in the geographical environment, an important role being given to climate changes at global, regional, national and local levels, as well as training students in appropriate skills and attitudes, rules of conduct, examples of good practices, including the training of climate resilience competence.

Didactic strategies for development the competence of climate resilience for adolescents

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Climate resilience competence requires a system of knowledge, values, attitudes and behavioural strategies. The knowledge component focuses on the activation of functional knowledge in case of climatic calamities and the mobilization of internal resources for one's own survival, but also proactivity, support and involvement in collective survival actions. In the formation of climate resilience competence, the focus must be on didactic strategies that seek to interpret and apply functional knowledge in concrete situations, so that the person is prepared to face any climate calamities he may face – experiential learning, task-based learning, simulation, role play etc.

National Park Cheremoskyi - interannual dynamics of meteorological indicators on its territory

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KEYWORDS: meteorological indicators, air temperature, atmospheric pressure

Climatic features of the National Park Cheremoskyi (Chernivtsi region, Ukraine) are determined by the location of the territory in the middle mountains, where the altitudinal belt is superimposed on the specifics of the microclimate. Significant daily fluctuations in air temperature are observed on its territory, as well as certain differences of these indicators in individual years. Therefore, the maximum and minimum temperatures should be taken into account for a more detailed description of the temperature regime. Meteorological observations were carried out on the territory of the National Park Cheremoskyi during 10 natural years in order to find out the interannual dynamics of meteorological indicators on the territory. The results of generalization of weather indicators (average daily air temperature, air humidity indicator and atmospheric pressure) are shown in this work for the period from 2011 to 2021.

Impact of late and early frost on agriculture. Case study – Republic of Moldova

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KEYWORDS: climate change, dangerous frosts, perennial plantations

Frosts, through their extreme manifestations, can completely disrupt the growth and development of plants. It influences the decision to place crops, determining their cultivation areas. For a number of crops (mostly thermophilic), these areas are very limited, for example, vineyards, orchards, citrus fruits, etc., for the rest they are wider (barley, spring wheat, potatoes, etc.). Frosts cause significant material damage to agriculture. Heat-loving crops are especially sensitive to frost.

The destructive effects of frosts on plants are explained by the freezing of water in the cell sap, the formation of ice crystals in the intercellular spaces and the dehydration of plant tissues (Sakai, 1987; Vitasse, 2019).

The effect of frost on different crop groups may differ and depends on:

– the development phase;
– plant health status;
– underlying surface;
– intensity and duration of frosts.

The harmful effect of low temperatures is manifested in the damage to shoots, flowers and ovaries, the formation of frost cracks. Spring frosts during the flowering of fruit crops, damage flowers and ovaries reduce by 10-15% or completely destroy the harvest (Balan, 2021).

On the territory of the Republic of Moldova, spring frosts can be observed even more than a month after the stable temperature above 10°C (Botnari, 2023). Dangerous frosts that appear at the beginning of autumn come before the end of the vegetation period with negative temperatures against the background of average daily temperatures above 10°C (Botnari, 2023).

From year to year, the perennial plantations, among which we specify the apple, peach, apricot, cherry plantations, in the months of April and May (fig. 1), when the trees begin to bloom actively, are affected by spring frosts, thus canceling the enormous efforts made by farmers to obtain a good harvest.

Frosts during flowering of fruit trees can partially or completely destroy the fruit crop. Plant parts damaged by frost wither and dry quickly. This is facilitated by the fact that frostbite usually occurs when the sky is clear during the night, and the morning sun aggravates the degree of damage, causing rapid thawing of the tissues.

The most dangerous are the spring frosts in the period with an average daily temperature above 5-10 °C. Flowers of most fruit trees are damaged at a temperature of -2.2°C, and young ovaries - at -1.1°C. The critical temperature that damages flower buds of cherry, sweet cherry, plum, apple and pear trees that have started to grow is -4°C. Berries (blackberries, raspberries, strawberries) lose flowers and ovaries during frosts around -2°C (Babuc, 2012, Balan, 2021, Augspurger, 2009). Heavily damaged flowers and set fruits fall, partially damaged fruits develop deformed.

For viticulture, spring frosts are most dangerous if they occur in the second phase of the growing season. Spring frosts damage the leaves, flowering buds, shoot tips, grape inflorescences, autumn frosts damage the leaves, sometimes the berries are affected.
The vine freezes already at -5...-7°C, becomes hard and brittle, cracks when bent. Some of the cell contents turn into ice. With a further decrease in temperature, less and less water remains in the cell sap, and the solution eventually loses its fluidity, the ability to breathe and, therefore, to live. Approximately the same picture is observed with strong heating. That is why, in real drying, we observe the same picture as in drying due to the freezing of water.
Secondly, damage to the mesh of buds is often associated with actual drying. It is clear that overwintering vine buds contain a certain amount of nutrients. However, they cannot live alone for a long time without an influx of substances from the surrounding tissues, and they need their constant influx. If such a supply is stopped for a long time due to the freezing of the solution in which they are contained, the "eyes" buds will die sooner or later (the sooner, the less reserve nutrients are deposited). With low nutrient reserves, even in fairly warm winters with light frosts, there is very strong damage to the "eyes" buds. The idea here is that on warm days, the grape plant loses much more plastic substances for respiration than on frosty days. Therefore, even light frosts are enough to kill the buds on weakened bushes.
In addition, a number of environmental factors also influence vine freezing of bare bushes. For example, the presence of frost on a vine reduces the temperature in the morning when it is evaporated by the sun's rays to 2°C, and a pronounced radiation character causes a cooling of the soil or snow layer by 4-5. °C compared to the temperature at a height of 1 m. From this it becomes clear that, all things being equal, "eyes" buds the ground or snow cover are the most affected (Augspurger, 2009, Balan, 2021).
Late spring frosts are predominantly radiative. It happens in the complete absence of wind and a cloudless sky. It is known that during radiative frosts, the height of the cold air layer is often only 0.5-1.0 m, and above the thermometer shows a positive temperature; the soil has a temperature of +3...5°C.
The difference in air temperature at different heights above the ground surface is quite large and reaches 4-5°C. For example, at a height of 10 cm above the ground, it is equal to -2 ° C, then at a height of 0.5 m - 0 ... 6 ° C and at a height of 1.5-2 m - + 2 ... + 2.6 ° C.
Along with radiative frosts, there are also advective frosts, which are caused by the penetration of cold air.
And if during radiative frosts the leaves of plants are covered with frost, and therefore freezing occurs only after dew forms, then during advective frosts there is neither dew nor frost. Therefore, combating advective frosts requires completely different means of combating them than radiation frosts. The fight against advective frosts is quite difficult, especially with snow winds, or even impossible. But fortunately, such frosts are quite rare.
Early-ripening crops are more vulnerable to frost as opposed to medium- and late-ripening crops, however, the impact of some secondary factors such as: meteorological / synoptic factors, application of incorrect cleaning work, loading of crop, incorrect use of fertilizers, quality of rootage, application of chemicals and last but not least genotype induce negative aspects in development (Sakai & Larcher, 1987; Augspurger, 2009; Norby et al., 2003).
Taking into account the agricultural orientation of the Republic of Moldova, where the fruit branch is one of the main components of agriculture, over 25 thousand ha are occupied under apple, apricot, peach plantations, we consider it appropriate to pay special attention to the study of meteorological conditions for the formation of the productivity value of this crop. Thus, the apple, apricot and peach culture was taken as a case study.
The purpose of this study was to study the dependence of their degree of deterioration by spring frosts on the development phase of flower buds in apple, apricot and peach varieties in the climate conditions of the Republic of Moldova.

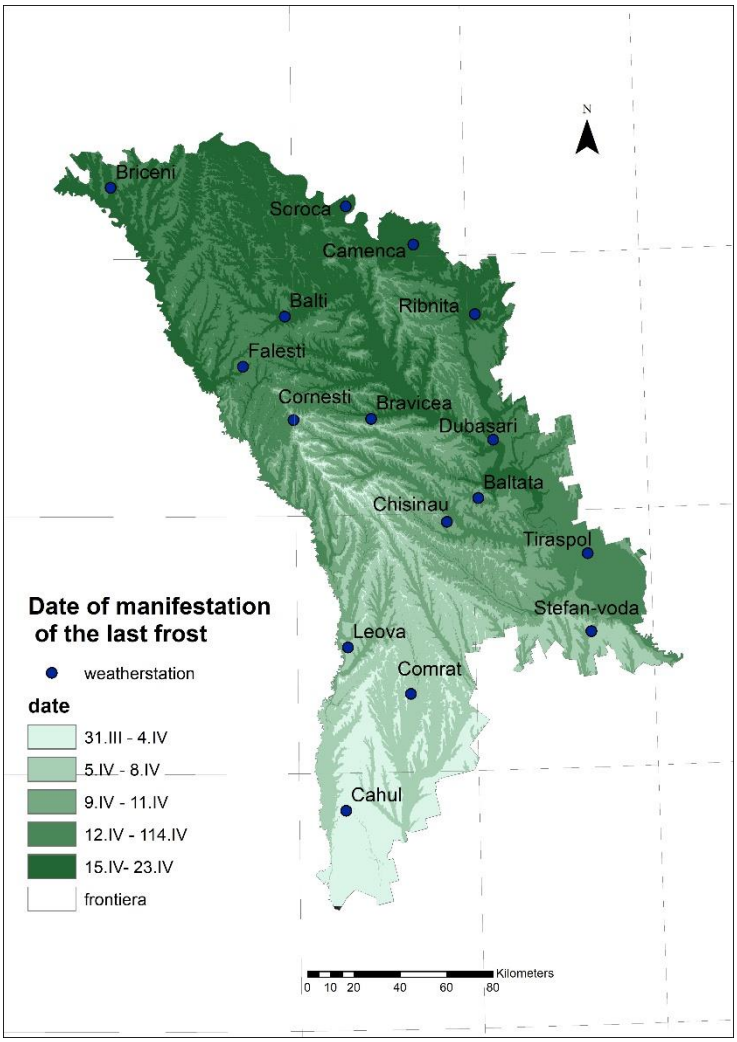

Figure 1 Date of manifestation of the last frost (1990 - 2020).

The results achieved will contribute to:
- optimizing agricultural technologies by minimizing their negative influence;
- the correct location of multi-annual crops in the soil;
- to minimize the additional expenses incurred by farmers;
- to develop and modernize forecasting and prevention methods;
- strengthening of means of protection etc.

The study period covers the period between 1990 – 2020. The date of the last frost was estimated by the principle - the last day of the month when the temperature drop below 0°C if occurred in spring (Bogdan, 1999). In order to determine the critical periods when late-spring frosts can become dangerous for multi-annual crops, characteristic parameters such as their duration and intensity for the period 1990 to 2020 were analyzed.

For the analyzed period (tab. 1), cases of frost that overlap with the phenological phases of development in apple are between 1 and 8 cases (Florești) in 2020. Thus, we can highlight the years in which most cases of frost occurred among them mention 2007, 2008, 2016, 2017, 2019, 2020.

Table 1. The duration and intensity of late frosts in the phenological range of swelling of the buds – the end of flowering

Meteo. station	years	Intensity (°C)	Duration Case (days)	Meteo. station	years	Intensity (°C)	Duration Case (days)
Briceni	2007	-1.7 - -2.0	4(6)	Cahul	2012	-3.4	1(1)
	2015	-0.2 - -3.8	3(6)		2013	-3.2 - -8.2	2(8)
	2016	-1.2 - -3.5	6(13)		2020	-1.3 - -4.9	1(3)
	2020	-0.1 - -6.7	7(16)	Bravicea	2007	-0.3 - -3.0	7(9)
Drochia (Soroca)	2007	-1.1 - -3.3	6(7)		2019	-0.1 - -4.1	5(13)
	2008	-2.7 - -2.8	2(6)		2020	-1.5 - -9.5	5(11)
	2012	-0.3 - -2.4	5(5)	Chisinau	2020	-1.2 - -3.9	3(8)
	2014	-2.0 - -7.1	2(4)	Străşeni (Bravicea)	2007	-0.3 - -3.0	7(9)
	2016	-1.2 - -3.9	2(6)		2019	-0.1 - -4.1	5(13)
	2017	-0.1 - -1.6	5(6)		2020	-1.5 - -9.5	5(11)
Camenca	2007	-0.4 - -1.3	4(5)	Floreşti (Bălţi)	2014	-1.0 - -3.5	2(4)
	2012	-0.5 - -2.1	2(3)		2016	-0.6 - -6.1	6(14)
	2013	-2.9 - -12.0	3(12)		2019	-2.0 - -4.1	4(6)
	2014	-1.3 - -5.6	3(5)		2020	-0.4 - -9.7	8(19)
	2015	-1.6 - -5.4	6(12)				

Also, from the analysis of the obtained results we can see that there are years when dangerous frosts manifested earlier by the phenological phase of swelling of the buds, which tells us about the fact that apple plantations in these years were bypassed by the danger induced by this meteorological phenomenon.

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Correlative links between wind as a climatic element and particle pollution in the atmosphere of cities from Moldova

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Air pollution represents the greatest risk to the health of the population, especially in urban areas. The present study used data from 25 stations in the network of the National Agency for Environmental Protection (APM), from the Region of Moldova (counties of Suceava, Botoșani, Iași, Neamț, Bacău, Vaslui, Galați, Vrancea), in the period 2009-2022.
One of the most important factors in the dispersion of pollutants in the atmosphere is wind. In the studied area, the correlations between PM10 and wind are negative (demonstrated with the help of Pearson coefficients), because their diffusion is directly proportional to the wind speed (the higher the wind speed, the higher the diffusion of noxae in the air).
The analysis of the wind regime (direction and speed) was carried out with the WRPLOT (Wind Rose Plotting) software based on the hourly data. In the Moldavian Region of Romania, winds from the NW prevail, especially in the first part of the year, followed by those from the SE during the summer-autumn period. The high frequency of these winds is also favoured by the configuration of the relief. High velocities intensify evapotranspiration and diffusion of noxae, and atmospheric calm allows uneven heating and accumulation of vapours and pollutants, depending on the local characteristics of the land surface, favouring through high temperatures and humidity, the formation of convective cells and generators of precipitation in the form of showers, quantitatively rich (acid rain).
In the studied area, the shortest duration of calm is recorded in spring, and the longest in autumn. Atmospheric calm favours air pollution, because it allows pollutants to accumulate in the vicinity of mobile sedimentary dust emissions, resulting in an increase in their concentration.

Contributions regarding the natural population movement of Sadova village (Suceava county) during the period 1992-2021

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KEYWORDS: natural dynamics, birth rate, mortality rate, fertility rate, couple stability index, natural balance

The natural population movement has a significant impact on society, representing an important aspect of demographic studies and public policy planning. A declining or aging population can lead to challenges related to the labour force and the economic sustainability of the community.
This study aims to highlight the demographic changes recorded in the village of Sadova, Suceava county, over the last three decades, based on information obtained by querying the Tempo database of the National Institute of Statistics. This database provides information at the local level, with the reference point being the population by residence, i.e., all individuals with Romanian citizenship whose address is within the territory of Romania as stated in their identification documents.
An essential starting point in understanding the natural population movement is represented by the trends regarding the two demographic indicators taken into account, namely, natality and mortality. The evolution of birth rate is closely analysed in relation to fertility intensity and, implicitly, with changes in attitudes and behaviours towards marriage, cohabitation, and divorce.
The changes in fertility behaviour experienced during the demographic transition can be illustrated through the general fertility rate, which represents the ratio between the number of live births by women aged 15-49 years.
During the communist regime, the institution of marriage was encouraged not only by parents but also by the authorities, who resorted to various measures, including imposing a celibacy tax or restricting single individuals' access to state-owned housing. After 1990, the marriage rate steadily decreased both at the national level in Romania and in Suceava County, although it experienced fluctuating trends in the case of the Sadova locality.
The couple stability index, calculated as the ratio of divorces to marriages, shows lower figures in Sadova when compared to both Suceava county and Romania as a whole. This implies that the village enjoys comparatively stronger couple stability, likely influenced by factors such as mutual respect, efficient communication, aligned parenting approaches, wisdom, patience, the preservation of traditional values, and faith.
The birth rate, a complex demographic phenomenon indicating the frequency or intensity of births within a population, has exhibited fluctuating trends over the years: the lowest value was observed in 2017 at 7.2‰ and the highest value was recorded in 2014 at 16.0‰. In contrast, the birth rate in Suceava County reached its peak in 1992 at 15.1‰.
The decision of a woman or a family to determine how many children to have is influenced by a complex range of factors, including but not limited to: the financial aspects of raising and caring for children; the availability of educational opportunities for women and the attainment of favorable professional positions; the overall financial well-being of the family; marital status; the ability to balance professional life with childcare responsibilities.

General mortality, as a demographic phenomenon, refers to the frequency of deaths within a specific population and over a delimited period of time. In 1992, the highest mortality rate was recorded at 14.8‰, surpassing both the mortality rate in Suceava County, which was 10.4‰, and the national mortality rate in Romania, which was 11.7‰.

In contrast, the infant mortality rate, which reflects the frequency of deaths under one year of age compared to live births during the same period, remained at 0 for a period of 22 years. The highest value was recorded in 2004, at 90‰. Despite the technology aimed at improving maternal and infant care, premature births continue to be prevalent, representing the leading cause of infant mortality, as indicated by reports from the Ministry of Health.

The natural balance is determined by the difference between the number of live births and the number of deaths, expressed as a proportion of the population. Since 1990, the natural balance of the population in Sadova village, recorded on January 1 of each reference year, has also exhibited fluctuating trends.

The natural population movement is a topic of crucial importance, and it is essential to research, monitor, and develop appropriate policies to address the implications of demographic changes brought about by the evolution of this phenomenon.