7TH INTERNATIONAL SYMPOSIUM OF SOIL PHYSICS

BOOK OF ABSTRACTS

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7th International Symposium of Soil Physics

Book of abstracts

17 March, 2026, Budapest, Hungary

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7th International Symposium of Soil Physics

17 March 2026, Budapest, Hungary

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8:30-9:00 Registration – upload presentations

9:00-9:05 Welcome - Ágota Horel, HUN-REN ATK, Institute for Soil Sciences
9:05-9:15 Conference opening: Kálmán Rajkai, DSc., HUN-REN ATK, Inst. for Soil Sciences

9:15-10:30 Section 1 (S1): New methods, advances, and technologies in soil physics (chair: Andrzej Bieganowski), **presentations: 12 minutes each +3 minutes for questions**

9:15-10.30

1) Rafał Mazur (Institute of Agrophysics PAS, Poland) Splashability – a measure of soil susceptibility to splash erosion and its significance
2) Michał Beczek (Institute of Agrophysics PAS, Poland) Soil splash phenomenon – from single to consecutive raindrop impacts
3) István Waltner (Hungarian University of Agriculture and Life Sciences, Hungary) Laboratory evaluation of the evaporation reduction effect of selected mulch materials
4) Sándor Vágó (HUN-REN CSFK Geographical Institute/ELTE, Hungary) Methodological problems of measuring and calculating soil aggregate stability in top- and subsoil
5) Hilda Hernádi (HUN-REN ATK Institute for Soil Sciences, Hungary) Selecting a rapid dispersion protocol for laser diffraction: early (1–5 min) averages indicate that Calgon is unnecessary?

10:30-11:00 Coffee break

11:00-12:15 Section 2 (S2): Monitoring and modeling soil processes (chair: Ágota Horel)

1) Tibor Tóth (HUN-REN ATK Institute for Soil Sciences, Hungary) Sodic soils, the tough guys of soil physics

2) Mateusz Suchanek (University of Agriculture in Krakow, Poland) Thermal regime of Luvisols as an indicator of microclimatic differentiation on north- and south-facing slopes
3) Ronald Kolcsár (HUN-REN ATK Institute for Soil Sciences, Hungary) Data-driven and expert-based grouping methods in service of soil hydrological modelling
4) Zsolt Kozma (Budapest University of Technology and Economics, Hungary) Soil hydraulic aspects of a regional water balance modelling effort in the Tisa River Basin
5) Mahrokh Shafiei (Hungarian University of Agriculture and Life Sciences, Hungary) Downscaling MODIS LST using Landsat 8 to improve soil thermal monitoring in Hungary

12:25-13:25 Lunch (short walk to the restaurant from the venue)

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2) András Makó (HUN-REN ATK Institute for Soil Sciences, Hungary) Fluid–solid phase interactions influence soil aggregate stability: evidence from water and hydrophobic nonaqueous phase liquid (NAPL) tests
3) Viktória Labancz (HUN-REN ATK Institute for Soil Sciences, Hungary) Effect of aqueous media on soil particle size distribution determined by laser diffraction method
4) Máté György (Budapest University of Technology and Economics, Hungary) Structural heterogeneity versus functional homogeneity - hydrological soil clustering of the MARTHA database

14:30- Coffee break and start of poster section

14:30-16:45 Poster section (Chair: István Waltner)

All posters will be presented in digital form only (landscape orientation). Please note that the poster **session consists of two parts**: a **short introduction** of the posters, **3 minutes each**, by one of the authors; and a **free discussion** at the poster exhibition. There will be three presentation blocks, each followed by a short on site discussion.

14:30-14:55 Short introduction of the posters - Block 1
14:55-15:15 Free discussions at posters - Block 1

15:15-15:40 Short introduction of the posters - Block 2
15:40-16:00 Free discussions at posters - Block 2

16:00-16:25 Short introduction of the posters - Block 3
16:25-16:45 Free discussions at posters - Block 3

Posters:

Block 1

1. Romutė Mikučionienė (Higher Education Institution, Lithuania) Evaluation of the durability and clogging properties of filter materials used in drainage systems in Lithuania (S1)
2. Lucia Toková (Institute of Hydrology, Slovak Academy of Sciences, Slovakia) Influence of microplastic type and size fraction on saturated hydraulic conductivity of sandy loam soil (S1)
3. Máté Katona (Univ. Sopron, Hungary) Investigation of the applicability of laser diffraction particle analysis for indirect determination of the water retention capacity of forest soils (S1)
4. Aliz Füleki-Veress (Hungarian University of Agriculture and Life Sciences, Hungary) Assessment of wettability in representative Hungarian soil types (S1)(**on-line**)
5. Magdalena Ryżak (Institute of Agrophysics PAS, Poland) An example of water drop splash on different plants (S2)
6. Gergely Jakab (HUN-REN CSFK Geographical Institute, Hungary) Aggregation as a function of organic matter content and composition (S3)
7. Balázs Madarász (HUN-REN CSFK, Hungary) Future directions in soil aggregate stability assessment (S1)(**on-line**)
8. Justína Vitková (Institute of Hydrology, Slovak Academy of Sciences, Slovakia) Effect of ecological additives on saturated hydraulic conductivity of silty clay soil (S3)
9. Hilda Hernádi (HUN-REN ATK Institute for Soil Sciences, Hungary) Soil physical investigations related to the pilot dredging of the Kis-Balaton Bárándi-water and the agricultural use of sediment (S2)

Block 2

10. Skaidre Suproniene (Lithuanian Research Centre for Agriculture and Forestry, Lithuania) Agricultural practices shape soil physicochemical properties and microbial functional potential in cropland soils (S3)
11. Gyöngyi Barna (HUN-REN ATK Institute for Soil Sciences, Hungary) Effect of trampling on soil parameters (S3)
12. Gražina Kadžienė (Lithuanian Research Centre for Agriculture and Forestry, Lithuania) Impact of tillage systems, cover crop management, and environmental factors on root distribution and CO_2 efflux (S3)
13. Mona Maghsoudlou (HUN-REN CSFK Geographical Institute, Hungary) Influence of soil physicochemical properties on ^{137}Cs activity concentration distribution and variability in urban soils of Ózd, Hungary (S3)
14. Unenmunkh Ganbold (Eötvös Lóránd University, Hungary) Effect of increasing concentration of an anionic surfactant on some soil physical properties (S3) (**on-line**)

15. Vaida Steponavičienė (Vytautas Magnus University, Lithuania) Long-term impact of tillage strategies and crop residue management on soil quality in winter wheat cultivation (S3)(**on-line**)
16. Barbara Viola (Hungarian University of Agriculture and Life Sciences, Hungary) Demonstrating ground level shifts through penetration measurements (S2)

Block 3

17. Ieva Erdberga (Latvia University of Life Sciences and Technologies, Latvia) Latvia's Soil of the Year 2026 (S2) (**on-line**)
18. Andor Bódi (HUN-REN ATK Institute for Soil Sciences, Hungary) In-row and between-row soil moisture changes under different inter-row management in a vineyard (S2)
19. Tibor Zsigmond (HUN-REN ATK Institute for Soil Sciences, Hungary) Long-term monitoring of soil moisture content under different land uses (S2)
20. Király Csilla (HUN-REN CSFK Geographical Institute, Hungary) Soil gas monitoring system to understand behaviour of allochthonous CO_2 in the Balaton Highland (Hungary, Central Europe)(S2)
21. Mihály Kocsis (HUN-REN ATK Institute for Soil Sciences, Hungary) High-Resolution (25 m) digital soil texture mapping for Transdanubia, Hungary, using legacy soil profile data (S2)
22. Györgyi Gelybó (Hungarian University of Agriculture and Life Sciences, Hungary) Effect of water retention in irrigation channels on spatial patterns of water table depth (S2) (**on-line**)
23. Gábor Halupka (Hungarian University of Agriculture and Life Sciences, Hungary) What happens with rainwater in a dry valley, neighbouring agricultural fields? (S2)

16:45-16:55 Conference closing, final remarks

Abstracts of oral presentations

Section 1: New methods, advances, and technologies in soil physics

(chair: Andrzej Bieganowski)

Splashability – a measure of soil susceptibility to splash erosion and its significance

Rafał Mazur[1], Agata Sochan[1], Rafał Pelczar[2], Michał Beczek[1], Magdalena Ryżak[1], Cezary Polakowski[1], Andrzej Bieganowski[1]

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Splash erosion, caused by the direct impact of the kinetic energy of raindrops on the soil surface, is the initial stage of water erosion, determining the further development of erosive processes, such as surface, rill, and gully erosion. At this stage, mineral particles become detached and redistributed, soil aggregates are destroyed, and a surface crust is formed, which significantly modifies the physical properties of the soil.

From the point of view of soil health, splash erosion leads to the selective loss of the finest soil fractions and organic matter, which are crucial for structural stability, water capacity, and biological activity. These processes result in reduced infiltration capacity, limited gas exchange, and a decrease the productive potential of the soil. Splash erosion therefore plays a significant role in the long-term degradation of soil functions.

The significance of this process is intensified in the context of climate change, characterized by an increase in the frequency and intensity of extreme precipitation events. Increased precipitation energy contributes to the intensification of splash erosion, which can lead to accelerated soil degradation, especially in agricultural areas with limited vegetation cover.

Research on soil susceptibility to splash erosion provides key information on soil resistance to erosion processes and allows early identification of degradation risks. As an initiating factor, the *splashability* can be treated as a prognostic indicator of total soil loss, enabling better modeling of erosion processes and the development of effective soil protection strategies. Taking the *splashability* factor into account in scientific research and soil management practice is crucial for maintaining soil health and sustainability in the face of progressive climate change.

The study was partially funded by the National Science Centre, Poland, in the frame of project no. 2024/55/B/ST10/01326.

Soil splash phenomenon – from single to consecutive raindrop impacts

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Soil splash phenomenon is one of the important, yet often overlooked, processes of water erosion. It occurs when falling raindrops strike the soil surface, causing the detachment and ejection of splashed material, and transport thereof over different distances. This phenomenon has significant consequences for the environment, leading to among others the loss of soil material, the breakdown of soil aggregates, the changes of soil structure and infiltration parameters, or is responsible for the displacement of microorganisms, pathogens, and pollutants within the ejected particles.

Most erosion studies to date have focused on large-scale research using rainfall simulators or based on natural rainfall events. A much less common approach was research based on the use of a single drop measurements or a sequence of falling drops. These are an important elements in understanding the basic mechanisms of soil splash phenomenon. Thus, the aim of this study was to present the methodologies and aspects related to the study of the impact of successive drops on the soil splash.

It is important to understand how raindrops fall onto soil because each subsequent impact may alter its properties. Consecutive raindrop impacts can affect the course of splashing and thus the process of particle ejection or surface deformation. This study considered quantitative and qualitative changes in the splashed material, including the number of ejected particles and the mass of material transferred. Based on the mass measurements with splash cup it was it was possible to determine changes in the characteristics of the splashed material, taking into account the ejected solid and liquid phases (ejected soil and water). The use of a high-speed camera made it possible to observe changes in the course of the phenomenon.

Acknowledgments: This work was partly financed from the National Science Centre, Poland; project no. 2022/45/B/NZ9/00605.

Bibliography

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Beczek M., Ryżak M., Sochan A., Mazur R., Polakowski C., Hess D., Bieganowski A., 2020: Methodological aspects of using high-speed cameras to quantify soil splash phenomenon. Geoderma, 378, 1-13.

Laboratory evaluation of the evaporation reduction effect of selected mulch materials

István Waltner[1], Malek Abidli[2], Barbara Viola[1,2], Kata Őszi[1], Antonnella D'Ciofalo[1], Ágota Horel[3]

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Mulch materials (or in a broader sense: materials used for soil cover) have long been utilized for their effect of reducing soil evaporation and thus conserving soil moisture (besides other potential beneficial effects). Most related studies, however, are primarily based on field-based studies, making standard comparison of the effects of these materials relatively difficult. In order to assess and compare the relative evaporation reduction effect of different soil cover materials applied at different thickness, we have established a set of 15 laboratory "mini lysimeters" (evapotranspirometers), allowing parallel measurement of different treatments with sufficient repetitions for statistical analysis. The current study aims to present the initial findings out our experimental setup, and the lessons learned.

Our initial experiment included 3 different mulch materials (pine bark mulch, crushed white marble, straw mulch). In addition we have also included a geotextile fabric in some of the treatments. Simulating soil and capillary action, we have used quartz sand in the lysimeters. Mulch materials were applied at three thickness levels, 2, 4 and 6 cm.

Our results have indicated that the methodology is capable of demonstrating and quantifying the effects of the mulch materials on evaporation. Initial results indicate that hygroscopic effects initially might actually increase evaporation, while upon reaching equilibrium, the effect of mulch thickness was clearly demonstrated. While within the observed thickness range, linear functions have proved to fit well. Interestingly, the applied geotextile layer (when not covered by other mulch layers) has increased evaporation compared to the "bare soil" treatments.

Methodological problems of measuring and calculating soil aggregate stability in top- and subsoil

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Aggregate stability is a critical and widely studied physical soil property, influencing water holding capacity, pore size distribution, and overall soil health. However, it exhibits spatial and temporal variability, driven by e.g. agricultural practices, such as tillage and cultivation. Despite its importance, a standardized measurement protocol is lacking, and microaggregate size tresholds remain inconsistent across classification systems. Our research evaluated aggregate stability under varying cultivation methods within a long-term agricultural experiment, across the whole soil profile of a Chernozem. The examination of the subsoil was included to complement recent results concerning subsoil organic matter dynamics. A further aim was to explore connections among soil organic matter content, composition and aggregate fractions. We used wet sieving to determine six soil particle/aggregate size fractions (2-20 µm, 20-50 µm, 50-63 µm, 63-250 µm, and >250 µm), as these are the most commonly used. This research highlights two critical methodological problems. First, a correction for sand content is needed to obtain accurate aggregate stability data. For this, laser diffraction particle size distribution data were used. Still, there is no universally applicable method for converting volume to mass distribution when using an arbitrarily chosen number of fractions and thresholds. Secondly, knowing the distribution of sand particles across the aggregate fractions alone would not be sufficient, because the percentage of sand particles within aggregates must also be known to correct the results. Our results indicate, that the masses of fractions 20-50 µm and 20-63 µm as well the 50-250 µm and 63-250 µm are significantly different, consequently the calculated MWD (Mean Weigth Diameter) and GMD (Geometric Mean Diameter) values for aggregate stability also differ based on the threshold used. The fraction between 50-63 µm had the lowest concentration of organic matter, but this resulted in a significant difference only when examined separately from the neighbouring fractions.
The research was supported by the National Research, Development and Innovation Fund via NKFIH-152750, which is kindly acknowledged. We also kindly thank the Institute for Soil Sciences of the HUN-REN Centre for Agricultural Research for providing the opportunity to conduct research on the long-term experiment.

Keywords: aggregate stability, laser diffraction, volume to mass conversion, soil microaggregate fractions

Selecting a rapid dispersion protocol for laser diffraction: early (1–5 min) averages indicate that Calgon is unnecessary?

Magdalena Ryżak[1], Andrzej Bieganowski[1], Agata Sochan[1], Cezay Polakowski[1], Gyöngyi Barna[2], **Hilda Hernádi**[2], Viktória Labancz[2], Zsófia Bakacsi[2], András Makó[2]

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Laser diffraction measurements of particle size distribution (PSD) are highly sensitive to sample dispersion. A routine protocol should provide a stable and comparable PSD within the first minutes of measurement while maximizing clay release. We compared dispersion treatments using only the mean results of the first five measurements (1–5 min window) to identify the most suitable routine method.

Four contrasting soil samples were analyzed with a Mastersizer 3000 system. Treatments combined chemical dispersant use (Calgon: yes/no) with ultrasonication time (0, 1, 2, or 4 min). For each treatment, clay–silt–sand fractions and full PSD curves were evaluated as averages of the first five measurements.

Contrary to our previous routine practice, Calgon + 4 min ultrasonication was not the most effective treatment for releasing clay. In most soils, the highest clay fractions were obtained with no Calgon + 4 min ultrasonication. The high-clay Kisújszállás sample showed a maximum clay fraction already at no Calgon + 2 min, but the 4 min setting remained the most robust choice for a unified routine protocol. As expected, sand content generally showed an inverse pattern relative to clay: treatments yielding higher clay content tended to yield lower sand percent.

Examination of mean PSD curves (1–5 min averages) suggested that under Calgon + ultrasonication, increasing ultrasonication time was accompanied by an increase in a coarser size range (sample-dependent, ~10–300 μm), while other fractions decreased. Simultaneously, the submicron clay peak (~0.7 μm) increased with longer ultrasonication. This combination is consistent with a possible secondary aggregation/re-formation effect in the presence of Calgon during the early measurement "window". Such patterns were generally not observed without Calgon.

Conclusion: For rapid laser diffraction measurements evaluated within the first 1–5 minutes, the recommended routine dispersion protocol is no Calgon + 4 min ultrasonication. Further testing on extreme soil types is warranted.

Acknowledgement: This research is supported by the Hungarian National Research, Development and Innovation Office Foundation (Grant No. OTKA K134563) and by a common grant from the Hungarian and Polish Academy of Sciences (Grant No. NKM2023-40).

Section 2: Monitoring and modeling soil processes

(chair: Ágota Horel)

Sodic soils, the tough guys of soil physics

Tibor Tóth[1], Grzegorz Jozefaciuk[2], Tibor Novák[3], Kálmán Rajkai[1], Tibor Filep[4], Lajos Blaskó[3], András Makó[1], Gyöngyi Barna[1]

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Sodic soils, also known as solonetz soils, show a close relationship between their chemical properties (salinity, sodicity, and alkalinity) and various physical properties (aggregation, water retention, hydraulic conductivity, etc.). Although their extent is limited in the country, due to their peculiar characteristics and the difficulty of their management/improvement, Hungarian sodic soils were the subject of special attention during the last century. When extensive soil reclamation projects in the country came to an end in the second half of the 20th century, the gap between international and national research on these soils widened. However, growing interest in environmental protection and nature conservation has brought these soils back into the spotlight. Recent studies, based on updated technology and statistical concepts, have provided new data and insights. The talk presents new data (i-v) complementing and further developing traditional approaches.

As a continuation of long-term studies on soil reclamation, the effect of different treatment variants on various soil properties was interpreted on newly plowed farmland in Karcag after different periods of time (i). In another study, the comparison of soil profiles in a natural topographic sequence in Hortobágy showed that physical properties were not only a consequence of chemistry, but also factors contributing to the differences between the different altitudinal levels of the topographic sequence (ii). In a similar environment in Hortobágy, field devices were tested for characterizing soil compaction and infiltration at different altitudinal levels (iii). Also in samples collected in Hortobágy, sodicity and alkalinity appeared to reduce mesopore radii and pore complexity (iv). Another nationwide physicochemical study of salt-affected soil profiles showed that the average water vapor adsorption energy decreased logarithmically with increasing sodium adsorption ratio and linearly with increasing pH (v).

Thermal regime of Luvisols as an indicator of microclimatic differentiation on north- and south-facing slopes

Mateusz Suchanek, Tomasz Zaleski

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Soil temperature is a fundamental physical parameter controlling a wide range of soil processes, including heat and water fluxes, biological activity, and energy exchange between the land surface and the atmosphere. Due to its thermal inertia, the soil profile responds slowly to atmospheric changes and records long-term local and microclimatic conditions. This study investigates whether the thermal regime of Luvisols developed from silty parent material can be used as a sensitive indicator of microclimatic differentiation between north- and south-facing slopes.

Continuous soil temperature measurements were conducted at five depths (0.1–0.8 m) on two contrasting slopes with identical soil type, land use (permanent grassland), and similar geomorphological setting, differing primarily in slope exposition. Monthly thermal characteristics describing mean temperature, daily amplitude, variability, vertical temperature gradients, phase lag, attenuation of thermal waves, and rates of heating and cooling were derived from multi-year observations. Multivariate analysis was employed to synthesize the information contained in the thermal profiles and to separate dominant modes of variability.

The first principal component represents a seasonal signal common to both slopes and is governed mainly by shallow-layer temperatures and surface thermal dynamics, reflecting the annual cycle of solar radiation. In contrast, the second principal component clearly discriminates between the north- and south-facing slopes throughout the year, including winter months, indicating persistent microclimatic differences. This component is primarily controlled by mean temperatures in the deepest soil layers (0.6–0.8 m) and by temperature gradients in the shallowest and deepest parts of the profile, which reflect both short-term radiative forcing and long-term heat accumulation.

The results demonstrate that Luvisols with silty texture effectively record microclimatic contrasts related to slope exposition. Deep soil layers provide particularly robust indicators of long-term energy balance differences, largely unaffected by short-term atmospheric variability. These findings highlight the potential of soil thermal regimes as integrative proxies for microclimatic differentiation in temperate landscapes.

Data-driven and expert-based grouping methods in service of soil hydrological modelling

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Our understanding of soil hydraulic properties can be greatly enhanced by regional and national 3D soil hydraulic maps, which is essential in environmental assessments. When running large-scale models to estimate complex soil characteristics, data aggregation often becomes a necessity. Our study presents one such aggregated „soil hydrologic groups map" for the entire area of Hungary, created through a combination of k-means clustering and expert-based rules. Eight hydraulic parameters across six depths of the 100 m resolution 3D HU-SoilHydroGrids were considered in the clustering process. The small spatial extent and sparse representation of certain rare soil types with extreme characteristics make their accuracy on these purely statistics-based maps low. In order to account for these soil types, an expert-based refinement was carried out, that incorporated parameters, such as soil profile depth, genetic soil type, electrical conductivity, and exchangeable sodium content. Our final map consists of 68 soil hydrologic groups, all defined by distinct hydraulic properties, namely parameters that describe the water retention curve (van Genuchten parameters) and saturated hydraulic conductivity. By enabling a consistent treatment of similar soils, our map supports hydrological modelling, environmental management, and agricultural planning on a national-scale in Hungary.

Acknowledgement: The research was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF 2.3.1 21 2022 00008 project.

Soil hydraulic aspects of a regional water balance modelling effort in the Tisa River Basin

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Soils have a distinctive role in the water cycling. In a non-linear way soil hydrological properties influence surface and subsurface flow accumulation, prolonged water availability for vegetation, and aquifer storage on various spatial and temporal scales. Therefore, adequate soil information is essential, when making water balance calculations.
Here, we present a case study from the Danube River Basin (DRB) to illustrate how a regional scale distributed parameter hydrological model utilizes soil information. The introduced Community Water Model (CWatM) is capable of simulating surface water and groundwater processes, including river discharge, actual evapotranspiration and storage in snow, reservoirs, soil and groundwater, at daily time step over multiple decades, with a 1 arcmin spatial resolution and with varying land cover conditions.
The introduced implementation of the CWatM for the DRB utilities the Mualem-van Genuchten parametrization for the moisture retention curve and the hydraulic conductivity curve of the EU-SoilHydroGrids 3D database (7 soil depths for the top 2 m).
In our presentation we introduce (i) the general approach with which the CWatM simulates subsurface water movement processes, (ii) the representation of soil information in the model, (iii) the scaling coefficient-based approach followed during the model calibraoitn, (iv) certain calculation results with special attention to soils and (v) results of a sensitivity analysis on soil and other applied parameters.
We conclude with some practical considerations for possible future directions both for the actual regional model improvement and for the soil database directions.

Acknowledgement: This work was supported as part of DANUBE WATER BALANCE, an Interreg Danube Region Programme project co-funded by the European Union.

Keywords: hydrological modelling, Community Water Model, CWatM, Danube River Basin, EU-SoilHydroGrids

Downscaling MODIS LST Using Landsat 8 to Improve Soil Thermal Monitoring in Hungary

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Land surface temperature (LST) plays a key role in monitoring agricultural drought and surface moisture stress. However, LST estimates for field-scale agricultural applications remain challenging because most satellite products involve a trade-off between spatial and temporal resolution. MODIS provides daily LST observations with coarse spatial resolution (1 km), which limits their direct use for within-field analysis. In contrast, Landsat 8 offers finer spatial detail but at a much lower temporal frequency. To address this limitation, a spatial downscaling framework was developed to enhance MODIS LST from 1 km to approximately 100 m resolution. The approach was implemented in Google Earth Engine and applies month-specific linear regression models during the growing season (April–October). This period was selected to capture dynamic changes in soil thermal behaviour across different crop growth stages and to account for seasonal variability in land surface conditions. Monthly calibration allows the relationship between MODIS and Landsat observations to adapt to phenological and environmental variations. The framework was evaluated over an agricultural area in Békés County, located in south-eastern Hungary. Results indicate that the downscaled product improves spatial representation of field-level thermal patterns while maintaining temporal consistency, providing a practical and transferable tool for satellite-based soil thermal monitoring in Hungarian agricultural landscapes.

Section 3: Monitoring and modeling soil processes

(chair: Zsófia Bakacsi)

Earthworm biodiversity: an engineering solution for soil structure and erosion control in agricultural landscapes

Agnieszka Józefowska

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Soil erosion poses a significant global challenge, with an average annual loss of approximately 2.8 t ha^{-1}, while soil formation in Europe is estimated at only 1.4 t ha^{-1} annually (Borrelli et al., 2017; Verheijen et al., 2009). Earthworms, acting as "ecosystem engineers," bolster three pillars of soil resilience: porosity, a stable structure produced via coprolite deposition, and a rich organic matter pool. The three ecological groups—epigeic, endogeic, and anecic—operate synergistically: anecic species create deep vertical burrows that improve water air exchange; endogeic species enhance microporosity and mix organic material in the upper horizon; epigeic species process surface litter. Their activity raises infiltration rates 2–15 times (Shipitalo & Le Bayon, 2004) and reduces surface runoff (Sharpley et al., 1979). Earthworms also deposit coprolites at 2–268 t ha^{-1} yr^{-1}, adding 1–5 cm of new surface soil per year (Blanchart et al., 1997). These aggregates are richer in clay, organic carbon and nutrients, forming a rough, water stable surface that slows runoff (Sharpley et al., 1979). However, complexities remain: biopores can become preferential pathways for agro chemical leaching (Lubbers et al., 2013); freshly deposited casts are initially erodible—a "temporal paradox" that resolves only after curing (Sharpley et al., 1979); and earthworm stimulated microbial activity may increase CO_2 and N_2O emissions (Lubbers et al., 2013).

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Fluid–solid phase interactions influence soil aggregate stability: evidence from water and hydrophobic nonaqueous phase liquid (NAPL) tests

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Soil aggregate stability governs infiltration, runoff and erosion, yet most evaluations rely on water-based tests and may therefore confuse stability against mechanical effects with fluid-specific degradation pathways. Here we assess how the surrounding liquid controls macro- and microaggregate stability in various Hungarian soils and genetic horizons.

We analysed representative soils differing not only in texture, but also in soil organic matter content, exchangeable cation composition, and swelling clay mineral abundance. Macroaggregate stability (MaAS) was quantified as the proportion of stable aggregates after wetting and mechanical treatment, while microaggregate stability (MiAS) was derived from particle-size distribution measurements by comparing the clay content of the dispersed and non-dispersed states. Measurements were performed in deionized water and in a non-aqueous phase liquid (NAPL; Dunasol 180/220) to separate water-driven physicochemical effects from predominantly mechanical disaggregation.

Across samples, stability metrics differed systematically between media, indicating that solid–liquid interactions fundamentally modify aggregate breakdown. The wetting and dispersive behaviour observed in Dunasol is attributed to its hydrophobic (nonpolar) character; under NAPL conditions, disaggregation is expected to be governed primarily by mechanical forces applied during the tests, with limited swelling-related contributions. In contrast, water promotes a more complex set of processes in addition to mechanical impacts: (i) swelling of expandable clay minerals, and (ii) ion-specific hydration effects around exchangeable cations, which alter interparticle forces and can enhance dispersion depending on cation ratios. These mechanisms motivate the use of cation-balance indicators (e.g., a modified SAR-type metric) to interpret soil-specific responses.

Overall, the results demonstrate that aggregate stability is not solely a soil-intrinsic property but emerges from the quality of fluid–solid phase interactions, which differ sharply between polar (water) and apolar (NAPL) media. Explicitly accounting for liquid phase, ion composition and swelling mineralogy is therefore essential for soil-specific interpretation of stability data and for linking aggregate behaviour to hydrological features.

Keywords: macroaggregates; microaggregates; disaggregation; swelling clay minerals; ion-specific hydration; dispersion

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Effect of aqueous media on soil particle size distribution determined by laser diffraction method

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Laser diffraction method (LDM) is widely used for determining the soil particle size distribution (PSD) because of its rapid and reproducible measurements. Compared to conventional sedimentation-based methods, LDM requires smaller sample amounts and shorter analysis time. However, PSD results obtained by LDM strongly depend on dispersion conditions, and the influence of the aqueous medium is often insufficiently considered.

The present work investigates how different aqueous media affect particle disaggregation behaviour during LDM measurements. Eight Hungarian soil samples with contrasting physical and chemical properties were analysed using a Malvern Mastersizer 3000. Measurements were performed in three aqueous media (distilled water, demineralized water and tap water) combined with different dispersion treatments (no treatment, ultrasonic dispersion, chemical dispersion with sodium hexametaphosphate (Calgon), and their combinations). Particle size fractions derived from LDM were evaluated with particular attention to changes in the fine fraction.

The aqueous medium influenced the extent and stability of particle dispersion in all soils. Depending on the aqueous medium and soil properties, incomplete disaggregation, re-aggregation or flocculation processes occurred during the measurement. Tap water, characterised by higher ionic strength and dissolved ion content, generally enhanced interparticle interactions, while low-ionic-strength media promoted greater apparent proportions of fine particles. The magnitude and direction of these effects varied among soils, reflecting differences in mineral composition, surface properties and aggregation state.

These results demonstrate that the physicochemical characteristics of the aqueous medium play a measurable role in LDM-derived PSD results. Differences in aqueous media may therefore introduce systematic variation in particle size fractions determined by laser diffraction.

Keywords: LDM, particle size distribution, different aqueous media

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Structural heterogeneity versus functional homogeneity - hydrological soil clustering of the MARTHA database

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There is a recurring question in environmental science, whether the spatial heterogeneity of soils is also accompanied by notable variation of soil hydrological behaviour. Our aim was to investigate this so-called "structural heterogeneity versus functional homogeneity" issue by using variably saturated zone simulations and the Hungarian soil database MARTHA v3.1.4. The purpose of the applied functional classification method is to simulate the water balance components of different soil profiles under the same meteorological forcing and then cluster them based on their hydrological response.
We used 2552 soil samples with adequate data availability (fitted van Genuchten parameters of the soil moisture retention curve, saturated hydraulic conductivity) to set up and run 200 cm deep homogeneous soil profile models in Hydrus-1D, which differed only in their soil hydraulic parametrization. The simulations covered a 1-year period with daily time steps. Two types of upper boundary were applied: (i) 1 mm/day constant precipitation for 30 days then no precipitation, (ii) measured precipitation time series from Hungary over the whole period. The bottom boundary condition was 'Seepage face'.
Hydrological indicators were derived from the simulation results (surface runoff, average root zone saturation, storage change, bottom boundary flux, flowthrough/percolation wetting front volume at 40 cm depth, break through curve characteristics for the constant precipitation). These indicators were used to classify the soil profiles using k-means clustering.
1974 simulations were successful, from which 9 clusters were formed. These represent distinct hydrological behaviour for the same forcing time series, indicating the applicability of the proposed classification method.

Keywords: soil hydrology, functional evaluation, Hydrus-1D, MARTHA database

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Abstracts of poster presentations

Evaluation of the durability and clogging properties of filter materials used in drainage systems in Lithuania

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This study evaluates the durability and clogging behavior of protective filter materials used in drainage systems in Lithuania. Field investigations of drainage pipes installed 10–20 years ago revealed minimal sediment accumulation, indicating effective performance of filter materials in preventing clogging. Visual inspection and thermal analysis showed that approximately 30% of the filter material volume consists of soil particles. X-ray diffraction and optical microscopy confirmed the presence of quartz sand, clay, and secondary minerals such as calcite, dolomite, gypsum, albite, anorthoclase, zeolites, and calcium silicate hydrates formed during pedogenic processes. These compounds exhibit binding properties, contributing to the formation of conglomerate layers that may reduce permeability over time. The findings suggest that natural soil processes and material quality significantly influence drainage system functionality, highlighting the need for long-term monitoring of filter material performance.

Influence of Microplastic Type and Size Fraction on Saturated Hydraulic Conductivity of Loamy Sand Soil

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In recent years, microplastics have increasingly been recognized as important environmental pollutants. While their occurrence and impacts in aquatic ecosystems have been widely studied, knowledge of their effects on soil ecosystems, particularly on soil physical and hydraulic properties, remains limited. Previous research suggests that the influence of microplastics on soil hydraulic behavior depends strongly on factors such as polymer type, concentration, shape, and particle size. In this study, we investigated the effects of two commonly used polymers, polylactic acid (PLA) and polystyrene (PS) across three size fractions (small <100µm, medium 100–200µm, and large >200µm) on the saturated hydraulic conductivity of a loamy sand soil. Saturated hydraulic conductivity was measured under laboratory conditions using an automated KSAT system (METER Group GmbH, Munich), allowing for precise and reproducible assessment of soil water flow. The results indicate that the effects of microplastics on soil hydraulic conductivity varied considerably depending on polymer type and particle size. In loamy sand soil dominated by sand-sized particles, the addition of small PLA microplastics (<100µm) tended to reduce saturated hydraulic conductivity, likely due to pore blockage. Medium-sized PLA particles (100–200µm), however, showed no significant effect on hydraulic conductivity. In contrast, the incorporation of small and medium PS particles resulted in slight increases in saturated hydraulic conductivity, suggesting differences in particle rigidity, surface properties, or soil–plastic interactions. Application of larger microplastic particles (>200µm), regardless of polymer type, leading to increases in saturated hydraulic conductivity. These findings highlight the importance of considering microplastic characteristics when assessing their potential impacts on soil hydraulic functioning.

Keywords: microplastics, PLA, PS, saturated hydraulic conductivity, KSAT

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Investigation of the applicability of laser diffraction particle analysis for indirect determination of the water retention capacity of forest soils

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Due to changing climatic conditions, there has been increased interest in forestry in the quantifiable water retention capacity of soils and the direct and indirect determination of the water available to plants. Forestry relies primarily on the direct determination of metric potential measured under ex-situ laboratory conditions, but there is also growing interest in indirect determination using pedotransfer functions (PTF). One of the most important parameters in these PTFs is soil texture, which is primarily determined by examining the particle size distribution (PSD) of soils. Several new methodologies for determining PSD have been developed in recent decades, and the laser diffraction method is one of the fastest and least demanding in terms of sample size. Its applicability is currently the subject of research. The aim of this research is to examine the applicability of PSD data obtained from the laser diffraction method for the indirect determination of AWP in Luvisol and Cambisol soils under forest stands. For the study, forest soil types formed from loess were selected, from 84 sections collected from the western part of Hungary, at a depth of 100 cm, with sampling every 10 cm, we prepared a series of 840 measurements, during which we determined the PSD using a pipette method and laser diffraction measurement, and from these, we determined the AWP and matrix potentials calculated for five pF values using an empirical and a random forest-based PTF. According to our results, the outcomes from the two methods showed a statistically significantly stronger correlation primarily in the lower pF ranges. in the case of empirical PTF calculations, laser measurement showed a stronger correlation with pipette results, while in the case of random forest analysis-based PTF, laser measurement showed a weakly significant correlation with traditional measurement. This comparative study successfully examined the applicability of the new measurement methodology for estimating water management parameters. In the future, such a method could contribute to a more accurate and efficient assessment of the water balance of forest areas and, thereby, to forest management decisions that are adapted to climate change.

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Assessment of wettability in representative Hungarian soil types

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Detailed investigation of the water-repellent (hydrophobic) character of soils has come into focus over the past century. Even today, our information on the regional or global occurrence of this characteristic soil physical property remains only approximate; what can be stated with confidence is that dry, warmer-climate regions may be particularly affected. Available research has demonstrated that soil wettability - expressed as soil water repellency (SWR) - can strongly influence soil water regime and hydrophysical properties, especially water retention and hydraulic conductivity. For certain characteristic soil types, this property can be estimated reliably; however, the development and spatial distribution of hydrophobicity may be controlled by multiple factors of both natural and anthropogenic origin.

Based on the results of our methodological pre-tests, the KRÜSS DSA 100 drop shape analyzer proved to be a well-suited instrument for assessing soil wettability. The device determines the apparent contact angle (cAm) from the spreading behavior of a liquid droplet deposited on the surface of the solid phase, and it also provides indirect information on infiltration times (water drop penetration time - WDPT). In our measurement campaign, we analyzed samples from the Hungarian Soil Structure Database (HunSSD). In this paper, we characterize wettability indicators of samples taken from different genetic horizons of representative Hungarian soil types (brown forest soils, chernozems, meadow soils, and skeletal soils).

Based on our preliminary experiments, we selected the pellet (pastille) sample preparation approach from the pellet-based and adhesive-tape methods described in the literature. During evaluation, the measured contact angle and infiltration time values were compared with previously available complementary information (soil analytical and soil physical data, morphology, within-profile position, land-use type). The measurement series enabled a detailed assessment of the characteristic HunSSD soil groups from a novel and previously less-studied perspective: soil wettability.

Keywords: soil hydrophobicity, contact angle, KRÜSS DSA 100, drop shape analyzer, HunSSD (Hungarian Soil Structure Database)

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An example of water drop splash on different plants

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Water splash during rainfall occurs when a drop of water hits a rigid surface on its way through the air, causing it to break or split into smaller droplets. Such obstacles include not only soil, but also various objects such as leaves or branches of plants. The course of the splash affected by single drop impact was observed on leaves of plants with varying hydrophobicity and selected conifer branches. The splash was caused by a drop with a diameter of 4.2 mm falling freely from 1.5 m. The qualitative and quantitative characteristics were obtained by the use of high-speed imaging technique. The splash phenomenon was parameterized and described numerically, which allowed us to determine the differences in the phenomenon depending on the properties of surface on which it occurred. The splashes on the leaves were characterized by equivalent diameter, velocity of drop propagation, average number of ejected droplets, velocity of ejected droplets, while the splash on the branches was described by the number and size of droplets formed by the breakdown of an incident drop and the angle at which they travelled down. The falling drop broke into the largest number of droplets on highly wettable pink lotus and blue spruce branch, which had sharply pointed needles grew in all directions. This type of research is essential for understanding the processes and mechanisms of interception and throughfall also in terms of the amount of water reaching the soil as well as soil splash erosion

Keywords: splash, water drop, wettability, leaf surface, coniferous plants, high-speed cameras

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Aggregation as a function of organic matter content and composition

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Aggregation of mineral particles ensures soil structure and porosity. The hierarchical system of soil aggregates provides opportunities for air and moisture storage, as well as sufficient space for biological production and root growth. Consequently, the aggregation degree is one of the most essential soil health indicators. Aggregate formation and stability, however, are complex processes affected by several physical, chemical, and biological properties. The most relevant binding agents are clay content and composition, organic matter content and composition, $CaCO_3$ content, and (micro)biological production. One of the primary aims of tillage is also the maintenance of soil structure via aggregate formation. Even though the role of cultivation systems on soil properties and consequently aggregation is not fully understood in its complexity. The present study compared aggregation levels across various tillage systems and soil depths in a cultivated Chernozem. The mean weight diameter (MWD) of the aggregates was highest in the plowed layer and decreased with depth and with tillage intensity. Plowing caused the highest variability in MWD in both the topsoil and the subsoil, whereas no-tillage plots showed low variance. No direct linkage between aggregation and organic carbon content, composition of the organic matter, or inorganic carbon content was found. Results suggest that plowing does not necessarily trigger a drop in soil structure, and the current degree of aggregation is rather the result of complex mechanisms than single soil properties.

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Future directions in soil aggregate stability assessment

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Soil aggregate stability is a key indicator of soil health and quality, as it reflects important properties such as erodibility, water infiltration, and water storage capacity. Several methods are available to assess aggregate stability, and selection depends on the study's objectives. Given the growing emphasis on soil quality assessment, there is an increasing need for methods that are both reliable and efficient in terms of time and cost. Among the established approaches, some methods are relatively simple to apply, whereas others require more complex and expensive equipment. Water-stable aggregates (WSA) are commonly determined using wet sieving techniques to evaluate aggregate resistance to water. In this study, WSA measurements were performed with an Eijkelkamp wet-sieving apparatus (approx. 7,700 EUR), following the method of Kemper and Koch (1966). To determine the mean weight diameter (MWD), multiple sieve sizes (0.25, 1, 2, and 5 mm) were used, allowing aggregates to be weighted proportionally to their size distribution. In addition, a custom wet-sieving device was constructed based on the design described by Bavel (1949). The apparatus moves the selected sieves vertically in water at 30 cycles per minute, with an amplitude of 38 mm, for 10 minutes. The production cost of the custom-built device was approx. 770 EUR. The third method applied in this study was a mobile phone application developed by the American Soil Health Institute and released on 4 December 2023 (World Soil Day). The application is freely available online. It evaluates soil aggregate stability by capturing images of aggregates placed in a Petri dish before and after 10 minutes of soaking and analysing the changes using a machine image recognition algorithm. We compared the results of the three aggregate stability assessment methods across 14 different soil types in Hungary. Overall, the methods showed good, though not strong, correlations within the tested sample set. Considerable uncertainty was observed in sandy soils, whereas for the remaining soil types, the results suggest that the conventional, more expensive and labour-intensive method could potentially be substituted by a free, widely accessible, and rapid testing approach.

Keywords: Aggregate stability, WSA, MWD, SLAKES

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Effect of Ecological Additives on Saturated Hydraulic Conductivity of Silty Clay Soil

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In recent years, there has been increasing interest in the use of ecological additives such as biochars and hydrogels. Biochar, with its porous structure, promotes the stabilization of organic matter in soils. However, its properties are often limited, highlighting the need for modification. Hydrogels are three-dimensional, cross-linked polymer networks with high water absorption capacity, derived from natural or synthetic polymers. Their application can improve soil structure, enhance water retention, and reduce nutrient losses through leaching. Recent studies increasingly emphasize the potential of combining biochar and hydrogels, as their joint application merges the physicochemical properties of biochar with the swelling capacity and flexibility of hydrogels, potentially contributing to long-term soil stability.

Our study was focused on saturated hydraulic conductivity (Ks), which was measured by the falling head method, in silty clay soil (control) and three types of ecological additives: biochar (produced by pyrolysis of sunflower husks at 650°C), modified biochar (biochar from sunflower husks chemically modified with ammonium hydroxide), and hydrogel (an alginate-based hydrogel filled with biochar from sunflower husks). All additives were mixed with silty clay soil at 1% concentration.

A significant effect of treatment on the measured Ks was observed (one-way ANOVA, $p < 0.001$). Biochar application resulted in significantly higher values compared to all other treatments (Tukey's HSD, $p < 0.05$). The modified biochar treatment did not differ significantly from the control. The hydrogel treatment resulted in the lowest values among all treatments and differed significantly from biochar and control treatments. In the biochar treatment, the soil matrix became sufficiently aerated, leading to enhanced water infiltration. The assumption that the hydrogel treatment would further compact the soil and increase water retention was also confirmed. However, in clay soil, this effect cannot be considered positive, as excessive compaction and water retention may adversely affect the plant root system. Nevertheless, additional hydrophysical measurements are required in order to draw definitive conclusions.

Keywords: silty clay soil, biochar, hydrogel, saturated hydraulic conductivity

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Soil physical investigations related to the pilot dredging of the Kis-Balaton Bárándi-water and the agricultural use of sediment

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A critical element in the operation of the Kis-Balaton Water Protection System (KBWPS) is to reduce the risk of eutrophication associated the internal load from the accumulated sediment. Within the VVNL 2/H sub-project, a trial dredging was carried out in Bárándi-water area, which is the primary recipient of the transported materials from the watershed of Lake Balaton by River Zala. A pilot field experiment was established on the arable land of MATE Georgikon Campus using spring barley as a test crop, and dewatered sediment in 0, 15, 22.5, 30, 37.5 mm equivalent doses. The study objectives were to characterize the sediment of Bárándi-water relevant to management and reuse.

Based on the results of laboratory analyses of the sediment, and soil samples our study addressed the following questions: a) does the sediment composition hinder its agricultural use; b) does sediment properties change substantially during dewatering; c) what are the potential effects of sediment application on soil physical and chemical properties and on yield. Finally, we delineate in target maps that area within the catchment where the sediment could be used with greatest agronomic and environmental benefits.

The close interdependence between the sediment's physical and chemical properties and their spatial heterogeneity influences the technically justified depth and spatial extent of dredging, and it is important factor governing environmental risk during and after dredging. Overall, the sediment of Bárándi-water appears suitable for agricultural reuse. Results from the first year of field-scale application are promising, indicate potential improvements in the arable soil physical status – particularly in aggregate stability – and in selected chemical characteristics. High spatial resolution (25 m) basic property and target maps (area of sandy, clayey or acidic nature soil) within the catchment support the environmentally sound reuse of dredged sediment, planning and water management at both catchment and local level.

Keywords: lake sediment, spatial heterogeneity, aggregate stability

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Agricultural practices shape soil physicochemical properties and microbial functional potential in cropland soils

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Soil structure dynamics and soil functions are closely linked to microbial processes regulating organic matter turnover and nutrient cycling. This study assessed how contrasting agricultural practices influence soil physicochemical properties, microbial diversity, and functional potential in temperate cropland soils. Field investigations (2024–2025) were conducted in nine organic/regenerative farms, five intensive farms, and a controlled field experiment with six tillage and cover crop treatments. Soil organic carbon, water-extractable organic carbon, total N, P_2O_5, K_2O, and pH were analyzed together with microbial abundance (qPCR), taxonomic composition (DNA metabarcoding), and functional genes involved in N and P cycling (nifH, ureC, nitrification, denitrification, phoC, phoD). Enzyme activities were also determined.

Most soils showed moderate organic carbon (1–3%) and total N (0.1–0.3%), while mineral N and available P varied according to fertilization regime. Fields grouped into five clusters based on agrochemical properties, partly reflecting fertilization strategies. In the experimental trial, reduced tillage (harrowing) and conventional tillage supported 2–3 times higher bacterial and fungal abundance than no tillage (direct drilling). Incorporation of white mustard biomass in ploughed plots reduced total microbial abundance and functional gene copy numbers, whereas under direct drilling it significantly increased phoD gene abundance. Nitrogen cycling genes were most abundant under reduced tillage. Microbial richness and evenness (Chao1, Shannon) did not differ significantly between organic and intensive systems. However, taxonomic composition shifted depending on soil properties and crop rotation. Functional gene abundance varied up to 2–5-fold with tillage intensity, indicating that soil disturbance affects microbial functional potential more strongly than overall diversity. Overall, microbial diversity in these managed soils was relatively stable across farming systems, whereas tillage, fertilization, and crop rotation shaped microbial functional capacity and nutrient cycling processes relevant to soil structure and soil functions.

Effect of trampling on soil parameters

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One consequence of overgrazing is that excessive trampling by animals causes soil compaction, which affects the soil's water, air, and nutrient management. In this study, we examined the effect of trampling in Hortobágy in 2025 July: on three different plant communities: closed steppe on loess, annual salt pioneer sward, and salt meadow. We performed the following soil tests: field infiltration with a MiniDisc Infiltrometer, compaction assessment with pocket push-cone penetrometer, determination of moisture content, electrical conductivity, pH; additionally we also determined the number of species and plant cover.

Trampling of the soil reduces the volume of the pores between solid particles in the soil due to compaction. As expected, the hydraulic conductivity was higher in not trampled areas on closed steppes on loess and annual salt pioneer sward. We observed the opposite on salt meadow, which may be due to the cracked nature of the soil. In the case of closed steppes on loess and annual salt pioneer swards, the penetration value was higher in trampled areas, clearly demonstrating the effect of regular animal passage. As the moisture content of the soils differed in the three habitats, the wettest annual salt pioneer swards showed the least resistance, as wet soil offers little resistance to pressure.

We found that trampling reduced the number of plant species. Further consequences may include reduced plant growth and the formation of increasingly waterlogged patches.

If trampling causes adverse changes that are contrary to the objectives of land users (grazing livestock and nature conservation), such as reduced grass yield for livestock, or the disappearance of valuable species for nature conservation, then intervention is necessary and the impact of trampling must be reduced, for example by fencing off the trampled area or relocating livestock.

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Impact of Tillage Systems, Cover Crop Management, and Environmental Factors on Root Distribution and CO_2 Efflux

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Tillage intensity and crop management strategies play an important role in shaping root system development and soil carbon processes in cereal-based agroecosystems. This study examined the combined effects of three tillage intensities (conventional ploughing, shallow harrowing, and no-tillage); and two agricultural technologies (traditional management and an integrated system incorporating cover crops) on winter wheat root distribution, soil microclimate, and soil CO_2 efflux over three growing seasons (2022–2024). A split-plot field experiment was established to measure root length density, root diameter, soil CO_2 efflux, soil temperature, and volumetric water content. Results showed that the integrated cover crop–based technology consistently enhanced winter wheat root development, increasing root length density by 6–13% compared with traditional management across all seasons. No-tillage further promoted root proliferation relative to harrowing and ploughing treatments, whereas root diameter remained largely unaffected by either tillage or management system. Soil CO_2 efflux varied substantially among years, with markedly higher emissions recorded in 2022 than during the drier 2023 and 2024 growing seasons, underscoring the importance of interannual climatic variability. Across treatments, CO_2 efflux was positively correlated with root length density but has low relationships with soil moisture and temperature. These findings indicate that tillage intensity and cover crop integration influence soil CO_2 dynamics primarily through modifications of root spatial distribution rather than through changes in root morphology or soil microclimatic conditions alone. Incorporating root-based indicators therefore provides valuable mechanistic insight into how conservation-oriented agricultural practices regulate soil carbon fluxes in temperate cereal production systems.

Influence of soil physicochemical properties on ^{137}Cs activity concentration distribution and variability in urban soils of Ózd, Hungary

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Urban soils exhibit distinct physicochemical heterogeneity due to long-term anthropogenic disturbance, complicating understanding of how soil structure regulates radionuclide retention and mobility. This study investigates the distribution of artificial ^{137}Cs and its relationships with some of the key soil physicochemical properties, including ammonium (NH_4^+), nitrate (NO_3^-), total organic carbon (TOC), carbonate content ($CaCO_3$), pH, redox potential (Eh), and particle-size distribution (clay, silt, sand) in 36 urban soil samples collected from Ózd, a former industrial city in Hungary. A multivariate statistical approach, including Spearman rank correlation, multiple linear regression (MLR), and principal component analysis (PCA), were applied to identify the dominant factors explaining ^{137}Cs variability.

Measured ^{137}Cs activity concentrations ranged from below detection limit (DL = 0.3 Bq kg^{-1}) to 19.3 ± 0.5 Bq kg^{-1} (mean: 6.2 ± 3.8 Bq kg^{-1}; median: 6.3 Bq kg^{-1}), representing substantial spatial variability. Significant positive correlations were observed between ^{137}Cs and silt, NH_4^+, TOC, and Eh, whereas negative correlations were found with sand and $CaCO_3$. The MLR model identified NH_4^+ and silt as significant predictors, explaining 45% (R^2 = 0.45) of total ^{137}Cs variations. From this model, predicted and measured activities were strongly correlated (r = 0.70, p < 0.0001). The PCA determined three soil groups reflecting different controlling mechanisms: (i) the strong positive correlations between ^{137}Cs activity concentration and NH_4^+, and Eh indicate that ^{137}Cs variations at these sites are primarily governed by cation exchange and redox-related processes in the soil, attributed to elevated fertilization in urban green spaces (e.g., certain parks, playgrounds, kindergartens) and agricultural areas; (ii) the positive correlations with fine fractions (silt and clay) and a negative correlation with sand demonstrate that ^{137}Cs distribution in this group is largely controlled by soil texture-dependent sorption mechanisms, due to influence of transported or redistributed technogenic materials in open areas and some urban green spaces (e.g., certain parks and playgrounds); and (iii) the negative correlation between ^{137}Cs and $CaCO_3$ suggests reduced retention in carbonate-rich industrial soils, highlighting the influence of anthropogenic carbonate inputs. This integrated statistical approach provides a robust framework for assessing ^{137}Cs activity concentration retention and transport in structurally disturbed urban soils.

Keywords: Urban soils; ^{137}Cs; soil texture; redox potential; ammonium; carbonate; multivariate statistics

Effect of increasing concentration of an anionic surfactant on some soil physical properties

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Surfactants are widely used in cleaning products, pesticides, or even in remediation. They can enter the soil through wastewater and pesticides. We added a biodegradable anionic surfactant, Sodium Cocoyl Isethionate (SCI), to different soil samples in terms of soil texture, soil organic carbon, acidity and salinity. This surfactant is often used in cosmetic and self-care products and is commercially available.

In this research, we investigated how SCI suspension can change the physical and chemical properties of the soil. We treated seven soils, with different properties, with three different concentrations of 0.5; 1 and 1.5% surfactant suspensions, the ratio of soil to surfactant solution was 1:10. After that, we dried the samples at room temperature, then sieved them through a 2 mm sieve, and the following tests were performed: particle size distribution, pH, electrical conductivity, slake-test (with SLAKES app), microaggregate stability, hygroscopic water content (according to Sík; hy_1).

In the Solonetz soil, neither pH nor electrical conductivity showed significant differences between the treatments, but in the other soil types we found such. In the case of the A horizon of the acidic Luvisol, we obtained the highest aggregate stability with the slake test; in the case of horizon B, due to the effect of increasing surfactant concentration, the aggregate stability (as indicated by slake test) increased. Over the studied assortment of samples the total average values of hygroscopic water content decreased significantly by increasing surfactant concentration.

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Long-term impact of tillage strategies and crop residue management on soil quality in winter wheat cultivation

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This study evaluates how different soil preparation methods and the retention of straw influence soil health parameters within winter wheat. The research was conducted at the Vytautas Magnus University Experimental Station in Lithuania, utilizing a long-term field trial initiated in 1999. The soil at the site is classified as Epieutric Endocalcaric Planosol (Endoclayic, Episiltic, Aric, Drainic, Endoraptic, Uterquic). Initial topsoil assessments identified a sandy loam texture with a slightly alkaline pH of 7.6, an organic carbon (OC) content of 1.65%, and available nutrient levels of 266 mg kg^{-1} for P_2O_5 and 134 mg kg^{-1} for K_2O. The investigation focused on comparing multiple soil tillage systems, including conventional and reduced tillage, while accounting for the influence of straw retention. Key analytical parameters encompassed soil properties, soil structure, and stability to better understand how management practices impact soil health and fertility. Implementing reduced tillage and maintaining straw residues yielded beneficial effects on soil properties during winter wheat cultivation. These management strategies appeared to enhance organic matter levels and improve soil structural integrity. Such practices have the potential to support increased microbial activity and improved nutrient availability, both of which are vital for maintaining soil fertility.
The study concludes that while these results are promising, continued research is essential to fully explore the long-term practicalities and implications across diverse agricultural settings, considering factors like climate and crop rotation.

Keywords: sustainable tillage, soil properties, crop rotation

Demonstrating ground level shifts through penetration measurements

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The aim of the research is to examine the effects of different agricultural cultivation practices, with particular emphasis on the compaction of soil by machinery and changes in penetration resistance. During the research, we measured changes in soil parameters in three treatments, by simulating different soil cultivation methods, with particular attention to calculating soil penetration resistance. The research was conducted at the experimental site of the Hungarian University of Agriculture and Life Sciences. The study area was divided into three 1 m^2 plots. Four penetrometer measurements were taken within each plot, and the mean value was subsequently calculated. Across the experimental area, it can generally be observed that penetration resistance increases proportionally with depth, then decreases in the range of 40-50 cm. The highest resistance (mean: 286 kPa) occurred in the case of no-tillage, followed by reduced tillage (mean: 265 kPa), while the lowest soil resistance occurred in the case of conventional tillage (mean: 209 kPa). During the measurements, we concluded that the soil surface had vertically shifted compared to the first treatment as a result of the different treatments. During the disturbance of the top 30 cm of soil, there was a slight rise, fall and lateral displacement, which determined the results of the penetrometer measurements. Our results indicate that the potential vertical shift in reference height should be considered and accounted for during the presentation of penetrometer results in future studies. In the case of conventional tillage, the surface profile was the most variable and uneven, due to irregular clod formation. Mechanical loading after cultivation increases soil compaction, causing the surface height to shift again and penetration resistance to increase by 47.38% compared to the previous treatment in the top 30 cm of soil. The results of the study clearly indicate that surface displacement caused by soil cultivation methods and mechanical loading (soil compaction) is closely related to soil resistance.

Latvia's soil of the year 2026

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Climate change caused by ill-considered economic decisions places an increased burden on ecology and therefore on natural sciences. The greatest burden in maintaining the balance of biocenoses is on the soil, as is its foundation. However, the transfer of scientific knowledge to the legal framework is taking place very slowly. Only in 2025 was "EU Directive on Soil Monitoring and Resilience" accepted, that makes an in-depth understanding of soil a mandatory component of the economy. Qualitative knowledge transfer is the main condition for public understanding of the importance of soil in ecological, economic and social processes. The Soil of the Year initiative has developed in Central Europe over the last decade and has proven itself to be a successful way to arouse public interest in soil. In 2025 scientists of Latvia University of Life Sciences and Technologies initiated the Soil of the Year movement in Latvia as well, and in 2025, during a seminar dedicated to World Soil Day, on December 6, the Latvia's Soil of the Year 2026 was selected by voting. The selected soil was discovered 160 m from the Baltic Sea coast, in Kalngale, in a relief depression and, according to the Latvian classification version 2009 is Mucky-humus podzolic gley soil. This study describes in depth the properties, processes and formation conditions of this soil. The soil is located in the Seaside Forest ecosystem, which is one of the most dynamic and at the same time sensitive forest ecosystems, which are formed by the interaction of specific natural factors, such as relief, wind, sandy bedrock and the influence of the sea. In such areas, even small differences in relief can cause noticeable changes in the soil moisture regime, nutrient availability and soil formation processes, which directly affect both the vegetation structure and the growth parameters of forest stands. The story of selected soil highlights the sandy bedrock, which is 1/3 of the bedrock of Latvian soils; the positive anthropogenic impact on difficult-to-develop areas affected by active aeolian and coastal erosion processes; the importance of soil in maintaining fragile biocenoses; in accumulating carbon in for plant development challenging conditions; the importance of knowledge transfer, as the initiator of the soil profile is a student.

In-row and between-row soil moisture changes under different inter-row management in a vineyard

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Vineyards are highly vulnerable to soil degradation, often prone to erosion, and require intensive management practices. This study evaluates the multi-year impact (2023–2025) of different inter-row management strategies - no-tillage (NT), tillage (T), and cover cropping (CC) - on soil-plant-water interactions. The research was conducted on a Calcaric Cambisol, Loamic (WRB) sloping vineyard. Field campaigns were performed twice annually, targeting the flowering and harvest phenological stages, to measure soil water content (SWC) measured with Campbell HydroSense II, soil temperature, and carbon-dioxide emissions measured with EGM-5 Portable CO_2 Gas Analyzer across a seven-point sampling for each management system.
A strong correlation was observed between the soil temperature and carbon dioxide emissions in all management types ($p < 0.05$). The tilled (T) management resulted in the lowest average carbon dioxide emissions (0.42 $mgCO_2/m^2/s$). Based on average measurement data from three years, CO_2 emissions were approximately 76% higher in the cover-cropped (0.73 $mgCO_2/m^2/s$) and no-tillage (0.74 $mgCO_2/m^2/s$) inter-rows compared to the tilled inter-row management. Average soil water content (SWC) was higher in the inter-rows (SWC = 15.98%) across all treatments compared to the rows (SWC = 14.29%), although the difference was not statistically significant. Higher SWC levels were recorded at the upper slope positions compared to the lower positions in all managements. In the inter-rows of the NT and CC treatments, soil temperatures were lower, and CO_2 emissions were higher compared to the rows; conversely, in the T treatment, lower soil temperatures and higher CO_2 emissions were observed within the rows. In terms of inter-row management, both no-tillage and cover cropping resulted in comparable SWC levels, suggesting a similar impact on the soil moisture balance.

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Long-term monitoring of soil moisture content under different land uses

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Long-term studies of soil moisture dynamics have become increasingly important due to changes in precipitation patterns and the increasing frequency of water-deficient periods. The aim of the present study was to investigate the temporal and spatial variability of soil moisture and temperature across four different land-use types (forest, grassland, cropland, and vineyard) at different slope positions.

The study was carried out in the Upper-Balaton region, Hungary, where the field monitoring system has been working since 2020. Soil moisture and temperature data were collected at a depth of 15 cm using TEROS 12 and 5TM sensors, data were recorded by EM50 and ZENTRA Z6 loggers (Meter Group). Physical and chemical soil parameters were determined in the laboratory. Using the measured data and the Saxton & Rawls model, we calculated the Wilting Point (WP) and Field Capacity (FC) to analyze the annual frequency of daily averages within these categories. Soil samples for physical (e.g., soil texture) and chemical (e.g., total C, N content, SOC, K_2O, P_2O_5, pH) analyses were collected at the beginning of the experimental setup in triplicate.

Our data showed that slope position has a strong influence on soil moisture dynamics due to different soil parameters. The highest clay content was found at the vineyard upper slope positions and in the cropland, while the lowest clay content was characteristic of the vineyard lower slope positions.

Soil moisture content (SMC) was significantly different for each land use type based on slope positions ($p < 0.05$). The highest average soil moisture content was observed in cropland (26.76%), while the lowest was at the forest upper slope position (8.12%). The proportion of days with soil moisture below the WP was the highest at the grassland lower and forest upper slope positions (> 95%). The most favorable conditions for water availability were observed at the lower slopes of the vineyard, where the number of days within the available water content (AWC/DV) range exceeded 85%. Considering the collective average of all land-use types, we found that 2022 was the driest year, with 61.64% of all measured SMC values falling below the WP. The most humid year was 2025 with 64.36% of measurements falling within the AWC/DV zone.

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Soil gas monitoring system to understand behaviour of allochthonous CO_2 in the Balaton Highland (Hungary, Central Europe)

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Soil gas monitoring is a tool to detect allochthonous CO_2, which may have a deep reservoir origin (e.g. lower crust, mantle). This approach is particularly sensitive since the soil physical properties control gas transport, storage, as well as temporal variability. Therefore, continuous measurements of soil gas composition provide key information on gas fluxes and also the role of soil structure, moisture, and meteorological conditions.
The study area is located in Badacsonytördemic, in the Balaton Highland, Hungary (Central Europe), where soil CO_2 originates from both biogenic production and allochthonous sources related to crust and/or mantle degassing. This area is a well-studied, where springs contain CO_2, which originated from the mantle. The latter is supported by carbon and noble gas stable isotope signatures of dissolved gases in local groundwaters and springs (Lange et al., 2024). The study site is characterized by heterogeneous vegetation (such as fruit trees, corn, lavender) and sloping topography. Soils, developed on slope sediments, contain basaltic rock fragments and carbonate precipitations, resulting in vertically and laterally heterogeneous soil physical properties that influence gas permeability and diffusion.
In this context, an Integrated Geodynamic Station (IGS) was established in the southwestern part of the study site, combining soil gas, seismological and meteorological monitoring. Soil gas is continuously sampled from a depth of approx. 85–95 cm, representing the zone below the main root influence but above the unweathered substrate. Sampled soil gas is transported into a heated and dehumidified chamber to minimize the effect of soil moisture and condensation on analyses followed by gas composition measurements by FTIR spectroscope. Hereafter, the measured gas samples can be trapped for further studies, including Raman spectroscopy and stable isotope (C, O, H, N) analyses. In addition to continuous monitoring, spatial surveys of CO_2 concentration and Rn activity concentrations were conducted during two seasons (August and November in 2024) in an extended area around the IGS.
Acquired detailed soil profile analysis revealed carbonate precipitation below the root zone and a marked change in grain size distribution at approximately 80 cm depth, coinciding with the soil gas sampling horizon. Organic carbon content of the soil decreases with depth, indicating reduced biological CO_2 production and highlighting the increasing role of physical transport processes in controlling soil gas concentrations at depth of ~ 1m. According to the monitoring of the area, correlation between Rn222 and CO_2 concentration cannot observe, for this reason the positive anomaly of CO_2 concentration may be connect to the biological activity of the soil.

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High-resolution (25 m) digital soil texture mapping for Transdanubia, Hungary, using legacy soil profile data

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High-resolution soil texture information is a key input for agro-hydrological assessments and climate adaptation planning, yet such data are often unavailable at appropriate spatial and depth resolutions. Since the 1970s, extensive soil survey information has been compiled for agricultural areas in Hungary, resulting in the NATASA (Large-scale Soil Mapping Profile-level Database) legacy dataset, which currently contains approximately 37,000 soil profiles and 148,000 soil layers, including detailed subsoil horizon data. In this study, we produced 25 × 25 m digital soil texture maps for Transdanubia (western Hungary), focusing on four counties (Somogy, Vas, Veszprém, Zala) within the Balaton catchment region.

Sand, silt and clay contents were estimated from profile observations using pedotransfer functions developed from the MARTHA database (Hungarian Detailed Soil Physical and Hydrological Database), with the predictions primarily driven by an index expressing the upper plasticity limit according to Arany, and further supported by basic soil properties. Prior to modelling, field descriptions and laboratory records were critically reviewed and harmonised within a quality-control workflow informed by the Hungarian genetic soil classification system and professional criteria, implemented as a “pedophenomenological” filtering approach to ensure consistent nomenclature and map-ready data structure. Spatial prediction followed the SCORPAN framework and used environmental covariates representing terrain, geology, groundwater conditions, long-term mean temperature and precipitation, and land cover. Depth-explicit predictions were generated for the standard GlobalSoilMap intervals (0–5, 5–15, 15–30, 30–60, 60–100 and 100–200 cm) using random forest regression kriging in R. Model performance was evaluated by five-fold cross-validation, reporting R^2, mean error (ME), mean absolute error (MAE) and root mean square error (RMSE). The resulting depth-resolved texture layers provide a robust foundation for deriving additional functional soil property maps (e.g., hydrophysical characteristics) and for assessing waterlogging and drought sensitivity of agricultural landscapes under increasing weather extremes.

Keywords: legacy soil data, soil profile data, "pedophenomenological" approach, DSM, 25 m spatial resolution, soil texture maps

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Effect of water retention in irrigation channels on spatial patterns of water table depth

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Water retention is important because it helps local communities to cope with extreme hydrological events (drought and heavy rainfall) in the Pannonian Region. The ClimaPannonia project, where we are testing nature-based solutions like log dams, water-reuse systems and water retention in irrigation channels can facilitate climate adaptation.
In our work at the MATE KÖTI Irrigation Experimental Station in Szarvas, we examined how periodically stored irrigation water in a 420-meter educational irrigation canal influences the groundwater level. For this purpose, we installed experimental groundwater monitoring wells - each 4 meters deep – at ten points (located 3 m, 10 m, 100 m, and 150 m from the canal) in the connected agricultural field (soil type of the area is Vertisol). Groundwater level was measured daily at all observation points during the canal's filling periods in September 2025. We identified the micro-topographic variations of the arable field using high-precision drone surveying (digital elevation models).
When the temporary used canal was filled, we measured significant rise in groundwater levels in the nearby wells. At a distance of 3 meters from the canal embankment, groundwater levels increased by 56–170.5 cm by the fourth day after filling. At 10 m distance, the rise ranged from 48 to 130.5 cm, but at 100 m and 150 m away from the canal only about a 2 cm increase was detected. We continue the measurements regularly to determine not only the effect of the canal filling but also the influence of water-level fluctuations in the nearby Holt-Körös oxbow-lake and a connected fishpond system.
Our preliminary results indicate that water stored in irrigation canals can substantially raise groundwater levels in surrounding areas, which can enhance the climate resilience of local habitats.

What happens with rainwater in a dry valley, neighbouring agricultural fields?

Preliminary results of an ongoing on-field measurement campaign in Püspökszilágy, Hungary

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A long-term on-field measurement campaign began in the spring of 2025 in Püspökszilágy, Hungary. Sub-surface probes are detecting changes in soil moisture content across several soil profiles in a basically dry valley, with a high risk of runoff from neighbouring agricultural fields. The valley currently treated with different nature-based solutions (log or leaky dams), aimed at reducing the risk of flash floods that might endanger the village of Püspökszilágy. Our goal is to explore the effect of the log dams on the water content of the neighbouring soil profiles.
We installed the measurement probes on the slope alongside the log dams' reservoir at two locations. Each spot hosts 3 sets of probes, up on the slope, containing 5-5 individual probes installed at 0, 20, 40, 60, 80 cm below the surface. Also, field and laboratory data on soil physical and chemical characteristics were collected, including exploration of the vertical layering of sediment behind the log dams.
The first data from the measurements campaign already provide insight into soil moisture variation through the detected vertical profiles, including the shift caused by snow-melting.
Based on the almost one-year-long data series, we identified distinct peaks in the moisture curves, with clear differences depending on the position of the probes along the slope. This way, we can get deeper understanding of how soil moisture changes with depth along slopes and influenced by agricultural runoff and nature-based water retention measures.

Keywords: Soil moisture measurements, eventual precipitation events, agricultural plots, Nature-based Solutions

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