II. Natural Hazards and Climate Change Conference

Session 7 Challenges of Water Management in a Changing Climate

Simplicity or complexity? Identifying the optimal approach for flood hazard mapping – *Kaveh Ghahraman, Fatemeh Nooshin Nokhandan, Balazs Nagy*

Advanced Mapping and Integrity Assessment of Artificial Levees Using Machine Learning–Driven Electrical Resistivity Tomography for Natural Hazard Risk Analysis – *Diaa Sheishah, Enas Abdelsamei, Ahmed M. Ali, György Sipos*

Cross-comparison of national drought monitoring products in Central Europe using a new drought impact database – *Nirajan Luintel, Piet Emanuel Bueechi, Johanna Lems, Wouter Dorigo*

Inappropriate land use and vegetation cover: water scarcity in the climate-affected lowland regions of Hungary – *Benedek György Tóth, Zoltán Bátori, Alida Anna Hábenczyus, András Kelemen, Kata Frei, Orsolya Valkó, Balázs Deák, Csaba Tölgyesi*

The impact of climate change on the thermal stratification of a shallow polymictic lake – *Sebestyén Török, Péter Torma*

Droughts and floods: monitoring, prediction and artificial intelligence in the Hungarian Water Management – *Zoltan Liptay*

Simplicity or complexity? Identifying the optimal approach for flood hazard mapping

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Floods are among the most devastating natural hazards worldwide, and their frequency and intensity have increased due to climate change. Identifying flood-prone areas is crucial for effective risk mitigation and management. Various methodologies have been employed for flood hazard mapping, utilizing different types of data. In recent years, Synthetic Aperture Radar (SAR) data and machine learning algorithms have gained popularity due to their capability to analyze complex flood patterns. However, these approaches present significant challenges, including data preprocessing complexities and computational demands. Alternatively, simpler methods relying solely on Digital Elevation Models (DEMs) offer a more accessible means of flood hazard assessment. This study aims to compare three different approaches to flood-prone area identification, each with distinct data requirements: DEM-based analysis, SAR data utilization, and an integrated approach combining multiple data sources. By evaluating the strengths and limitations of each method, this research seeks to determine the most effective approach for flood hazard mapping, balancing accuracy, data availability, and computational efficiency. The findings will provide valuable insights for researchers and policymakers in selecting the most suitable methodology for flood risk assessment and management.

Advanced Mapping and Integrity Assessment of Artificial Levees Using Machine Learning–Driven Electrical Resistivity Tomography for Natural Hazard Risk Analysis

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As climate change intensifies the frequency and severity of extreme weather events, the structural integrity of artificial levees has become increasingly critical for flood hazard mitigation. Many aging levee systems face deterioration, making reliable assessment of their condition a growing challenge—particularly due to the heterogeneous and complex nature of their construction materials. This study combines electrical resistivity tomography (ERT) with borehole (BH) data to explore the structure and materials of two levees, with the goal of better understanding how they perform during floods. The method improves the links between water content and other physical properties from borehole samples, while encouraging the use of non-destructive geophysical techniques—especially for estimating important factors like grain size (D50). This approach reduces reliance on conventional destructive testing. By using four machine learning models—Random Forest Regressor (RFR), Artificial Neural Network (ANN), Linear Regression (LR), and Support Vector Regression (SVR)—we found connections between resistivity from ERT, water content, and grain size. RFR yielded the highest predictive accuracy ($R^2 = 0.81$), outperforming ANN (0.74) and both LR and SVR (0.66). These results show that combining machine learning with ERT and BH data can better evaluate the state of levees, offering important information for flood risk assessments and improving strategies to deal with climate-related natural disasters.

Cross-comparison of national drought monitoring products in Central Europe using a new drought impact database

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Droughts have severe impacts on the environment and economy, particularly in regions with high water demand and low annual precipitation. Central Europe is one of those regions. We assessed six national drought monitoring products in Central Europe using a novel impact database developed within the Clim4Cast project (1). The database synthesizes reports in national newspapers, published between 2000 and 2023, on observed drought impacts on various sectors, including agriculture, hydrology, water management, economy and technology, and wildlife. The drought monitoring products comprise drought indicators such as standardized precipitation index (SPI), standardized precipitation evapotranspiration index (SPEI), and standardized soil moisture index with different aggregation periods. We evaluated the drought indicators using: 1) the area under the receiver operating characteristics curve (AUC) to assess their ability to detect drought, and 2) the correlation between drought index severity and the number of reported impacts to measure their ability to capture the impact severity.

The performance of the drought indicators varies by region and aggregation period. The AUC values for some drought indices exceed 0.8 for Czechia, Croatia, and Slovenia, while in Austria, the AUC values for most drought indicators remain below 0.7. Correlation values for many drought indicators remain below 0.6 in most countries, with correlations mostly below 0.3 in Slovakia, Slovenia, and Croatia. With an increasing aggregation period, the correlation generally decreased, while AUC values showed a more complex pattern, initially increasing, peaking at around 6-12 months, and then decreasing with longer aggregation periods. These results aid in understanding the strengths and weaknesses of drought monitoring products in each country and assist in developing a common drought monitoring framework for Central Europe.

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Inappropriate land use and vegetation cover: water scarcity in the climate-affected lowland regions of Hungary

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Increasing temperatures and decreasing precipitation negatively affect underground water resources in the lowland regions of Hungary and have resulted in several meters of groundwater decline since the 1970s. Regional anthropogenic factors such as inappropriate landuse and vegetation cover may also have a role in the loss of groundwater resources. Here, we aimed to reveal the effects of afforestation and biological invasion as potential threats to the ground water recharge. We monitored vertical soil moisture dynamics in the most commonly planted forest types of lowland Hungary and compared them to neighboring grasslands. We found that plantations, particularly non-native pine stands, deplete the moisture content of unsaturated soil layers, preventing groundwater recharge throughout most of the year. We also studied the hydrologic effects of the most common invasive plant of the region, common milkweed (Asclepias syriaca). Despite being a herbaceous species, its large leaf area, deep roots and clonal growth form allows for a large evapotranspiration capacity, potentially contributing to the depletion of soil moisture resources. With a removal experiment we could confirm this, as invaded areas had significantly lower soil moisture in the upper 1-m soil layer than uninvaded grasslands but by removing milkweed shoots, the moisture content in the soil could be restored within a year.

Our results suggest that inappropriate land use and vegetation cover can act synergistically with climate change in lowland Hungary and exacerbate water scarcity. We recommend the reconsideration of landuse strategies, and promoting grassland restoration as a nature-based solution for mitigating climite change effects, instead of establishing new forests. We also would like to draw the attention to the importance of milkweed suppression as it not only serves biodiversity protection but also water resource protection purposes.

The impact of climate change on the thermal stratification of a shallow polymictic lake

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Lakes are highly sensitive to climate change, which makes them important and efficient sentinels. Changes in meteorological factors, such as air temperature and wind, influence the mixing conditions of the lakes' while also altering their energy balance and thermal structure, which can directly affect their ecosystems. As a clear consequence, changes in the lakes' oxygen conditions can be observed, which have contributed to the increased frequency of algal blooms in recent years, such as the record-setting algae bloom in Lake Balaton in 2019, which occurred after more than 20 years of successful eutrophication management. Most studies focus on deep lakes, although shallow lakes are more exposed to internal or external changes due to their limited depth and water volume, making them respond more sensitively to the impact of climate change or anthropogenic effects. The long-term consequences of these changes are largely unexplored in shallow lakes. Therefore, this study examines the changes in the thermal structure of Lake Balaton, a large but shallow polymictic lake, over the past 40 years. The investigations are carried out using the one-dimensional General Ocean Turbulence Model (GOTM), which uses a k-ε turbulence model for vertical mixing, providing stratification results on a physical basis. The model was calibrated and validated for several years of in situ measurements, while for the past simulations, bias-corrected ECMWF ERA5 reanalysis time series were used. The study furthermore investigates the applicability of simple neural networks in calculating a shallow lake's thermal structure with strong daily cycles. The set-up neural network model was trained and validated using the same data as the one-dimensional model, with its results being compared against the GOTM, which served as the reference.

Droughts and floods: monitoring, prediction and artificial intelligence in the Hungarian Water Management

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In my presentation I will discuss the current status of the Hungarian draught monitoring and prediction system and how it is interconnected with the national hydrological forecasting system. I will also discuss the flood forecasting approach applied in Hungary through the current operational systems in both regional and local scales. Artificial intelligence type methods are becoming more and more widespread in the water management sector and there are also ongoing developments in Hungary in the field of hydrological forecasting and data management. Participation in global forecasting projects is new topic where we also represent the local knowledge and share our experiences with hydrologists all over the World