HydroCarpath International Conference

Catchment and River Processes in Regional Hydrology: Field Experiments and Modelling in Carpathians

Abstracts of the Conference

Edited by
Péter Kalicz, Kamila Hlavčová,
Silvia Kohnová, Marija Mihaela Labat, Csenge Nevezi, Zoltán Gribovszki

Vienna, Austria,
Bratislava, Slovakia,
Sopron, Hungary
26 November 2021

Working Committee of Environmental Sciences and
Working Committee of Forestry,
Regional Centre of the Hungarian Academy of Sciences,
Veszprém (VEAB)

The work of editors is partly supported by the EFOP-3.6.1-16-2016-00018 – *Improving the role of research+development+innovation in the higher education through institutional developments assisting intelligent specialization in Sopron and Szombathely* project.

HydroCarpath 2021 online conference
2021-11-26 9:00–14:00

ISBN 978-963-334-414-9 (pdf) DOI: 10.35511/978-963-334-414-9

Contents

ASSESSMENT OF DIMENSION-REDUCTION AND GROUPING METHODS FOR ESTIMATING CATCHMENT RESPONSE TIMES

ESZTER DÓRA NAGY, JÓZSEF SZILÁGYI

Budapest University of Technology and Economics, Department of Hydraulic and Water Resources Engineering; Budapest University of Technology and Economics, Department of Hydraulic and Water Resources Engineering (nagy.eszter@emk.bme.hu)

Several clustering methods are used in hydrology to enhance the estimation of different runoff characteristics. However, there is no literature available on the efficiency of clustering methods concerning the estimation of catchment response times (Tr). Different catchment response time parameters, i.e., the time of concentration or lag time, are often estimated using empirical equations, including different catchment descriptors (CDs). In order to set up a new empirical equation, we performed a thorough analysis of 61 Hungarian catchments consisting of i) the calculation of the measured value of Tr based on the most recent Detrending Moving-Average Cross-Correlation Analysis (DMCA)-based estimation method using measured rainfall and runoff time-series; ii) an assessment of the 60 CDs for the 61 catchments; iii) a comparative analysis of three dimension-reduction techniques, and; iv) seven clustering methods. Our analysis concluded that the All Possible Regressions method outperformed the other dimension-reduction methods, while the clustering methods performed less predictably. Several clustering methods performed better than the grouping based on geographical units, but the estimation error only decreased in a few cases compared to the regional (one cluster) estimation. The root mean square error of the Wisnovszky equation (the one most often used in Hungary) is 13.6 hours, which was reduced to 6.77 hours and then to 5.80 hours, when the most suitable CDs were identified. Also, two clusters were created based on the catchment widths, respectively.

DESIGN SUPPORT IN PANDA FOR THE SUPPLEMENTARY TREATMENT OF NITRATES IN TREATMENT PLANT EFFLUENTS

TAMÁS GÁBOR PÁLFY[1,2], PÉTER KALICZ[2], ZOLTÁN GRIBOVSZKI[2]

[1] Ghaemesh Digital Wetland, 38 chemin des Fonts, Sainte-Foy-les-Lyon, 69110, France
[2] Institute of Geomatics and Civil Engineering, University of Sopron, 4 Bajcsy-Zs. Str., Sopron, H-9400. Hungary (tamas@ghaemesh.com)

Free water surface wetlands (FWS) address the nitrogen in carbon-poor effluents of wastewater treatment plants (WWTPs). We present four WWTPs (4000 to 165000 PE) that are located near Sopron, Hungary, as the subject of our investigation. Three of them provide a flow-through biological treatment and the fourth is a Sequencing Batch Reactor (SBR) that is now decomissioned. Although the emission standards have been met, the total nitrogen concentration in the recipient streams falls short of the EU Water Framework Directive (2000/60/EC) . The aim of our study was to model the effect of different FWS designs on the quality of the effluent before decision making takes place.

For our case study, four time series were engineered based on WWTP effluent data. Then, eight FWS that had been featured in the review work of Kadlec (2012) were catalogued; the complete range of the rate of denitrification appearing in the wetlands was covered. The geometry, flow velocity, denitrification rate (coefficient k), and temperature (coefficient θ) parameters were catalogued. The time series and catalogue data were then imported into the Panda Pond modelling tool. We scaled supplementary treatment for the four WWTPs by creating thirty-two simulation setups.

Our results indicate that predictive modelling should avoid settling with median k values and that professionals must seek better hydraulic standardization and sure designs with higher k values instead. According to the best designs, the footprints shrink by a factor of 4.5 to 5.0 compared to the median. We conclude that the FWS wetland standardization could reduce the amount of land needed. Replicability issues would become less of a concern, and evidence-based design of FWS could become mainstream.

Acknowledgements: Special thanks to Tibor Varga and colleagues at Sopron Water for supporting this work with data and technical information.

Mapping riverbed material with Deep Learning – a field study from the Danube

Alexander Anatol Ermilov, Sándor Baranya, Gergely Tikász, Márton Schrott, Gergely Benkő

Budapest University of Technology and Economics, Department of Hydraulic and Water Resources Engineering; Budapest University of Technology and Economics, Department of Hydraulic and Water Resources Engineering (ermilov.alexander@emk.bme.hu; baranya.sandor@emk.bme.hu; tgergely2000lg3@gmail.com; schrott.lorinczmarton@gmail.com; benke.greg@gmail.com)

The constant interaction between a river flow and its riverbed is especially important when it comes to alluvial rivers such as the Danube. These rivers flow in a channel composed of their own sediment. On one hand, they erode their bed in some places by washing away the sediment, while also building it somewhere else and depositing the transported particles where the flow has less energy. On the other hand, a riverbed also influences the flow via hydraulic resistance and friction. This interaction is important in multiple human-related aspects, such as fluvial navigation (maintaining a waterway's depth), bank filtration, flood risk management (shape of a channel) or hydropower (sedimentation problems in a reservoir). On the other hand, the riverbed is the home of many species; hence the mechanism is relevant for ecohydraulic studies. Despite its importance, however, current bed material sampling methods are limited and energy consuming. They mostly provide information at given points of a river, which can be challenging when one wishes to measure and describe the transition zones of a river (e.g., the Hungarian section of the Danube), where silt, sand, and gravel can all be present, thereby creating a varying riverbed composition both over time and in space. As a result, recent studies have been focusing on developing new methods that could replace and further improve traditional methods. In this paper, we introduce an artificial intelligence-based (AI) Deep Learning method, where the algorithm analyses underwater videos by taking images of the river bed from a moving vessel to estimate the local grain size distributions (GSD) of the uppermost sediment layer. The main advantage of this method is its potential in assessing continuous bed material composition data along river transects. A short reach of the Hungarian Danube was chosen, as a case study, where we compared the AI-based GSD information against the results of conventional physical samplings. Furthermore, another novel image-processing method was involved in the study, which uses Wavelet transformation to provide GSD from the images.

A thorough comparative analysis of the different techniques was performed to understand their benefits and shortcomings and to outline a combined approach for future applications.

THE VALUE OF ASCAT DATA FOR THE CALIBRATION OF A CONCEPTUAL HYDROLOGICAL MODEL

MARTIN KUBÁŇ[1], ADAM BRZIAK[1]

[1] Department of Land and Water Resources Management, Faculty of Civil Engineering, Slovak University of Technology, Bratislava, Slovakia

Conceptual rainfall-runoff models have been used for decades as a tool for the simulation of the hydrological phenomena. The demand for quality simulation results increases each year. In our paper, we focused on the quality of the input data and the setup of the objective functions. For the multi-objective calibration, we used runoff data with a combination of the soil moisture ASCAT data. In recent studies, a combination of the runoff and scatterometer soil moisture data almost always improved the soil moisture simulation or the reaction of the soil moisture submodel to the rainfall-runoff events in the catchments and did not detect any improvement in the runoff simulation. In our case, we are trying to focus on improvements in both the soil moisture and runoff simulation in the validation period. The validation results showed us that we achieved a better soil moisture simulation, and we also detected an improvement in the runoff simulation in catchments with a lower mean elevation and with a high cover percentage of the agricultural lands.

Keywords: ASCAT, efficiencies, Austria

CHARACTERISTICS AND PROCESS CONTROLS OF STATISTICAL FLOOD MOMENTS IN EUROPE - A DATA-BASED ANALYSIS

DAVID LUN[1], ALBERTO VIGLIONE[2], MIRIAM BERTOLA[1], JÜRGEN KOMMA[1], JURAJ PARAJKA[1], PETER VALENT[1,3], GÜNTER BLÖSCHL[1]

[1] Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Vienna, Austria
[2] Department of Environment, Land and Infrastructure Engineering, Politecnico di Torino, Turin, Italy
[3] Department of Land and Water Resources Management, Faculty of Civil Engineering, Slovak University of Technology, Bratislava, Slovakia

Recent studies have sought to characterize variations of the annual maximum flood discharge series over time and across space in Europe. To further support these studies, we conducted a pan-European assessment of process controls on key statistical properties of these series, including the mean annual flood (MAF), the coefficient of variation (CV) and the skewness (CS) of flood discharges. We analysed annual maximum flood discharge series from 2370 catchments in Europe without strong human modifications covering the period 1960–2010. We explored how the estimated moments MAF, CV and CS vary due to catchment size, climate and other controls across Europe.

The process controls on the flood moments are identified through correlation and multiple linear regression analyses, and the interpretation is aided by a seasonality analysis. Precipitation-related covariates are found to be the main controls of the spatial patterns of MAF in most of Europe except for regions in which snowmelt contributes to MAF, where air temperature is more important. The Aridity Index is, by far, the most important control on the spatial pattern of CV in all of Europe. Overall, the findings suggest that, on the continental scale, climate variables dominate over land surface characteristics, such as land use and soil type, in controlling the spatial patterns of flood moments.

Finally, to provide a performance baseline for more local studies, we assess the estimation accuracy of regional multiple linear regression models for estimating flood moments in ungauged basins.

THE IMPACT OF RAINFALL EVENTS ON THE DEVELOPMENT OF DEGRADATION PROCESSES FROM THE PAST TO THE PRESENT, CASE STUDY: ZAGOZDONKA CATCHMENT, POLAND

NÉMETOVÁ ZUZANA[1], **KOHNOVA SILVIA**[1], **ADAM KRAJEWSKI**[2], **KAZIMIERZ BANASIK**[2]

[1] Slovak University of Technology, Faculty of Civil Engineering, Department of Land and Water Resources Management, Bratislava, Slovakia
[2] Warsaw University of Life Sciences – SGGW, Department of Water Engineering and Applied Geology, Warsaw, Poland

Intensive rainfall events and soil degradation processes are in a correlated relationship, where the more frequent occurrence of precipitation events leads to a significant deterioration of degradation processes and may be the trigger of other related processes. Worsening land degradation influences people and ecosystems and pressures the planet towards mass extinction, thereby impacting a sixth of all species. Moreover, it leads to serious consequences for the nutrient and carbon cycles, land productivity, and worldwide socio-economic conditions. In the study an analysis of the impact of precipitation events on degradation processes was performed in a catchment located in Poland (the Zagozdonka river basin) for the period of 1963–2020. Daily precipitation totals were processed as input data for modelling degradation processes using the event and the physically-based EROSION-3D model. Physically-based models are considered to be a younger generation of models with a more innovative and beneficial method for the assessment of different types of degradation processes. A total of 57 simulation runs were separately performed for each year with the land-use structure reflecting the individual years. During the period under review, several intense precipitation events were identified, and their impact on degradation processes was recorded. The paper aims to determine the impact of rainfall events on land degradation processes from the past to the present in order to analyse changes over the centuries; it also emphasize the significance of management practices in correlation with the environment and with regard to ensuring soil protection. To illustrate how changes in rainfall patterns affect soil degradation processes, the tabular results were processed in the form of graphic outputs. The results underline the importance of proper land-use management and soil protection and reflect the response of the river basin to intense rainfall events.

Keywords: intensive rainfall event, soil degradation processes, hydrological extremes

COMPARISON OF THE SURFACE SOIL MOISTURE IN A FOREST AND A NEIGHBOURING MEADOW LOCATED IN A VALLEY

CSENGE NEVEZI[1], DÁVID SCHMIDT[2], ELŐD SZŐKE[1], ZOLTÁN GRIBOVSZKI[1], PÉTER KALICZ[1]

[1] University of Sopron, Faculty of Forestry, Institute of Geomatics and Civil Engineering
[2] University of Sopron, Faculty of Forestry, Institute of Botany and Nature Conservation

Soil moisture is one of the most important factors that helps sustain an ecosystem's balance. In 2018, research began in the Hidegvíz Valley experimental catchment that aimed to reveal the connections between the hydrological and botanical characteristics in an alder forest and a neighbouring meadow. The data collection started in 2018, and ended successfully after one year in 2019. This study focused on the changes that occurred in the surface soil moisture, groundwater levels, vegetation, and related meteorological parameters. All the results showed that the hydrological factors linked to the botanical characteristics, particularly between the surface soil moisture and the plants' water uptake. After these promising results, we decided to monitor the soil moisture changes and the coenology further by supplementing them with any available historical data.

The first soil moisture dataset collection in this study area started in 2017, but only in the alder forest. One year later the area was expanded to the forest edge and the wet meadow, and the measurements have continued since then. The data collecting method was the Time Domain Reflectometry (TDR), because it is one of the fastest and easiest methods for determining surface soil moisture in this sampling area. However, during the winter, when the surface is mostly frozen, the data cannot be collected with the TDR instrument. After the analysis, the results showed that the surface soil moisture changes are following the precipitation characteristics in all three ecosystems. In general, the wet meadow has the highest value of the surface soil moisture, the forest edge has medium value, and the alder forest has the lowest value. This trend appears to change to the opposite if a longer drought period is occurring, i.e., the alder forest has the highest soil moisture out of the three ecosystems.

Keywords: surface soil moisture, ecosystem, TDR

POSSIBILITIES OF USING STRUCTURAL SUBSTRATE WITH A BIOCHAR COMPONENT IN BLUE-GREEN INFRASTRUCTURE PLANNING

TIMEA PETROVÁ, VIKTÓRIA TYUKOSOVÁ, MARTINA MAJOROŠOVÁ

Slovak University of Technology, Department of Land and Water Resources Management, Radlinského 11, 810 05, Bratislava, Slovakia (timea.petrova@stuba.sk)

The main purpose of implementing a blue-green infrastructure into an urban environment is to use the filtration capabilities of greenery. The conjunction of vegetation with water elements helps to achieve optimal conditions while mitigating the negative effects of climate change. The reduction of the harmful microclimatic properties of an urban environment can be mitigated by a sufficient number of quality "green areas". In the case of a dense urban structure, insufficient conditions for the growth of a root system are some of the main factors influencing growth characteristics and the ability to avoid post-planting stress. Therefore, an alternative use of the substrate, i.e., structural substrate as an element of water retention measures with the vegetation component in places with an insufficient rooting volume or with an unsuitable soil horizon, can be included among the solutions suitable for an urban environment.

The aim of the study is to create the implementation and subsequent evaluation of the growth potential of vegetation due to the unfavourable conditions of the urban environment with a modern method of using structural substrate employing biochar, in comparison with the classical type of substrate used. A model from abroad that grows vegetation in a structural substrate shows considerable potential using a drainage system in areas with low space requirements for the growth of woody vegetation.

Keywords: urban landscape planning, structural substrate, water retention measures

DESIGN OF THE CHARACTERISTICS OF CONTROL FLOOD WAVES IN CONDITIONS OF CHANGES IN A HYDROLOGICAL REGIME

VIERA RATTAYOVÁ, A. LIOVÁ, KAMILA HLAVČOVÁ, JÁN SZOLGAY, ROMAN VÝLETA, PETER VALENT

Slovak University of Technology, Department of Land and Water Resources Management, Radlinského 11, 810 05, Bratislava, Slovakia (rattayovaviera@gmail.com)

Changes in climatic characteristics and consequent changes in discharges and the hydrological response of watersheds raise questions about the safety of water structures. Water structures are designed based on hydrological characteristics corresponding to the period in which they were constructed. Therefore, changes in flood wave characteristics (shape, volume and culmination discharges) may significantly impact the functionality of these structures.

The study aims to propose a methodology for the construction of design flood waves, which are important for ensuring the safety of water structures. A case study was realized in the Little Carpathians karst watershed of the Parná stream, which is above the Horné Orešany reservoir dams profile.

We selected a set of characteristic flood waves with the maximum annual and maximum seasonal discharges from a 30-year of hourly time series of discharges. A broad spectrum of baseflow separation methods to find a suitable method to separate the base flow from the total discharges were applied. This issue has an important role in the estimation of flood wave characteristics. Using the selected methods of baseflow separation, flood wave volumes and characteristic shapes of the maximum annual and seasonal flood waves were determined. The flood wave volumes and shapes were determined using the Floodsep program.

Subsequently, the statistical processing of the maximum peak discharges determined the N-year maximum annual and seasonal discharges. Then, for pairs of the N-year discharge and their associated volumes, a join distribution of probability was constructed by a copula. From the copula, the associated volume of the N-year culmination discharge was selected, and the probability of exceeding or reaching it was determined. Based on this analysis, a set of control flood waves was determined.

This research provides sufficient results for designing control waves important for assessing water structures with extreme loads and establishing a functional methodology for assessing other water structures in the region.

Analysis of changes in daily discharge characteristics using the MPI and KNMI climate scenarios until 2100 in selected river basins in Slovakia

Zuzana Sabová, Silvia Kohnová

Slovak University of Technology in Bratislava, Slovakia

It is expected that in the future, water will be the resource most severely affected by climate change. Several studies have already shown that small perturbances in the amount and frequency of precipitation can also result in significant impacts on monthly discharges and changes in their regime. Therefore, this study is focusing on an evaluation of changes in average monthly discharges and selected characteristics of maximum and minimum discharges up to 2100 using the MPI and KNMI climate scenarios. Two catchments, i.e., the Jablonica gauging station in the Myjava River basin and the Banská Bystrica gauging station in the Hron River basin, were selected for the analysis. To calculate and compare future changes in the hydrological regime, the daily discharge time series data were used. The data observed were from 1981 to 2010; the modelled data uses the HBV rainfall-runoff model and the modelled data for the MPI and KNMI climate scenarios from 1981-2100. The whole time period was then divided into four time periods, i.e.,1981–2010, 2011–2040, 2041–2070, and 2071–2100. The Indicators of Hydrologic Alteration (IHA) software was used to analyze changes in the average monthly discharges and selected characteristics of the maximum and minimum discharges (m-daily maximum and minimum discharges). The results showed an increase in the average monthly discharges in February, March and April, and a decrease in the average monthly discharges in August and September. An increased incidence and duration of droughts are expected in the future, especially in the summer months, and periods of increased discharges are expected in the spring.

Key words: IHA software, average monthly discharges, MPI and KNMI climate scenarios, Myjava River Basin, Hron River Basin

ISOTOPIC HYDROGRAPH SEPARATION IN THE HYDROLOGICAL OPEN AIR LABORATORY, AUSTRIA

BORBÁLA SZÉLES[1], JURAJ PARAJKA[1], L. HOLKO[2], S. WYHLIDAL[3], K. SCHOTT[4], C. STUMPP[5], P. HOGAN[1], L. PAVLIN[1], P. STRAUSS[6], G. BLÖSCHL[1]

(1 Institute of Hydraulic Engineering and Water Resources Management, Faculty of Civil Engineering, Vienna University of Technology, Vienna, Austria (szeles@hydro.tuwien.ac.at)
(2 Institute of Hydrology, Slovak Academy of Sciences, Bratislava, Slovakia (holko@uh.savba.sk)
(3 NES, Nuclear Engineering Seibersdorf GmbH, Seibersdorf, Austria (Stefan.Wyhlidal@nes.at)
(4 BOKU University of Natural Resources and Life Sciences, Institute of Soil Science, Stable Isotope Group, Tulln, Austria (katharina.schott@boku.ac.at)
(5 BOKU University of Natural Resources and Life Sciences, Institute for Soil Physics and Rural Water Management, Vienna, Austria (christine.stumpp@boku.ac.at)
(6 Federal Agency of Water Management, Institute for Land and Water Management Research, Petzenkirchen, Austria

Exploring the isotopic composition of precipitation and streamflow in small catchments and the event and pre-event components of precipitation events using two-component isotopic hydrograph separation may better explain overall catchment behaviour, more specifically the sources of the origin of the water. The aim of this study is to investigate the origin of water for different streamflow gauges in a small agricultural catchment that represent different runoff generation mechanisms. The analysis will be performed in the Hydrological Open Air Laboratory (HOAL) in Austria, a 66 ha experimental catchment dominated by agricultural land use. One of the main specialities of this research catchment is that several tributaries of the catchment representing different runoff generation mechanisms are gauged. Two-component isotopic hydrograph separation (for both ^{18}O and ^{2}H) will be conducted for three streamflow gauges (the catchment's inlet and outlet, and a tile drainage system) for multiple events in the period 2013–2018. The results will be linked and interpreted using additional observations such as time-lapse images of overland flows, electric conductivity measurements, groundwater level changes, evapotranspiration measurements, etc. The aim is to explain and discuss the processes of rainfall-runoff generation in small agricultural catchments.

ANALYSIS OF THE IMPACT OF SOIL EROSION MODEL PARAMETERS ON A FINAL EVALUATION OF SOIL EROSION PROCESSES

MATÚŠ TOMAŠČÍK, KAMILA HLAVČOVÁ, ZUZANA NÉMETOVÁ , MICHAELA DANÁČOVÁ,

Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Department of Land and Water Resources Management (michaela.danacova@stuba.sk)

The aim of the study is focused on an evaluation of the input of soil parameters into the physically-based EROSION-2D erosion model. The initial parameters entered into the erosion model directly influence the model results and thereby the resulting evaluation of the soil erosion processes. Soil parameters specific to the selected physically-based EROSION-2D model are hydraulic roughness, erosion resistance, and the correction factor. These parameters were calibrated by comparing the modelled volumes of the soil sediment with the measured data on the experimental plots and by the parameter catalogue. This proves differ as a result of variously. At the same time, it was found that sediment removal is most influenced by the parameters of erosion resistance input and hydraulic roughness in connection with the slope conditions in the area. The correction factor and the initial soil moisture have the most significant influence on the volume of surface runoff.

Keywords: Erosion-2D model, soil parameters, erosion processes, calibration

CHANGES IN THE COMPOSITION AND MORPHOLOGY OF FLOODPLAIN FORESTS RESULTING FROM MANAGEMENT OF THE DANUBE BASIN

VIKTÓRIA TYUKOSOVÁ, TIMEA PETROVÁ

Slovak University of Technology, Department of Land and Water Resources Management, Radlinského 11, 810 05, Bratislava, Slovakia (viktoria.tyukosova@stuba.sk)

The construction of the Gabčíkovo Nagymaros waterworks, which began their operations in 1992, disrupted the natural dynamics of the water regime of the Danube River. These changes in the water regime and the movement of the surface water and groundwater levels caused the modification or loss of habitats that bore the characteristic features of floodplain habitats.

These modifications resulted in changes in the morphology and of the composition of floodplain stands. These changes are traceable in the historical records of dendrological and botanical research. Changes in the branch system of the Danube River and the cutting off of the side channels from the main riverbed blocked the natural migration corridor. Plant diaspores used to be transported by these channels. These corridors allowed only one-way spreads. By the blocking of these migratory routes, the relocation of indigenous species stopped, which thereby prevented the natural regeneration in the structure and of the composition of the floodplain forests. Improper anthropogenic interventions in the landscape, such as the construction of roads crossing the floodplain, the cultivation of monocultures of hybrid poplars, and the deforestation of areas for agricultural purposes, also harmed the state of the biodiversity of the floodplain stands. The changes in the water regime and the consequent intensive agricultural activity on deforested lands caused eutrophication in the area, especially in reaches where the floodplain forest still has a hydrological connection with the main flow of the Danube. These factors have led to changes in the dendrological and botanical composition, that are perceptible when comparing data from 1951 through the present. Average new tree species are added every decade, while the indigenous species are slowly declining.

Keywords: floodplain habitats, indigenous species, forest morphology, floodplain stands

Index