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Abstracts of the Conference

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ESTIMATION OF THE EVAPOTRANSPIRATION RATES OF LAKE NEUSIEDL AND ITS WATERSHED ON A MONTHLY SCALE

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The focus of this work is the estimation of the evapotranspiration rates of Lake Fertő (hereafter referred to as "Lake Neusiedl") and its watershed for 1973-2015 in a monthly scale.

The determination of average long-term lake evaporation is not a simple task, as one needs to account for reed-covered areas and changes in heat storage over time. In exceptional cases, such as in the case of Lake Neusiedl and its catchment, when the area of the lake and the reed belt is a relatively large portion of the entire watershed, the evapotranspiration (ET) of the reed belt can be estimated using the water balance of the catchment.

For estimating the evaporation, Morton's WREVAP program, which is based on this complementary relationship, was used. Three types of areas were distinguished in the calculations: open water, the reed belt and the remaining parts of the catchment area, by making use of the principle of the conservation of mass. Accordingly, the mean annual ET rate of the watershed should equal the total evaporated water from the three sub-areas. For the calculations it was necessary to determine the size of the sub-areas and the amount of their evaporation.

The ET rate of the total catchment area can be determined by a simplified water balance of the watershed as the difference between precipitation (P) and runoff (Q). In previous independent research, Morton's Complementary Relationship Lake Evaporation (CRLE) model proved to be the most reliable method to define open water evaporation, so it was preferred in these calculations. With the help of the Morton's Complementary Relationship Areal Evapotranspiration (CRAE) model, the ET rate of the remaining parts of the catchment area (without the lake and reed belt) could be estimated. After these calculations, the only missing value in the water balance equation was the ET rate of the reed belt.

The results of these methods were compared to several independent evaporation estimations, such as the evaporation values of the Northern Trans-Danubian Water Authority and the Austrian water authority experts.

Keywords: evaporation, evapotranspiration, climate change, water balance, Lake Neusiedl

WATER BALANCE OF DIFFERENT LAND COVER TYPES IN HUNGARY

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The water balance of different land cover types in Hungary was analyzed using remote-sensing based evapotranspiration (ET) maps (1 km^2 spatial resolution). The spatially distributed recharge (R) was calculated as the difference of precipitation and evapotranspiration: $R = P - ET$. During the examined period (2000–2008) ET and R were 90% and 10% of the precipitation amount. ET and R were analyzed in the context of land cover types based on Corine Land Cover 2006. As the raster maps have 1 km^2, while the Corine vector map has higher resolution, a number of ET and R pixels would be calculated to more than one land cover type. Thus, only pixels with at least 90% covered by the same land cover type were selected. The ET and R of "forest and semi natural areas" category were analyzed by regions within the context of groundwater depth and leaf area index (LAI).

This research has been partly supported by the Agroclimate.2 VKSZ_12-1-2013-0034 project.

Keywords: evapotranspiration, recharge, water balance, land cover

USING QMRACATCH – A HYDROLOGICAL PROCESS MODEL INTEGRATING MICROBIAL INFECTION RISKS – TO IDENTIFY SUSTAINABLE MANAGEMENT OPTIONS FOR LONG-TERM DRINKING WATER RESOURCE PLANNING

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River water resources in urban environments play a critical role in sustaining human health and ecosystem services, as they are used for drinking water production, bathing and irrigation. In this study the QMRAcatch hydrological process model was used to assess required long-term virus infection protection for drinking water production. The study area is located on a river/floodplain area along the Danube; it is used for drinking water production by river bank filtration and further disinfection. The aim of this study was to simulate concentrations of human enterovirus and human-associated genetic fecal markers in the River Danube and to develop future scenarios based on projected climate and population growth in collaboration with urban water managers. The scenarios identified until 2050 include increased wastewater discharge rates due to the projected growth in the urban population, an increase in river low flows and flood peaks (Parajka et al., 2016), and more frequent storm and overflow events of urban sewer systems. Based on the simulation results for the scenarios developed, sustainable requirements of the drinking water treatment system for virus reductions were evaluated to achieve the health risk target. The model outcomes are used to guide practical and scientifically sound management options for long-term water resource planning.

This paper was supported by FWF (Vienna Doctoral Program on Water Resource Systems W1219-N22) and the GWRS project (Vienna Water) as

part of the “(New) Danube-Lower Lobau Network Project” funded by the Government of Austria and Vienna, and the European Agricultural Fund for Rural Development (LE 07-13).

Keywords: microbial water quality, riverbank filtration, scenario simulations

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SPATIOTEMPORAL VARIATIONS OF ORGANIC MICROPOLLUTANTS AND FAECAL INDICATORS DURING BANK FILTRATION ALONG A HIGHLY DYNAMIC RIVER

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The fate of organic micropollutants during riverbank filtration (RBF) along a large and highly dynamic river was studied using a combination of spatiotemporally resolved sampling and 3D transport modelling. A total of 9 micropollutants were analyzed using LC MS/MS, next to standard chemical parameters, two faecal indicator bacteria, bacterial spores and genetic microbial source tracking (MST) markers. The RBF system shows a decrease in micropollutant and faecal indicator bacteria concentrations from the river towards the drinking water abstraction Well 1 (well 1). For some compounds, however, concentrations stayed fairly stable throughout the aquifer. Three dimensional transport modelling showed that Well 1 abstracted different water during different flow conditions.

Keywords: micropollutants, riverbank filtration, transport

MULTIDISCIPLINARY ASPECTS FOR ADAPTATION TO CLIMATE EXTREMES IN FORESTRY

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Ongoing climate change and the shorter return period of climate extremes have been observed to affect the distribution and health status of forest ecosystems in the Carpathian Basin.

Our aim were (1) to synthetize the existing database and scientific results in order to find connections between the observed tendencies of site conditions and the tree species composition, as well as (2) to estimate the expected change of the water balance, the soil water storage capacity and the potential vegetation cover due to climate change.

Climate tendencies were analysed for all Hungarian forest regions using meteorological observations for the past and based on regional climate change scenarios until 2100. Actual evapotranspiration was derived from remote-sensing products. For climate impact analysis the Budyko-model was applied in spatially-distributed mode. Field measurements were carried out to determine the effects of the hydrological extremes on the soil water holding capacity. Water stress was defined using the modified Thornthwaite-type monthly model. Potential vegetation of forest stands was determined from site conditions and modified according to climate scenarios.

Observed temperature and precipitation records of the last 50 years refer to a warming and drying tendency of summers that is projected to be more intense until the end of the century. Increase of the frequency and severity of extremely hot droughts can lead to higher evapotranspiration rate and to the limited amount of available water, especially on sites with low soil water holding capacity. Consequently, a significant change of the plant species composition and potential vegetation cover is expected, first of all in case of the drought sensitive forest tree species. The identification and use of chemical markers as potential indicators for the selection of climate resistant trees for future propagation material will be of major importance.

These synthetized information provides a multidisciplinary aspect for detecting potential climate change impacts and for supporting adaptation in forest ecosystems.

Acknowledgements: Research was supported by the Higher Education Structural Adjustment Fund (FSA).

Keywords: climate change, extreme events, water balance, available water, potential vegetation cover, climate resistant trees

1D MODELLING OF THE WATER BALANCE OF POPLAR PLANTATIONS

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In Slovakia an objective of Ikea Industries Ltd., is to establish 4, 000 ha of a new short rotation plantation (SRP). It is widely known that the water supply is one of the most important site parameters for poplar hybrids. Biomass production decreases in periods of water shortages, and long periods of drought can even cause the decaying of the trees. The key parameter for the plantations is the water supply, because the water storage capacity of the sand and the coarse sandy soil is low. In addition, a new source of problems could be the impact of climate change (extreme temperatures and water shortages).

The water balance of the vadose zone was simulated using HYDRUS 1-D software to test the suitability of the site conditions for poplars. Since the model was mainly developed for modelling the water balance in non-forest areas, we introduced crown interception (INT), reduced potential evapotranspiration (PET-INT), and precipitation (P-INT) as upper boundary conditions for the model. We modelled two varieties of sites: two-layer (sandy loam, sand) and three-layer (sandy loam, sandy clay, sand) soil; in the case of individual soil profiles, two other variants for the lower boundary conditions was analyzed. In one case free drainage, otherwise, a constant pressure head, was assumed.

The actual transpiration was higher in the presence of the water table close to the surface, which was induced by a constant pressure head. Otherwise, the close to the surface sandy clay layer increased the water-holding capacity of the soil, so this effect also raised the transpiration rate. In summary, the actual transpiration was the highest for the three-layer soil profile at a constant pressure head, while in the case of the two-layer soil, the free drainage was the lowest.

Supported by the ÚNKP-17-2-I New National Excellence Program of the Ministry of Human Capacities. This research was also supported by the EFOP-3.6.2-16-2017-00018 projects.

Keywords: SRP, hybrid poplar, groundwater, HYDRUS 1-D

INTRODUCING THE ECONIMC DECISION FRAMEWORK INTO SOCIO-HYDROLOGY

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How can you describe two-way coupled feedbacks of water systems and society? We use an interdisciplinary approach to tackle complex scientific questions in the emergent field of socio-hydrology. An economic framework is added to hydrological and resource management research, and mathematical optimization methods are developed and improved.

The applications are optimal decisions in two fields. Firstly, a society or a firm in flood risk areas chooses optimal investment strategies for flood protection measures. Secondly, household consumption and farmers fertilizer decisions yield strategies for phosphorus management in a general equilibrium framework.

The poster provides an overview of four research articles on the applications.

Keywords: socio-hydrology, optimal decisions, economic framework

NEW TERRESTRIAL AND SATELLITE-BASED SNOW MAPPING METHODS ON A LOCAL SCALE AND THEIR APPLICATION IN SNOW-HYDROLOGICAL MODELLING

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Despite their hydrological relevance to the surrounding lowlands, high elevation areas always were and still are regions with a strongly limited measurement infrastructure for reasons of cost and remoteness. A scale gap in data thereby exists, especially between alpine measurement sites, which deliver point data, and regional scale satellite products. This is of particular importance as many snow-hydrological processes take place on a local scale and as the spatially distributed description of these processes in models is difficult and needs to be carefully evaluated. Here, we present three recent snow mapping methods using LIDAR, camera and satellite data that can potentially close the existing gap. We show the advantages and pitfalls of the different measurement approaches as well as a modelling example of the Zugspitzplatt catchment in Germany. There, we use the data not only for evaluating the model but also to improve the setup of the model itself.

THE RECARE PROJECT – PREVENTING AND REMEDIATING DEGRADATION OF SOILS IN EUROPE THROUGH LAND CARE. THE MYJAVA RIVER BASIN CASE STUDY.

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The world's soils face a wide range of threats that could undermine the very basis of our current way of life. Recently, Europe has seen flooding that dramatically and tragically demonstrates how such threats can impact people's lives and property. As well as making people aware of these threats to soil, European scientists involved in an EU-funded project called RECARE are working with those people who manage soil, i.e., farmers, planners, builders, and policymakers, to identify practical measures to ensure that these urgent threats are not just stopped, but whenever possible, reversed. Working on 17 case studies across Europe, from Iceland to Cyprus, these scientists and managers are developing solutions to the problems of flooding and landslides, desertification, soil erosion, soil compaction, the contamination of soils, soil biodiversity, loss of organic matter, salinization, and soil sealing. A team of researchers from the Department of Land and Water Management at the Faculty of Civil Engineering, SUT in Bratislava, is working as a partner of the RECARE project, and is focusing on problems of protecting soil against floods and water erosion.

The Myjava Hills highlands are known for their quick runoff response and related muddy floods, which are determined by both natural and socio-economic conditions. The present-day cultural landscape of the Myjava Hills is the result of approximately 600 years of the anthropogenic transformation of the naturally forested landscape. The drivers for this flood-prone regime, which also experiences frequent flash floods, include impervious subsoils, frozen subsoil, extreme variability in precipitation, and adverse land use changes. The deforestation and agricultural cultivation of extensive areas have caused an enormous intensification of the originally natural landscape-forming processes and tillage erosion. The combination of adverse hydrological conditions, such as the impervious subsoils, frozen subsoil, and changes in extreme precipitation mentioned above, has led to the development of gullies. These processes increase the slow and harmful geomorphic changes, thereby leading to erosion from tillage and gullies.

Three types of experiments on plot, hill slope and catchment scales have been undertaken at the Myjava pilot sites within the RECARE project. Two

experiments were carried out at the locality of the Turá Lúka hill slope, i.e., measurements of the generation of surface runoff on small experimental plots, and measurements of the characteristics and development of the erosion gully on that site. The treatment to be tested during the first experiment is crop management on arable land. The treatment to be tested during the second experiment is the construction of small wooden check dams, which were inbuilt for the stabilisation of the gully. The third experiment was provided near the town of Myjava in the Svacenický Creek catchment, where the sedimentation of a small water reservoir (polder) at the catchment's outlet was monitored. During this experiment the off-site effect of soil erosion resulting in the sedimentation of a small water reservoir was examined. Land use management will be tested for reducing the sediment transport from the catchment slopes.

Complex Urban Ecological Investigation at the Area of Székesfehérvár city, Hungary – Preparation of a Water, Soil and Microbiological study

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The University of Sopron initiated a complex urban ecology project in September 2010 which has been focusing on the effects of urbanization. Based on former results, monitoring measurements will start this year.

The main purpose of this current study is to monitorize the actual contamination level of soil and sediment properties in Székesfehérvár, supplemented with mesofauna investigations.

In our investigation, the chemical and physical characteristics of 144 soil surface samples will be analysed in Székesfehérvár and in its surroundings. Heavy metal contents of Cd, Co, Cu, Ni, Pb and Zn will measured. The city is surrounded by agricultural territories, thus toxic element enrichment is also possible on the suburb due fertilization. High amount of toxic elements are expected in soils of watercourses. Therefore, water and sediment properties will be tested to complete the soil database. The sediments show a high capacity to accumulate and integrate the low concentrations of trace elements in water through time. For bioindication analyses, the main groups of soil mesofauna will be examined. Biological quality of soil will be evaluated using the QBS index based on the microarthropod groups present in the soil samples. In selected plots, impact of pollution will be evaluated also by Collembola community data as bioindicator.

Field and laboratory results can be processed using geospatial methods and become comparable with former database.

Acknowledgements: Research was supported by the Higher Education Structural Adjustment Fund (FSA).

Keywords: sediment investigations, soil properties, soil mesofauna, urban ecology, water quality

EXAMINATION OF THE TERRITORIAL DISTRIBUTION OF ECOLOGICAL FEATURES INDICATED BY AQUATIC MACROINVERTEBRATES

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According to the EU Water Framework Directive (WFD), the most important element in the assessment of an ecological status is the biological status, which is determined by the status of five groups of organisms (including benthic invertebrates). Macroinvertebrates indicate many environmental factors well; therefore, they are very useful in detecting changes in the status of an environment.

The main aim in this research was to investigate the territorial distribution of the main metrics indicated by the macroinvertebrate data, because this can show the local differences and anomalies, which can indicate the impact of human pressures.

The quantitative and representative macroinvertebrate data stem from the WFD's biological monitoring from 2007 to 2015. The macroinvertebrate data was processed using the ASTERICS 4.0.4 program. The program calculated some important metrics (i.e., microhabitat distributions, longitudinal zonation, functional feeding guilds, etc.). The metrics were plotted using the coordinates of the monitoring points of the ArcGIS 10.4 program.

The Laboratory of the Government Office of Győr-Moson-Sopron County is thanked for the macroinvertebrates data; furthermore, the use of the basic data of the monitoring points from the West-Transdanubian Water Directorate is also greatly appreciated.

Keywords: aquatic macroinvertebrates, territorial distribution, autoecological information, functional feeding guilds, microhabitat, longitudinal zonation

COMPARING BIAS-CORRECTED RCM SIMULATIONS WITH A SPECIAL FOCUS ON HYDROLOGICAL APPLICATIONS

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Global climate change not only means higher temperature values, but also changes in the distribution of precipitation in space and over time. Both excess moisture and water scarcity may result in different problems, e.g., infrastructural damage, capacity deficiencies in hydroelectrical systems, agricultural losses, transportation difficulties, and unsatisfied public water demands. Hydrological processes (e.g., runoff, infiltration, snow accumulation and melting, etc.) are clearly determined by climatic conditions; therefore, in order to make estimations for future hydrological processes, we have to take climate models into account. The aim of our study is to develop a methodology, which is able to simulate runoff values in the past as well as in the future.

In this study we have used a distributed, physically-based DIstributed WAtershed (DIWA) hydrological model. It takes into account all the relevant processes of the hydrological cycle (e.g., interception, snow accumulation and melting, infiltration, soil moisture redistribution, evaporation, transpiration, subsurface and surface runoff, etc.) and also the key factors that determine these processes (e.g., topography, land cover, LAI, texture and properties of soil layers, etc.). The amount of precipitation and the temperature, which are necessary input data for DIWA, are provided by the observation-based CARPATCLIM database for a historical period, and the RegCM4 simulations for historical and future time periods. The validation of the regional climate model applied showed that RegCM4 underestimates precipitation in the summer, but overestimates it in the rest of the year. In order to eliminate these systematic errors, we applied different bias correction methods. To test the reliability of these corrected time series, a hydrological simulation driven by regional climate model outputs for the past has been completed. In our study we compare runoff values for a historical time period from different DIWA simulations using the CARPATCLIM, the raw and bias-corrected RegCM4 (based on different methods). We applied different bias correction methods to the raw RegCM4 outputs:

- the delta method, using the ratio of the mean and/or standard deviations of the observed and simulated time series;

- a percentile-based method, using multiplicative/additive correction factors, determined by empirical distribution functions;
- a weather generator-based method, using corrected average and standard deviations.

In order to achieve our final goal, we will perform a weather generator-driven Monte-Carlo simulation-based analysis that will allow us to statistically compare the runoff characteristics between the present and future climate conditions.

If the hydrological simulation driven by the RegCM4 outputs is reliable for the historical period, then we can proceed with hydrological simulations for the future as well.

FLOODS AND LONG-TERM WATER-LEVEL CHANGES IN MEDIEVAL HUNGARY

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In documentary evidence from the Carpathian Basin 21 flood data are presently known from the 11^{th}-13^{th}, 82 from the 14^{th} and 120 from the 15^{th} centuryies; out of these cases 62 were reported in connection with the Danube. The evidence is mainly related to individually reported, ongoing flood events, while a smaller portion of the reports refer to consequences of past flood events and/or frequent flooding. In archaeological and sedimentary evidence, which is partly related to the Danube and partly to other waterflows, lakes and wetlands, either periods with more frequent great or extraordinary flood events or long-term hydrological changes (water-levels: high or low) can be detected from the 6^{th} century onwards. Due to the scarcity or complete lack of documentary evidence, up to the 13^{th} century mainly low-resolution data are available on water-level changes, and therefore the late high-medieval and late medieval period can be discussed in more detail.

Concerning individually-reported flood evidence, the period of the mid- and late 1330s and the 1340s (1342 and 1343 in centre) seem to be richer in recorded flood events, while both in archaeological and documentary evidence - either individually reported or past/frequent floods -, the first and the last decades of the 15^{th} century (especially on the Danube) appear to have been richer in reported flood events. Moreover, periods, potentially richer in great floods, might have also occurred around the turn of the 12^{th}-13^{th}, early 13^{th} and in the second half of the 13^{th}-early 14^{th} centuries: in these later cases, however, the low quantity of the evidence does not yet permit to draw firm conclusions.

In the presentation, after an introduction on the source evidence and the available database, flood-rich periods - based on high, medium and low-resolution documentary, archaeological and natural scientific evidence - are provided. Furthermore, examples of great flood years, extraordinary floods as well as flood-related longer-term (hydromorphological) processes are presented. Due to the abundant information available in documentary and archaeological evidence, the socio-economic responses to short-, medium- and long-term can be as well analysed: in the presentation some short case studies, mainly related to the Danube and partly to other waterflows, are presented and discussed.

Keywords: flood rich periods, medieval Hungary and Slavonia, long-term hydrological and socio-economic response

SYMBOLIC REGRESSION FOR THE ESTIMATION OF THE TRANSFER FUNCTIONS OF HYDROLOGICAL MODELS

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Current concepts for the regionalization of the parameter of spatially distributed rainfall-runoff models rely on the a priori definition of transfer functions that globally map land surface characteristics (such as soil texture, land use, digital elevation, etc.) into the model's parameter space. However, these transfer functions are often chosen ad hoc or derived from small-scale experiments. This study proposes and tests an approach for inferring the structure and parametrization of possible transfer functions from runoff data to potentially circumvent these difficulties. The concept uses context-free grammars to generate possible propositions for transfer functions. The resulting structure can then be parametrized with classical optimization techniques. Several virtual experiments are performed to examine the potential for an appropriate estimation of transfer functions; all of them use a very simple conceptual rainfall-runoff model with data from the Austrian Mur Catchment. The results suggest that a priori defined transfer functions are in general well identifiable by the method. However, the deduction process might be inhibited, e.g., by noise in the runoff observation data, which often leads to transfer function estimates of a lower structural complexity.

Water-Related Changes in the Land Cover in the Carpathian Basin since the 19th Century

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Due to the water regulation and wetland reclamations of the 19th-20th centuries, water-related surfaces are the most endangered habitats in Europe's lowlands. Changes in the water-related surfaces in the Carpathian region have been analysed on the basis of a historical land cover dataset created for the project "200 years of land use and land cover changes and their driving forces in the Carpathian Basin", which is supported by the NASA Land Cover and Land Use Change Program. The database contains digital historical maps in three time layers (1820s-1860s, 1920s-1940s and 1950s-1970s); the land cover information has been mapped from topographical military maps using a $2 \cdot 2$ km sampling grid. The actual land cover information was derived from the CORINE 1:100 000 database (EEA 2006).

The planned poster presentation aims at showing an assessment of the changes of 'water', 'wetland' and 'wet grassland' surfaces. The transformations are demonstrated by map series and transition matrices. While the shrinking of open water surfaces is relatively moderate, the wetlands and wet grasslands show significant changes. Their joint proportion has decreased by a third since the 1950s-1970s. The drying of the plains signifies a huge risk of aridification, which has serious consequences for the mitigation potential of the climate change as well.

The research was supported by the Agroclimate 2 project (VKSZ_12-1-2013-0034).

Improvement of the ecosystem services of soil by sustainable land management practices in the Myjava River basin

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The main aim of this study is the development of methods for the assessment of the ecosystem services (ESS) of soils within the RECARE project and the participatory identification of measures to combat soil threats caused by floods in the Myjava River basin. The Myjava Hills highlands are known for their rapid runoff response and related muddy floods, which are determined by both the natural and socio-economic conditions. Within the frame of the mentioned project, the ESS framework with detailed relationships between the ecology, societal response, driving forces and also human well-being was identified. Next, to assess the SLM practices in the pilot basin, the stakeholders, who showed an interest in solving the flood protection problems in their areas, took an active part in the process of evaluating, scoring and selecting the best sustainable land management practices (SLM) for the flood protection of the soil. The methodology for assessing soil ecosystem services for the Myjava River basin and proposals for improving ESS by flood protection technologies is being developed through consultations with the end users, i.e., the stakeholders, by using their knowledge and opinions about the soil threats and protection of the soil as well as the ecosystem services of the soil. Agricultural technologies in the fight against soil loss resulting from erosion have been implemented for many years (mitigation of ploughing, vegetated strips, drains). Many technologies were discussed at the workshop, and some of them were selected for potential experiments and testing. The local stakeholders were interested in the proposed measures and technologies for the protection of soil against flooding in their area. From the results which were proposed, the technology of vegetative strips was top rated within the total results among all the SLM measures in all the categories; it was followed by water-retaining ditches and small wooden dams. Building a polder least meets the proposed SLM criteria.

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Keywords: Ecosystem services, RECARE project, Myjava catchment, stakeholders, flood protection

VARIABILITY OF SNOWPACKS IN SPACE AND OVER TIME

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The study deals with an evaluation of the variability of snow accumulation and snow melt on micro and regional scales. The variability of a microscale is evaluated by field measurements of snow cover characteristics (depth, water equivalent, and density) and discharges from a small mountain catchment. A method for calculating snow distribution influenced by wind that uses the morphometric characteristics of the terrain is developed. The long-term variability of snow melt is evaluated using 25 years of measurements at the Kühtai climate station in the Austrian Alps by melt factors. The spatial variability of melt factors is evaluated in the small mountain catchment. The variability of snow cover on a regional scale is evaluated by processing MODIS satellite data using a new method for determining snow line elevations. Besides the development and validation of this method, snow line elevation and snow-covered areas are evaluated in selected basins in space and over time.

Key words: snow, snow water equivalent, mountain catchment, MODIS

STEPS IN THE PROCESS OF ERADICATING *Fallopia japonica* IN AREAS CLOSE TO RIVERS

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Invasive plants invade natural ecosystems; they are introduced and allochthonous; they act like dominant and aggressive plants at a new locality. These species inhibit autochthonous species. The situation is complicated when the invasive plants grow in riverbank vegetation. The uncontrolled growth of invasive plants, such as *Fallopia japonica*, is dangerous, and there is a need to find a solution to this issue. One of the possibilities is prevention and eradication.

This work is focused on the time flow and steps to eradicate *Fallopia japonica*. It is important to take adequate steps during the process. Eradication can be mechanical, chemical or combined. The results are influenced by the choice of adequate methods. The chemical approach was selected by using a herbicide and was also mechanical by cutting and deracinating the invaders.

The process of the research is ongoing. The results will be visible in future vegetation periods. The behavior of the species will be monitored. The time flow is very important in this research because the plants are living organisms. The future vegetation periods will show if there has been any success.

Keywords: *Fallopia japonica*, eradication, invasive plant

IDENTIFICATION OF CATCHMENTS WITH SIMILAR FLOOD CHARACTERISTICS IN AUSTRIA AND SLOVAKIA

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Floods are generated by a complex interplay of various processes that are influenced by climatic, physical and human factors [1]. Multivariate statistical methods such as cluster analysis can assist in the identification of factors which influence flood behavior. The main objective of this study was the identification of catchments with similar flood characteristics in Austria and Slovakia. The grouping was applied to 555 gauging stations located in Slovakia (59) and Austria (496) with the length of observation from 30 to 51 years during the period 1960-2010. The identification of similar regions is performed using the nonhierarchical k-means clustering algorithm. The silhouette method was used for determination of the optimal number of clusters. The analysis is performed for two different combinations of catchments and flood seasonality characteristics. The first combination consists of the mean catchment elevation, forest cover and concentration of floods around the mean date of flood occurrences (r). The second combination consists of a catchment area, the mean catchment elevation, forest cover, and concentration of floods around the mean date of flood occurrences (r). For both combinations, optimal number of clusters was 2. Not including the catchment area in the analysis (the first combination) resulted in both a higher global average silhouette width and a higher average silhouette width over each of the individual clusters. These larger silhouette widths indicate a higher degree of confidence in the two clusters obtained. Cluster 1 is located in lowland areas and is characterized by a wide temporal spread of the timing of floods (February to July). Cluster 2 is located in mountainous areas and is characterized by summer floods (June and July), which have a high temporal concentration (a strong seasonality).

Keywords: clustering algorithm, floods, Slovakia and Austria

Can Numerical Modeling Error Analysis Methods Determine Changes in a Watershed?

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In order to promote long-term sustainable water management in northwestern Hungary, decision-makers need to understand the hydrological variability in the region. To better quantify hydrological variability in the region, this study developed rainfall-runoff models of four watersheds in the Kisalföld region. The models were then used to identify variations in runoff characteristics caused by climatic factors or fundamental alterations to the watershed itself through the application of numerical error analysis.

The HEC-HMS continuous rainfall-runoff model was calibrated using data from 2008 to 2015. Then validations were performed using data between 2000 and 2015. Graphical comparison of predicted and measured runoff vs. time allowed us to make adjustments during the calibration phase, and served as a qualitative measure during validation. To better quantify differences between model prediction and measured performance, two statistical measures were used: the Nash-Sutcliffe model Efficiency (NSE); and the Kling-Gupta Efficiency (KGE). Both NSE and KGE were evaluated during the calibration and validation phases.

In 2010, a significant jump occurred in the error analysis for all four watersheds. Additionally one watershed showed significantly different error behavior during validation compared to calibration period. The jumps were caused by a significant climatic event, such as the rainfall in 2010. Another impact detected through error analysis was the re-channelization of one watershed. Follow-up investigation revealed that the channel was rebuilt upstream from the gauging station. By observing the continuous statistical error measurements, changes can be detected in either climatic conditions, watershed characteristics, or may indicate gauging or data collection errors.

This work was undertaken as part of a project founded by the EFOP-3.6.1-16-2016-00017.

Keywords: watershed hydrology, numerical modeling, statistical measure, impacts on watershed

Mapping Seasonal Runoff in Northwestern Hungary

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Seasonal variability in stream flow is a key factor in water resources management. Since predictable patterns in seasonal water availability are important data for water resource management decisions. However, predictability is difficult where stream flow measurements are not available. To alleviate the problem, we have applied watershed index and geostatistical methods to map seasonal runoff in northwestern Hungary. Thirty-six gauged watersheds were selected to evaluate seasonal variability of runoff based on 15 years of measured data. Pardé numbers were used to describe long-term monthly distribution of flows. At first the maximum monthly flows were determined and then the watersheds were clustered based on the Pardé distribution. With trend analysis the yearly variation of the flows were evaluated. Finally, geostatistical interpolation methods were applied to predict regional monthly flows using point kriging at gauged and ungauged locations. A cross-validation error analyses method was used to evaluate the goodness of the geostatistical prediction.

This work was undertaken as part of a project founded by the EFOP-3.6.1-16-2016-00017.

Keywords: geostatistics, point kriging, Pardé, seasonal runoff, runoff prediction

THE APPLICATION OF TWO PHYSICALLY-BASED EROSION MODELS IN SMALL CATCHMENTS: A CASE STUDY OF THE MYJAVA HILL LAND, SLOVAKIA

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The goal of this study is the application of two physically-based erosion models, i.e., EROSION-2D and EROSION-3D, in small Slovak catchments. These two models are event-based and calculate potential soil water erosion during actual measured rainfall events on agricultural land (Schmidt, 1996). Both models are predominantly based on physical principles and simulate surface runoff, the erosion or deposition of material, and the detachment of soil particles for a single event. They provide good tools to simulate and quantify soil erosion, but have not been established for use in Slovak basins yet. The soil system of Erosion 3D is based on the fourth edition of the soil classification of "Bodenkundliche Kartieranleitung" ("KA 4", AG Boden, 1994). Because of different soil classifications, the first step required the creation of an overplot of the KA 4 textural system with the USDA textural system used in Slovakia. The model requires three input parameters, i.e., the relief, precipitation and soil. The first two parameters are relatively easy to obtain by taking advantage of a precise DEM with a $10 \cdot 10$ m resolution, and the precipitation data sets of the selected rainfall event, which was measured at the Myjava meteorological station. However, the soil input parameters are more complicated, which is why we focused on the creation of soil input data sets for Slovak conditions, including the establishment of a Parameter catalogue for every soil input parameter. The catalogue has been configured on the basis of an overplotted textural triangle.

The erosion models were applied to two small catchments (0.3 km^2 and 6.3 km^2) situated in the Myjava Hill Land in the western part of Slovakia, which is known for its quick runoff response and related erosion processes. The calculations were performed for three storm rainfall events and eight initial soil moisture scenarios, which were established by terrain measurements. Fallow, silage corn and winter wheat were chosen as the land cover types in order to estimate the variability of the soil erosion processes between the different field management practices.

The results point to differences between the EROSION-2D and EROSION-3D models, which had been expected. On the one hand, the differences in the values of the resulting parameters are relatively much greater, especially in the

case of the different land cover types. On the other hand, the effect of variable initial soil moisture on all the results calculated is the same in both models. This presented an obvious trend, which is described by a polynomial function with a high degree of correlation. In light of the storm rainfall events, the results show that the intensity of rainfall can be more important than the total amount of precipitation. Finally, we are able to say that we successfully set the models´ input parameters for Slovak conditions (mainly the soil conditions) and that both models are useful tools for estimating the soil erosion processes in the Myjava Hill Land. Of course, it is necessary to confront our results not only with other possible erosion models (empirical or physical), but also with actual in situ measured data and apply these tools in other catchments in Slovakia with different physical-geographic conditions.

Keywords: potential soil erosion, EROSION 2D and 3D, event-based model, initial soil moisture

Measurement, monitoring and assessment of changes in gully erosion in the Myjava River Basin

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Gully erosion is a form of water erosion, which mainly threatens cultivated slopes (soil and economic losses). The processes of this type of erosion are closely related to the formation of muddy floods during which a large transport of soil particles occurs. The high concentration of eroded material threatens water resources and their surroundings, roads and settlements, thereby creating erosion depressions called gullies.

On the territory of Slovakia there are many areas affected by gully erosion, one of them being the Myjava river basin. The Myjava catchment is one of the regions that has been largely affected and transformed by humans. The greatest changes in this landscape occurred due to the "Kopanice colonization" and later in the period of the collectivization of agriculture. This historical development of the landscape resulted in the catchment being characterised as having rapid runoff responses and related muddy floods, both of which are determined by natural and socio-economic conditions.

The article deals with the problems of the occurrence and formation of gully erosion in the Myjava catchment, with the aim of analysing the network of gullies on the historical maps. Based on the map analysis (1^{st} military mapping, 3^{rd} military mapping, topographic maps and basic maps), a gully erosion map was created for each time period.

For a detailed analysis of gully erosion, we focused on monitoring a selected gully in the Myjava Land Hills - Turá Lúka. The historical maps and data were used to assess changes in the spatial location of the gully during different time horizons. Nowadays, the gully is the subject of further experiments focusing on the assessment of changes in its volume and selected parameters (length, width, depth and slope of the bed) using a terrestrial laser scanner, UAV technology and GNSS. It is a representative experiment on a hill slope scale. The measurements were taken at various times during the RECARE project to monitor the dynamics of erosion processes in the gully. The results from the measurements show that despite stabilization measures (small wooden check dams), the erosion processes are still ongoing. Then we compared the years 2014 and 2015; the volume had increased by more than 10%. The gully volume increased by almost 80 m^3 between the years 2015 and

2016, which represents an 8% increase. Significant changes in the parameters of the length and average slope of the erosion gully were not recorded except for the fact that the slope conditions in front of five of the wooden check dams were partly reduced, which was caused by deposits of eroded soil particles. Erosion (an increase in the longitudinal slope) was recorded on two of the check dams.

Keywords: gully erosion, Myjava River Basin, analysis of the maps, measurements and monitoring

MULTISCALE AGRICULTURAL DROUGHT MONITORING IN AUSTRIA

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Natural phenomena such as droughts generally occur on large regional scales. They have an impact on the water cycle and, consequently, on vegetation. While those regional phenomena can already be observed on a coarse scale of a few tens of kilometres, local impacts that are visible between fields or within single fields require fine-scale data and analysis.

The aim of this work is to improve the understanding of soil moisture-vegetation dynamics on different scales (coarse, medium, and field scale) and to support the interpretation of satellite and in situ datasets. Moreover, locations in an agricultural area which are most likely to be affected by water scarcity events shall be identified by combining different satellite and in situ datasets. The study area is a hydrological open air laboratory (HOAL), which is operated in an agricultural catchment in Petzenkirchen (lower Austria).

The current state of the work will be presented at this conference. It deals with an analysis of coarse-scale datasets over the study area. The focus is put on a retrieval algorithm of soil moisture from backscatter data of the ASCAT sensor. By comparing the satellite dataset to in situ soil moisture measurements, retrieval parameters that model the effect of vegetation on the signal are optimized so that they better represent the local conditions of the study area. Moreover, an insight into the collection of in situ soil moisture and vegetation data at the HOAL is given.

Keywords: agricultural droughts, soil moisture, remote sensing

PARAMETRIZATION OF A RAINFALL-RUNOFF MODEL FOR SIMULATING RUNOFF UNDER CHANGING CLIMATIC CONDITIONS

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The aim of the paper was the parameterization of a spatially distributed rainfall – runoff model on selected river basins. In this work the WetSpa model was used for estimating the impact of land-use changes (in a forest's composition) and global climate change on the runoff regime in selected river basins. Distributed rainfall-runoff model simulations are often used to evaluate the impact of changes on the generation of runoff. These models have the advantage of reflecting the effects of land use on spatially distributed model parameters. This work contains land use change scenarios of forest associations and also scenarios of global climate change. Two types of land-use scenarios for the horizon 2075 were used to simulate runoff under changed land-use conditions. Assuming global climate change according to GCM, a CCCM circulatory model and an incremental climate change model created within NKP scenarios were developed.

Outputs from the KNMI and MPI climate scenarios were used to simulate runoff. Both types of change scenarios were prepared, and the runoff under the new conditions was simulated.

The results obtained suggest that such changes in land use (a change in a forest's composition) can have a significant impact on runoff changes in climatic conditions.

Keywords: rainfall-runoff modelling, global climate change, land-use change

SATURATION AREA DYNAMICS AND RUNOFF GENERATION ON AN AGRICULTURAL HILL SLOPE

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Understanding the dynamics of a saturated area on a hill slope is important when investigating the formation of a rapid overland flow, which often occurs during rainfall events on clayey semi-arid catchments. In this study we analyse saturated area dynamics during rainfall events in relation to the controlling parameters (i.e., soil moisture, amount and intensity of rainfall) to conceptualize the response of the saturated area to different events and field conditions. We visually observed the occurrence of ponding and surface runoff on a relatively flat, tile-drained agricultural hill slope ($15 \cdot 100$ m^2, 4% slope) using a web camera by taking time-lapse pictures every minute and processing the images to obtain the spatial patterns of the saturation area. A total of 10 saturation area dynamics during rainfall events were captured by the camera during two observation periods (August 2014 - April 2015, July - December 2016). We found that the saturation area dynamics at the study site are related to the surface runoff (rill flow) coming from an upstream source area, which is relatively flat. This rill flow formation causes a nonlinear relationship between the saturation area's expansion and the incoming rainfall on the near-stream downslope area. We identified four phases of saturation area dynamics that are related to the ongoing surface runoff process: (1) LP – Local ponding (no rill flow formation), (2) RO – Run on (rill flow passes through the site), (3) RRO – Rain on run on (rill flow on the site develops into sheet flow, which intercepts the rainfall), (4) REC – Recession (contraction of saturation area). The magnitude of the saturation area dynamics in each phase is related to the rainfall intensity (LP and REC phase) and the rainfall intensity and hill slope saturation (RO and RRO phase). An overland flow is only observed when the RO phase occurs, which depends on the state of the soil saturation across the hill slope. The magnitude of the rill flow, which controls the magnitude of the saturation area dynamics, depends on the rainfall intensity and the degree of soil saturation on the midslope and downslope areas.

Keywords: saturation area, surface runoff, hill slope

AGRICULTURE AS ONE OF THE POSSIBLE NEGATIVE FACTORS AFFECTING WATER QUALITY IN SURFACE STREAMS

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Agriculture is one of the largest consumers of fresh water in the world, using an average of 70% of all its resources. Is also considered a negative factor that influences the quality of water in surface streams. As a result of adverse water quality, there is a negative environmental problem of water eutrophication. Water quality in Slovakia as well as in other countries of the world decreased during the 20^{th} century. In some countries of the world this trend continues even today, on the other hand, the quality of water in some river section on Slovak territory has generally improved since 1989.

The negative impact of the decline in water quality is mainly due to increasing of population density and urbanization along rivers, it is also due to excessive and unnatural exploitation of water sources, as well. Sources of pollutants are divided into point and nonpoint sources (diffuse pollution). A typical example of a point source of pollution is an urban and industrial waste water outlet. The most important nonpoint source of pollution is agriculture and the use of land. The most important elements of diffuse pollution are insoluble substances, nutrients, fertilizers and toxic substances (for example, nitrates, nitrites, phosphates, chlorides and sulphates).

The article presents the results of the consumption of industrial and organic fertilizers on the territory of Slovakia in the period 2006 – 2015. We identify areas with the highest as well as the lowest levels of fertilization within our territory during this period. The data of the consumption of fertilizers in the monitored area of the agricultural land (in tonnes, but also in kg/ha) for the individual districts of Slovakia during the period 2006 – 2015 was provided by the Central Agricultural Control and Testing Institute in Bratislava. The total fertilizers consumption was calculated as the sum of the level of fertilization in each crop year for each district individually. In calculating the average consumption of fertilizers, instead of the sum function, the function of a simple arithmetic mean was used, but the input data was not in tonnes, but in kg/ha. During the period, the amount of organic fertilizers applied prevailed over industrial fertilizers. The most significant of all fertilizers were industrial fertilizers based on nitrogen. In the group of industrial fertilizers, a moderate increase in their consumption between 2005 and 2015 was observed, with the amount of industrial fertilizers applied increased by 20 kg/ha in the period

2010 – 2015. On the other hand, in the group of organic fertilizers, a decrease in the level of fertilization was observed. Both the total and the average consumption of organic fertilizers had a slightly decreasing trend in Slovakia.

Keywords: source of pollution, agriculture, industrial and organic fertilizers, surface streams

MODELLING OF RAINFALL-RUNOFF PROCESSES IN DIFFERENT CLIMATIC CONDITIONS

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Rainfall-runoff (r-r) models are widely used for climate change impact studies. Previous studies have shown that the models are not suitable when climatic conditions change, but they are often used in such conditions. The intention of this study is to revisit this conclusion and also to provide more general insights into this topic (i.e., into the applicability of particular r-r models under climatic conditions that are different from the calibrated ones; this is also known as the "extrapolation capacity of the models"). It is well known that common sources of uncertainties that are associated with hydrological modelling include errors in the model's structure, problems in the calibration procedure (e.g., parameter estimates), errors in the inputs used for the calibration, etc. In this study, these sources of uncertainties were considered. The main goal of this research was to better understand the process for the calibration and validation of particular hydrological models in research and practice.

The methodology applied in this study is tested over the territory of Austria, which represents a data-rich environment. Wu used a large sample of 213 catchments spread throughout Austria. In our investigation, a hydrological model (the TUW model) was used. This model follows the structure of the HBV model, which is popular among modeling communities. The TUW model was chosen because it proved suitable for our study objectives. We calibrated and validated this model for three 10-year periods between 1981 – 2010, during which climatic characteristics (i.e., precipitation and air temperature) changed. The model's overall consistency (i.e., the model's performance and the uncertainty of the parameters) was assessed over these three contrasting climatic periods.

The results clearly indicate that the model's uncertainties are associated with the climatic characteristics (e.g., changes in precipitation). Our results suggest that it would be suitable to re-calibrate a model if the climatic conditions change. These results also have implications in operational model applications (e.g., forecasting, design, etc.). The results from this study can help to improve understanding of how to use hydrological models under conditions different from those used for the model's development; on the other

hand, more analysis needs to be done in the future to verify this methodology.

Keywords: Climate change, TUW model, model uncertainty, parameter uncertainty, Austria

SUBSURFACE ION ACCUMULATION AND TREE ROOT-GROUNDWATER CONNECTIONS UNDER BLACK LOCUST (*Robinia pseudoacacia*) AND POPLAR (*Poplar sp.*) STANDS ON THE GREAT HUNGARIAN PLAIN

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The connection between roots and groundwater is one of several factors included in forest-(ground)water systems. The accumulation Ca^{2+} and Cl^{-} ions under black locust (*Robinia pseudoacacia*) and poplar (*Poplar sp.*) stands was investigated in this work in order to understand the subsurface edaphical and hydrological effects of tree water-uptake. The $CaCO_3$ content, pCl and hygroscopicity values were measured from soil samples taken on the Great Hungarian Plain. Twenty-two sites with the two tree species investigated and clear $CaCO_3$ and pCl accumulation peaks were chosen for further investigation.

The different ion accumulation curves clearly reflect the different water-uptake strategies of the tree species: The poplar, with high water consumption and dependence on groundwater, generates higher ion accumulation. The soil texture has no effect due to the direct root-groundwater connection. The black locust with less water consumption, generates no or lower ion accumulation. The root-groundwater connection is indirect; thus the soil texture has a clear effect here. The results show that ion accumulation could be used as an indicator of tree-generated subsurface hydrological processes, although more research is needed on this topic.

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Keywords: water regime, water uptake strategy, root structure

SEPARATION OF SCALES IN THE EFFECTS OF TRANSPIRATION ON LOW FLOWS

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The aim of this study is to understand on what spatial scales evapotranspiration and streamflow are linked during low flow periods. The analysis is performed in the Hydrological Open Air Laboratory in Austria, in a 66 ha experimental catchment. It has been determined that tributaries that represent different runoff generation mechanisms, such as tile drainage and excess saturation wetland runoff, also feature diurnal streamflow fluctuations. The spatio-temporal differences between the streamflow fluctuations observed at twelve outlet points of the catchment are explained by the differences in the vegetation coverage, the runoff generation mechanisms, and the groundwater-surface water connectivity. The lag times associated with the diurnal and seasonal time scales are estimated using a solar radiation-driven model. The three model parameters show a seasonal evolution, which gradually increases from spring to autumn. Lag times between radiative forcing and evapotranspiration increase from 4 to 11 hours from the spring to the autumn as the catchment disconnects from the stream. The recession time scales increase from 25 days in the spring to 60 days in the autumn, which is related to the decreasing storage of subsurface water on the catchment scale. The observations and model simulations suggest that the riparian vegetation connected to the groundwater (about 2% of the catchment) induces the diurnal streamflow fluctuations, while the entire catchment drives the seasonal fluctuations.

Keywords: diurnal streamflow fluctuations, low flows, evapotranspiration

SUDDEN SPREADING OF CLUB-RUSH (*Schoenoplectus litoralis*) IN LAKE NEUSIEDL

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The aim of the study was to assess the current population of *Schoenoplectus litoralis* and compare the results with data collected in 2016 by comparing any changes in the number, size, density and inflorescence proportions of the club-rush.

The three populations found in Lake Neusiedl increased to a stable population of four with a greater size, possibly caused by climate change. These populations are at Kőbokor, Lake Püspök, Lake Hidgségi and Lake Gémes. In addition, three new small populations emerged further afield. These three are at Fertőrákosi Bay, Lake Herlakni and Rucás Bay.

The measurements of the club-rush patches were done by GPS point-determination. These data were stored and totaled in a geographical information database. A thematic map with this database was made that shows the location, size, density and fertility of the club-rush. The data was also compared with data from 2007 and 2008; from this comparison it could clearly be seen that in previous years, large patches accounted for most of the population; however, in 2016, 70% of the population came from smaller patches. This trend could be explained by the spreading characteristics of the species and with the fragmentation of previously large patches, which had been mentioned earlier. As in the previous studies, the largest stable population of Lake Neusiedl is at Lake Kőbokor, which is followed by Lake Püspök and Lake Gémes, and the lowest with the population at Lake Hidegség. A significant amount of diversity was observed among the different locations in the size, density and inflorescence proportions of the patches. These differences lead to the conclusion that the population at Lake Fertő can be considered stable.

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MULTI-OBJECTIVE OPTIMIZATION OF PHOSPHORUS MANAGEMENT IN AUSTRIA

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As a fertilizer, phosphorus plays a key role in global food security; on the other hand, its emissions into water bodies are a main cause of the eutrophication of aquatic ecosystems. Moreover, phosphorus is a non-renewable resource. Efficient and sustainable phosphorus management is thus very important. However, any measures taken to improve phosphorus management will have impacts on the management of other resources and the wider environment.

By combining material flow analysis of the phosphorus fluxes and stocks of Austria with elements of life cycle assessments, it will be possible to analyze these interactions in order to identify co-benefits, conflicting goals, and a pathway towards an overall optimal management strategy. For instance, the national phosphorus and nitrogen cycles are closely connected to each other, and measures to improve phosphorus management have mainly positive effects on nitrogen management.

Ultimately, the work on this project should lead to the development of a methodological framework for multi-objective optimization, which can also be applied to other substances.

Keywords: multi-objective optimization, resource management, phosphorus

FLOOD RISK REDUCTION THROUGH THE OPTIMIZATION OF A SMALL WATER RESERVOIR

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The increasing frequency and magnitude of flash floods is motivating water managers and other authorities to focus on enhancing flood protection of small headwater watersheds, which are especially vulnerable to this type of flooding. One of the ways to achieve this goal is to increase the volume of existing small water reservoirs (SWR) dedicated to the storage of flood waves. This paper investigates the possibilities of utilizing SWR Vrbovce (western Slovakia), which is currently being used for water storage and as a fishery, to reduce flood discharges. During the investigation a flood wave with a return period of 100 years was estimated using a design storm approach. The following assumptions were made: the design storm event generated a flood wave of the same return period; the design storm had a constant intensity; and its duration was equal to the time of concentration; the shape of the flood wave's hydrograph was triangular with a rising falling limb ratio of 1:2. In order to transform the flood wave through the SWR, a simple model was proposed that takes the hydraulics of the SWR's outlet structures into account. The flood wave transformation was carried out according to the current state of the reservoir's operations and three alternative scenarios with smaller values of the initial water volume. In addition, a relationship was built between the water level and the transformative effect of the SWR. The results showed that even a small decrease in the initial water level could significantly increase the ability of the SWR to flatten a 100-year flood wave.

Keywords: Small water reservoir, flood wave transformation, design storm approach, SCS CN