Euro-Mediterranean Network of Experimental and Representative Basins
and
University of Sopron

Water balance of small catchments in a changing climate

Abstracts of the Workshop

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Contents

HIDEGVÍZ VALLEY EXPERIMENTAL CATCHMENT OF UNIVERSITY OF SOPRON, HUNGARY

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The Hidegvíz Valley experimental catchment was established by lecturers and research scientists of University of Sopron at the end of 1980's. It provides an opportunity for foresters, environmental- and geoscientists to do interdisciplinary research. Our experiments are going on different spatial and temporal scale.

The catchment is located to the West of Sopron, in the middle of Sopron Hills, in a 6 square kilometre drainage basin of the Rák Brook (Figure 1). The area is heavily divided by valleys and ravines. The area's altitude is between 370 and 550 metres above the sea level. The average slopes are of 37% but slopes of 60% are also not rare.

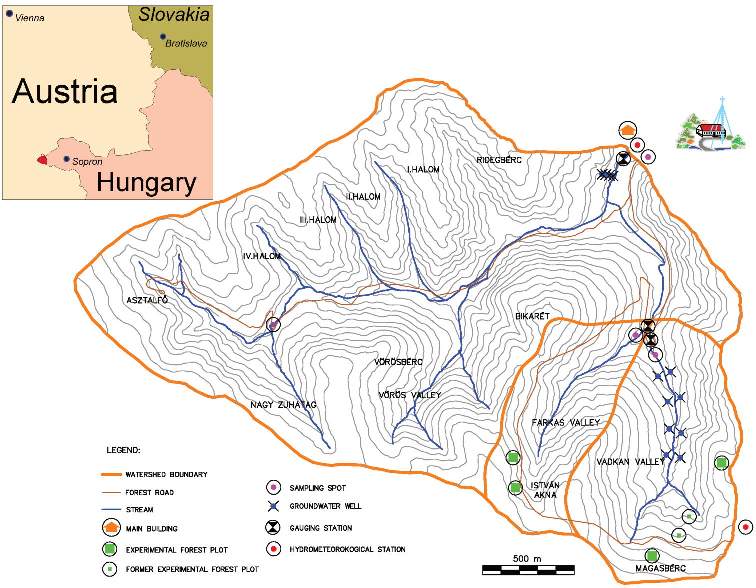

Figure 1: Map of experimental catchment with observation network

The drainage system of the area consists of the main valley of western-eastern direction, the Rák Brook and the minor valleys joining in from northern and southern directions.

The geology of the catchment is crystalline bedrock and Tertiary (Miocene) fluvial sediment, which is strongly unclassified. The fluvial sediment was deposited in five layers. In this area podzolic brown forest soils, highly acidic non-podzolic brown forest soils and lessivated brown forest soils have evolved. To a small extent eroded skeletal soils and on the bottom of the slopes also colluvial soils can be found.

The area enjoys a sub-alpine climate, with daily mean temperatures of 17°C in the summer, and 0°C in the winter, and with an annual precipitation of 750 mm, late spring and early summer being the wettest and fall the driest seasons.

The most typical types are beeches mixed with hornbeam, sessile oak, spruce and larch, settled spruce forests as well as alder groves in valleys as hygrophilous associations.

The goals of the experimental basin project are the followings: better knowledge and quantification of forest hydrological cycle elements, forest vegetation (in different tree species and ages) and forest management activities effects on stream flow regime, gain data for hydrological modelling, teaching field hydrological measurements for students.

(a) (b)

Figure 2: The main meteorological station (a) and the micro climate station (b)

These aims may be reached by long-term onsite observations, by analysing and processing data collected in natural environments while taking into consideration the life cycle of tree vegetations. Since this type of field analyses are quite tools-, costs- and timeconsuming, the creation and arrangement of this research area can be carried out over a longer time period attaching gradually new research units to the already existing parts.

The main experiment station is located at the outlet of the catchment, where can be found an open-air automatic hydro-meteorological station (Fig. 2(a)). There are several experimental forest plots, some of them are instrumented with micro-climate stations (Fig. 2(b)). Following experiments are going on the plots: canopy and litter interception, soil moisture, tree growth, sap flow, and ground water level. We follow with attention forest management activities and phenological changes. Gauging stations are settled some sub-catchments (Fig. 3(a)) and the main cathcment outlet (Fig. 3(b)). Beside continuous hydrograph records, the sediment yield and some physical-chemical parameters of streams are measured as well.

(a) (b)

Figure 3: Gauging station for sub catchments (a) and the weir at main catchment outlet (b)

One of the most important characteristic of the Hidegvíz Valley experimental watershed is that it is self-organising. There is no central control and no constant staff. Research work is based on the decisions and voluntary work of university lecturers and students. The operation and development of the equipments of the research is carried out by the personal commitment and successful grant applications of the people involved. In spite of this, an implicitly acknowledged concept (aims and principles) and a spontaneous cooperation exist to make the research more and more complex.

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THE EXPERIMENTAL BASIN ROSALIA OF THE BOKU UNIVERSITY VIENNA, AUSTRIA

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The University of Natural Resources and Life Sciences (BOKU) is operating an experimental basin south of Vienna (see Fig. 1). The basin area is approx. 2.7 km^2. Originally used for field training of forestry students, the purpose of the basin Rosalia was widened towards interdisciplinary research in the 1980s. First, forest ecological and hydrological studies were in the focus and supported by installations of meteorological stations and a runoff gauge (see also table 1). Also the main building with offices, lecture and computer rooms, and housing facilities for approx. 50 persons was constructed in those years. Since 2010 the leading board of BOKU university decided to extend the scope of the Forest Centre Rosalia and to stimulate further research. So complementary research groups from soil science, soil physics and hydrology were starting advanced observation programs. The multidisciplinary aspect will be expanded by planned joint projects dealing with greenhouse gas exchange monitoring and calamity scenarios where the impact of forest degradation on selected sites caused by limited water supply will be investigated.

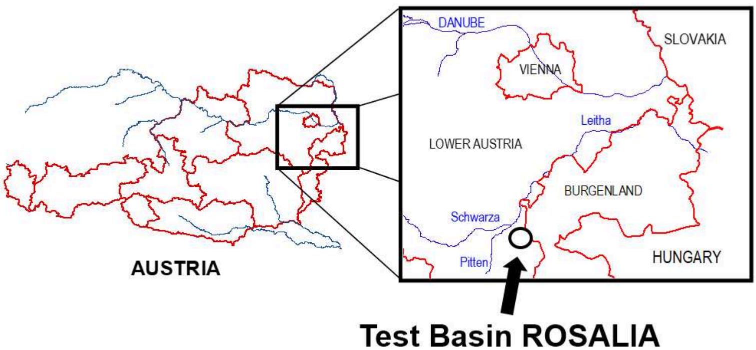


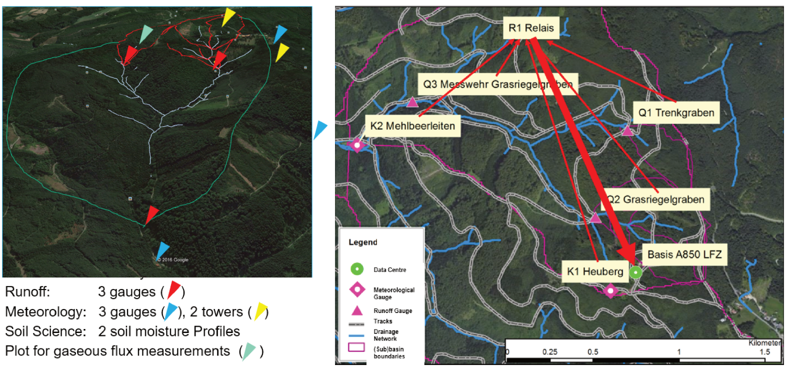
Figure 4: Location of the experimental basin Rosalia

In 2014 the hydrology institute IWHW at BOKU decided to set new activities in field monitoring. Two additional gauges were added at tributaries with 9 and 27 hectars drainage basin (see Fig. 2), respectively. A radio telemetry system was implemented for unified data acquisition, central data storage and web-based data access for all involved parties.

Table 1: Description of the test basin Rosalia

(Sub)basin	Ofenbach, Leitha, Donau
In operation since	1989 (1 discharge gauge, 3 meteorological stations) 2015 (2 discharge gauges, 4 soil moisture profiles, 3 precip. Gauges)
Coordinates, elevation	47°42’32.2” North, 16°16’54.6” East, 451 m a. sl.
Catchment area	2.7 km^2
Elevation range	415 m – 718 m a. sl.
Climate (rain, temp.)	Mean annual rainfall: 784 mm (1989 – 2009) Mean air temperature: 6,5 °C (in 660 m a. sl.)
Land use	Forest
Discharge (min, max, mean)	3.0, 688, 8.3 l/s (1989 – 2010)

This data acquisition system is open and flexible for adding new measurement devices also from other disciplines (see Fürst, 2016).



(1) (2)

Figure 5: (1) Boundaries of test basin and observation network (2) Data transfer via radio transmittance

For many of the planned research activities the water balance and runoff components within the basin are of high importance. A high spatial resolution based on nested sub-basin observations enables and supports different research questions. Some scientific topics are as follows:

- Spatio-temporal distribution of fluxes (mass and energy)
- Runoff formation (surface / subsurface)
- Vegetation impact on fluxes (energy, evapotranspiration, runoff)
- Observation and measurement techniques (plot scale, integrative, “from point to areal scale”)
- Assessment of extremes
- System and scenario analysis (climate change, clear-cut, calamity)

Figure 6: H-flume type runoff gauge at Rosalia basin (tributary Mittereckgraben)

The aim of the experimental basin Rosalia is to continue and widen the range of environmental observations and generate a comprehensive and valuable data base. This may furthermore be a good asset for advanced research and joint project applications in international programs.

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HIGH SPATIAL RESOLUTION MAPPING OF TOP SOIL MOISTURE CONTENT

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The moisture status of the upper 10cm of the soil profile is a key variable for the prediction of a catchment's hydrological response to precipitation, and of pivotal importance to the estimation of trafficability. Prediction, and even mapping, of topsoil water content is complicated, not in the least because of its large spatial heterogeneity. In IRIDA, an EU/JPI project, measurements, models and weather predictions will be applied to estimate the soil moisture status at the sub-field scale in near-real time. The project is in its early stages, during which the relevant parameters will be selected that will allow for soil moisture mapping on agricultural fields at a 10 m resolution.

The project will combine the measurement of soil water content and vegetation (cereals) cover at three spatial scales in a small agricultural subcatchment in south-eastern Norway (27 ha). At the point scale, weekly measurements of the soil moisture content are taken in combination with an image of the vegetation cover. At the field level, a drone equipped with a multispectral camera is employed. For the larger scale, satellite data are acquired and processed to show the development of the plant cover during the growing season.

Even at point level, significant differences between measurements of soil water content are observed. While the standard deviation of series of replicate point measurements often outweighs trends at the plot (tens of meters) scale, trends and patterns are distinguishable. Preliminary results in this stage of the project, show that fairly good estimates of soil moisture in the upper 10 cm of the profile can be obtained with a fairly simple multilinear regression model. The variables of the model that currently performs best are: slope (% inclination), hillslope position (0 in the talweg to 1 on the ridges), catchment area (m^2), soil moisture storage capacity (mm), average day temperature sum (deg C), and Normalised Difference Vegetation Index (as obtained from the Sentinel 2 satellite).

It was observed that generally, areas where the crop cover was poorly established, the topsoil was drier. This raises the issue of the ratio between evaporation and transpiration at the plot level, and further investigation is required into the negative feedback loop between vegetation cover and soil moisture content. The current performance of the model is expected to improve after the establishment of a correlation between the vegetation cover percentage as assessed by handheld camera image processing (point level), the vegetation index as captured by the UAV and the NDVI from satellite.

Climate change impacts on the water balance – Case studies in Hungarian watersheds

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The impacts of climate change will alter the various components of the water balance on a global, regional and local scale. These changes will be measurable mainly by the altering spatial distribution of temperature, precipitation, and evapotranspiration values.

The water balance of some Hungarian watersheds was analyzed based on a spatially distributed robust hydrological model that was calibrated by actual evapotranspiration values of CREMAP (Complementary-relationship-based Evapotranspiration Mapping Technique).

In the period of the model calibration (2000–2008) evapotranspiration (ET) and runoff (R) were calculated to be about 90% and 10% of the precipitation in the examined watersheds. ET was analyzed in the context of land cover types.

The long-term averages of the different elements of the water balance were estimated with a spatially distributed Budyko-model that was applied on a resolution of 1·1 km. In case of the surplus water affected (e.g. by surface or subsurface inflow) areas where evapotranspiration exceeds precipitation, ET and R were calculated with another simple model that works on the analogy of pan evaporation. For seasonal changes, a Thornthwaite-type monthly step water balance model was used.

Using precipitation and temperature results of different regional climate model simulations as input data, projections of the main components of the water balance (ET, R) were calculated for three future periods and then compared to a reference period (1981–2010).

In the 21st century, a slight increase in long-term evapotranspiration is projected, which may cause a substantial reduction in the long-term runoff in the examined watersheds. In the summer period a significant decrease in soil moisture is expected. It can be more and more often below the water stress level.

The research was supported by the “Agroclimate 2 (VKSZ_12-1-2013-00-34)” EU-national joint funded research project.

FLOW PROCESSES AND SUBSURFACE DRAINAGE SYSTEMS

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In Norway, and many other countries, subsurface drainage systems are a necessity to practice agriculture. First of all to facilitate optimal crop growth conditions during the growing season by controlling the water level. But equally important is the functioning of subsurface drainage systems when it matters land preparation to facilitate sowing and harvesting activities during springtime and late summer, early autumn. Too high soil moisture content during these periods will lead to soil compaction and hence a reduction in soil quality. Drainage systems, through control of the groundwater level, have a direct influence on the soil moisture content. To facilitate tillage practices and harvesting depending on soil type, the soil moisture content has to be at 80–90% of the field capacity in the top 20 cm of the soil profile. During periods with excess precipitation, a rapid drawdown of the groundwater table is necessary, made possible by a narrow drains spacing which in Eastern Norway under grain production vary from 8–10 m and in areas along the west coast of Norway, under grass production, can be 6 m. To get information about the present day functioning of subsurface drainage systems, drainage runoff from small field scale catchments have been analysed. The main objective was to get information about the half time , i.e. the time required to reduce the runoff to 50% of the runoff at the onset of a recession period. In principal the recession period can be described by an exponential relation in which the discharge over time, q_t, is a function of $q_0 \cdot exp(-\alpha t)$, in which q_0 is the discharge at the onset of the recession period and α is the recession coefficient. Several times the recession period had to be described by a to-exponential approach to obtain a best fit, which might indicate the presence of a dual flow process towards the drainage system. The average half time for the small field scale catchments varied from 6–16 hours, indicating a fast drawdown of the water level. The variability in half time for individual fields might indicated a change in the soil physical parameters over time. Further research will be carried out as soil physical parameters are an important input to models to predict information about among others the soil moisture content, which again is important related to agricultural practices. The analysis of subsurface drainage is carried out as part of IRIDA, an EU/JPI funded project.

PRECIPITATION AND RUNOFF IN THE HIGH TATRA MOUNTAINS IN THE PERIOD 1961-2010

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The High Tatra Mountains (area 341 km^2, elevation up to 2 655 m a.s.l.) are the highest mountain range of the Carpathians. Because they are located in two countries (Poland and Slovakia), evaluation of water balance components has been done separately. Recently, we have conducted the first evaluation of precipitation and runoff regimes for the entire territory of the High Tatra Mountains. We used daily precipitation from ten stations located at elevations 694-2635 m a. s. l. and daily discharge from six small catchments (areas 43 km^2 to 83 km^2). The analysis revealed higher precipitation and altitude gradients of precipitation on the northern (windward) side of the mountains. Runoff from the catchments located on the northern side of the mountains was also higher than on the southern side, but the mean elevation of northern catchments is higher as well. We have evaluated temporal evolution of a number of precipitation and runoff characteristics over decades 1961-1970 to 2001-2010. We did not find significant trends over the entire period. However, an increase in the number of days with daily precipitation 40-60 mm during the warm season (May to October) was found for the last decade. Frequency of the long wet periods in decades 1991-2000 and 2001-2010 increased in comparison to previous decades. Although the runoff characteristics did not exhibit significant trends, the number of events classified as small and large floods increased in the decade 2001-2010. Annual catchment precipitation and runoff on southern side of the High Tatra Mountains did not indicate a change in the water balance regime. Extended results on water balance will be presented at the workshop.

THE IMPACT OF THE URBAN ENVIRONMENT AT SIX SUB-CATCHMENTS OF RÁK CREEK IN THE AREA OF SOPRON

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During our investigation, we analyzed the urban soils from stream banks and sediment sample of Rák Creek in the area of Sopron, Hungary. The aim of this work was the determination of the anthropogenic influence on a given stream that flows through an urban area (in this case through the city). The assumption was that the streamflow becomes increasingly polluted with toxic elements as it passes through Sopron. We tried to determine the extent to which the stream is polluted. We had 72 urban soil samples at 36 points at 0–10 and 10–20 cm depths on six subcatchments for analyzing the background pollution of Rák Creek. In addition, six soil samples from the bank and 12 sediment average samples were taken from the dead region and from the thalweg as well. We analyzed the physical and chemical parameters as well as the heavy metals (e.g. Cd, Co, Cu, Pb, Zn and Ni) in all of the samples. Two element fractions, the total (HNO_3+H_2O_2-extractable) and the available (NH_4-acetate+EDTA-extractable) were used for element determination. Toxic elements were measured by ICP-OES in the urban soils and the sediments as well. Urban soils of sub-catchments confirmed the following tendency. On the investigated creek points, the Co and Ni values were below the natural background limits (Co_{total} 4.90-14.53 mg·kg^{-1}, $Co_{available}$ 0.64-3.12 mg·kg^{-1}; Ni_{total} 10.77-24.61 mg·kg^{-1}, $Ni_{available}$ 0.75-3.21 mg·kg^{-1}). Cu_{total} content was low except in the case of GYORI point.

Pb_{total} were under the pollution limit, but $Pb_{available}$ were higher than the suggested pollution limit (>25 mg·kg^{-1}) in the sediment of thalweg and in the soil of the creek bank at the GYORI site. Summarized, GYORI point was the most polluted; this is also confirmed by the enrichment factor (EF). EF for Pb and Zn increased as we moved toward the city. Based on the investigated properties, there were significant differences in heavy metals between the urbanized and non-urbanized areas. The concentrations of heavy metals were higher in the dead region than in the thalweg except for the GYORI samples. According to our results, the city affects the stream and its influence appears in the values: as soon as the stream reaches the city, most of results increase.

This research is supported by TÁMOP 4.2.1.B-09/1/KONV-2010-0006 and the “Agroclimate 2” (VKSZ_12-1-2013-0034) EU joint national funded research projects.

INTERCEPTION IN A CHANGING CLIMATE – AN EXAMPLE FROM THE HIDEGVÍZ VALLEY

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Tree canopies play a rather important role in forest hydrology. They intercept significant amounts of precipitation and evaporate back into the atmosphere during and after precipitation event. This process determines the net intake of forest soils and so important factor of hydrological processes in forested catchments. Average amount of interception loss is determined by the storage capacity of tree canopies and the rainfall distribution.

Canopy storage capacity depends on several factors. It shows strong correlation with the leaf area index (LAI). Some equations are available to quantify this dependence. LAI shows significant variability both spatial and temporal scale. There are several methods to derive LAI from remote sensed data which helps to follow changes of it. In this study MODIS sensor based LAI time series are used to estimate changes of the storage capacity.

Rainfall distribution derived from the FORESEE database which is developed for climate change related impact studies in the Carpathian Basin. It contains observation based precipitation data for the past and uses bias correction method for the climate projections.

In this study a site based estimation is outworked for the Sopron Hills area. Sopron Hills is located at the eastern foothills of the Alps in Hungary. The study site, namely Hidegvíz Valley experimental catchment, is located in the central valley of the Sopron Hills. Long-term interception measurements are available in several forest sites in Hidegvíz Valley. With the combination of the ground based observations, MODIS LAI datasets a simple function is developed to describe the average yearly variations in canopy storage. Interception measurements and the CREMAP evapotranspiration data help to calibrate a simple interception loss equation based on Merriam's work. Based on these equation and the FORESEE bias corrected precipitation data an estimation is outworked for better understanding of the feedback of forest crown on hydrological cycle.

This research has been supported by the Agroclimate.2 VKSZ_12-1-2013-0034 EU-national joint funded research project, and the first author's work was also supported by the János Bolyai Scholarship of the Hungarian Academy of Sciences.

COMPARISON OF TWO SPATIALLY DISTRIBUTED EVAPOTRANSPIRATION MAPPING METHODS BY MONTHS

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Evapotranspiration (ET) is a significant element of the water balance. For example, its magnitude reaches about 90% in Hungary. That makes ET a good parameter for the calibration of hydrological models. Though, calibration needs good, spatially distributed ET maps to work.

Monthly ET values of the spatially distributed ET maps CREMAP and MOD16 were compared for the area of Hungary and for the vegetation period of the year 2008. CREMAP is a calibration free product that was validated for the area of Hungary, and that is an accepted ET map for the country. As it had been produced only for the years 2000–2008, a map was needed that is being updated on a regular basis. This map was the MOD16 product, provided by the MODIS Global Evaporation Project. The aim of our research was to evaluate the ET values of MOD16 in comparison with that of the CREMAP values.

The difference between the two products varied by seasons. It was the highest in summer, when MOD16 values were 25 mm lower than CREMAP values. In spring and autumn MOD16 estimated higher values by about 6 mm.

Seasonal changes affected the ET differences in the main landcover types similarly to the average differences. The similarity was backed by calculated strong correlations. That means that the calculation of the ET values of different landcover areas by the two methods were similarly affected by the seasonal changes.

The seasonal ET differences by elevation zones shown not too strong correlation between elevations higher or lower than 200m AMSL. However, the trend of the ET differences were like the average at elevations lower than 200m AMSL. That means elevation has some effect on the ET differences.

This research was supported by the “Agroclimate.2” (VKSZ_12-1-2013-0034) EU-national joint funded research project.

PRECIPITATION VARIABILITY AND TRENDS IN A CHANGING CLIMATE

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Changes in climate regimes have been projected by different models, and this means that adjustments in the global hydrological cycle are to be expected. The local impact of these changes is often not well understood. Increased variability in the water system likely imply modifications in the volume and temporal and spatial distribution of water availability (surface, subsurface and groundwater) and fluxes (e.g. flow regimes, peak runoff), at the basin scale. In addition, changes in extreme precipitation are likely to have greater immediate impact on water resources and society than any small change in the mean precipitation amount. However, estimates of these changes are difficult to establish; the uncertainty is high. The sustainable management of water and other resources and the need to define measures to adapt and minimize the effects of changes in water regimes require that the regional environmental, hydro-climatic and socio-economic conditions are characterized: attention is being devoted to these questions worldwide.

This presentation gives an overview of commonly applied statistical approaches to this end, that have been aiming at the increased understanding of changes and trends in precipitation and other relevant atmospheric variables. Main issues discussed include: i) several data and methodological limitations that can bias the assessment of those changes, in particular those of anthropic origin; ii) the need to focus on understanding the processes' behaviour at multiple temporal and spatial scales; iii) requirements regarding using appropriate temporal and spatial resolution data and long enough record lengths to allow exploring the different (scaling) regimes in precipitation and its extreme dynamical fluctuations.

Using thermal infrared imagery for quantifying soil surface processes

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At present, our understanding of the soil hydrologic response is restricted by measurement limitations. In the literature, there have been recurrently requests for interdisciplinary approaches for understanding and quantifying soil surface processes and to try to overcome the limitations that are inherent to conventional measuring techniques, at different scales (e.g. basin, hillslope, field, plot).

Infrared thermography is a versatile, accurate and fast technique of monitoring surface temperature and has been used in a variety of fields, such as surveillance, medical diagnosis, industrial processes optimisation, building inspections and agriculture. However, many applications are still to be fully explored. In surface hydrology, it has been successfully employed as a high spatial and temporal resolution non-invasive and non-destructive imaging tool to e.g. access groundwater discharges into waterbodies or quantify thermal heterogeneities of streams.

It is believed that thermal infrared imagery can grasp the spatial and temporal variability of many processes at the soil surface. Thermography interprets the heat signals and can provide an attractive view for identifying both areas where water is flowing or has infiltrated more, or accumulated temporarily in depressions or macropores. Thermal infrared imagery has the capacity to indirectly make a quantitative estimation of several hydrologic processes. Examples of applications: estimation of drop size distributions, mapping infiltration, microrelief, soil water repellency and macropores; estimating overland and rill flow velocities (de Lima and Abrantes, 2014a,b; de Lima et al., 2014a,b, 2015a,b; Abrantes et al., 2017).

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MONITORING CHALLENGES IN RAPIDLY CHANGING ENVIRONMENTS

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With climate change and increasing anthropogenic pressure, alarmingly accelerated changes to water bodies and catchments are being observed all around the globe. There is an urgency of monitoring methods that are capable of accompanying these trends and provide updated and detailed data that can support water and soil management actions. Often, the status of environmental conditions are based on isolated measurements, without regard to the spatial and temporal variability of water quality and ecology. The collection of data (e.g. sensors, sampling, and imaging) using mobile platforms is gradually becoming more common and appraised, with new applications and uses being explored every day. Data accessibility and readiness for use is also crucial to enable quick actions and interventions.

This work describes novel data collection possibilities in catchment-scale surface water bodies. Sensors were installed in mobile platforms (including boats and underwater drones) to assess spatial data variability. Additionally, smartphones and mobile apps backed the reading of test strips and other field sampling methods in real-time, and prompted the upload of data to online platforms. Such quick environmental scans were applied at multiple locations with different water systems in The Netherlands, Indonesia and Denmark (ongoing).

Results give an indication of (reference) values of basic water quality parameters such as turbidity, electrical conductivity, dissolved oxygen or nutrients (ammonium/nitrate). The work conducted showed how local water managers and stakeholders can use new technologies in favor of data quality and quantity. The latter highlighted autonomous collection of data, real-time access to datasets and quick response triggered by events as top needs for monitoring improvement. In small catchments, this technology can have high impact by supporting better informed resources management decisions.

Water balance of the German Fischbach catchment in a changing climate

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The Fischbach catchment with a size of 37.9 km^2 is located in central Germany in the federal state of Hessen. It is part of the larger Gersprenz catchment (515 km^2) which discharges into the Main river and is therefore part of the Rhine basin. The Fischbach stream has a length of around 10 km with a difference of altitude of 250 m. Some smaller tributaries discharge into it. The gauge "Groß-Bieberau 2" is located 1.2 km to the mouth of the Gersprenz and corresponds to a catchment area of 35.4 km^2. Special about the Fischbach catchment is the availability of long-term daily rainfall observation data since 1936 as well as discharge values which are continuously registered at "Groß-Bieberau 2" by local authorities since 1974. Additionally, the Section of Engineering Hydrology and Water Management of TU Darmstadt started a monitoring program in 2016. Therefore, water level and discharge values are available at selected sampling locations along the river course for depicting the spatial and temporal variability.

For the region, predictions about the impact of climate change are already published. In winter an increase of precipitation is to be expected, in summer a decrease. As a result, there will be a streamflow increase of 10% in winter and a decrease of 15% in summer. In addition, an increase in extreme weather events is to be expected, particularly heavy rainfall events which will have a high impact on hydrology. To develop adaptation strategies, we will present a method for analysing and estimating these consequences for future water management.

MICRO-ENVIRONMENT MEASUREMENT IN THREE DIFFERENT SMALL CATCHMENTS IN HUNGARY

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Aquatic macroinvertebrates are heavily influenced by the climatic changes even in temperate, forested habitats. The potential impacts of global climate change may be an increase in water temperatures, changes in seasonal patterns (including intensity) of precipitation and runoff which can alter hydrologic characteristics of aquatic systems. Rapid changes in hydrology caused by extreme heavy rainfalls – especially if there are clearcuts within the catchment area – may cause changes in the hydromorphology, restructure the stream bed or alter the path of the stream itself. All these affect the species composition, that is why the investigated aquatic ecosystems, the streams in forested area have limited ability to adapt to climate change.

In recent study, the samples were taken from three streams which are located in similar, forested areas. The sampling sites were chosen along a climatic gradient. The first sampling site is in Mecsek mountains (South Hungary), the second one is in Kőszeg mountains (West Hungary) and the third one is in Sopron mountains (Northwest Hungary).

The biological samples were taken with a specific cross-section transect arrangement, applying a new, microhabitat-based quadrat sampling method in all selected areas. Parallel with the macroinvertebrate sampling, there were taken hydraulic measures too. The velocity profile, shear velocity, shear stress, drag force and the Reynold's and Froude numbers were estimated to define the near-bed hydraulic conditions, which influence the community structure of aquatic macroinvertebrates.

The main aims of the study were recognize differences along the climatic gradient in a similar habitat types of small streams in forested area if there are any, check up the ability of detection fine differences between similar communities of the new sampling methode which focuses on the microhabitat-structure of certain stream sections instead of taking and analyzing composit samples from the whole section. One more additional important aim was to investigate the microhabitat preference of the Habitats Directive Annex II. Dragonfly species, the Cordulegaster heros which inhabits each sampling sites.

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