NORDIC WATER 2016

XXIX Nordic Hydrological Conference

August 8-10, 2016 Kaunas, Lithuania

THE ROLE OF HYDROLOGY TOWARDS WATER RESOURCES SUSTAINABILITY

ABSTRACTS

Kaunas, 2016

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THE ROLE OF HYDROLOGY TOWARDS WATER RESOURCES SUSTAINABILITY

Editors

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The conference is being organised by the Laboratory of Hydrology, Lithuanian Energy Institute, in collaboration with Aleksandras Stulginskis University, Vytautas Magnus University and Nordic Association for Hydrology (NHF).

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NORDIC
WATER 2016

PREFACE

NORDIC WATER is a conference series focused on water resources, hydrology and related sciences. The conference will bring together scientists to talk about recent trends in water research and water resources management. The XXIX Nordic Hydrological Conference was held at the Vytautas Magnus University, Kaunas, Lithuania. Kaunas has been fated to become an important historical and cultural heart of Lithuania. In 1408, Magdeburg rights were granted to the city of Kaunas by the privilege of Vytautas the Great. During the early 20th century, governed by its first Burgomaster Jonas Vileisis, Kaunas was the home of the Lithuanian Government and the capital city; a period considered by many as the golden age of the city. However, history tells us that even before this date, the city, situated at the confluence of the rivers Neris and Nemunas, experienced many other periods of great prosperity and national importance.

Since 1997, when the conference on „Hydrology and Environment" with involved participants from all the Nordic and Baltic countries was held in Kaunas, it is the second time Lithuania will host an important international Nordic-Baltic hydrology meeting. NORDIC WATER 2016 aims to discuss the role of hydrology towards water resources sustainability in its widest sense. It will provide a forum for scientists and practitioners to exchange their views on assessment and prediction of key variables of water cycle along with scientific knowledge on advanced methods and modelling technology.

Changes in water quantity and quality in the Baltic Sea region occur as consequences of global, regional and local changes including environmental factors, climate change and human-induced impacts. Therefore, science-based knowledge on the assessment and prediction of hydrological processes due to the changes, is essential to achieve sustainable water resource systems. The dynamic assessment of water resources allows providing more reliable predictions of temporal and spatial water availability and water quality. In this context the conference will address the role hydrology plays in the assessment of the changes in hydrological cycle along with the ability to predict the variations in hydrological processes striving for water resources sustainability. The conference outcomes are expected to contribute to more effective integrated water resources management at regional and national scales.

NORDIC WATER 2016 represents many fields in hydrology and water resources science. In total over 80 abstracts were submitted from16 countries. Most of the contributions came from the Nordic and Baltic countries. All submitted abstracts were evaluated by scientific committee. After the conference authors are given a possibility to submit their original contributions for publication in a special issue of Hydrology Research journal.

We thank all the contributors who have made this conference possible. This includes all scientific and organising committees members. We would like to express our most sincere thanks to all the authors who submitted either oral or poster presentations. In particular, we are very grateful to the three keynote speakers: Zbigniew Kundzewicz, Thomas Kjeldsen and Per-Erik Jannson. The funding from all the sponsors is also well acknowledged. Special thanks to the main sponsors LEI, ASU, VDU, KAUNO ENERGIJA, AGA and HNIT-BALTIC, BIURO PASAULIS and NEPTŪNAS.

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Chair of scientific committee
Aleksandras Stulginskis University

Diana Meilutytė-Lukauskienė
Chair of organising committee
Lithuanian Energy Institute

INTRODUCTION OF KEYNOTE SPEAKERS

ZBIGNIEW W. KUNDZEWICZ (POLAND)

CHANGES IN FLOOD RISK IN EUROPE

Zbigniew W. Kundzewicz is Professor of Earth Sciences and Corresponding Member of the Polish Academy of Sciences. He holds doctorate and habilitation in hydrology from the Institute of Geophysics, Polish Academy of Sciences, Warsaw, Poland. He has led the Climate and Water Department in the Institute for Agricultural and Forest Environment, Polish Academy of Sciences in Poznan, Poland (since 1990) and has been a Senior Scientist in the Potsdam Institute for Climate Impact Research (PIK) in Potsdam, Germany (part time, since 2001). His main scientific contributions have been in the areas of extreme hydrological events (and floods in particular) and climate change impacts on water resources. He has been a four-fold Coordinating Lead Author of publications of the Intergovernmental Panel on Climate Change (IPCC). He was a Member of the Advisory Group on Environment (including Climate) for 7th Framework Programme of the European Commission. He was an Alexander von Humboldt-Foundation Research Fellow at the University of Karlsruhe and a Scientific Officer at the World Meteorological Organization in Geneva. He has been Editor and Co-Editor of scientific periodical Hydrological Sciences Journal and member of editorial boards of several scientific journals. He has published over 400 scientific publications. His H-index after Web of Science is equal to 26. Prof. Zbigniew W. Kundzewicz received Polish state orders: Golden Cross of Merit and Knight's Cross of Polonia Restituta, a Great Golden Seal of the City of Poznań (Poland), a Tison Award of the International Association of Hydrological Sciences (IAHS), and two awards of the Polish Academy of Sciences. He is a Polish citizen.

THOMAS KJELDSEN (UNITED KINGDOM)

UNDERSTANDING THE EFFECT OF URBANISATION ON FLOOD HYDROLOGY

Dr. Thomas Kjeldsen is trained as a civil engineer (MSc, PhD) from the Technical University of Denmark and has 15 years research experience focusing on mathematical and statistical modelling of hydrological and environmental systems, with particular emphasis on extreme events. He has led the development of the current UK industry standard methods for flood frequency analysis, notably the Revitalised FSR/FEH rainfall-runoff method, and the improved FEH statistical method. Recent research projects include studies of the effect of urbanisation on extreme flood events; joint probability analysis of flood events based on rainfall-runoff modelling, development of a statistical extreme value procedure for regional and non-stationary analysis of flood events, the use of local data in flood frequency estimation, including historical flood data, and the link between extreme flood events and change in flood risk management policy.

PER-ERIK JANNSON (SWEDEN)

THE USE AND DEVELOPMENT OF MATHEMATICAL MODEL TO UNDERSTAND THE ROLE OF WATER AND CLIMATE RELATED PROCESSES IN HYDROLOGICAL AND ECOLOGICAL PROJECTS

Prof. Per-Erik Jansson has been keeping a key role in development of mathematical models including their implementation into a user-friendly software. The CoupModel (www.coupmodel.com) is the current model used in many different projects today and during the latest 15 years. Prior the release of the CoupModel the SOIL and SOILN models was developed within a number of ecosystem related projects during a 25 year period. A wide range of applications within hydrology, soil science, ecology has been presented.. Especially the connection to climate change and climate variability and the corresponding abiotic and biotic components has been in focus for a number of different climate regions from semi-arid regions, wetlands and boreal areas. Key subjects are winter related processes of snow and frost in the soil, water balance and evapotranspiration of different land use, soil surface evaporation, nitrogen leaching and nitrogen turnover in ecosystems, soil carbon processes, green house gas emissions, irrigation with saline water, effects of road salt applications. Per-Erik Jansson defended his PhD at Uppsala University during 1980. He was appointed as professor of agricultural hydrotechnics at SLU during 1990 and later on at KTH 1999 as professor of land and water resource sciences. He is emeritus since 1 September 2015.

ABSTRACTS

IMPACT OF METEOROLOGICAL PARAMETERS ON FORMATION OF HYDROLOGICAL EXTREMES IN THE LITHUANIAN RIVERS

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ABSTRACT

Increase of hydrological extremes in recent decades has significant impact on natural and human systems. An unprecedented number of extreme events in different regions of the world was fixed in the first decade of the 21st century. In Lithuania, hydrological extremes (spring flood and drought) highly depend on changes of meteorological parameters (precipitation, temperature and snow cover). Spring floods occur after increase of temperature, formation of large snow cover and heavy rain. Formation of hydrological droughts depends on the amount of precipitation and the level of the surface water and groundwater. The main task of this research is to evaluate the impact of meteorological parameters on formation of hydrological extremes in the Lithuanian rivers (Nemunas, Merkys and Neris). The estimated characteristics of hydrological extremes are maximum discharge of spring flood and 30-day minimum discharge.

Long-term series of daily discharge, temperature, precipitation, thickness of snow cover were used from 10 meteorological and 3 hydrological gauging stations. The evaluation of relation between meteorological parameters was done for the reference period 1961-1990 and for last year period 1991-2014. There were estimated that spring floods mostly depends on snow accumulation conditions in the cold season, thickness of snow cover, precipitation amount during the thaw, increase of temperature and intensity of snow melting. Correlations between maximum snow cover (during the cold period) and maximum discharge into three catchments fluctuate from 0.59 to 0.73. Hydrological droughts depends from meteorological parameters (precipitation ratio) and many physical-geographical factors (groundwater feeding, level of soil moisture reserve), therefore significant relations were not established.

Keywords: hydrological extremes, maximum discharge, 30-day minimum discharge, temperature, precipitation, snow cover

Acknowledgement

This research is a part of a scientific study “Impact Assessment of Climate Change and Other Abiotic Environmental Factors on Aquatic Ecosystems” (project No. SIT-15034) funded under National Research Programme “Sustainability of agro-, forest and water ecosystems (2015–2021)”.

TOWARD CLIMATE CHANGE ADAPTATION OF LARGE LAKES IN SWEDEN AND THEIR SURROUNDING COMMUNITIES

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ABSTRACT

The large lakes of Sweden provide services to many people and stakeholders for a broad range of operations. The lakes serve as freshwater resources for ca 2 million people, are part of hydropower production and act as important transport routes. Climate change brings most likely a change of the pattern of precipitation and runoff which will cause either increase or decrease in water levels meaning elevated risk for flooding or drought, deterioration of natural habitats and water quality with substantial impacts for various stakeholders.

The project will study the impact of climate change on the large lakes of Sweden and identify the consequences it may have for the future use and development of the lakes and their vicinity. This includes, for example, the function of lakes as drinking water sources, flooding in the surrounding communities, deterioration of natural habitats along the shores, shipping, hydropower, agriculture and forestry. Further, the project will identify the water-related conflicts and problems in and around the large lakes both under the present and future climate conditions.

The results from this investigation will be a basis for the decision-makers for their work on climate change adaptation and mitigation and planning for the future.

Keywords: climate change, conflicts, large lakes, water

SENSITIVE AREAS AND SEWAGE EFFLUENT DISCHARGES' INFLUENCE – THE PRACANA RESERVOIR CASE STUDY, OCREZA RIVER, PORTUGAL

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ABSTRACT

The Ocreza River is located in Central Portugal and has it source in an important Alpine chain called Gardunha. The Freixada River is a tributary of the Ocreza river. The Pracana's waters have an important role by being abundantly used in agriculture, the main economic activity of these communities, and for human consumption. Characterization, monitorization and control of the impact due to several wastewaters treatment plants discharges on water quality is of crucial importance. This study focuses on the Proença-a-Nova wastewater treatment plant, which discharges directly into the Freixada River, which contributes directly to the Pracana reservoir.

Twelve geo referenced water samples were collected between the sewage effluent discharge and the Pracana's confluence during the hydrological year of 2010. Secondary inflows were identified and water samples collected downstream at approximately equal distances. Sampling campaigns were conducted during three different periods: rainy winter (January), intermediate conditions (March) and dry season (June). The following chemical parameters were analyzed: biochemical oxygen demand (BOD5), dissolved oxygen concentration (DO), dry residue, Ptotal, Ntotal, pH, temperature and microbiological parameters. DO, BOD5 and the microbiological parameters were used as indicators for the presence of organic compounds for evaluation of environmental pollution.

The pollution simulation was performed using a coupled hydrodynamic and water dispersion model using the QUAL2kw software. The simulation results are consistent with field observations and demonstrate that the model has been correctly calibrated. The results obtained in different simulated scenarios tell us that the water course of study shows water quality quite satisfactory for multiple uses and should not be an issue to the Pracana reservoir's water quality. However, due to the values of BOD5,water is not fit for human consumption. In conclusion, before the discharge of effluent at the water line, the treatment of BOD5 should be improved.

Keywords: Pracana Reservoir, Tagus Watershed, QUAL2Kw, Wastewater treatment plant

APPLICATION OF DIFFERENT HYDROLOGIC MODELS IN FLASH FLOODS SIMULATION

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ABSTRACT

In recent years, the flash flood occurs frequently and intensively. It has become a world-wide focus in the field of disaster prevention and mitigation. The flash flood critical rainfall determination method, flash floods forecasting model and experience forecasting method are the most commonly used methods. This study focused on the application of hydrological models for flash floods simulation.

The research has adopted 7 flood forecasting models with different types and structures: topography-based API model, Xinanjiang Model, Xinanjiang Model with excess infiltration, Sacramento Model, IHACRES, BP-KNN Model and TOPKAPI. Every model will be applied in semi-humid and semi-arid watersheds Banqiao, Maduwang, Zhidan in China, which have high risk of flash floods. According to the characteristic of flash floods, a set of evaluation for the simulation results isput forward. The purpose is to find out one or several hydrological models fit for research area and to provide reference for future related research.

Combining with topography and runoff characteristics of each watershed, the paper collected and compared various simulation results of different models. Results indicated that models performed varies in semi-humid and semi-arid basins because of the complicated runoff mechanism in these areas. Among the conceptual hydrological models, Xinanjiang Model with excess infiltration performed better than the models with single runoff mechanism. TOPKAPI has a better simulation results than the lumped models topography-based API model and IHACRES. However, it has higher data requirements. BP-KNN model contains no physical mechanism and performed best in calibration period, but the accuracy falls greatly in validation period.

Keywords: flash floods, hydrological models, semi-humid and semi-arid watersheds

EVALUATION OF SURFACE WATER QUALITY– A TRANSBOUNDARY WATERSHED CASE STUDY (PORTUGAL-SPAIN)

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ABSTRACT

Surface water is usually exposed to contaminants. These contaminants change the natural mechanisms, altering contaminant behaviour and, consequently, their dispersion. Water self-depuration is an ecological process aiming to restore the natural watercourse balance, which depends on the quality and the quantity of topical and diffuse inflows.

The main goal of this research is the evaluation of surface water quality from Águeda River and its self-depuration hability into different quality scenarios. Thirty-six surface water samples were collectedalong the Águeda River (Portugal-Spain transboundary watershed) and its principal tributaries. Biochemical oxygen demand (BOD5), dissolved oxygen concentration (DO), dry residue, Ptotal, Ntotal, pH, temperature and microbiological parameters were analysed, during May of 2012. BOD5, DO and microbiological parameters were used as indicators for the presence of organic matter and for evaluating water quality of the Águeda River and contaminant dispersion.

Simulation of different quality scenarios was undertaken using Qual2Kw software and the river's self-depuration ability discussed. The obtained scenarios, mainly revealed good water quality for the biological parameters. The obtained model's calibration was in the 95% confidence intervals for most of the analyzed parameters.

After the model calibration, prediction scenarios were built. One scenario, intending to assess the influence of accidental discharges of contaminants in a specific point source, and a second one, the influence of minimum flow rates, representing an extremely dry year. The two considered scenarios revealed that self-depuration capacity is more affected by the presence of minimum flow rates than topical discharges, attesting a large potential for self-depuration along the Águeda River.

The properly calibrated QUAL2Kw turned out to be a suitable tool for building a diffusion model for pollutants. After calibration and validation, it is an excellent exercise in the construction of predictive scenarios which helps decision-making entities to characterize and manage the hydrological response in space and time.

Keywords: surface water, Qual2Kw, Águeda River, watershed, self-depuration

IMPACT OF CLIMATE CHANGE, DRAINAGE AND LAND-COVER UPON HEMIBOREAL STREAMFLOW

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ABSTRACT

The objective of the present study was to define the major factors which have impacted the long-term changes in the discharge of the Vienziemīte brook from 1946 to 2002. The major factors included the changes in the land-use, the drainage of the basin and the global climate warming.

The analysis of the topographic maps and Land Corine data demonstrated that the changes in the land-use within the river basin were essential between 1951 and 1973. The increased forest areas insignificantly influenced the changes of discharge.

In 1974 and 1975 the Vienziemīte basin was drained by 70%. Therefore, two data sets of ten years before to (1964-1973) and after (1975-1984) drainage works were compared. The annual mean and minimum discharges and the minimum discharge during summer months statistically significant at $p<0.05$ increased. No changes in the maximum discharge were identified.

In the analysis of the impact of the climate warming, the two following data sets were used: 1975 – 1987 when there was no essential climate warming and 1988 – 2002 when there was essential climate warming. In the study period of 1988-2002 the mean, minimum and maximum discharges increased from January to March and decreased in April and autumn (September-November). However, not all changes were statistically significant. The maximum discharge of the year observed early in January and February (before in March and April).

Keywords: climate change, forests, drainage, discharge, stream, Latvia

LONG-TERM AND SEASONAL CHANGES IN HYDROLOGICAL REGIME OF RIVERS IN LATVIA

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ABSTRACT

The goal of the study is to evaluate long-term and seasonal changes of the river runoff, water temperature of river upper layer and ice regime parameters under the changing climate conditions and their regional peculiarities in Latvia.

The runoff regime is characterised by analysing the annual total and mean runoff, the summer (May–October) and winter (November–February) minimum discharge and the discharge of the high water period (1951-2009). The study revealed that in the result of the climate change, the distribution of river runoff becomes more even as the differences between the runoff of the winter low water period and the maximum runoff in spring have decreases in all the hydrological regions.

In the course of describing the thermal regime (1945-2000), the long-term and monthly trends of the monthly mean and maximum water temperature from May to October of rivers in Latvia are analysed. The analysis of the relation of the long-term changes of the long-term mean water temperature and the air temperature reveals a positive trend, in particular in spring. The analysis of the relation of the long-term changes of the negative maximum water temperature and the statistically insignificant air temperature reveals that in the case of the annual maximum water temperature the physical geographic and anthropogenic factors of the basin may have a much more impact.

The analysis of the ice regime (1945-2012) indicates statistically significant later freeze-up, earlier break-up and the decrease of the duration of ice cover and the thickness of ice cover which is mainly determined by the reduced sums of negative air temperatures during the last decades. The biggest changes in the ice regime parameters are characteristic of the West and Central parts of Latvia which is determined not only by warmer and more humid winters, but also the distance to the Baltic Sea.

Keywords: hydrological regime, runoff, water temperature, ice regime, long-term and seasonal changes, rivers, Latvia

SENSITIVITY ANALYSIS OF THE CONCEPTUAL MODEL METQ

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ABSTRACT

Sensitivity analysis aims to identify the main parameters that affect model performance, and it plays an important role in model parameterization and calibration. The goal of this paper was to test the operation of the hydrological calculation in the model METQ using the sensitivity test and to develop proposals to improve the performance of the model. METQ is a conceptual hydrological model developed by scientists of Latvia University of Agriculture. It is used for ice flood forecasting, discharge forecasting and water balance studies. In this paper, we apply the METQ model on the Vienziemite River in Vidzeme region. The sensitivity test was applied using 10 years of the daily weather observation's data series (temperature, precipitation and vapour pressure deficit). The sensitivity test was carried out for each sub - basin, separately changing the set of the model parameters in 50 % range. The results were analysed using the graphical method and the statistical method's t-test and ANOVA. The research results show that most of the model parameters are stable. However, it is necessary to pay particular attention to the seven parameters in the model METQ. The changes of a few parameters gave significant impact ($p < 0.05$) on the model output. In this study was found that errors in the data and model structure lead to relevant uncertainties in the parameter optimization. Slight changes in some parameters or variables may lead to a significant alteration in the conceptual model simulation result. The model METQ can simulate the runoff of the river catchment with an acceptable accuracy.

Keywords: the METQ model, parameters, sensitivity analysis, t-test

HISTORICAL EVOLUTION OF SEAWATER INTRUSION INTOGROUNDWATER AT CITY LIEPAJA, LATVIA

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ABSTRACT

Groundwater quality in coastal areas is frequently affected by seawater intrusions as a result of extensive water pumping. Groundwater pumping in former decades has caused significant seawater intrusion into confined aquifer at city Liepaja, Latvia. Due to changes of economic situation, the pumping rate of groundwater has decreased as well as he state of seawater intrusion.

The aim of the study is to reveal historical evolution of seawater intrusion and the changes in groundwater chemistry from 1970 to nowadays. Historical data about groundwater quality (major ions), groundwater levels and pumping rates are used to assess the evolution of sweater intrusion and impacts of pumping rates on groundwater chemistry. Multivariate statistical methods were applied to distinguish groundwater groups with different characteristics according to several time frames.

Results indicate that the extent of seawater intrusion has minor changes between years 1970-1990, but at the beginning of 1990 signs of retreat of seawater intrusion can be observed. Groundwater quality has been affected by the decrease of industrial pumping rate in the central part of Liepaja as a result of financial crisis in 2007-2008. Multivariate statistical analysis indicates feasible intrusion from deeper-situated aquifers. Despite the fact groundwater pumping rate and restoration of groundwater levels have significantly decreased, the quality of groundwater shows minor improvement.

Keywords: coastal area, multivariate statistics, time series, cation exchange, groundwater quality

Acknowledgement

This research was supported by NRP EVIDENT project “Groundwater and climate scenarios” subproject “Groundwater Research”.

OBSERVED TRENDS IN HEAVY PRECIPITATION AND CLIMATOLOGICAL DROUGHT EVENTS IN LATVIA

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ABSTRACT

The study investigated long-term variability and trends of climatological drought and heavy precipitation events in Latvia using data from 10 meteorological stations for the period of 1925-2011 and for meteorological station Riga-University for the period of 1850-2011. An ensemble climate change indices derived from daily precipitation data were computed and analysed. Climatological drought was characterized by three indices: number of constitutive dry days, Standardized precipitation index and Fire safety index. Over the entire observation period a large inter annual variability and also, in some periods, inter decadal variability has occurred. The driest period has been between 1858 and 1877 (average annual precipitation 550 mm), while the period after 1977 stands out as rather wet (average annual precipitation 700 mm). The heavy precipitation days (>10 mm) showed the positive trend and strong inter decadal variability. Long-term trend for very heavy precipitation days (>20 mm) was not clearly pronounced, due to rather high inter annual and inter decadal variability. During the period from 1850 to 2011 days of precipitation exceeding the 99th percentile were observed at least 1-2 times per year, both in the cold and the warm period of the year, but in some years 3-4 times per year. With this, no significant tendency in the changes was identified, however it was noticed that the number of days with extreme precipitation was higher in the 20th century than in the 19th century. The long-term changes in climatological drought indices show significant weather conditions during winter and cold half of a year. On a country wide scale, results indicate that more droughts happened at the end of the studied time series. There are spatial differences, but in most of the stations drying tendencies are apparent in the warm season. The strong relationship, especially during the last two decades, has been found between drought indices and amount of fires in the warm period.

Keywords: heavy precipitation, climatological drought, trend analysis

ANALYSIS OF RUNOFF HYDROGRAPHS FALLING LIMBS FOR MOUNTAINOUS CATCHMENT

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ABSTRACT

The hydrology of mountainous watersheds is very specific and is affected mainly by geology and subsurface flow. It is difficult to describe the whole runoff process when particular sub processes are not understood well. This paper focuses on the analysis of watershed behaviour during precipitation free periods without the influence of snowmelt. As a study area, watershed of the Kamenice has been chosen with the outlet located at Kristianov station. The watershed is located in Jizera Mountains and the water from it flows to a big reservoir which is a part of water supply system. The watershed has an area of6.26 $km^2$and an average slope 12.2 % and is completely forested. The vegetation cover has undergone significant changes in recent decades from complete deforestation as a result of acid rains to present state of recovered forest. The reason for a selection of this watershed consists mainly in the fact that it is not influenced by man-made constructions and that the response hydrographs have simple shape. The work is a part of complex research focused on the continuous modelling aiming to identify causes of hydrologic drought in late spring and early summer periods.

The analyses presented in this paper are focused on the mathematical description of falling limbs of runoff hydrographs. These were carried out mainly for purposes of fast runoff hydrographs subsequent to important rainfall-runoff events. Within the analyses, the description of runoff after the causal precipitation was investigated by fitting falling limbs by mathematical functions. For this purpose, a number of runoff events recorded in the period lasting almost ten years was used. The dataset of mathematical functions parameters was then analysed using statistics measures. The results show that the response of a watershed can be well described mathematically and that the behaviour of the watershed can be understood as consistent.

Keywords: runoff hydrograph, mountain hydrology, falling limb, Kamenice

NON STEADY BEHAVIOUR IN SUBSURFACE DRAINAGE RUNOFF

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ABSTRACT

Subsurface drainage systems are considered to be a highway for nutrient transport, but also suspended sediments are being discharged through the drainage system. Different flow processes can be responsible for this, including soil matrix and macro pore flow. Discharge measurements with hourly time resolution have been carried out on subsurface drainage systems in a number of small agricultural fields in Norway. An analysis has been carried out on several recession periods with the objective to identify different flow processes. In this case the runoff during the recession period is considered to be represented by one or more linear processes. An indication of this was obtained through the continuous measurement of the electrical conductivity in the drainage runoff in one small field. The results showed that in almost all cases more than one flow process is available. The Akaike Information Criteria was used to test whether the identification of more than one flow process gave an improvement. An additional result from the recession analysis was that the results were different for over time, which means that there is a non-steady behaviour, which might be caused by a change in the soil physical parameters responsible for flow processes in the soil. This can have implications for process based modelling of water and nutrient losses from agricultural small fields and catchments.

Keywords: subsurface drainage, flow processes, recession analysis

SPATIAL VARIATION OF PRECIPITATION IN THE HUANG-HUAI-HAI RIVER BASIN UNDER CLIMATE CHANGE

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ABSTRACT

The Huang-Huai-Hai River Basin covers the major political and socioeconomic centers of China. Thus, flood protection and economic development by sustainable water supply are important. Due to this, it is imperative to study distribution and variation of precipitation characteristics under climate change. As hydrological observations are limited, scholars have done more research on daily, monthly, and annual data but less research on hourly data. Meanwhile, short-term extreme precipitation is the main cause of urban flooding and related rural disasters and analysis of these patterns can reflect trend changes of extreme hydrological events. This paper uses daily and hourly data from six rainfall stations in the Huang-Huai-Hai Basin representing the precipitation characteristics over the basin. A variety of statistical methods is used to analyze the observations. Intensity-duration curves are used for extreme value characteristics. The results show that the annual precipitation amount is increasing in the northern area of the Huang-Huai-Hai Basin. Similarly, the southern areas display a decreasing trend. The annual effective rainfall intensity shows an overall increasing trend. Analyzing the extreme values of precipitation in the basin shows that short-term rainfall intensity displays both increasing and decreasing trends depending on the latitude. Thus, there is no general trend but instead changes in rainfall climate that is spatially dependent. This may be connected to spatial changes in the occurring East-Asian monsoon that is influencing the general rainfall climate in the area.

Keywords: Huang-Huai-Hai, precipitation characteristics, trend analysis, rainfall intensity duration curve

NAVIGATION IN ICE AND ICING OF VESSELS IN THE SOUTHEASTERN PART OF THE BALTIC SEA IN PORTS OF LITHUANIA

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ABSTRACT

The South-eastern part of the Baltic Sea is rather unfavourable for the sea navigation in the late autumns and winters because of ice formation. Additionally, ships and their equipment in the sea are affected by icing on vessels' structures in frosty and hydrometeorological disadvantageous conditions. Consequently, the mentioned superstructure icing can highly impair stability and safety of the ships. The purpose of the research is to analyse collected available data of the near coastal hydrometeorological conditions, discuss the factors that influence the superstructure icing of vessels and observe the possibilities of navigation of the sea-going vessels and open sea terminals in ice. The major attention in the research is paid to the Lithuanian part of the Baltic Sea where two significant ports are situated: the Port of Klaipėda and the single-point-mooring (SPM) type open sea oil terminal in Būtingė. Long-term data from Klaipėda meteorological station in Melnragė suburb has been taken for investigation and prediction of the phenomena of icing of vessels and ice formation in the sea water. The continuous observation of hydrometeorological data during the period of 1961-2014 is the key to verify the existing very special circumstances that cause issues of the ice formation and the icing of vessels in the South-eastern part of the Baltic Sea ports in Lithuania. There are specific factors and statistics provided in the article that determine and prove the causes of the phenomena: calibration of water and weather temperature, prevailing winds, precipitation and level of water evaporation. Generally, the scientific analysis of the research could be further used to determine, decide on measures to avoid the dangerous situations and improve the existing activity problems of the ports.

Keywords: South-eastern Baltic Sea, sea ice, icing of vessel, navigation, hydrometeorological conditions

EVALUATION OF RESTORATION MEANS FOR CHANNELIZED STREAMS UNDER LITHUANIA'S CONDITIONS

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ABSTRACT

From the 1920's through the 1990's and especially in post-World War II period, most streams in Lithuania were channelized. Channelization is the deepening, clearing, and straightening of meandering streambeds resulting increase of stream flow velocity and the rate at which water is drained away from agricultural land. Channelized streams have better hydrodynamic parameters and can reduce the overall volume of water therefore better fits the needs of land reclamation. At the same time drastically modified morphometric parameters caused unfavorable conditions for biodiversity along stream beds and banks reducing the amount of vegetation which means less food and cover for wildlife. Most of West European countries have a good practice for restoring of channelized rivers. This experience is quite new in Lithuania and starting today with several pilot projects.

The main purpose of pilot project initiated by EPA is to restore stream meandering with minimal efforts allocating artificial obstructions at a right place and reach the necessary stream velocities to initiate the stream bed deformations and meandering consequently. The aim of our study was to evaluate the effect of proposed restoration measures under conditions of dense channel network and tile drainage systems in Lithuania. Two channelized streams from group of selected by restoration projects are discussed in this paper.

For this purpose 1D hydrodynamic model was applied. All necessary data (digital terrain model, flow boundary conditions etc.) for model inputs were collected by field works. The results of different simulation scenarios revealed, that installed obstructions accelerates bed deformations processes and initiates meandering process. At the same time, it is concluded, that numerical simulation can tell us about initiated bed and bank erosion process, but it is much more difficult to predict long term results.

Keywords: channelized stream, stream restoration, meandering, simulation model

UNCERTAINTIES AND INTERACTIONS IN HYDROLOGICAL MODELLING. A CASE STUDY OF A MOUNTAINOUS CATCHMENT IN SOUTHERN NORWAY

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ABSTRACT

The aim of this study is to investigate how the uncertainties in inputs and observed streamflow influence the parameter estimation, streamflow predictions and model evaluation. We used the elevation distributed HBV model operating on daily time steps. For parameter inference we used a Bayesian formulation and the MCMC routine Dream. The uncertainty in precipitation inputs was represented by ensembles based on a meta-gaussian random field approach. Temperature ensembles were based on random sampling of the temperature laps rate combined with a 3d kriging routine. Streamflow ensembles were generated based on possible realizations of a multi-segment rating curve model. We sampled precipitation and temperatures randomly each day, whereas the streamflow ensembles were based on using the same rating curve for the whole time series. In our calibration experiments we introduced the uncertainty in parameters, precipitation and streamflow in a cumulative manner. Further, we investigated the effect of having less information on precipitation and streamflows by removing critical observations form the complete dataset. We also investigated the effect of streamflow uncertainty on model evaluation. An interesting result was that evaluating predictions obtained on a different rating curve than the one used for calibration could result in improved evaluation scores. We also find that estimating the water balance is challenging since both precipitation inputs and streamflow observations have pronounced systematic component in their uncertainties.

Keywords: precipitation-runoff modelling, uncertainty, Bayesian method

EVALUATION OF DESIGN FLOOD ESTIMATES

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ABSTRACT

The motivation for this work is to update the Norwegian guidelines for design flood estimation based on local data. Design flood estimates forms the basis for flood risk management and is a legal obligation when building infrastructure such as dams, bridges and roads close to water bodies. The current guidelines for design flood estimates recommend to use an index flood approach if less than 30 years of local data is available. For 30-50 years of data a 2 parameter distribution is recommended, and for more than 50 years of data, a 3 parameter distribution is recommended. In this study we evaluated the Pearson III, Generalized logistic, Gamma, Generalized extreme value and Gumbel distributions. For estimating distribution parameters, ordinary and linear moments, maximum likelihood and Bayesian methods were used. We set up a test bench for local flood frequency analysis using data based cross-validation methods in order to evaluate which combination of distribution and estimation method provided the best fit and if the evaluation depend on record length. The criterions were based on stability and reliability of flood frequency estimates.

Keywords: flood frequency analysis, design flood, model evaluation

LONG-TERM CHANGES IN RIVER RUNOFF IN ESTONIA

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ABSTRACT

The Estonian rivers runoff and its changes in 1924–2014 were analysedfor five main watershed areas: Lake Peipsi, Gulf of Finland, Gulf of Riga, West-Estonian Archipelago and Koiva river basin. The analysis includes extensive monitoring dataset, which covers nearly 70% of the Estonian territory. The total annual runoff from Estonia is found as the sum of observed runoff at gauging stations situated in the lower reaches of the rivers and estimated runoff from ungauged areas. Runoff from unmonitored areas is calculated separately for five watershed areas using the average specific runoff of these regions. To detect trends and regime shifts in runoff time series Mann-Kendall trend test and STARS (Sequential T-test Analysis of Regime Shifts, known also as the Rodionov test) were used.Long-term runoff trend analysis shows an increase during the observation period. The 30 year moving average of annual runoff indicates a high statistical confidence of this growing trend. Additionally, there appears to be a declining trend in the share of spring floods. A tool has been developed to provide monitoring-based runoff estimations for the selected period from freely chosen areas of interest. This web-based tool is linked to the national databases so it works with up to date data.

Keywords: long-term surface water runoff, rivers of Estonia, trends, regime shifts, assessment tool

IMPACT ANALYSIS OF CLIMATE CHANGE AND AGRICULTURE WATER USE AS REASONS FOR CHANGES IN INFLOWS TO LAKE URMIA

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ABSTRACT

Rapid development of water use for agriculture in Iran has led to over-exploitation of water resources in Lake Urmia basin, northwest Iran. The lake, once one of the largest hyper saline lakes in the world, has been shrinking dramatically since 1995 and now holds less than 10% of its original volume. Frequent and long dry periods, climate change and variability have intensified the lake desiccation process during recent decades. This study aims to assess impact of environmental changes on the Lake Urmia inflows regimes during 1965-2013 in four 12-year time windows indicating pre-development, transition and, post development periods. A new impact index is used to assess changes in flow magnitude, timing and variability in lake inflows. Comparing the results of pre-development and transition periods reveals the effect of climate change, while comparing it with post-development period identifies the impact of reservoirs (dams) and diversions along rivers to meet increasing agricultural water demands. Results from 25 hydrometric stations throughout the lake basin were used to show that up-stream catchments show minor changes in flows indicating that climate change is not a reason for reduced lake level. The changes in magnitudes of flows in downstream stations show that lower lying agricultural regions are the main consumer of water. Among 14 main rivers flowing to the lake, Aji-Chay River, flowing form northeast to the lake, is the highest impacted river in the region.

Keywords: climate change, agriculture, impact assessment, Lake Urmia, Iran

THE SPATIO-TEMPORAL IMPACTS OF SELECTED CLIMATE CIRCULATION PATTERNS ON SWEDISH HYDROLOGY

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ABSTRACT

The aim of this work is to identify, understand and quantify the climatic drivers behind the seasonal and inter annual variability in Swedish streamflow. Our hypothesis is that different climate circulation patterns, such as the North Atlantic Oscillation, Arctic Oscillation and Scandinavian Pattern amongst others, govern the hydrological variability in different parts of the country as well as during different periods of the year. This is the first attempt at systematically investigating the connection of climate variability with the spatial and temporal variability of streamflow in Sweden. This knowledge is highly relevant both for understanding the natural stream flow variability and for assessing future climate change impacts.

The first step was to differentiate between the different hydrological processes involved in the generation of streamflow across the country, such as the predominance of snow or rain in the catchment. For that, a cluster analysis of the standardised monthly streamflow data from 64 gauging stations in unregulated systems across Sweden was performed. The cluster analysis divided these stations into five hydrological regions with homogeneous streamflow variability. The hydrological year in each of these regions was divided into well-defined hydrological periods and the chain of cause and effect connecting streamflow variability to the different circulation patterns was established. Only those connections that were both statistically significant and for which a plausible chain of causality could be established were selected for further analysis. With the help of cross wavelet transform, a detailed characterization of the underlying temporal relationships between the hydrological periods in each region and the relevant circulation pattern was made.

Keywords: teleconnection pattern, variability, cluster analysis, cross-wavelet analysis

THE DEVELOPMENT AND TESTING OF A CLIMATE SERVICE PROTOTYPE FOR THE HYDROPOWER INDUSTRY IN SWEDEN

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ABSTRACT

Hydropower accounts for nearly 50% of Sweden's energy production annually. Thus, the management and of water resources is of great importance. In seasonally snow covered regions, such as the Ume River in northern Sweden, the winter precipitation is often temporarily stored in the snowpack during the colder months and released over a relatively short period of intense flows when the temperatures become warmer. Hydropower operators need to redistribute this asymmetric temporal distribution of resources to maximise energy production throughout the year. This is achieved by storing the excess water from the spring flood period for use later in the year when streamflows are lower and the energy demands high. To this end operators need spring flood volume forecasts to assist them in planning reservoir regulation. However, it has been shown that the spread in the forecast error of operational hydrological forecasts in Sweden have not changed significantly over the last 30 years. The aim of this work is to address these issues.

A climate service prototype that forecasts the spring flood volume has been developed for Swedish hydropower river systems. The prototype is a multi-model comprising of three different model-chains: (1) an analogue chain, where analogue years from a historical dataset of precipitation and temperature observations are selected to drive a rainfall-runoff model (HBV); (2) a seasonal forecast chain, where bias corrected meteorological seasonal forecasts of precipitation and temperature from the ECMWF are used to drive a rainfall-runoff model (HBV); and (3) a statistical downscaling chain, where large-scale circulation variables from the ECMWF seasonal forecasts are downscaled together with snowpack data directly to spring flood volumes. These different chains are combined into a multi-model ensemble forecast. The prototype is evaluated against the operational seasonal forecast system at SMHI using a leave-one-out cross validation scheme. The evaluation is performed at ten gauging stations in the Ume River for the period 1981-2015.

Keywords: seasonal forecast, spring flood, climate service, prototype, multi-model, hydropower

IDENTIFICATION OF PARAMETERS IN THE STORAGE-DISCHARGE RELATIONSHIP FOR FLOODS: A CASE STUDY IN THE SAMEURA DAM BASIN, JAPAN

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ABSTRACT

The storage-discharge relationship is an important property of many hydrological models. Although the nonlinearity of river flow recession was proposed to be a power law function of the type $S=aQ^b$ (where Q is the discharge, S is the storage) in early studies such as that of Horton (1936), a major problem still lies in the uncertainties of the coefficient a and exponent b for engineering applications. The most utilized model for the flood runoff analysis in Japan is based on the power law function of the storage-discharge relationship. However, a set of a and b in the power law function is different in each flood event, causing difficulty in estimating and forecasting the flood runoff hydrographs accurately.

Our recent study of performing the sensitivity analysis for low flow parameters suggested that the optimum values of two parameters in the storage-discharge function can be characterized by an inversely proportional equation (Fujimura *et al.*, PIAHS 371, 2015). The aim of this study is to expand our previous study to identify the parameters in the storage-discharge relationship for floods. The hydrological model used in this study comprises the combination of the storage-discharge function and the Diskin-Nazimov rainfall infiltration model. The study basin is the Sameura Dam basin (472 km^2) located in the mountains of Shikoku in western Japan. For the sensitivity analysis, 14 flood events of a single peak hydrograph are selected from hourly data for a period of 20 years. In order to optimize the set of a and b by maximizing the Nash-Sutcliffe efficiency, 2,400 simulations are carried out for each flood event by changing the values of a and b using a double-loop algorithm.

The results showed that the optimum values of the sets of a and b in the storage-discharge relationship fell on a linear line on the log-log graph, and thus can be represented by the power law function.

Keywords: flood runoff, storage-discharge relation, power law function, sensitivity analysis

COMBINED HYDROLOGICAL AND WATER-USE MODELLING: A TOOL TO ASSESS SUSTAINABILITY OF WATER RESOURCE

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ABSTRACT

We present the distributed hydrological model J2000-Rhône which encompasses representations for three major water uses (hydro-power, irrigation and drinking water supply). In response to a demand by the regional water agency in charge of the French Rhone river basin, the model was set-up over the whole Rhône basin (lying both in Switzerland and France, 96 000 km^2). The objectives were to assess human influence on discharge and sustainability of water resource under climate change. An average pixel size in the model is 5 km^2, allowing for robust results for catchments larger than 50 km^2. The model skills were tested at more than 200 control stations with observed discharge time-series. Some of them reflect influenced conditions, while most of them correspond to natural river flow. After the performance of the model had been assessed in present-climate for natural and influenced conditions, coarse scenarios were built to represent possible evolutions of the water demand in future. These scenarios follow demographic trends and optional public incentives with respect to water policy. The model was able to highlight zones of likely upcoming tensions on the water resource. It also helped assessing opportunities of mitigation by changes of e.g. agricultural practice. Data-collection and interpretation were both the cornerstone and the most limiting steps of our model set-up and evaluation. It underlines the importance of decent, institutional effort in data collection and management.

Keywords: hydrological model, water use, sustainability, irrigation, water management

IMPROVEMENT STRATEGY OF THE SNOW MODULE OF A DISTRIBUTED HYDROLOGICAL MODEL

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ABSTRACT

The distributed hydrological model *J2000-Rhône* is a tool to assess the sustainability of the water resource with respect to different water uses over the French part of the Rhône basin, France. An average 25% of this basin is located above 1000 m a-s-l, resulting in an important effect of solid precipitation and snow cover on hydrological regimes. Here, we present the improvement strategy of snow modelling in *J2000-Rhône*, whose initial formulation for snow relies on a degree-day approach. Improvements first concern an adaptation of the meteorological forcing to mountain areas: in this respect we compare two meteorological forcing data commonly used over France, namely the SAFRAN reanalyses by Meteo-France, and the SPAZM interpolation product for precipitations by EDF. The former proposes 300m wide altitudinal bands at 8km spatial resolution, while the second is at kilometric resolution and relies on locally-calibrated altitudinal precipitation gradients. In a second step, the impact of the model grid choice on the modelling performance is analysed, thanks to a very modular grid-delineation tool which preserves the homogeneity of slopes, aspects and altitudes within the grid-cells. These homogeneous grid-cells are the basis for the regional calibration of relevant snow-model parameters, most notably the degree-day factor, for which we prescribe seasonal variations. Our improvements are mainly assessed through comparison to river discharge data at the outflow of alpine head catchments. Prospects include comparison of model outputs to remotely-sensed snow cover fractions from the Sentinel 2 satellite. Our methodology comes in support to hydrological and water use modelling at the regional scale.

Keywords: hydrological model, snow model, degree-day, mountain hydrology

BASE NUTRIENT LEACHING IN THE FERTILIZED HYBRID ASPEN (POPULUS TREMULOIDES X POPULUS TREMULA) PLANTATION CULTIVATED IN AGROFORESTRY SYSTEM IN LATVIA

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ABSTRACT

Plantations characterised by high yields such as short rotation forestry (SRF) are becoming popular worldwide for biomass production and their role acknowledged in the Kyoto Protocol. In the Baltic countries, where forestry has traditionally been oriented to long rotation periods (commonly 50-120 years), SRF with rotation periods less than 30 years is a new silvicultural concept. Agroforestry is a unique land use system that intentionally blends perennial vegetation and herbaceous land cover types to enhance crop productivity, profitability, providing wildlife habitat and maintaining biodiversity, enhance soil enrichment (in particular carbon sequestration) and reducing erosion, enhance microbial communities in soil and overall enhance soil, air and water quality in agroecosystems. Hybrid aspen (Populustremula L.× P. tremuloides Michx.) is a man-made hybrid between the European aspen and the North American trembling aspen. In the Baltic Sea region, hybrid aspen is one of the most promising trees (hybrids) for biomass production due to high growth rates.

Four replications of four different fertilisation subplots – control (no fertilisation), wastewater sludge, wood ash and digest ate, the size of each – 30 x 24 m, were established in the spring of 2011. Soil solution samplers were installed vertically into the soil in each subplot at 60 cm depth in the summer of 2011. Soil solution was sampled twice a month during the frost-free period. The following chemical parameters were measured in the water samples: nitrate (NO3-N); phosphorus (PO43-P); potassium (K). This research focuses on base nutrient leaching calculations using conceptual model METQUL2012 and soil solution chemistry data. The results show difference in basic nutrient leaching amounts by used fertiliser. There is strong evidence that Hybrid aspen gives significant groundwater treatment effect.

Keywords: Hybrid aspen, METQUL2012, basic nutrient leaching, groundwater treatment, carbon sequestration

THE CHANGES OF LAKE HYDROLOGICAL REGIME: A CASE STUDY OF LAKE USMA IN LATVIA

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ABSTRACT

Fluctuations of Lake Usma level are characterized by rhythmic, periodic changes over the centuries. Climate change and human impact on natural processes influence and change hydrological regime of Lake Usma. To find sustainable management solution of Lake Usma there is a need to understand causes of its hydrological regime changes. In this research we try to separate natural and anthropogenic factors that impact water level fluctuation of Lake Usma. Daily monitoring data of water level fluctuation of Lake Usma (1927-2014) are divided in three time periods: the first time period (1927-1956) before a significant anthropogenic impact, the second time period (1957-1998, 2000-2001) after a land reclamation works and eel weir construction (1966) and the third time period (2002-2003, 2011-2014) after the hydropower station operation. Comparison of monthly water level fluctuation data was made. In the first time period monthly data of water level of Lake Usma shows normal hydrological regime of North Europe Lake, with the highest water level in the end of April. The second time period shows the significant rise of water level Lake Usma. In the third period there is observed the highest water level in March and in summer with very small water level fluctuation amplitude of Lake Usma. It indicates that there is significant changes of water level fluctuation of Lake. Two stage modelling tool for anthropogenic and natural factors separation was built. First stage consists of conceptual hydrological model METQUL2012 to calculate discharge of 10 inflow catchments of Lake Usma and second stage consists of water level calculation tool of Lake. The result shows significant impact of anthropogenic and natural factors on water level fluctuations of Lake Usma.

Keywords: METQUL2012, lake hydrology, anthropogenic

INTEGRATION OF URBAN HYDROLOGICAL RESPONSE UNIT INTO THE CONCEPTUAL MODEL METQ

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ABSTRACT

The growing world population leads to higher urbanization and changes of watershed structure. The aim of this research is to highlight the necessity of urban hydrological response unit integration in the conceptual model METQ. The conceptual model METQ is build for rural areas however it cannot be used for watershed with urban areas. The integration of urban hydrological response unit in the model structure has been made during the last years. Model takes in to account not only runoff but also the water flow from sewage water treatment plants. Similarly to previous versions of the model METQ, the METQUL2012 is applied in the simulation of the daily runoff of rivers with different catchment areas. The calibration and validation of the model was done for various periods of river runoff observation records from 1966 to 2015. In present study, the model METQUL2012 is tested for the simulation of the daily runoff for the River Nerina at Bulduri. The watershed of Nerina is characterised by urbanized areas – 22%. Input data for the model are daily mean meteorological data from meteorological station at Rīga (Riga airport). Sufficient or even good coincidence between the observed and simulated daily discharges was obtained. The results show strong evidence that integrated urban hydrological response unit gives significant improvement of model results for urban areas.

Keywords: hydrological response unit, integration, METQUL2012, urban

IMPLEMENTATION OF EU WATER FRAMEWORK DIRECTIVE IN LITHUANIA: STATUS OF WATER BODIES IN PROTECTED AREAS

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ABSTRACT

Under implementation of Water Framework Directive in Lithuania four river basin management plans for river basin districts of Nemunas, Dauguva, Lielupė and Venta were prepared and approved by Lithuanian government in 2010. Within the project "Updating of river basin districts management plans and programmes of measures" updated river basin management plans and programmes of measures were prepared. The measures that are foreseen in these documents will be implemented over the period 2016-2021.

Status of water bodies was analysed and evaluated in protected areas. Good ecological status/potential has not been achieved in 192 river water bodies. Most of the river water bodies (147) in protected areas were assigned to moderate ecological status/potential. Part of river water bodies were classified as bad (35) and very bad (10) ecological status/potential. Ecological status/potential of lake water bodies was classified as follows: 20 – moderate, 10 – bad, 1 – very bad. Comparison of changes of status of surface water bodies in protected areas of first and second management cycles will be presented during the presentation.

Hydrological and hydrotechnical measures that are designed in the nature management plans prepared for "Natura 2000" territories were analysed. Re-naturalisation of water regime, blocking of the drainage channels and other measures will ensure the improvement of status of water bodies in protected areas.

Keywords: WFD, status of water bodies, protected areas, measures

INFLUENCE OF SNOW AND ICE ON THE ICELANDIC HYDRO POWER SYSTEM

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ABSTRACT

Snow and ice are important water resources worldwide. In Iceland glaciers cover about 11% of the land area and receive about 20% of the total precipitation. Currently Landsvirkjun operates 14 hydro power stations in five operation areas in Iceland supplying about 72% of total annual electric energy production. About 36% of the glacier covered area in Iceland is within catchments harnessed by Landsvirkjun. Glacier-fed rivers significantly modify stream flow volumes, variability and timing by temporarily storing water as snow and ice. Total annual catchment runoff is highly dependent on glacier melting and accumulated snowpack volume. Contribution of flow from glaciers is on average 45% of the total inflow to the Icelandic hydropower system while specific glacier-fed rivers have over 85-90% contribution during years with high melt. Overland flow (snow and precipitation) contribute on average about 25% of the total inflow. During the melt season various factors can influence glacier melt, contributing to a dry or wet hydrological year, such as availability and transport of sand and volcanic tephra both due to wind and volcanic activity in and near the glacier ablation area, which directly influences melt with increased capabilities to absorb energy. In spring and summers characterized by high precipitation less material is transported to the ablation zone resulting in less glacier melt. Reliable operational plans of hydropower plants and understanding of the current hydrology is vital as the energy system in Iceland operates in a closed loop with hydropower as base energy provider. Variability in hydrology between hydrological years can influence operations and availability of energy.

In this study, mass and energy balance of glaciers and discharge rates for selected catchments in Iceland for the period 1992–2015 are analyzed. The goal is to identify the influence of variability in albedo, winter snow thickness, summer snowing events and other relevant variables, based on in-situ measurements, aimed at identifying potential scenarios for high and low melt periods.

Keywords: hydropower, snowmelt, glaciers, albedo, runoff

IMPROVING HYDROLOGICAL FORECASTING SKILL IN SNOW DOMINATED REGIONS VIA SNOW DATA ASSIMILATION

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ABSTRACT

Snow melt runoff predictions provide valuable information for hydropower reservoir management in regions dominated by snow, and a lot of research has been focused on reducing the forecast errors by correction of forecast models using information from snow measurements. The main causes of failure to systematically improve the seasonal forecasts have been attributed to on one hand the problem to translate point or line survey data into representative sub-basin average values, or on the other hand how to downscale satellite based data to the sub-basin scale, especially in mountain areas. However, equally important could be to understand importance of the uncertainties in initial conditions (the snow storage at the start of the forecast) versus the uncertainties in the meteorological forecast. The objective of this study is to make a systematic evaluation of the improvement in seasonal spring melt forecast skill by assimilation of various types of snow data - in-situ observations and/or satellite remote sensing data for a number of hydropower reservoir basins in Sweden representing different amount of snow domination. Data assimilation methods such as Ensemble Kalman filter have was used to update the simulated water storages in snow and soil during the initialization period before forecast issued at different times through the winter and melt season. In here, we evaluate methods for updating hydrological models by use of: 1) operational snow depth measurements from SMHI, 2) satellite based data on snow water equivalent and snow cover area from EU FP7 project CryoLand, and 3) pre-operational manual observations of snow depth, snow density and snow water equivalent located close to hydropower reservoirs in the Swedish mountain area, operated by hydropower management company Vattenregleringsföretagen AB. Results show that assimilation of snow information improved spring melt forecasts in most of the study areas and study years. It was mainly manual observations of snow water equivalent and satellite based data on fractional snow cover area that where useful for improving the forecasts. However, model updating with snow data does not always lead to improved simulations of river discharge and reservoir inflow probably due to: 1) the uncertainty in the weather forecast/climatological forecast is more important than the uncertainty in the snow conditions at the start of the forecast, 2) the updating methods do not take into account systematic representation errors in the assimilated snow information in an adequate way, and 3) the manual snow observations are most sparse and the satellite based data is most uncertain in the mountain areas that are most interesting for spring melt runoff predictions from a hydropower management perspective.

Keywords: snow observations, remote sensing, data assimilation, spring melt runoff forecasts

MODELING BED CHANGE AND SOLID TRANSPORT IN CLEANED DITCH NETWORK OF DRAINED PEATLAND FOREST

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ABSTRACT

Drained peatlands comprise an important area of managed boreal forests, covering in total 15 million ha. Sustaining forest productivity in these areas requires regular ditch network cleaning. In Finland, cleaning is annually conducted on 1% of the 4.7 million ha of peatlands drained for forestry. Among forestry practices, suspended solid loads from newly cleaned ditches induce severe stress on surface waters deteriorating their ecological status, especially in headwater catchments. Understanding and predicting erosion and solid transport is essential in developing more efficient water protection strategies, as targeted by the EU Water Framework Directive. The harmful consequences of ditch cleaning on water quality are traditionally explored based on the paired catchment approach measuring suspended solid loads at catchment outlets. This approach proves useful for quantifying the exported loads, but delivers little information about the underlying processes within the ditch network. Recent studies have underlined the importance of examining and quantifying erosion, deposition and transport processes within the ditch network. They report ditch banks as important sources of erosion and suggest see page flow and wetting-induced loosening of the disturbed soil material as potential causes. Furthermore, solid transport has been observed to be supply-limited, which indicates that the depth of the available loose surface layer on the ditch bottom varies. This study exploits these findings from a modeling perspective by incorporating descriptions of open channel bed change and solid transport into an integrated hydrological model. We applied the model to a 5.2 ha peatland catchment, which was intensively monitored after ditch network cleaning. Preliminary results imply that consolidation of deposited peat sediments and precipitation induced detachment from the banks play an important role in simulating solid transport in drainage networks of forestry peatlands. Such modeling approach would further enable investigation of water protection strategies before their implementation, supporting efficient management of harmful loads.

Keywords: ditch cleaning, drained peatland forest, erosion, modeling, suspended solids

RIVER REGIME ALTERATION AND ITS IMPACTS ON ESTUARINE ZONE

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ABSTRACT

Estuarine zone are one of the most important environments among of the coastal zones. Flow regime alteration at estuarine could reflect the flow regime impact due to climate change and anthropogenic activity in whole river basin. Arvandroud river is an estuarine zone where is placed at south west of Iran and discharged to Persian Gulf. This transboundary river is formed from the confluence of Karoun and Shatolarab (Tigris and Euphrates confluence). The 942000 km^2 basin is extended through the Iraq, Iran, Turkey, Syria and Jordan. The basin has been modified by more than 110 dam during last 70 years. Due to head water modification and flow regime alteration, the large area of estuarine and connected wetland (Hooralazim) are dried, sand storms in riverine cities are dramatically increased (e.g. Ahvaz city), soil and water quality were destroyed because of extended tidal zone and etc. The main purpose of this paper is evaluating the role of different tributaries modification on the Arvandroud flow regime alteration. Three major flow regimes attributes as timing, magnitude and variability of flow has been calculated as timing factor (TIF), magnitude factor (MIF) and variability factor (VIF). By combining these factors, the flow regime impact factor (IF) has been scaled between (0-1) and the flow regime impacts are classified into five groups as low (0.80<IF<1.0), incipient (0.60<IF<0.80), moderate (0.40<IF<0.60), severe moderate (0.2<IF<0.40), and drastic (0.0<IF<0.20). By using the monthly flow data of 41 gauge stations, the flow regime alteration was evaluated for different points of basin. The flow regime impact map has been developed for the magnitude, timing, variability and of total impact for all tributaries. Comparison between (1951-1965) and (1981-1995) as pre and post impact period shows, all head water gauges where are placed above dams were classified as low impact for flow regime alteration, while, among of three main tributaries at the Karoun river with IF=0.72 (classified as Incipient impact), the Tigris and Euphrates with the IF= 0.29 and 0.38 shows the severe impact. The impact factor for the Arvandroud (estuarine area) is 0.20 and indicates the drastic impact.

Keywords: river regime alteration, Tigris and Euphrates, impact assessment

EXTREME POINT ALTERATION IN HYDROLOGY OF SMALL CATCHMENTS DUE TO PEAT HARVESTING

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ABSTRACT

Peat is a harvested for horticulture and energy uses resulting in significant land use changes. Peatlands are in pristine conditions usually covered by forest and wetland vegetation with some degree of natural drainage networks. In the peat harvesting process, the forest or wetland area is ploughed, levelled and condense drainage system is constructed to lower groundwater levels. This causes considerable impacts on hydrological process including changed groundwater table, surface infiltration and runoff generation. To analyse changes, Korentosuo (64.87672°N, 26.83599°E) peat harvesting site was observed which is located in the Oulujoki river basin in northern Finland. Here peat is harvested (area about 2.1 km2) since 2010 which operation plans for another 20 years. To evaluate hydrological alterations, a rainfall-runoff model based on SCS method was developed by using Hec-Hms software. The model was run for two periods to analyze pre and post- impact hydrology. The curve number (CN) for pre-impact period was selected from literature suggested by USCS, and for the post impact period the CN estimated based on observed rainfall-runoff events during 2012 and 2013. The result show that three major flow characteristics (magnitude, timing and shape of hydrograph) were changed. The model was run with rainfall of different return periods (10-100 years) using long term observed precipitation data (1961-2012) in Oulu airport and Kaiani. Shorter rainfall durations were obtained by downscaling using the Bel method. In term of timing, the base time of runoff hydrograph from 18-20 hours for pristine catchment was reduced to less than two hours with significant increases the peak flows (about 10 times). Through this hydrological change, a low continuous flow with long base flow was changed to significant high flow during with little base flow.

Keywords: peatland, rainfall-runoff, SCS method

WATERSHED SCIENCE AND SUSTAINABLE WATER RESOURCES MANAGEMENT

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ABSTRACT

Water is an essential resource for sustaining life and civilizations in the world. Since the 20th century, different programs and approaches have been implemented in coping with the global water supply crisis, including supply management, efficiency improvement, demand management, water rights, integrated water resources management. At the same time, rapid advancements have also been taking place in tracing, mapping, remote sensing, networking, and modelling technologies in hydrological research. Despite those programs and advancements, a water supply crisis is intensifying globally. Worldwide, approximately 2.6 billion people lack access to safe drinking water supply and improved sanitation, and water-associated diseases cause serious illness of over 300 million people each year, and by 2025 over 3.5 billion people will face water shortages. Apparently, a new approach is needed to tackle the pressing global water crisis.

Since watershed is the natural unit for water resources management, a watershed science needs to be developed /redefined to address the water resources issues holistically. The main feature of the watershed science is that it couples the natural and human systems by taking into full account the development and implementation of policies, processes, technologies, and leadership structures in hydrological research and water resources management to ensure the better understanding, distributing, protecting, and improving the movement and characteristics of water resources at multiple spatial and temporal scales. The research first reviews the advances in hydrological research and water resources management, and then discusses issues and challenges facing the global water community. Subsequently, through watershed case studies of the Heihe River Watershed in Northwest China and the Tennessee River Authority in the US, it describes the core components of the watershed science: 1) inventorying, monitoring, and modelling; 2) goal setting; 3) water allocation; 4) indicator setting and measurement; 5) organization and decision making process; and 6) feedback analysis.

Keywords: water shortage, water shed processes, watershed science, water resources management

A TOOL FOR COMBINING OBSERVATIONS AND SIMULATIONS AND IMPROVE THE CHARACTERIZATION OF REGULATED RIVERS

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ABSTRACT

SMHI uses S-HYPE (a setup of the HYPE Open Source model for Sweden) to simulate the hydrologic conditions in approximately 37,000 sub-basins. These sub-basins are coupled in river networks and include both regulated and unregulated rivers. The results from the model are used for reporting within the EU Water Framework Directive (WFD) and shared openly at http://vattenwebb.smhi.se. For regulated rivers, seasonal regulation routines for over 500 dams have been estimated which the model simulates on a daily time step. In reality, however, many dams are regulated at higher than seasonal frequencies due to an uneven electricity demand. Therefore, observations from dams with short-term regulations need to be included in the analysis, as well as their hydrological impact on downstream river reaches. If neglected, the hydrologic regime of regulated water bodies may be wrongly characterized leading to erroneous classification within the WFD.

We developed an interactive JavaScript tool to improve the characterization of regulated rivers by combining observations and simulations in an innovative way. In a web browser, the user starts by selecting a river reach to be characterized. Upon selection, the tool automatically collects the boundary conditions of the selected river reach (discharge inputs from the main channel, tributaries and local runoff) from a pre-existing S-HYPE simulation provided by SMHI. In the next step, the user may upload observed time series and/or define regulation routines at arbitrary points along the river reach. Following user inputs, the tool recalculates downstream conditions by combining the boundary conditions with the new information provided by the user. Using these results together with pre-existing simulated reference conditions (unregulated discharge) provided by SMHI, the tool calculates and presents different indicators of hydrological alteration to support work within the WFD.

Keywords: regulated rivers, hydrological modelling, Water Framework Directive, hydrological regime

COUPLING A GLOBAL HYDRODYNAMIC ALGORITHM AND A REGIONAL HYDROLOGICAL MODEL FOR LARGE-SCALE FLOOD INUNDATION SIMULATIONS

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ABSTRACT

The global hydrological models usually generate larger bias on river discharges than the regional hydrological models for large-scale river basins. Consequently, the flood inundation maps based on the global hydrological results have large uncertainty for regional decision-makings. Many regional flood inundation simulations apply the coupled 1D/2Dand fully 2D hydrodynamic models using detailed river cross-section information and high resolution elevation data. These models are rarely used for large-scale river basins due to intensive data requirements and computational resources. To bridge the gap between the global and regional flood inundation simulations, we coupled the global hydrodynamic algorithm from the CaMa-Flood (Catchment-based Macro-scale Floodplain) Model and the regional hydrological model SWIM (Soil and Water Integrated Model) for large river basins in Europe. As a first step, we tested this new model in a meso-scale catchment Mulde (ca. 6000 km^2), a sub-catchment of the Elbe basin in Germany. This model simulates both the daily discharge at gauge Bad Tueben and the flood inundation area during flood events. The results show that the Cama-Flood hydrodynamic algorithm can well reproduce the daily discharges from 1991 to 2003. It even out performs the Musk in gum flow routing method, which is the default routing method in SWIM, especially for the flood events. The simulated flood inundation area in August 2002 is also comparable with the observation along the main river. However, this coupled model is problematic to simulate the flood inundation area in small headwater sub-basins in the Mulde basin.

Keywords: CaMa-Flood, SWIM, Mulde, large-scale, flood inundation

UNCERTAINTY REDUCTION IN REGIONAL WATER BALANCE MAPPING BY REGIONALIZATION STUDY OF A HYDROLOGICAL MODEL IN SEASONALLY SNOW-COVERED MOUNTAINOUS CATCHMENTS

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ABSTRACT

Prediction in Ungauged Basins (PUB)has been identified by the International Association of Hydrological Sciences (IAHS) as one of the most challenging topics in current surface hydrology research. Regionalization, as one of the core objectives of PUB initiative, has been used for assessing and predicting hydrological response in ungauged regions. Regionalization methods can generally be classified as regression methods, spatial proximity methods and physical similarity methods. After more than a decade of intensive study, many methods and developments have been proposed and applied for PUB. However, how to reduce the uncertainty for such predictions still remains as one of the most challenging topics in hydrological research, because of the complexity of hydrological mechanism, the diversity of drainage basins, the restriction of data and limitations of models themselves. As a result, there is no universal method available for regionalization. In this study, performance of existing regionalisation methods will be evaluated and modified to produce best simulation results for the seasonally snow-covered mountainous catchments in Norway, in order to reduce the uncertainty in regional water resources assessments and water balance mapping. To perform the study, the monthly water balance model WASMOD will be calibrated and regionalised using long-term data from145 catchments. The study will contribute to the theoretical understanding and development of regionalisation methods, as well as to produce spatially distributed runoff data for a high resolution water balance mapping of Norway.

Keywords: regionalization, predictions, uncertainty, water balance mapping

ANALYSIS OF WATER RESOURCES VARIATION IN THE POYANG LAKE BASIN, CHINA WITH WAVELET AND R/S METHODS

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ABSTRACT

Along with global climate change, regional water resource is predicted to change. As a branch of the Yangtze River, the Poyang Lake basin has suffered from serious droughts and floods during the past several decades, which caused great damage to local residents and ecosystems. Based on the observed streamflow from five main tributaries and the outlet of the Poyang Lake basin during the period 1960-2013, this paper investigates the variation characteristics and future trend of water resource by using the method of wavelet and Rescaled Range (R/S) analysis. According to wavelet decomposition, streamflow of all the gauging stations show an increasing trend before 1998, and then turn to decrease after that year. On this basis, Hurst indices were calculated for the streamflow series before and after the year 1998, and then the effectiveness of R/S analysis in trend predicting was verified. Further analysis shows that the Hurst indices of streamflow of the outlet of Poyang Lake basin and that of the main tributaries in the basin during the study period are less than 0.5 (0.224～0.339). These values, deviate from the increasing trend of the long-distance correlativity of streamflow of the six gauging stations, except for Lijiadu station, and therefore a decreasing trend is forecasted for the whole basin, except for Fuhe sub-basin.

Keywords: streamflow time series, wavelet decomposition, R/S analytical method, Hurst index, the Poyang Lake basin

MULTIFRACTAL CHARACTERISTICS OF STREAMFLOW SERIES AND HYDROLOGICAL EFFECT OF WATER CONSERVANCY PROJECT IN THE POYANG LAKE BASIN, CHINA

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ABSTRACT

Investigation of the multifractal characteristics of streamflow series can effectively reveal the complicated nonlinear structure of hydrological process, which is important for the understanding of the mechanism of water circulation. Based on long-term daily streamflow series of Waizhou, Meigan and Lijiadu stations, this paper explored multifractal temporal scaling properties of the Poyang Lake basin by using a multifractal detrended fluctuation analysis (MF-DFA) technique, and investigated the hydrological effect of water conservancy project. The results indicate that the streamflow series of the Poyang Lake basin are non-stationary. The three gauging stations almost show a similar multifractal characteristic for daily streamflow series, while different for monthly streamflow series. Due to differences in drainage area, characteristics of precipitation and underlying surface, the width of singularity spectrum among the three stations revealed that there are spatial differences in the complexity of the daily streamflow. The complexity of streamflow on Waizhou is larger than the other two of gauging stations. As an example, the completion of Wan'an reservoir in middle Ganjiang River has changed the natural hydrological processes downstream, leading to a different fractal characteristic with comparison to the case of no dam effect.

Keywords: hydrology, multifractal, MF-DFA, hydrological effect of water conservancy project, the Poyang Lake basin

LINKS BETWEEN SHIFTS IN SNOWMELT TIMING IN FINLAND AND LARGE-SCALE CLIMATE SIGNALS

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ABSTRACT

This study analyses the first and last days of snowmelt events and the number of days (duration) between those throughout a water year (Sep-Aug). Such parameterswere estimated using daily precipitation and temperature measurement at Kaisaniemi, Kajaani and Sodankylä stations in southern, central and northern Finland as input datasets to a temperature-index snowmelt model. Then, shifts in the parameters at all three stations during 1909-2008were determined. As snowmelt is a sensitive hydrological variable to seasonal temperature, particularly during spring, variations and trends in spring (Mar-May) temperature at each station were evaluated during the study period. To explain changes in snowmelt timing and spring temperature, their correlations with the well-known large-scale climate signals over Finland were measured. Long-term (1908-2008) avergare values indicated the longest snowmelt duration at Kajaani (186 days), and then at Sodankylä (152 days) and Kaisaniemi (147 days). Snowmelt duration significantly ($p<0.05$) shortened at both Kaisaniemi (0.26 days/year) and Kajaani (0.23 day/year) over the period 1908-2008, but not at Sodankylä. At Kaisaniemi, shorter snowmelt duration was associated with the eailer last day (0.31 days/year) of snowmelt, but at Kajaani with the later first (0.11 days/year) and the earlier last (0.10 days/year) days. At Sodanklylä, significant earlier last day (0.18 days/year) of snowmelt was found, without any effects on the snowmelt duration. Spring temperature showed increasing trends at both Kaisaniemi (0.02 °C/year) and Sodankylä (0.02 °C/year), but not at Kajaani. The results showed thatthe North Atlantic Oscilation (NAO) and the Arctic Oscillation (AO) mainly influnced snowmelt timing and spring temperature at Kaisaniemi and Sodankylä, while the East Atlantic/West Russia (EA/WR) pattern at Kajaani.

Keywords: snowmelt timing, trend analysis, climate signals, Finland

CENTURY-LONG VARIABILITY AND TRENDS IN SNOWFALL SEASON PARAMETERS IN FINLAND

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ABSTRACT

In this study, snowfall sea on (SS) was defined as the duration between first and last days with precipitation falling form as snow within a water year (Sep-Aug). Accordingly, snowfall season parameters (in terms of start (SSS), end (SSE) and length (SSL)) at Kaisaniemi, Kajaani and Sodankylä stations in southern, central and northern Finland were estimated using daily precipitation and temperature measurement as input to a temperature-index snowmelt model. Then, the variability and trends of SSS, SSE and SSL at all three stations during 1909-2008were analysed. To explain such changes in SS parameters, their correlations with corresponding seasonal temperature were measured: autumn (Sep-Nov) temperature in correspondence with SSS, spring (Mar-May) temperature with SSE, and the average of previous autumn and current spring temperatures with SSL. Finally, most influential atmospheric circulation patterns (ACPs) for changes in SS parameters and their corresponding seasonal temperatures were identified. In average, SSL was naturally longer at higher latitudes: 211 days at Sodankylä, 192 days at Kajaani and 146 days at Kaisaniemi. Significant ($p<0.05$) shortening trends in SSL were determined at both Kaisaniemi (0.17 days/year) and Kajaani (0.16 days/year) stations during 1908-2008. Such changes were associated with signifcant earlier SSE (0.15 days/year) at Kaisaniemi, while with significant later SSS (0.1 days/year) at Kajaani. At all three stations, significant moderate relationships were found between SS parameters and their corresponding seasonal temperatures, with higher correlations at lower latitudes where rho ranged from: -0.40 to -0.52 for SSL, 0.47 to 0.21 for SSS and -0.34 to -0.46 for SSE. At Kaisaniemi, all seasonal corresponding temperatures to SSS, SSE and SSL showed significant warming trends ranging from 0.01 to 0.02 (°C/year) during the study period. Both seasonal temperatures corresponding to SSL and SSE warmed at Sodankylä at the rate of 0.02 (°C/year) over the period 1908-2008.However, no significant trends were found in seasonal temperatures corresponding to SS parameters at Kajaani. The North Atlantic Oscilation (NAO), the Arctic Oscillation (AO) and the East Atlantic/West Russia (EA/WR) pattern were the most significant ACPs affecting variability and trends in SSS, SSE and SSL and their seasonal corresponding temperatures in Finland. The NAO was mainly predominant at Kaisaniemi, the EA/WR pattern at Kajaani and Sodankylä, and the AO at all three stations.

Keywords: snowfall season, trend analysis, atmospheric circulation, Finland

VARIABILITY OF RIVER HABITAT SURVEY FEATURE SCORES IN LATVIA AND ITS RELATION TO TWO BIOLOGICAL QUALITY ELEMENT GROUPS

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ABSTRACT

The aim of this research was to investigate variability of hydromorphological parameters calculated from River Habitat Survey and its relationships with selected biological quality indicators. Hydromorphological alterations are among the most important factors, affecting river water quality and it is necessary to understand relationships between natural distribution of abiotic parameters, pressures and its impact on biological communities. Previous studies on hydromorphological conditions of Latvian rivers have focused mainly on natural streams, and this is the first attempt to analyse biological response to morphological parameters, covering full gradient from natural to impacted streams.

This study summarises results of three projects, carried out by Institute of Biology, Laboratory of Hydrobiology. Overall, 90 sites in 62 small and medium-sized lowland rivers in Latvia were investigated. Both hydromorphological (RHS, riparian land use) and macroinvertebrata data were analysed for all 90 sites, and macrophytes – for 54 sites.

Within this research, weak, but statistically significant correlations between different scores delivered from RHS and biological indices have been found. Relationships with HQA subscores were weak for both studied biological quality elements (maximum r^2=0.22 for macroinvertebrates and r^2=0.21 for macrophytes). Although invertebrates responded with higher intensity to morphological parameters than macrophytes (share ratio's 37.7% and 20% respectively), their mean response was weaker (mean r^2=0.10 for macroinvertebrates and r^2=0.16 for aquatic plants). PCA analysis showed no significant differences between distribution of hydromorphological variables in different river basins in Latvia. Our study revealed that habitat morphological alterations has larger impact on biological quality elements than stream's habitat diversity. From all tested biological indices, ASPT for macroinvertebrates and MIR for macrophytes were best correlated to hydromorphological variables and degradation indices. Macroinvertebrates tend to have wider range of response intensity to hydromorphological alterations, but macrophytes correlate more closely to riparian vegetation alterations.

Keywords: river Habitat Survey, hydromorphology, benthic macroinvertebrates, macrophytes

EFFECT OF LOCAL WIND FIELD ON A DISPERSION OF PASSIVE TRACERS

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ABSTRACT

Majority of lakes in Finland are shallow and thereby wind has an important role when considering their circulation dynamics. Finland's nationwide meteorological observation network has been created for the purpose of weather forecast and aviation, thus a large portion of the stations is located at airports. Therefore the studied lakes are in most cases far away from observation stations. If the terrain is flat between the lake and a meteorological station, the wind field is expected to be quite similar in both locations. In case the topography is complex, such assumption cannot be made, and spatial as well as temporal deviation in the wind field is to be expected. These deviations cause significant differences in model calculations of the distribution of substances in lakes.

Our study lakes L. Tuomiojärvi and L. Palokkajärviare connected by a small channel (length 130 meters, width 5 meters, depth less than 1 meter) were water can flow freely. We examined the influence of the wind on the water exchange through the channel. We measured water height with two high accuracy devises on both sides of the channel and measured water flow in the channel.

In addition to measurements we performed hydrodynamic simulations of the lakes using the 3-dimensionalmodel code COHERENS in order to understand the effect of varying wind fields on exchange of water between the two lakes and circulation in general. We performed simulations with 1) wind speed and direction measured at the nearest official meteorological observation site located 15 km north of our study lakes, and 2)wind speed and direction measured at the lakes. There are clear differences in the simulated concentration fields of numerical tracers, representing e.g. contaminants, as well as in concentration time series.

Keywords: wind field, current field, water flow, model, COHERENS

INDEX-BASED ANALYSIS OF CLIMATE CHANGE IMPACTS ON ENVIRONMENTAL CONDITIONS FOR FISH

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ABSTRACT

Climate change is expected to have a strong effect on fish as it will affect the flow regime and cause loss of habitat, reduce biodiversity, change the community composition and behavioral habits. As part of the project on Climate change impact assessment for selected sectors in Poland (CHASE – PL) we assessed the consequences of climate change in large-scale in the river basins of the Vistula and the Odra, and meso-scale in their sub-basins of Barycz and Upper Narew. Since fish can be regarded as a good indicator of stream health, we focused our attention only on this biotic group. We assessed how climate change causing changes in streamflow would influence the environmental conditions of fish in the large and meso-scale river basins in Poland.Data on current and future streamflow were obtained with the use of the Soil and Water Assessment Tool (SWAT) driven by a set of nine EUROCORDEX Regional Climate Models. We evaluated the flow regime change with the use of Indicators of Hydrological Availability (IHA) methodology by obtaining current and predicted future values of the indicators under the conditions of climate change. On the basis of literature review we assessed which IHA parameters are ecologically relevant and significant for fish in Polish conditions. For the large-scale analysis we chose 20 IHA parameters for further analysis. For the meso-scale we focused on target fish species and also assessed the relevant IHA parameters.. The last step was to convert the results into "traffic light" maps with a use of a grading system.The results show influence of climate change on environmental conditions for fish.

Keywords: Climate change, impact, streamflow requirements, fish, index, indicators, modelling, Vistula, Odra

EFFECT OF ENVIRONMENTAL CONDITIONS ON CONTAMINANT RETENTION IN TREATMENT PEATLANDS

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ABSTRACT

Natural wetlands, particularly peatlands, have a vast relevance for passive treatment of mining wastewater due to their worldwide abundance and the ability to effectively remove pollutants through settling, biochemical processes and adsorption. Plant material and organic and mineral soil particles provide a substantial surface area in treatment peatlands for adsorption of contaminants. Adsorption is crucially effected by environmental conditions, such as temperature and pH, as well as the type and concentration of contaminants in wastewater. Temperature changes can cover quite a broad range in northern climates and changes in contaminant concentration can occur due to dilution in the events of storms, snowmelts and after the closure of mines. Similarly, pH of mine wastewater can vary considerably depending on the mineral composition of ore and employed processes. Therefore, the effects of dilution, temperature and pH on sorption and leaching of arsenic (As), antimony (Sb), nickel (Ni) and sulphate (SO_4^{2-}) from mining process wastewater and drainage water on peat, obtained from treatment peatlands, was studied in batch sorption experiments. The results demonstrated that although retention of contaminants on peat is widely affected by environmental conditions and degree of dilution, a single straightforward positive or negative correlation between the two is often non-existent across the entire studied range of values for a particular parameter. In general, leaching of As to process wastewater was negligible compared to adsorption, and extreme temperatures and lower pH resulted in higher adsorbed quantities. Sb leaching was promoted by stronger dilution and higher pH. SO_4^{2-}leached in general and especially at weaker dilutions while Ni demonstrated higher quantities in adsorption than desorption. Leaching from the most heavily loaded layers in the peatlands was most pronounced.

Keywords: sorption, leaching, mine water, treatment peatlands, metals, sulphate

SUB-DAILY PRECIPITATION EXTREMES IN OBSERVED DATA AND REGIONAL CLIMATE MODEL SIMULATIONS

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ABSTRACT

The study compares characteristics of observed sub-daily precipitation extremes in the Czech Republic with those simulated by HadRM3 and RCA4 regional climate models (RCMs) driven by reanalyses, and examines diurnal cycles of hourly precipitation and their dependence on precipitation intensity and surface temperature. Warm season (May–September) maxima of 1h to 24h aggregations are analyzed. The observed maxima of short-duration events (1h, 2h and 3h amounts) show one diurnal peak in the afternoon, which is simulated reasonably well by RCA4, although the peak occurs too early in the model. HadRM3 provides an unrealistic diurnal cycle with a peak during the night-time and a minimum in the afternoon coinciding with the observed maximum for all 3 ensemble members, which suggests that convection is not captured realistically. Distorted relationships of the diurnal cycles of hourly precipitation to daily maximum temperature in HadRM3 provide further evidence that the underlying physical mechanisms are misrepresented in this RCM. The analysis of the GEV distribution for short-duration precipitation maxima (1h, 2h and 3h amounts) shows that the RCMs are not able to capture the range of the shape parameter estimates realistically, either leading to too many (nearly all; HadRM3) or too few (RCA4) grid boxes in which the shape parameter estimate corresponds to a heavy tail. This suggests that the distributions of maxima of sub-daily precipitation amounts are severely distorted in the RCM-simulated data and do not match reality well. Analyses of projected changes of sub-daily precipitation extremes in climate change scenarios based on RCMs may therefore be misleading and need to be interpreted with caution.

Keywords: sub-daily precipitation, regional climate models, precipitation extremes, Central Europe

LONG TERM CHANGES OF DISSOLVED ORGANIC CARBON FLOWS FROM TERRITORY OF LATVIA

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ABSTRACT

Climate change and growing impact of human activities is influencing concentrations of refractory organic substances in waters. An indicator in this respect are flows of natural organic substances – humic substances (major part of dissolved organic carbon DOC). Transfer from adjacent areas, industrial effluents and non-point pollution sources as well as infiltration from wetlands can be sources of increased fluxes of DOC. Flows of DOC has been analyzed worldwide, but there are few publications concerning water chemical composition and DOC in waters of Latvia. The aim of this study is to describe long term changes of DOC concentrations in surface waters of Latvia, factors controlling DOC runoff, spatial variability of water chemical composition, possible impacts of pollution sources, as well as climate change.

Within this study, the DOC concentrations in the major rivers and lakes of Latvia have been determined as well as experimental studies of DOC flows in Salaca River basin (river basin in the North Vidzeme Biosphere reserve with minimal human impacts) and agricultural basins has been studied to calculate export values depending on the land-use character. Impact of other major water ingredients on DOC budgets has been studied. The dynamics of DOC flows depending on land use pattern and soil properties in Latvia are described, including emissions by industrial and agricultural production. In these changes evidently climate change signals can be identified. The water chemistry of a large number of lakes and rivers has been determined and the possible impact of water chemical composition on DOC flows has been evaluated.

Long-term changes (1977-2013) of concentrations of DOC do not follow linear trends but rather show oscillating patterns, indicating impact of natural factors, e.g. changing hydrological and climatic conditions. There is a positive correlation between content of DOC and water discharge. This study did not reveal a clear correlation between the concentrations of DOC and land-use types within the river basin. A closer relationship was found between TOC concentrations and soil texture.

Keywords: dissolved organic carbon, climate change, brownification, discharge

ANALYSIS OF FLOODS ON LIELUPE, VENTA AND GAUJA RIVERS

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ABSTRACT

Floods are one of few natural hazards Latvian river basins is exposed to. Larger or smaller scale floods and inundations are frequent natural phenomena on the rivers of Latvia. Floods can occur in all seasons with different intensity and duration. In some years can be more than one flood episode, sometimes in different seasons. Therefore for analysis are used not only annual maximum discharge data series but maximum winter season (November – April) discharge data series and maximum summer season (May – October) discharge data series. Not all annual maximum discharge causes inundations, in some years inundations are observed more than once – in winter and summer seasons. Climate is changing and it contributes to changes in hydrological regime and flood character. Floods were divided by their origin: snow, rain or mixed. For each flood case were done analysis based on flood magnitude, modality and duration, not only origin. The aim of this paper is to analyze how changes nature of flooding in Latvian rivers, is there any long-term changes in prevailing flood origin or duration of flooding events.

Frequency analyses were done for annual maximum discharge data series, maximum winter season discharge and maximum summer season discharge data series at Gauja River near Sigulda, Lielupe River near Mezotne station and Venta River near Kuldiga stations.

Results showed that annual maximum discharge pattern changes – in past century dominated snow induced floods, now more often is registered mixed origin and rain induced floods. Longest duration is for mixed origin floods, they have highest modality too.

Keywords: annual maximum discharge, flood origin

GROUNDWATER SURFACE WATER INTERACTION IN ESKERS

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ABSTRACT

Eskers are postglacial sand and gravel deposits that constitute one of the main aquifer types of Northern Europe. Eskers are typically connected to surface waters and often discharge to streams, lakes, wetlands and springs. Such important ecosystems are in many cases dependent on stable groundwater discharge. Protection of groundwater dependent ecosystems is often required against extensive water abstraction and different types of land use including forestry in the recharge and discharge areas. A summary of 10 years of experience in esker hydrology will be presented. The role of forestry and other land uses, water abstraction and climate change will be discussed and compared. Different methods to observe complex processes in discharge zones and ecosystems will be presented including examples from traditional flow, water level and pressure measurements, isotope techniques and infrared imagery surveys. Recent effort in numerical modeling using fully integrated models such as HydroGeoSphere will be presented showing analysis of flow paths in a complex hydrogeological setting with many groundwater-surface water interactions.

Keywords: groundwater, hydrogeology, ecosystems, peatlands, eskers, isotopes, modelling.

IMPACT OF ANTHROPOGENIC PRESSURE ON THE WATER QUALITY IN TWO LATVIAN RIVER BASINS

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ABSTRACT

The aim of this study was to investigate changes of water quality in rivers of the Venta and Lielupe river basin district. Anthropogenic pressures differ among the studied rivers. Most of the Lielupe River basin is designated as a nitrate vulnerable zone where the intensive agricultural activity is responsible for elevated nutrient concentrations. It is proved that agricultural runoff is major issue causing the pollution of surface water ecosystem in Latvia. Since 1995, the use of fertilizers (especially nitrogen containing)in Latvia has increased 5 times. We have found a weak statistically non-significant increase of nitrate concentrations for period 2000-2013 in the studied medium and large rivers, while phosphorus concentrations still mostly show a decreasing tendency. Extremely high nitrate concentrations exceeding 11.5 mg N/l are observed in mild winters, late autumn or early spring when surface runoff favours leaching of nitrogen compounds from catchments where arable lands occupy more than 50 % of the catchment area. It is well-known that the communities of benthic invertebrates reflect the long-term impact of multiple stressors, e.g., pollution, oxygen conditions, hydromorphological modifications. For this reason, in 2013 benthic invertebrates from 60 river stretches in both Venta and Lielupe River basin districts were sampled and analysed. Calculated indices based on the occurrence and species composition of benthic invertebrates reveals that the higher percentage of rivers that fail to reach at least a good ecological status are found in the Lielupe basin.

Keywords: agriculture, benthic invertebrates, land use, nutrient concentrations, trend analysis

COASTAL AND FLUVIAL FLOOD HAZARD IN LATVIA, FLOOD RISK MANAGEMENT PLAN FOR 2016-2020

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ABSTRACT

Flood Hazard and Flood Risk Maps as well, as the Flood Risk Management Plan for 2016-2020 (FRMP) have been prepared during year 2015 in the frame of the Project „Proposals for National climate change adaptation strategy, identifying the information and measures for adaptation to climate change, as well as the assessment of the effects and costs" under the European Economic Zone Norwegians Financial instrument. One of the Project' objectives was to design the EU Flood Directive 2007/60/EK (FRD) complain Flood risk information system that includes as interactive flood maps, and early warning hydrological forecast system in Latvia.

In accordance with the Initial Flood Risk Assessment (2007) 25 areas with potential significant flood risk were identified and reported in Latvia. These areas are divided between 4 River Basin Districts, and 10 of them are in Daugava RBD, 8 in Venta RBD, 5 in Lielupe RBD and 2 in Gauja RBD. Therefore, the FRMP and flood maps were prepared for these 25 territories. The Program of measures is based on the Assessment of the significant environmental risks counting the flood risk that has been carried out in 2014, and included proposals from municipal administrations for achievements of flood protected areas.

The flood hazard maps of Venta, Lielupe and Gauja RBDs were created using one-dimensional HEC-RAS Model and application of the ArcMap application Geo-RAS. Daugava RBD flood modelling was carried out in 2011 using Mike-Basin model. Two types of floods, coastal and fluvial, have been modelled, though only spring flood was defined for the 1-st stage of FRMP.

Present article shows the results of flood hazard and flood risk mapping for Latvian APSFRs, and Program of measures created for the Flood Risk Management Plan as well, as problems and details of flood modelling.

Keywords: flood hazard and flood risk maps, flood risk management plan for 2016-2020 of Latvia

SPATIAL DISTRIBUTION AND TEMPORAL CHANGES OF THE RIVER WATER TEMPERATURES IN THE BALTIC COUNTRIES

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ABSTRACT

Water temperature is an important physical parameter of water quality, used for the assessment of ecological status of surface waters according to the Water Framework Directive (WFD) 2000/60/EC. Thermal regime of the rivers in the Baltic countries is not sufficiently studied. Presented research describes the spatial distribution and temporal variation of river water temperature in the Baltic countries using a unified methodology. Object of the research – average water temperature of rivers during the warm period (May-October) of the year and the warmest month (July). Long-term data series of water temperature observations (selected series in LT – 25, LV – 36 and EST – 20 water gauging stations)were used to determine temporal and spatial variations in parameters. The contour maps of water temperature of warm season (May-October) and warmest month (July)were compiled for the rivers of the Baltic countries using data series for the period 1961–1990 (in LT – 41, LV – 36 and EST – 17 water gauging stations). These maps allow the evaluation of water temperature for the unmonitored rivers. The maps of the spatial distribution of water temperature show that river feeding type, river size, basin topography and lakes in the basin are the factors that have the biggest impact on river water temperature. Analysis of long-term changes of rivers water temperature showed the positive trends over the past two decades. In the standard normal period (1961–1990) the average warm season water temperatures were 14.9 °C in Lithuanian rivers, 13.2 °C in Estonian rivers and 14.6°C in Latvian rivers, while in the last year period (1991–2010) these temperatures were 15.4 °C and 13,5 °C, accordingly in Lithuania and Estonia.

Keywords: water temperature, warm season, rivers of the Baltic countries, spatial distribution, temporal changes

Acknowledgement
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THE EFFECTS OF WATER LEVEL CONTROL STRUCTURES ON NUTRIENT REDUCTION IN AGRICULTURAL RUNOFF

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ABSTRACT

Water level control structures can beutilized to maintain proper water levels and control flow rates in open ditches. These outlet structures provide water flow conditions and environments favourable for natural water treatment processes including sedimentation of suspended solids and particle bound nutrients, as well as retention of dissolved forms of nutrients through biological and chemical processes. This study was initiated in 2013 and involved installation and monitoring of twelve water level control structures in the open ditches that accumulate subsurface drainage and surface runoff from agricultural land managed by the "Vecauce" (training and research farm of the Latvia University of Agriculture) and other farmers. Water samples were collected at inlets and outlets using a grab sampling routine and analyzed for nitrate-nitrogen (NO_3-N), ammonium-nitrogen (NH_4-N), total nitrogen (TN), orthophosphate-phosphorus (PO_4-P), and total phosphorus (TP) concentrations. Besides, field measurements of chemical and physical parameters were carried out using the YSI 6920 V2 multi-parameter water quality probe. The performance and nutrient removal efficiency varied widely over the experimental structures depending on the surface area/catchment area ratio, nutrient concentrations at the inflow, meteorological and hydrological conditions in the catchment areas. Overall, this study highlighted the potential of water level control structures to reduce nutrient concentrations in agricultural runoff.

Keywords: agricultural land, open ditches, water level control structure, nitrogen, phosphorus, retention

THE IMPLEMENTATION CONCEPT OF NITRATE MODELLING COMPONENT IN THE GROUNDWATER MODEL METUL

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ABSTRACT

The groundwater model METUL is conceptual mathematical model and originally it was developed for modelling groundwater level fluctuations. The input data for the model is daily mean air temperature and relative humidity or vapour pressure deficit, and also total amount of daily precipitation. Over the time this model was upgraded to the model METQ which calculated river discharge. Last upgrade in 2011 was implementation of parameter autocalibration facilitating the work with the model. The model consists of multiple separate programmable blocks allowing easy reorganization of model mathematics and algorithms. Currently we are working to implement a mathematical component which will allow us to calculate the balance of nitrate in soil and transport to groundwater. Such balance consists of initial amount of nitrates in the soil, nitrates derived from biogeochemical reactions, and nitrates in influent and effluent. The concept of nitrate modelling is based on separate model elements and their interactions which can be defined using one or more transfer functions. These functions are dependent from external factors as well as defined empirically. These external factors include land use. In case of agricultural land use factors include type of crops growing, vegetation period, air, soil and water temperature and other factors. The challenge of this work is to find how these elements can be combined and mathematically described.

Keywords: METUL, nitrate modelling

SPATIO-TEMPORAL HYDRO-CLIMATE VARIABILITY IN FINLAND

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ABSTRACT

Climate in Finland is changing rapidly, which has direct impacts on society and nature. Temperature and precipitation are increasing and runoff patterns changing. These hydro-climatic trends have been well studied previously, but the changes in variability are less known. The understanding of hydro-climatic variability is an important part of climate change studies. Therefore, the aim of this research is to assess the spatial and temporal changes in hydro-climatic variability in Finland by analysing temperature, precipitation and runoff for the years 1962-2014 using a sub-basin scale dataset. Temporal changes in variability were analyzed by constructing country and sub-basin scale sliding median absolute deviation (MAD) time series. Areas with similar temporal changes in variability were then identified using agglomerative hierarchical clustering for sub-basin scale MAD time series. Analyses were done at both annual and seasonal scales. Results give a very mixed picture, with trends and patterns of variability differentiated spatially and by season. However, some clear areas were found, where hydro-climatic variability follow similar patterns of change on annual and/or seasonal scale. With regard to temperature, results revealed significant decreases in annual and winter variability in the whole study area, as well as in summer variability in northern Finland, and an increase in autumn and summer variability in the south and south-west, respectively. In terms of precipitation, mean annual variability showed an increase at country scale, but the only statistically significant changes are decreases in variability in southern parts of Finland. Spring variability showed significant decreases in the middle parts of Finland. For runoff, winter and summer variability showed increases during the whole time period, especially in middle parts of Finland. These findings provide new information on hydro-climatic variability in Finland and improve the possibility to adapt and predict the changes in hydro-climatic conditions, including weather extremes.

Keywords: Finland, climate change, climate variability, temperature, precipitation, runoff

TEN YEARS OF EXPERIENCE IN AUTOMATED SOIL MOISTURE MEASUREMENTS

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ABSTRACT

Soil is a mixture of minerals, organic matter, air, water and the organisms that together support life on Earth. Plants need all these components for healthy growth. In this study we deal with one continuous, reliable and budget soil moisture measurement in a profile using Campbell Scientific's CR200 logger, which is attached to four CS625 water content reflectometer sensors and one temperature probe. Soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil. In this case we use dielectric constant and time domain reflectometry (TDR). The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, content of organic material, temperature or electric conductivity. Allfive analog channels ofthe device are in use.A probe installed at an angle of 45 degrees with the surface will give an indication of the water content of the upper 20 cm of soil. Four sensorsare installedin such a wayas to obtain ameasured80cm from thesurface layer. Dielectric methods for soil water content measurement exploit the strong dependence of soil dielectric properties on water content. When water freezes, the permittivity falls. In wintertime sensors operates assoil frost indicators. In summertime when a soil becomes dry, plant transpiration drops because the water in increasingly bound to the soil particles by suction. Water content in unsaturated zone has an important role for groundwater recharge, agriculture, forestry, soil chemistry, and climate change. In the long term we will see increasing or decreasing water content tends.

Keywords: soil moisture measurements, time domain reflectometry, time series

ASSESSING IMPACT OF LAND USE AND CLIMATE CHANGE ON WATER QUALITY IN TWO CONTRASTING MESO-SCALE CATCHMENTS IN POLAND

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ABSTRACT

The Upper Narew (4280 km^2) and the Barycz (5520 km^2) are two Polish, meso-scale, lowland catchments, contrasting in terms of land use, water management and water quality. Semi-distributed process-based SWAT model was applied in both catchments for assessment of climate change impact on selected water quality parameters. Multi-site calibration and validation against observed discharge, sediment loads and nutrients loads (nitrogen and phosphorus compounds) gave predominantly satisfactory goodness-of-fit measures which enabled further model use for scenario analysis. Impact of land use on water quality can be assessed by comparing model current state results in terms of nutrients loads and concentrations which are on average around 80-100% higher in the Barycz than in the Upper Narew catchment.

Nine GCM-RCM runs projected to the year 2100 for RCP 4.5 and 8.5 provided within the EURO-CORDEX experiment were first bias-corrected using quantile mapping method and then used as an ensemble of climate change scenarios in SWAT. Precipitation projections were largely consistent in showing an increasing precipitation trend, present particularly in winter and spring, in both catchments. This clearly affected the hydrological and biogeochemical cycle and resulted in higher projected water yield, increased erosion, and elevated nitrogen and phosphorus emission to water bodies.

The rate of change caused by climate is more visible in late future (2071-2100) than in the near future (2021-2050) and is more intensive for nitrogen than for phosphorus, which is related to its dominating transport pathway via baseflow, whose value is high in two lowland catchments. Yet, the magnitude of these climate-induced changes in nutrient emission is in most cases lower than the currently observed differences in nutrient loads between the Narew and the Barycz. Nevertheless, the results suggest that improving bad water quality in the Barycz catchment will be in the future hampered by the effect of climate change.

Keywords: SWAT, climate change, nutrient loads, catchment management, hydrological modelling

CHANGING SNOW CONDITIONS AND VEGETATION PATTERNS: IMPACT ON BOREAL FLOW CONDITIONS

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ABSTRACT

Recent climate projections and studies indicate drastic changes in snow cover extent, properties and timing in boreal areas. Snow cover duration is expected to decrease in Finland and more frequent warm spells and rain-on-snow events will lead to more variable snowpack. Snowmelt acts as a major input to northern hydrology affecting soil moisture conditions, recharging groundwater and sustaining flow during the winter and early summer. Simultaneous to changing climate and snow conditions the vegetation patterns are evolving due to natural and/or anthropogenic processes. Vegetation, snow properties and the physical catchment structure together with climate conditions determine the hydrological response of the catchments. However, their co-evolution, interconnections and impact on hydrology are still not completely understood.

In this study, existing long (over 30 year) and spatially well represented monitoring time series from meteorology and hydrology monitored at dozens of headwater catchments in Finland are combined with multi-source data. We utilize latest calculation methods, high resolution digital elevation model and remote sensed vegetation inventory data sets. The objective is to evaluate the impact of changing environmental factors on snow cover and consequently on boreal headwater flow conditions. The evaluation will be done by determining relevant streamflow signatures for different catchments and analysing their relationships and sensitivity to catchment structure and changes in vegetation and snow cover.

The results are needed for deeper understanding of the future hydrological behaviour of the boreal catchments which is necessary information for future decision making in water resources management and sustainable bioeconomy in boreal region.

Keywords: snow, vegetation, headwater, boreal, flow, hydrology

SIGNIFICANT CHANGES OF MODERN RIVER DELTAS UNDER THE IMPACT OF CLIMATE FACTORS AND HUMAN ACTIVITY

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ABSTRACT

Since the mid-20th century, hydrological regime of rivers and seas was subjected to climate change and human activity. Water runoff and sediment load of many rivers noticeably decreased under the impact of human activities. These phenomena are connected with water withdrawal for the economic needs and flow regulation. Reservoir construction led to water losses due to evaporation and sediment deposition because of trapping effect. As a result of global warming, water level in the World Ocean and related seas began to rise. The mentioned changes in the regime of rivers and seas had a pronounced effect on river deltas, including their morphology, ecological conditions, natural resources, population and economy. These effects were connected with a specific geographic position of river deltas between river basins and receiving water bodies (oceans, seas, lakes). By the end of the 20th century, deltas of many rivers become the most changeable and ecologically vulnerable geographical objects. Many deltas were subjected to inundation and abrasion of their sea coasts by waves, salinization of soils, surface waters and groundwater, landscape degradation, deterioration in the socioeconomic complex. For example, the sea coasts were eroded in the deltas of the Danube, Rhone, Ebro, Nile, Niger, Zambezie, Huanghe, Red, Chao Praya, Indus, Godavari, Mississipi, etc. The hydrological and morphological processes in the deltas of five main rivers emptying into the Caspian Sea (Volga, Ural, Terek, Sulak, and Kura) during the large-scale sea level rise over 1978–1995 by 2.35 m and reduction of river sediment load after reservoir constructions were studieed in detail. One of the results of our investigations was a method of analogy, which helps to answer the important questions: which hydrological and morphological processes at the river mouths in the Caspian region can be considered as possible analogs of processes expected in the deltas of rivers in the world in the near future.

Keywords: river delta, sea level, water runoff, sediment load, climate change, human activity

THE ASSESMENT OF GROUNDWATER STATUS FROM LEGISLATION TO IMPLEMENTATION

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ABSTRACT

The Water framework directive together with groundwater directive has been launched by the European Commission in 2000 and 2006 respectively to enhance the water environment in each of the EU member states, based on river basin management. This has posed a number of challenges to the authorities that have been responsible for water management at national, regional and municipality level. No commonly standards have existed to assess the ecological status of the water bodies. Not all of the criteria commonly used for up to decades in the different member states to evaluate impacts on water bodies have been based on ecological evidence. Moreover, the directives are not thoroughly precise as to the methods to be applied for impacts and status assessment.

All these challenges have called to actions at different level. At the European level a Common Implementation Strategy (CIS) has been defined involving, among others, the establishment of various working groups that are responsible for the development and of common methods suggested to be used in the different member states in accordance with guidelines written by members of the working groups. At the scale of member states or regional river basin authorities, new methods and concepts had to be developed and tested. These may provide the base for impact and status assessment, but may be applied at a scale, which can be different from the scale of more local authorities, such as municipalities.

The challenges that accompanies the implementation of the European directives requires a good cooperation between all involved parts, such as lawyers, scientists and river water managers at the national regional and local scale.

The article provides an overview of the challenges and how those might be tackled to ensure a realistic implementation of the directive at the various scales involved.

Keywords: Water frame work directive, groundwater directive, river basin management

ANALYSIS OF LOW FLOW INDICES UNDER VARYING CLIMATIC CONDITIONS IN POLAND

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ABSTRACT

Changes in low flow indices under a future climate are estimated for ten selected catchments in Poland. A simulation approach is applied to derive daily flow series for the catchments under changing climatic conditions, following the RCP 4.5 and RCP 8.5 emission scenarios. The climate data for these simulations are obtained from the EURO-CORDEX initiative, in the form of time series of precipitation and air temperature derived from six different RCM/GCMs for the time periods: 1971-2000, 2021-2050 and 2071-2100. The HBV rainfall-runoff model is applied to simulate flow and other hydrological variables. The model is calibrated and validated using the available precipitation, air temperature and flow observations from the periods 1971-2000 and 2001-2010 respectively. Two objective functions are used for calibration: Nash Sutcliffe and log transformed Nash-Sutcliffe coefficient. The latter is better suited for representation of low flows, and the model performance is verified using climate models simulations for the reference period (1971-2000). Finally, the models are run using the bias corrected precipitation and temperature data simulated by RCM/GCM models for the two periods: 2021-2050 and 2071-2100. We derive low flow indices for the simulated time series, including the annual minima of 7-day mean river flows; the number, severity and duration of low flow events, and the base-flow indices. We perform the uncertainty analysis of the estimates of low flow indices taking into account uncertainty related to hydrological modelling and climate projection variability. Results indicate a large influence of climate models, as well as objective function applied during hydrological model simulations, on the low flow indices obtained. Comparison of indices from the two future periods 2021-2050 and 2071-2100 with the reference period 1971-2000 confirms the trends obtained in previous studies, in the form of a projected decrease in the frequency and intensity of extreme events.

Keywords: climate change, low flow, Poland

TRANSPORT OF NUTRIENTS AND SEDIMENT UNDER DIFFERENT SUBSUFRACE DRAINAGE SYSTEMS

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ABSTRACT

Effective drainage of arable soils is needed under Nordic climate conditions to ensure good growing conditions. As a result of drainage measures field hydrological conditions change which has also impact on erosion and transport of nutrients to surface water bodies. The aim of this study is to quantify nutrient losses under different subsurface drainage systems and to improve understanding of field-scale hydrological and transport processes in subsurface drained soils. The experimental site consists of four tile drained field sections in south-western Finland. The soil is heavy clay and the mean slope is 1%. The original tile drains were installed in 1952 with drain spaces of 16 m (fields A, B and C) and 32 m (field D). Drainage of fields A and C was renewed in June 2008 and that of field D in June 2014. The new drain spaces were 6 m (A), 8 m (C) and 10,7 m (D). Drain flow and tillage layer runoff from each field section have been continuously measured since May 2007. Concentrations of total P, PO_4-P, total N, NH_4-N, NO_3-N and suspended solids have been determined from flow weighted composite water samples. Depth of the groundwater table and soil moisture (0-30 cm layer) have also been measured in each field. The measurements will continue to the end of 2016. High variation in drain discharges and nutrient concentrations and loads between the drainage systems and years have been detected. Subsurface drains are an important route both for nutrient and sediment losses. The results indicate higher nutrient losses after renewal of the old tile drainage systems mainly due to the increased drainage flow. Besides the drainage measures, the role of hydrometeorological conditions, soil characteristics and topography in the water flow and nutrient loading has been evaluated.

Keywords: drainage flow, surface runoff, nitrogen, phosphorus, clay soil, field scale

TOWARDS IMPROVED ESTIMATIONOF HYDROLOGICAL VARIABLES IN POORLY GAUGED BASINS

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ABSTRACT

The estimation and prediction of hydrological variables for ungauged basins is still a big challenge. Also, it can be problem for poorly gauged basins.

In Estonia, most stations of national hydrometric network are situated close to the river mouth. Therefore gauged basins are large and heterogeneous. Often, it is difficult to estimate upstream tributary runoff, especially when hydrological conditions are not stable.

The study was carried out at Estonian Environmental Agency as part of the Project „Development of data-modelling system and the decision support tool for the integrated marine and inland water management.“ Water level data loggers were installed to collect additional data from tributaries of two river basins - River Vihterpalu (480 km^2) and River Keila (631 km^2). River flow was calculated using stage-discharge relation as regular discharge measurements were carried out.

Similarities and differences between experimental basins and "donor" basin are discussed providing insight into the existing knowledge of regionalisation and catchment management in Estonia.

Keywords: poorly gauged basins, water level data loggers, regionalisation

POTENTIAL EFFECTS OF CLIMATE CHANGE ON NUTRIENT FLUXES IN AGRICULTURE-DOMINATED RIVER BASINS IN LITHUANIA

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ABSTRACT

It is widely recognised that climatic changes lead to disturbances in the water cycle due to the feedbacks between rising temperatures and hydrologic processes. In Lithuania, these changes can influence the possibilities for agricultural production and runoff conditions, and thereby the losses of nutrients from agricultural fields to water environments. To be able to adapt production methods and minimize environmental impacts, a better knowledge of how nutrient (N and P) losses will be influenced by changes in hydrology as a consequence of climate change is required. The dynamic FYRISNP model based on source apportioned gross and net transport of nitrogen and phosphorus in rivers and lakes has been used in this study for evaluation of the impact of climate changes on nutrient loads in two large-scale agriculture dominated river basins in Lithuania. The study was done in the Minija and Nevėžis River basins (A=2940÷6141 km^2) situated in different regions of the country. The two basins represent diverse hydrology and nutrient load conditions from anthropogenic and natural sources. Monthly water discharge and water quality sampling data of total nitrogen (N_{tot}) and total phosphorus (P_{tot}) for the period 1995-2005 from 13 sites along with digital information for delineation of sub-basins and a database on the point source emissions, atmospheric deposition and land use statistics with included lake and stream surface area for each of the sub-basins were used to calibrate and validate the model. Furthermore, two global climate models and the emissions scenarios A2, A1B and B1 for the three time periods: 1986–2015 (control), 2016–2045 (near-term scenario) and 2071-2100 (long-term scenario) were used to make climate change projections. These projections were the used to drive the HBV hydrological model to assess the effects on hydrology. Finally, the results from projected changes in air temperature and runoff were adapted in the FYRISNP to simulate nutrient fluxes. The obtained results indicate that nutrient loads will increase under projected climate scenarios. In particular, seasonality will experience large changes: the most significant increase is expected in winter months and decrease during the summer months. The seasonal pattern of nutrient fluxes is expected to change with higher runoff during winter. The changes found in climate and hydrology would influence nutrient retention processes too. Although the retention is expected to increase, it would be less than expected increases in the inputs. Such information at the river basin scale is the first of its kind in Lithuania and is valuable for river basin managers that are currently updating river basin management plans.

Keywords: climate change, agriculture, nutrient, Lithuania

Acknowledgement. This research is a part of a scientific study "Impact Assessment of Climate Change and Other Abiotic Environmental Factors on Aquatic Ecosystems" (project No. SIT-15034) funded under National Research Programme "Sustainability of agro-, forest and water ecosystems (2015–2021)".

FEEDBACK OF MORAINIC SHALLOW LAKE WATER ECOSYSTEM TO INTEGRATED IMPACT OF CLIMATE CHANGE AND WATER LEVEL MANAGEMENT SCENARIOS

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ABSTRACT

During the past 100 years, human beings have had significant impact on almost all the wetlands in Lithuania. Most of them were drained to create agricultural land. Therefore, about 80 per cent of all the wetlands in agricultural landscape in the country disappeared or have been significantly altered.

The Biržulis Lake with surrounding adjacent wetlands, located in western Lithuania in the catchment of the Virvytė River, is a valuable habitat for flora and fauna. However, the lake was also affected and, after the level of the water had been lowered few times by the 1970s, it significantly lost its natural value. Altered hydrological regime (reduced surface area, water volume and water level fluctuations) followed by external pollution loading, abandoned management (grazing and mowing) of wet grasslands and improper use of fish resources led to fast succession of vast areas of floating reed bed along with the development of "dead zones" and bush areas surrounding the remnant of the lake. Such developments resulted in substantially decreased biodiversity, predatory fish biomass, water self-purification abilities, production and aesthetic/recreational services provided by the lake. In order to prevent the ongoing further deterioration solutions have to be found.

Therefore, the main objective of this study was to evaluate the impact of various water level scenarios on the Biržulis Lake and adjacent wetlands benefiting to the favourable lake ecosystem restoration. For the scenarios the physically-based distributed parameter model SIMGRO was used. The analysis included near-term (2016–2045) and long-term (2071-2100) projected climate changes to assess the effects on hydrology along with the selection of the most acceptable water regime restoration alternatives. Detailed results of the analysis on the effects of measures benefiting to the ecosystem restoration will be presented in the paper.

Keywords: Biržulis Lake, climate change, ecosystem restoration, Lithuania

AN IN SITU CONTINUOUS MEASUREMENT OF THE CARBON FLUXES IN STREAMS DRAINING BLANKET PEATLANDS IN IRELAND USING A NON-DISPERSIVE INFRARED SENSOR METHOD

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ABSTRACT

The dynamics of CO_2 in freshwater steams has high uncertainties and is an issue of importance in stream carbon dynamics. This is particularly true of peatland drainage systems where connectivity between streams and the peatland CO_2 store leads to significant variations in outflows and high variability in the efflux rates of CO_2. The relationship between CO_2 and other carbon species is a crucial dynamic in the overall carbon cycle of this land use type. Indeed, in the absence of an understanding of the efflux dynamics of dissolved CO_2 and catchment specific hydrological transport mechanisms it is not possible to develop appropriate water quality management strategies. This study has sought to establish a series of monitoring stations at selected location in the upland blanket peatlands in Ireland. A series of submerged non-dispersive infrared sensors enclosed in a water impermeable, gas permeable polytetrafluoroethylene membrane will be placed at strategic locations in the freshwater streams. These sensors will provide a continuous record of CO_2 efflux rates and will be maintained at a constant depth in the water body by a protective float and housing mechanism. This approach requires detailed site specific meteorological and hydrological conditions to be monitored on a continuous basis including temperature, precipitation and atmospheric pressure. The methodology presented is necessary to address the very real challenges of diurnal and seasonal flux rates and to aid understanding of the temporal dynamics and controlling factors of CO_2 transport in peatland dominated stream systems. Outputs of this study will have a direct bearing on approaches to water quality and will feed into a future research in the areas of terrestrial–aquatic connectivity of groundwater, surface water and carbon cycling in the landscape.

Keywords: peatlands, carbon cycle, freshwaters, carbon dioxide

TRANSBOUNDARY RIVER FLOW IMPACTS OF HYDROPOWER DEVELOPMENT IN THE UPPER MEKONG BASIN

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ABSTRACT

The Mekong River Basin in Southeast Asia is undergoing massive hydropower development. Currently the basin has at least 57 large dams (dam height > 15 m) and plans for over 100 more. The hydropower dams are built to satisfy increasing energy demand and to promote economic growth, but at the same time they are altering the flow regime (i.e. the annual flood pulse) of the entire river and affecting the productivity of one of the world's richest inland fisheries. We analysed the impacts on transboundary river discharge of the hydropower dams in the upper reaches of the Mekong in China. The analyses were based on observed daily river discharge data (1960-2014) from three locations and a distributed hydrological model. We found that the existing dams have considerably affected the river flow regimes since 2011 and the largest flow impacts occurred in 2014, after the completion of the largest dam in the basin, Nuozhadu dam. The most notable changes were increased dry season discharge (Mar-Apr) by +121%…+187%in northern Thailand (Chiang Saen) and by +41%…+67%in Cambodia (Kratie), as well as decreased wet season discharges (Jul-Aug) by -32%…-46% and 0%…-6%, respectively. The results furthermore showed that river flows are becoming increasingly unpredictable due to hydropower operations – particularly during the dry season. These changes in discharge are well in line with previous model-based estimates, although partly showing larger changes than previously simulated. Altogether, our findings show that the hydropower operations in the upper reaches of the Mekong have considerably modified the river flow regime throughout the Mekong River. Impacts are expected to increase as more hydropower dams are being built.

Keywords: Mekong River, hydropower development, transboundary, discharge, flood pulse

CLASSIFICATION AND LONG-TERM CHANGES OF RIVERS WATER TEMPERATURE REGIME IN ESTONIA

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ABSTRACT

Water temperature plays an important role in aquatic ecosystems as it influence on their biological activity and growth. It is also important as a major impact factor on chemical reactions that can impact water quality of water bodies and affect aquatic life in general. In addition, water temperature is used in the water policy to ensure an ecological status of rivers. Water temperature regime of the Estonian rivers was studied almost 50 years ago therefore in this study all possible long-term daily/weekly water temperature records (from 20 to 69 years) from 20 monitoring sites were used. Rivers were classified into three thermal groups according to the average monthly water temperature for two warm seasons (April-November and May-October) in the period 1961-1990. The classification provides a basis for more extensive research and management of streamflow regime not only in a local but also in a regional scale as well. In addition, water temperature of July, as warmest month, was analysed. The average water temperature for the period of April-November was 10.7°C and for May-October was 13.2 °C. Mann-Kendall trend test was used to detect a trend in time series. Significant warming trends of long-term water temperature were determined in big rivers and in the rivers with prevailing portion of precipitation in the feeding type. Negative trends were found in smaller rivers and in the rivers where ground water were dominate in the rivers feeding. Strong relation was found between air temperature and water temperature anomalies that allows to suggest that changes in water temperature can be associated with climate change.

Keywords: Estonian rivers, water temperature regime classification, trends, long-term changes

HYDROGEOCHEMICAL PATTERN OF UPPER TO MIDDLE DEVONIAN FRESHWATER AQUIFERS IN LATVIA AND ESTONIA

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ABSTRACT

About 60-70% of inhabitants in Latvia and 60-65% in Estonia use groundwater via public water supply systems. Middle to Upper Devonian aquifers mostly contain freshwater, therefore are important drinking water sources in both countries. Due to geological conditions or human induced activities groundwater often does not meet the quality standards set for drinking water. Elevated iron and manganese concentrations are common problem in water supply system. Fluorides mostly do not exceed permitted limit value in drinking water, but in some areas its natural content is too low leading to the development of dental caries.

The aim of this study is to investigate the linkage between different water types and trace elements (with an emphasis to Fe, Mn and F) concentrations. As a result, six distinct groundwater groups were distinguished using hierarchical cluster analysis, the main geochemical processes within each group were identified applying principal component analysis. Further, the available information on other trace and biogenic elements concentrations, stable oxygen isotope ($\delta^{18}O$) values, geological conditions and modelled saturation indexes were used to support the findings.

The results show that the first group comprises the wells yielding groundwater with elevated salinity and locating in vicinity of Riga or at coastal areas. In the second group gypsum dissolution is responsible for the formation of calcium-sulphate water type exhibiting the highest F content within the study area. The remaining four groups all belong to calcium-magnesium hydrogen carbonate water type. However, each group has its own hydrochemical characteristics and differs from the others in trace or biogenic element content, major ion ratios, oxidising-reducing conditions or water bearing rocks.

Keywords: groundwater chemistry, drinking water quality, multivariate statistical analysis, trace elements, stable oxygen isotope

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INVESTIGATION OF SURFACE WATER-GROUNDWATER INTERACTIONS IN THE SALACA HEADWATERS USING WATER STABLE ISOTOPES

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ABSTRACT

The ratios of the stable isotopes in the water are a natural conservative tracer of the hydrological cycle with the exception when condensation of water vapour or evaporation from open water surface takes place. During evaporation remaining liquid water is enriched in heavy isotopes. Due to unidirectional transport of the water transpiration from plants and evaporation from soil surface do not change noticeably the isotopic composition of the remaining soil water.

The aim is to characterise the isotopic values of different water types in the Salaca River basin and test if their contribution can be identified in the Salaca river runoff. A monthly monitoring programme is initiated to observe the primary inputs postulated to be precipitation water and discharge from the Lake Burtnieks and compare their isotopic signature to the water sampled from Rivers Salaca and groundwater discharging into it. The discharge of the Salaca River in the study region is dominated by the Lake Burtnieks.

A monthly groundwater and surface water stable isotope monitoring programme was initiated on August 2015 covering the most of the important surface and groundwater types in the study region – groundwater and surface water in the raised bogs, free-surface groundwater including artificially drained agricultural lands, water emerging from the Lake Burtnieks as well as Burtnieks and Arulika confined aquifers. $\delta^{18}O$ and δD were measured in all samples.

We have found that, springs Govsala show stable isotopic values, therefore it portray stable local recharge conditions with water source distinct from that found just few meters deeper in the Burtnieki aquifer. The water emerging from Lake Burtnieks at the source of River Salaca at late summer and autumn has a strong evaporation signal, which is gradually diluted downstream.

Keywords: surface-groundwater interaction, stable isotopes, monitoring.

Acknowledgement

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CONCURRENT TREND ANALYSIS OF TEMPERATURE, PRECIPITATION AND SNOW COVER OVER NORWAY

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ABSTRACT

Northern latitudes are experiencing faster warming than other regions, partly due to the snow-albedo feedback. A reduction in snow cover, which has a strong positive feedback on the energy balance, leads to a lowering of the albedo and thus, an amplification of the warming signal. Norway, in particular, can be considered a "cold climate laboratory" with large gradients in geography and climate that allows studying the effect of changing temperature and precipitation on snow in highly varying regions. Previous research showed that during last decades there has been an increase in air temperature for the entire country and a concurrent reduction in the land surface area covered by snow. However, these studies also demonstrate the sensitivity of the trend analysis to the period of record, to the start and end of the period, and to the presence of extreme years. In this study, we analyse several variables and their spatial and temporal variability across Norway, including mean, minimum and maximum daily temperature, daily precipitation, snow covered area and total snow water equivalent. Climate data is retrieved from seNorge (http://www.senorge.no), an operationally gridded dataset for Norway with a resolution of 1 km^2. Analysis primarily focused on three overlapping 30-year periods (i.e., 1961-1990, 1971-2000, 1981-2010), but also tested trend sensitivity by varying period lengths. For each climate variable the Theil-Sen trend was calculated for each 30-year period along with the difference between 30-year mean values. In addition, indices specific to each variable were calculated (e.g. the number of days with a shift from negative to positive temperature values). The analysis was performed for the whole of Norway as well as for separate climatological regions previously defined based on temperature, precipitation and elevation.

Results confirm a significant increase in mean daily temperatures and accelerating warming trends, especially during winter and spring (mainly November, January and April). This accelerated warming occurs at the critical beginning and end of the snow cover season, where a notable decrease in snow cover also is found. This suggests a positive land-atmosphere feedback between increased air temperatures and reduction in snow cover. The last decade (2000 – 2010) features the smallest snow covered area and lowest values of snow water equivalent. The regional analysis clearly shows a stronger increase in the temperature trend in Northern Norway: in the first 30-year period the trends are negative or around zero, while in the end they are around 1.5 °C/30 years. In the other regions a positive trend is seen in the first period (~1 °C/30 years) increasing to around 1-1.5 °C/30 years in the two last 30-year periods). Finally, precipitation increases in winter, spring and summer (with a lower intensity in the most recent 30-years periods), and decreases in autumn. This contributes to a lower snowfall in the beginning of the snow season, suggesting that the reduced snow cover is due to both a reduction in precipitation as well as an increase in temperature. This study provides an important contribution to the understanding of the driving forces of changes in snow cover.

Keywords: trend analysis, climate change, Norway, temperature, precipitation, snow

PROJECTION OF LITHUANIAN RIVERS RUNOFF, TEMPERATURE AND THEIR EXTREME VALUES UNDER CLIMATE CHANGE

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ABSTRACT

The research aims to understand and project the effects of changing climate on Lithuanian river runoff and water temperature. Climate change is expected to affect the extremes of the major river indices that impact fundamental ecological processes in river ecosystem. The available runoff and temperature data of rivers from three different hydrological regions of Lithuania (Western, Central and Southeastern)were used. HBV software was applied for modelling of hydrological processes in the selected river catchments. The expected future changes of runoff and water temperature were projected according to a new set of scenarios (called Representative Concentration Pathways (RCPs)) presented in the Intergovernmental Panel on Climate Change Fifth Assessment Report. The projected extreme values of runoff (flood and low flow discharges) and water temperatures in 21st century were compared to the ones from the past period. The results showed the decrease of spring flood discharges and low flow of summer period in the end of 21st century. The increase of river water temperature is expected according to climate change scenarios as well. The results are going to be used for an integrated impact assessment of climate change on aquatic animal diversity and productivity.

Keywords: runoff, water temperature, extreme values, climate change scenarios, HBV software, projections

Acknowledgement

This research is a part of a scientific study “Impact Assessment of Climate Change and Other Abiotic Environmental Factors on Aquatic Ecosystems” (project No. SIT-15034) funded under National Research Programme “Sustainability of agro-, forest and water ecosystems (2015–2021)”.

NATURAL STREAMFLOW SIMULATION FOR TWO LARGEST RIVER BASINS IN POLAND AT HIGH SPATIAL AND TEMPORAL RESOLUTION

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ABSTRACT

The objective of this study was to carry out high-resolution simulations of natural daily streamflow using the SWAT model in a dense network of river reaches of the transboundary Vistula and Odra basins (VOB), which occupy 313 000 km^2. To this end, a novel spatial calibration approach (cluster-based calibration, CB) was proposed. It consists of four steps: (1) selection of a large sample of 80 non-nested, representative gauged catchments with relatively unimpaired streamflow within the model domain; (2)clustering this catchment set using a suite of statistical techniques into the flow regime classes; (3) performing cluster-oriented model calibration and uncertainty analysis; (4)transferring calibrated parameter sets and ranges using standard regionalization techniques from donor to target catchments. Comparison of this approach to single-site (SS)calibration shows that the latter is considerably worse when evaluated in the set of 80catchments in terms of the model performance measures (median Kling-Gupta Efficiency of 0.47 vs. 0.7 for cluster-based calibration). Parameter transfer from 80 catchments to the remaining areas of the VOB enabled evaluation of model performance at the two basin outlets, which appeared to be similarly good for CB and SS calibration. Hence, cluster-based calibration leads to a model parametrization that provides more reliable flow simulations at a range of spatial scales, and should be therefore recommended over single-site calibration. Simulated natural daily discharge and monthly water balance for the 1954-2013 period has been made publicly available as the CHASE-PL - Natural Hydrology data set (CPL-NH). The developed model was used in the climate change impact assessment using an ensemble of bias-corrected EuroCORDEX Regional Climate Models.

Keywords: SWAT model, Vistula, Odra, high resolution

VARIABILITY OF PRECIPITATION IN POLAND UNDER CLIMATE CHANGE

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ABSTRACT

Knowledge of the characteristics of precipitation and its seasonal and monthly distribution is essential for correct evaluation of water balance in a given area. Due to the climate change, annual sums of precipitation are slightly changing in Poland. They are slightly growing, but, what is more important, seasonal and monthly distributions of precipitation are also changing. Only the correct assessment of the changes in every element of the hydrological cycle may lead in a consequence to more effective integrated water resources management at regional and national scales.

This research is aimed at identification of properties of the seasonal and monthly variability of precipitation observed in Poland in the interval 1951-2013 and projected for the future horizon, 2061-2100. The subject of analysis were time series of monthly precipitations in 43 stations in Poland.

In order to describe the changes in temporal distribution of precipitation within a year, time series of monthly sums of precipitation, and the index describing the share of summer precipitation within the annual sum were examined. Occurrence of lowest and highest monthly sums of precipitation in consecutive months of the year was analysed for individual decades. The trend detection in the analysed time series was carried out, using parametric and non-parametric tests. The obtained results of trend detection in observed data were compared to the projections for the future.

Precipitation is extremely difficult to model due to a strong temporary and spatial variability. While regional climatic models reconstruct annual sums of precipitation for the area of Poland fairly well, they perform poorly when it comes to displaying seasonal and monthly distribution of precipitation. That is why projections for the future bear considerable uncertainty. In this research, the regional climate model MPI-M-REMO was chosen for comparison of present trends in the distribution of precipitation with the projections for the future. Earlier validations indicated that this model represents precipitation conditions in Poland reasonably well.

Keywords: precipitation, temporal and spatial distribution, projections, Poland

IMPROVEMENTS OF INPUT DATA AND FUTURE APPLICATIONS OF A HYDROLOGICAL MODEL

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ABSTRACT

Hydrological models are an important tool to investigate and understand the behaviour of hydrologic systems. The relatively high groundwater component of the runoff in Iceland, together with rapidly changing mass balance of the glaciers and high spatial variability of meteorological conditions makes it feasible to use distributed models instead of lumped ones. The hydrological model WASIM has been employed in studies carried out at the Icelandic Meteorological Office in the past years. WaSiM is a physically based, deterministic and spatially distributed model used for study of hydrological processes in river basins

The Icelandic Meteorological Office (IMO) has since 2015 been running operationally the high resolution numerical weather prediction (NWP) model HARMONIE. HARMONIE is a non-hydrostatic convection-permitting NWP and is operated at 2.5 km horizontal resolution over a domain that covers Iceland and the surrounding seas (Palmason et al. 2016). The HARMONIE data have been tested as input into the WaSiM model in Iceland and first results look very promising by substantially improving calibration. Results for simulation of daily discharge have shown up to 50% higher Nash-Sutcliffe model efficiency coefficient by only changing from previous precipitation data to the HARMONIE precipitation.

Large portion of the total energy consumption in Iceland originates from hydropower. The last estimation of the hydropower potential was conducted in 1981. Since then, there have been major technical developments that call for a renewal of estimation of hydropower potential. This study presents the benefits of using WaSiM distributed model to map and assess theoretical hydropower potential along river segments within catchments. This applies also in challenging meteorological conditions, by using input data from HARMONIE.

Keywords: hydropower potential, hydrological modelling, spatially distributed hydrological model

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LOW FLOW CHARACTERISTICS OF ICELANDIC RIVERS

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ABSTRACT

The knowledge of low flow characteristics of rivers is essential for comprehensive and sustainable water management in a rising demand for water utilisation. The total runoff of Iceland is estimated to be around 5000 m^3/s, whereof 1000 m^3/s enters the river system as groundwater. The runoff and base flow characteristics of Icelandic rivers are to a great extent governed by the volcanic formations that shape the country. Direct runoff/glacial rivers are mainly confined to the tertiary part of the country whereas springs and springfed rivers are abundant in the volcanic zone making substantial part of the base flow of some of Iceland´s major glacial rivers.

The groundwater module of the hydrological model WaSiM has been applied in a few catchments in Iceland. However, the present WaSiM model in use covering the country does not deal comprehensively with surface/groundwater interchange (Jónsdóttir, 2008). However, field studies and analysis of river hydrographs reveal that the bulk of the groundwater, or around 600 m^3/s, enters the river systems in the highlands, but the rest as springs in the lowlands. There is a substantial difference in the low flow characteristics of direct runoff, direct runoff/glacial rivers and rivers with a substantial groundwater component.

The present study analyses the low flow characteristics of 13 glacial rivers in Iceland for which daily average flow data is available for up to a 30 year period. Two methods are used to identify droughts. Based on the monthly cumulative streamflow volume throughout each hydrological year, the Streamflow Drought Index (SDI) is calculated by comparing to average monthly streamflow volumes. Analysing this data, transfer matrices are formed which describe the probability of transferring from a given state to another, thus aiding in forecasting. The threshold level (TL) method is then used to identify droughts, their duration and severity. In this method, drought periods are identified when the streamflow falls below a suitably chosen threshold level. Finally, frequency analysis of low flow events is performed to estimate the probability of occurrence of low-flow events for management purposes. Extreme value analysis is done by fitting a Weibull distribution to the observed data of annual minimum streamflow by the method of moments. This is done specifically for the winter season as the majority of severe droughts occur during the months of February-April when precipitation primarily falls as snow and cold temperatures limit melting.

Keywords: low flow analysis, low flow forecasting, frequency analysis, SDI, TL, streamflow drought index, threshold level, extreme value analysis, Icelandic rivers, glacial rivers

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THE INFLUENCE OF DUNE STRUCTURE AND FUNCTION ON FEN ECO-HYDROLOGY IN THE BUCKRONEY-BRITTAS DUNE-FEN SYSTEM-IRELAND

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ABSTRACT

The Buckroney-Brittas Dunes and Fen system is defined as a Special Area of Conservation (SAC)and is situated approximately 55km south of Dublin City on the east coast of Ireland. The Buckroney dunes have cut off the outflow of a small river at Mizen Head and a large alkaline fen has developed comprising a complex mosaic of habitats with well-developed plant communities of significant conservation value. It is backed to the west by a dense swamp of Common Reed (*Phragmitesaustralis*) and has five Red Data Book plant species. Alkaline fen systems can be described as mire systems that contain peat or tufa comprising sedge and brown moss communities and develop on soils that tend to have a calcareous hydrological supply and are permanently waterlogged. Water level fluctuations are limited and a peaty substrate exists. Slow groundwater flow rates are related to the structure and dynamics of the dune system. This coupled with the limited fluctuations in nutrient supply in the Buckroney fen maintain high levels of biodiversity and mitigate peat loss and erosion. Such systems are sensitive to changes in the climatic regime and local hydrology. Fens in Ireland are considered as eco-hydrological systems under threat and many have been given the protected status of SAC under the EU Habitats Directive. This research focuses upon the interconnectedness of dune system structure, morphology and hydrodynamics in controlling the functioning and ecological status of the associated fen system. It attempts to present a mechanistic understanding of the processes of fen water control over various spatial and temporal scales and links dune structure and function to fen eco-hydrological status and biodiversity.

Keywords: Alkaline fen, coastal dune system, climate, vegetation models

ASSESSMENT OF ECOLOGICAL QUALITY AND BIOLOGICAL DIVERSITY OF SMALL AND MEDIUM SIZED STREAMS OF ABAVA BASIN, LATVIA

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ABSTRACT

According to Water Framework Directive the best water management system is river basin management based on the natural geographical and hydrological units instead of administrative or political boundaries. At the same time, there is not sufficient knowledge of assessment of biological quality elements including macrophytes at the river basin level. Thus, the aim of our study was to find out ecological quality of streams assessed by species composition and abundance of macrophytes at the basin scale. The study area is the River Abava Basin (west central part of Latvia) with the catchment area 2030 km^2. In general 30 sites of 13 streams belonging to dominant river types in Latvia – medium-sized and small-sized streams were studied. The relationships between macrophyte coverage, number of taxa, trophic indices, diversity indices and environmental variables (stream velocity, substrate type, shading, stream depth and width) were investigated. We found that the main factors controlling macrophyte coverage in small and medium sized streams of Abava Basin were stream velocity and width. Simultaneously number of macrophytetaxa was depended on substrate type. Macrophyte Biological Index for Rivers (IBMR) correlated only with stream velocity while Mean Trophic Rank (MTR) did not correlate with any of measured environmental factors. Ecological quality of rivers defined by IBMR indices showed that there were no differences between small sized and medium sized streams, however the differences were observed among regulated and unregulated streams. The mean IBMR value showed moderate ecological quality for unregulated streams in comparison with regulated streams with poor ecological quality. MTR index indicated moderate ecological quality for both stream types.

Keywords: aquatic macrophytes, environmental factors, trophic indices, species richness, basin scale

THE PEAT EXTRACTION IMPACT ON HYDROLOGICAL REGIME OF THE RAISED BOG

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ABSTRACT

Hydrological regime of naturally raised bog has been impacted by peat extraction. Peat extraction changes water level and affects processes in naturally raised bog even 50 years after peat extraction is finished.

Zalais bog is located in Kemeri national park. Almost 60 years ago peat was extracted in this territory and hydrological regime has not been returned to its natural state. In result, there are quarry in the middle of raised bog which has been excavated to sandy bottom. Moreover, on the edges of quarry are working drainage system. In literature we can find several studies of affected raised bogs, but there is limited knowledge about quarry effects to hydrological regime of the raised bog.

This research analyses groundwater level fluctuations in 6 monitoring wells, which are located in direction from the peat extraction field to the natural raised bog, where no drainage ditches is. One water level well is located in the quarry to detect associations of hydrological regime in raised bog ecosystem.

The sixth monitoring well is located in the natural raised bog territory 500 m from quarry, and this monitoring well has been selected as the control well for undisturbed bog hydrological regime. The water level is measured each 30 min using Mini-Diver data loggers. The result shows that the quarry's impact on the hydrological regime of the naturally raised bog decreases starting with the distance of 120 m. In this particular raised bog ecosystem, without groundwater fluctuations, elevation differences play important role, as well as swelling and shrinking of bog active layer (*arotelm*).

Keywords: raised bog, hydrological regime, groundwater fluctuations

CHANNEL FLOOD ROUTING IN PLAIN TIDAL RIVER NETWORK EFFECTING TOWN FLOOD CONTROL AND DRAINAGE

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ABSTRACT

The towns with dense population and advanced economy are widely distributed in plain tidal river network areas. Obviously influenced by monsoon and tide, the towns always suffer from flood disasters which result in serve losses. In recent years, many flood control works such as flood bank and gate are built to protect the towns. But those projects could not meet demand of towns flood control and storm drainage. In this research, the hydraulic area named HANGJIAHU in Tai lake Basin of China and town named Shengzein HANGJIAHU area were selected as study objects and hydrologic records and reasons of flood disasters were analysed first. To simulate the flood routing precisely, rivers in the town were simulated with hydrodynamic model MIKE11, the rainfall-runoff process of agricultural land was simulated with hydrodynamic model based on MIKE21 and urban land was considered as model MIKE URBAN. After that, flood processes under different tide processes were simulated. The simulation results show that cultivated land of Shengze town suffers the most serious flood disaster. From the analyses of flood disaster simulation result, the channel flood routing in plain tidal river network adverse effects on the town flood control and storm drainage and management measures for improving present conditions of town flood control and drainage were put forward. This research serves as an attempt to explore the measure of town flood control and storm drainage, and provides reference for town flood risk management.

Keywords: tide, town, flood routing, flood control and storm drainage, MIKE

THE STUDY ON HYDRODYNAMIC MODELLING APPROACH TO SIMULATE THE OVERLAND FLOW IN PLAIN RIVER-NET AREA

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ABSTRACT

Considering the dense river network, the large amount of polder areas on the low farm land and the tidal effect in Taihu lake basin, the overland flow process of the plain tidal river-net area is very complicated. The overland flow, also known as surface runoff, is the primary cause of flooding, especially in urban areas. The process of overland flow in Taihu basin has been considered as a very typical modelling casein numerous previous studies where coupled hydrodynamic and hydrological model is widely used. However, there are some difficulties and limitations for wide application. Firstly, a large number of polder areas lack measured data such as soil lithology and groundwater tables, so that the application of distributed hydrological model is limited. Secondly, the reliability of calibration and validation is discounted by the lack of observed discharge data. Thirdly, the lumped hydrological model cannot be used to simulate the two-dimensional flood condition, which is of great importance for flood risk management.

Concerning the limitations above, the paper explored the impact on overland flow simulation, as different hydrodynamic modelling approaches being employed. In addition, the paper studied on data pre-processing methods, especially the Digital Elevation Model (DEM) data. One of the most significant ways to pre-process the DEMs is merging. The merged DEM retained the most accurate elevation information available while generating consistent slopes and aspects. In this paper, three different methods for improving the merging of grid-based DEMs was proposed. Besides, a thorough analysis of these three methods was presented. Moreover, In order to verify the reasonability of using the hydrodynamic model to simulate the process of overland flow, the simulation result of this hydrodynamic model was compared with that of the other two different models. One is the hydrological model of the same polder area based on MIKE11/NAM model, and the other one is the coupled hydrodynamic and hydrological model which is widely used in the simulation and design in Taihu Basin. Above all, the paper provides a set of modelling approaches using hydrodynamic model based on MIKE11/21 coupled model to simulate the process of overland flow and the corresponding data pre-processing method. Moreover, the paper analysed the availability of the application of this hydrodynamic modelling approach in overland flow simulation as well as the two-dimensional flood simulation in much larger areas for further researches.

Keywords: overland flow, hydrodynamic model, MIKE11/21, NAM, DEM

EVALUATION OF SHORT-TERM HYDROLOGICAL FORECASTS RELATED TO HIRLAM AND ECMWF WEATHER FORECASTS: CASE OF LATVIA

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ABSTRACT

Hydrological forecasts are often highly useful in many modern civilization activities when natural hazards, for example, severe floods may occur. Short-term hydrological forecasts are one of the most useful in these situations, providing information two days in advance. Weather forecastsprovided by several NWP models are widely used data for modellinghydrological forecasts. In this research, HIRLAM and ECMWF weather forecasts were used to calculate short-term hydrological forecasts. Its aim was to evaluate which weather forecasts would provide better assessment of hydrological conditions.

Hydrological forecasts were calculated for three river catchments in Latvia: Abava – Renda, Gauja – Sigulda and Dubna – Sīļi, representing regional differences inhe territory of Latvia. Time periods were chosen to comprise each hydrological phase during theyears 2013 and 2014thatare associated withextraordinary events.The modelling process was carried out using the semi-distributed conceptual IHMS-HBV model. The acquired forecasts were compared to real observations and against each other.

The model calibration results for respective river catchmentswere evaluated with the Nach-Sutcliffe efficiency koeficient and the values varyfrom 0.86 to 0.88. By conducting a comparative analysis of the calculated short-term forecasts, it was ascertained, that slightly better results in precision and timing on volume of the water were obtained using ECMWF weather forecastsfor all three studied river basins. Hydrological forecasts calculated using HIRLAM forecasts were overestimated and using ECMWF underestimated. Greater errors for all hydrological forecasts were on the second day of the forecast.

Although,calculatedhydrological forecasts using ECMWF weather predictions were more precise, information provided by similar sources should be used to apprehend possible events in various hydrological systems.

Keywords: hydrological ensemble forecast, numerical weather prediction model, comparative analysis

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