Nordic Hydrological Conference 2018

Hydrology and Water Resources Management in a Changing World

Knut Alfredsen, Chong-Yu Xu and Kolbjørn Engeland (Eds.)

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2018

REPORT

Nordic Hydrological Conference 2018

Published by: Norges vassdrags- og energidirektorat

Editor: Knut Alfredsen, Chong-Yu Xu and Kolbjørn Engeland

Authors:

Printing: NVEs hustrykkeri
Circulation: 0
Cover: Arne T. Hamarsland, NVE
ISBN 978-82-410-1724-7
ISSN 1501-2832

Summary: This report contains the abstracts submitted to the XXX Nordic Hydrological Conference organised by the Norwegian Hydrological Council (NHR) and the Nordic Association for Hydrology (NHF).

Keywords: NHF, NHR, NHC2018, Nordic Water

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and energy directorate (NVE)

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July 2018

Main organisers of the conference

NHF

Norwegian Hydrological Council

In cooperation with

NVE

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Norwegian University of Science and Technology

GEOLOGICAL SURVEY OF NORWAY
- NGU -

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With funding from
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Preface

The Nordic Hydrological Conference (NHC) is a biennial event, focusing on improved understanding of the water cycle and the practical application of hydrological methods within applied science and national planning in the Nordic and Baltic countries. The Nordic Hydrological Conferences have traditionally focused on the applied science and scientifically based decision-making. Hydrological knowledge has become increasingly important in a globalized world as a basis for legislation, e.g. through EU directives related to water and as a basis for sustainable utilisation of water resources, e.g. related to development of renewable energy or irrigation schemes. Hydrological information and knowledge is needed to enable decision making and planning related to daily, weekly, seasonal, annual, decadal perspectives for water for consumption, for the design and operation on infrastructure and for protecting the public against water related hazards.

The main topic for the conference in 2018 is "Hydrology and water resources management in a changing world". It reflects key challenges in both the scientific communities as well as the public and private sectors managing water resources. The International Association of Hydrological Sciences (IAHS) has selected "Panta Rhei – Everything Flows", as the main topic for the scientific decade 2013–2022. This initiative aims to improve the understanding of the changing dynamics of the processes governing the water cycle and the connections with rapidly changing human systems. At both the national and the European level, many research projects have impacts of changes in climate, society and the environment as their main topic.

The NHC 2018 is an excellent venue for dissemination of project results and for accumulating knowledge across projects and institutions. It offers a platform for sharing of knowledge between the Nordic and Baltic countries, contributes to linking research and practice, and is a forum where both young and more experienced hydrologists can meet.

Hosting the Nordic Hydrological Conference (NHC) circulates among the members of the Nordic Association for Hydrology (NHF), and each member state has the responsibility to arrange the conference every 16th years. Last time Norway hosted NHC was in 2002 in Røros. This year Bergen, the rain capital of Norway, hosts the conference. The conference venue is situated next to "Bryggen", the city's old wharf area – one of Norway's most popular attractions and a UNESCO World Heritage site. During the conference, the participants are introduced to how management of groundwater is important for preserving this world heritage site. Bergen City and the surround region faces many hydrology-related challenges related to flood hazards, drinking water supply and hydropower.

NHC 2018 represents many fields in hydrology and water resources science. In total 115 abstracts were submitted from more than 20 countries. Most of the contributions came from the Nordic and Baltic countries. All submitted abstracts are evaluated by the 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 committee 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 five keynote speakers: Tor Håkon Bakken, Helen Bonsor, Marco Borga, Lee Brown and Tone Muthanna. The funding from all the sponsors is also well acknowledged. Special thanks to the main sponsors NordForsk, The Norwegian Research Council, The Norwegian Water Resources and Energy Directorate, Statkraft, and Asplan Viak providing cash funding and NTNU, NGU, University of Oslo, BKK and NIVA providing in-kind to prepare the conference.

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Chair of the scientific committee, NTNU

Kolbjørn Engeland,
Chair of the organising committee, NVE

LIST OF ABSTRACTS

EVALUATION OF THE HYDROLOGICAL MODEL HYPE F ENVIRONMENTAL FLOW IN THE SOUTHERN NORWAY

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ABSTRACT

Many hydrological models have been used to generate runoff in ungauged basins in Norway. This study aims to asses the performance capabilities of a new hydrological model HYPE (Hydrological Prediction of the Environment), to predict environmental and low flows in ungauged basins as a requirement for applying the European Water Framework Directive (WFD) for the Southern region of Norway. The model set up was done for 38 unregulated discharge stations, in which seven years of data was taken as calibration period and another seven years of data was taken as model validation period. Two different combinations of objective function namely Nash-Sutcliffe Efficiency (NSE) and Kling and Gupta Efficiency (KGE) adjusted for bias were used to obtain calibrated and optimum model parameters. Furthermore, a multiple model evaluation criteria KGE, relative bias and mean absolute error were used to evaluate the simulated output discharge from the model and to compare it with the observed discharge. Results from the model outputs has been used to quantify the Indicators of Hydrological Alterations (IHA indexes) and the Common Low Flow (CLF) for the seasonal regime flows. The overall results showed satisfactory optimum parameters that can be transferred for the whole region and use to predict runoff in ungauged basins.

Keywords: Hydrological model; Environmental flow; Runoff in ungauged basins; Southern Norway

AN EXTENSIVE ANALYSIS OF THE CHALLENGES RELATED TO OVER EXPLOITATION OF GROUNDWATER IN LAGOS, NIGERIA

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ABSTRACT

Lagos is the largest city in Africa and one of the fastest growing cities in the world. One of the biggest challenges currently facing the city is a crisis in the city's water management. On the water supply side only 10 % of the population can be served by the public utilities, due to an inadequate infrastructure, a poor institutional and regulatory framework, insufficient resources and other factors. This does not only mean that 90 % of Lagosians have to find alternative sources for their water supply, such as private boreholes and (often informal) water vendors, but it also entails a strong dependency on groundwater as the main source for clean water in Lagos, increasing the risk of over exploitation. Over exploitation potentially worsens the water supply situation as it encompasses issues like saltwater intrusion, lowering of the water table and land subsidence. The focus of this paper lies on the challenges of over exploitation in relation to Lagos. The main risks of over exploitation are identified and the institutional, organizational, societal, technical and regulatory framework is analyzed. With the help of the analysis and practices from other cities facing similar problems, this paper aims to provide positive steps to prevent the 'wicked problem' of over exploitation and to make Lagos less dependent on groundwater resources.

Keywords: Lagos; Groundwater; Over exploitation; Sustainable water management; Developing country; Subsidence; Saltwater intrusion

UNCERTAINTY OF RUNOFF PROJECTIONS IN LITHUANIAN RIVERS

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ABSTRACT

The accuracy of the projections of future runoff highly depends on many factors related to climate change. Therefore, the uncertainty of runoff projections gets higher with each new sources of origin. Usually, the main sources of uncertainty are linked to global climate models (GCMs) and climate change scenarios (RCPs), but there is less attention on influence of statistical downscaling (SD) methods as a new source of uncertainty. This research focuses on evaluation of uncertainty of runoff projections related to major sources of origin (RCPs, GCMs and SD methods) in selected rivers of Lithuania. The territory of Lithuania is divided into South-Easter (LT-SE), Central (LT-C) and Western (LT-W) hydrological regions, which are characterized by different source of river feeding. For this analysis, most typical rivers of mentioned regions (Šventoji – LT-SE, Nevėžis – LT-C and Minija – LT-W) were selected and hydrological models of these rivers using the HBV software were created for estimation of uncertainty differences of runoff projections. For near (2021-2040) and far (2081-2100) future, the projections of selected rivers according to the three RCP scenarios (RCP2.6, RCP4.5 and RCP8.5), three GCMs (GFDL- CM3, HadGEM2-ES and NorESM1-M) and three SD methods (Bias Correction with variable, Change Factor with variable and Quantile Mapping) were created. Uncertainty of projections of annual discharges was evaluated applying the combinations of projections according to uncertainty sources. Analysis of runoff projections of the rivers Šventoji and Nevėžis showed that SD methods were the source of the largest uncertainty in both analysed periods. Meanwhile, in the Minija River the most significant uncertainty source was GCMs. Also the uncertainty analysis of projections of spring and flash floods was performed. Understanding the uncertainty of runoff projections will let better identify which uncertainty source has the most significant influence on the final results and, respectively, provide an opportunity to create more accurate runoff projections.

Keywords: Uncertainty; Runoff projections; Climate change; RCP; Statistical downscaling; GCM

DOES SEASONALLY FROZEN SOIL INFLUENCE HYDROLOGICAL PARTITIONING? A GLOBAL META-ANALYSIS

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ABSTRACT

Seasonally frozen soils are widespread in the Northern hemisphere. It is often implicitly assumed that frozen soils promote surface runoff in these regions. However, the reported hydrological effects of frozen soil remain controversial and contradictory; soil frost influence on the hydrology appears to be highly site and event specific. Several factors, such as land use, antecedent soil moisture conditions, and scale of the measurement have been suggested as reasons for the ambiguous effect of frozen soils on hydrology. We present an exhaustive meta-analysis review of circa 150 scientific publications that draw a conclusion about the influence of seasonal frost on hydrological partitioning (infiltration, runoff, percolation, groundwater recharge or transpiration). With the purpose of identifying factors that make soil frost influence more evident in some cases/sites than in others, we extracted data about the experimental setup, spatial and temporal scale of the measurement, porous media properties, site characteristics, and other relevant attributes reported in the reviewed literature. We present the first results of our analysis exploring the hydrological effects of frozen soils with a first ever global scale dataset and analysis, with the aim to draw conclusions that extend beyond individual site investigations. Our work provides a novel analysis of key factors determining the hydrological importance of frozen soil, which is needed in mitigating to a changing soil thermal regime in the north.

Keywords: Frozen soil; Cold climate hydrology; Hydrological partitioning; Infiltration

ANALYTICAL METHODOLOGIES IN GROUNDWATER PROTECTION ZONE´S DELINEATION – A PORTUGUESE CASE STUDY

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ABSTRACT

The growing need to overcome the scarcity of water for human consumption, together with the unquestionable importance of quality and quantity of groundwater, requires an adequate protection of this resource through the delineation of protective perimeters. Protection zone delineation and associated restrictions have become indispensable tools in the preservation of groundwater resources considering regional adjustments and locally-appropriate solutions. Hydrogeological parameters are considered to allow protection zone delineation for abstraction´s security design.

In this research, two analytical methods are compared - the Fixed Radius and the Wyssling methods - in the definition of abstraction's sustainable exploitation in two different examples, located in the granitic rocks of Serra da Gardunha, Central Portugal. The studied abstractions - Eirinha 1 and Eirinha 2 - are included in the subsystem of Casal da Serra and concerns to a set of artificial underground galleries, semi-horizontal and stretching within a section of about 1.80 m tall and 0.60 m wide. These granitic rocks show high density of fracturation and are locally weathered. The groundwater flows shallowly and approximately parallel to the topography, indicating a short residence time, as suggested by the low mineralization of these waters (EC: 20 - 40 μS/cm).

The fixed radius method is a relatively simple and inexpensive one. However, the obtained results are inaccurate as it takes into consideration a very limited number of factors. The protection perimeters' computation showed circles centered on the abstractions upstream and downstream overprotective and far beyond the limits of the considered recharge zone. Otherwise, the Wyssling´s method considers the hydraulic gradient allowing a more accurate protectionist measure, both upstream and downstream and better adjusted to the reality. The obtained results by the Wyssling method are more satisfactory and adequate to the study area geomorphological features.

Keywords: Protection perimeters; groundwater; Fixed Ray; Wyssling; Portugal

WATER-MANAGEMENT IN ARABIAN'S NORTHWEST BADIA (DESERT). HYDROLOGICAL ARCHAEOLOGICAL APPROACHES AND BEDOUIN LESSONS

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ABSTRACT

Water is playing an important role in the past and present in demography and civilizations. It is concentrate around rivers and shrinking far away from water. The *Badia* of northwest Arabia has limited and seasonal water resources controlled the distribution of the occupations in the northwest Arabian *Badia* since thousands year. The paleo - environment, paleo - climate and climate changes have been effected on the water resources of the northwest Arabian *Badia*. This forced the people to establish water management systems and strategies adapt and deal with the extreme environmental conditions and less water. The water management systems and strategies was developed through the time, and proved technically to be Compatible with the topography and the geology of the northwest Arabian *Badia*. This contribution is shedding the light on water management systems and strategies of the chalcolithic pre-oasis culture of the northwest Arabia, and The Bedouin knowledge of water management systems and strategies for harvesting water. Furthermore It'll clearfy and mentions the land use and the topographical and geological and hydrological experiences of pre-oasis people and Badu which gave them the ability to choose and build the right water management systems referring to the topography and the geology of the northwest Arabian Badia (desert).

Keywords: Water harvesting; Archaeological hydrology; Water management; Arabian peninsula; Dry land; Sustainable water resources

HYDRODYNAMIC MODELLING OF TEMPERATURE DISTRIBUTION IN A SHALLOW DIMICTIC LAKE, SE-NORWAY

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ABSTRACT

Lake Årungen is a relatively shallow and highly eutrophic lake in SE-Norway, which thermally stratifies during summer. The stratification development impacts nutrient dynamics and algae growth and the aim of this work is to use a hydrodynamic model to simulate the vertical temperature distribution in the lake. Empirical data shows that dissolved organic carbon (DOC) in Scandinavian lakes are increasing. Enhanced DOC concentrations, in addition to organic and inorganic particles, affects light penetration, which in turn has an effect on the temperature profile. The model we apply is developed for accurate modelling of density stratification in lakes and reservoirs, and is a buoyancy extended k-epsilon model. The goals of the work are to determine the effect of climate change and/or change in water quality on the temperature profile. As input for the model, we use available meteorological and hydrological data, particularly a nearby climate station at Søråsjordet. Furthermore, we have developed a model to generate a stochastic wind field with the aim of more accurately studying the stratification process. The modelling results are compared with a time series of empirically measured temperature profiles from 2008 to 2016. The work is in progress, and we will show results from the modelling procedure, both predicted future scenarios and a comparison with past observations.

Keywords: Hydrodynamics; Density stratification; Limnology; Lake modelling

NEW CLIMATE SERVICES TO FACILITATE WATER RESOURCES MANAGEMENT IN A CHANGING WORLD

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ABSTRACT

Currently 174 countries have ratified the convention of the Paris Agreement, with ambitious efforts to combat climate change and adapt to its effects. To help in these efforts, EU has established a new service, the Copernicus Climate Change Service (C3S), run by the European Centre for Medium-Range Weather Forecasts (ECMWF). The C3S brings together expertise from across Europe to deliver the service with open data and information to a broad user community in multiple sectors. This presentation will show results from the two proof-of-concepts for sectorial information systems provided to C3S by the Swedish Meteorological and Hydrological Institute (SMHI). The results are presented in web-based Demonstrators, which are fully integrated and equipped climate services. The overall aim is to bridge the gap between institutes who provide climate-impact data on one side, and water managers and policy makers on the other side. This was done through co-design with users and capacity development among engineering consultants and agencies, known as 'knowledge purveyors', who acted as the interface between data providers and water managers. The goal was to add value to data and ensure that available information is useful for water management at local and regional scales.

The first service covers model ensembles of 69 pan-European water indicators and 5 variables of seasonal forecasts, and it was evaluated in 15 case-studies across Europe. The main target group was consultants working in the water sector with climate adaptation of their clients business in water management. The results show that by using indicators, climate impact assessments could be done without having to run a full production chain from raw climate model results – instead the indicators was included in the local workflow with local methods applied, to facilitate decision-making and strategic planning to meet the future for abroad range of businesses in the water sector.

The second service covers some 20 indicators globally at various resolutions, produced from results of 19 climate models and evaluated in some 20 showcases. Half of the global climate impact indicators are water related. The target groups are organisations and companies operating globally, but also local/regional experts, acting as Knowledge Purveyors for local/regional climate issues on each continent. The water-related impact indicators were produced by using the new World-Wide HYPE model, which is a catchment based hydrological model with an average resolution of 1000 km^2 globally. The overall aim is to ensure user uptake of relevant and high-impact climate information world-wide, addressing sectors such as health, safety, water-security, transport, biodiversity, tourism, agriculture and food production.

This new scientific data can be downloaded as NetCDF or Excel format and is easily visualized by various menu choices and zooming in maps of the web interface. All data comes with metadata as well as information on confidence and robustness, key-messages on spatial patterns and trends, guidance to users on further tailoring to local conditions and tools for communications with decision-makers. The presentation will focus on the scientific tools and approaches used in the data production chain and lessons learnt from working with users in practical applications.

Keywords: Open data; Climate change; Impact indicators; Future projections; Adaptation measures

MODELING OF OKRA BASED ON PHYSIOLOGICAL RESPONSE UNDER SALINE IRRIGATION FOLLOWED BY DILUTION OF SALTS

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ABSTRACT

Two Okra cultivars (Chinese Green and Chinese Red) were subjected to saline irrigation (0, 0.6, 1.2, &1.8%) with Equal Proportion of NaCl and $CaCl_2$ followed by re-watering (0.6-0, 1.2-0.6, 1.8-1.2%). Saline irrigation Significant reduces water status, Photosynthetic attributes and growth parameters. More reduction was found at 1.8% levels, more than 85% redundancy in growth parameters due to decreasing in photosynthetic attributes in both cultivars. Re-watering gave positive effect for the recovery of plant after higher stress.

Chinese red show better recovery at 1.2-0.6% but Chinese green show better recovery at 0.6-0.0% levels. Models were developed between Dry weight, leaf tensity and saline irrigation levels. Considering re-watering water use efficiency and net photosynthetic rate, the optimum values of salt tolerance for Chinese green and Chinese red were 0.73% and 0.90%, respectively. Predicting re-watering levels that gets through developed models were also showed good response same at which levels optimize values were found. According to optimize value and predicting re-watering levels the best re-watering degrees of Chinese green have to re- watering at 0.73% to 0.36% and Chinese red have to re-water at 0.90 to 0.45%. This study developed method to utilize saline water resources and gets maximum production.

Keywords: Okra; Photosynthetic rate; Leaf tensity; Salt stress; Re-watering

EVALUATION OF J2000G HYDROLOGICAL MODEL ON SNOWMELT SIMULATION: LATYAN CASE STUDY

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ABSTRACT

In mountainous catchments, snow melt can have a significant impact on the water balance. In many parts of the world snow plays an important role as a natural reservoir for water supply. Specifically, high- altitude and semi-arid regions with abundant snow can have a large capability to balance and distribute scarce water resources. In this study the spatially distributed process-oriented hydrological model J2000g was used for the 431 km² large Latyan River catchment in Iran. The target was to derive spatially distributed estimates of the quantity and timing of hydrological balance terms and state variables like rainfall, runoff, snow water equivalent (SWE) and snow melt. The model uses the distribution concept of Hydrological Response Units (HRU) to account for the spatial variability of the natural environment within the basin. The comparison of the separate SWE models resulted in values between 0.28 - 0.68 for Nash-Sutcliff Efficiency (NSE) and 0.53 - 0.83 for the coefficient of determination (r^2). For the catchment models, the comparison of the simulated runoff with measured data showed NSE values between 0.78 and 0.82. According to the results, with the J2000g model the hydrological dynamics and the snow melting processes of the sub-basins within the Latyan catchment have been meaningfully simulated. It is summarized, that the single modules and in particular the snow components of the J2000g model along with the HRU distribution approach are well suited to elaborate the project objectives. It is therefore concluded, the model should be considered for similar catchments in Iran to analyse and quantify important hydrological dynamics information to support sustainable water resources management.

Keywords: J2000g; Simulation; Snow Water Equivalent; Snowmelt; Latyan Catchment; Hydrological Response Unit

RIVER RUNOFF IN PERMAFROST ZONE

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ABSTRACT

Features of forming and approaches to modelling of a rain floods for small rivers of a zone of permafrost breeds are considered. As basic data the data on the most heavy rains and the floods caused by them and recorded on experimental reservoirs of the Kolyma and Bomnaksky experimental stations are used.

On the basis of the available ideas about the dynamics of an active layer of permafrost breeds and results of the pilot studies executed in different years, the mathematical model allowing to consider a heat-sink role of a thawed layer and moss tow is offered. For accounting of features of forming of a rain flood the modelling HEC-RAS system allowing to reproduce the flood hydrology in specific conditions of slope regulation on the basis of a method of a Clark's unit hydrograph is used.

In the considered mountain conditions the layer of seasonal thawing is provided by products of aeration and is spread by frozen breeds. The superficial runoff in such conditions is not formed even in case of high intensity of rainfall, and occurs in the subsurface way on contact with a roof of permafrost which is a water resistant. On this water resistant the filtered moisture flows down in the direction of a slope and gets to primary hydrographic network. The surface of permafrost is provided by ice-cold breeds and is characterized by difficult topography.

Under a layer of a moss and lichen soil and thickness of a friable cover well developed microrill network which is traced practically to a watershed is noted, but it is not fixed even on large-scale maps. Due to water genesis when thawing an active layer the drain on the smallest reservoirs is noted even at a long absence of rainfall. The superficial slope runoff (storm, on A.N. Befani [1] classification) here practically does not form.

Keywords: Rain floods; Forming of a drain; Mathematical model; Permafrost soil; Water balance sheet stations; Single hydrographer; Slope regulation

BRIDGING THE GAP BETWEEN DISCIPLINES TO SOLVE FUTURE WATER CHALLENGES IN CITIES, WITH EXAMPLES FROM THE UK

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ABSTRACT

Our water resources and environments both, above, and below, ground are a key component of our future cities. The use of research and information of our waters is an essential component part of the evidence required for governments to be able to develop new spatial solutions to deliver key priorities: to deliver required housing alongside better places; to find new integrated solutions to reducing our emissions by 80 per cent by 2050; to develop vibrant economies, alongside new transport and energy pathways; and to increasing the resilience of communities to environmental change.

The Planning Bill (2017) Scotland, positions national planning policy and to be Scotland's core spatial policy, to delivering Scotland's Energy Strategy, Economic Strategy and Climate Change delivery plan. Water resources and City Regions play key component roles in meeting these challenges, and to developing resilient people and places. To meet these challenges, and to utilise and manage water resources to greatest effect in new placemaking approaches, the Bill calls for new ways of collaboration across professions to support future policy approaches.

This talk discusses some of the work and case studies being led in Scotland to support city development policy processes, to: develop a collegiate understanding of what types, scales and layering of environmental evidence are required to help support local development planning policy deliver key priorities; key challenges and opportunities for management of water resources; and, what communication and connectivity between organisations and disciplines are required to increase the accessibility, and impact, of environmental information, to planning policy and holistic placemaking approaches. A comparison to work within planning policy in Oslo highlights the international pertinence and transferability of this discussion.

Keywords: Planning Policy; Connectivity; Understanding; Transformation

INTERNATIONAL KNOWLEDGE EXCHANGE ON INFILTRATION OF STORMWATER UNDER EXTREME CLIMATE AND GEOHYDROLIC CIRCUMSTANCES

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ABSTRACT

Urbanisation and climate change have an effect on the water balance in our cities resulting in challenges as flooding, droughts and heatstress. Implementation of Sustainable Urban Drainage Systems (SuDS) can help to restore the water balance in cities by storing and infiltrating stormwater into the subsurface to minimise flooding, restoration of groundwater tables to prevent droughts, lowering temperatures by evapotranspiration to fight heatstress. Urban planners and other stakeholders in municipalities and water authorities struggle with implementing SuDS at locations where infiltration of water seems challenging. Questions arise as: *can you infiltrate in countries as The Netherlands with parts under sea level, high groundwater table and low permeable soil? Can you infiltrate in Norway with low permeable or impermeable bedrock and frozen ground most of the year? How do you find space to implement SuDS in the dense urban areas of Bucharest?* These questions are answered by researchers of the JPI Water funded project INovations for eXtreme Climatic Events (INXCES).

To answer the question on *'can we infiltrate stormwater under worse case conditions?*', testing of the hydraulic capacity take place at rainwater gardens in Norway (Bergen and Trondheim) and (bio)swales in the low lying parts of The Netherlands. The first results show that even under these 'extreme' hydraulic circumstances the hydraulic capacity (or empty time) is sufficient to infiltrate most of the stormwater throughout the year.

INXCES exchanged researchers on an international level, shared research results with stakeholders and sets up guidelines for design, implementation and maintenance of SuDS to promote the implementation of sustainable water management systems throughout the world.

One of the tools used to promote SuDS is www.climatescan.nl, an open source online map application that provides an easy-to-access database of international project information in the field of urban resilience and climate adaptation. The tool is able to map several sustainable urban drainage systems as has been done for Norway, The Netherlands, Romania and other countries in the world. The tool is used for engagement with stakeholders within EU projects as INXCES and WaterCoG and resulted in international knowledge exchange on infiltration of stormwater under extreme climate and geohydrolic circumstances.

Keywords: SuDS; Infiltration; Stormwwater; Flood resilience; INXCES

INVESTIGATION THE EFFECT OF SLOPED SURFACE WATER BODIES ON GROUNDWATER FLOW & HYPORHEIC EXCHANGE VIA AN ANALYTICAL SOLUTION

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ABSTRACT

Stream-wetland-aquifer systems are important coupled water systems in terms of hydrological, and ecological point of view. Determination of hyporheic flow between an aquifer and a wetland or a stream plays a crucial role in clarifying the hydrological characteristics of these coupled systems. Therefore, experimental, numerical and analytical approaches are used to determine the flow exchange among these water systems quantitatively. This study focuses on a stream-wetland-aquifer system with sloped surface water tables in a stream and a wetland. The stream is defined as a boundary condition into the aquifer domain and a wetland is incorporated into the groundwater flow equation as a source/sink term. An analytical solution for the groundwater flow equation is developed under the said conditions for steady state case. Then, the dominant parameters on flow exchange between surface water bodies and an aquifer are determined by conducting a sensitivity analysis. In addition, the interaction flow rate and the hyporheic flow path in an aquifer are determined. After several simulations, the slope of the surface water table is found as the dominant parameter on surface water/groundwater interactions. If the slope of the stream water table is greater than the slope of wetland water table, stream boundary condition dominates the hyporheic flow. As the slope of the wetland water table increases, wetland source/sink term dominates the hyporheic flow. Moreover, fluctuations in interaction flow rates are observed in wetland dominated systems.

Keywords: Stream-aquifer system; Wetland-aquifer system; Hyporheic exchange; Analytical solution; Sloped water table

EXTREME FLOOD IN SMALL STEEP CATHCMENT CASE UTVIK

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ABSTRACT

Extreme weather events, natural disasters and failure of climate change mitigation and adaptation are the risks with the highest likelihood of occurrence and largest global impact. According to the Natural Perils Pool the direct compensations over the 10 last years due to Natural Hazards (NH) have costed Norway alone 27 Billion NOK and the Public Sector even more. Historically the attention have been on floods in the larger watercourses. Due to a changing climate it is both expected and experienced more frequent and more extreme rainfalls creating violent flash floods in small catchments. The flood in Utvik July 2018 is an example of such an event. Over a periode of 4 hours the flow in river Storelva in Utvik increased from less than 5 m^3/s to around 200 m^3/s. With a catchment of 25 km^2 this corresponds to a spesific runoff of at around 8000 l/s, km^2 which is considered extremely high. Estimates indicate that a precipitation causing the flood to be 80 to 100 mm over 4 hours. In this study a distributed hydrological model isestablished for the catchment. The parameters in the model is based on tests from different catchment in the region and from a short term observated timeserie of runoff in Storelva from novermber 2017.

Keywords: Flash Floods; Spesific runoff; Utvik; Climate Change

SHYFT: A COMMUNITY RESOURCE FOR HYDROLOGIC PREDICTION

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ABSTRACT

We introduce Statkraft's Hydrologic Forecasting Toolbox (Shyft) as a framework for community based hydrologic forecasting in operational environments. There have been several efforts to develop a Community Hydrologic Model. Weiler and Beven (2015) recently outlined the arguments for such an initiative and provide a healthy summary of the challenges that have to date hindered development. Unique from numeric weather prediction, hydrologic modeling is conducted with a diverse set of objectives and requirements. Scale issues, both temporal and spatial, as well as the aim of the simulation, present a challenge to the creation of a singular framework. Several new initiatives are underway that will move toward community based modeling. Perhaps the most notable are two frameworks with quite different objectives. First, the WRF-Hydro framework provides a hydrologic routing scheme connected to the well know Weather Research and Forecasting (WRF) model. The SUMMA framework addresses the problem of multiple model hypothesis testing and enables the user to select a variety of model configurations to test the uncertainty developed from model assumptions. Herein, we introduce a third framework, most similar to SUMMA, but with a distinction – the aim of the framework is operational hydrologic forecasting, and we address not only uncertainty developed through model selection and configuration, but also provide mechanisms to assess variability in prognostic capabilities driven by the selection of forcing data. The main aim of Shyft is to provide end-users the possibility to test and evaluate new hydrologic formulations and configurations to a forecast system. Shyft is released open source and currently being developed by Statkraft AS.

Keywords: Hydrologic modeling; Community model; Uncertainty

INTEGRATION OF SEASONAL FORECASTING IN WATER RESOURCES DECISION SUPPORT TOOLS

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ABSTRACT

Seasonal forecasting can affect decision making in many water-related sectors including water supply, hydropower and agriculture as well as flooding. Hydrological seasonal forecasts over periods of weeks to months are particularly useful for water resources management where future flows depend on storages such as snow accumulation or man-made reservoirs. Within the EU FP7 project EUPORIAS, DHI has developed a decision support system for water resources management to exploit the latest generation of climate model- based forecasts, combining seasonal meteorological forecasts and seasonal hydrological forecasts. While the potential of seasonal forecasting, is widely recognised, seasonal forecasting has yet to be fully exploited. One reason is the coarse spatial resolution at which seasonal meteorological forecasts are available, while water resources managers or reservoir operators are interested in much finer resolutions. The second reason is the perception that these forecasts are highly uncertain.

In this paper, we use a case study in Spain to illustrate the design and development of a seasonal forecasting tool to address these challenges and user needs. The Añarbe reservoir is operated to fulfil the different requirements for hydropower production and water supply as well as environmental and flood protection. The rainfall exhibits a strong seasonal pattern and large variation in amount from year to year. Previous studies have shown that the North Atlantic Oscillation provides some seasonal predictability in the precipitation over the Iberian Peninsula. In the second case study, for the Colbun hydropower plant in central Chile, reservoir inflows are affected by both runoff generated directly from precipitation and indirectly through snow accumulation and snowmelt. Previous studies suggest that ENSO phenomena influence the precipitation patterns. Our results suggest that while the precipitation forecasts exhibit considerable uncertainty, snow storage, reservoir storage and operation strongly affect the hydrological response and improve the reliability of the seasonal hydrological simulations.

Keywords: Seasonal forecasting; Climate services; User needs; Decision support tools

COMBINING THE DANISH SURFACE-GROUNDWATER INTERACTION MODEL AND A HIGH RESOLUTION (0.4 M) LIDAR ELEVATION MODEL FOR DEVELOPMENT OF AN INTEGRATED FLOOD WARNING SYSTEM IN DENMARK

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ABSTRACT

Storm surges, cloudbursts and prolonged rain led to multiple types of floods in Denmark that were responsible for economic damages of 2-3 billion Danish kroner per year in recent years. Sea water levels and groundwater levels are furthermore found to be increasing, and it is necessary to consider the interplay between antecedent catchment wetness and precipitation events for more accurate flood risk assessment of both the near and distant futures in Denmark. The current study is undertaken with the aim to develop an integrated flood warning system that includes modelling of the interactions between surface and groundwater and applies high-resolution inundation mapping. For this purpose, the existing national surface-groundwater interaction model (DK-model; www.dkmodel.dk), being based on MIKE SHE/MIKE 11, is advanced to simulate shallow (near-surface) groundwater levels (100 m) and water levels in streams, as described by Henriksen et al. (see abstract). Stream cross-section data were extrapolated to represent the stream valley (2 m resolution), and stream water levels were modelled using 1-D hydrodynamic hydraulic solution (MIKE HYDRO River replacing MIKE 11). The simulated water levels are consecutively used for inundation mapping using the Danish high resolution (0.4 m) lidar elevation model (DEM). A Python script was developed that applies cost allocation technique to map the inundated area using the national hydrologically adjusted DEM data. Initial results show compliance with observed flooded areas, as documented by photos and satellite data. The performance of the integrated flood warning system is further evaluated and discussed based on comparison of simulated floods with satellite derived maps of groundwater flooding/wetness (time series NDWI analysis of Sentinel-2/Landsat data) and event fluvial floods (based on commercial very high resolution optical satellite data), including fluvial floods during storm surges.

Keywords: National flood risk model; Fluvial flood; Groundwater flood; Inundation mapping; Satellite data

DROUGHT RISK ASSESSMENT ON AGRICULTURE IN THE BOLIVIAN ALTIPLANO

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ABSTRACT

Droughts are major natural hazards leading to water and food shortages and as well have long-term environmental, economic, and social impacts on the population. However, impacts of droughts vary on a seasonal and annual timescale, and are dependent on the vulnerability and capacity to prevent and respond to droughts. The aim of this study was to assess the drought risk on crop yield in the Bolivian Altiplano. The results contribute to developing drought preparedness that is proactive rather than reactive, and promote risk-based management measures. The study was performed using a combination of gauged and satellite imagery data for climate, soil, and crop production. More specifically, data for precipitation, temperature, evapotranspiration, soil type, soil moisture, groundwater level, vegetation, and crop yield were used to analyse the drought impacts on agriculture in the studied region. The outcome of the study shows that precipitation is the main factor leading to drought events. However, the drought severity also depends of other factors involved in the growing season, for instance the soil has an important role for water storage. The water storage in the soil was analysed by relating the climatological, hydrological and soil parameters. Thus, drought assessment depends on various number of elements, that studied collectively can improve the understanding of drought impacts on agriculture and provide information and resilience against drought preparing for better drought management. Some of the drought management strategies to be implemented could be irrigation systems, selection of crops or varieties resistant to droughts, and resources allocation to producers before the occurrence of a drought event.

Keywords: Hydrological drought; Crop yield; Soil water storage; Drought management

ANALYSIS OF INFLUENCE FACTORS OF SOIL INFILTRATION BASED ON CT SCANNING TO DETECT THE 3-D CHARACTERISTICS OF MACROPORES AND ROCK FRAGMENTS IN FOREST STONY SOIL

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ABSTRACT

Macropore is the main factor for soil hydraulic properties, the characteristics of rock fragments will also affect soil water infiltration. However, what kind of characteristics of macropore and rock fragments is the determining factor for water flow in forest soil remain unclear. The objectives of this study were to quantitatively relate the 3-D network characteristics of macropores and rock fragments to saturated hydraulic conductivity, and to ascertain the main influencing factors of soil water infiltration in forest stony soil. Intact soil columns were taken from forest soil in northern china, and all intact soil columns were scanned using industrial computed tomography (CT) to quantified macropore and rock fragment characteristics including number, volume, surface area, mean tortuosity, mean angle, mean diameter of macropore and number, volume, surface area, mean diameter of rock fragment. The K_{sat} of three soil layers (0-10cm, 10-20cm, 20-30cm) were determined in six samples, and all columns were determined by water infiltration experiment. The results showed the saturated hydraulic conductivity of surface soil in mixed forest land is larger than that in pure forest soil, however, with the depth of soil layer, the difference of saturated hydraulic conductivity between mixed forest and pure forest is decreasing. Saturated hydraulic conductivity significantly negatively correlated with surface area density, volume density of rock fragment and mean tortuosity of macropore, and positively correlated number density, surface area density, volume density of macropore. Macropore and rock fragments codetermine the soil saturated hydraulic conductivity. Volume and surface area of macropore and rock fragment have the greatest influence on soil saturated hydraulic conductivity, which determines the soil water infiltration capacity. The effect of macropores on soil water infiltration is greater than that of rock fragments.

Keywords: Macropore; Rock fragments; Forest soil; Industrial CT; Water infiltration

DISAGGREGATION OF LARGE-SCALE ATMOSPHERIC DATA: A NON-DETERMINISTIC GEOSTATISTICALLY-BASED APPROACH

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ABSTRACT

In this contribution, a geostatistically sound approach inspired by a soil simulation strategy known as the "pilot point" technique is proposed to simulate heterogeneous rainfall fields respecting average values known over large scale domains. It typically allows the disaggregation of atmospheric reanalysis, GCMs outputs or large scale stochastic weather simulations. The disaggregation is based on an "a priori" small- scale simulation over the final grid, conducted as in Leblois & Creutin (2013). The two main components of this "a priori" simulation are a first Gaussian field thresholded to get a 0/1 rainfall indicator field and a second Gaussian field transformed to get a non-zero rainfall field, the non-zero rainfall field being then multiplied by the indicator field. The novelty is that the Gaussian fields can be iteratively modified so that the final simulation will reach the wished large-scale values. The disaggregation is not deterministic and reintroduces small-scale variability implicit in the large-scale data, giving an instrumental picture of the conditional uncertainty. The technique was developed within a stochastic weather simulation project led by Sintef; it is presently tested under Norwegian and French climates.

Keywords: Disaggregation; Geostatistics; Hydrology; Climate.

SIMULATING THE UTVIK FLOOD OF 2017 WITH A 2D HYDRO- AND MORPHOLOGICAL MODEL

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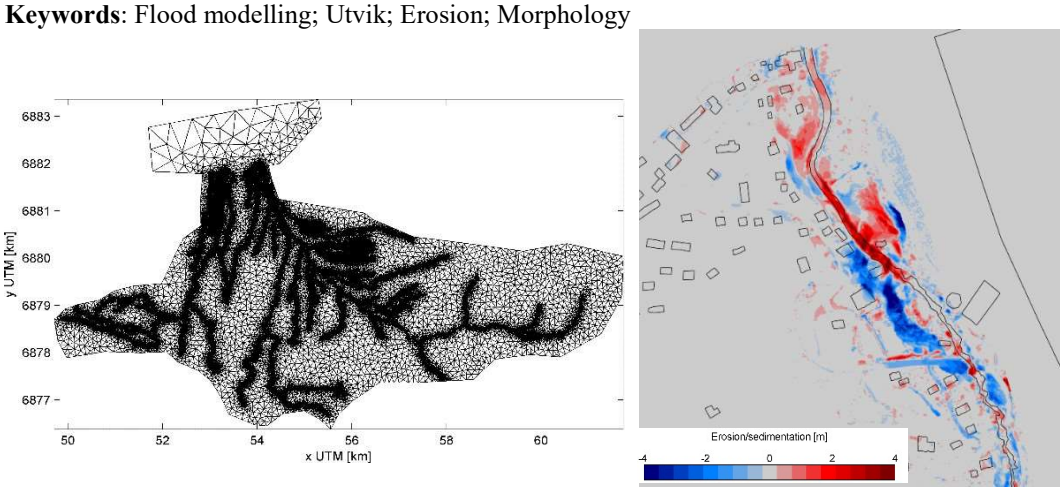
ABSTRACT

On the 24th of July 2017 a thunderstorm caused a large flash flood in the township of Utvik, Norway. The flood caused extensive damage to bridges, houses, infrastructure and property. The main river with a catchment area of around 25 km^2, altered its cause in the downstream section of the township.

We used a 2D process-based hydro- and morphodynamic runoff model to simulate the flood. This FINEL2d model spans the complete catchment area and has a resolution ranging from 100m to 1m in the area of particular interest. Radar image data was used for the rainfall model input. We modelled 2 scenarios: the first scenario used the model in hydrological mode only. The second scenario used the hydrological + morphological model. Here the sediment transport plus bottom changes were calculated each time step. The first scenario underestimates the flood levels and not all the flood paths in Utvik are reproduced. The second scenario is able to accurately simulate the observed flood paths and water levels. Furthermore the model is able to reproduce the observed erosion/sedimentation pattern. According to the model and LiDAR bed levels taken after the flood, sediment accumulated in the most downstream section of the river in Utvik, which is what would be expected on such a delta. Here the river slope and velocities decrease and the sediment carrying capacity becomes less, leading to sedimentation. As a consequence of this sedimentation the water levels are raised further, causing additional flooding.

The results show that towns build in deltas are particularly flood prone due to the additional sedimentation effect. High-resolution, morphodynamic modelling can assist in prediction of this effect and help identify high flood-risk areas.

Keywords: Flood modelling; Utvik; Erosion; Morphology



ANALYSIS OF THE INFLUENCE OF FOREST ON THE RUNOFF FROM SMALL MOUNTAINOUS CATHCMENTS

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ABSTRACT

The drought hazard has become a much discussed topic in the Czech Republic as well as in other Central European countries in last decade. Different measures are being discussed to be applied within the mitigation of expected climate changes impacts. Increased frequency and severity of droughts and changes in the variability of flows belong to these expected impacts. Among others, good shape of the landscape consisting also in the increasing percentage of forest cover and building small water reservoirs is considered to be very important. This contribution focuses on the influence of forests on the runoff conditions in small catchments. The influence is assessed for small catchments in Jizera Mountains where the forest cover has changed significantly in recent decades since the time when they were destroyed by acid rain. These catchments are therefore very suitable to demonstrate the influence of forest of different age on the runoff conditions. In this contribution, the influence is studied based on the runoff coefficients for selected events and on the rate of drainage after significant precipitation events. The data for more than 15 years' period since 2000 were used for this purpose. It covers the most significant change in the forest cover in the area of interest. The results indicate the influence of the forest on the runoff conditions despite the difficulties related to other influences.

Keywords: Runoff hydrograph; Forest cover; Landscape retention

GROUNDWATER BALANCES AND THEIR ROLE IN WATER RESOURCE MANAGEMENT: TOOLS FOR SUSTAINABLE STRATEGIES

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ABSTRACT

Despite sufficient precipitation to meet water resources needs, many regions with limited soil cover and crystalline bedrock currently or in the near future can be expected to experience water quantity and/or quality issues. In these types of terrains, knowledge of limited local hydraulic conductivity and effective porosity within the fractured bedrock are the key factors for sustainable groundwater extraction. Spatial behaviour of storage characteristics and extraction show strong heterogenic behaviour. This is supported by data from The Geological Survey of Sweden's well archive, which shows a lack of spatial correlation after even a few hundred meters. Modelled storage maps were significantly correlated with both estimated specific capacity and depth to groundwater. However, the storage parameter showed strong bimodal behaviour in its distribution, most likely due to the effect of the different geological strata, in this case hard rock with extremely low effective porosities and limited soil cover with relatively higher effective porosities. Additionally, a simple groundwater balance which incorporates this limited storage was carried out which showed very promising results when compared to groundwater level measurements in 2016 and 2017. Results illustrate that effective estimation of in-situ effective porosity is vital in effectively capturing the behaviour of local groundwater resources. However, thickness of different soil layers which may be very limited spatially has important implications for available groundwater resources and these layers likely function as a recharging reservoir making regional recharge estimates highly dependent on local geological features. The effect of parametric sensitivity on storage calculations within the model further illustrates the importance of reducing the local parametric uncertainty for sustainable groundwater resources management. Furthermore, combining these sensitivity analyses with extraction maps could prove vital in directing limited resources for reduction of parametric uncertainty at the municipal level.

Keywords: Crystalline Rock; Groundwater; Scale Effect; Geographic Information Systems; Coastal Aquifer

COUPLING OF A DETAILED SNOW MODEL TO WRF-HYDRO FOR GLACIER MASS BALANCE AND GLACIER RUNOFF STUDIES

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ABSTRACT

Glacier melt is an important water source in many regions, specifically during summer when the magnitude of the summer peak river flow depends greatly on the contribution of melt water from snow and ice to the total river flow. This contribution from glaciers to total flow plays a key role in the glacier-fed rivers in populated regions where summer flows are crucial for irrigation, human consumption and energy production. Many regional 'atmosphere-only' models typically do not have the detailed information about runoff routing processes, which are important components in the hydrological cycle. Furthermore, coupled atmosphere-hydrological models, that gives detailed information about runoff routing processes does not necessary have the information of glacier melt when the mass balance is negative. This is specifically important now when glaciers more often have a negative mass balance, and the runoff from the glacier system changes as the ratio of snowmelt to ice melt changes.

We have incorporated the detailed Crocus snow model, as a glacier mass balance model, into the Noah-MP land model, within the Weather and Research Forecasting - Hydro (WRF-Hydro) modelling system. By linking a surface mass balance glacier model to the WRF-Hydro system (WRF-HydroGlac), the interactions between the energy, water and mass balance budgets over glaciated river basins can be better depicted and projected future impacts, better understood. We will demonstrate the WRF-HydroGlac model with a mass balance and snowpack/glacier runoff study of a the highly observed Hardangerjøkulen.

Keywords: Hydrological Modelling, Glacier mass balance and discharge

HISTORICAL FLOOD INFORMATION USED FOR FLOOD FREQUENCY ANALYSIS

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ABSTRACT

There is a need to estimate design floods for areal planning and the design of important infrastructure. A major challenge is that the required return periods of 200, 500, or 1,000 years are much longer than the typical length of a flood time series. Design flood estimates are therefore based on extrapolation, and the estimation uncertainty might be large. The aim of this study is to investigate if the use of historical information improve design flood estimation. Annual maximum floods from streamflow stations were combined with historical flood information indicating water levels for the largest floods in the last two to three hundred years. The aim of this study is to assess the added value of using historical data for flood quantile estimation and how the added value depends on data availability and the estimated length of the historical period. A Bayesian approach was used and we investigated data from two location in Norway. The results show that there is added value in using historical information. The largest improvements is seen when the magnitude of the historical floods is known, and when the length of the systematic record is short. If the historical flood sizes are not known, whereas the number of floods above a perception threshold is known, the added value is the greatest when the perception threshold is relatively high. It is also recommended to set the length of the historical period to be the time span from the first historical event to the end of the historical period plus the average time spacing between the historical events.

Keywords: Flood frequency analysis; Historical floods; Design flood

PRECIPITATION PHASE UNCERTAINTY IN COLD REGION CONCEPTUAL MODELS RESULTING FROM METEOROLOGICAL FORCING TIME STEP INTERVALS

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ABSTRACT

Precipitation phase determination is a known source of uncertainty in surface based hydrological, ecological, safety, and climate models. This is primarily due to surface precipitation phase being a result of cloud and atmospheric properties that can't currently be measured from the ground. Adding to uncertainty, many conceptual hydrological models use a 24 hour average air temperature to determine precipitation phase. However, meteorological changes to atmospheric properties which control precipitation phase often substantially change at sub-daily timescales. Many weather stations report parameters at sub-daily timescales that could be used in place or in conjunction with air temperature to improve precipitation phase parameterization in conceptual models.

This study used 30,908 weather observations with an air temperature (AT) -2 to 4°C and an identified precipitation phase occurring during the observation to identify thresholds for different precipitation phase determination schemes (PPDS). This dataset represents over 35% of precipitation observations over a 5 year period for 48 Norwegian weather stations.

The model uncertainty (precipitation phase error) from PPDS using AT, dew-point temperature (DT) and wet-bulb temperature (WB) thresholds were compared using averaged, and time of observation readings at 1, 3, 6, 12, and 24hr time periods. PPDS methods requiring sub-daily time steps, or additional observed elements at the time of observation were also tested. These observation groups include; 1.) occurring before and after an air mass boundary, 2.) different sea surface temperatures, 3.) with or without snow cover, 4.) with different cloud heights, and 5.) during different NAO phases.

An important result to consider in future modelling was that precipitation phase uncertainty grew 30-50% from the use of 1hr data to 24hr data. For example air temperature uncertainty at 1hr was 14.51% compared to 19.94% using 24hr data. There was also little difference between 1hr and 3hr uncertainty, common time steps for surface meteorological observations.

Keywords: Precipitation Phase; Snow Model; Temperature Threshold; Conceptual Models

DECREASING PRECIPITATION PHASE UNCERTAINTY IN HYDROLOGICAL MODELS USING SUB-DAILY TIME STEPS AND SUPLIMENTAL DATA TO IMPROVE TRADITIONAL METHODS

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ABSTRACT

Precipitation phase determination is a difficult task known to cause uncertainty in meteorological and hydrological modeling. This uncertainty affects outputs of safety, ecological, and hydrological models, and is of increased importance in areas such as Scandinavia where an abundance of precipitation occurs within the air temperature range of -3 to 5°C.

To address this uncertainty, datasets with over 1 million Swedish and Norwegian weather observations with an identified precipitation phase and an air temperature (AT) between -3 and 5°C were used to find optimal rain snow thresholds. The datasets represent over 35% of all precipitation observations, and over 99% of the incorrectly identified precipitation phase events occurring during a 16 year calibration period and a 6 year validation period for 85 and 84 Swedish and Norwegian weather stations respectively.

Conceptual hydrological models typically use precipitation and AT to determine precipitation phase. However, precipitation phase at Earth's surface is a result of cloud properties and atmospheric energy exchanges between hydrometeors and the air they fall through. These latent and sensible heat exchanges are not measured by available surface data. However, thresholds in conceptual models could be improved by adding supplemental variables from weather observations such as cloud height, relative humidity, and change in AT over time. Physiographic station data could also be used to adjust thresholds for groups of stations.

The Norwegian calibration resulted in 11.64, 11.21 and 8.42% error for dew-point temperature (DP) (- 0.2°C), AT (1.2°C) and wet-bulb temperature (WB) (0.3°C) thresholds respectively. Individual station thresholds ranged from -0.7 to 1.2°C, -1.2 to 0.9°C, and -0.1 to 2.5°C for WB, DP, and AT respectively. AT thresholds were found to increase with cloud height reducing total error by 5%. Creating thresholds for different station groups based on proximity to the ocean, and topography was also found to decrease precipitation phase uncertainty.

Keywords: Conceptual Models; Snow Model; Temperature Threshold; Precipitation Phase

VADOSE ZONE HYDRAULIC ASSESSMENT IN URBAN AREAS – IN SITU EXPERIMENTS

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ABSTRACT

Urban soils, subject to regular moistening (rain, snow melting, irrigation, water supply network losses, and others) will have a high degree of saturation and a lower variation of the hydraulic conductivity value when reaching the degree of saturation, as opposed to a soil exposed to a long period of drought. In both situations due to the lithological heterogeneity, significant variations may occur in relatively close locations. Engineering approaches use the value of the vadose zone hydraulic conductivity as for a saturated state. This minimal value is considered suitable especially for urban soils, where the percolation time may drastically vary in distinct points within the same area, as it is dependent on the texture, degree of compaction, and thickness. Determining the hydraulic conductivity for different saturation degrees and highlighting its variation over time requires numerous field test locations in the horizontal and vertical plane. In the case of heterogeneous soils, as the water infiltration area is larger, the obtained hydraulic conductivity value better characterizes the area. This paper shows an analysis of the values obtained for saturated hydraulic conductivity on vadose zone urban soils, by applying four methods of in situ assessment: Single ring infiltrometer, Double ring infiltrometer, Minidisk infiltrometer, and the Inverse auger method. The analysis has been made by comparing the results obtained by each method, between several tests carried out at the same location and at distinct locations within the same plot, as well as between the used methods. A stochastic analysis indicates a direct correlation between the hydraulic conductivity and the infiltration surface. A better understanding the urban vadose zone behavior increases the urban hydrology and urban hydrogeology knowledge and support further an enhanced urban water management.

Keywords: Urban soil; Vadose zone; Hydraulic conductivity; Infiltration area; Urban water management

DEVELOPMENT OF ADVANCED SNOW MODELLING PLUGIN EXPLOITING THE MIKE 1D API

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ABSTRACT

The MIKE 1D engine is a reengineering and merger of the calculation capabilities of MIKE's collection system and river simulation packages (MIKE URBAN / MOUSE and MIKE 11) into one engine. The vision with the MIKE 1D engine is to bring existing functionality of the two engines into one engine to optimize performance and utilize functionality from both domains. This includes both the hydrological and hydraulic processes. As part of this development some powerful new features have been introduced. Firstly, the new engine is parallelized and hence can utilize multiple cores when available during the simulation. Secondly an extensive and powerful API. (Application Programming Interface) is provided. This API can be used to add customized or new functionality within the model without modifying the core model code, through a plugin approach. In this paper, we present the new MIKE 1D engine and API capabilities. We demonstrate these capabilities with a software plugin that implements a new distributed snow modelling approach within the rainfall-runoff module. This new modelling tool is applied to catchments in South America, where melting snow from the Andes Mountains is used to generate power.

Keywords: New technology for hydrological modelling; Advanced snow modelling; Hydrological and hydraulic modelling

EVALUATING THE VALUE OF BIAS CORRECTION OF HIGH- RESOLUTION SATELLITE RAINFALL PRODUCT (CHIRP) TO SIMULATE STREAM FLOW INTO LAKE ZIWAY, ETHIOPIA

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ABSTRACT

Significant lowering has been observed in the Lake Ziway volume, which hinders the lake services for a wide variety of ecosystems. However, the contribution of water withdrawal, land cover change and climate change has not been quantified yet due to scarce data for rainfall-runoff modeling.Satellite hydro-meteorological estimate may serve as important inputs for modeling in an area of data scarce and poorly gauged region. In this study, we evaluated the runoff simulation from near-real time, Climate Hazards Group Infra-Red Precipitation (CHIRP) satellite rainfall product at daily temporal and 0.05^0 X 0.05^0 spatial resolution for a period from 1984 to 2016 over Lake Ziway watershed, Eastern Africa. The bias of satellite rainfall estimate must be removed before estimates receive applications. We applied a non-linear power bias correction method using in-situ rainfall data as references.The bias-corrected CHIRP were used to calibrate and simulate rainfall-runoff using Hydrologiska Byråns Vattenbalansavdelning(HBV) model at Katar and Meki catchments, two major river inflows into the lake.

The HBV model revealed good performance when evaluated using Nash-Sutcliffe model efficiency (NSE) and relative volume error (RVE) objective functions for the calibration and validation periods. For calibration period (1986 to1991), the value of NSE was 0.77 and 0.62, and the RVE was -4.31 and -3.78 for Katar and Meki catchments respectively. The verification period(1996-2000) revealed NSE values of 0.56 and 0.58, and RVE values of 8.21 and 7.51 for both catchments. Simulation result indicates that, Katar and Meki rivers contribute a runoff volume of 626.7MCM (61% for the Katar and 39% for the Meki) to Lake Ziway for the period from 1986 to 2016. On average attribution of up to 7.2% annual runoff volume reduction obtained during simulation over time. Our study shows that bias corrected CHIRP satellite rainfall estimates play a major role in estimating catchment runoff and lake inflows. Further study should incorporate lake level simulation and climate change impact assessment to assess the likely current and future behavior of lake.

Keywords: Runoff modeling; CHIRP Precipitation; HBV; Bias Correction; Lake Ziway; Katar; Meki

MAPPING AND MONITORING GROUNDWATER AND IMPLEMENTING THE GROUNDWATER DIRECTIVE IN NORWAY

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ABSTRACT

The state of Norwegian water
In Norway, almost 30.000 water bodies are so far registered as part of the EU Water Directive implementation. The majority of water bodies are located in rural and unpolluted areas and the quantitative, qualitative and ecological status is generally good or very good. However, 10% of the water bodies are reported to be in a bad or very bad ecological condition. And as much as 37% of the Norwegian water bodies are classified to be at risk not to achieve the environmental targets by 2021. For the 1.100 *groundwater* bodies classified so far, the situation seems to be considerably better, or at least it is classified as such. Not more than 7% are considered to be at risk to achieve a chemical status less than "good" by 2021.

For 40 years, NGU has monitored Norwegian *unaffected* groundwater sites in another project, "The Norwegian soil- and groundwater network (LGN)". The results have shown that natural levels of chemical parameters are generally acceptable throughout the country; from a drinking water as well as from an environmental perspective. But monitoring and mapping groundwater bodies potentially *affected* by human activity has hitherto been less prioritized. Consequently, the existing knowledge on extent, environmental impact and groundwater quality is therefore insufficient as a basis for the Water Framework work in such areas. In the absence of hydrogeological data, interpretations on e.g. groundwater body extent have been mainly based on geological surface maps without depth information, whereas the *chemical* state has been based on assessing area load, mainly from agriculture, infrastructure and urbanization.

Monitoring groundwater bodies
In order to fill some of these knowledge gaps on potentially affected groundwaters, NGU has initiated a project where 10 groundwater bodies located under surface activities such as urban settlements and agriculture, have been monitored. They have been characterized thoroughly and will be monitored through the coming years and hopefully decades. The monitored sites represent different geological, geographic and climatic conditions, and are meant to represent common groups of groundwater bodies with similar load and hydrogeological conditions. The aim is to *assess,* and if justifiable, *minimize* the need for mapping and monitoring of common groundwater types documented through the project to be at low risk. The project started in spring 2016 and is a joint effort between NGU, The Norwegian Environment Agency (Miljødirektoratet) and The Norwegian Water Resources and Energy Directorate (NVE).
The sites have been mapped by compiling previous geological/ hydrogeological surveys, and supplementing these with field studies using georadar, drilling, and water sampling. Groundwater has been sampled 2-4 times each year from surveillance wells and groundwater springs. Physical and inorganic chemistry parameters have been analyzed as well as pesticides for agricultural sites, and a range of organic pollutants (e.g. THC, PAH, BTEX) for urban sites. Digital CTD loggers (conductivity, temperature and depth) have been installed in some selected monitoring wells.

Results that will be presented
Pesticides and environmental pollutants have been detected in some of the groundwater bodies, but in low concentrations and classified as "in good chemical state". However, the CTD-divers have shown significant conductivity peaks during periods between the sampling campaigns.

Consequently, sampling has been adapted to achieve chemical data records from these interesting situations, and to assess their causes and mechanisms.
Long-term monitoring series represent considerable data quality challenges since methods, equipment and sometimes procedures will need to be changed and developed. But the results are also unique and may provide early warnings about megatrends concerning e.g. regional or long-range pollution, climate, weathering, CO_2 uptake, acidification, and a range of unforeseeable trends with unforeseeable consequences. On the conference we will present some trends, status and plans for future groundwater monitoring in Norway, both from this new project on potentially affected sites, and from the 40-year span monitoring campaign (LGN) at unaffected sites.

FLOOD DAMPENING IN HYDROPOWER SYSTEMS

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ABSTRACT

Floods are a major threat to human life and property on a worldwide basis, and Norway is no exception. However, Norway has a massive storage capacity in its hydropower system which could provide a potential to significantly reduce flooding/flood peaks in regulated catchments. The dampening would depend on a number of factors, such as the free reservoir capacity, ability to draw down reservoir prior to a flood event, regulation capacity, spillway capacity, etc. To investigate this potential, a literature study to establish the current state of research on flood dampening from reservoirs (both purely flood dampening reservoirs and multi-purpose reservoirs) on a national and international scale will be carried out, with an attempt at summarizing various methods utilized and results obtained from studies. Furthermore, the flood dampening effect of both single and multi-reservoir systems will be modelled and investigated. For the single-reservoir system, a basic model will be constructed in Microsoft Excel. For the multi-reservoir system, the Orkla catchment will be modelled in WEAP (Water Evaluation and Planning System). Both models will investigate the impact of regulation compared to the natural conditions, as well as the effect of initial storage (spring vs. autumn filling) and drawdown prior to the flood event. Based on the knowledge obtained from the literature study and the results from modelling various scenarios, the potential for creating a flood dampening factor based on regulation capacity and various other watershed/reservoir characteristics will be explored. Such a factor will be evaluated for both single- and multi-reservoir systems.

Keywords: Reservoir; Multi-reservoir; Flood dampening; WEAP

SPATIAL PATTERN OF SOIL HYDRAULIC CONDUCTIVITY IN THE HEIHE RIVER WATERSHED, NORTHWEST CHINA

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ABSTRACT

Spatial variability of soil hydraulic conductivity significantly affects hydrological modeling and water resources management of river basins, especially in the arid and semiarid mountainous watersheds. In this study, a total of 32 soil profiles with 5 layers within 0-70 cm were sampled under different land cover types: forest, meadow, high coverage grassland (HCG), medium coverage grassland (MCG) and barren land in the upper reach of the Heihe River Watershed, Northwest China. Saturated hydraulic conductivity (K_S) was measured for each sample. The vertical variation of K_S and soil hydrological response under different land covers were analyzed. Results show that K_S value in layer 5 was significantly lower than the values of above 4 layers. K_S decreased in the order of forest, meadow, HCG, MCG, and barren land, corresponding to the degree of vegetation degradation. The K_S decreased with depth under forest, HCG and barren land, but increased first and then decreased under meadow and MCG. The dominant stormflow paths (DSP) for different land covers were different: forest was dominated by deep percolation (DP), HCG was dominated by subsurface flow (SSF), meadow was prevailed by Hortonian overland flow (HOF) and had no SSF, while MCG and barren land were also dominated by HOF, but still formed SSF. The results provide important information for improving the accuracy of mountainous hydrological modeling, and in turn supporting sustainable management of water resources in the study watershed.

KEY WORDS: saturated hydraulic conductivity; soil hydrological response; the Heihe river watershed, Northwest China.

TRANSITION OF A NATIONAL WATER RESOURCES MODEL TO A FLOOD RISK MODEL FOR DENMARK

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ABSTRACT.

The purpose has been to develop a methodology for modelling of shallow groundwater levels and water levels in rivers, to transition a national water resource model (DK model: www.vandmodel.dk) toward a national flood risk model for use in Climate Change Adaptation, Disaster Risk Reduction and water management. To improve simulated shallow groundwater level performance, a more detailed resolution (500 m to 100 m) and new data representing shallow groundwater (upper 10 meter below the surface) were incorporated. To enhance water level simulation, observations from streams and the sea and complex structures and cross sections, extended to the entire river valley (based on DEM 2 m resolution), were incorporated. Furthermore, an advanced hydraulic solution for water level simulation in MIKE HYDRO River, was included. Model transition and testing was done in two case studies Storå (1146 km^2) and Odense å (1025 km^2). A new and robust calibration strategy was developed. The test and evaluation based on independent observations and event data resulted in an improved performance of simulated shallow (near surface) groundwater levels (to around 2 m for RMSE: 5-95 %) and an improved performance for water levels in streams (to around 20 cm) with a parameter distribution for Manning n applicable for a national model. Downscaling and simplified solutions were tested to minimize computation time.

Keywords: National flood risk model; Shallow groundwater; Sea water level; Stream water level

EVALUATING HYDROLOGICAL PERFORMANCE OF THE LID MODULE IN MIKE URBAN; A CASE STUDY IN GREFSEN, OSLO

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ABSTRACT

Paved surfaces, increased precipitation amount and intensity, and a limited capacity in the sewer systems cause a higher risk of urban flooding and frequent combined sewer overflows (CSOs). This is a common problem in Oslo, Norway, and cities around the world. Low impact development, also referred to as green stormwater controls, is a possible solution to mitigate the consequences by managing some of the stormwater locally and reducing the amount of water routed into the sewers. One of the critical CSOs in Oslo is located in the Grefsen catchment. Frequent overflows contribute to significant pollution loads to Akerselva, an important, historical and recreational river flowing through Oslo. The objective for the next decade is to reduce this CSO to a maximum of three events every third year. To evaluate the effect of LID locations, the green roof and the bioretention modules in the MIKE URBAN model have been used. The first step of the method was to evaluate the hydrological performance. Observed data from two pilot green roofs in Oslo and a bioretention cell were used to evaluate the performance. Nash- Sutcliffe efficiency coefficients have been used to assess the power of the model. To simulate the water movement and overflows in the Grefsen catchment area, a calibrated model was applied using the previously evaluated LID modules. MIKE URBAN has been proven to be a satisfying tool when modelling stormwater controls. The case study approach has been valuable to test the real life complexity typically faced in modelling urban combined systems. Moreover, modelling is important to identify possible placements for stormwater controls making it an important tool for planning and managing storm events in the future.

Keywords: Urban drainage; CSO; Mike Urban; LID; Hydrological modelling; Decision-making

EUROPEAN AND NATIONAL CLIMATE SERVICES FOR IMPROVED DECISION MAKING IN THE WATER SECTOR - CHALLENGES AND OPPORTUNITIES

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ABSTRACT

The Copernicus Climate Change Services aims at developing a system to provide information that will help societal and business sectors improve decision making and planning regarding climate change adaptation in Europe. One proof of concept research projects, "End-to-end Demonstrator for improved decision making in the water sector in Europe (EDgE)", has brought together stakeholders, hydrologists and informatics specialists to bridge the gap between climate and hydrological data provided by scientists, and the information needed by policy makers and managers in the water sector. In Norway, the Norwegian Centre for Climate Services (NCCS) has the same objective, providing climate and hydrological projections as a basis for climate change adaptation across sectors. We describe the value of a European Climate Services compared to existing national services.

The stakeholders range from advanced users applying their own modelling tools to users with little knowledge about climate change and hydrology. The needs of these user groups, range from downloading climate projections to be used as forcing data in their own models to users that request simple information in their national language. Advanced stakeholders with economic interests in many countries, see the need for European Climate Services that provide a consistent dataset across Europe. Less advanced stakeholders are less likely to use a European Services.

By a strong and systematic focus on user involvement, EDgE allowed stakeholders to influence on the development of hydrological indicators, how to represent uncertainty, the map viewer user interface and user guidance. The approach built competence both for scientists and stakeholders.

The climate and hydrological projections provided by EDgE and NCCS was compared. This illustrated challenges in diverging results, the need for explanations of such result and advantages of model ensembles. Further, there is still a need to optimize how climate projections can be used to improve decision making.

Keywords: Climate services; Climate change adaptation; Water sector

CAN FRESH SNOW FALLING IN THE SPRING ACCELERATE SNOWMELT?

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ABSTRACT

In large parts of northern and central Sweden there is a common perception that fresh snow falling in the springtime "eats" the underlying old, coarse-grained snow and accelerates snowmelt. The exact origin of this expression is unknown and it does not seem to have caught attention from the scientific community yet. Could it be true and, if so, what processes could be accountable? We evaluated the truthfulness of the perception using SNTHERM, a one-dimensional snow model developed by the US Army Corps of Engineers, together with meteorological observations from Rensjön outside Kiruna in northern Sweden. A number of simulations were conducted to examine snowmelt rates under combinations of weather and snow pack conditions. Hourly time series of typical spring weather types were constructed from the meteorological observations: (1) sunny warm days and cold clear nights, (2) mild and windy days and nights, (3) rainy days and nights. The melting of two types of snow pack conditions were investigated: (a) only coarse-grained, old snow, and (b) a layer of fresh snow on top of coarse-grained, old snow. Preliminary results from the simulations reveal complex melting patterns in different layers of the snow pack, which can be attributed to variability of the forcing data (weather) as well as to snow layer characteristics. A possible explanation of the expression is therefore that the arrival of fresh snow in the spring can coincide with a change in weather that accelerates snowmelt.

Keywords: Snowmelt; Fresh snow; Old snow; Spring; SNTHERM

WATER BALANCE ONLINE: TOWARDS CONTINUOUS ASSESSMENT OF WATER AVAILABILITY, CONSUMPTION AND STRESS

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ABSTRACT

During 2016-2017 large parts of Sweden experienced unusually dry conditions, mainly due to shortage in precipitation during two consecutive winters. In total, 42 municipalities issued restrictions on water use and there was an urgent need of hydrologic information to secure the supply of drinking water. In some areas streams which normally have water flowing all year around went dry with an uncertain impact on the local environment. Droughts are very unusual in Sweden and information on water availability, consumption and stress was not readily available. To meet the demand for up to date information and enable efficient management, SMHI developed an online presentation of local water balance calculated by the national hydrological model S-HYPE. The online service presents the different variables of the water balance (precipitation, evapotranspiration, net outflow, and changes in storage of snow, groundwater and surface water) in amount of millimetres as well as in relation to historical data. The water balance is presented for different time periods (last 3, 6, 12 and 24 months). Results show that water balance calculations are useful to identify areas with lower than normal water availability and that this information is of great support to local authorities. The service can be used to explore causes of limited water availability, e.g., precipitation deficit, high evaporative demand or excessive net outflow due to regulation or water extraction, but results show that there is a lack of data on water extraction that prevent results to be reliable at the small/local scale. Ongoing work will provide more detailed information on water extraction, and this will enable continuous assessment of water stress in the near future to assist the balancing act between different water uses and environmental protection.

Keywords: water balance, drought, extraction, water consumption, water stress

REGIONAL CALIBRATION OF A SPATIALLY DISTRIBUTED HYDROLOGICAL MODEL AT 1 KM RESOLUTION FOR THE WHOLE NORWAY

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ABSTRACT

A robust hydrological modeling at a fine spatial resolution is needed for the whole Norway to estimate and project hydrological components in the past and under future warming conditions. However, it requires detailed observational data and expensive computational resources. This work aims to set up the distributed HBV model with a physically based evapotranspiration (ET) scheme at 1 km resolution for the whole Norway and calibrate/validate it for over 120 catchments. The Penman-Monteith equation was implemented in the HBV model and the vegetation characteristics were derived from the Norwegian forest inventory combined with multi-source remote sensing data at 16 m spatial resolution . The whole country was reclassified into 5 climatic zones based on 4 temperature and precipitation indices. For each zone, the model was calibrated independly by optimizing a multi-objective function including the Nash-Sutcliff efficiency and volume error of selected catchments. In total, there are 85 catchments for calibration and 39 for validation. The estimated ET for the whole country is comparable with the outputs of the Global Land Evaporation Amsterdam Model (GLEAM) for the period 2000 - 2010. The model shows good performance and transferability for simulated river discharge, with median daily NSE of 0.64 and 0.70, and median volume error of −1% and -3% in the calibration and validation catchments.

Keywords: Regional calibration; Norway; HBV; High resolution

DILUTION OF SALINE WATER BASED ON PLANT'S PHYSIOGICAL AND ELECTROPHYSIOLOGICAL CHARACTERISTICS

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ABSTRACT

Salinity and water scarcity are major environmental problems which are limiting the agricultural production. This research was conducted to construct a model to find out appropriate regime to dilute saline water based on physiological and electrophysiological properties of *Brassica napus L*., and *Orychophragmus violaceus (L.)*. Plants were treated under salt stressed concentration of NaCl (NL_1: 2.5, NL_2: 5, NL_3: 10; g L-1); Na_2SO_4 (NO_1: 2.5, NO_2: 5, NO_3: 10; g L-1) and mixed salt concentration (MX_1: NL_1+ NO_3; MX_2: NL_3+ NO_1; MX_3: NL_2+ NO_2; g L-1) and 0 as control, followed by re-watering. Growth, physiological and electrophysiology traits were highly restricted under high salt concentration levels at NL_3, NO_3, MX_1 and MX_2, respectively. However, during rewatering phase, growth, electrophysiological and physiological parameters were recovered well. Consequently, the increase in net photosynthetic rate was noted under moderate stress condition which was 44.13, 37.07, and 43.01%, respectively in *Orychophragmus violaceus (L.)* and 44.94%, 53.45% and 63.04%, respectively were found in *Brassica napus* L. According to the results, the best dilution point was 5–2.5% for NaCl and Na_2SO_4 alternatively, whereas it was 10–0.0% for mixture of salts. Therefore, the effect of salinity in *O. violaceus* and *B. napus* may also be reduced effectively by dilution of saline irrigation. It would be a better approach to utilize dilute saline water for irrigation instead of applies direct saline water to plant. This study provides new insight in the field of agricultural engineering to plan irrigation scheduling considering the crop ability to salt tolerance and irrigation water use efficiency by apply specific quantity of irrigation calculated based on the salt dilution point. It would be helpful to balance between irrigation amount and optimum crop water consumption in salt affected regions and to utilize saline water in order to safe fresh water resources.

Keywords: dilution model; plant growth traits; leaf tensity; net photosynthetic rate; physiological capacitance; re-watering; salt stress

CLIMATE CHANGE RISK ASSESSMENT FOR HYDROPOWER: EXPERIENCE FROM THE NENSKRA PROJECT IN GEORGIA

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ABSTRACT

We have been involved in the preparation of the Climate Change Risk Assessment (CCRA) for the proposed Nenskra hydro-power plant (280 MW) in Georgia which will be built on the Nenskra River (a tributary of the Enguri river). The project consists of an 870-m long asphalt Face Rockfill Dam which will impound a reservoir covering an area of 2.7 km^2. Additional water will be diverted into the reservoir and hydropower plant through two secondary intake structures, from river Nakra and another small tributary.

The process for the CCRA consists of the establishment of the methodology for the CCRA, a high-level screening of risks, preparation of climate data md relevant impact assessment models, Detailed Climate Risk assessment and Risk management.

The CCRA is restricted to establishing how changes in climatic variables will affect the project and identifies ways in which the project can cope. Potential changes and resulting impacts include changes in the water balance and inflow to the power system, sedimentation, glaciers among others. There may also be changes in frequency, magnitude and spatial distribution of other natural hazards. Changes may affect energy production (amount, seasonality, security of supply), reservoir storage, floods and dam safety and eventually the project economy.

We have been involved in establishing a framework for the study by harmonizing guidelines from different entities and experience from research and case studies that have dealt with studying the climate risk associated with some hydropower projects in different parts of the world. We describe the methodology, models and procedures used/to be used on the project. We have prepared climate change ensembles and calibrated a hydrological model that can be used to model the water balance and components of the hydrological cycle such as snow melt and changes in glaciers.

Some preliminary results will be presented as this is a work in progress.

Keywords: Climate change; Risk assessment; Hydropower

GREEN ROOFS FOR STORMWATER MANAGEMENT IN NORDIC COUNTRIES

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ABSTRACT

Green roofs have in the last decades gained increasing interest as a blue-green stormwater solution that can contribute with multiple benefits to urban environments. The performance of the living infrastructure of a green roof is strongly dependent on the climate. Local performance estimates and design principles are important.

Field studies have been carried out in 4 different Norwegian locations representing a large variation in precipitation amounts, winter and summer temperatures. The results include data from 3-8 years of studies at 16 different small scale plots (8-15 m^2) representing different extensive green roof configuration (4-15 cm depths). Green roof performance with respect to retention (volume reduction) and detention (peak flow reduction and delay) of stormwater will be presented and discussed with respect to climatic conditions and green roof configurations.

Resilient stormwater management needs to be based on set of stormwater solutions to answer to the future cities complex challenges. The role of green roofs in such a treatment train will be discussed focusing on which challenges can be addressed with a green roof and which needs to be solved in combination with other stormwater solutions.

There is a need for performance estimates to be able to account for green roofs as a part of the stormwater treatment train and for design purposes. The performance of living infrastructure, like green roofs, will vary from event to event as a result of variations in prior weather conditions and vegetation development. However, these processes are quite complex while most engineers prefer more simplified and schematic design rules. Based on results from field studies and theoretical framework, a method to estimate performance and design extensive green roofs will be presented.

Keywords: Extensive green roofs; Cold climate; Stormwater management

THE CALIBRATION AND VALIDATION OF FOREST HYDROLOGICAL RESPONSE UNIT OF CONCEPTUAL HYDROLOGICAL MODEL METQ

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ABSTRACT

In Latvian forest science, studies on the interactions between forest and water ecosystems have always been important, and forest management impact on water quality has gained special attention of late. Forest felling, drainage system maintenance and forest road construction are among those forestry operations that alter the nutrient cycling and, if improperly conducted, may deteriorate water ecosystems. Scientifically sound information on the background levels of nutrient leaching and convenient and easy-to-use planning tools for forest managers are necessary to address this issue.

To enable assessment of the impact of forest management on a catchment scale, a conceptual hydrological model METQ, developed at Latvia University of Agriculture, was calibrated for use in forested catchments. The study area was located in the central part of Latvia, Veseta river drainage basin in experimental forests where the discharge is measured on a main ditch of the drainage system with V-notch weir since 1968. The size of the studied catchment is 91.8 ha, forest cover more than 90%.

Complete rows of field data, such as daily run-off, average temperature, amount of precipitation and relative humidity data from Skriveri meteorological station (~45 km distant) from 1981 to 1999 were used for the model calibration. The validation period was from 2000 till 2015. Confined aquifer discharge present in the study area was also included in the model.

The calibration and validation results of the forested catchment parameters were satisfactory and achieved the recommended limits NSE > 0.75; R2 > 0.75; RSR < 0.70 and PBIAS +/- 25 % for calibration and validation period. This paper gives recommendations for forested catchment parameter application for the conceptual hydrological model METQ.

Keywords: Conceptual hydrological model METQ; Forested catchment; Forest management; water quality

WATER QUALITY ASSESSMENT WITH SIMULTANEOUS SATELLITE IMAGERY IN BIN EL OUIDANE DAM (MOROCCO)

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ABSTRACT

Monitoring water quality in large dams is a necessity and obligation to protect this stored water against various forms of pollution. Unfortunately it is difficult to achieve given the large surface area of the dams, and the quantity of chemicals product needed to analyze several samples in a monthly manner. In this purpose, our study aims to determine the relation between water quality parameters and Sentinel imagery reflectance. The in situ sampling were carried out in Bin El Ouidane Dam (Azilal province) followed by physicochemical parameters analyzes in laboratory. These measurement results were compared with the pixels reflectance in each sampling location to investigate the correlation that can exist between bands and laboratory results. The regression and correlation results were significant between water temperature, electrical conductivity, chlorine, nitrate, phosphate, bicarbonate and sentinel 1, 2, 3 bands. This obtained correlation has been developed and transformed into predictive models describing the correlated water quality parameters throughout Bin El Ouidane Dam. These parameters generally vary during the sampling month (May) in allowable values with an average of 400µs/cm as electrical conductivity, 0.5 mg/L for nitrate, 75mg/L in Chlorine and 0.8mg/L for the phosphate. As a conclusion, this study constitutes the first made effort to use satellite imagery data to map water quality parameters in Moroccan dams and showed a great potential in term of prediction

Keywords: Water Quality; Sentinel imagery; Predictive models; Cartography.

EFFECT OF VEGETATION ON FLUVIAL SEDIMENT TRANSPORT AND DEPOSITION - COMPUTATIONAL AND EXPERIMENTAL MODELLING APPROACH

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ABSTRACT

Streams and floodplains provide important habitats for various aquatic and terrestrial species. These areas, however, are often subject to anthropogenic alterations such as clearing of vegetation or dredging, or they may experience excessive sedimentation or eutrophication due to, for example, agricultural activities in the catchment. Today, streamrestoration and environmentally sound channel management is increasingly taking place. These activities aim at, for example, returning the natural state of streamhabitats, protecting the streams from over-sedimentation or maintaining a desirable flow-vegetation- sedimentation interaction. For successful river management, it is essential to understand the fluvial, morphological and biological processes of the stream.

Vegetation has a major impact on the flow characteristics, sediment transport and deposition especially on small streams and floodplains. However, the interactions between flow and natural vegetation and their consequences on sediment processes are still poorly understood as direct field measurements are complicated to perform. Measuring disturbs the processes and the vegetation density may vary spatially and unpredictably. These processes can be computationally modelled time and cost efficiently. Presently, however, hydraulic models rely on simplified description of vegetation, resulting in uncertainties for scenarios with complex natural vegetation. In addition, reliable modelling requires measurement-based flow and sediment transport data.

In this study, we set up a 3D hydraulic model to predict sediment processes measured in experiments in a controlled indoor flume laboratory. In the experiments, detailed patterns of the flow and fine sediment transport and deposition are determined under different vegetative conditions representative of natural lowland channels. For the new experimental dataset, we assess the feasibility of the model and identify needs for further development of the modelling approach.

Keywords: Stream vegetation; Sedimentation; Computational fluid dynamics; Flume experiment

ESTIMATION OF SEDIMENT THICKNESS AND BEDROCK TOPOGRAPHY OF MAINLAND NORWAY

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ABSTRACT

Distribution of sediments and weathered rocks govern storage of water in the catchment. It is therefore of interest to explore the spatial distribution of sediments depth (D) and bedrock topography (B) in a hydrological context. The purpose was to model D and B as stochastic functions in space. To achieve this goal we explored relevant information in Quaternary maps (QM), digital elevation models (DEM), and a public well database. Even though public databases store large number of recordings, the estimation uncertainty of D and B may be significant. Thus, the uncertainties of D and B are equally important as their most likely values. In this study, we explore different geostatistical methods for modelling of the uncertainties. The challenge is to capitalize on secondary information derived from QM and DEM, to minimize and express the estimation uncertainty. If the results fulfil user-defined requirements for estimation uncertainties, the goal is to produce maps of the bedrock topography that covers a domain overlapping the sampling domain of the available databases, which in this case corresponds to mainland Norway. A common property of the explored methods is to minimize negative impact of preferential location of the observation points, which leads to clustering and bias in the empirical data material.

Keywords: Geostatistical modelling; Sediment thickness; Bedrock topography.

CHARACTERIZATION OF RAINFALL CAUSED FLOODS IN THE LATVIAN RIVER BASINS DURING THE AUTUMN-SUMMER PERIOD OF YEAR 2017

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ABSTRACT

The end of the august and autumn in year 2017 was rich with precipitation in Latvian river basins. Autumn (September – November) was the second wettest since observations. Water flow in several cases exceeded the norm. In many observation stations in period from August to November water levels were higher than in spring of 2017.

In the second decade of August in eastern part of Latvia amount of precipitation in 36 hours reached 50- 160 mm. In the August 24th in Rezekne observation station totally registered 123.1 mm, it is a new record for daily maximal precipitation amount in this station. After intensive rainfall water level raised rapidly in Daugava River and other rivers in this basin. Floodplains and lowest places in this region were flooded widely, but water levels with return period of 10 years was not exceeded. Highest water levels in August in Daugava River has been observed in year 1987.

This highly intense precipitation episode in Daugava River basin was a start of extremely wet autumn. In autumn periodically a rapid water level rise due to intense rainfall was recorded. In some cases intense precipitation zones crossed whole Latvia. Such intense was precipitation on 18th of September when water levels in whole Latvia started to rise rapidly. Episodes of intense precipitation in autumn were so often that soil became very wet, water levels after rainfalls lowered very slowly and situation with every next episode got worse. Due to intensive rainfalls in August and September three months before the end of the year in four observation stations observed precipitation already exceeded yearly norm. In the first part of October water levels again raised and in Irbe River reached highest observed maximal water level in October. High water levels and water flows were observed again in November. Such extremely wet autumn made unfavourable conditions for river freeze-up.

Keywords: Flash floods; Latvian river basins; Intense rainfall

A FINNISH INFRASTRUCTURE ON COLD CLIMATE HYDROLOGY- ECOLOGY INTERACTION STUDIES IN THE ARCTIC LAPLAND

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ABSTRACT

Arctic hydrology is essential to understand ecohydrological changes in seasonally snow covered catchments in the Boreal, sub-Arctic and Arctic. We present an overview of an interdisciplinary study on hydrological monitoring, ecohydrological process studies and advanced hydrological modelling at Pallas site in the Arctic Finland. The study supplements an ecosystem-atmosphere supersite with hydrological information crucial to understand many questions related to ecosystem functioning and the impact of global change on these processes. The research presents conceptual process understanding from established hydrological monitoring, a recently developed novel isotope hydrology experimental set-up, and an outlook on other ongoing and future work. Interactions between snow melt, runoff, and groundwater in different type of landscapes will be presented.

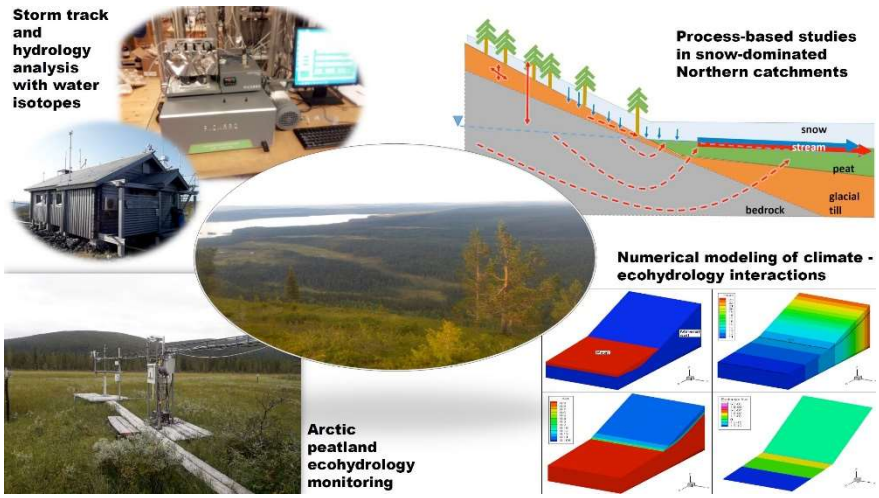

Fig.1 Pallas Arctic supersite.

HUMIC-RICH STREAM AND SHALLOW KARST AQUIFER INTERACTIONS ASSESSED FROM THE HYDROCHEMICAL EVIDENCE: THE CASE STUDY OF THE TUHALA KARST SYSTEM (N ESTONIA)

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ABSTRACT

Approximately 33% of consumed domestic groundwater in Estonia is abstracted from diverse shallow karst aquifers of the Silurian-Ordovician carbonate aquifer system. Mires are widespread on the karst aquifer outcrops of Northern Estonia forming the headwaters for numerous humic-rich streams. Our hypothesis was that such streams, frequently sinking into karst aquifers, could be a significant impact on the shallow groundwater quality. This study aimed to characterize the hydrochemical and hydrodynamic interactions of the humic-rich Tuhala River and the mantled Tuhala karst system hosted by the shallow Nabala-Rakvere aquifer, a locally important groundwater resource in Harju County, Northern Estonia. Hydrodynamics, specific conductance, major ion chemistry and humic substances were observed in a total of 16 surface- and groundwater monitoring points covering the study area throughout October 2016 – October 2017.The collected data was assessed by combining time-series analysis, multivariate statistics and end-member mixing model. Although, throughout the study period, all sampled waters were of the Ca-HCO_3 type, the mixing of of the humic-rich streamwater with the groundwater within the shallow aquifer could be determined during low, medium and high flow conditions by selected conservative and reactive natural tracers. The obtained evidence suggests a direct hydraulic connection and hydrochemical interaction between the humic-rich stream, the karst system and several dug and drilled wells screening the Nabala- Rakvere aquifer.

Keywords: Groundwater/surface water interactions; Karst aquifer; Natural tracers; End-member mixing model

CHANGES TO THE WATER BALANCE OVER A CENTURY OF URBAN DEVELOPMENT IN TWO NEIGHBOURHOODS: VANCOUVER, CANADA

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ABSTRACT

The objective of this study is to examine the long-term water balance of two suburban neighbourhoods in Vancouver, Canada, with particular emphasis on the effect of urbanization, densification and irrigation. The whole lifespan of these areas is studied starting from 1920 when the development of the areas started to 2010 when the areas were fully developed to modern suburban areas. The two neighbourhoods have different surface characteristics and development schemes which affect the hydrological processes. The simulations are made using Surface Urban Energy and Water Balance Scheme (SUEWS) with meteorological forcing data obtained from WATCH Forcing Data reanalysis product. Unlike previous studies of the effect of urbanization on the local hydrology, densification of already built lots are explored with a focus on the neighbourhood scale. Irrigation is the dominant factor of water balance, accounting for up to 56% of the water input on an annual basis in the study areas. This may surpass garden needs and partially go to surface runoff. Without irrigation, evaporation would have decreased over the 90 years at a rate of up to 1.4 mm $year^{-1}$ and runoff increased at 4.0 mm $year^{-1}$ with the increase in paved surfaces due to urbanization and densification. The results of this study can help us to understand better the effect of urbanization and densification on local hydrology and inform of the dominant factors in the suburban hydrological cycle.

Keywords: Urban hydrology; urbanization; SUEWS; WATCH Forcing Data

ASSESSMENT OF THE URBAN RUNOFF AND GROUNDWATER QUALITY IN THE RECREATIONAL AREA OF TORSHOVDALEN (OSLO, NORWAY)

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ABSTRACT

Oslo is one of many cities that is facing new challenges on handling urban runoff water. Recent climate trends have led to the increased occurrence of intense rainfall events. In urban settings, these events lead to the generation of large volumes of surface runoff in short time periods which demand innovative solutions in what regards stormwater management. Re-opening of rivers and streams previously laid into pipelines is one of such solutions. The Agency for Water and Sewerage works in the municipality of Oslo has created an interdisciplinary project with students from different academic disciplines, where the goal is to solve stormwater related problems and reduce the amount of stormwater going to treatments plants. Torshovbekken that runs along Torshovdalen, is part of a combined sewage system – the urban runoff water and the sewage are led into the same pipeline before processing at a sewage treatment plants. Separation of urban runoff water from the sewage collection system is the biggest challenge before re-opening of the Torshovbekken. This master thesis focuses on the water quality of the urban runoff, infiltration water and the groundwater in the Torshovbekken watershed. Since Torshovbekken is part of a combined sewage system, contamination of groundwater from sewage leakage might occur, and therefore, the biological and chemical oxygen demand (BOD and COD) will be measured in water samples. This data, together with the measurement of field parameters (e.g. pH, electrical conductivity), analysis of inorganic elements and fossil fuel-derived organic carbon, will help to discern natural patterns of water quality and anthropogenic inputs.

Keywords: Stormwater management; Water quality; Urban runoff; BOD and COD: Re-opening of streams

CONCEPTUAL CATCHMENT TYPOLOGY FOR ANALYZING EUTROPHICATION RISKS IN SURFACE WATERS IN DENMARK

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ABSTRACT

The systematic national monitoring of hydrology and water quality in Danish surface waters dates back to the late 1980'ies. A hydrological and water quality monitoring programme in smaller Danish catchments (micro-catchments being typically < 30 km2) was launched for agricultural catchments (>60% farmed) and undisturbed natural catchments (<10% farmed) covering a range of hydrogeological conditions. These micro-catchments form the water body response datasets related to physical conditions and water chemistry. In this initial attempt to develop a catchment typology we have used a national hydrological model (DK- model) to map four different hydrological regime types for a total of ca. 3,300 Danish micro-catchments. Thereafter, the water chemistry datasets from our agricultural and natural micro-catchments were classified into each of the four hydrological regime types and average nitrogen (N) and phosphorus (P) concentrations and loads for a recent five years period were calculated. Thereafter, the micro-catchment typology formed were statistically tested for differences in water chemistry including the different N and P forms. This presentation will shows the outcome of this catchment typology for Denmark, the area covered by each catchment type as well as examples of the temporal dynamic in nutrient concentration and the possible impact for eutrophication of each catchment type.

We thank Nordforsk for funding the analysis of this data under the BIOWATER Nordic Centre of Excellence project (https://biowater.info).

Keywords: Micro-catcments; Typology; Hydrogeology; Water Chemistry

YEAR 1900 RUNOFF IN DANISH STREAMS: IMPLICATIONS FOR NITROGEN LOADINGS AND REFERENCE CONDITIONS

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ABSTRACT

Data from 18 hydrometric stations with at least 80 years' of runoff data available and five climate stations with daily precipitation were analysed with the aim of estimating stream runoff conditions around year 1900 as part of achieving a knowledge on year 1900 nitrogen (N) loading estimates for the EU Water Framework Directive implementation in Danish coastal waters. A statistical Mann-Kendall test was applied to investigate the development in stream runoff and precipitation and to predict runoff around the year 1900 supported by a numerical rainfall-runoff model (NAM), set up and calibrated for three selected stations based on observed data of runoff, temperature and precipitation. A trend of increasing annual runoff was observed at all hydrometric stations over the past 80 years, with the most pronounced increase being ca. 165 mm (33%) in annual runoff supported by similar trends in annual precipitation. The statistical trend analyses of measured runoff estimated the runoff level in 1900 to have been 5 to 48% lower than at present. The hydrological model NAM estimated a 25 to 37% lower runoff around year 1900. Hence, despite the challenge of quantifying the exact uncertainty of the runoff estimates around year 1900, it is reasonable to conclude that year 1900 runoff was significantly lower than compared to present day conditions. The implications of these changes in runoff conditions for estimation of the reference N-loading to Danish coastal waters around year 1900 will be highlighted and discussed.

Keywords: Year 1900; Runoff; Nitrogen Load; Reference Conditions

ASSESSMENT OF HYDROLOGICAL PROCESSES AND NUTRIENT LOSSES IN AGRICULTURAL LANDSCAPE AS AFFECTED BY DRAINAGE SYSTEMS

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ABSTRACT

Artificial subsurface drainage systems and open ditches implemented in agricultural lands can be considered as the beginning of hydrographic network thus having a direct impact on flow conditions and water quality all the way downstream. In order to describe hydrological behavior and patterns of nutrient losses from agricultural lands several monitoring sites were established under the Agricultural Runoff Monitoring Programme in Latvia. This study presents monitoring results obtained at the Berze and Mellupite research sites where both sites consisted of subsurface drainage field and small catchment. Continuous flow measurements were carried out using hydraulic measurement structures, pressure transducers, and data loggers, while water samples were collected on a monthly basis as flow proportional composite samples. Water samples were analyzed for nitrate-nitrogen (NO3-N), ammonium-nitrogen (NH4-N), total nitrogen (TN), orthophosphate-phosphorus (PO4-P), and total phosphorus (TP) concentrations in accredited laboratories. Information on meteorological conditions was obtained from the on-site weather stations or if those malfunctioned from the nearest weather stations operated by the State Limited Liability Company" Latvian Environment, Geology and Meteorology Centre".

Long-term monitoring results (1995 – 2017) indicate a high variability in annual precipitation ranging from 469.4 to 827.1 mm and 472.8 to 1039.2 mm, for the Berze and Mellupite site, respectively. Consequently it had an effect on annual runoff at both scales of this study, e.g., annual runoff varied between 56.6 and 331.8 mm and 136.5 and 375.9 mm, at the subsurface drainage field scale for the Berze and Mellupite site, respectively. As precipitation is not evenly distributed throughout the year, it results in high runoff contribution after the growing season, during this period of the year also nutrient losses are the highest. In September of 2017, heavy precipitation caused flooding conditions across the territory of Latvia. Flooding conditions were also observed at the small catchment of the Mellupite research site resulting in the highest discharge recorded since the beginning of the monitoring period where the peak discharge was exceeded almost two times.

Keywords: Agricultural drainage: Runoff; Long-term and seasonal distribution; Flood occurrence; Nutrient losses

CHALLENGING THE STATIC PREDICTION OF TIME TO PEAK

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ABSTRACT

In modelling peak flows, understanding and characterizing the hydrologic response to rainfall events is vitally important. One of the parameters utilized to characterize the catchment response time is the Time to Peak (Tp), which encompasses the time from the start of a rainfall event to the time peak flow (Qp) is reached. Previous works into understanding the influencing factors of Tp have been static in nature— dependent upon either catchment characteristics or storm size, with no consideration into the variability in Tp between storms or seasons. For this study, an extensive set of data was compiled including nearly 1600 storms and the corresponding catchment characteristics of 171 stream gauges across the UK. These data points span three decades and this breadth of temporal data allowed meaningful annual trends to be observed. Analyses were completed using traditional means as well as machine learning utilizing artificial neural networks (ANN). These analyses demonstrate seasonal effects upon the significance of key catchment variables. Further trends were observed, demonstrating a strong negative correlation between Tp when normalized by catchment length and slope, storm Qp. These trends demonstrate that Tp is dependent upon not only static catchment characteristics, but also the magnitude of the storm as well as the period of occurrence. This study analyzed an extensive set of storms spanning three decades and the entirety of the UK, to further understand the dynamic nature of Tp. Trends in this data demonstrated a correlation with Qp, allowing the size of the storm to be accounted for, and with SMD demonstrating seasonal variations in prediction of Tp.

Keywords: Artificial neural networks, Catchment response time; Time to peak; Peak discharge; United Kingdom; Hydrology; Hydrological modelling

WATER BALANCE OF A NORDIC URBAN CATCHMENT BY MIKE URBAN

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ABSTRACT

Over 50% of the world's population are living in urban areas and more and more people will move to urban areas. Oslo, the capital city of Norway, expects to grow by 20% by 2030 according to Statistics Norway. At the same time, water security in urban areas is an emerging research topic in recent years due to more frequent water related hazards. For example, Oslo has experienced several severe hazards in the recent past years and more areas are becoming more vulnerable and exposed to high potential risks because intensive rainfall and warmer climate in the future. The Urban hydrological system is very complex due to interaction with the sewer system and human dominated changes on the land surface. Here we build an urban hydrological modelling system by employing Mike Urban, which is a global-wide used urban hydrological model. This modelling system is tested on a typical Nordic suburban hydrological catchment, Grefsen-Kjelsås in Oslo. We will study water balance in this catchment, and evaluate impacts of land surface changes as well as test different Low Impact Development (LID) techniques. In addition to the scientific merits, this study will also contribute to an ongoing project in the Grefsen Kjelsås area.

Keywords: MIKE Urban; Norway; Urban hydrology; Water balance; LID

HYDROLOGICAL SIMULATION IN A GLACIERISED AREA WITHOUT SUFFICIENT DATA

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ABSTRACT

Glaciers in Norway are an important source of streamflow that can have major impacts on both natural hazards (floods) and water resources available for hydropower production. Both are very important to security and development of society. However, there is not a suitable glacier model for Norwegian glaciers and for integration with hydrological models. In this study, we test an empirical glacier model to account glacier dynamics and its parameters under the framework of the HBV model. Additionally, we drive two model settings, i.e. with glacier dynamics routine and without glacier dynamics routine with two version of meteorological data, SeNorge 1.1 and SeNorge 2.1 for the present climate as well as projections of the future climate. We examine the differences in the hydrological simulations caused by driving data, parameter calibration and model structures. The results provide insights of the sources of uncertainties in hydrological simulations and the magnitude of uncertainties.

Keywords: HBV; Glacier; Data scarcity; Uncertainty

ASSESSMENT OF THE REGIONAL FUTURE PROJECTIONS OF FLOOD IN NORWAY BY PALEOCLIMATE DATA

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ABSTRACT

The reliable estimation of extreme flood events is important for the design and operation of infrastructure, flood risk management, and planning. The flood frequency estimation guidelines from different European countries showed that the value of historical data is generally recognized, but practical methods for including this data into risk analysis are most likely not available. Recently, there are studies for improving the reliability of the current flood risk assessments by harvesting the information on past extreme events contained in the historical data sets. A combination of stream gauge, historical, and paleoflood records was used to extend extreme flood records which has proven to be useful in improving flood frequency analysis. In the study, we attempt to use the paleoclimate and paleoflood data, which provide the viable ranges of flood intensity in the study watersheds of Norway, to qualitatively constrain/evaluate the future projection from a high-resolution regional climate model, i.e. Weather Research and Forecasting modeling system (WRF). The historic and future changes (1900-2100) in regional flood probabilities based on GCM data (i.e. NorESM) will be estimated. In general, a method of qualitative assessment of the realism of regional future projections of floods in Norway will be conducted in the study.

Keywords: Paleoflood records; Regional climate model; Regional flood; Future flood projection

FLOOD RISK MAPS OF ESTONIAN INLAND WATER BODIES

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ABSTRACT

Report according to the Floods Directive (i.e. Directive 2007/60/EC) was completed in Estonia in 2016. Output of this work fulfilled the Directive targets to assess the flooding risks of inland and coastal water bodies and to visualise the flood extents on corresponding digital maps. Flood maps were created for the nine extreme event scenarios, with probability exceedance once per 2, 5, 10, 25, 50, 100, 200, 500 and 1000 years.

GIS analysis was performed in ESRI *ArcMap10.2.2* and *ArcHydro* modelling environments based on monthly absolute maximum water level values recorded within the state hydrological network. Altogether 800 hydrological flood risk map layers were created using data from 152 gauging stations. From the used data sets 30% belonged to the monitoring stations with observation period longer than 50 years, 25% belonged to the period between 25 and 50 years, 30% between 10 and 25 years, and 15% between 4 and 10 years. Flood extents on the ground were visualised on corresponding raster layers for most of Estonian major rivers and lakes. A simple probability exceedance equation of maximum values was used for the initial estimates and statistical software *JMP Pro 12.1* for analyses of data probability distributions.

Before completion of the report, the existing flood risk maps covered only a small fraction of Estonian area, i.e. territory of some major cities only, located in the coast of the Baltic Sea. The flood estimation tool, developed by us, is simple, allows to model and visualise both the flood extents and depths for different types of landscapes with inland streams and lakes, but it depends on the availability of hydrological data and the quality of digital elevation models.

Keywords: Flood risks modelling; GIS flood mapping; Statistical flood risk prediction; Floods Directive

SEASONAL RIVER DYNAMICS IN CHANGING COLD ENVIRONMENTS

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ABSTRACT

Freezing temperatures and the presence of ice cover during winter alter flow and sediment transport, which affect hydropower production, flood mitigation procedures, inland water navigation, water engineering and the ecological state of the rivers. The cold river environments are especially sensitive to climatic change impacts, as shortened frozen period and increased winter flooding have been forecast. At the same time, the seasonal sediment transport, and the risk for faster erosion of banks and sedimentation of estuaries increase. Seasonal data would be needed to enable the enhancement of sustainable planning of river environments. However, seasonal data is scarce, which id due to the lack of suitable methods. Therefore, development and testing of field measurement approaches in different type of river environments is necessary.

In this study, we develop the field measurement approaches, and by applying them and by analyzing the measurement results, the understanding of seasonal, in particular wintertime, river dynamics is increased in changing cold environment rivers. The study sites differ from each other especially regarding their hydro- climatological characteristics during winters, and their forecasts of future climatic change impacts. The detailed aims are: 1) to study the impacts of seasonal hydro-climatological variation on annual total sediment transport (bed, suspended and dissolved transport) and on the changes in risks of sedimentation and flooding by applying the enhanced observation methods; 2) to determine the source areas of the total sediment transport and their driving processes by applying new remote sensing methods. More precisely, the morphological changes of the channel (including banks) are determined, in addition to the seasonal and spatial variation of the driving processes, and the interlinkages between these processes. These processes include flowing water, river ice, geotechnical characteristics, ground water impact and sub-aerial conditions. The preliminary results are presented.

Keywords: Ice-covered flow; Seasonal processes; Total sediment transport; Morphological changes; Field measurement methods; Remote sensing; Process interactions

QUANTIFYING THE FLOW PATHWAY FEATURES IN FORESTS OF A ROCKY MOUNTAIN USING MULTI-TRACER

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ABSTRACT

Preferential pathways are crucial channels for water and solute infiltration. To better investigate the features of flow pathways in forest soils, multi-tracer (Brilliant Blue and NaBr) experiments were conducted in pure forests dominated by *Quercus variabilis BI.*, and *Platycladus orientalis (L.) Franco*., respectively. Additionally, the total infiltration depth of 40 mm was selected. In the soil layer of 0–30 cm, both tracers were mainly accumulated in the soil layer of 0–20 cm, where roots abundant. The spread area of Br^- was wider and deeper than that of BB. In the preferential pathways, the content of both tracers with a weak separation was larger than that in the surrounding soil matrix. In conclusion, our results indicated that larger part of solute is transported along macropore pathways formed by roots in forest ecosystem.

Keywords: Type of preferential pathways; Tracer experiment; Brilliant Blue; NaBr; Forest; Roots

MAP SERVICES FROM NVE

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ABSTRACT

The presentation will give an introduction to NVE's useful web map services related to hydrology and water issues. The Map Catalogue from NVE (Kartkatalog fra NVE, *kartkatalog.nve.no*), ensures easy access to the maps services, including access to geodata and map tools. All map services and map tool in the Map Catalogue are public. At NVE the use of geographic information systems (GIS) has played and important role since 1991 when developing, maintaining and sharing the national hydrological datasets and map services. GIS has also been used frequently for doing analyses related to water and hydrology. Examples of map tools, which will be presented, are NEVINA and xGeo. NEVINA, *nevina.nve.no,* is an interactive map tool automatically calculating catchments, field and climatic parameters and flow indexes for a freely chosen point along the waterway. xGeo.no is an expert map tool used for preparedness, monitoring and forecasting of floods, avalanches and landslides. Using maps and date for navigation a huge number of gridded datasets are made available. xGeo contains hydrological data from 1957 and one week ahead. The national water system databases, and access to Norwegian geodata from Geonorge.no, will be presented in brief.

Keywords: Map service; Map tool; Geodata; NEVINA; xGeo; Geonorge

ANALYSIS OF STATUS AND TRENDS IN SHORT TERM FLOW REGULATION IN NORDIC RIVERS

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ABSTRACT

With EU's aim of reaching up to 20% of total energy consumption by renewable sources, hydropower will have a significant role in Europe's future energy market. Increasing demand for adjustment energy might have also effect on hydropeaking conditions on regulated rivers. In this study, we quantified and compared with the effects of hydropower type and catchment properties on short term flow conditions across multiple Nordic rivers. Multiple years hourly discharge data from 150 gauging stations or hydropower dams on major pristine and regulated rivers spread across all of Norway, Sweden and Finland was used. For the analysis indices developed by Carolli et al., (2015) and hydropeaking (HP1) and ramping rates (HP2) were used to quantify hydropeaking across all the studied stations. Rivers with run-of-the-river (ROR) type hydropower showed higher hydropeaking values during summer and autumn, whereas, rivers with combination of dams and tunnel based power plants (sites in Norway) had higher hydropeaking values during spring and autumn. An analyses of aggregated monthly power production (for Finland only) since 2007 and its relationship with aggregated hydropeaking values, revealed that HP1 and HP2 have higher values for months with less power production and lower for months with high power production. According to this analysis, there is an increase in hydropeaking in Nordic rivers over the period of last two decades, which might have resulted from the use of hydropower as an adjustment source of energy. Thus, there is a clear need for optimization of hydropower operations in the Nordic countries in terms of local hydropeaking and environmental flow conditions.

Keywords: Hydropower; Hydropeaking; Regulation; Nordic rivers

HOW WELL CAN WE MODEL CHANGES IN THE INDICATORS OF HYDROLOGICAL ALTERATION?

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ABSTRACT

The indicators of hydrological alteration (IHA) describe different ecologically relevant properties: the magnitude of the monthly flows, the magnitude of annual extremes, the frequency and duration of low and high pulses, the timing of extreme events and the rate and frequency of changes. As there are numerous hydrological indices, the hydrological models are often not calibrated for each index individually, but instead the model is optimized once using, for instance, the Nash-Sutcliffe Efficiency or the Mean Absolute Error as objective function.

The objectives of the present study are to: (1) Estimate the differences between the IHAs modelled with a model calibrated using the Nash-Sutcliffe efficiency as an objective function and a model calibrated to each IHA individually and (2) Estimate the impact of the different calibration approaches for the estimated changes in IHAs.

The main part of the study is carried out for 574 catchments in the U.S. using a lumped conceptual hydrological model. A distributed model is applied to a subset of 5 catchments for investigating the impact this has on the modelled IHAs.

The results show that there are important differences in the abilities of the hydrological models for reproducing the IHAs depending on the applied calibration strategy. Possible approaches for improving the quality of the modelled IHAs obtained with models calibrated using the Nash-Sutcliffe coefficient are discussed.

Keywords: Indicators of hydrological alteration; IHA; Rainfall-runoff model; Calibration

THE PERCEPTION OF CATASTROPHIC FLOODS IN THE EASTERN EUROPE: A CASE OF THE NEMUNAS RIVER BASIN

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ABSTRACT

The Nemunas River basin falls within the territories of five different countries – Belarus, Lithuania, Russia, Poland and Latvia. The basin area is 98200 km² and the average discharge is 504 m^3/s. In this basin, the beginning of spring flood highly depends on rapid rise of air temperature, heavy precipitation and sudden snow melting. Extremes of mentioned factors influence the formation of catastrophic floods, which cause damages and create huge economic losses. In this study, the conditions of formation and consequences of two catastrophic floods in 1958 and 1979 in the Nemunas River basin were studied in more detail. The flood of 1958 affected large territories, which cover three countries and reached a historical peak discharge (6580 m3/s at Smalininkai WGS (water gauging station) in Lithuania). The flood peak in 1979 reached 5300 m3/s (at Neman WGS in Russia) and also made a lot of damages. Estimations of the hydrometeorological parameters (maximum snow water equivalent, precipitation during the flood, volume of flood, volume of water resources in the basin) as well as runoff coefficients were performed for the selected catastrophic floods. The differences between the main drivers and formation of two analysed floods were identified. From the outcome of this study, it is possible to conclude that the spatial distribution of maximum snow water equivalent (before the beginning of flood) and precipitation (during the flood) as well as runoff coefficient in different parts of the Nemunas River basin had a significant impact on the formation of the studied catastrophic floods.

Keywords: Nemunas River; Catastrophic flood; Snow water equivalent; Flood volume; Runoff coefficient

CONTROLLING FACTORS OF WATER STORAGE AND RUNOFF IN BOREAL HEADWATERS

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ABSTRACT

Water stored in catchments controls the runoff generation in headwater systems and maintains their high biodiversity through sustaining baseflow. However, the role of climate, snow and catchment characteristics on storage and low flows in boreal regions are poorly understood. In this study, we calculated catchment storage, and storage sensitivity of streamflow, from hydrograph analysis for 61 boreal headwater catchments along the climate and geographical gradient found in Finland, exposing the variability of storage properties in the region. We further explored the connection between the computed storage indices and low flow conditions in summer and winter periods. The calculated storage properties were used to identify their controlling factors in selected climate, snow and catchment characteristics in order to assess the relative importance of different factors that make the catchments vulnerable to climate and environmental change. We found that the most sensitive areas to these changes were located in the south boreal coastal zone with fine grained soils, agricultural areas and snow to precipitation (S/P) ratio below 0.3, while in the forested mid- and north-boreal zone with till and peatland soils and higher S/P ratio the catchments were less sensitive. In addition, we found a threshold at S/P ratio of 0.35, which suggests that above this zone, the climate and snow dominate the hydrologic processes related to summer low-flows, and below this ratio the catchment characteristics are more important. The relationship was present in the summer, but not in the winter low flows. These findings suggest that in warming climate the changes in the hydrologic processes will be pronounced at certain S/P ratio border zones, highlighting the strong connectivity between snow and ecologically important summer low-flows. Moreover, the impact of anthropogenic pressures on storage properties was shown in agricultural areas and drained peatlands, which had negative effect on low-flows.

Keywords: Catchment storage; Low flow; Snow; Headwater; Sensitivity; Boreal

AQUIFER VULNERABILITY IN PARTS OF YENAGOA, SOUTHERN NIGER DELTA, NIGERIA

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ABSTRACT

This study on aquifer vulnerability assessment in certain parts ofYenagoa, Bayelsa State, Southern Niger Delta, Nigeria, adopted the use ofDRASTIC method based on geographic information system (GIS) model to delineate areas susceptible to contamination. Seven hydrogeologic parameters were applied for the aquifer vulnerability evaluations which include depth to water table, net recharge, soil media, impact to vadoze zone, aquifer media, topography, and hydraulic conductivity. Data relating to the seven hydrogeologic parameters of the model were obtained and transformed in the model into seven maps by GIS to develop the DRASTIC vulnerability map which shows the three different forms of aquifer vulnerability namely high, moderate, and low zones. The communities within the high vulnerable zones include Swali, Agudama, Ovum, Igbogene, Okutukutu, Onopa and Okolobiri. Those within the moderate vulnerability zones are Kpansia, Etegwe, Yenezue, Azikoro, Opolo, Tombia, Biogbolo and Akenfa and in the low vulnerability zones, we have Amarata, Yenezuegene, Edepie, Azikoro, Akenfa and Okaka. The high vulnerability zones ranking was attributed to very high depth to water table, high net recharge, high hydraulic conductivity and permeability of gravelly sand in the aquifer media. The moderate vulnerability zones were due to high net recharge, low porosity of silt/clay in vadoze zone, siltyloam in soil media and high hydraulic conductivity. The low vulnerable zones were influenced by impermeability of clayloam in the soil media, low porosity of siltyclay in the vadoze zone and low topographic slope percent.

Keywords: Aquifer; Vulnerability; DRASTIC; GIS

INFLUENCE OF ANTHROPOGENIC LAND COVER CHANGES IN NORWAY ON LOCAL TO REGIONAL PRECIPITATION

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ABSTRACT

Changing land cover from open landscapes to forestry is gaining traction as a viable government led action in Europe to reduce atmospheric CO_2. In fact, pilot afforestation programs have already begun in parts of Norway. However, the impact of these anthropogenic changes to land cover on the regional climate is poorly understood, particularly at high latitudes. It is possible that such changes to the land cover could counteract the original intentions of the afforestation policy. For example, a study by de Noblet-Decoudre *et al.* (2012) has shown that impacts from land cover change on the regional climate can be as important as greenhouse gas forcings. This study examines the impact of land cover changes for afforestation purposes on the hydrological cycle at local and regional scales. ERA-Interim reanalysis data is downscaled to 3 km from the period 1996-2005 over Norway using the Weather Research and Forecasting (WRF) model. Two high-resolution 10-year regional climate simulations are performed which differ by land cover. The first simulation (CTRL) represents the land use and land cover of present day Norway while the second applies the estimated land cover changes described in the Norwegian government's policy on afforestation. Comparisons between these simulations show the impact of land cover changes on the hydrological cycle due to afforestation.

Keywords: Precipitation extremes; Land cover changes; Afforestation; Hydrological cycle.

References:
de Noblet-Ducoudré et al. 2012. *J. Climate* 25:3261-3281.

ASSESSING THE IMPACTS OF CLIMATE CHANGE ON AN URBAN DRAINAGE SYSTEM IN TRONDHEIM, NORWAY

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ABSTRACT

In recent years, climate change has lead to an increasing number of high intensity rain events causing flooding in urban areas around the world. Studies of different future climate scenarios indicate that this increase will continue both in intensity and frequency. In Trondheim municipality in Norway, many parts of the urban drainage network have insufficient capacity to meet the anticipated increase in runoff. To date, there exists no long-term climate projections for Trondheim of the high temporal resolution needed in assessing future requirements to the hydraulic capacity of the drainage system. The development of methodologies that cope with this is therefor necessary in order to give a better basis for planning and dimensioning of the urban drainage system.

In this study, temporal downscaling of existing climate projections using the scaling concept and the GEV distribution will be conducted. Observed precipitation data from the Risvollan measuring station and daily local projections spatially downscaled from Global Circulation models (GCMs) will be used. The methods applicability to propagate IDF curves will be considered as it is essential in the planning and dimensioning of urban drainage systems. The method will be tested for the Lerkendal catchment in Trondheim using the MIKE Urban model to assess the future hydraulic capacity. Lerkendal catchment is an urban multi land use catchment with a combined sewer system and a high degree of clay deposits. Applying this method will enable municipalities to better target existing and potential hydraulic bottlenecks in the sewer system.

Keywords: Climate change; Temporal downscaling; GEV-distribution; IDF-curves; Urban drainage; Hydraulic Capacity

DOWNSCALING AND BIAS-CORRECTING CLIMATE AND HYDROLOGICAL PROJECTIONS FOR SVALBARD

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ABSTRACT

Projected climate variables from global climate models (GCMs) are too coarse-scaled to be applied for impact studies. Further, GCMs are imperfect and may have biases. Methods to downscale and bias-correct GCM output are used to alleviate these problems. Here, we describe how temperature and precipitation data from an ensemble of Arctic-CORDEX projections are downscaled and bias-corrected for the period 1971— 2100. After re-gridding to 1×1 km, the data are bias-corrected through empirical quantile mapping, using downscaled reanalysis data as "observed data". The resulting bias-corrected and downscaled data are further used to force the hydrological model HBV to produce gridded runoff, snow water equivalent, soil moisture and other hydrological variables. Until now, no dataset of gridded hydrological variables exists for Svalbard, and gridded datasets for climate variables exist only for the historic period. Limited access to observations make up the main challenge for climate projections at Svalbard. No more than 15 temperature stations, nine precipitation stations, and two active runoff stations are available for an area of ≈ 60 000 km^2 (corresponding to one third of South Norway). Thus, bias-correction and downscaling exercises for Svalbard rely on reanalysis datasets, which have already been downscaled for the historical period.

Keywords: Svalbard; Downscaling; Bias-correction; Temperature; Precipitation; Hydrological variables

INVESTIGATING HYDROGEOLOGIC CONTROLS ON GROUNDWATER DROUGHT HAZARD IN SWEDEN AND FINLAND

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ABSTRACT

Understanding droughts has historically been given low priority in Sweden and Finland, countries of high water abundancy. However, according to the drought monitor of the Joint Research Centre (EDO, http://edo.jrc.ec.europa.eu/), large parts of Scandinavia have since the beginning of 2015 continuously been classified with medium to high risk of being impacted by drought. By summer 2017, groundwater drought was evident in large parts of Sweden according to the Swedish Geological Survey (SGU). Societal impacts included restrictions on water consumption, irrigation bans, and private wells running dry in certain regions. In Finland, the response of groundwater systems differ with the last major groundwater drought occurring in 2003 (based on the Finnish Environmental Institute's (SYKE's) monitoring network). This resulted in cautiousness regarding water usage. The propagation of dry periods, from precipitation deficit to groundwater drought, as well as their severity and persistence, is poorly understood for Swedish and Finnish hydro(geo)logical systems. Therefore, we investigate historical and geographical patterns of periods with low water tables. While geological conditions are similar among the countries, patterns of drought events vary between Sweden and Finland due to differences in regional climate. In a comparative study, we investigate the propagation of drought with the indices SGI (Standardized Groundwater Index) and SPI/SMRI (Standardized Precipitation Index/Standardized Snow Melt and Rain Index) in different Swedish and Finnish hydrogeological settings. Further, we explain propagation based on system characteristics using decision tree learning. By determining significant controls, such as aquifer properties and dimensions, we provide a guideline for the precipitation signal to serve as a proxy for groundwater levels. This proxy can subsequently be used for an improved understanding of impending drought hazards in gauged and ungauged aquifers.

Keywords: Groundwater; Drought analysis; Hydrogeologic controls; Sweden; Finland

NEW REGIONAL SHORT-DURATION RAINFALL STATISTICS FOR SWEDEN

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ABSTRACT

Short-duration rainfall statistics for Sweden has been based on a relatively limited amount of observations. For example, one of the main data bases used comprises 10-15 years of data from 15 municipal stations with most of them located in the southern part of the country. This has limited the possibility to discern regional differences and also to estimate intensities associated with return periods > ~10 years. In this work, we used ~20 years of 15-min observations from ~130 stations in the national meteorological network to produce new national statistics. Initially, we made a cluster analysis to identify homogeneous regions in Sweden, with respect to the extreme short-duration rainfall statistics. This analysis lead to a division into four regions: south-western, south-eastern, central and northern Sweden. In each region, observations were then merged into long regional time series, following the classical station- year method. Supporting analyses were performed to make sure that extremes from different stations within each region could be considered independent realizations of the same rainfall climate. The final statistics comprise regional values valid up to at least 100 years' return period and with quantified uncertainty. In southern Sweden, the new statistics agree overall well with previous national statistics, but in central and northern Sweden the new statistics have lower intensities for the corresponding combination of duration and return period. The new regional statistics agree overall well with statistics in our neighbouring countries.

Keywords: Extreme rainfall; Intensity-duration-frequency; Regionalization

PLANNING GREEN INFRASTRUCTURE IN URBAN AREAS WITH THE TANGIBLE LANDSCAPE

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ABSTRACT

A tangible landscape (TL) is a tangible user interface (TUI) that enables geospatial modeling and visualization via direct manipulation of physical malleable models. By combining physical malleable models with Geographical Information Systems, TL allows the exploration, analysis and synthesis of specific spatial problems in precise, systematic, transparent and quantified manner and in near-real time.

Green infrastructure (GI) consists of modifications of the landscape to manage wet weather impact on urban landscapes. These modifications involves the creation of swales, rain gardens and retention ponds, among the possible solutions. Placing GI in the landscape, requires therefore a good understanding of the dynamic and complexity of surface water flow in urban enviroments, and how changes in this urban fabric affects the flow pattern of the surface water. It necessitates also a high degree of flexibility to account for different urban configurations that, occurs as a function of landuse changes overtime.

The tangible landscape technology (TLT) addresses these necessities by allowing simulating and comparing of different scenarios and possible models with each other, in a near-real time.

At the Norwegian Water Resources and Energy Directorate (NVE), TLT served as a testbed for green infrastructure solutions. For this purpose, the SIMulate Water Erosion model (SIMWE) was implemented in the tangible lanscape (TL) and tested in a hands-on workshop in collaboration with the Oslo Architecture School (AHO).

HIGH-RESOLUTION HYDROLOGICAL PREDICTION IN URBANIZED AREAS

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ABSTRACT

Traditionally, hydrological modelling and forecasting has focused on predominantly rural river basins, relatively large in size (~hundreds of km²) with relatively slow hydrological response. This focus has partly been goverened by limitations in the resolution of both forcing data and geographical data. Generally, a daily time step has been used with sub-basins sized some tens of km². Recent advances, however, have made it possible to perform multi-basin hydrological modelling at higher spatial and temporal resolution. These advances include both improved high-resolution forcing data, notably precipitation observations by weather radar, and improved high-resolution land-use data for basin characterization. In many regions it is today possible to set up and run hydrological models with single- km²-sized sub-basins and an hourly modelling time step, and sometimes even higher resolutions. This makes the models more applicable in fast-responding basins, e.g. basins with a significant fraction of urban environment, and potentially useful for urban flood simulation and forecasting. In this work, we have set up and calibrated the HYPE model for hourly simulation of discharge in catchments with a significant fraction of urban land-use in Sweden, Denmark and Finland. The results are mixed, which is expected in light of e.g. the difficulty of providing accurate high-resolution focing data as well as the absence of hydro-dynamics in HYPE, but in some basins the performance is good. Future development will be discussed, including the possibility to couple hydrological and hydro-dynamic models for improved urban flood risk prediction.

Keywords: Urban flooding; Forecasting; Extreme rainfall

WATER TEMPERATURE MODELLING OF SMALL HIGH ARCTIC STREAM (FUGLEBEKKEN, SW SPITSBERGEN)

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ABSTRACT

The water temperature is the main variable affecting physical, chemical, biological properties, and processes in ecosystems. Thermal regimes in rivers and streams are expected to change in responsible sensitive to climate change, especially in the highly vulnerable Arctic.

The study focuses on the understanding of main processes/drivers shaping stream thermal regime and its dynamics in of a small high Arctic stream. The study site - unglaciated Fuglebekken catchment - is located next to the Polish Polar Station Hornsund in SW Spitsbergen. The stream flow in Fuglebekken has a seasonal character and is influenced by the variability of the thermal-radiation factors (atmospheric influence) together with snow water and groundwater sources. Thermal regimes in streams reflect the balance of numerous physical processes that cause heating or cooling with short- (e.g., hourly, daily) or long-term (e.g., annual, decadal) temperature trends due simply to changes in the relative importance of these processes through time. Results of water temperature measurements conducted during multiple ablation seasons are characterized by large variation throughout ablation seasons. In late autumn water freezes up and remains frozen during winter and spring.

On basis of available hydro-meteorological observations both physical and data-based models (air2stream, StreamFlow, stochastic transfer function, two Mohseni et al.-based procedures) few models are developed and applied to explain water temperature variability over time. Comparisons among simulations obtained by different models should help us understanding the major sources of stream temperature variability in this specific catchment. Finding the best models is important for the further research. In the second step the calibrated models are planned to be applied for the simulation of future climatic conditions projected with the help of high resolution climate simulations available from Polar- CORDEX. Description and attribution of stream temperature changes are key to understanding how these ecosystems may be affected by climate change.

The financial support for this work has been provided by the Polish National Science Centre through grant No. 2016/21/B/ST10/02516. This work was also partially supported by the Institute of Geophysics, Polish Academy of Sciences within statutory activities No 3841/E-41/S/2018 of the Ministry of Science and Higher Education of Poland, and from the funds of the Leading National Research Centre (KNOW) received by the Centre for Polar Studies for the period 2014–18.

Keywords: Water temperature modelling; Fuglebekken catchment; Svalbard; Arctic

EVALUATING EFFECTS OF WEED CUTTING ON WATER LEVEL AND RUNOFF CALCULATIONS IN DANISH LOWLAND STREAMS

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ABSTRACT

In Denmark, there are more the 400 hydrometric stations in natural streams, where runoff is calculated based on relations between discharge and water stage. In many of these streams, growth of aquatic plants influence the hydraulic conditions by increasing the resistance against flow thereby affecting the stage- discharge relations.

Flow resistance associated with aquatic plants is the main reason for active maintenance of aquatic plant populations in streams, and weed cutting is carried out regularly in many lowland streams to increase drainage of agricultural land and preventing flooding by increasing the discharge capacity. The fluctuations caused by weed growth and cuttings results in highly dynamic stage-discharge relations.

In the present study, we examined linkages between weed cutting practice and water level reductions in 126 small and medium-sized Danish streams, with continuously monitored discharge and water level data (from 1990 to 2012). A total of 3,000 weed cutting events performed downstream from the monitoring stations were included in the study. We examined reductions in the stream water level and the influence of the cuttings on the stage-discharge relation especially the importance of timing and frequency of weed cutting for the reduction and subsequently rise in water levels. Furthermore, we exemplify the impact of weed cutting for stage-discharge relations in Danish lowland streams.

Keywords: Runoff; Water level; Maintenance; Aquatic plants; River management; Flooding

MODELLING RUNOFF FROM PERMEABLE SURFACES IN URBAN AREAS

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ABSTRACT

Climate change and urbanization increases the pressure on combined sewer systems in urban areas resulting in increased combined sewer overflows, degraded water quality in receiving waters, and changing stream flows. Permeable surfaces are increasingly used to combat the challenges regarding runoff to combined sewer systems. The variation in urban soil characteristics together with the initial conditions before a rainfall event are important factors effecting the infiltration process and consequently runoff characteristics. In this study SWMM is used to evaluate the initial moisture content contribution to runoff in urban soils using Horton and Green Ampt infiltration models. A sensitivity analysis was carried out to get an improved understanding of the consequences of choosing the incorrect parameter values for urban soils. A case study from Baden-Baden was used to evaluate how permeable surfaces are contributing to the runoff based on initial soil moisture content using the STORM model. The initial soil moisture content is critical for urban flood management and flood risk analysis based on urban hydrological models. Awareness of urban permeable surfaces and how they contribute to the rainfall-runoff cycle and the importance of suitable parameter values for urban soil characterization are therefore essential.

Keywords: Permeable surface; SWMM: STORM: Initial Soil Moisture; Urban Soils; Hydrological Modelling: Urban Drainage

DEVELOPMENT OF LAKE VICTORIA 2D HYDRODYNAMIC MODEL IN COMSOL MULTIPHYSICS SOFTWARE

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ABSTRACT

Lake Victoria is the second largest fresh water body in the world, located in East Africa with a catchment area 68,800 km^2. The hydrodynamic processes of the shallow (40 – 80 m deep) water system are unique due to its location at the equator, which makes Coriolis effects weak.

The model is describes a St.Venant shallow water model of Lake Victoria developed in COMSOL Multiphysics software, a general purpose finite element tool for solving partial differential equations. Depth soundings taken in smaller parts of the lake were combined with recent more extensive data to resolve the discrepancies of the lake shore coordinates. The topography model must have continuous gradients, and Delaunay triangulation with Gaussian smoothing was used to produce the lake depth model. The model shows large-scale flow patterns, passive tracer concentration and water level variations in response to river and tracer inflow, rain and evaporation, and wind stress. Actual data of precipitation, evaporation, in- and outflows were applied in a fifty-year simulation model. It should be noted that the water balance is dominated by rain and evaporation and model simulations are validated by Matlab and COMSOL. The model conserves water volume, the celerity gradients are very small, and the volume flow is very slow and irrotational except at river mouths. Numerical experiments show that the single outflow can be modelled by a simple linear control law responding only to mean water level, except for a few instances. Experiments with tracer input in rivers show very slow dispersion of the tracer, a result of the slow mean velocities, in turn caused by the near-balance of rain with evaporation. The numerical and hydrodynamical model can evaluate the effects of wind stress which is exerted by the wind on the lake surface that will impact on lake water level.

Keywords: Bathymetry; Lake Flow & Steady state analysis; Water Level Validation & Concentration; Assessed Wind Stress.

MAPPING AREAS EXPOSED TO EROSION AND WATERFORCES DURING EXTREME FLOODS IN STEEP TERRAIN

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ABSTRACT

Extreme weather events, natural disasters and failure of climate change mitigation and adaptation are the risks with the highest likelihood of occurrence and largest global impact. According to the Natural Perils Pool the direct compensations over the 10 last years due to Natural Hazards (NH) have costed Norway alone 27 Billion NOK and the Public Sector even more. Historically the attention have been on floods in the larger, slow responsing watercourses. Due to a changing climate it is both expected and experienced more frequent and more extreme rainfalls creating violent flash floods in small catchments. In steep rivers this induce rapid changing discharges and large waterforces resulting in erosion and rivers taking new courses, destroying communities and threatening livelyhoods and live. Municipalities are responsible for mapping the risks natural hazards induce. When it comes to the risks due to floods in steep rivers it is still a lack of approach and methodologies to handle this analysis. In this study different approaches is tested to reconstruct the event in Utvik July 2017 and a methodology suggested to test possible scenarios in another river. In this study the neighbouring river in Innvik is used as a demonstration case.

Keywords: Flash Floods; Water forces; Erosion; Dynamic hydraulic simulation

A SIMPLE FLOOD FORECASTING SYSTEM IN ICELAND

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ABSTRACT

In Iceland the Meteorological Office (IMO) monitors natural hazards and works in close collaboration with the Department of Civil Protection and Emergency Management as well as the Icelandic road and coastal administration in relation to flood events. In April 2017, a simple flood forecasting model using the deterministic spatially distributed hydrological model WaSiM, with input data from the high resolution numerical *weather prediction* (NWP) *model HARMONIE,* was setup for two catchments in Iceland. Its daily run provides the Icelandic Met Office with 48h discharge forecasts and is aimed at helping the monitoring department at the IMO in the assessment of flooding episodes. During this first year of implementation, the flood forecasting system has proven to be very reliable and despite its simplicity it has contributed to a better warning system, giving both accurate information about the timing of floods and a correct order of magnitude after some bias correction.

Keywords: WaSiM; Hydrological modelling; Flood forecast; Flood warning.

THE USE OF ANALOGUE SORTING METHOD FOR AN OPERATIONAL STREAMFLOW FORECAST SYSTEM

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ABSTRACT

K-nearest neighbours algorithms (or analogue sorting methods) are commonly used in simple climate models for ensemble forecasting. Previous works have shown these methods could be used successfully to produce reliable daily streamflow forecast. This method necessitates only limited pre-processing and was investigated in combination with the high-resolution Harmonie meteorological dataset (hindcast and forecast data) for the prediction of daily streamflow of Icelandic watersheds. The research assessed the best combination of predictors in terms of the quality of results and computation efficiency, and the possible use of statistical processing of the forecast for bias correction. The results of this work are the starting point for the setup of an operational forecast system for Icelandic watersheds to supplement the more complex forecasting model already in place.

Keywords: k-nn algorithm; Analogue sorting; Streamflow forecasting.

IMPACT OF CLIMATE AND CATCHMENT CHARACTERISTICS ON HYDROLOGICAL DROUGHT DEVELOPM MENT AND SEVERITY IN SWEDEN

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ABSTRACT

Hydrological drought can have severe consequences for nature and society, including problems with agriculture, drinking water supply and hydropower production. In Sweden, in recent history, severe hydrological drought events have rarely occurred, but last years' severe events and their consequences in drinking water and agriculture showed that Sweden is not exempt to this hazard and its impacts. In addition, according to future climate projections, severe drought events might become more frequent in the coming decades. Knowledge about hydrological drought (e.g. how it develops and factors affecting its severity) is important for water management, but in Sweden there are still few studies dealing with this subject. This study aims at identifying the role of catchment and climate characteristics in drought severity – here expressed in terms of duration and deficit volume – and drought development in Sweden. We used meteorological and river discharge data for a set of 89 Swedish catchments covering different types of climate and catchment characteristics for the period of 1961–2016. We first identified the catchments that are most susceptible to severe hydrological drought and then associated the different levels of severity with particular climate and catchment characteristics. In addition, we categorised the hydrological drought events according to the typology available in the literature. This typology is process-based, meaning that the different categories depend on how precipitation deficits and temperature anomalies cause deficits in river and groundwater discharge. This allowed us to identify which processes are most important for the development of severe hydrological drought events. The processes were also linked to particular climate and catchment characteristics. The results show which regions and hydrological types in Sweden require most attention.

Keywords: Hydrological drought; Sweden; Drought propagation

APPLICATION OF DATA FROM THE GRACE AND GRACE FO SATELLITES FOR QUANTIFYING HUMAN IMPACTS ON FRESHWATER AVAILABILITY

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ABSTRACT

The NASA/German Gravity Recovery and Climate Experiment (GRACE) and GRACE Follow On (GRACE FO) missions have mapped variations in terrestrial water storage (the sum of groundwater, soil moisture, surface water, snow, and ice) at regional scales on a monthly basis since 2002. Unlike conventional remote sensing systems that measure various wavelengths of electromagnetic radiation emitted or reflected from the Earth, GRACE and GRACE FO measured spatial and temporal variations in Earth's gravity field based on perturbations to the orbits of two identical satellites. After removing the effects of atmosphere and ocean circulations using ground based observations and models, changes in terrestrial water storage are inferred from the gravity field variations. Hence GRACE and GRACE FO have been the only systems able to monitor all forms of water on and below the surface, which has revolutionized our understanding of changes in freshwater availability. In this presentation we evaluate apparent trends in terrestrial water storage during the GRACE period and identify those that have been caused by unsustainable groundwater consumption or climate change. For example, melting of ice sheets and glaciers caused by global warming accounts for the largest terrestrial water storage losses, while groundwater is being depleted by agricultural usage in India, the Middle East, and parts of the U.S. and China, among others. We also describe how data from GRACE and GRACE FO can be integrated with other data within a land surface model in order to improve their spatial and temporal resolution, separate the effects on the terrestrial water storage components, and apply the results for drought and extreme wetness monitoring.

Keywords: GRACE; Remote Sensing; Groundwater; Drought; Agriculture; Water Consumption

MULTIPLE-PURPOSE USE OF HYDROPOWER DAMS IN HIGH ALPINE AREAS

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ABSTRACT

More than 90% of the current Swiss glacier mass will be lost by the end of the century due to climate warming. As a consequence, artificial water reservoirs will become more important for the management of water resources to sustain the current favourable runoff regime with high glacial discharge in summer where the need for irrigation is highest. This leads to two questions: where can such new reservoirs be set up, and how can these storages be optimally managed and used for multiple purposes?

To answer the first question, suitable locations of potential new hydropower dams were identified where glaciers will retreat over the course of the 21th century. To this end, glacier evolution and ice thickness models were used to estimate when areas will become ice-free and to characterize the subglacial topography which would become exposed. Then, the hydropower potential of artificial storage reservoirs placed in these newly ice-free basins was quantified under various future climate scenarios. In addition, the feasibility of hydropower development at each location was determined by taking into account environmental, economic and technical factors.

Such reservoirs may also become useful for other water sectors during seasons or specific situations with water scarcity. A recent study showed that a strategy of replacing glacial water storage with artificial storage reservoirs could offset up to 65% of the summer runoff deficit expected to arise from diminishing summer meltwater availability in the European Alps.

To answer the second question, we set up a water management model (WEAP) for an Alpine catchment in Switzerland, where precipitation is relatively low and water demand for irrigation, tourism and energy production is significant. There, we demonstrate how existing and potentially new hydropower reservoirs can be optimally managed to mitigate temporary drought situations under future climate and water demand scenarios.

Keywords: Hydropower dams, Water management, Alpine areas, Multi-purpose use of water

PREDICTING SOIL EROSION AND SEDIMENT YIELD IN OUED EL ABID WATERSHED, MOROCCO

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ABSTRACT

Soil salinization is a phenomenon considered to be a real onsite and offsite threats to natural resources in arid and semi-arid climates. The phenomenon is controlled by soil (texture, depth, slope etc.), anthropogenic factors (drainage system, irrigation, crops types, etc.), and climate factors. This study was conducted in the watershed of Oued El Abid in the upper part of Oum Er B'IA watershed in the region of Beni Mellal-Khenifra, Morocco, aimed at localising saline soil using remote sensing and a regression model. The spectral indices were extracted from Landsat imagery (30 m resolution) after image treatment. The linear correlation of electrical conductivity, which was calculated based on soil samples (ECs), and the values extracted based on spectral bands showed a high accuracy with an R^2 of 0.80. This study proposes a new spectral salinity index using Landsat bands B1 and B4. This hydro chemical and statistical study, based on a yearlong survey, showed a moderate amount of salinity, which threatens dam water quality downstream the watershed and soil quality. The results present an improved ability to use remote sensing and regression model integration to detect soil salinity with high accuracy and low cost, and permit intervention at an early stage of salinisation.

Keywords: Soil salinization; Water quality; Remote sensing; Regression model; Watershed

COMPARING LABORATORY EXPERIMENTAL MEASURED C-VALUES WITH FIELD OBSERVATIONS

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ABSTRACT

Predicted climate changes combined with urbanisation increases the performance demand on urban stormwater management structures. The rational method with the runoff coefficient (C) is one of the most commonly used design tools in stormwater management. The runoff coefficient is the most essential part of the equation to caputre landuse. In Norway, green roofs are gaining popularity as a stormwater management measure. However, more knowledge is needed on the runoff coefficient from green roofs in order to improve design calculations. This paper compare laboratory and experimental field studies to investigate observed runoff coefficients, C from different types of green roofs. Comparing laboratory and field observed values a model can be developed and calibrated to calculate the C factor for differently composed vegetated roofs. The laboratory measured runoff coefficient is found by the standard German method given in the "FLL Guideline". Where the runoff coefficient is the ratio between the runoff at the end of precipitation and the amount added. Both combinations of layers and layers alone were tested, enabling the influence from each single layer to be studied. The runoff coefficients from the field were calculated using observed precipitation and runoff from existing green roofs in Oslo, Trondheim, Sandnes and Bergen. The events were selected based on soil moisture and the intensity of the rainfall, which are factors influencing the runoff coefficient. By comparing these values, this study will show to what degree using runoff coefficients for design of green roofs as stormwater structures is a suitable choice.

Keywords: Detention; Green Infrastructure; Green Roof; Rational Method; Runoff Coefficient; Urban Storm Water

INTERCOMPARISON OF MULTIPLE-TYPE STATISTICAL DOWNSCALING METHODS IN MODELING CLIMATE CHANGE IMPACTS ON HYDROLOGY

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ABSTRACT

Many statistical downscaling methods have been proposed to bridge the gaps between coarse resolution climate model outputs and fine resolution requirements of hydrological model inputs. These statistical downscaling methods can be classified into perfect prognosis (PP), model output statistics (MOS) and stochastics weather generator (SWG) categories. Many studies have evaluated different statistical downscaling methods in hydrological climate-change impact modeling, but always failed to account for the method differences among all three categories. If the differences among the three categories were determined, reference could be given to end-users to select appropriate downscaling methods for impact studies. Thus, this study selected ten commonly-used statistical downscaling methods from the three categories, exploring both the method and category differences in hydrological climate-change impact modeling. Two reanalysis datasets (NCEP/NCAR-R1 and Era-Interim) were used as surrogates to climate models and the case study was implemented on four watersheds of different drainage sizes. Results show that the SWG and distribution-based bias correction methods performed relatively best in reproducing the statistical characteristics of observed precipitation, followed by the change factor, mean-based bias correction and PP methods. But these methods behaved similarly in downscaling temperatures. For hydrology simulation, the performance rank of the ten methods was consistent with that in downscaling precipitation. When comparing the downscaling results of using different reanalysis datasets, it is found that downscaling using Era-Interim reanalysis generally reproduced the observed climatic and hydrological features better, especially for variability. But using different reanalysis datasets did not change the performance rank of these downscaling methods. Besides, watershed scale effects were not observed in this study, which was reflected by the consistent performances of these methods over different watersheds. Overall, this study emphasizes the importance of selecting appropriate downscaling methods for studying climate change impacts on hydrology, and the distribution-based bias correction and SWG methods are recommended.

Keywords: Statistical downscaling methods; Climate change; Hydrology; Uncertainty

SENSITIVITY ANALYSIS OF OCEAN AND TOPOGRAPHIC FACTORS USED TO CREATE A PHYSIOGRAPHIC BINNING SCHEME FOR HYDROLOGY IN SCANDINAVIA

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Abstract

Many conceptual surface based hydrological models use threshold temperatures to determine precipitation phase. However, precipitation phase at Earth's surface is a result of cloud and atmospheric properties, not commonly measured by surface weather stations. This results in unnecessarily large uncertainties for precipitation phase determination in cold region hydrological, safety, and climate models. This uncertainty can be reduced through physiographic identification of areas likely to have vast differences in their land surface energy exchanges with the atmosphere.

This study uses 681,620 weather observations with an air temperature (AT) -3 to 5°C and an observed precipitation phase to identify rain snow thresholds resulting in the least modeled precipitation phase uncertainty for AT, dew-point temperature (DT), and wet-bulb temperature (WB). This dataset represents 38 and 42% of precipitation observations over 16 years for 85 and 84 Swedish and Norwegian weather stations respectively. The Norwegian observations had 11.64, 11.21 and 8.42% error for DT (-0.2°C), AT (1.2°C) and WB (0.3°C) thresholds respectively. Individual station thresholds had a range of -0.7 to 1.2°C, -1.2 to 0.9°C, and -0.1 to 2.5°C for WB, DP, and AT respectively.

To reduce threshold varience, the influence of topography and oceans was considered. Stations were grouped into; windward (WW) ocean, WW coast, WW fjord, WW hill, WW mountain, leeward (LW) mountain, LW hill, LW rolling hills, and LW coast. The sensitivity of the physiographic grouping variables; percentage water, and varying elevation were tested at ranges of 5, 10, 15, 20, and 25km circles. Preliminary results from a 15km test show that 1.) the Norwegian ocean (1.4°C) and coast (1.5°C) groups had a higher AT threshold than hill (0.9°C), and mountain (1.0°C) stations, helping reduce precipitation phase uncertainty. 2.) Swedish landscapes downwind of the mountains had much less variability than Norwegian landscapes, resulting in less gains when applying physiographic AT thresholds.

Keywords: Physiography, Geographic Landscape, Snow Model, Temperature Threshold

AQUIFER VULNERABILITY AND RISK ASSESSMENT – THE TAGUS RIVER CASE STUDY, PORTUGAL

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ABSTRACT

In compliance with the Nitrate Directive (Directive 91/676/EEC), six Nitrate Vulnerable Zones were designated in Portugal. One of them, the Tagus river vulnerable zone, was recently extended to the Setubal peninsula since increased farming and livestock activities have threatened the shallow aquifer of the Mio- Pliocene hydrogeological system. In fact, the threshold value of 50 mg/L NO_3, established by the Directive, are excelling in several wells.

Several indicators are frequently applied to assess groundwater vulnerability to diffuse nitrate pollution from farming areas. Two methods were used: 1. one based on intrinsic criteria and using the intrinsic characteristics of the aquifer (geological and hydrogeological attributes), the DRASTIC and, 2. the second one including anthropogenic factors such as land use, the Susceptibility Index (SI). The results were after overlaid to the nitrate's spatial distribution and allowed to identify high and low-risk clusters for nitrate contamination. The SI method is an adaptation of the DRASTIC method; the main differences, including the addition of a parameter defining Land Use (LU) and thus, abandoning the concept of a purely intrinsic vulnerability assessment. The exclusion of three DRASTIC parameters: S (Soil), I (Impact of the vadose zone) and C (Hydraulic conductivity), also reduces the level of redundancy. The SI has been widely practiced in other areas of Portugal and abroad, demonstrating that, by including a parameter for land use it is possible to produce more reliable results, despite the debatable role of nitrate attenuation, particularly under aerobic conditions. Finally, SI allowed to break down the impact of land use changes, to characterize the spatial distribution of vulnerability patterns and therefore, to assess groundwater's quality risk.

Keywords: Nitrate Vulnerable Zones; DRASTIC; Susceptibility Index (SI); Risk assessment; Tagus river.

CAN NUMERICAL WEATHER PREDICTION (NWP) MODEL BASED METEOROLOGICAL DATA PRODUCTS REPLACE TRADITIONAL GAUGE MEASUREMENTS AS INPUTS TO HYDROLOGICAL MODEL FOR HYDROPOWER PRODUCTION SIMULATION?

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ABSTRACT

Hydrological models require accurate and representative meteorological inputs for better prediction and hence efficient management of water resources. Norwegian hydropower companies use time series of precipitation and temperature gauge measurements as inputs to hydrological models to estimate inflow for hydropower production simulation. These traditional gauge observations represent point measurements and require a dense network of gauges to measure input on the catchment scale. Dense gauge networks are not common, and even if they exist, poor maintenance can lead to poor quality data. Further, operation and maintenance of these gauges in remote mountainous areas incur considerable recurring expenses. Numerical Weather Prediction (NWP) model based metrological data products on the catchment scale are becoming available as commercial products and it is interest for hydropower companies to use them as a substitute for gauge measurements.

The present study assesses the use of NWP model based hourly precipitation and temperature data products for use in hydrological models. First, the study compares the time series of data products with recorded gauge observations at 26 gauge locations in the Nord Trøndelag region of northern Norway. Then, the study evaluates the performance of data products as input to the PINE-HBV hydrological model with hourly and daily timestep. For that, three catchments with the area of 700 km^2, 350 km^2 and 200 km^2 respectively in this region are used to setup HBV models. Prediction of flow and snow water equivalent are assessed.

It was found that correlation between the data product and measured gauge precipitation were highly variable and daily values showed better correlation than hourly. Further, preliminary investigation shows that simulated flow with the data product as the input to the HBV model with daily timestep is nearly as good as the same model with gauge measurements as input. Even though daily simulation of HBV model with data product as input fails to simulate some of the observed high peaks, the simulated volume of flow matches observed flow which is important for hydropower production planning.

Keywords: Model based meteorological data products; HBV hydrological model; Inflow prediction; Hydropower

BIOWATER: A NORDIC CENTRE OF EXCELLENCE ON INTEGRATED LAND AND WATER MANAGEMENT FOR A SUSTAINABLE NORDIC BIOECONOMY

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ABSTRACT

BIOWATER is a Nordic Center of Excellence that gathers a critical mass of freshwater and catchment processes scientists to analyse and understand impact of bioeconomy and the "green shift" on water resources. The green shift will most likely mean that the current land use will change. We may use the forests in new ways, and the types of crops we grow may change. The management practices in both agriculture and forestry can become quite different from today. Together with on-going climate change this can have far- reaching effects on hydrology and water quality in both rural and downstream urban areas.
BIOWATER aim to provide an integrated understanding of how land use and climate changes will influence water resources including water quality and ecosystem services dependent on water flows. By evaluating the impact of various land use scenarios and options on hydrology, biogeochemistry, inland water quality, ecology, ecosystem services, as well as socio-economic costs and benefits, BIOWATER will strengthen the available knowledge base to identify the window of opportunities for sustainable bio- economic development in the Nordic countries. BIOWATER has a clear goal and work plan to provide the input needed for future policies and actions related to these subjects. BIOWATER will link key research institutes and scientists and by developing a program of doctoral education cooperation, in addition to the end-user involvement from the onset of the Centre. This will provide opportunities for collaboration between experienced researchers as well as form a platform for PhDs and post-doctoral researchers. The center will interact with policy makers and stakeholders on the opportunities and limitations of the green, bio-economic shift for the rural North.

Keywords: Green shift, Water quality, Hydrology; Land use; Climate change; Ecosystem services

REVIVAL OF A TINY HYDROLOGICAL RESEARCH CATCHMENT IN SOUTH- EAST NORWAY- WHY NOT MEASURE EVERYTHING?

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ABSTRACT

The tiny (7500 m^2), forested Muren research catchment , near Oslo, Norway, was during the 1990s, densely instrumented with more than a 100 observation points for measuring groundwater levels. The aim was to investigate the link between shallow groundwater dynamics and runoff. The research activities in the catchment was discontinued in 1999. In 2016 the Norwegian Water Resources and Energy Directorate decided to re-establish the Muren research catchment with modern and automated measuring techniques in order to further investigate interactions between groundwater and runoff dynamics. In 2017, 25 groundwater observations wells were installed together with runoff- and water level measurements, snow depth and meteorological measurements such as radiation (long wave and short wave), temperature (air and ground), air pressure and relative humidity. A fully equipped meteorological station was installed 120 meters away from the catchment station. The temporal resolutions of the measurements are five- and fifteen minutes depending on the variable. In the coming months and years we intend to investigate: 1) relations between runoff- and groundwater recessions, 2) river network densities and subsurface saturation, 3) impulse-response timing as function of saturation, 4) impulse-response, wave celerities or darcian velocities and 5) proxy energy balance models (with temperature and precipitation as input) for snowmelt and evapotranspiration as substitutes for energy balance models with measured input. Certainly, other interesting questions will present themselves in time and we invite colleagues and, in particular, students in hydrology to come help us to crack the numerous enigmas at Muren.

Keywords: Groundwater-runoff interactions; Research catchment; Forest hydrology

APPLICABILITY OF URBAN STREETS AS TEMPORARLY FLOOD WAYS

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ABSTRACT

Climate change coupled with urbanization and its increasing impervious surfaces have caused major challenges for the water sector worldwide. In Norway an ageing infrastructure with already insufficient drainage capacities result in large amounts of runoff during high intensity rainfall events causing frequent floods in urban areas. Due to limited available space to handle the future projected increase in stormwater, there is a need to utilize already occupied space for stormwater management, such as roads and streets, during extreme events. Limited research has been done on the design and applicability of urban streets as temporarily flood ways diverting stormwater to the nearest recipient. This paper will study the benefits and limitations of adapting urban streets as safe flood ways to route stormwater by modelling the effect of different street design. The study uses a case from Bergen, a city on the west coast of Norway, where steep hillsides and a wet coastal climate makes it prone to flash flooding. Urban streets in Norway are required to secure universal design for accessibility while fulfilling functional design criteria for traffic safety. Streets as flood ways will require additional hydraulic performance criteria in addition to flood safety and hazard management for the public. This paper investigates the functional performance criteria for urban streets to fulfil all the above criteria. The resulting performance criteria are presented as a generalized framework to evaluate the applicability of streets as urban flood ways, including the impact of flood risk and hazard management of controlled flooding. The framework can be used to evaluate the applicability of multifunctional streets used as urban flood ways and can be adapted by municipalities as a decision support tool in urban planning and local stormwater management.

Keywords: Climate Change; Flood Ways; Hydrological Modelling; Stormwater Management; Urban Drainage; Urban Flood.

SPATIAL GRADIENTS IN STABLE WATER ISOTOPES CONSTRAIN THE WATER CYCLE IN WEATHER PREDICTION AND CLIMATE MODELS

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ABSTRACT

The stable isotopic composition of water vapour and precipitation, expressed by the quantities dD, d18O, d17O and the secondary parameters d-excess and 17O-excess, contains information about the condensation history of water vapour in the atmosphere. The complex interplay of atmospheric flow and topography in Norway, and the location in the storm track, lead to precipitation arriving from a wide variety of source regions. Results from spatial sampling of meteoric, surface waters, and coastal water samples in southern Norway provide first insight into the spatial gradients from coast to mountains. Measured at the recently established national infrastructure facility FARLAB at the University of Bergen, analyses provide also insight into evaporation conditions at the moisture sources from the secondary parameters d-excess and 17O-excess. In particular the parameter d-excess shows differences in moisture origin between the western and eastern part of Southern Norway, that indicate different transport patterns due to topography. This work lays a foundation for how stable isotope measurements at meteorological to seasonal time scales can provide powerful constraints on the entire water cycle in weather prediction and climate models.

Keywords: Stable Isotopes; Surface waters; Meteoric waters; Climate model; Weather forecasting.

RUNOFF MODELLING FROM ARABLE LAND

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ABSTRACT

Runoff from arable land is a challenge with respect to water quality. Of that reason, the Norwegian Agricultural Environmental Monitoring Programme (JOVA) was initiated to document the relation between land use, soil conditions and hydrology. In this project, which is a work in progress, we focus on the hydrological response from rainfall and snowmelt on arable land by taking advantage of time-series recorded in the JOVA programme. We apply the principle of rainfall runoff simulation implemented in the Distance Distribution Dynamics (DDD) model (Skaugen and Onof, 2014) where runoff is calculated as a convolution of precipitation and snowmelt. The coefficient in the convolution filter is deduced from recession analysis and the shortest distance between grid points and the drainage network. Catchment water saturation is estimated as part of the water balance. Because the relation between catchment saturation and contaminant runoff is closely related, we expect the hysteresis between saturation and runoff to play a cardinal role. The aim of the study is to model runoff from arable land with a parsimony of calibration parameters in order to transfer results to catchments with less empirical data for validation of modelling results.

Keywords: Rainfall runoff modelling; Arable land; Catchment saturation.

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LAND-ATMOSPHERE INTERACTIONS IN COLD ENVIRONMENTS (LATICE): THE ROLE OF ATMOSPHERE - BIOSPHERE – CRYOSPHERE – HYDROSPHERE INTERACTIONS IN A CHANGING CLIMATE

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ABSTRACT

Climate change is impacting the high latitudes more rapidly and significantly than any other region of the Earth because of feedback processes between the atmosphere and the underlying surface. A warmer climate has already led to thawing of permafrost, reduced snow cover and a longer growing season; changes, which in turn influence the atmospheric circulation and the hydrological cycle. Still, many studies rely on one-way coupling between the atmosphere and the land surface, thereby neglecting important interactions and feedbacks. The observation, understanding and prediction of such processes from local to regional and continental scales, represent a major scientific challenge that requires multidisciplinary scientific effort. LATICE, which is recognized as a strategic research initiative by the Faculty of Mathematics and Natural Sciences at the University of Oslo, aims to advance the knowledge base concerning land atmosphere interactions and their role in controlling climate variability and climate change at high northern latitudes. The consortium consists of an interdisciplinary team of experts from the atmospheric and terrestrial research fields, with the long term aim to improving parameterizations of processes in seasonal snow climates. Observations are key for improving Earth System Models and the group has established a high resolution measurement infrastructure site in a mountain region, Finse, including a stationary and a mobile eddy-covariance tower. The network of instruments provides high resolution data for estimating the water and surface energy balance, as well as CO_2 fluxes. Here, we present the LATICE concept; its main research areas and activities, along with some first results based on observations and integrated modelling efforts at Finse. This include among other, a study of the occurrence of rain-on-snow events, and a comparison of seasonal patterns of flux estimates and simulated snow cover at using the land-surface model CLM4.5-BGC. The latter results demonstrate the challenges related to data-model comparisons in mountainous terrain, nevertheless our CLM results show realistic flux magnitudes and seasonal patterns.

Keywords: Land-atmosphere; Flux measurements; Snow; Finse; Modelling

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MINE WATER INFLUENCE TO THE FRESHWATER ECOSYSTEM IN THE KURTNA LAKE DISTRICT, ESTONIA

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ABSTRACT

Kurtna Lake District in north-eastern Estonia is surrounded by industrial landscapes and has been influenced by increasing rate of human activities. Kurtna is the lake-richest region in Estonia: there are 38 lakes per 30 sq. km, from which 18 belong to the Natura 2000 network of the EU. In the beginning of the 1950s, rapid expansion of oil shale mining and related industry started in the vicinity of Kurtna, raising the need for technological water and for discharging pumped minewater. The water from Estonia and Viru oil shale mines was directed through Lake Nõmmejärv and four lakes downstream of it. In the current study ecosystem response of Lake Nõmmejärv to the changes in the properties of inflowing water are analysed and discussed. Mine water has a distinctly different composition from natural water – different temperature, high mineralisation (due to SO^{2-}, HCO_3^-, Ca^+, Mg^+) and high content of suspended matter. In 1937, when the lake was in natural condition, the level of sulphates was around 6 mg l^{-1}, while in the 1980s the corresponding values were mostly between 200 and 300 mg l^{-1}, and nowadays it exceeds 300 mg l^{-1}. Sulphates are known to be a potential threat to water environments, because under anoxic and low pH conditions, sulphate-rich sediments can release toxic H_2S, leading to the resuspension of phosphorus from sediment to lake water. For modelling the possible internal loading of P on the lake we analysed five P fractions (including inorganic and nonreactive P) from sediment cores. During the last decades, Lake Nõmmejärv has shifted toward more eutrophic state and there are notable changes in sediment composition and biodiversity. Nevertheless, the lake is still in equilibrium state, because of low organic matter content of mine water and fast water exchange (up to 40 times per year), which prevents the formation of anoxic conditions. Since the Viru mine was shut down (summer 2013), the water exchange has been much slower (~17 times per year). We can hypothise that in the future, after the planned closing of the Estonia oil shale mine, the ecological state of the lake could shift dramatically.

Keywords: Water quality; Mine water; Human influence; Lake ecosystem; Sulphates; Natural lakes

THE WATER SCARCITY PARADOX AND THE ADOPTION OF WATER-CONSERVATION TECHNOLOGY IN SOUTH AFRICA

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ABSTRACT

This paper proposes a framework that studies the conditions under which households adopt grey water treatment technologies in South Africa. The main purpose of grey water technology adoption is to extend the water usage lifecycle within households and reduce investment that is allocated to centralized wastewater treatment plants. The microeconomic framework proposed in Foster and Rosenzweig (2010) is adapted to household characteristics to study the relationships between socio-economic features and adoption of water-conservation measures that aim at reducing the volume of water treated in centralized wastewater treatment plants. The theoretical model is tested in using choice experiment that presents households with various choice sets to induce them reveal their preferences over targeted technologies with particular attributes. Our methodology highlights the household-specific features as well as current institutional factors that affect adoption of wastewater treatment technologies. Both Multinominal Logit (MNL) and Scaled MNL models are applied to newly collected data from 300 households in the city of Mpumalanga. Our preliminary results show that easiness of use, externalities (smell), and costs remain important attributes for households' choice of wastewater treatment technologies. Our results show also that households are willing to invest in more costly grey water treatment technologies to reduce their likelihood of facing severe water scarcity. Additionally, factors such as years of schooling, geographical location and income are influential factors that drive willingness to pay. Our analysis provides important insights to understanding the timing and behavioural attitudes that surround adoption of water-conservation technologies in water stressed cities in the developing world

Keywords: Technology adoption; Water conservation; Public policy, South Africa

TOWARDS A NEW GENERATION OF ALTERNATIVE WATER SUPPLY SOURCES THROUGH TECHNOLOGY ADOPTION: LESSONS FOR GREY WATER IN SOUTH AFRICA

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ABSTRACT

Water scarcity is one of the biggest challenges faced by some cities in South Africa. Current initiatives taken in such cities support development of alternative water supply sources that limit the volume of water extracted from surface and groundwater sources. The purpose of this paper is to investigate the factors that drive adoption of water conservation measures in South Africa. This research is applied to the city of Cape Town- one of the most water stressed city in South Africa. Targeted water conservation measures are grey water treatment technologies that are not only expected to promote alternative water supply sources and therefore water security, but also to induce on-site water treatment options that reduce investment allocated to centralized wastewater treatment plants. We use a choice experiment approach and investigate households' preferences and estimate the mean willingness to pay for each grey water treatment technology attributes. Our methodology highlights also the household-specific features as well as current institutional factors that affect adoption of wastewater treatment technologies. Both Multinominal Logit (MNL) and Scaled MNL models are applied to newly data collected from 300 households in the city of Cape Town. Our preliminary results show that easiness of use, externalities (smell), and costs remain important attributes for households' choice of wastewater treatment technologies. Our results show also that households are willing to invest in more costly grey water treatment technologies to reduce their likelihood of facing severe water scarcity. Additionally, factors such as years of schooling, geographical location and income are influential factors that drive willingness to pay. Our results provide a platform that can support design and an implementation of important public policies that mitigate water scarcity and ensure water security in the city of Cape Town.

Keywords: Technology adoption; Water conservation; Public policy; South Africa

IMPORTANCE OF DYNAMIC RIVER NETWORK IN DISTANCE DISTRIBUTION DYNAMICS HYDROLOGICAL MODEL

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ABSTRACT

The dynamics of runoff in distance distribution dynamics (DDD) hydrological model has been derived from the catchment features using GIS combined with a runoff recession analysis. The method for describing the runoff dynamics of a catchment is based on the distance distribution derived from the catchment topography. The distances from the points in the catchment to the nearest river reach are calculated for marsh and non- marsh portion of a hillslope. The distance distributions help in developing unit hydrographs, which account the delays and storages of water in the hillslope. The distance distributions of the river network are also important component of the model since the delays and storages in the river network affect the hydrographs at the outlet of the catchment. In the existing DDD model, the hillslope and the river network distance distributions are constant for the whole simulation periods. We hypothesize that, in reality, the river network density increases during extreme precipitation events and saturations of the subsurface, and t reating it as constant during low, medium and high (flood) flows only approximates the real behavior of the catchment. In this study, dynamic river networks are introduced to improve the approximations i. e. a river network denser than the observed river network is included in the model and is activated during subsurface saturation and higher precipitation events. The study results show that the dynamic river network improves the model, and this improvement would be important in using the model for practical flood forecasting and design of infrastructures in small catchments.

CONSIDERING GROUNDWATER RECHARGE AND FLOW IN URBAN DEVELOPMENT PLANNING – A CASE STUDY FROM TORSHOVDALEN, OSLO

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ABSTRACT

Recent research has focused on the hydrogeological responses to climate change in urban areas, and the use of hydrogeology as a tool for storm water management. This case study is a part of a larger interdisciplinary pilot project initiated by the Agency for Water and Sewerage works in the municipality of Oslo. Encompassing disciplines includes engineering, landscape architecture, economy, and hydrogeology. The study will focus on river restoration to increase the infiltration capacity, retain overflow, and ensure secure waterways in Torshovdalen. Recharge patterns have been altered during the last decades, as a result of climate change and urbanization affecting the natural hydrological cycle. Impermeable surfaces are preventing water from penetrating the ground, lowering the evaporation potential and causing surplus water flooding. Surface runoff is currently directed and combined with the sewer system in Oslo. Applying best practice storm water management principles by re-opening Torshovbekken will not only regulate surface water but also restore local ecology, and protect nearby infrastructure from flooding. It will be important to monitor and observe the long-term effects on the natural hydraulic regime after daylighting the stream for future research. Three parameters will be investigated: geological units and underground structures (i.e. heterogeneity below ground), infiltration capacity, and hydraulic heads. Previously recorded data will be utilized and new data will be collected in the field to improve the geological understanding, and define hydraulic properties of the unsaturated and groundwater zone. ArcGIS will be used to map the aquifer including recharge zones and hydraulic gradients. Monitoring of groundwater levels and water quality, characterization and mapping of the area will be important tools for estimating the water balance and evaluating the pros and cons of re-opening Torshovbekken.

Keywords: Storm water management; Urban hydrogeology; Climate change; Surface runoff.

COMPARISON OF DIFFERENT SAMPLING STRATEGIES TO DETERMINE NITROGEN TRANSPORT IN STREAMS AS BASIS FOR EMISSION-BASED REGULATION

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ABSTRACT

This study investigates the importance of the sampling strategy in streams regarding the determination of the yearly nitrogen (N) transport based on nitrogen and discharge data from 2015-2017. Today the N transport in streams in Denmark is calculated based on the concentration of total N in water samples and discharge measurements and a sampling strategy based on technical guidelines developed by a GUDP project (Poulsen et al., 2016). Among other things, the calculated annual N transport determines the loading of N to coastal waters which is controlled by emissions of N from diffuse (mainly agriculture) and point sources to surface waters.

The current guidelines state that the number of water samples and discharge measurements per year depends on the hydrological regime of the stream, assuming an uncertainty of less than 10% for the calculated annual N transport. The sampling frequency can in practise be less frequent (monthly) in streams having a stable hydrological regime (groundwater fed streams) and higher frequency (fortnightly) in streams having an unstable hydrological regime (tile drained catchments). We compared two different streams with daily nitrate measurements to assess, whether this assumption can be validated.

In contrast to our expectation, we found that the uncertainty of determining the annual N transport is highest in the stream having the most stable hydrological regime as compared to an unstable regime type stream. Moreover, we compared the daily nitrogen measurements from the stream with the unstable hydrological regime to nitrogen measurements from a new NITRATAX plus sensor from HACH to test this new technology and investigate the difference between determining the nitrogen transport based on different methods.

Acknowledgements: This study is funded by a grant from the GUDP in Denmark.

Reference: Poulsen J.R., Tornbjerg H., Windolf J., Larsen S.E., Krongvang B., Højberg A.L. 2016; Vandløbsmålinger som grundlag for emissionsbasseret kvælstofregulering, Institut for Bioscience, Aarhus Universitet

Keywords: Stream measurement; Small catchment hydrology; Sampling strategy; Uncertainty; Nitrogen regulation; HACH NITRATAX plus sensor

MODELING EXTEME DROUGHT AND CLIMATE CHANGE IMPACTS ON DROUGHT IN FINLAND

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ABSTRACT

While Finland has abundant water resources, droughts can still occur and have the potential to cause large damages in different economic sectors. Possible impacts of drought and changes in drought caused by climate change were assessed by modelling the runoff and discharges during the most severe drought in Finland during the last century. The meteorological observations of this period in 1939–1942 were used as input of Finnish Environment Institute's Watershed Simulation and Forecasting System (WSFS) to simulate the hydrology in present day watersheds and in projected future conditions. The modelled long lasting severe drought causes largest damage to agriculture, hydropower, forestry and water supply sectors. The impacts caused by drought and the risks to water security vary greatly in different parts of Finland and are largest in small watersheds in southern and south-western Finland, where the water use is large compared to the available water resources and there are few lakes. On the other hand, the water level also falls lowest in the largest unregulated or only mildly regulated lakes causing potential damage in these areas. Climate scenarios based on different RCPs (Representative Concentration Pathways) were used to assess climate change impacts on average droughts and to the severe drought event of 1939–42. Climate change scenarios project on average a shift to lower discharges and water levels during summer and higher during winter. With most scenarios, the drought risk in Finland decreases due to increase in precipitation, while some scenarios project lower water levels during summer and during the extreme drought especially in southern and central Finland. Water security in Finland in regards to drought risk can be regarded as high, but drought risks are often not recognised and not prepared for. Carrying out drought preparedness plans and promoting agricultural adaptation could further improve the resilience of Finnish society.

Keywords: Drought; Climate change; Finland; Hydrological modeling

THE APPLICATION OF DIGITAL FILTERS AND MEASUREMENTS UPSCALE FOR IDENTIFICATION OF RUNOFF COMPONENTS FOR THE BERZE RIVER

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ABSTRACT

The contribution of different runoff components for the Berze River basin (872 km^2) is rather unknown as it has not been studied before. The data sets of observed daily average runoff (Q_{obs}) for the outlet of the Berze River and subsurface drainage field (0.76 km^2) located adjacent for the time period of 2005 to 2014 were used to identify the runoff components for the Berze River. Two digital filters including Baseflow separation index (BFI) and SWAT baseflow separator were applied. For the Berze River, surface runoff (Q_s) and runoff through drainage pipes (Q_{dr}) are referred to be two components of quick response while the remaining part contributes to groundwater runoff (Q_{gw}) as slow response. For the drainage field, similar approach was used where the components of quick and slow flow response were assumed to be the surface runoff and runoff through drainage pipes, respectively.

An alternative method was developed to quantity different runoff components. This method was based on following equation: $Q = a \times e^{b \times GWT} - c = f(GWT)$, where a, b, and c are values adjusted, while e is an exponential constant. For this method additional groundwater table data sets covering the period of 2006 to 2014 was applied. For the Berze River it was assumed that groundwater runoff and runoff through drainage pipes corresponds to $f(GWT)$. For the drainage field, only the component of runoff through drainage pipes can be characterized as $f(GWT)$. The contribution of surface runoff for both the Berze River and drainage field can be reflected as fallows $Q_s = Q_{obs} - f(GWT)$.

The component of runoff through drainage pipes was upscaled as fallows $Q_{dr\_River} = Q_{dr\_Drainage} \times F_{dr}$, where F_{dr} is a fraction of the Berze River basin where subsurface drainage systems are installed. The results indicated that the contribution of groundwater runoff, runoff through drainage pipes and surface runoff at the outlet of the Berze River varied between 43.7% and 61.9%, 18.8% and 22.2%, 18.8% and 36.1%, respectively

Keywords: Drainage field; Groundwater table; Components of river runoff; Digital filters; Measurements upscale

RISK ASSESSMENT FOR URBAN AREAS PRONE TO FLOODING AND SUBSIDENCE

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ABSTRACT

One of the goals for the JPI Water funded project INovations for eXtreme Climatic Events (INXCES) is to provide risk assessment tools for urban hydro-climatic events. Combining disciplines increases the capacity to manage and improve the mitigation of the infrastructure for stormwater in urban areas. INXCES is an European collaboration among the cites Bergen, NO, Groningen, NL, Bucharest, RO, and Luleå, SE.

In urban areas infrastructure, such as sewage and drainage systems, is installed in the subsurface to cope with surface water and stormwater runoff. However, the natural patterns are preferred hence human effort. A flood model using Digital Elevation Model (DEM) show the flow patterns of stormwater and areas exposed to flooding. Combining mapping of natural flow paths and flood modelling, areas prone to flooding is accentuated. The subsurface infrastructure in these prone areas are exposed to larger quantities of water during heavy rainfall events, which is becoming more frequent due to climate change. Results from this interdisciplinary study, will give the water and wastewater authority a risk assessment to pinpoint areas where water infrastructure is more exposed to failure, clogging and damages.

Furthermore, we argue that areas that are prone to repeated flooding are more exposed for subsidence in the ground. Larger movement in the ground will cause damage to the infrastructure, such as cracking of pipelines and damage to buildings, roads etc. By combining results mentioned above with subsidence data (InSAR date collected from Satellites), a risk assessment map can show areas to prioritize. Subsurface measures such as SUDS (Sustainable Urban Drainage Systems) can be a resilient solution to a recurrent problem in an urban area, as a remediation to flooding (and drought) and as stabilisation of ground conditions.

Keywords: Flood model; Subsidence; Natural flow path; Risk assessment; Flood resilience; INXCES

MODELLING PAST AND PRESENT CLIMATE OF SVALBARD BY DOWNSCALED REANALYSES

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ABSTRACT

The network of weather stations observing temperature and precipitation in the Svalbard region is sparse. Most of the stations are located at the west-coast, and at low altitudes. The biased location and limited number of stations is not sufficient to provide a representative description of temperature and precipitation over the entire Svalbard archipelago. Measuring correct precipitation is also challenging at Svalbard, due to strong winds, drifting and blowing snow, responsible for considerable undercatch, especially of solid precipitation. With the aim of obtaining a more consistent climate description covering all parts of Svalbard, we therefore use an existing 1x1 km dataset, derived from downscaling the ERA40/ERA Interim reanalyses.

In this study, we present an analysis of past and present climate at Svalbard for the period 1957 until present. The analysis includes climatological maps of annual and seasonal mean temperature and precipitation for the period 1971-2000 as well as a description of the temperature and precipitation development since 1957 at selected locations. The reanalyses dataset is evaluated against observed temperature and precipitation at the individual stations. The results of this study will further be used in the report “Climate of Svalbard 2100” which is currently compiled by the Norwegian Centre for Climate Services. The dataset will there also be used as a basis for hydrological modelling.

Keywords: Svalbard, Climate; Past; Present; Temperature; Precipitation; Reanalyses

PREDICTIVE MODELLING OF URBAN WATER CONSUMPTION

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ABSTRACT

Domestic water demand emerged as an important focus for scientific research since the 1950s. The initial studies were applied to Anglo-Saxon cities with the main objective of developing deterministic econometric models. These models assessed the elasticity and inelasticity of the water demand according to the price, but could also include other variables related to sociodemographic and climatic characteristics. More recently, other variables associated to water demand, such as territorial, demographic, environmental or technological factors, have been incorporated to improve planning and supply management. These new empirical approaches aimed at establishing an association between water consumption and a set of explanatory variables, using a large number of observations and classical statistical methods, (i.e. multiple linear regression or geographically weighted regression). However, these methods were constrained by the need of data linearity and normality.

This work shows the application of a machine learning method to the modelling of water demand for the first time. Regression trees (RT), a multivariate, spatially non-stationary and non-linear machine learning approach, was used to build a predictive model of water demand at the city of Sevilla census tracts. The RT model was fitted to the relationship between the annual water demand and numerous explanatory variables related to socio-demographics and urban aspects. RTs allowed estimation of water demand with an error of 22 l and determination of the main driving variables. This research, thus, shows an alternative to the hitherto applied cluster and linear regression approaches for modelling water demand and paves the way for a new set of further scientific investigations based on machine learning methods.

Keywords: Water consumption; Census tract; Machine learning; Regression trees

COMPARING TEMPORAL AND SPATIAL VARIABILITY OF UNCERTAINTY SOURCES FOR FUTURE RUNOFF PROJECTIONS IN UNGAUGED REGIONS

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ABSTRACT

The topic of uncertainty quantification, understanding and reduction has attracted intensive attentions for climate change and hydrological impact studies in recent decades. Several uncertainty sources have been investigated, like climate models, greenhouse gas emission scenarios, downscaling methods, and hydrological models. In previous studies, the climate model is considered as the main contributor of the uncertainty in most cases. However, the contribution of uncertainty sources varies with time and space, and there is no consistent and comprehensive conclusion about the temporal and spatial uncertainty pattern or characteristics. Furthermore, previous works have seldom investigated the uncertainty sources of future runoff projections in ungauged basins, which use the regionalization methods to estimate the model parameters. Aiming to fill this gap, this study will estimate the uncertainty contributions for runoff projections in ungauged basins, which includes the regionalization methods as another source of uncertainty, together with climate models and hydrological models. In this study, we will apply three climate models, three hydrological models and three regionalization methods to simulate the runoff projections from 2006 to 2100 for 108 catchments in five different runoff regimes in Norway, which makes it possible to evaluate the temporal and spatial differences. Then, variance decomposition methods will be applied to quantify the uncertainties in the runoff projections. This work will help hydrologists and water managers to understand the role of regionalization methods for runoff projections in ungauged basins, compared with other sources of uncertainties.

Keywords: Uncertainty analysis; Climate change; Hydrological models; Regionalization; Temporal and spatial variability

THE STUDY ON DECISION INDEX SYSTEM OF COLLABORATIVE OPTIMIZATION DESIGN WITH GREENLAND AND THE RAINWATER SYSTEM IN THE VIEW OF SPONGE CITY

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ABSTRACT

With the rapidly development of sponge city, the urban greenland and the rainwater system are the important aspects of the construction. In this study, through literature review of the papers with the key words of stormwater management, ecological city, ecological landscape, rainwater pipe network and engineering decision, decision indexes and integration, the first index-system was built, then research the specific goal under the first index-system, through three times of the experts consultation, the final decision index-system was built. The research method can be applied in many related fields, and the results of the study has practical significance and guide the practice or the future studying.

Keywords: Decision index; Sustainable stormwater management; Rainwater system; Collaborative optimization

SPATIO-TEMPORAL CONSISTENT POST-PROCESSING OF DAILY MEAN TEMPERATURE PROJECTIONS - APPLICATION IN TRØNDELAG OF NORWAY

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ABSTRACT

In many applications, coarse-resolution climate projections need to be downscaled to a finer spatial resolution. However, current approaches are unable to model the sub-grid spatio-temporal variability, and thus cannot correct the possible biases in spatial and/or temporal structure of the climate projections. We propose a procedure that carries out bias correction and downscaling in two steps. In the first step, we identify and correct the biases at model scale. We upscale gridded observations to the grid of the climate model. We then correct the errors in the first two moments that relate to spatial features such as latitude, longitude and elevation, as well as the errors in the linear trend and seasonality. In the second step, we model the spatio-temporal residual variability at observation scale using a statistical model. With this model, we can draw a set of pseudo-observations and use these as a base to stochastically downscale the bias-corrected climate projections from the first step to the observation scale.

We employed the daily mean surface temperature projections from two EUR11 CORDEX data sets based on different GCM-RCM combinations, and the gridded observation data set (SeNorge version 2.1) at 1×1 km resolution. We applied the method to data from Trøndelag, a region in the central part of Norway. We estimated the statistical models in the control period from 1970 to 2005, and produced adjusted projections at a resolution of 1×1 km from 2065 to 2100. We found that compared to empirical quantile mapping, the proposed method generates results that have more consistency in space and time.

Keywords: Post-processing; Spatio-temporal consistency; Statistical downscaling

CROWDSOURCING AND ONLINE APP IN URBAN FLOOD MANAGEMENT

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ABSTRACT

A common and huge challenge in risk and disaster management such as urban flood is the lack of effective communication, especially instant communication from the general public when sudden flooding occurs. There is a strong need to facilitate complementary risk management for authorities to communication with public in addition to mainstream channels. In a recent international project, possibility of using crowdsourcing combined with online App for public early warning system was evaluated. Taking into account of technical, juridical and, to some extent, economical concerns, the study was implemented with following components: 1) user requirements and data integrity analysis; 2) market analysis with main focus on three pilot countries: Sweden, Denmark and France with online and paper- based interviews and workshops; 3) user needs and analysis based on interviews and meetings with stakeholders; 4) country comparison study to identify the similarities and differences between the three countries; 5) final analysis on the outcome of the project and the future outlook with recommendations. Results showed that a smart tool for the stakeholders including public (general citizens), service providers, authorities, municipalities as well as academies is very much appreciated. It should enable multi-direction information flow and dissemination: given by citizens directly on the app already available on social media and given by authorities on their official and non-official channels. It should have functions to help citizens to be warned when a flood is going to happen, explain behaviour to adopt, communicate with loved ones about their situation, help authorities to gather understandable information on online map tool, communicate vital information to citizens through online tools and communicate to the key participants via most effective way available.

Keywords: Urban flood communication; Crowdsourcing; Online App; Flood warning system

SPATIOTEMPORAL VARIATIONS OF EXTREME PRECIPITATION AND THEIR CONNECTION TO ELEVATION OVER SICHUAN BASIN, CHINA

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ABSTRACT

In recent decades, extreme precipitation events have attracted the attention of many scholars. Based on daily precipitation records at 34 meteorological stations over Sichuan Basin, the spatiotemporal variations of 10 extreme precipitation indices during 1961–2016 were investigated. The results showed that Sichuan Basin, central-western China, can be clustered into three homogenous sub-regions via the K-means method based on latitude, longitude and elevation. From sub-region 1 to sub-region 3, the elevation decreased gradually. In Sichuan Basin, most indices (except extreme very-wet day (R99), maximum 1-day precipitation (RX1day) and simple daily intensity index (SDII)) showed decreasing trends, but only consecutive wet days (CWD) was statistically significant. In terms of sub-regions, only consecutive dry day (CDD) showed an insignificant decreasing trend, all other indices insignificantly increased in sub- region 1; only CWD and maximum 5-day precipitation (RX5day) exhibited decreasing trends in sub-region 2; while most indices (except SDII) showed decreasing trends in sub-region 3. Precipitation extremes were sensitive to changing environments, and the assumption of stationarity of extreme precipitation in the Sichuan Basin was invalid, especially in sub-region 2 and sub-region 3. Except CDD, the trends of most extreme indices showed positive correlations with the elevations. Additionally, the correlations between elevations and the magnitudes of the trends in number of moderate precipitation days (R10mm), very wet day (R95) and wet-day precipitation (PRCPTOT) were statistically significant. On the whole, the upward trend of precipitation was relatively prominent at higher elevations, while the downward trend was more prevalent at low elevation stations. The results of this study are useful to master the change rule of local precipitation extremes, which will help for water resources management and disaster prevention and control.

Keywords: Extreme precipitation; Sichuan Basin; Elevation

COMBINING MULTI-MODEL AND MULTI-MEMBER ENSEMBLES TO ESTIMATE TEMPORAL-SPATIAL VARIATION OF CLIMATE CHANGE UNCERTAINTIES FOR CHINA

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ABSTRACT

Internal climate variability (V), climate model and greenhouse gas (GHG) emission are three main sources for climate change uncertainty. Three uncertainties are usually estimated for studying their relative importance. Uncertainties of climate model response (M) and GHG emission (S) are consistently estimated as a spread of climate changes using multi-model ensembles under multi-scenario in general literature. However, there is less agreement in estimating V. Recently, a multi-member ensemble (MME) has been developed to study V in climate change impacts. MME is produced by driving a climate model under a same emission scenario but with multiple initializations. Inter-member difference manifests V. Combining multi-model and multi-member ensembles, this study investigated relative importance of three uncertainties for temperature and precipitation projections and its temporal-spatial variation over the 21st century in China. Prior to investigating the temporal-spatial variation, their relative importance based on V estimated by MME was compared to that estimated by multi-model individual time series at national scale. Results show that V from MME is qualitatively similar to that from multi-model individual time series. MME method may be more reliable in reflecting temporal evolution of V in a centurial horizon. V and M dominate total uncertainty before 2050s, particularly for precipitation. S is dominant in late 21st century as 60%-80% of total uncertainty especially for temperature. Mean temperature change is projected to be greater than its total uncertainty before 2050s, while its total uncertainty becomes greater thereafter. Both annual precipitation and extreme precipitation changes are less than their total uncertainties throughout this century. Cold regions tend to have great mean temperature change uncertainties, e.g. northern China and the Tibetan Plateau. Regions with arid climate tend to have great uncertainties for annual precipitation and extreme precipitation changes, e.g. northwest China. Some region with most precipitation is also great in V like southernmost China.

Keywords: Climate change; Uncertainty; Internal climate variability; Global climate model; Greenhouse gases emissions scenario; China

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