Norwegian Hydrological Council

Program

5th Conference on Modelling Hydrology, Climate and Land Surface Processes

17.-19. September 2019

Lillehammer, Norway

Norwegian Meteorological Institute

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Tuesday 17.September

10:30-	Registration	
11:30-12:45	Lunch	
13:00-13:15	Opening of the 5th conference on modelling Hydrology, Climate and Land Surface Processes	Ole Einar Tveito chair of the organizing committee Hege Hisdal chair of the Norwegian Hydrological Council
Session 1: Water Cycle extremes		*Chair: Hege Hisdal*
13:15-14:00	**Key note: Hydro-climatic extremes in a changing environment**	Lena M. Tallaksen Department of Geosciences, University of Oslo, Oslo, Norway
14:00-14:20	The Water Cycle Extremes in Cold Climate: A case study of Latvia	Inga Grinfelde, Anda Bakute Latvia university of life sciences and technology
14:20-14:40	Constructing and simulating a rain-on-snow climatology for Norway	Pardeep Pall, Jean Iaquinta, Lena Tallaksen, Frode Stordal University of Oslo, Department of Geosciences
14:40-15:00	Applying NWP-ensembles to identify different large scale setups for analyzing local extreme precipitation	Karianne Ødemark, Ole Einar Tveito, Malte Müller MET Norway
15:00-15:30	*Coffee break*	
Session 1: Water Cycle extremes (cont.)		*Chair: Nils-Otto Kitterød*
15:30-16:15	**Key note: TBA**	Etienne Leblois Irstea, Lyon, France
16:15-16:35	Subsurface-state equals runoff ? – it depends	Thomas Skaugen, Søren Boje, Knut Møen, and Anne Ellekjær Stavang 1Hydrology Department, Norwegian Water resources and Energy Directorate;2Norwegian University for Life Sciences
16:35-16:55	Analysis on the added value of accounting for slope/aspect and shading effects in hydrologic simulations	Olga Silantyeva1, Lena M. Tallaksen1, John F. Burkhart1,3, Ola Skavhaug2, Sigbjørn Helset3 1 University of Oslo, 2 Expert Analytics AS, 3 Statkraft AS
16:55-17:15	seNorge_2018 observational gridded datasets over Norway	Cristian Lussana, Ole Einar Tveito, Ketil Tunheim Norwegian Meteorological Institute, Oslo, Norway

Tuesday 17.September (cont.)

17:15-17:45	Introduction to the poster session (short max. 2 min presentations of the posters)
17:45-19:00	Poster session with drinks
19:30-	Dinner

Wednesday 18.September

Session 1: Water Cycle extremes (cont.)		*Chair: Oddbjørn Bruland*
09:00-09:20	Direct statistical downscaling of monthly discharge from atmospheric variables in catchments with differing contributions from snowmelt	Shaochun Huang 1, Deborah Lawrence 1, and Irene Brox Nilsen 1,2 1 Norwegian Water Resources and Energy Directorate (NVE), Oslo, Norway, 2 Norwegian Centre for Climate Services
09:20-09:40	Characteristics of winter warming events and the influence of such events on the ground surface temperature along alpine environmental gradients in southern Norway	Rune Strand Ødegård 1), Ketil Isaksen 2) and Cristian Lussana 2) 1)Norwegian University of Science and Technology and 2)Norwegian Meteorological Institute
Session 2: From modelling to decisions		*Chair: Oddbjørn Bruland*
09:40-10:25	**Key-note: Addressing the usability gap: critical challenges in transitioning from research to services and applications**	Stefan Sobolowski NORCE Norwegian Research Centre, Bjerknes Centre for Climate Research
10:25-10:45	What could the consequences of extreme rainfall be in Oslo?	Julia Kvitsjøen, Tharan Fergus The Agency for Water and Wastewater Services, City of Oslo; Faculty of Science and Technology, Norwegian University of Life Sciences
10:45-11:15		Coffee break
Session 2: From modelling to decisions (cont.)		*Chair: Asgeir Sorteberg*
11:15-11:35	Impact of different parameterizations of potential evapotranspiration on estimation of hydrological drought duration in a changing climate	Wai Kwok Wong1, Shaochun Huang1, Stephanie Eisner2, Stein Beldring1 1 The Norwegian Water Resources and Energy Directorate (NVE), P.O. Box 5091, Majorstua, 0301 Oslo, Norway 2 Norwegian Institute of Bioeconomy Research (NIBIO), P.O. Box 115, 1431 Ås, Norway
11:35-11:55	A statistical technique for designing the lowest navigable water level under changing environment	Lu Wang, Ping Xie, Chongyu Xu State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan, China; Department of Geosciences, University of Oslo, Oslo, Norway

Wednesday 18.September (cont.)

11:55-12:15	Improving long-term hydropower inflow forecasts by assimilating snow data	Felix Matt (1), Jan Magnusson (1), Geir Nævdal (2), Adam Winstral (3), John F. Burkhart (4) 1) Statkrat AS, 2) NORCE, 3) SLF, 4) University of Oslo
12:15-13:30	*Lunch*	

Session 2: From modelling to decisions (cont.)		*Chair: Asgeir Sorteberg*
13:30-14:15	**Key note: High impact environmental events, the role of Earth System modelling**	Øystein Hov The Norwegian Academy of Science and Letters/Norwegian Meteorological Institute
14:15-14:35	Integrated assessment of the impacts of, and interactions between climate, land use and the hydrological cycle	Stein Beldring1, Stephanie Eisner2, Shaochun Huang1, Jan Magnusson1, Rasmus Astrup2, Wai Kwok Wong1 1. Norwegian Water Resources and Energy Directorate, P.O. Box 5091, Majorstua, 0301 Oslo, Norway. 2. Norwegian Institute of Bioeconomy Research, P.O. Box 115, 1431 Ås, Norway
14:35-14:55	Impacts of weighting global climate models on quantifying hydrological responses to climate change	Hui-Min Wang, Jie Chen, Chong-Yu Xu, Hua Chen, Xiangquan Li State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan, China; Department of Geosciences, University of Oslo, Oslo, Norway
14:55-15:15	Lake temperature and global warming	Sverre Anmarkrud1, Alemayehu Adugna Arara2, Anne Kværnø3, and Nils-Otto Kitterød1 1) Norwegian University for Life Sciences, 2) Hawassa University, Ethiopia, 3) Norwegian University of Science and Technology
15:15-15:45	*Coffee break*	
15:45-18:00	*Excursion/guided tour along river Mesna*	
19:30	***Conference dinner***	

Thursday 19.September

Session 3: Learning from environmental data: from field observations to machine learning (cont.)		*Chair: Jan Magnusson*
09:00-09:45	**Key-note: Exploring Landscapes and Ecosystems by Studying their Streams**	James Kirchner ETH, Zürich, Switzerland
09:45-10:05	The rain check	Rasmus E. Benestad, Abdelkader Mezghani, Kajsa M. Parding, Helene B. Erlandsen The Norwegian Meteorological Institute
10:05-10:25	New short-range weather forecast products improved by citizen observations	Cristian Lussana, Thomas Nipen, Ivar Seierstad, and Christoffer Elo Norwegian Meteorology Institute
10:25-10:45	Novel framework for merging radar and gauge precipitation in cold climates	Kuganesan Sivasubramaniam, Knut Alfredsen, Ashish Sharma Norwegian University of Science and Technology (NTNU), Norway and University of New South Wales (UNSW), Australia
10:45-11:15	*Coffee break*	

Session 3: Learning from environmental data: from field observations to machine learning (cont.)		*Chair: Jan Magnusson*
11:15-11:35	High-frequency satellite radiation data as input to hydrological modelling	Sjur Kolberg Enki hydrologi
11:35-11:55	The isotopic state of the Norwegian snow pack during the Easter week 2019 - results from a citizen science experiment	Harald Sodemann (1) and Mika Lanzky (2) 1) Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, (2) Department of Geosciences, University of Oslo
11:55-12:15	On the use of an explicit snow scheme in numerical weather prediction and operational snow mapping	Trygve Aspelien, Mariken Homleid, Tuomo Mikael Saloranta MET-Norway, NVE
12:15-13:30	*Lunch*	

Session 3: Learning from environmental data: from field observations to machine learning (cont.)		*Chair: Ole Einar Tveito*
13:30-13:50	Application of machine learning emulators in parameter identification for a distributed hydrological model	Aynom T. Teweldebrhan, John F. Burkhart, and Thomas V. Schuler Department of Geosciences, University of Oslo
13:50-14:10	Nowcasting precipitation by Random Forest	Yiwen Mao, Asgeir Sorteberg, Ivar Ambjørn Seierstad, Thomas Nils Nipen University of Bergen
14:15-14:45	Discussion, final remarks, closing the conference.	

Train to Oslo/Oslo Airport 15:07 ***Train to Trondheim 16:11***

Posters

Combining streamflow time series, historical information and paleodata in statistical flood frequency analysis – a case study from the Glomma river in Norway
Kolbjørn Engeland (1), Eivind Støren (2), Anna Aano (1)
(1) (NVE), Oslo, Norway , (2) Department of Earth Science and Bjerknes Centre for Climate Research, University of Bergen, Norway

An event based evaluation framework for hydrological ensemble forecasts
Elin Langsholt and Gusong Ruan

Moisture sources and isotope signatures of snow and water vapour at the Norwegian mountain station Finse (1222m)
Mika Lanzky (1), Alexandra Touzeau (2), Harald Sodemann (2), Simon Filhol (1), Sven Decker (1) and John Burkhart (1)
The Norwegian Water Resources and Energy Directorate

Estimating likely changes in peak flow magnitudes in small catchments under a future climate
D. Lawrence (1) , Ó. Rognvaldsson (2), T. Skaugen (1), A. Sorteberg (2), W. K. Wong (1)
(1) Hydrology Department, Norwegian Water Resources and Energy Directorate (NVE), Oslo, Norway (2) Geophysical Institute, University of Bergen, Bergen, Norway

From large-scale atmospheric circulation to flooding in Norway: Using machine learning to infer non-stationarity
Jenny Sjåstad Hagen (1,2), Asgeir Sorteberg (1,2), Deborah Lawrence (3), Jostein Bakke (2,4), Dimitri Solomatine (5)
1. University of Bergen, Geophysical Institute, Bergen, Norway. 2. Bjerknes Centre for Climate Research, Bergen, Norway. 3. Norwegian Water Resources and Energy Directorate, Hydrology Department, Oslo, Norway. 4. University of Bergen, Department of Earth Science, Bergen, Norway

The 2018 Northern Europe Hydrological Drought and its Drivers in a Historical Perspective
Sigrid J. Bakke, Monica Ionita, Lena M. Tallaksen
University of Oslo

Hydrological Modelling of a Steep Norwegian Catchment using SHyFT
Nitesh Godara & Oddbjørn Bruland
Norwegian University of Science and Technology

Runoff modelling on arable land
Anne Ellekjær Stavang, Ståle Leif Haaland, Nils-Otto Kitterød, Thomas Skaugen
Norwegian University of Life Sciences, Environmental Sciences and Natural Resource, NVE

Assessment of the water and energy balance simulations of CTSM using satellite-based observations over Scandinavia
Yeliz A. Yilmaz, Lena M. Tallaksen, Frode Stordal
Department of Geosciences, University of Oslo, Oslo, Norway

The effects of wind on lake stratification – A stochastic approach
Sverre Anmarkrud1), Alemayehu Adugna Arara2), Anne Kværnø3), and Nils-Otto Kitterød1)
1) Norwegian University for Life Sciences, 2) Hawassa University, Ethiopia, 3) Norwegian University of Science and Technology

Abstracts

Tuesday 17.Sep 13:15

Hydro-climatic extremes in a changing environment

Lena M. Tallaksen

Department of Geosciences, University of Oslo, Oslo, Norway

l.m.tallaksen@geo.uio.no

Abstract

Hydro-climatic extremes occur on different spatial and temporal scales, ranging from local, short term events, such as heavy storms and flash floods, to large-scale (regional to continental scale) long duration (weeks to years) events, such as drought and heat waves. Extremes affect every aspect of our society and to meet the societal need for preparedness and disaster management, the research community is challenged by underlying, critical science questions, including the need for improved knowledge on governing processes. A warming climate has already led to changes in the water cycle and there is overwhelming evidence that not only the mean state is changing, but that climate is also becoming more variable; that is there is an increase in inter-annual variability as well as in the frequency and nature of extremes (IPCC 2013). The effect of climate extremes is not necessarily linear and small changes in climate may produce large changes in impact severity. In addition, compound events, here defined as the combination of multiple drivers (e.g. rain-on-snow or dry-and-hot) as well as multi-scale events (e.g. clustering of events in space or time that are not necessary extreme themselves, such as two wet or dry years), may produce a cumulative effect leading to extreme impacts and hazards not previously observed. As stated in the 5th IPCC report “series of combined risk” may cause unusually extreme events leading to unexpected impacts on society, ecology and economy. Recent examples from Norway include more frequent and heavy rainfall extremes and associated flooding and landslides (western and northern Norway; 2014, 2015), extreme warm and dry winter conditions causing devastating wild fires (western Norway; January 2014), and extreme drought and related heat waves (Scandinavia; summer 2018). Events like these may be a warning of what we can expect more of in the future and that we are less prepared for given our current knowledge and management practice. In this presentation focus is on the main drivers and governing processes of extreme (compound) events in Europe - and Norway in particular - their characteristics and wider environmental and societal impacts as illustrated by recent examples.

Tuesday 17.Sep 14:00

The Water Cycle Extremes in Cold Climate: A case study of Latvia

Inga Grinfelde, Anda Bakute

Latvia university of life sciences and technology

inga.grinfelde@llu.lv

Abstract

At the beginning of the 21st century, the extremes event occur more often. The cause of hydrological extremes is climate change and change of land use as well as management of the catchment area. In Latvia, several droughts and flood events occur with increasing frequency. The aim of this study is to evaluate the simultaneous and sequential occurrence of droughts and floods and the interaction of land use change and catchment area management practice. Three catchments are analysed in this study to evaluate three extreme events scenarios. The climate data are used with extremes from 2000 till 2018. The conceptual model METQ were used to calculate hydrological components of three extreme events scenarios for each catchment. The results show strong evidence of extreme droughts long term impact on groundwater levels.

Tuesday 17.Sep 14:20

Constructing and simulating a rain-on-snow climatology for Norway

Pardeep Pall, Jean Iaquinta, Lena Tallaksen, Frode Stordal

University of Oslo, Department of Geosciences

pardeep.pall@geo.uio.no

Abstract

Rain-on-snow (ROS) events are multivariate hydrometeorological phenomena requiring a combination of rain and snowpack, with complex processes occurring on and within the snowpack. Impacts include floods and landslides, and rain may freeze within the snowpack or on bare ground, potentially affecting vegetation, wildlife, and permafrost. ROS events occur mainly in high-latitude and mountainous areas, where sparse observational networks hinder accurate quantification – as does a scale mismatch between coarse (50-100 km) resolution re-analysis products and localised events. A recent study (Pall et al., submitted; available at: https://eartharxiv.org/k72ej/) uses a high (1km) resolution observational data set for mainland Norway to construct a ROS climatology for recent decades. Its main result is that, compared to 1961-1990, ROS events in the 1981-2010 period decrease most in the southwest in winter, southeast in spring, and north in summer (consistent with less snow cover in a warming climate), and increase most in the southwest, southern mountains, and north in winter-spring (consistent with increased precipitation and/or more snow falling as rain in a warming climate). The pattern of ROS winter-spring events also broadly correlated with the North Atlantic Oscillation, and the Scandinavia pattern – and more so with the Arctic Oscillation, particularly in the southern mountainregion where long-term ROS trends are significant. Here we investigate this result further, by using a high-resolution climate model to simulate a Norwegian ROS climatology and evaluate it against the aforementioned observed climatology (1981-2010). Using insights from the evaluation, simulations for a future period (2070-2100; under the IPCC RCP8.5) will also be performed. A particular focus is on the connection between large-scale meteorology and local ROS events. This work forms a contribution to the LATICE (Land-ATmosphere Interactions in Cold Environments) and EMERALD (Terrestrial ecosystem-climate interactions of our EMERALD planet) projects at the University of Oslo.

Tuesday 17.Sep 14:40

Applying NWP-ensembles to identify different large scale setups for analyzing local extreme precipitation

Karianne Ødemark, Ole Einar Tveito, Malte Müller

MET Norway

karianneo@met.no

Abstract

When designing water management infrastructure, such as dams, an assessment of the theoretically maximum probable precipitation (PMP) is necessary. The currently applied approach in Norway is time consuming and the results are influenced by subjective judgements. The most recent World Meteorological Organization manual for estimation of PMP recommends to apply physically based atmospheric models, especially for areas where orographic precipitation is significant.

Ohara et al. (2011) studied probable maximum precipitation for a catchment in California and applied a regional scale high resolution physical atmospheric model, where the boundary and initial conditions where altered to maximize precipitation. How to best set up a model system for providing these estimates is a challenge, and any guidelines for this is currently not established.

This study applies a similar approach where instead of manipulating the initial and boundary conditions we make use of ensembles. We utilize a physical numerical model chain all the way from a global climate model down to catchment scale by downscaling the global model output with a regional forecast model. 30 years model run of present day climate from the Ec-Earth model is used to find the most extreme precipitation event which in turn is perturbed to get an ensemble of 10 plausible extreme precipitation realizations. The 10 ensembles are then downscaled with the regional model AROME, Met-Norway's operational weather forecast model, to a resolution of 2.5 x 2.5 km.

This approach yields a maximization of precipitation over a selected area, in a physically consistent and balanced way. We look at maximized precipitation values aggregated over several days, and the relatively large differences between ensemble members on catchment scale caused by small differences on larger (synoptic) scale. Special focus is on the variations in the large scale moisture flow in the climate model, which serves as input values for AROME, and thus what is the state at the domain boundary for the regional model. The placement of moisture flux at the boundaries provides locally quite different precipitation values in the western area of Norway, as well as differences in the time evaluation of the precipitation event.

Tuesday 17.Sep 15:30

TBA

Etienne Leblois

Irstea, Lyon France

etienne.leblois@irstea.fr

Abstract

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Tuesday 17.Sep 16:15

Subsurface-state equals runoff ? – it depends

Thomas Skaugen, Søren Boje, Knut Møen, and Anne Ellekjær Stavang

1Hydrology Department, Norwegian Water resources and Energy Directorate;2Norwegian University for Life Sciences

ths@nve.no

Abstract

In most model concepts in hydrology, there is a direct link between state of the subsurface and runoff. In a simple bucket model, the intrinsic idea is that the higher water level, the higher the runoff. Such a bucket has an exponential recession curve. A corollary of the bucket model is that recession should inform uniquely of subsurface states; a high difference between subsequent runoff values implies high storage and a small difference implies small storage. For several Norwegian catchments, we can observe a clear relationship between runoff (Q) and a recession characteristic, $\Lambda=\log(Q(t))-\log(Q(t+\Delta t))$.The Distance Distribution Dynamics (DDD) model relies on this relation for estimating subsurface celerities and subsurface reservoir capacity. However, there are many examples where this relationship is not so clear and increasingly so for smaller catchments and high temporal resolutions. Groundwater modellers provide convincing cases against the concept that groundwater discharge is described by a single-valued function of storage. At the tiny research plot (0.0075 km2) Muren, in Bærumsmarka, southern Norway, we are able to test the basis for such a concept with state of the art runoff measurements and numerous (25 boreholes) groundwater measurements. At Muren it has proven very difficult to establish a relationship between the recession characteristic Λ and runoff measured at 15, 30, 60 minutes temporal resolution. Using the groundwater measurements, we are able to obtain an estimate of the catchment scale subsurface storage at high temporal resolution and investigate the relationship between subsurface storage and runoff. This is ongoing work and we look forward to present, for the first time the temporal distribution of catchment scale subsurface storage and evidence (or not) of hysteresis.

Tuesday 17.Sep 16:35

Analysis on the added value of accounting for slope/aspect and shading effects in hydrologic simulations

Olga Silantyeva1, Lena M. Tallaksen1, John F. Burkhart1,3, Ola Skavhaug2, Sigbjørn Helset3
1 University of Oslo, 2 Expert Analytics AS, 3 Statkraft AS

olga.silantyeva@geo.uio.no

Abstract
Radiation flux is a major component of earth's energy balance. It is the driving factor for various processes withing the earth's atmosphere and surface. However, the precise measurement of insolation is still subject to errors due to number of effects such as clouds and terrain shading. At regional scale the main issues is the existence and quality of radiation measurements in mountainous areas. The observational errors typically propagate through simulations leading to less accurate predictions of events such as snowmelt.
We further develop SHyFT framework (https://github.com/statkraft/shyft), which is an operational tool for distributed hydrologic modeling. Our current progress accounts for terrain topography. The new part of the tool allows detailed capture of topography and simulates slope/aspect and shad- ing effects. The radiation flux is translated onto inclined surfaces based on the method developed by [Allen et al., 2006]. The shading effects are added as a part of new triangulation tool (https://github.com/expertanalytics/rasputin).
We expect that new functionality will help us investigate the hypothesis formulated in [Fan et al., 2019] that in energy-limited areas insolation contrast between sunny and shady slopes impacts water and vegetation. In order to conclude about the added value of the new methods at regional scale we are going to simulate number of local cases to asses impact on snowmelt and vegetation. The formulated results will be interesting for water planning in hydropower production as well as for weather predicting specialists.
This work is a part of LATICE (Land Atmosphere Interaction in Cold Environments) project at the University of Oslo.
References
Richard G. Allen, Ricardo Trezza, and Masahiro Tasumi. Analytical integrated functions for daily solar radiation on slopes. Agricultural and Forest Meteorology, 139:55–73, 2006.
Y. Fan et al. Hillslope hydrology in global change research and earth system modeling. Water Resources Research, 55(2), 2019.

Tuesday 17.Sep 16:55

seNorge_2018 observational gridded datasets over Norway

Cristian Lussana, Ole Einar Tveito, Ketil Tunheim

Norwegian Meteorological Institute, Oslo, Norway

cristianl@met.no

Abstract

seNorge_2018 is the newest member of the seNorge family of observational datasets that have been produced on a daily basis at the Norwegian Meteorological Institute (MET Norway) since 2002. The dataset includes: daily total precipitation; daily mean, minimum and maximum temperature for the Norwegian mainland covering the time period from 1957 to the present day. The fields are presented on a regular grid with 1 km of grid spacing. seNorge data are used for several applications in climatology, hydrology and meteorology and this version is the first to provide minimum and maximum daily temperatures.

seNorge_2018 is based on in-situ observations from the MET Norway's climate archive and the ECA&D dataset. The data are quality controlled both through automatic checks and by MET Norway staff. The gauge observations are adjusted for wind-induced undercatch, which is quite important in Norway.

This presentation focuses on the spatial interpolation methods for both temperature and precipitation. The two methods follow a similar approach, where the fields are first estimated over larger scales, subsequently we move to local scales. At the end, we aim at delivering the best (i.e., highest effective resolution) product for each day given its data density.

For temperature, the larger scales are represented through the blending of several local vertical temperature profiles. Then, an Optimal Interpolation (OI) scheme adjust for the local scales. The previous seNorge version was similar, though seNorge_2018 features minor modifications (e.g., land-area fraction is in the spatial structure function) and an improved parameter optimization procedure. The results show significant differences from the previous version, especially along the coastline and in data-sparse regions. Minimum daily temperature is the most challenging temperature variable to represent.

For precipitation, a successive correction algorithm has been implemented, which iterates OI over a sequence of decreasing spatial scales. With respect to previous versions, the innovative parts are: (i) the interpolation is performed over transformed data so as to better comply with the assumption of normality; (ii) a gridded adjustment factor is added to improve the interpolation performances in data-sparse regions. This factor is derived by processing a decade of precipitation data from a high-resolution numerical model.

seNorge_2018 performances are evaluated through cross-validation and also by comparing it with other precipitation datasets.

The dataset is available for public download at http://thredds.met.no/thredds/catalog/senorge/seNorge_2018/catalog.html

Tuesday 17.Sep 17:15

Poster pitching

Abstract

Wednesday 18.Sep 09:00

Direct statistical downscaling of monthly discharge from atmospheric variables in catchments with differing contributions from snowmelt

Shaochun Huang 1, Deborah Lawrence 1, and Irene Brox Nilsen 1,2

1 Norwegian Water Resources and Energy Directorate (NVE), Oslo, Norway, 2 Norwegian Centre for Climate Services

ibni@nve.no

Abstract

The climate–hydrological modelling chain, in which hydrological simulations are run based on adjusted time series derived from climate models, is the most widely used approach for assessing likely changes in catchment-scale hydrological processes under a future climate. This approach, however, has many drawbacks, including the large uncertainties introduced by the complex modelling components and their linkages and the considerable time and computational expense required for producing the required hydrological series. We are currently testing an alternative approach for estimating future changes in seasonal runoff by applying direct statistical models for monthly discharge using large-scale atmospheric variables. As it is unclear how suitable such an approach is for catchments in which streamflow is generated by snowmelt, due to the significant time lag between snow accumulation and melting, we have applied this direct downscaling method to 42 Norwegian catchments with runoff generation regimes ranging from largely snowmelt-driven to almost entirely rainfall-driven. We have also tested a range of possible combinations of approaches, focusing both on a) how to best include information pertaining to snow storage as it affects runoff; and 2) developing robust and parsimonious statistical models that are suitable for further use with climate change projections. Accordingly, the effects of five different groups of probable predictors, three moving windows, calibration periods of two different lengths, and six combinations of pre-processing and statistical models were tested for the 42 catchments.

The results indicate that a combination of 13 independent climate variables, together with their lagged information, and a 3-month moving window give good and robust model performances in both calibration and validation periods. The combination of techniques giving the overall best results consists of grid point interpolation for quantifying the potential predictors, Pearson correlation analysis to identify the most suitable predictors and the relevance vector machine (RVM) approach for developing the statistical model. A 31-year calibration period was found to be sufficient for training the statistical models for the catchments, relative to the longer period tested. Based on the best predictors and methods, monthly streamflow can be well reproduced for most of the catchments considered and give an overall median NSE (Nash-Sutcliffe efficiency) of 0.84 and PBIAS (percentage bias) of 0% in the calibration period and a median NSE of 0.66 and PBIAS of -8% in the validation period. Somewhat surprisingly, the best performance of the direct downscaling method is associated with snow-dominant catchments in inland regions. We also established that the use of lagged information on atmospheric variables gives better results than relying on the snow variables available in the reanalysis data. The direct downscaling models give the poorest results for rainfall-dominant catchments along the coast in western, mid- and northern Norway, and this is strongly correlated with the inter vs. the intra-annual variability in streamflow in these regions.

Overall the results indicate that the direct statistical downscaling approach represents a valuable alternative method for assessing seasonal streamflow from large-scale climate information in catchments in which snowmelt plays a significant role in runoff generation.

Wednesday 18.Sep 09:20

Characteristics of winter warming events and the influence of such events on the ground surface temperature along alpine environmental gradients in southern Norway

Rune Strand Ødegård 1), Ketil Isaksen 2) and Cristian Lussana 2)

1)Norwegian University of Science and Technology and 2)Norwegian Meteorological Institute

rune.oedegaard@ntnu.no

Abstract

The intensity and frequency of winter warming events have been analysed in an area of central southern Norway from the coast of Møre to the Swedish border. The most detailed studies have been made in Dovrefjell based on the meteorological stations Dombås (from 1868) and Fokstugu (from 1924). The whole area has been analysed based on seNorge datasets from 1957.

We have used five different climate indices to detect the occurrence of winter warming events following the suggestions of Vikhamar-Schuler et al. (2016). In addition we have used the Warm Spell Duration Index (WSDI). The winter season is defined as the months November–March. The results show a marked increase in the frequency and intensity of winter warming events during the last 30 years. The results from Dombås show a marked increase in events the last 30 years compared to the previous 120 years. There is also an increase in warm events with precipitation.

The response of the near ground surface temperatures (GST) to such events in permafrost and mountain areas is strongly modulated by snow cover, vegetation, soil type (mainly water content and porosity) and the amount of rain. Thus, the GST response at the dry and strongly wind-exposed ridges are of shorter duration and weaker than in snow bed sites with different soil types and more developed snow cover, vegetation cover and basal ground ice.

The results have been used to evaluate the impact on the ground surface temperature (GST) along alpine environmental gradients in the mountain areas of Stortussen, Kaldfonna, Kolla and Tron in southern Norway. We assess this by a gradient approach where the scientific activities are carried out in permanent plots (macro- and microplots, 10x10m and 1x1m respectively) located along three environmental gradients: 1) A regional coast - inland gradient, 2) A local elevation gradient along the mountain slopes and in different aspects and 3) A small-scale ridge - snow bed gradient. The study is part of the GLORIA project (Global Observation Research Initiative in Alpine Environments - www.gloria.ac.at).

Reference:

Vikhamar-Schuler D, Isaksen K, Haugen JE, Tømmervik H, Luks B, Schuler T, Bjerke J. 2016. Changes in winter warming events in the Nordic Arctic Region. Journal of Climate 29, doi: 10.1175/JCLI-D-15-0763.1

Wednesday 18.Sep 09:40

Addressing the usability gap: critical challenges in transitioning from research to services and applications

Stefan Sobolowski

NORCE Norwegian Research Centre, Bjerknes Centre for Climate Research

Abstract

Advances in computing power and improvements in our understanding of the coupled components of the earth system have translated into models with unprecedented detail, fidelity and predictive skill. For example, current state-of-the-art atmospheric models are able to explicitly represent fine scale convective processes and then couple to distributed hydrological models which output stream flow on scales of 10s to 100s of meters. And all this at sub-daily temporal resolutions needed capture the episodic nature of extreme events and for simulation periods that cover climate time scales (e.g. tens of years, allowing for computation of robust statistics. Yet what does this all mean for decision makers? Despite the push from governmental agencies, funding agencies and international organizations (e.g. WMO) towards operationalization of so-called climate services it appears at times that the gap between research and decision making has never been larger. In this talk, I will highlight some of the recent advances in convection permitting modeling and the implications these results have for water resource managers, hydropower providers and planners. I then juxtapose this with recent activities that have focused on bottom up development of climate services. This juxtaposition will illustrate just how far away we are from a direct link between research and actual decision-making. However, there is some cause for optimism as the gaps are now being identified and needs are clearer. For many decision makers the need is not the latest development in cutting edge research but rather a well-informed and effective interlocutor. The same goes for the scientist working in the other direction, attempting to discern “user needs”. A possible way forward with some concrete recommendations is outlined our experiences in Norway as a guide.

Wednesday 18.Sep 10:25

WHAT COULD THE CONSEQUENCES OF EXTREME RAINFALL BE IN OSLO?

Julia Kvitsjøen, Tharan Fergus

The Agency for Water and Wastewater Services, City of Oslo; Faculty of Science and Technology, Norwegian University of Life Sciences

julia.kvitsjoen@vav.oslo.kommune.no

Abstract

Several cities and towns in the Nordic countries have experienced urban floods with a different array of damages in recent years. The consequences of the potential damage of extreme precipitation in urban areas that have not experienced such events are often assessed and based on the lessons learned from "famous" flood events in neighbouring countries. It is especially the flooding in Copenhagen, Denmark in 2011 that has been used as a template for the qualitative assessment of potential damage. The question is whether the damages from Danish capital are representative and can be transferred to the rest of the Nordic urban areas, including Oslo?

Using qualitative methods based on incomplete data and from different geographical settings can lead to erroneous and discretionary results of the consequences of extreme events. This may provide the wrong background data for decision making and inadequate climate adaptation of urban areas and in the worst case, result in dramatic consequences for inhabitants. How can the estimation of potential damage become more attuned to local conditions? What is the alternative to the existing practice of sometimes indiscriminately copying others experiences?

This study is based on a quantitative analysis method that is expected to provide a more reliable data basis for the assessment of impacts from urban flooding than qualitative reviews. Two scenarios for urban flooding in Oslo have been carried out by charging the hydraulic models with extreme rainfall of the same size that caused flooding in Copenhagen 2.7.2011. The first scenario is run in MIKE FLOOD with main river course included in the model; the second scenario is carried out in MIKE 21 if ducts are out of service due to erosion. Results from hydraulic analyses were used as the basis for the calculation of a selection of economic impacts. Results shows that the consequences of an extreme event in Oslo will be significantly higher for both scenarios than suggested in the current decision making tools for city planning using experience and data from Copenhagen.

A significant disadvantage in using the quantitative method for assessing the consequences of urban flooding are the data requirements and need for specialised expertise in hydraulic modelling and economic analysis. These requirements can be particularly challenging for smaller settlements. This study has identified site-specific parameters in urban areas that affect the damage from urban flooding. These parameters can be used to categorise various urban areas and then use this information to improve the qualitative analyses of consequences from urban flooding in other urban settings.

Wednesday 18.Sep 11:15

Impact of different parameterizations of potential evapotranspiration on estimation of hydrological drought duration in a changing climate

Wai Kwok Wong1, Shaochun Huang1, Stephanie Eisner2, Stein Beldring1

1 The Norwegian Water Resources and Energy Directorate (NVE), P.O. Box 5091, Majorstua, 0301 Oslo, Norway 2 Norwegian Institute of Bioeconomy Research (NIBIO), P.O. Box 115, 1431 Ås, Norway

wkw@nve.no

Abstract

We examine the effects of two different parameterizations of potential evapotranspiration (Ep) on runoff projections in Norway simulated by the distributed, gridded version of the HBV model, with a focus on drought duration. The first Ep parameterization is solely a function of air temperature. As air temperature increases due to global warming, the Ep in the model increases accordingly. However, the effects of changes in other atmospheric climate variables, such as surface radiation, humudity and wind speed, likely play an important role on future estimate of Ep as well. The second approach which is based on Penman-Monteith formulation takes these into account. The HBV model with both parameterizations were calibrated and validated in the historical period using the SeNorge 2.1 precipitation and temperature data. For Penman-Monteith approach the additional climate data required were provided by the MTCLIM model. To study the impact of Ep on future runoff estimation, the HBV model was then forced with bias-adjusted precipitation and temperature fields of 1x1 km resolution derived from regional climate model outputs using empirical quantile mapping method. The threshold level method was used to select drought events for both present and future climates. Changes in runoff drought duration in summer were identified and compared.

Wednesday 18.Sep 11:35

A statistical technique for designing the lowest navigable water level under changing environment

Lu Wang, Ping Xie, Chongyu Xu

State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan, China; Department of Geosciences, University of Oslo, Oslo, Norway

c.y.xu@geo.uio.no

Abstract

The lowest navigable water level is the minimum water level that allows standard ships or fleets to navigate safely, which is usually designed by the synthetic duration curve method and the guaranteed rate frequency method. These two methods are both based on the assumption that the water level time series are stationary, i.e., the statistical parameters of the data series such as mean and variance do not change over time. However, changes in climate or the constructions of water infrastructure project appear to be altering the formation process of river water level obviously. As a result, water level conditions of different periods have become quite varied and the series have shown non-stationary characteristics.

To design the lowest navigable water level in a more reliable way under a changing environment, we propose a statistical technique based on hydrological component analysis to transform the original non-stationary series into stationary ones corresponding to different environmental conditions. First, deterministic components (including trends, jumps and periodicities) of the series should be detected and removed by using hydrological variation diagnostic system to gain stochastic components. The next step is to compose the stochastic component and the deterministic component under each certain environment to obtain reconstructed stationary series. At last, the lowest navigable water level is designed based on reconstructed series by using guaranteed rate-frequency method.

The application of the proposed technique was demonstrated in estimating the lowest navigable water level at Gaodao hydrological station located in Guangdong Province. Results show that the mean and variance of the water level series have an upward jump variation at 1999 and 2000, respectively. The lowest navigable water level at 95% guaranteed rate designed considering the non-stationarity of the data series is 1.98 meters higher than that designed under the past environment. For both navigation safety and economic reasons, it is necessary to adjust the lowest navigable water level at nearby river.

Acknowledgement: This presentation is supported by the UTFORSK project of the Norwegian Center for International Cooperation in Education (SIU) (UTF-2016-long-term/10024).

Wednesday 18.Sep 11:55

Improving long-term hydropower inflow forecasts by assimilating snow data

Felix Matt (1), Jan Magnusson (1), Geir Nævdal (2), Adam Winstral (3), John F. Burkhart (4)

1) Statkrat AS, 2) NORCE, 3) SLF, 4) University of Oslo

felix.matt@statkraft.com

Abstract

Accurate long-term forecasts of inflows to reservoirs are of vital importance for optimally planning hydropower production. In snow-rich regions, where the spring snowmelt is often the largest contributor to annual reservoir inflow, such forecasts may be improved by assimilating snow observations to achieve more accurate initial states for the hydrological models prior to the prognosis period. In this study, we test whether an ensemble Kalman based approach is useful for this purpose for a mountainous catchment in southern Norway. For fifteen years, annual snow observations near peak accumulation at three locations were assimilated into a distributed hydrological model. After the update, the model was run for a four-month forecasting period with forecasted inflows compared to a base case scenario that did not include the snow observations. The assimilation framework improved the forecasts in several years, and in two of the years the improvement was very large compared to the base case simulation. At the same time, the filter did not degrade the forecasts largely, indicating that though the updating might slightly degrade performance in some years it maintains the potential for large improvements in others. Thus, the framework proposed here is a viable method for improving snow related deficiencies in the initial states, which translates to better inflow forecasts.

Wednesday 18.Sep 13:30

High impact environmental events, the role of Earth System modelling

Øytein Hov

President of Commission for Atmospheric Sciences, WMO. Affiliation: Norwegian Meteorological Institute and The Norwegian Academy of Science and Letters, Oslo

Abstract

Seamless modelling and prediction in the WMO context means to consider all compartments of the Earth system as well as disciplines of the weather–climate–water–environment enterprise value cycle (monitoring and observation, models, forecasting, dissemination and communication, perception and interpretation, decision-making, end-user products) to deliver tailor made weather, climate, water and environmental information covering minutes to centuries and local to global scales.

The grand challenge of accelerating advances in Earth system observation, analysis, and prediction capabilities was postulated by Shapiro et al. (2010). In this context seamless prediction was introduced for sub-seasonal to seasonal prediction to span the boundary between weather and climate (Brunet et al. 2010). These authors extended the use of seamless beyond the realm of atmospheric predictions to include the consideration of biophysical, medical, and socioeconomic factors pertinent to successful decision making.

At the World Weather Open Science Conference (2014) seamless prediction was used more generally to cover timescales from minutes to months, considering all compartments of the Earth System including hydrology and atmospheric composition, and linking to users, applications and social sciences.

Seamlessness is now viewed as a useful concept to express the need for information for users, stakeholders, decision makers that is smooth and consistent across the artificial barriers that exist because the information comes from different observing systems, models, time and space scales, or compartments of the Earth system. Thus, in the context of WMO, seamless prediction considers not only all compartments of the Earth system, but also all disciplines of the weather–climate–water–environment value cycle (monitoring and observation, models, forecasting, end-user products, dissemination and communication, perception and interpretation, decision-making) to deliver tailor-made weather, climate, water and environmental information covering minutes to centuries and local to global scales.

Based on the broad consensus at WWOSC 2014 (WWOSC, 2015) and subsequent discussions in WMO, the evolution of science driven seamless Earth system modelling supported by interoperable observation systems for the provision of weather, water, climate and environmental services is now a top priority. This is done through the Seamless Global Data Processing and Forecasting System, as described in the project (S/GDPFS) chaired jointly by Commision for Basic Systems and Commission for Atmospheric Sciences and where an implementation plan was presented to Congress-18 (WMO, 2018).

S/GDPFS also provides a strong driving force for bridging the gap between meteorology and hydrology both for observations (interoperability of observing systems, benefitting from the combined strengths in the approach taken by the meteorological and hydrological communities, respectively, to observations) and modelling (regional and global Earth system models for forecasting, reanalysis and projections on all scales). It is our view that the international organizational support of hydrology forecasting has much to gain from

the opportunities that science now offers to respond even better to societal needs. WMO has a realistic organizational and technical framework to pursue the science to service evolution, including relevant science projects and moving towards a better balance and interoperability of observation systems. WMO should as a high priority prove itself to be the best place to get more operational value out of mature science results related to hydrology and the weather-water coupling on all temporal and spatial scales, from the smallest to the largest. To realize the full potential of the Earth system approach taken by WMO, the strongest partnership possible with the hydrology community should be strived for, a community that protects societal interests and reduces risks of a very significant economic value, perhaps even exceeding that of weather.

The new S/GDPFS implementation plan is written with an Earth system approach, embracing weather, water, climate and environmental systems, and all time and space scales as well as interfaces with societal needs and societal economics. It says "Assessment of evolving capabilities combined with insight into the requirements of meteorologists, climatologists, hydrologists and environmental scientists and their user communities will be a vital component of a future S/GDPFS, but so too will be the role of research for pull-through of new observational and predictive capabilities into operations and to feed the needs of users back into research. Using these new approaches will quickly address some of the greater forecasting challenges. These time-bounded activities will need to assemble experts from across the disciplines within WMO and beyond to solve problems and deliver useful, beneficial cross-compartment solutions." The Earth system approach also requires a close integration with the ocean community, where IOC of UNESCO is the main body.

The moment has come to encourage and support research and innovation in the generation of decision-relevant information and knowledge about the evolving Earth system on all scales, weather on all scales, water, climate and the environment, building on a seamless Earth system model development where science and the translation of mature science results translate into application happen in a continuous value cycle supported jointly by research, operations and users/stakeholders (Hov et al., 2017).

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Wednesday 18.Sep 14:15

Integrated assessment of the impacts of, and interactions between climate, land use and the hydrological cycle

Stein Beldring1, Stephanie Eisner2, Shaochun Huang1, Jan Magnusson1, Rasmus Astrup2, Wai Kwok Wong1
1. Norwegian Water Resources and Energy Directorate, P.O. Box 5091, Majorstua, 0301 Oslo, Norway. 2. Norwegian Institute of Bioeconomy Research, P.O. Box 115, 1431 Ås, Norway

stein.beldring@nve.no

Abstract

The project I:CAN (Impacts: Climate, Antroposphere and Nature) funded by the Research Council of Norway has the objectives to (i) improve the quantitative assessment of the components of the water cycle in Norway by explicitly including land use changes in the model procedures; (ii) demonstrate the effects of land use and climate changes on the hydrological cycle; and (iii) bridge the gaps between local, regional and global hydrological impact assessments. Detailed, high-resolution maps of forest structure and land use have been produced and have been coupled with a spatially distributed hydrological model for assessing the impacts of climate and land use change on water resources. The consistency in hydrological model results from present to future climate is ensured by using physically correct methods for describing the interface between the atmosphere and the land surface. Introducing the Penman-Monteith algorithm into the spatially distributed hydrological HBV model resulted in improved model simulations. Historic time series of forest structure have been constructed in order to study individual and combined effects of land cover change, in particular forest change, and climate on land surface water fluxes over the last decades. Hydrological model studies show that land use and forest management strategies influence snow cover dynamics, surface albedo, land surface water and energy fluxes, however, changes in climate had a larger impact than land use changes on streamflow for the previous 60 year period. Analysing simulations with an energy-balance snow model reveal that the sensitivity to changes in grid resolution depend both on the spatial variablity of climate within a region as well as on the parameterisation procedure used for processes within the snow pack and at the snow-atmosphere interface.

Wednesday 18.Sep 14:35

Impacts of weighting global climate models on quantifying hydrological responses to climate change

Hui-Min Wang, Jie Chen, Chong-Yu Xu, Hua Chen, Xiangquan Li

State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan, China; Department of Geosciences, University of Oslo, Oslo, Norway

jiechen@whu.edu.cn

Abstract

In studies of climate change impacts on hydrology, it is common to use an ensemble of climate simulations to obtain future streamflow projections. The climate simulations in a multi-model ensemble provide various projections to future climate and are often regarded to have equal weights. Nevertheless, global climate models (GCMs) have different abilities to simulate regional climate, which challenges the rationality of equal weighting. Correspondingly, some weighting methods have been proposed in the climate field, but most of them are only based on GCMs' performances in reproducing the observed climate. However, the transformation process from climate variables to hydrological responses is nonlinear, and thus, the weights determined based on climate variables may not be correctly translated to hydrological responses. It may be more straightforward to weights GCMs according to their ability to represent hydrological simulations. Accordingly, the present study assigns weights to GCM simulations based on their ability to reproduce the impact variable (streamflow) and investigates their influences on the quantification of hydrological impacts. In specific, the hydrological responses are simulated by inputting the ensembles of 29 raw or bias-corrected climate simulations into a calibrated hydrological model, respectively. Eight weighting schemes are then employed to determine the weights for the members based on streamflow simulations. The impacts of weighting GCMs are investigated with respect to reproducing the observed streamflow indices during the reference period and quantifying the uncertainty of hydrological changes for the future period. The results show that for the streamflows simulated by raw GCMs, streamflow-based weights better represent the mean hydrograph and reduce more biases of annual streamflow than the weights calculated based on climate variables. However, as to the streamflows simulated by the bias-corrected GCMs, the streamflow-based unequal weights do not bring significant differences to the multi-model mean and uncertainty of hydrological changes. This is because climate simulations have been corrected to become rather close to the observed climate. Overall, since bias correction has become an essential procedure when studying hydrological responses to climate change, the equal weighting method may still be a viable and conservative choice for handling bias-corrected ensembles.

Wednesday 18.Sep 14:55

Lake temperature and global warming

Sverre Anmarkrud1, Alemayehu Adugna Arara2, Anne Kværnø3, and Nils-Otto Kitterød1

1) Norwegian University for Life Sciences, 2) Hawassa University, Ethiopia, 3) Norwegian University of Science and Technology

nils-otto.kitterod@nmbu.no

Abstract

Water temperature is crucial for aquatic life in lakes and reservoirs. In particular, vertical circulations and temperature stratifications are decisive for the biological dynamics in these water bodies. The impact of global warming, however, is not easy to predict because lakes and reservoirs integrate climatic boundary conditions and upstream catchment processes. To evaluate possible impacts of specific changes, we implemented a hydrodynamic lake model (Simstrat, 2019) and simulated timeseries of vertical temperature profiles where we had empirical control of the boundary conditions and the vertical temperature responses. We scrutinized plausible effects of wind by simulating vector fields as an Ornstein-Uhlenbeck process, which corresponds to a stationary auto-regressive process of order one. For this study we used observed time series from the lake Årungen and energy balance and wind velocities from the Søråsjordet climate station at Ås, Norway. The parameters in Ornstein-Uhlenbeck process were estimated by using the multivariate least square estimation technique. After model validation of the wind model, we generated synthetic wind data and simulated the effect of different wind scenarios on the water temperature profile. By comparing vertical temperature simulations for the lake based on observed wind velocities and realizations from the stochastic wind model as boundary conditions, we reproduced the main character of the observed lake temperatures and the associated uncertainties.

Thursday 19.Sep 09:00

Exploring Landscapes and Ecosystems by Studying their Streams

James Kirchner

Dept. of Environmental System Sciences, ETH Zurich/Swiss Federal Research Instit

kirchner@ethz.ch

Abstract

Streams integrate the water, solutes, and sediments from their drainages, and thus they act as mirrors of the surrounding landscape. Patterns of streamflow and chemistry can therefore shed light on physical, chemical, and biological processes at the scale of whole ecosystems.

Here I review current and recent research linking landscapes to the streams that drain them. Groundwater levels and stream flows exhibit diurnal cycles in response to snowmelt in springtime and plant water use during the growing season. These cycles vividly illustrate how aquifers and streams mirror ecological processes in their surrounding landscapes. In addition, stream networks extend and retract, both seasonally and in response to individual rainfall events, dynamically mapping out variations in subsurface transport and in the balance between precipitation and transpiration.

A key attribute of the terrestrial water cycle is the partitioning of precipitation into its two ultimate fates: "green water" that is evaporated or transpired back to the atmosphere, and "blue water" that is discharged to stream channels. Measuring this partitioning is difficult, particularly on seasonal timescales. However, isotopic tracers and water flux measurements can be combined to quantify how isotopically distinct inputs (such as summer vs. winter precipitation) are partitioned into different ultimate outputs (such as evapotranspiration and summer vs. winter streamflow). This "end-member splitting analysis" can help in gauging the vulnerability of both water resources and terrestrial ecosystems to changes in seasonal precipitation.

Stream flow and water quality vary dynamically across multiple scales. Water quality time series spanning the periodic table, from H^+ to U, exhibit universal fractal scaling on time scales from hours to decades, complicating efforts to identify water quality trends. Isotope tracers such as ^{18}O, ^{2}H, ^{3}H, and ^{14}C can used to quantify water ages over seven orders of magnitude, from hours to thousands of years. These tracers show that streamwaters are often much younger than the groundwater aquifers from which they are derived.

Examples such as these will be presented to illustrate the close coupling between landscapes and the waters that drain them, and to demonstrate how streams can be used as windows into ecosystem processes.

Thursday 19.Sep 09:45

The rain check

Rasmus E. Benestad, Abdelkader Mezghani, Kajsa M. Parding, Helene B. Erlandsen

The Norwegian Meteorological Institute

rasmus.benestad@met.no

Abstract

Local effects of climate change include changes in probabilities and frequencies of weather phenomena. It is important to quantify such probabilities, and a traditional approach in simulating climate changes is (1) to use regional climate models in order to simulate the day-by-day weather variations under present and plausible future conditions, and (2) subsequently derive changes in the probabilities based on such results. For instance, return values for extreme precipitation can be estimated based on yearly maxima from simulated daily precipitation and best-fit to a probability density function (pdf) using extreme value theory (EVT). Another alternative is to estimate changes in the probabilities directly based on the parameters characterising the probability density function. We present a promising alternative to the traditional approach for quantifying the probability for heavy daily precipitation, based on a simple empirical model tested on a large volume of available daily rain gauge data world-wide. We present a framework of simple mathematical expressions which let us explore new aspects of rainfall statistics. They make it possible to attribute the change in likelihood of heavy precipitation to different factors and to make a rough estimate of 10-year-return values for daily rainfall with limited amount of data. We present an analysis for how the 10-year return-values in Europe have changed over the period 1961-2018 and whether the rain has become more extreme due to more rainy days or due to higher intensity once it rains. The simple framework also can be used to derive an expression for the variance in the daily precipitation amount. One advantage of this framework is that it readily can be adopted in empirical-statistical downscaling and the projections of future rainfall patterns, and hence may benefit climate change adaptation.

Thursday 19.Sep 10:05

New short-range weather forecast products improved by citizen observations

Cristian Lussana, Thomas Nipen, Ivar Seierstad, and Christoffer Elo

Norwegian Meteorology Institute

cristianl@met.no

Abstract

MET Norway produces new high-resolution (1 km) forecasts and analyses suitable for input to hydrological modeling. The products merge information from a numerical weather prediction (NWP) model, in-situ observations from professional and citizen weather stations (Netatmo), and measurements from MET Norway's radar network. Variables include surface temperature, precipitation, wind speed, humidity, downwelling shortwave radiation, cloud cover, and pressure. The analyses and forecasts are updated every hour, cover Scandinavia and Finland, and are freely available.

The accuracy of the products are significantly improved by citizen observations, which are consumer-grade instruments owned by private individuals. Although, the placement of some stations are poor, the high network density combined with appropriate quality control methods give the observations a unique advantage.

We have produced a dataset of hourly analyses back to 2013-09, providing an archive for calibration purposes. We show evaluation of this dataset against existing NWP models and the SeNorge analyses using observations from independent weather stations.

Thursday 19.Sep 10:25

Novel framework for merging radar and gauge precipitation in cold climates

Kuganesan Sivasubramaniam, Knut Alfredsen, Ashish Sharma

Norwegian University of Science and Technology (NTNU), Norway and University of New South Wales (UNSW), Australia

kuganesan.sivasubramaniam@ntnu.no

Abstract

Hydrological studies require accurate precipitation estimation on a catchment scale. Spatial interpolation using gauge precipitation as a single source of data often proves insufficient to obtain a distributed precipitation field with accurate spatial variation over the catchment in concern. Further interpolation becomes a challenging exercise in a sparsely gauged area. In this aspect, weather radars hold promise as they measure precipitation over a large area with high spatial and temporal resolution. However, weather radars measure precipitation indirectly using remote sensing technique and they are subject to several sources of errors. Even if there are errors and uncertainties in the radar precipitation estimates, it is commonly accepted that the most useful information from weather radar is the spatial pattern of the precipitation. Several studies have shown the usefulness of merging the radar and gauge precipitation to get an improved precipitation field. Most of them consider radar as a secondary source of information to improve the spatial interpolation of gauge precipitation field.

In the present study, we adopted the nonparametric and forecast combination techniques to develop a novel framework to merge the radar and gauge precipitation in cold climates. The increasing availability of long-term radar precipitation rate observations makes it possible to apply nonparametric techniques in the radar precipitation estimation. Since air temperature is an essential variable to differentiate the phase of precipitation in cold climates, air temperature was used as an additional variable in the nonparametric estimation. Four years of hourly radar precipitation rates from the Norwegian national radar network, hourly gauge precipitation from nearly 100 precipitation gauges and gridded observational air temperature data over the Oslo region in Norway with the study area of 100 km radius from the Hurum radar station were used to test the proposed method. First, the study used a k-nearest neighbor (k-nn) regression estimator with radar precipitation rate and air temperature as two covariates and corresponding gauge precipitation as observed response to ascertain nonparametric radar precipitation estimates (k-nn estimates). Then the k-nn estimates were merged with Thin Plate Spline (TPS) interpolated gauge precipitation. The merging is performed using a forecast combination approach, where the two sources of precipitation are considered equally important and combination weights for each data source are calculated based on their past error history.

The nonparametric k-nn estimation noticeably eliminates the bias (mean error) in the radar precipitation. The use of air temperature as an additional covariate in the k-nn model leads to a decrease in the root mean squared error (RMSE) considerably compared to the model without air temperature. The combination of k-nn and TPS estimates within the proposed merging framework reduces the RMSE by 25 % compared to the original radar precipitation rates. As a result, the present study generated a continuous hourly timeseries of improved radar-based precipitation field for the study region.

Further, the methods and the findings presented in this study can contribute scientifically to the growing interest of utilizing existing weather radar facilities for hydrological applications in the boreal region.

Key words: weather radar, precipitation, nonparametric, k-nearest neighbor, forecast combination, merging radar and gauge, cold climates

Thursday 19.Sep 11:15

High-frequency satellite radiation data as input to hydrological modelling

Sjur Kolberg

Enki hydrologi

Sjur.Kolberg@enki-hydrologi.no

Abstract

Remotely sensed data for downwelling short- and longwave radiation are available from EUMETSAT's geostationary MSG satellite, with 30-minute resolution and approximately the same delay. The current investigation has evaluated these products against ground measurements and hydrological simulations, aiming at their use as input data in hydrological models.

For shortwave radiation, the satellite data as well as meteorological forecasts are evaluated using measurements from approximately 50 stations in NIBIO's network, as well as ten sensors installed during the project. The evaluation has focused on clearness indices normalising for solar elevation and atmospheric scattering, to avoid overly optimistic conclusions arising merely from common incident angle and day length. For longwave radiation the analysis is based on formerly published data, augmented with six Norwegian stations owned by NIBIO, Sintef and project participants.

For shortwave radiation, the experiments conclude that the satellite data are valuable as augmentation and/or replacement for ground measurements, particularly for remote areas. Radiation forecasts from the Norwegian Met office's Arome model show good agreement with both satellite- and ground-based measurements. The satellite data exhibit some weaknesses in the northernmost part of Norway, which is at the very edge of the MSG images.

For longwave radiation it is shown that locally estimated correction factors found in literature, can be predicted from latitude. The new measurements from this investigation confirm that the connection is also valid for higher latitudes (60-63 N). This result reduces the need for local estimation of correction factors, otherwise recommended in literature.

The remotely sensed data underestimate longwave radiation during winter, and overestimates during summer. The winter underestimation is the stronger but has less impact on the snowmelt simulation for which these data are intended. The latitude-based correction removes a substantial part of the systematic errors, both for the stations found in literature, and the six high-latitude stations analysed in this investigation.

The effect of different radiation data in hydrologic modelling was evaluated in ten catchments around southern Norway, using four combinations of ground and satellite data for short- and longwave radiation. Broadly, a moderate improvement was achieved by using remotely sensed data for both short- and longwave radiation, also when the hydrological model was calibrated to each of the four input scenarios separately.

Thursday 19.Sep 11:35

The isotopic state of the Norwegian snow pack during the Easter week 2019 - results from a citizen science experiment

Harald Sodemann (1) and Mika Lanzky (2)

(1) Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research,
(2) Department of Geosciences, University of Oslo

harald.sodemann@uib.no

Abstract

Snapshot sampling of the snowpack or surface hydrology is a valuable means to obtain spatial gradients of hydrologic variables. The stable isotope composition allows for identification of atmospheric processes during water transport or after snow deposition to the ground. Spatially resolved snapshot sampling of the water stable isotope composition in the snowpack across Norway has been carried out during the Easter week 2019 with the help of ordinary citizens. In total 80 participants collected more than 200 samples distributed across snow-covered regions of Norway. Samples have been analyzed for oxygen and hydrogen isotopes to assess the melting state and sublimation loss of the snow pack. Clear instructions and rigid data screening were key in ensuring sufficient data quality from this citizen science experiment. Thereby, we were able to obtain a unique snapshot of the late spring snowpack water isotope composition has been obtained. The data set will be applied to constrain isotope-enabled snow pack models and regional atmospheric models. Furthermore, the involvement of ordinary citizens in a scientific experiment provided the basis for valuable outreach activity.

Thursday 19.Sep 11:55

On the use of an explicit snow scheme in numerical weather prediction and operational snow mapping

Trygve Aspelien, Mariken Homleid, Tuomo Mikael Saloranta

MET-Norway, NVE

trygveasp@met.no

Abstract

On the use of an explicit snow scheme in numerical weather prediction and operational snow mapping

The physical parameterization of the soil-biosphere-atmosphere interaction is crucial in both climate simulations and Numerical weather prediction (NWP). A key component in this interaction is ground snow, which alters the physical processes significantly from non snow-covered conditions. In NWP models a good physical parameterization of ground snow is important for accurate predictions of e.g. air temperatures and wind speeds. The operational NWP model HARMONIE-AROME (MetCoOp-EPS), which is operated by MET Norway, has a relatively simple 1-layer snow parameterization scheme called D95 (Douville et.al. 1995). From a physical perspective a well working explicit snow scheme should outperform the relatively simple bulk scheme and improve the near surface fluxes in snow covered areas.

In this presentation we give an overview of the two snow schemes, the one layer snow scheme D95 and an explicit multi-layer snow scheme of intermediate complexity (ISBA-ES). We show its usefulness for operational NWP based on offline simulations with several vegetation types. A key component of an operational NWP system is assimilation of observations into the forecasts from the NWP system (data assimilation). Different algorithms which take into account the homogeneous coverage of snow on different vegetation types are tested. Finally it will be demonstrated how an offline model setup could provide an operational snow mapping product for Svalbard.

Thursday 19.Sep 13:30

Application of machine learning emulators in parameter identification for a distributed hydrological model

Aynom T. Teweldebrhan, John F. Burkhart, and Thomas V. Schuler

Department of Geosciences, University of Oslo

aynomtt@geo.uio.no

Abstract

Ensemble based methods have been widely used in uncertainty analysis and parameter identification for hydrological models. The main challenge with these approaches is, however, the prohibitive number of model runs required to get an adequate sample size. Here, we apply emulators to estimate the response surface and thereby to minimize the computational burden of the Monte Carlo (MC) simulation in parameter identification for a distributed conceptual hydrological model. The absolute bias of model predictions (score) and another based on the time relaxed limits of acceptability concept (pLoA) were used as likelihood measures to identify the behavioural simulations. Three machine learning models (MLMs) were built using model parameter sets and response surfaces with limited number of model realizations. The developed MLMs were applied to predict pLoA and score for a large set of model parameters. The behavioural parameter sets were identified using a time relaxed limits of acceptability approach based on the predicted pLoA values; and applied to estimate the quantile streamflow predictions weighted by their respective score. The three MLMs were able to adequately predict the response surfaces. The behavioural models identified based on the predicted response surfaces have performed very well in reproducing the median streamflow predictions both during the calibration and validation periods.

Thursday 19.Sep 13:50

Nowcasting precipitation by Random Forest

Yiwen Mao, Asgeir Sorteberg, Ivar Ambjørn Seierstad, Thomas Nils Nipen

University of Bergen

Yiwen.Mao@uib.no

Abstract

The primary methods used for nowcasting precipitation are extrapolating radar echoes and running numerical weather prediction (NWP) models at fine spatial-temporal resolutions. Both methods have limitations in terms of predictability, and the latter can also suffer from being too computationally expensive. This study explores the potential of using machine learning to further process the prediction results of radar and NWP in order to improve precipitation nowcasting effectively.

Specifically, a binary classification model trained by Random forest (RF) is applied at forty-two stations in Norway to predict whether there is precipitation in a specified hour. The predictors consist of precipitation-related fields output from radar nowcast and AROME as well as other meteorological fields from AROME projected at the same hour of observation from historical data (i.e., the predictands).

This study aims at clarifying what factors can influence the performance of the classification model. First, precipitation datasets are characterized by a much higher frequency of no precipitation than that of precipitation at most stations. Different approaches based on over-sampling and under-sampling are used to train the datasets characterized by imbalanced binary classes. The results show that both over-sampling and under-sampling can increase the detection rate of the minority class but decrease the precision of the detection (i.e., Type I error increases). Therefore, the overall performance of the RF model is not improved by using over/under-sampling. Second, increasing the size of training dataset by pooling data from a large number of weather stations cannot improve the predictability of the RF model. Thirdly, there is a strong positive relationship between the performance of the RF model and the predictability of precipitation by radar nowcast and NWP, which are the two leading predictors of the RF model. However, the overall predictability of the RF model generally exceeds that of radar nowcast and NWP because of other predictors used in the RF model. In conclusion, the performance of the classification model is mostly influenced by choice of predictors.

Poster

Combining streamflow time series, historical information and paleodata in statistical flood frequency analysis – a case study from the Glomma river in Norway

Kolbjørn Engeland (1), Eivind Støren (2), Anna Aano (1)

(1) (NVE), Oslo, Norway , (2) Department of Earth Science and Bjerknes Centre for Climate Research, University of Bergen, Norway

koe@nve.no

Abstract

Area planning and dam safety assessment is based on estimates of design flood sizes from 200 – 1000 years return periods. The length of streamflow time series is, in most cases, up to 50 years, and the longest are around 130 years. Design flood estimates are therefore highly influenced by sample uncertainty. Additional data source that can be used to increase or knowledge about floods and reduce uncertainty in design flood estimates include historical sources and sediment cores.

The main objective of this study is to assess the sensitivity of design flood estimation to the data sources included for a case study in Glomma. We used paleodata, covering the Holocene, historical sources back to around 1600 in addition to direct streamflow observations. The following questions were addressed:

(i) What is the impact of using historical data in design flood estimates?

(ii) In the paleo-record, for which period is stationarity in flood frequency a robust assumption?

(iii) Combining historical and paleo-record: how large is the largest observed flood in Holocene, and how can this information be used in design flood estimates?

(iv) What can we learn from the paleoflood data about the connection between climate and flood frequency?

Poster

An event based evaluation framework for hydrological ensemble forecasts

Elin Langsholt and Gusong Ruan

The Norwegian Water Resources and Energy Directorate

egl@nve.no

Abstract

The Norwegian Water Resources and Energy Directorate (NVE) runs a national flood forecasting and warning service, aimed at reducing economic and human losses caused by flood. According to the national strategy for floods, flood forecasting is regarded as a joint service provided by NVE and The Norwegian Meteorological Institute (MET). Assessing the performance of the service is crucial in improving it, and MET and NVE has a common approach towards this goal. One key activity for developing the service, is development and adaption of weather forecasts for hydrological models. A 2019 topic is testing and validation of the 10 ensemble members of the MetCoop ensemble prediction system (MEPS). This ensemble is recently taken into operational use in NVE. The ensemble drives HBV- and DDD models with 3 hours time steps for 148 catchments in Norway. MET provides MEPS forecasts every 6th hour, and the hydrological models are run accordingly.

An evaluation framework is under development in NVE, to evaluate the performance of the ensemble hydrological forecasts on extreme hydrological events. The ensemble streamflow predictions are evaluated against a reference streamflow, which is calculated by the hydrological model applying observed meteorological fields as input, and compared to the deterministic MEPS forecast. The framework includes several evaluation methods and scores, to assess the precision and accuracy of the ensemble forecast, as well as its ability to describe the uncertainty embedded in it. It includes visual graphs and geographically presented results, besides numerical scores.

The objective of this event based evaluation, is to get information about spread and bias characteristics of the hydrological ensemble forecast, to find systematic deviations according to geography and weather pattern and to test the performance of the ensemble forecast as a decision support tool. MET makes similar evaluations of the ensemble weather forecasts. This study will throw light on how the hydrological ensemble forecast responds to the weather forecast, when processed through the hydrological system, represented by a hydrological model. The evaluation framework will be tested through the 2019 season, and evaluation results for interesting events will be presented.

Poster

Moisture sources and isotope signatures of snow and water vapour at the Norwegian mountain station Finse (1222m)

Mika Lanzky (1), Alexandra Touzeau (2), Harald Sodemann (2), Simon Filhol (1), Sven Decker (1) and John Burkhart (1)
1) University of Oslo, Department of Geosciences, (2) University of Bergen, Geophysical Institute

mika.lanzky@geo.uio.no

Abstract

Snow in Norway is an important resource for the hydro power industry. In a future climate, the amount and distribution of snowfall might change as a response to a changed atmospheric circulation. We utilize stable water isotopes and tracking of atmospheric water vapour to investigate the sources of the Norwegian snow pack. By analyzing the moisture origin in order to understand its transport pathways, variability and extremes, we gain the knowledge needed to manage future changes.

We identify the climatological winter mean moisture origin for the Norwegian mountain station Finse (1222m, 60.6N, 7.5E), using a Lagrangian moisture source diagnostic based on the FLEXPART model and ERA Interim reanalysis data from 1979 to 2018. Moisture sources in the North Atlantic and Norwegian Sea are characterised in terms of the source location, travel distance and environmental parameters as temperature and humidity at the moisture source, as well as the inter-annual variability of these properties.

Snow pit sampling was carried out at Finse during the season 2017-18 and has been measured for their stable water isotopic composition, expressed by main parameters dD, d18O and derived secondary parameter d-excess, which is related to evaporation conditions. These results establish a baseline for the isotopic measurements and their use for comparison with moisture origin analysis and provide a guide for continuing field campaigns and in site observations.

In addition, we present initial results from continuous water vapour stable isotope measurements, high-resolution snowfall sampling, and snow pit measurements from the 2018/2019 winter season to provide insight into how the moisture source information is converted from an atmospheric signal to a deposited record in the snow pack. This will allow direct comparison of in situ isotopic measurements with moisture tracking analysis on an snowfall event basis.

Poster

Estimating likely changes in peak flow magnitudes in small catchments under a future climate

D. Lawrence (1) , Ó. Rognvaldsson (2), T. Skaugen (1), A. Sorteberg (2), W. K. Wong (1)

(1) Hydrology Department, Norwegian Water Resources and Energy Directorate (NVE), Oslo, Norway (2) Geophysical Institute, University of Bergen, Bergen, Norway

dela@nve.no

Abstract

Estimating likely changes in peak flow magnitudes in small catchments under a future climate in Norway

Projected changes in precipitation under a future climate in Norway point towards larger increases in short-term precipitation intensities than in daily. In small, rapidly responding catchments, this may lead to increases in peak flows that are larger than changes hereto estimated from daily data and models. The climate change factors currently in use in Norway for adaptation to future flood hazard were developed using models and data with a daily time step. Future changes in the instantaneous flood peak have yet to be quantified. In this study, we have used three alternative climate data 'sources' to determine whether such effects can be assessed from higher temporal resolution climate simulations and data: 1) 3-hourly bias-adjusted EUROCORDEX RCM precipitation and temperature time series for reference (1970-2000) and future (2070-2100) periods; 2) observed and perturbed 3-hourly time series for reference and future time periods constructed using change factors for individual quantiles estimated from raw EUROCORDEX RCM data (i.e. unaltered by bias adjustment); and 3) control and perturbed simulations of observed extreme precipitation events using the WRF model in a pseudo-warming experiment with a 2□C increase in temperature. Although not all of the outcomes from the three approaches are directly comparable, they each highlight relevant factors for interpreting potential changes in flood hazard in small catchments due to increases in sub-daily precipitation intensities.

Three-hourly precipitation and temperature series from 5 SMHI-RCA4 runs (EUR11), representing 5 GCMs, were used to develop bias adjusted and quantile perturbed input series for hydrological modelling for 65 small catchments (< 160 km2) distributed across Norway. The WRF atmospheric model was also run for a domain covering the southern half of Norway with three grid resolutions (2 km, 4 km, and 12 km) and a 1-h time step. These runs simulated 28 observed extreme precipitation events during the period 2005-2014 with durations of 30 to 174 hours for today's climate and with a +2 degree temperature increase. An ensemble of precipitation values for each event were extracted and merged with the full continuous time series for each of 48 catchments. Time series from all three methods, as well as the corresponding 24-h aggregated series, were then used as input to the DDD hydrological model for each catchment.

Hydrological simulations using the bias-adjusted EUROCORDEX data produce an increase in the average annual maximum flood that is on average 20-25% higher for 3-h peak flows relative to 24 h average flows for the catchments. The simulations based on the quantile-perturbed data suggest that both precipitation increases and temperature changes contribute to the increased flood hazard, due to changes in snow cover. In many cases, the increases in peak discharge are considerably higher than those estimated from increases in precipitation intensity alone.

However, no effect of catchment area was seen in the simulations based on the EUROCORDEX data, possibly due in part to the EUR11 grid resolution (~12 km). The WRF simulations support this in that hydrological simulations based on data from the 2 km grid produces the largest changes in the maximum discharge (up to a 60% increase), and this effect is most evident in the smallest catchments. This result highlights the potential benefit of high-resolution climate simulations for supporting impact research concerned with quantifying extreme flows in small, rapidly responding catchments.

Poster

From large-scale atmospheric circulation to flooding in Norway: Using machine learning to infer non-stationarity

Jenny Sjåstad Hagen (1,2), Asgeir Sorteberg (1,2), Deborah Lawrence (3), Jostein Bakke (2,4), Dimitri Solomatine (5)

1. University of Bergen, Geophysical Institute. 2. Bjerknes Centre for Climate Research,. 3. Norwegian Water Resources and Energy Directorate, Hydrology Department. 4. University of Bergen, Department of Earth Science, 5. IHE Delft Institute for Water Education, Integrated Water Systems and Governance Department

jenny.hagen@uib.no

Abstract

Non-stationarity refers to abrupt changes in statistical properties of floods or flood-drivers. It has long been acknowledged that design floods derived from flood frequency analysis – on which safety standards are based – should reflect non-stationarity to facilitate adaptive strategies and long-term flood risk management in a changing climate. Although efforts have been made at incorporating non-stationarity in flood frequency analyses, fully integrated modelling approaches in which non-stationarity intrinsically is transferred within the model structure is still missing. With increasing availability of data with variable formats, resolutions, and spatial and temporal coverage, the challenge lies in maximizing information from available data in complementary model structures that intrinsically embed non-stationarity. In affiliation with the project "Climate Hazards and Extremes" at the Bjerknes Centre for Climate Research, the aforementioned task is addressed throughout a four-year funded PhD (2018-2022) at the University of Bergen. The first year of research focuses on reducing a priori assumptions about statistical properties of floods and flood-drivers encountered in statistical downscaling, bias-correction and hydrological model calibration. Physically-based input variable selections from long-term climate simulations (Coupled Model Inter-comparison Project 5) are investigated to shorten the state-of-the-art hydrological climate-impact model chain with machine learning algorithms. The Norwegian Hydrological Reference Dataset for Climate Change Studies is used to train committee models for flood prediction over the next century, with the aim of capturing highly non-linear relationships detected in the instrumental period. This poster presents the roadmap of the PhD and preliminary results.

Poster

The 2018 Northern Europe Hydrological Drought and its Drivers in a Historical Perspective

Sigrid J. Bakke, Monica Ionita, Lena M. Tallaksen

University of Oslo

l.m.tallaksen@geo.uio.no

Abstract

In Europe, several extreme summer drought events have occurred the last two decades, with the 2018 northern European drought as the most recent example. A better understanding of the combined characteristics and the large-scale atmospheric circulation driving such events is of high importance to enhance drought preparation and mitigation. The objective of this study was to investigate the historical distinctiveness of the May-August 2018 meteorological situation and the accompanying northern Europe meteorological and hydrological drought. Further, the study looked into relations between large-scale atmospheric circulation patterns and aggregated summer (June-August) streamflow in Fennoscandia (Norway, Sweden and Finland). Analysis based on the E-OBS datasets and NCEP reanalysis showed record breaking May and July temperatures in large parts of northern Europe associated with blocking systems centred over Fennoscandia. Persistent precipitation deficits caused dry conditions over large parts of northern Europe, as indicated by the standard precipitation index for a three-month accumulation period (SPI-3). In June, record low or near-record low streamflow were found in 56% of the observation stations with 60 years of daily data, expanding to 74% in July. Extreme streamflow conditions sustained in south-eastern Sweden and Finland throughout 2018. A similar pattern was found for Norwegian groundwater levels, however, only a few stations had persistent extreme conditions beyond August. Relations between summer streamflow and large-scale atmospheric circulation patterns were investigated based on composite maps of 500mb geopotential height anomalies for years of high and low values of the first three principal components (PCs) of summer streamflow observations in Fennoscandia. The two first PCs showed unusually low summer streamflow in 2018. The first PC was associated with a high-pressure system similar to the one observed in 2018, whereas the second PC was associated with a high-pressure system over the North Sea. Overall, this study highlights the uniqueness in meteorology and hydrology in Northern Europe the summer of 2018, as well as potential drivers associated with low summer streamflow in Fennoscandia.

Poster

Hydrological Modelling of a Steep Norwegian Catchment using SHyFT

Nitesh Godara & Oddbjørn Bruland

PhD Candidate & Professor, Norwegian University of Science and Technology

nitesh.godara@ntnu.no

Abstract

Hydrologic processes are very difficult to estimate due to their non-linearity and highly complex relationships among different parameters. The hydrologic processes depend on many parameters such as precipitation, temperature, relative humidity, wind speed, solar radiations, evapotranspiration, vegetation, soil characteristics, land use, land cover etc. which makes it much more complex and difficult to get a reliable relationship among all the parameters. This will further raise the question of getting compatible results with that of observed values. Choosing the right hydrologic model is very important for getting good results. Reliable results can be obtained if the right hydrologic model is chosen for a particular catchment having particular characteristics and the purpose of research. These results can be further used to find out the impact of climate change, change in land use, urbanization, forecast runoff and extreme events like flash floods etc. This paper shows a brief review of the five hydrologic models viz. SHyFT (Statkraft Hydrologic Forecasting Toolbox), HBV (Hydrologiska Byråns Vattenbalansavdelning), MIKE SHE (Systeme Hydrologique European), HEC-HMS (hydrologic engineering center-hydrologic modelling system) and SWAT (Soil and Water Assessment Tool). The review is based on the model availability and accessibility, amount of input data required, routines available, size of catchment, available resolution of data, model calibration, required resolution of output, efficiency of model in different climatic and topographic
regions, and their limitations. This compilation of the five models will provide guidance to choose appropriate model for a particular type of situation, problem, catchment size, region or condition for which these models are most appropriate.

Poster

Projected changes in frost-change days for Norway (1971–2100)

I. B. Nilsen1,3, W. K. Wong1,3, Inger Hanssen-Bauer2,3, O. E. Tveito2,3

1 Norwegian Water Resources and Energy Directorate, Middelthuns gate 29, 0368 Oslo – Norway 2 Norwegian Meteorological Institute 3 Norwegian Centre for Climate Services

ibni@nve.no

Abstract

A frost-change day (FCD) is one or more crossings of the freezing point on the same day, and such crossings may cause icing and slippery surface conditions. We have analysed trends in the number of frost-change days using daily maximum and minimum temperatures for the historical period (1971–2016) and projections (2006–2100). A frost-change day is defined as Tmax > 0 °C and Tmin < 0 °C on the same day. For the historical period, we used both stations and a gridded, interpolated 1x1 km dataset covering all of Norway (the seNorge.no dataset). For both historical datasets, we record the strongest changes in spring. Annually as well as in spring, a clear distinction is seen between lowlands (fewer frost-change days) and in elevated and northern areas (more frost-change days). There are fewer crossings in autumn when temperatures are generally above zero, and more crossings in winter when temperatures are generally below freezing. These results are consistent with the warming observed in recent decades in Norway. Cold regions experience more frost-change days because temperatures approach 0 from below, whereas milder regions experience fewer frost-change days because temperatures move away from 0 towards warmer conditions. This development will continue into the future. Results from downscaled projections (10 RCM/GCM combinations of RCP 4.5 and RCP 8.5 until 2100) reveal fewer crossings in the lowlands. More crossings are found in Finnmark and along the border to Sweden, north of 61° N. Similar to the historical changes, the strongest projected changes are occur in spring.

Poster

RUNOFF MODELLING ON ARABLE LAND

Anne Ellekjær Stavang, Ståle Leif Haaland, Nils-Otto Kitterød, Thomas Skaugen

Norwegian University of Life Sciences, Environmental Sciences and Natural Resource, NVE

anne.stavang@baerum.kommune.no

Abstract

Runoff from arable land is recognised as the main reason for water degradation, eutrophication and reduced water quality. The aim of the study was to simulate rainfall-runoff response on a 1h temporal resolution from an arable catchment by using the Distance Distribution Dynamics model (Skaugen and Onof, 2014). Model inputs are precipitation, temperature, and spatial information of the drainage network. Pre-processing includes recession analysis, to determine subsurface storage and hillslope celerities. The study area is the small agriculturally dominated catchment Skuterud, which is a part of The Norwegian Agricultural Environmental Monitoring Programme (JOVA). Two simulation alternatives were evaluated as part of the project. In the first alternative we used stream information from the river network database, in the second alternative we used the artifical drainage pipelines as drainage network. The calibration period is from 2000-2004, and the validation period 2005-2009. The results show an improvement of Nash-Sutcliffe efficiency (NSE) and Kling-Gupta Efficiency (KGE) criteria when artificial drainage was included. Model performance were further improved by a refined recession analysis based on the assumption that runoff and its corresponding recession charateristic is defined by a power law relationship. A master recession curve, created by fitting a straight line through the log-log recession plot, provided the overall best result with a NSE of 0.56 and KGE of 0.74. Limitation and uncertainties with the model include, but is not limited to, instrumental limitation for runoff measurements at low flow, hydrological impact on soil characteristics or seasonal influences.

Keywords: Rainfall runoff modelling, arable land, recession analysis.

References:

Skaugen, T. and Onof, C.: A rainfall-runoff model parameterized from GIS and runoff data. Hydrol. Process. 28, 4529-4542 (2014), DOI. 10.1002/hyp.9968.

Poster

Assessment of the water and energy balance simulations of CTSM using satellite-based observations over Scandinavia

Yeliz A. Yilmaz, Lena M. Tallaksen, Frode Stordal

Department of Geosciences, University of Oslo, Oslo, Norway

yeliz.yilmaz@geo.uio.no

Abstract

Simulating the terrestrial water and energy balance in land surface models plays an important role in our understanding of land atmosphere interactions. The latest version of the land component of NorESM, namely the Community Land Model (CLM5) - with its new name the Community Terrestrial System Model (CTSM) - has not been evaluated over Scandinavia in detail. This study has two main objectives. Firstly, we test CTSM over the Scandinavian region (including Svalbard). For this purpose, the land surface model was run offline (uncoupled) for 15 years between 2002 and 2016 at 0.25 degree resolution. Secondly, we exploit existing satellite-based data sets over Scandinavia. In this effort, we assess model performance by comparing the climatology of the water and energy balance components. In particular, we use monthly model outputs and compare with several observational data sets including the satellite retrievals from GRACE and MODIS, and reanalysis data sets from ERA5, GLDAS, and MERRA. Some of the key results are presented for variables such as terrestrial water storage anomalies, turbulent fluxes, net radiation, and skin temperature.