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Abstracts

Contents

Presentation type: Oral

Multi-Temporal Flood Mapping from Space: Insights into the 2015-16 Winter Storms

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Recent advances in satellite technology have resulted in improved quality and quantity of products suitable for flood monitoring. The wide geographical area covered by satellite imagery provides an advantage over in-situ measurements. The two Sentinel-1 Synthetic Aperture Radar (SAR) satellites provide data at an increased temporal resolution, with the UK covered every two days, and at a spatial resolution suitable for identifying flooding. Coupled with the European Data Relay System (EDRS), which reduces data delivery time from the satellite to the user, the development of real-time hazard monitoring systems utilising the freely available Sentinel datasets is now possible. During the winter of 2015-16, storms Desmond, Eva and Frank brought extreme rainfall to northern UK. A case study in Yorkshire has been used to highlight the potential for flood mapping using satellite SAR. A change detection, filtering and thresholding methodology has been developed and applied to Sentinel-1 scenes from December 2015 and January 2016. Areas of inundation have been validated against a Sentinel-2 optical image, with a total accuracy of 97%. Comparisons are also made to aerial images and the Environment Agency Flood Maps for Planning (EA FMP). Peak flood extents are observed on the 29th December 2015, during the aftermath of storms Eva and Frank. The denser time series provided by the dataset allows for mapping of the flood dynamics, showing the onset and retreat of the flood waters. Conclusions are drawn on both the potential and limitations when using Sentinel-1 to map flooding. Ongoing work, including improvements to the methodology and further validation of the results, along with the development of a real-time flood mapping tool, are highlighted.

Presentation type: Oral

How can we assess the resilience of our current water supply system against droughts not previously observed?

Christopher Rhodes

Mott MacDonald in consultation with Severn Trent Water Ltd.

As part of the next series of Water Resource Management Plans, water companies need to assess the resilience and response of their water supply system to extreme droughts. This is commonly tested using water resource modelling (using programs such as Aquator) which require the input of flow series, often derived from rainfall runoff modelling. In order to test these systems beyond what has previously been observed, one option is to create and simulate synthetic droughts, an approach which Severn Trent Water Ltd (STWL) has recently undertaken in consultation with Mott MacDonald.

Rainfall and PET data series for 200 scenarios (73-years in length, representing 20th century climatic conditions) were produced by Atkins/Met Office using a Weather Generator. These stochastic rainfall and PET series were fed through a calibrated rainfall-runoff model (HYSIM) for the relevant catchments, producing 200 series of synthetic (but realistic) flows for each catchment.

The computing costs to undertake water resource modelling with 200 sets of flow series is extensive so it was necessary to select a sub-set of these scenarios. This sub-set was selected for the 200-year and 500-year drought events (over 18, 24 and 30-month periods) using a statistical distribution for each, defined from historical data. A target accumulated flow was calculated from these statistical distributions with the synthetic droughts being searched and the closest drought identified for each period, magnitude and catchment. Thus, 18 scenarios were identified as suitable for water resource modelling and used to establish the impact on the deployable output.

This procedure can be applied to other systems facing similar computational constraints and offers a greater understanding of water supply system resilience to severe droughts.

Presentation type: Oral

Comparative performance of rainfall-runoff models on urban catchments.

James Fidal, Thomas Kjeldsen

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The introduction of urban land-cover changes the hydrological characteristics of catchments, as such there is a need to develop hydrological models to account for these changes.

This study presents a conceptual framework for explicitly accounting for effects of urbanisation on catchment rainfall-runoff characteristics. To represent the urban effects on infiltration and river routing a number of parameter-parsimonious extensions are introduced to an existing non-urban rainfall-runoff model. The ability of the new urban model to explain the urban effects was assessed by comparing the default (non-urban) model with the new urban model, using hydrological data from 29 urban catchments in the Thames catchment. Model performance was assessed using two methods, firstly comparing individual catchments performance through multiple performance criteria and a jackknife approach to test statistical significance between models. Secondly comparing the collective performance of all the catchments via a binomial distribution approach. Results suggest that the urban extension to the model can add explanatory power in urbanised catchments.

Presentation type: Oral

Quantile Regression Technique for Trend Analysis of Precipitation for Flood Risk Assessment in South Wales, UK.

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Climate change is an increasingly ubiquitous issue facing modern engineering. Whilst there will be many challenges, one of the most the pressing will be changes in precipitation patterns. Extreme weather events are predicted to result in flooding and droughts with broad impacts on the natural environment, biodiversity, and agricultural productivity. Increased understanding of potential variation in hydrological variables such as precipitation, air temperature and flood peaks can help to provide cost-effective solutions to water problems at global, regional and basin scales.

Linear quantile regression is used to model the trend of extreme precipitation to better inform flood risk assessments. This method allows for greater flexibility in comparison to other techniques as a regression model is created for the desired quantile of the conditional distribution of the response variable. Additionally, this method does not assume residuals and error distributions. The technique is implemented by aggregating daily rainfall data for each year and constructing a linear quantile regression model for the 98% quantile. The significance of the trend is tested using a null hypothesis for confidence levels of 90% and 95%. The results represent the flooding situation. The Tawe River Basin in the South of Wales, UK is selected as a study area and investigated using the daily observed precipitation from 7 rain gauges over a period of 40 years (1970-2010).

Presentation type: Oral

Yield response of Mediterranean Rangelands under the effect of climate change

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Climate change and its inherent effects on mean temperature and the precipitation variability can regulate the magnitude, frequency and duration of droughts and aridity with a profound effect on ecosystem productivity. Climate change may has a particularly significant impact on drylands, like the Mediterranean, constitutes an important research field, due to their remarkably unpredictable character and their influence from extreme events such as droughts. In this work, climate model data is obtained from 9 GCMs under Relative Concentration Pathways 2.6 and 8.5 of the 5th phase of the Coupled Model Intercomparison Project, and corrected for biases. The derived dataset is used for investigating the effects of climate change to project the development of vegetation in the Mediterranean rangelands by i) estimating the relative Standardized Precipitation Index and a modification of the UNEP Aridity Index to classify climate variability, and ii) modelling vegetation response to climate using the FAO crop-water production function. Two 40-year future study periods are compared with the baseline period 1961-2000 within a domain that includes the European Mediterranean.

A gradual increase in the intensity and severity of the drought events, as well as in their spatial extent is observed, and the majority of the Mediterranean areas drop at least one class in the aridity gradient. This reflects on the grazing lands' yield, as a reduction in the relative yield response up to 100% in individual regions, which may render them totally unproductive for the current species. However, an increase of yield is observed in mountainous areas which are currently characterized wet. Results raise concerns about the fate of the Mediterranean grazing lands.

Presentation type: Oral

Evaluating daily precipitation downscaled using SDSM and WRF + WRFDA models over the Iberian Peninsula

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Two downscaling exercises were performed for the Iberian Peninsula. First, the WRF model was nested inside ERA Interim with a 15x15 km² grid and 51 vertical levels. In one experiment (N), boundary conditions drive the model after the initialization. The second experiment (D) is configured as N, but 3DVAR data assimilation is run every six hours (00Z, 06Z, 12Z and 18Z) using observations from the PREPBUFR dataset. Both experiments use the NOAH land surface model and both simulations span the period 2010-2014, with a one-year spin-up (2009).

Second, the Statistical DownScaling Model (SDSM) was applied to estimate the precipitation over 21 sites across the Iberian Peninsula during the period 2010-2014. ERA Interim data with 0.75º grid resolution was used as predictor variables, calibrating from period 1979-2009. Previous work for Spain has shown that this configuration of SDSM produces similar or better results than WRF.

For both downscaling exercises, the obtained precipitation was evaluated over the Iberian Peninsula by means of several diagnostics including correlation with observed daily totals, root mean squared error, and standard deviation of amounts. The same verification tests were performed for ERA Interim.

Results show that northwestern Iberian Peninsula is well reproduced by WRF simulations and ERA Interim. This was not the case in the southeastern zone, where some discrepancies can be observed (particularly for the N experiment). Bias and RMSE values are better inland. For the SDSM, comparable results to the ones obtained by WRF D and ERA Interim are observed.

Accumulated annual values of precipitation show a recognizable pattern, highlighting the influence of Atlantic sources of moisture. The spatial pattern and values are comparable to the precipitation atlas produced by the Spanish Meteorological Agency (AEMET) for period 1971-2000. Further work is needed to improve the representation of convective precipitation in WRF along the Mediterranean coast.

Presentation type: Oral

Anglian Water System Supply Forecasting using AQUATOR Water Resource Modelling Software

Harriet Robson

Mott MacDonald Ltd, Anglian Water Services Ltd

Mott MacDonald are involved in the development of water resource network models covering the Anglian Water supply area using AQUATOR, a sophisticated software application that allows real-world complex water resource systems to be modelled. AQUATOR uses optimisation algorithms to simultaneously evaluate all water movements required to meet demand and make decisions on how to allocate water in the most efficient manner possible, considering constraints, costs, and resource states. Three separate models representing regions of Anglian Water's supply area were built, validated, and verified using AQUATOR, and used to determine robust Deployable Output estimates for 27 Water Resource Zones within the supply area, to be included in the development of Anglian Water's next Water Resource Management Plan (WRMP19). Anglian Water's supply area is classed as an area of severe water stress, due to a high population density and rainfall significantly below the national average, and the WRMP will outline how they will maintain the balance between supply and demand over the following 25 years, as well as how they will approach the longer-term challenges of population increase and climate change. A range of Deployable Output assessments will be carried out using AQUATOR considering: climate change scenarios; drought events; sustainability reductions to groundwater abstractions; and options to improve the supply-demand balance. The Deployable Output estimates will provide clear identification of the factors constraining water availability and movement within the Anglian Water supply area, and how future pressures and restrictions will affect the water resource system.

Presentation type: Oral

Mechanisms of Drought in sub-Saharan Africa

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University of Southampton

Drought is a major environmental hazard that affects a multitude of ecosystems and communities across all six inhabited continents; indirect impacts cause major losses over a number of socio-economic sectors, such as infrastructure, health, trade, industry and tourism, which can have a negative impact on economic development over a long time period. Regions that rely heavily on agriculture, such as sub-Saharan Africa, are particularly at risk from drought events due to the direct impacts, resulting in reduced crop production and increased need to import food.

Mitigation of severe drought events is a difficult task, as droughts tend to have a slow onset, without a defined start, and have a much longer temporal and spatial extent than other natural hazards, To predict the extent and severity of future drought events it is crucial to understand the mechanisms of drought behaviour using historical data. Using a combination of gauge data, remote sensing products and hydrological modelling techniques (combined in the African Flood and Drought Monitor system), we have conducted a preliminary statistical analysis across Sub-Saharan Africa to identify spatiotemporal variations in drought over the past 65 years and the connection with large-scale climate.

The connection of modes of climate variability, such as the El Nino Southern Oscillation (ENSO), with temporal aspects of drought behaviour is found to be a large contributing factor to drought risk and severity across the African continent. In particular, positive ENSO years tend to result in large areas of Sub-Saharan Africa experiencing drier than usual conditions, but this is not the case everywhere. Understanding the drivers of regional trends would contribute greatly towards seasonal forecasting, allowing local agriculture to adapt to changes in temperature and precipitation levels.

Presentation type: Oral

Large Scale 2D Flood Modelling Using Cloud Computing

Fergus McClean, Richard Dawson, Chris Kilsby

Newcastle University

In order to conduct a comprehensive continental scale flood risk analysis, modelling is required as the necessary observations are largely unobtainable. However, large scale flood modelling is inherently tricky. There are problems with data quality, storage and processing which demand vast computational efforts in order to fully simulate physical processes across land surfaces. To meet these challenges, I am developing a cloud computing platform which takes advantage of the on-demand scalability of Microsoft Azure to execute computationally intensive hydrodynamic simulations. This scalability enables many simulations to be carried out across large domains at high resolutions with varying parameterisations to enable substantive calibration and validation of 2D hydrodynamic models. The platform adopts a modelling workflow written in the Python programming language, connected to a server running PostgreSQL which stores input data and results. The main data sources are NASA's Shuttle Radar Topography Mission digital elevation model, precipitation from the ECMWF Interim reanalysis, OpenStreetMap, ESA's Sentinel 1, and flow records from the NRFA and GRDC. In the literature, not enough emphasis has been placed upon validating large scale model results using observed data. Therefore, this project is utilising both gauged river discharges and satellite snapshots of flood extent in order to take a more rigorous approach to validation. Repeatability of previous studies has also often been poor, as input data and modelling code is often not publicly available, therefore code and data associated with any publications will be made fully accessible. Presented here are the major software components of the platform, along with some initial results. The project is funded by NERC through the Data, Risk and Environmental Analytical Methods Centre for Doctoral Training.

Presentation type: Oral

Identifying Areas at Risk of Multisource Flooding

Ben Smith[1], Geoff Parkin[1] & the JBA Trust[2]

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High groundwater levels are known to increase the risk of flooding from an intense rainfall event. This is because the volume of water that ground can absorb is reduced, causing water to flow rapidly along the surface and into the river network. This can be a particular issue if a river is connected to an aquifer, as levels may increase as groundwater enters the river from below.

Despite this, there is an absence of detailed historical records documenting groundwater flooding or those instances where groundwater levels have exacerbated flooding from intense rainfall. I am therefore seeking to identify those areas around the UK that are likely to suffer from these ‘multisourced’ floods. Subsequently, these areas will be used as case studies in the development of a combined (groundwater-surface water) modelling approach aimed at providing a more comprehensive assessment of flood risk.

This work relies on two basic assumptions:

(1) that a river’s base level represents those waters derived from groundwater, and

(2) that sudden rises in level represent surface runoff from rainfall.

The analysis searches around 1000 high resolution river level records for instances of rapid rise superimposed on high base levels during periods of peak river level. It is predicted that areas at risk of multisource flooding will have a combination of permeable and non-permeable geology and perhaps the presence of impermeable urban areas. There is large anecdotal evidence of this happening within the UK’s chalk catchments.

Presentation type: Oral

Modelling and interaction of meteorological, hydrological and hydrodynamic processes in a flash flood event.

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Flash floods top rank the hydrological and natural hazards that threaten human life. Considering that approximately one in six properties in the UK are at risk of flooding and the impact of climate change in intensity and frequency of heavy rainfall associated with this events, it becomes crucial to understand and characterise these events and the interaction between processes to improve their identification and prediction. The current research proposes a three-stage modelling process in which rainfall, runoff and flooding are simulated using different numerical tools (a meteorological, hydrological and hydrodynamic model, respectively) and linked in a cascade methodology, allowing the assessment of the effects of initial parameterisations and model configurations. The first and completed stage comprises the rainfall maps obtained with a non-hydrostatic, meso-scale numerical weather prediction tool, the Weather Research and Forecasting model that assimilates atmospheric variables and yields, among other outputs, temporal and spatial distribution of rainfall from convective and non-convective schemes for a recent flash flood event in the UK. Results show a good approximation to ground measurements, and additional feedback on model performance was obtained after extensive model testing. The second stage of the research uses the outputs from the first stage as one of the input parameters of the numerical model: the Dynamic TOPMODEL, a semi-distributed tool that discretises the catchment into hydrologically similar areas throughout which the flow is routed hence estimating the discharge in the river network. This information will serve as boundary conditions for the third model in the final stage of the cascade, LISFLOOD-FP, a raster-based hydrodynamic model for flood simulation that solves channel flow using a one-dimensional kinematic wave approximation and a 2-D dynamic representation of flood flows. Advantages, limitations and main contributions of the research are highlighted in each stage, considering model parameters sensitivity and uncertainty evaluation.

Presentation type: Poster

Understanding drought propagation in the UK in the context of climatology and catchment properties

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Droughts are a complex natural phenomena that are challenging to plan and prepare for. The propagation of droughts through the hydrological cycle is one of many factors which contribute to this complexity, and a thorough understanding of drought propagation is crucial for informed drought management, particularly in terms of water resources management in both the short and long term.

Previous studies have found that both climatological and catchment factors cause lags in drought propagation from meteorological to hydrological and hydrogeological droughts. There are strong gradients in both climatology and catchment properties across the UK. Catchments in the north and west of the UK are relatively impermeable, upland catchments with thin soils and receive the highest annual precipitation with relatively low mean annual temperatures. Conversely, in the south and east of the UK, characterised by higher mean temperatures and lower annual precipitation, catchments are underlain by a number of major aquifers (e.g. Chalk, limestone) and are typically associated with high baseflow rivers. Here we explore the effects of these gradients in climatology and catchments on the propagation of droughts.

Using standardised drought indices (the Standardised Precipitation Index; the Standardised Streamflow Index; and the Standardised Groundwater Index) we analyse drought propagation characteristics for selected catchment-borehole pairs across the UK using observed data. We investigate how the timing, nature and predictability of drought propagation changes across the UK, given gradients in climatology and catchment characteristics. We use probability of detection methods, usually used for forecast verification, to investigate how well precipitation and streamflow deficits predict deficits in streamflow and groundwater levels and how this varies across the UK.

Presentation type: Poster

Obtaining natural flow series data in a modified upland catchment: A comparison of different techniques

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[2]Environment Agency - Groundwater, Hydrology and Contaminated Land

The Water Framework Directive and Habitats Directive are driving regulatory bodies and water managers to pursue a reversal of human disturbances to hydrological connectivity and natural flow regimes. Fundamental to the success of these hydro-ecological restoration projects is the need to gain a good understanding of pre-disturbance conditions in modified water bodies and catchments, however time series data for this period are often unavailable. A solution is to generate synthetic time series data under 'natural' conditions and a number of techniques are available, yet each has its own limitations and all are subject to some level of uncertainty. This study applies three commonly used approaches to estimate the natural flow regime of an upland catchment in North West England where both impoundment and abstraction occur and future management options are being considered. Results from a naturalised time series of post-impoundment data are compared against modelled natural flow obtained from a physically based spatially distributed hydrological model (SHETRAN) and data transferred from a physically similar catchment selected from the UK Benchmark Network, a subset of gauging stations from the national hydrometric network.
In accordance with Harmoni-CA guidance, uncertainty analysis will be carried out using techniques that aim to: 1) categorise and prioritise uncertainty, 2) increase the quality of information available, and 3) quantify and propagate uncertainty. A review of available techniques will be carried out to select the most appropriate methods for this study. These will be illustrated using preliminary data and modeling results from the study site.

Presentation type: Poster

Modelling flow towards a radial collector well: a comparison of analytical and numerical approaches

Sarah Collins

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High yields can be achieved in shallow aquifers with radial collector wells, comprising a central, vertical shaft, from which screened laterals are drilled horizontally into the aquifer. The characteristics of flow in the vicinity of a well are a major factor in successful well design. Analytical models for describing flow towards a radial collector well based on the assumption of uniform flux along the laterals were compared against one another and against a numerical model and field data. An approximate constant head boundary condition was created in a PMWiN model, and a non-uniform flux boundary condition loosely based on flowmeter data was implemented with an analytical point sink solution. All but one of the analytical solutions for determining drawdown around a well were found to produce identical results. The analytical models were found to match the numerical model exactly and to be in good agreement with field data. A new equation was developed that enables the analytical models to be approximated by a fully penetrating vertical well by defining an equivalent well radius, the so-called 'ersatzradius'. With the new equation, the vertical well model converges with the horizontal well model at a distance of roughly 75% of lateral length from the centre of the well. Whereas the non-uniform flux boundary condition produced a drawdown distribution similar to that calculated based on the assumption of uniform flux, the drawdown distribution created by the constant head boundary condition clearly shows increased inflow around the ends of the laterals. The drawdown distributions of all three boundary conditions converge just beyond the tips of the laterals. A new programming tool based on 2D and 3D analytical models was developed for calculating the drawdown distribution around a radial collector, horizontal or slant well in a confined, unconfined or leaky aquifer.

Presentation type: Poster

Data assimilation for fluvial inundation forecasting

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Accurate inundation forecasting during a fluvial flood can provide useful information about the movement of flood water. Data assimilation is a powerful mathematical technique which can be used to combine forecasts from numerical models with observations, resulting in better estimation of water depths and improved forecasting. In this work we use a hydrodynamic model to simulate flooding in an idealized river-like topography. We perform twin experiments in which we generate synthetic observations of water depths which mimic information available from satellite images. An ensemble Transform Kalman Filter is used to combine these synthetic observations with model forecasts. We show that reinitialising the model with corrected water levels can cause an initialization shock and demonstrate a novel solution for dealing with this.

As in related studies, we find that data assimilation can accurately correct water levels at the time of assimilating an observation. However, the corrected forecast then quickly relaxes to the open loop forecast where no observational information is taken into account. Our experiments show that the time taken for the forecast to relax to the open loop case depends on domain length; we find that observation impact is longer-lived in a longer domain. We also present results in which we use the state augmentation technique to correct both water levels and the parameter which controls channel friction processes in the hydrodynamic model. This greatly improves the forecast compared to correcting water levels alone.

Presentation type: Poster

Seasonal forecasting of reservoir inflows in Central Asia

Samuel G. Dixon and Robert L. Wilby

Department of Geography, Loughborough University

The management and construction of large, headwaters reservoirs in Central Asia has been a cause for disagreement in the region (Reuters, 2012). Some tension stems from the competing interests of upstream nations for hydropower generation during winter whereas downstream countries prioritise water for agricultural irrigation in summer. Operational seasonal forecasting using public domain information could alleviate tensions. Example interventions could be greater releases for hydropower during forecasted high flow years with confidence that refill would allow release for irrigation during the summer months. Remotely sensed, public domain data has the potential to work towards these requirements in the short-medium term by providing flow forecasts up to three months (Dixon and Wilby, 2016). Longer lead time operational river flow forecasts could facilitate increased hydropower production as well as reduced spillage, with demonstrated annual economic increases of more than $150 million for the Columbia River, United States (Hamlet et al., 2002).

This study utilises several remote climate drivers (NAO, ENSO and DMI) to forecast inflows to three key headwater reservoirs in Central Asia (Toktogul, Andijan and Nurek). We find that winter Niño 3.4 is significantly positively correlated to following summer inflows to Andijan and Toktogul ($p = 0.05$), as well as Nurek ($p = 0.01$) reservoirs for the period 1941-80. Winter NAO shows moderate negative correlations to summer inflows for all three reservoirs. Summer inflows were conditioned on previous index phase allowing differences in observed inflows to be leveraged for their seasonal forecasting potential. Both Kruskal Wallis and Kolmogorov Smirnov tests show significant differences in summer inflows conditioned on previous Niño 3.4 into Andijan ($p = 0.05$) and Nurek ($p = 0.01$) reservoirs. Such findings, based only on public domain information, show potential for improving the efficiency and safety of reservoir operations as well as reducing risks emerging from climate change.

Presentation type: Poster

Water Management at Canal & River Trust

Sarah Edwards

Canal and River Trust

Water is the lifeblood of the canals and rivers that we care for. The canal network has a rich engineering heritage that can prove challenging from a water management perspective. As well as providing water for navigation, the water also supports the riparian environment, including Sites of Special Scientific Interest and a multitude of canal-side businesses. This poster describes some of the roles of the Water Management team within the Canal & River Trust and the strategic work being carried out to maintain and protect the water supply for the future.

Presentation type: Poster

Evaluation of Seasonal Ensemble Streamflow Prediction Skill for the UK

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Skilful hydrological forecasts at seasonal lead times would be extremely beneficial to decision-makers who have to deal with management of droughts and water scarcity. Sources of streamflow predictability include (i) hydrological prediction: where knowledge of initial hydrological conditions (IHCs), such as soil moisture and groundwater states, can provide an estimate of future streamflow conditions and (ii) atmospheric predictability: where skilful seasonal prediction of weather and climate variables can be used to force hydrological models. The development of such a seasonal hydrological forecasting system must therefore understand where (different catchment characteristics) and when (forecast initialisation time and lead time) skilful predictions can be made. Results will be presented using the Ensemble Streamflow Prediction (ESP) method to benchmark hydrological forecast skill in the absence of skilful future rainfall predictions. The evaluation focuses on establishing where and when the system is most/least reliable from incorporation of IHCs only as to target where atmospheric predictability is most needed.

Presentation type: Poster

Defining the Hydrology of Heavily Urbanised Catchments: The Corn Brook, Manchester

Holly Hart, Jennifer Hill

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Whilst the impacts of urbanisation on watercourses are widely documented and researched, there have been few attempts to generalise these effects for use in rainfall runoff modelling in ungauged catchments (Kjeldsen, 2009). Within the UK, the most commonly used methods of flood frequency estimation are presented in the Flood Estimation Handbook (FEH). For small, urban and lowland catchments, which are highly relevant in the UK, a wide range of flood estimation methods can be utilised with greatly differing results.

The Corn Brook is an ordinary watercourse; it is approximately 8.5km in length and flows in a westerly direction towards Pomona Docks and the Manchester Ship Canal. Its catchment is heavily urbanised and the watercourse is largely culverted. As part of the Environment Agency Modelling Package 4, a hydrological assessment was required to inform the development of a linked 1D-2D hydraulic model (Infoworks ICM) for flood zone mapping purposes. This projects aims to reduce the levels uncertainty relating to the hydrology and flood zone extents compared to the previous study completed in 2009.

Selecting the most appropriate FEH method for flood frequency estimation on the Corn Brook was challenging for several reasons. These include; the incorrect definition of the topographic catchment on the FEH CD-ROM, the very highly urbanised catchment, no river flow or level gauges present, the catchment is dominated by an extensive combined sewer system. Standard FEH methods are therefore not appropriate for this complex catchment. However, the urban extension to ReFH was identified as most suitable to define its hydrology as it could account for the highly urban catchment. Therefore, the Urban ReFH method has been applied to Corn Brook catchment. This method splits catchments up into urban and rural areas, utilising the standard ReFH method for the rural sections and the urban ReFH extension for the urbanised sections. By creating a semi-distributed catchment with a range of inflows, both rural and urban mechanisms can be represented within one model.

Presentation type: Poster

Benchmarking hydrological model predictive capability for UK River flows and flood peaks.

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University of Bristol

Data and hydrological models are now available for national hydrological analyses. However, hydrological model performance varies between catchments, and lumped, conceptual models are not able to produce adequate simulations everywhere. This study aims to benchmark hydrological model performance for catchments across the United Kingdom within an uncertainty analysis framework.

We have applied four hydrological models from the FUSE framework to 1128 catchments across the UK, over a 20 year period. These models are all lumped models and run at a daily timestep, but differ in the model structural architecture and process parameterisations, therefore producing different but equally plausible simulations. Model performance was evaluated for each catchment, model structure and parameter set using standard performance metrics. The GLUE uncertainty analysis framework was then applied to produce simulated 5th and 95th percentile uncertainty bounds for the daily flow time-series and additionally the annual maximum prediction bounds for each catchment.

The results show that the model performance varies significantly in space and time depending on catchment characteristics including climate, geology and human impact. We identify regions where models are systematically failing to produce good results, and present reasons why this could be the case. We also identify regions or catchment characteristics where one model performs better than others, and have explored what structural component or parameterisation enables certain models to produce better simulations in these catchments. Model predictive capability for annual maximum flows was assessed for each catchment, through looking at the ability of the models to produce discharge prediction bounds which successfully bound the observed discharge.

These results improve our understanding of the predictive capability of simple conceptual hydrological models across the UK and help us to identify where further effort is needed to develop modelling approaches to better represent different catchment and climate typologies.

Presentation type: Poster

Observations relating extreme multi-basin river flows to very severe gales

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Fluvial foods are typically investigated as 'events' at the single basin scale. However, applying a recently developed methodology to identify the largest multi-basin peak flow events allows a statistically significant relationship between them and episodes of very severe gales (VSG) to be identified; such a systematic link has previously only very tentatively been proposed for extra-tropical cyclone seasons, where damaging wind and rain are commonly non-synchronous. Annual maximum river peak flow (AMAX) data during 1975-2014 for 261 non-nested catchments (i.e. with no other sites upstream) in Great Britain are used, and a 13-day window is selected. A simple correlation between metrics that are proxies for damaging wind and flooding is statistically significant ($r = 0.41$, $p = 0.0088$). Also, taking the most severe 50% and 30% of years for wind and flow respectively, co-occurrence is expected 6.6 times in 40 years whilst 10 are observed ($p = 0.021$; simulation with $n = 10,000$), making co-occurrence of the extremes 52% more likely than expected by chance. This has implications for emergency response and financial planning (e.g. insurance).

Presentation type: Poster

Flood Forecasting at the Environment Agency

Rosie Peel

Environment Agency

The Environment Agency play a key role in national and local scale flood risk management. In January 2017, I joined the national Modelling and Forecasting team within the EA which provides a 24/7 real-time flood forecasting service to ensure advance warning is given to our staff and the public of any potential flood or drought events. To do this, we gather the necessary information from our extensive gauge network and work closely with the Met Office who send us the information we need to run our forecasting models. As part of the Thames inland team, I am currently training to be a monitoring and forecasting duty officer as well as a river control duty officer. The river control duty officer, which is unique to just two locations in the country, is responsible for the continuous monitoring of levels, flows and major abstractions along the Thames. This is critical in co-ordinating and maintaining the balance between abstractions from the river for public water supply, navigation, power generation, the requirements of the diverse river ecology and flood risk.

This poster will outline the key data and tools used by the Modelling and Forecasting duty officers in flood risk management, in particular those used by the Thames inland teams.

Presentation type: Poster

Methods to assess uncertainties in flood forecasting: A Malaysian case study

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Damages and casualties due to river flooding can be reduced with non-structural flood control measures, namely with flood forecasting. However, the quality of a flood forecast is limited by three sources of uncertainty: (i) limited rainfall prediction, (ii) lack of reliable data on the catchment antecedent conditions and (iii) model not representative of all the processes involved. Available data quality plays a crucial role in flood forecasting modelling. Related to this, it is possible to make a distinction between "data poor" and "data rich".

It is important to provide decision-makers with information on the uncertainty related to the forecasted data, helping them to make better-informed decisions during flood warning situations. Four approaches are described in the literature in order to do so:

1. Simulation and resampling techniques (SR) are used when the statistics of the output (and thus the uncertainty) are obtained by running the model several times, randomly fed with the statistics of the input and the system[1];

2. Error based analysis (EB) provides an estimation of the uncertainty by directly analysing the model output errors. An interesting example is the non-parametric data-set approach (NDA)[2];

3. Training of special emulators through the use of statistical methods. Emulators are black box models (BB) meant to be a simplification of the processes that take place in the catchment, which can provide information on the uncertainty of forecasts[3];

4. Combining methods (CM), that use different uncertainty processors and apply the Bayesian forecasting system[4];

HR Wallingford is planning to implement a statistical tool to assess uncertainty of the operational flood forecasting model for the Kedah region, in Malaysia. Available data are scarce, therefore a simple approach is needed. Due to its simplicity and low computational power, EB through a 3D error-matrix is being applied and tested.

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Presentation type: Poster

Investigating uncertainties in ensemble hydrological reconstructions of drought events

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The UK is well known for its variable short-term climate however, deviations from its fluctuating norm can pose substantial threat. There have been 8 significant drought events in the UK over the past 40 years, which have impacted water supply, agriculture and the environment. However, observational streamflow records are limited prior to the 1960s. As part of the Historic Droughts project, within the NERC UK Droughts and Water Scarcity Programme, reconstructions of drought events using the hydrological model GR4J have been produced, covering the time period 1891 to present. These reconstructions will be useful to the academic and the water supply sectors, as well as others, as they provide previously unavailable data on the longer and more extreme droughts of the late 19th century.

This research demonstrates the uncertainties inherent in the hydrological modelling of these drought events, and how they affect simulations of drought characteristics such as drought duration and severity. In this study, the ensemble reconstructions of drought event characteristics, extracted using thresholds from modelled standardised streamflow index, are compared to observations for several catchments across the UK. Understanding the uncertainties in reconstructed drought data over the observational period will provide key insights into the modelling capabilities of drought event simulation, and will elude to the applicability of historic drought reconstructions in decision making scenarios.

Presentation type: Poster

Data Assimilation for REsilient City (DARE): urban flooding

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University of Reading

Urban and rural flooding can result from intense rainfall, flash floods, coastal floods or river floods. However, in cities, unlike in rural areas, there is very little open soil available for water storage and most floodwater needs to be to be transported to surface water or the sewage system. Also since most world's large cities are located on a coast/river floods due to climate changes are more likely to occur in a near future. Today, 54% of the world's population lives in urban areas, a proportion that is expected to increase to 66% by 2050.Thus, early and accurate urban flood forecasts are very important to minimise social and financial damage as well as potential loss of life due to urban floods.

The aim of the project is to produce a step-change in the skill of forecasts of urban flood forecasting. To achieve this we will use mathematical techniques called data assimilation which combine forecasts from dynamical models (with uncertain model predictions) with a diverse set of observational data to produce more accurate flood forecasts. We will look to achieve the improvements in urban flood forecasting through advancement in data assimilation techniques applied to urban flooding prediction and through the use of novel, 'smart' observations such as CCTV cameras in cities and SAR satellite images of flood extent and water height for urban areas.

Presentation type: Poster

Uncertainties and limitations of 2D-only breach hydraulic modelling: a case study of Thorpe Bay, Southend-on-Sea

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A 2D-only TUFLOW model was developed for Thorpe Bay, Southend-on-Sea to assess the residual risk of tidal flooding from a breach in the existing sea defence wall for the current (200 year 2005) and future (200 year 2115) scenarios. The hydraulic model simulates a breach width of 20m which opens 18 hours before the main tidal peak and remains open for 36 hours. This set-up allows the entire peak tide cycle to flow through the breach, representing the worst case scenario of breach flooding in Thorpe Bay. A number of limitations were identified, namely: the resolution and accuracy of LiDAR data used to represent topography; the digitisation of land use to assign Manning's roughness values; the resolution of the model, such as grid size and time step; accuracy of the tidal data provided by the Environment Agency; the location chosen for the breach to occur; the timing of the breach opening; breach length and the toe level of the sea defence wall.

Results for the current and future maximum flood extents for the Thorpe Bay area are presented and flood mechanisms described. In order to visually represent the effects of uncertainty within the study, the future maximum flood extents are presented for two sensitivity tests comparing different breach timings and breach lengths. All other model parameters, e.g. breach location and breach toe level, are kept comparable in order to isolate the effects of the uncertain parameters.

Ways to improve model accuracy are suggested, such as: obtaining topographical survey; undertaking site visits; decreasing grid size; verifying tidal data and sensitivity testing. The study summarises that uncertainty is inevitably inherent within any modelling study, but steps can be taken to reduce this. Hydraulic modellers should review the results carefully and sense-check their models, whilst always caveating the limitations and sources of inaccuracy.