

Circulation

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The Newsletter of the British Hydrological Society

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UK Hydrological Bulletin

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President's Piece

With "going digital" being a key part of many companies' (not to mention governments), your committee has been considering how we should be developing to best serve the interests of you, our members. Circulation has been a major communication tool within the Society since shortly after our foundation in 1983 – indeed in those early pre-internet years it was essentially the only means of widespread communication amongst members. Now there are plenty of other communication channels, and Circulation itself is available electronically through our website. The possibility of Circulation only being available as a pdf was first mooted many years ago, and the issue has been revisited at intervals. Initially an objection to such a change was that it would disenfranchise a significant number of members, but almost everybody now has an email address so that is a much lesser concern. However, even in the electronic age (with the Mailbase very widely used, and also channels such as Twitter) there have always been strong voices in support of the hard copy magazine dropping through the letter box once a quarter.

So, what do members think? If we were to stop the hard copy magazine there would be savings in printing and postage costs, but I strongly suspect that our membership numbers would not be much affected by reducing the subscription, or averting a future increase. In any case, although the balance sheet of the Society is important, I do not think that should be the main thing driving how the Society develops. Circulation (and indeed the Society) has evolved, but in many ways is not fundamentally different from the early issues in the 1980s. Yes, the size has changed, and it has moved from monochrome to a colourful and attractive format, but it still contains information about future meetings, and reports on past meetings and hydrological "events", not to mention missives from the President. Whilst not wanting to move from evolution to revolution just for the sake of it, it is important that we consider how to maintain the Society's relevance in a fast-changing world. Dropping the hard copy version of Circulation (whether to save money or because of a view that it is outdated) would not do much, and I would be reluctant to make just that change, but a revamp to make it an interactive form of communication might be a very positive development for the Society. Please let us know your views, either directly to me or via any member of the committee.

Since 2000 even-numbered years have seen either a National or International Symposium, the last such being at Cranfield in 2016. Although that meeting was a success, and appreciated by those who went, there was disappointment in the attendance, particularly in relation to the number who were there for the whole event. As a result the committee decided that the 2018 Symposium should be held over 2 rather than 3 days. It will be at the University of Westminster in central London on September 12th and 13th. I am grateful to my predecessor, Geoff Petts, for offering to host the event at "his" university, and for pursuing the arrangements

at a time when he has sadly been unwell. Please put the date in your diary and consider what you can offer in response to the Call for Papers so that this will be a vibrant and enjoyable event.

Peter Ede
President

BRITISH HYDROLOGICAL SOCIETY NATIONAL SYMPOSIUM

12th – 13th September, 2018

HYDROLOGY: ADVANCES IN THEORY AND PRACTICE

University of Westminster, Marylebone, London
(Opposite Baker Street Station, with accommodation available on site)

Organising Group:
Prof Geoff Petts (University of Westminster),
Mr Peter Ede, President BHS and Mott MacDonald Group),
Dr David Boorman (CEH)

Opening Keynote Address:
Prof Keith Beven, FRS (University of Lancaster)

CALL FOR PAPERS and POSTERS
We welcome abstracts for oral presentation and poster presentation on all areas of hydrology for Open sessions and also for the following Thematic sessions -

Hydrology and Sediment Systems
Chair: Prof D J Gilvear, University of Plymouth

Hydrology and Ecosystem Services
Chair: Dr A R G Large, University of Newcastle

Hydroecology
Chair: Prof P Wood, University of Loughborough

Please submit Abstracts for presentations and posters to g.petts@westminster.ac.uk before **Tuesday 10th April**.

The Yorkshire Integrated Catchment Solutions Programme:

using environmental science to deliver greater returns on investment.

As part of the 25 year Environment Plan launched at the beginning of this year, Defra have committed to multi-million pound investments in peatland restoration and natural flood management (NFM). They have also acknowledged a need to learn more about working with natural processes and to be informed by scientific evidence.

This is all very good news for the Yorkshire Integrated Catchment Solutions Programme (iCASP) hosted at Leeds University under the direction of BHS member, Professor Joseph Holden. iCASP was officially launched in July last year with funding from the Natural Environment Research Council.

Over the next five years, this 'impact' rather than research programme will broker partnerships of academics from the Universities of Leeds, York, Sheffield, and the National Centre for Atmospheric Science to work on co-designed projects with catchment stakeholders. By using existing environmental science to address challenges such as flooding, drought, peat degradation, deterioration in water and soil quality and climate resilience, the programme aims to realise significant regional economic and social benefits.



Even before the publication of the Environment Plan, iCASP had already identified peatland restoration and natural flood management as two areas where an integrated management approach drawing on the academic expertise of hydrologists, engineers, soil scientists, environmental economists and others could help to enhance both the flood alleviation schemes and peatland restoration works that are being developed in Yorkshire.

For instance, the £50 million phase one of the Leeds Flood Alleviation Scheme is now completed but after the 2015 floods, a further £35 million is to be spent to sustain the standard of protection in the face of climate change up to 2069. This second phase of works is taking a whole catchment approach and exploring how natural flood management measures which include installing woody debris dams, tree-planting, re-meandering and terracing river banks could be integrated effectively with hard engineering. Peatland restoration will also contribute to water retention in the uplands.

Furthermore, smaller Defra-funded pilot NFM projects are



already getting underway at different locations in the Yorkshire Catchment Area with varying needs for support with hydrological modelling and monitoring. These pilots will provide some very useful case study learning to inform the bigger Yorkshire schemes and others elsewhere in the UK.

Representatives from most of the flood alleviation schemes being taken forward in Yorkshire were able to come together at an iCASP workshop to exchange knowledge and design a project that will involve them all in accessing the expertise they need.

One of iCASP's first projects, therefore, will be field-testing the Environment Agency's Guidance on Working with Natural Processes, published at the end of last year and identifying and quantifying the co-benefits of natural flood management. For instance, many of the NFM measures improve water quality, habitats and recreational spaces as well.

This focus on co-benefits is aligned to the natural capital approach which has informed the Environment Plan and is core to peatland restoration as well. iCASP will be supporting the work being carried out by two big partnerships: Moors for the Future and the Yorkshire Peat Partnership. The latest research will be translated so that restoration work can be optimised to generate the greatest number of socio-economic and ecosystem benefits whilst also taking account of a changing climate. As if this weren't enough for hydrologists and other disciplines to get their teeth into, iCASP is also working up potential projects on better forecasting of surface water flooding and getting the most out of green infrastructure.

Susan Ballard
Communication Officer, iCASP

For more information about iCASP please see: www.icasp.org.uk

CIWEM

Working with Natural Processes:
The Evidence Behind Natural Flood Management
Edinburgh - Wednesday 14th March 2018

This conference, jointly coordinated by the Environment Agency, CIWEM and SEPA, is one of series of events to launch the Environment Agency's 'Working with Natural Processes Evidence Base', It will include presentations from a range of existing projects that have successfully implemented NFM measures on the ground, through effective partnerships, whilst drawing on a range of funding streams. It will also launch the NFM Network Scotland.

http://www.ciwem.org/events/working-with-natural-processes-the-evidence-behind-natural-flood-management-edinburgh/

The effect of land use on the aggregate stability of soils:



The 2017 Student Award went to James Whitefield, University of

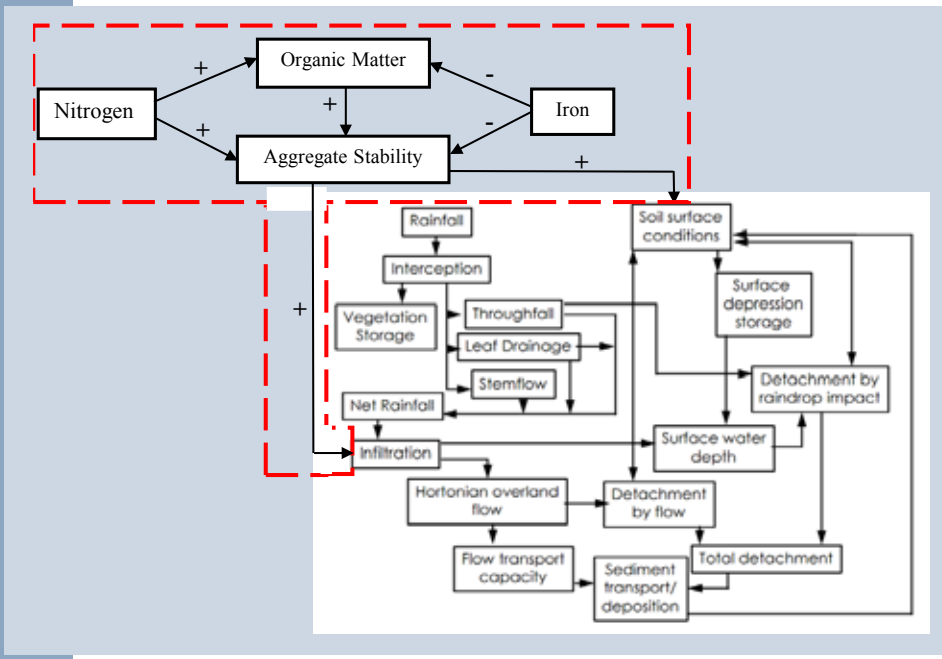
Soil aggregation results from the rearrangement, flocculation and cementation of particles such that particles and aggregates are bonded and held together by organic and inorganic substances. The aggregate stability of a soil is its ability to retain its solid and void space when exposed to stresses such as rain drop impact. Structural instability in a soil leads to the formation of hard setting surface horizons and also structural collapse and both, in turn, lead to soil erosion. High aggregate stability is an important factor in improving the soil in a vast number of ways, namely by decreasing erodibility and improving fertility and productivity. Severe negative consequences caused downstream due to the management of land within catchments is a global issue.

In this field study of the Bidwell Brook catchment, SW England, a variety of cultivated and uncultivated soils from eight land uses were tested for their particle size distribution, the percentage organic matter, and the concentrations of seven chemicals: nitrogen, phosphorus, calcium, magnesium, sodium, iron and aluminium. Also undertaken was a rainfall simulation to determine the erodibility of the soil's aggregates.

Of the three sizes of aggregate studied, larger aggregates were found to have higher aggregate stabilities and, when comparing between land uses using the smallest aggregate size class (4–5.6mm), those from uncultivated land uses were found to have much higher aggregate stabilities than those from cultivated land. The uncultivated water meadow (pasture land periodically inundated with water) was found to have the highest aggregate stability with a rainfall simulation survival index (RSSI) of 100, closely followed by woodland with 98. Permanent pasture was found to have slightly lower stability, with RSSI values of 93 and 94. Soils farmed following organic principles was were found to have higher aggregate stabilities – with RSSI values between 40 and 88 – than that undersoil from more conventional farming which had an RSSI value of 22.

Statistical analysis of the relationships between parameters previously linked to aggregate stabilityas cited in related literature revealed that of the twelve parameters, only two had significant positive correlation relationships with RSSI; organic matter and nitrogen concentration. One parameter, iron concentration, showed a significant negative correlation. Nitrogen concentrations were also found to show a significant positive relationship with soil organic matter percentage.

The determination of these relationships presents the basis for the design of a more accessible method for determining land use and an individual field's susceptibility to soil erosion whereby less testing is required and can be undertaken in the field at a lower economic cost. These



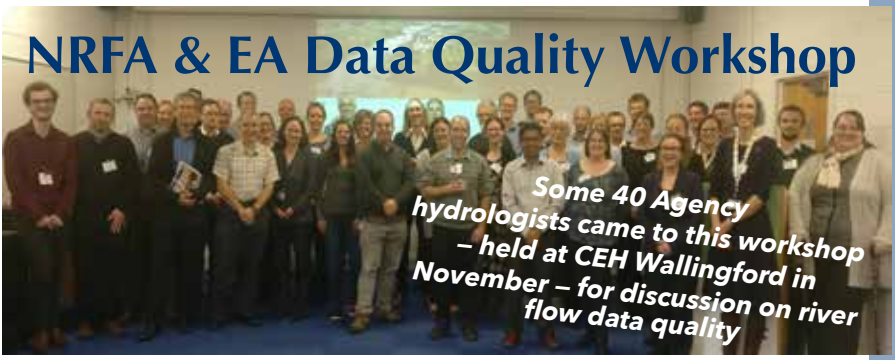
Conceptual flow chart adapted from the European Soil Erosion Model (EUROSEM) flow chart (Morgan et al. 1998). The parts outlined in red dashes are additions to the model showing how the aggregate stability relationships uncovered in this study fit into the model. Note: '+' denotes lines of positive relationships where, as one increases so does the other. '-' denotes lines of negative relationships where, as the parameter increases the other pointed towards decreases.

relationships were also used to adapt and added to the EUROSEM flow chart. Alongside this, consideration of future agricultural intensification and *in-situ* conditions is required. Through the isolation of the exact practices used in organic farming there is the possibility for a combined approach within more high output farming styles to reach future needs while mitigating against future soil degradation and erosion. This study showed how a change in the management of the land in the Bidwell Brook catchment could have significant positive connotations for the soil's erodibility.

New members

Nathan Abbott.....Manchester University
Samuel Flint.....Jacobs
Mark Bernhofen.....Jacobs
Anna-Louise Prince.....MWH-Global
Benjamin Marshall-Camm
Ewan Shilland... .....University College London
Hanna Kugachandran.....Richard Allitt Associates
Eric O'Connor.....Enzygo Ltd

NRFA & EA Data Quality Workshop



Some 40 Agency hydrologists came to this workshop – held at CEH Wallingford in November – for discussion on river flow data quality

The day began with NRFA Manager Isabella Tindall and EA Technical Specialist Hydrologist for the Thames area Emma Cross welcoming the group and setting out the objectives for the day; improving ways of working, sharing best practice and developing collaborations between the NRFA & EA. They were followed by NRFA Scientific Lead, Jamie Hannaford's presentation on how the NRFA use the EA's data. He explained the data analysis carried out on EA data in a number of areas ranging from the UK Hydrological Summary, to analysis on long-term trends (through the Benchmark Network) and assessments of major flood and drought events and all the way to the contribution to Europe-wide assessments and the Global Runoff Data Centre.

Next up, the group heard from the EA's Jane Allam, Technical Specialist Hydrologist for the Hertfordshire & North London area who explained what the EA's multi-year checks on daily mean flow data entail. She gave examples on how her team's work helps to identify trends and improve confidence in the data.

The final presentation of the morning was from the NRFA's Data Quality Coordinator, Cath Sefton who explained the NRFA's data acquisition and quality control processes. She highlighted that the NRFA data validation is a secondary level of checks aiming for UK-wide consistency, to complement the local knowledge contributed by the measuring authority checks and aims to have sufficient liaison to ensure that queries focus on problems not already identified by the measuring authority.

The afternoon session consisted of the group splitting up to attend four breakout sessions in order to discuss:

- how errors are corrected on both the NRFA & EA archives
- the future of river flow data quality control
- sharing best practices and methods
- quality control of extreme flows

The workshop objectives were well and truly met and the event allowed Hydrologists from the NRFA & EA not only to meet each other but to develop closer working relationships between the two organisations, which will ultimately lead to an increase in quality of river flow data. The day resulted in a number of actions that both organisations can take forward.

Thank you to all at the Environment Agency who attended and contributed, and to Emma Cross and John Waddingham of the EA who made the event possible.

Stephen Turner

About Drought

Maximising the impact of UK research on drought & water scarcity

Wednesday, 14 March 2018
Macdonald Burlington Hotel, Birmingham

Showcasing the latest developments and hands-on access to outputsfrom the £12m five-year Research Council-funded Droughts and Water Scarcity programme

This Programme supports improved decision-making and communication in relation to droughts and water scarcity for

- Water suppliers, energy suppliers & regulators
- Agricultural sector
- Environmental policy-makers, stakeholders & regulators
- UK Businesses, ranging from high volume industrial water users to local SMEs
- Community planning organisations, communities, and not-for-profit special interest groups

As well as hands-on interaction with key project datasets, you will be able to ask the experts about on-going developments and give feedback on how best they can be tailored to support your area of interest. The Showcase will give the opportunity to participants to interact with other stakeholders and researchers.

The Drought and Water Scarcity programme has been underway for over three years and has already led to significant advances in our understanding of the many complex, interlinked drivers of drought; the wide range of impacts and the diversity of management responses. The final phase of the Programme is now underway and, over the next 18 months, will synthesise the knowledge and outputs from the four research projects to maximise the impact of the Programme for a diverse range of stakeholders

Book your free place now using the online registration form.

The closing date for registration is **2 March 2018**.

Register here: **https://reg.nerc.ac.uk/aboutdrought/**

Registration for this free event is limited to four delegates from each organisation. We will contact you if this number has been exceeded. Please contact the Project Office at endows@ceh.ac.uk for further information.

Keep up with news and events from the UK Droughts & Water Scarcity Programme and its projects at the About Drought website - http://aboutdrought.info or follow @AboutDrought on Twitter.

Bringing flood modelling to your local community

Meeting reports

Joint CIWEM / BHS Pennine Group meeting
30 November 2017

Chris Allman from Mott MacDonald started the evening with his talk on hydrological uncertainty following large floods, citing the December 2015 flood that affected the town of Whalley, Lancashire. This was a very large event and the observed flow was much higher than previous high flows on the gauged record although the return period at the initial stage was unquantified. This event introduced new knowledge regarding flooding in the town and introduced uncertainties in the current growth curve.

Chris then went on to consider how to quantify this large event statistically: should we class this as an outlier and exclude it from th e hydrological analysis, or try to fit a new distribution to include this event? During his analysis, the variation in estimated return period ranged from 120–600 years. To make a better-informed decision, Chris decided to look back further into the historical record of flooding, based on the principles of new guidance released by the EA. He tried to find *quantifiable* flood history for although this is often qualitative and needs an adjustment for land use change, it can help to put the event into perspective and frequency. Chris concluded by highlighting that there is no correct answer but that it is necessary to ensure that you appreciate the uncertainties involved in hydrological estimation and communicate these clearly to future users who might be using this information to make significant decisions.

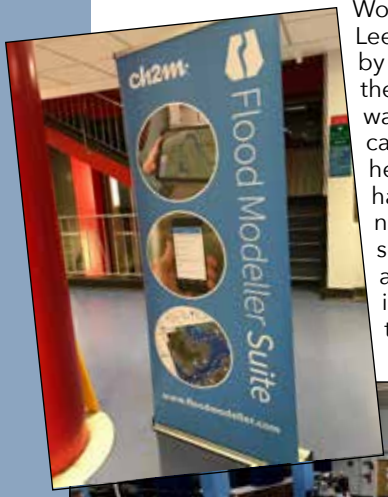
Adam Parkes from CH2M was the second speaker, on improvements and new features of the Flood Modeller Pro package. Adam discussed the Flood Cloud, which allows users to export and run models in the cloud. He also described new simulation windows, extra information on mass balance, the automated simulation builder and enhanced damage calculator. Finally, he discussed the next release of the software which will include new links with high performance computing, improved HEC importer, an EACSD builder and further tool improvements.

Luke Ballantyne from Arup returned to the 2015 flooding, this time in the city of Leeds and the difficulties in assessing the magnitude of the event due to peculiar structures, such as weirs under construction and half-built new flood defences reacting in uncertain ways. He discussed secondary and old channel networks that became reactivated and how the amount of flow through them was unknown. Again, Luke asked: should you include this event in hydrological analysis?

Luke had also looked at Leeds' longer historical flood record, in particularly the 1866 flood as a marker of another large event. However, the data on this event is mainly qualitative and subject to non-stationarity, due to urbanisation, changes in river hydraulics and blockage of old mill and lock systems that used to flow under Leeds train station. In conclusion Luke estimated the event as a 0.5% AEP but he stressed again the greater uncertainty in assigning a magnitude to this large event.

The final talk of the night was given by **John Jepps** from

Thomas Mackay Ltd, on simultaneous hydrological and hydraulic modelling of Wortley Beck in Leeds. John started by expressing the view that this was an unusual catchment that was heavily urbanised, had large sewer networks and some reservoir attenuation, including the Farnley balancing pond which could be used to store water but is full of silt and currently defunct.





An urban ReFH approach was implemented, FRQSIM was used to break the catchment up into sub-catchments, MasterMap helped define urban areas and a dummy network represented the sewer network. This meant that each part of the catchment was split up by its specific hydrological response. The hydrological estimates were then calibrated against the 2007 event. The results showed that the calibration improved the flow estimation within this catchment. This work highlights that hydrology cannot be undertaken in isolation and the standard approaches in the standard FEH approach needs to be challenged in unusual catchments.

Victoria Coates



This event will present innovative case studies, collaborative approaches and facilitate discussion on the scale of the issue and current progress on both rural and urban diffuse pollution.
The call for abstracts is now open : see website for full instructions
We welcome papers addressing the following areas (but not exclusively): emerging trends, policy drivers, innovative case studies, cost effective practice

http://www.ciwem.org/events/diffuse-pollution-evidence-effective-practice-and-lessons-for-policy-practice-and-investment-call-for-papers/

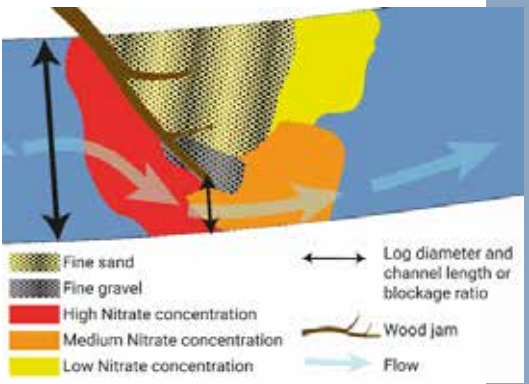
International Society for River Science
9-24 November 2017
New Zealand

As I am in my final year of my PhD, the 5th ISRS symposium on 'Integrating Multiple Aquatic Values' presented a timely opportunity to gain perspective and feedback on my research. I was keen to attend the ISRS conference to gain exposure to a wider interdisciplinary community of ecological and hydrological scientists, and the latest developments this rapidly evolving freshwater field. Certainly, the conference location was a draw. New Zealand is famed for is beautiful landscapes, but equally I wanted to learn more about the problems, properties and integrated solutions in a country so deeply connected with the "values of rivers" from the Maori culture.

The first presentation entitled "Relationships between large wood in rivers, benthic macro-invertebrate, and hyporheic invertebrate" in the Invertebrate Ecology session was very well received. I presented the results of a field study on the benthic and infaunal invertebrate communities around in-channel large wood at the Hammer Stream (West Sussex-UK). The audience was particularly interested in (i) the responses of big (macro-) and small (meio-) fauna, in terms of density, diversity and biomass, to the presence of wood and about the possibility of identifying species functional traits associated with wood; ii) the role of the wood in driving water exchange; and (iii) the role of other variables, i.e. temperature, sediment type, dissolved oxygen, associated with wood to explain ecological responses.

The second presentation was entitled "A new multi-scale approach to predict potential hyporheic exchange flow in rivers". This piece of work is a novel and transferable method to support river restoration in the identification of areas of potential hyporheic exchange at several spatial scales, from reach to catchment. I explained why a multiscale approach is needed to target river restoration planning that takes into consideration the hyporheic zone, and how the approach used in this study combines geostatistical analysis with current knowledge of the processes driving hyporheic exchange. This talk was also well received, and I was happy to see commonalities with approaches used in other disciplines.
Thank you very much BHS for awarding me with a Travel Grant to attend the Symposium, it was truly rewarding!

Chiara Magliozzi
c.magliozzi@cranfield.ac.uk,



In-channel large wood leads to heterogenous sediment, organic matter, nutrient and flow type

These AGU meetings need no introduction to Circulation readers : we know that they are huge affairs but its still nice to hear the impact that they have and how BHS delegates hold their own!

AGU Fall Annual Meeting

New Orleans

11th-15th December 2017

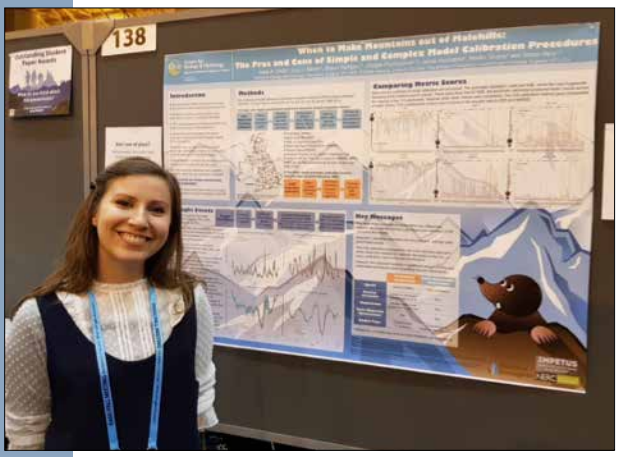
Katie Smith said....

Having attended AGU once before in 2013 when I was a PhD student, I had some idea of the scale of the conference, but it seems that this year whilst the Moscone centre in San Francisco was undergoing renovations, AGU decided to "go big or go home", hiring the 5th largest convention centre in the US (Moscone is 35th!). The New Orleans Ernest N. Morial Convention Center boasted 1.1 million square feet, and from end to end was over 1 km long. Many "Fitbit" jokes were made throughout the week, including my record score of over 11,000 steps before the first presentation at 8am on Monday morning! We certainly walked off our Po Boy's, Gumbo and Jambalaya.

I was there to present my work on the NERC UK Drought and Water Scarcity Programme, and my week focused on weather extremes from the start. Waking up on Sunday morning to a blanket of snow across the south of England it was a genuine miracle that my colleague and I got to the airport, let alone New Orleans. However, we made it and we joined the 24,000 other scientists eager to share their research.

AGU had a lot to offer and, unsurprisingly, I found myself struggling to decide how to spend my time. My highlights included: kicking off the conference with three full sessions on droughts; a lunchtime lecture on "how a geoscientist can save the world"; plenty on seasonal forecasting for water resources and natural hazards; and a poster on whether the great ice wall in "The Game of Thrones" could actually exist….

I presented my poster that explored the pros and cons of simple and complex model calibration procedures, applied to hydrological modelling of drought events. Being a strong advocate of novel science communication to draw in the crowds, I titled my poster according to a well-known saying "When to Make Mountains out of Molehills" (why would you do something complicated, when you can do something simple?!) Mr Mole certainly made an impression, as I got talking to scientists from all over the world, working on every aspect of the geosciences from planetary sciences, through

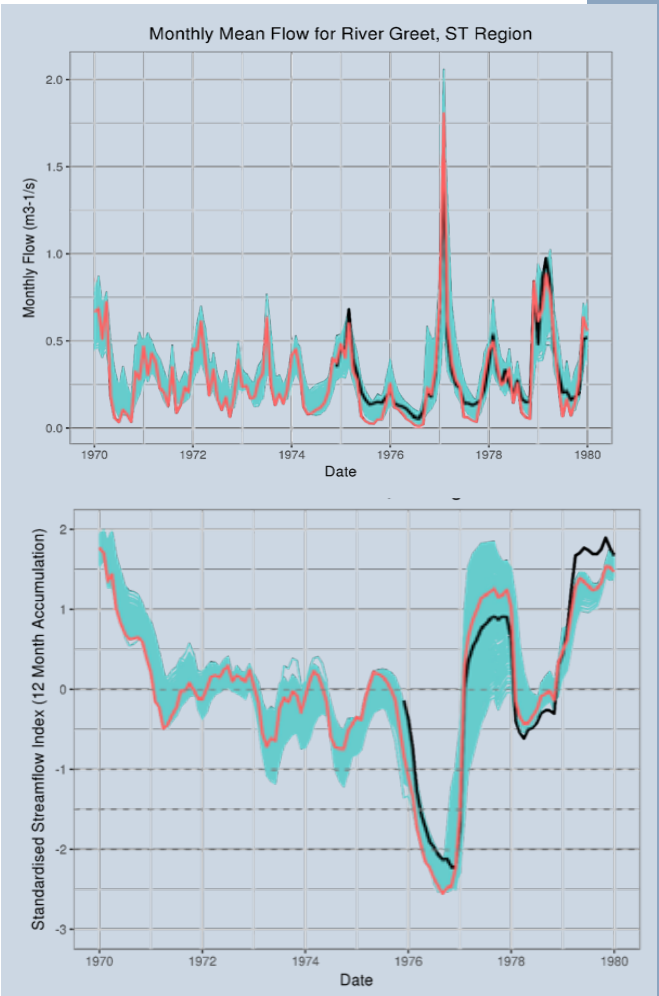


Me and my poster

hydrology, to education.

My research compared two approaches to calibrating the GR4J model: the inbuilt "automatic calibration" function - a very simple steepest-descent algorithm using the Nash Sutcliffe Efficiency evaluation metric; and a manual Latin Hypercube Sampled (LHS) approach that sampled 500,000 sets of model parameters and assessed them against 6 evaluation metrics, including low flows metrics Q95 and Mean Annual Minimum flows. I found that in general the automatic calibration did a very good job of simulating the observed flows, but that the LHS method that included low flows metrics provided better simulations of drought events. The LHS method also allowed for the further exploration of multiple model parameter sets, which provided an understanding of how the uncertainties in the model parameters affect the model outputs (see graphs).

I concluded that for many users, the automatic calibration is quick, simple and effective, however researchers who are using the model for specific applications may want to consider using a "multi-objective" approach that fits the model using both general, and more specific criteria.



Monthly mean flows and Standardised Streamflow Index (SSI-12) for the 1975-76 drought event on the River Greet in Severn Trent region. The automatic calibration procedure tends to underestimate low flow significantly. The top 500 LHS calibrated models have a wide range of uncertainty in this catchment, but the range encompasses the observations.

Now it is time to put pen to paper and write it up! Thank you BHS for the fantastic opportunity.

Katie Smith,
Centre for Ecology & Hydrology,
Wallingford.

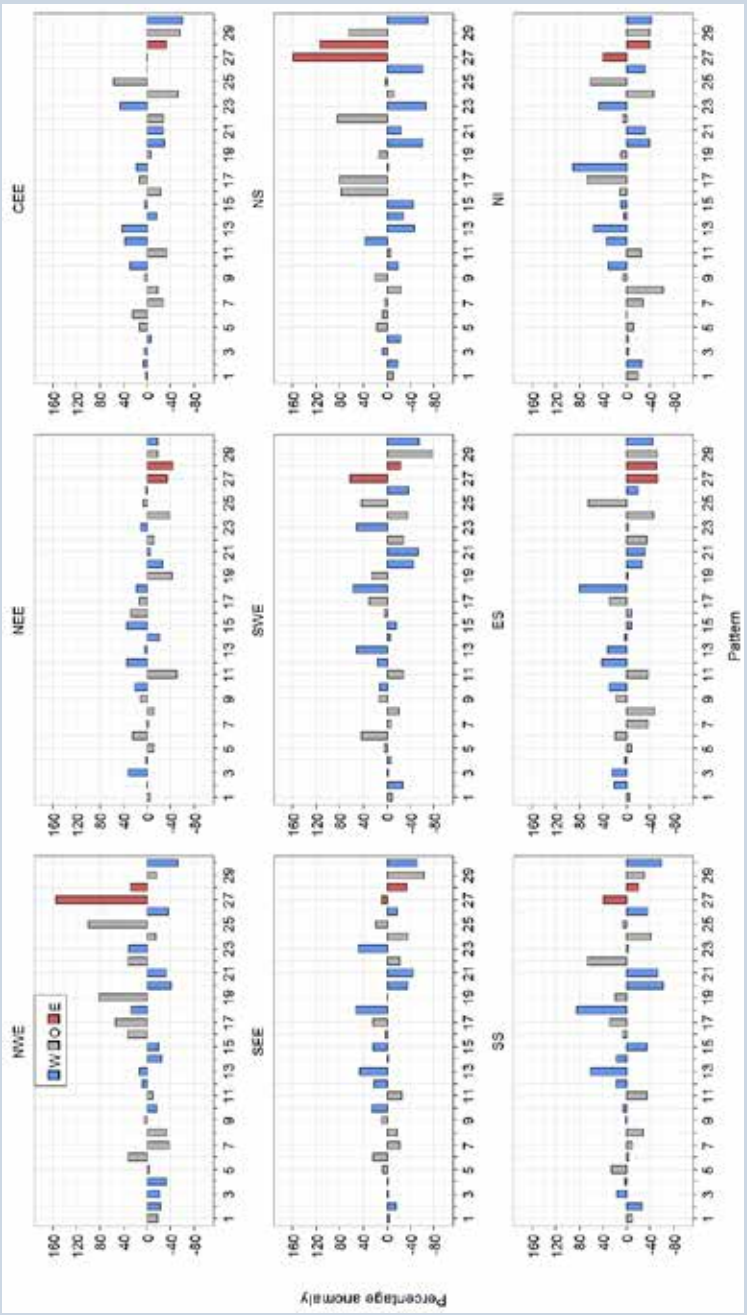
AGU accounts contd...

Doug Richardson from Newcastle University also went to 'The Big Easy'

One of the many sessions kicking off the conference at 8 a.m. on the Monday was "Hydroclimatic Extremes: Droughts". UK drought was well represented, with myself presenting work on linking meteorological drought with weather patterns, followed by **Katie Smith** giving the latest updates on the Historic Droughts project, featuring the exciting prospect of streamflow and groundwater reconstructions back to 1890. **Justin Sheffield** delivered the morning's invited talk on the importance of understanding how droughts and floods intersect. By developing a global flood and drought catalogue for the past 100 years, he and his team have been able to characterise long-term variability in risk, showing that changes have occurred on multi-decadal time-scales.

Moving from past events to future projections, **Luis Samaniego** presented work from the EDgE project, revealing results from a high-resolution, multi-model ensemble that suggest a significant increase in the number and spatial extent of European droughts by 2100. Linked to this work but focused on the Americas, **Dimitris Herrera** showed that anthropogenic forcing has likely intensified the drying trend in the Caribbean, while **Mauricio Zambrano-Bigiarini** outlined the contribution of temperature increases to Chilean droughts. Ending the session, **Ashish Sharma** enlightened the audience on the dangers of using common drought indices for simulated time series such as future projections, due to the differences between general circulation model data and observed data.

Clare Deser presented this year's Bjerknes Lecture, framing the problem of how to disentangle the climate's internal variability from anthropogenic influences, and how dynamical adjustment can be used to remove this internal atmospheric circulation variability from surface climate anomalies to reveal the forced response. The session "Advances in Characterising Extreme Storms, Flood Risk and Flood Risk Management" saw invited speaker **Andras Bardossy** present work investigating how the size of the urban study area relates to the frequency of extreme events. Following this, **Marco Marani** introduced the concept of meta-statistical extreme value theory techniques, which relaxes some asymptotic assumptions to make use of all observations. The recent rise in popularity of machine learning methods in hydrology was reflected by the number of talks and posters on this subject. **Bidhyananda Yadav** used a variety of machine learning methods to predict the baseflow index in more than 800 ungauged catchments in the USA, while revealed work on a Bayesian network approach to identify drivers behind the recent rise in water levels of the Great Lakes, USA, closing the water balance in this region for the first time. Unsurprisingly, work on the North Atlantic Oscillation (NAO) was well represented at AGU. **Gokhan Danabasoglu** explained the relationship between the NAO and Atlantic multi-decadal variability, with a persistent positive phase of the former leading to a positive phase of the latter, which in turn eventually may result in a negative phase NAO. **Rosemary**



Relative changes of weather pattern frequencies during droughts in different UK regions (Richardson *et al*. 2017
Reproduced from: Richardson, D., Fowler, H. J., Kilsby, C. G. and Neal, R. (2017), A new precipitation and drought climatology based on weather patterns. *Int J. Climatol*. doi:10.1002/joc.5199

Eade examined the decadal variability of the NAO, with a view to assessing just how unusual the strong positive phase between 1965 and 1990 was.

However, you cannot spend a week in New Orleans and only work. The city offers live jazz in every bar and brass bands on every street corner, a unique local cuisine and quirks such as a voodoo museum. Thank you to BHS for contribution to my useful (and fun!) trip to AGU.

Doug Richardson
Newcastle University

Aaron Smith from Aberdeen University writes....

We presented two case studies focusing on a variety of research gaps addressing the transit times and flow paths of water through various hydrological scales (soils, lakes, and catchments). This work highlighted my post-doc research at the University of Aberdeen, presented as both poster (Quantifying the role of vegetation in controlling the time-variant age of evapotranspiration, soil water and stream flow) in Hydrology, Plants as Builders and Plumbers of the Critical Zone (Poster Session only), and oral presentation (Quantification of evaporation and transit times in lake water budgets)

Identifying the sources of water which sustain plant water uptake is an essential prerequisite to understanding the interactions of vegetation and water within soil waters. Estimating the sources of root-water uptake is complicated by the notion of 'two-water worlds' which distinguishes more mobile and immobile water sources which respectively sustain streamflow and evapotranspiration. Water mobility within the soil determines both the transit time/residence time of water through/in soils and the subsequent age of root-uptake and xylem water.

We presented an approach to address these complexities through the use of time-variant probability distributions; conceptualising the transit times in the soil zone using a dual-storage soil column differentiating gravity (fast flow) and tension dependent (slow flow) water. The method was calibrated against measured stable isotope signatures of soil water at multiple depths (5, 10, 15, and 20 cm) and for xylem water within the dominant heather (Calluna spp. and Erica spp.) vegetation in a Scottish Highland catchment over a two-year period.

Within a 50 cm soil column, we found that there was a high preference for young water to percolate through the soil layer, particularly when the soils were most saturated. The high preference for young water to percolate, led to a more stable water age in soils comprising older water within the slow flow soil storage.

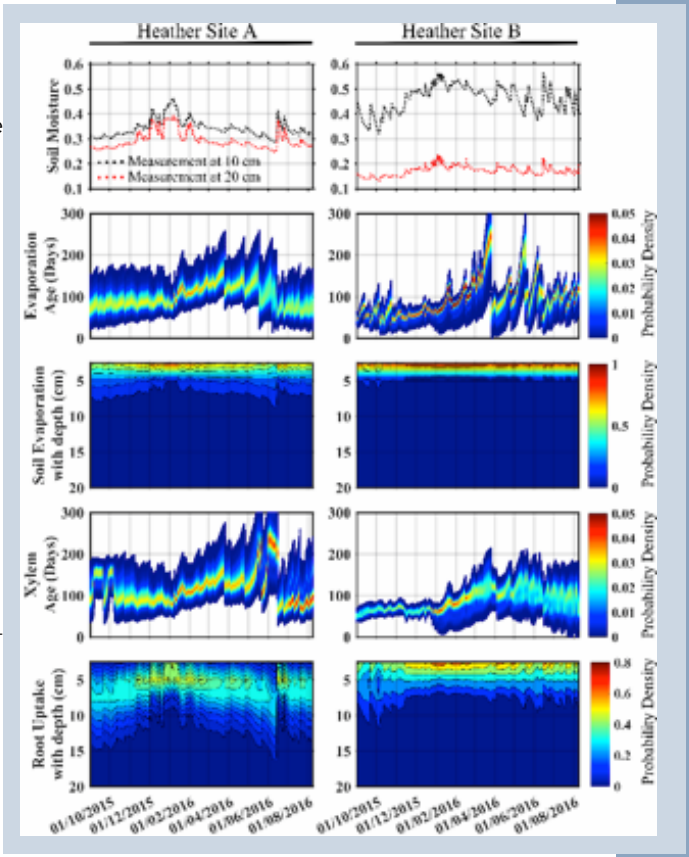
The significance of these results relates to the evaporation and xylem water ages and sources. Mean evaporation and xylem water age changed throughout the year and between sites (see Figure). The changes were driven by changes in the source of water for each flux, and thereby the soil moisture. During low soil moisture (i.e. lower than mean soil moisture), root-uptake was from lower depths, while higher than mean soil moisture showed uptake of near surface water.

In our humid, low energy environment, we found that xylem water comprises both mobile and immobile water. The division of soil storage into fast and slow flow, has shown potential to identify the sources

of plant water and vegetation and soil water interactions.

Evaporative fluxes from northern lakes are essential components of catchment water balances, providing large supplies of water to the atmosphere, and affecting downstream water availability. However, measurement of lake evaporation is difficult in many catchments due to remoteness and inaccessibility. Evaporative flux may also influence mean transit times of lakes and catchments, identified through water- and tracer mass-balance.

We combined stable water isotopes (δ2H and δ18O), transit, and residence time distributions in a non-stationary transit time model to estimate the evaporative flux from two lakes in the Scottish Highlands. The lakes were in close proximity to each other (~2 km) and shallow (mean depth, 1.5 m) with one large (0.88 km^2) and one small (0.4 km^2). Model calibration used measurements of precipitation, air temperature, water level, and isotopic stream compositions of lake inflow and outflows. Evaporation flux was identified using lake fractionation of δ^2H and $\delta^{18}O$. The mixing patterns of the lakes and the isotopic compositions of their respective outlets were accounted for by comparing three probability distributions for discharge and evaporation.



Simulations of evaporation water age and source, and xylem water age and source for Heather Site A and Site B

We found that the evaporation flux was strongly influenced by these discharge and evaporation distributions. Decreased mixing within the lake resulted in greater evaporation fluxes. One of the three distributions yielded similar mean daily evaporation and uncertainty for both lakes (max 5 mm/day), while evaporation using the other two distributions was inconsistent between the lakes.

Importantly, our approach also estimated distributions of evaporation age, which were significantly different between the lakes, reflecting a combination of inflow stream magnitude and the mixing

regimes. The mean evaporation flux age of the large lake was ~160 days, and ~14 days for the small lake. Our integrated approach of stable isotopes, time variant transit time distributions has shown to be a useful tool for quantifying evaporative fluxes and closing the water balance, while simultaneously providing useful transit times of fluxes for lake dominated catchments.

The large size of AGU provides numerous opportunities to garner new research ideas via presentations (both oral and poster) and discussions with some of the leading researchers in my field. These discussions may lead to potential future collaborations with the transit time research on which I am currently working. I am very grateful to BHS for providing funding via the travel grant which enabled me to attend this prestigious conference.

Aaron Smith
Aberdeen University

and finally, Sylvain Kuppel, also from Aberdeen

In December 2017 I attended AGU Fall Meeting for the fourth time since 2011, and it was by far the event I anticipated (and prepared for) the most (not that previous years had been a walk in the park!). The size of the meeting provides almost endless possibilities of learning about the latest research, such that crafting a precise schedule in advance had always been very helpful to make the most of my time on site. Yet, this year felt special in terms of "personal exposure", as I was chairing a session on Monday, and giving an oral presentation on Tuesday and a poster presentation on Friday.

The two presentations were intertwined, as they both explored the value of combining numerical modelling with field data to understand how soil-plant-water relationships shape water pathways in northern landscapes. For this I use the ecohydrological model EcH2O developed by a colleague at the University of Montana; one of the few models to propose a physically-based resolution of hydrological transfers, tightly coupled with the energy balance and vegetation dynamics, in a spatially-explicit domain. I have so far conducted my modelling experiments at a long-term experimental headwater catchment in the Scottish Highlands.

My poster was titled "Information footprint of different ecohydrological data sources using multi-objective calibration of a physically-based model as hypothesis testing", and deals with an important challenge in hydrological modelling: are the uncertainties brought by increasingly complex models matched by the increasingly diversified observation types we can use to calibrate these models? I used here 10 datasets collected at several locations and relevant of different processes (soil moisture, stream discharge, above-canopy net radiation, and pine transpiration), to assess to which extent the diversity of information content can inform on the suitability of EcH_2O to simulate key water flux and storage dynamics in the catchment.

To do so, I analyzed model-data fit and model uncertainty depending on the combinations of datasets used for calibration. It appears that stream discharge is poorly informative as it can be reasonably well simulated,

regardless of the calibration constraint, while capturing local flux and storage dynamics, such as soil moisture or pine transpiration, conversely required calibration with specific observations (Fig. 1). This indicates that the information footprint contained in observations varies for each type of dataset, and that a diverse database relevant to the different ecohydrological compartments is critical to identify a consistent model parameterization. Finally, this identified that simultaneously using all datasets provided the best overall performances.

These encouraging results served as a basis for the work presented during my talk: "Implementing water tracers and age in a physically-based, spatially-distributed model". Stable water isotope (^{2}H and ^{18}O) tracing has been extensively used in a wide range of geographical environments as a means to understand the sources, flow paths and ages of water stored and exiting a landscape. Tracers are also invaluable for testing model structure and accuracy. The EcH_2O was thus extended to track ^{2}H and ^{18}O (including fractionation processes), and water age, and evaluated (without isotopic calibration) against 16 isotopic datasets encompassing stream water, groundwater, soil moisture and plant xylem. Results show the importance of incorporating soil fractionation processes to explain stream isotope dynamics, particularly seasonal enrichment in this humid, energy-limited catchment. This generic process-based approach facilitates analysis of dynamics in isotopes, storage and ages for the different hydrological compartments (canopy to groundwater) and, in particular, the explicit partitioning between soil evaporation and plant transpiration (Fig. 2). By integrating ecohydrology, unsaturated zone, surface water, and groundwater hydrology processes, our study facilitated the assessment of how plant water use may affect preferential hydrological pathways in the critical zone.

Both the oral and poster presentations received encouraging and constructive feedbacks. The questions during the oral presentation gave me the chance to further develop my preliminary analysis of water ages in this session dedicated to hydrochronology, and further stress some key possibilities of the model and methodology. The other presentations also gave a lot of food for thought, and

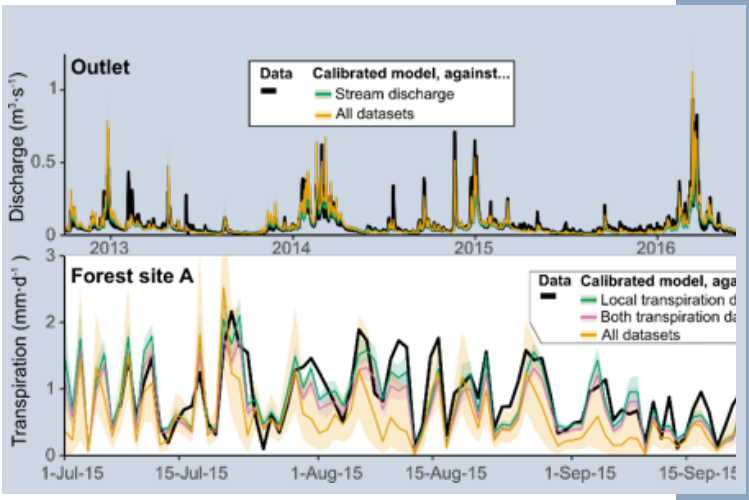


Fig 1 Model-data fit for stream discharge (top)and Scots pine transpiration (bottom) for various calibrationscenarios

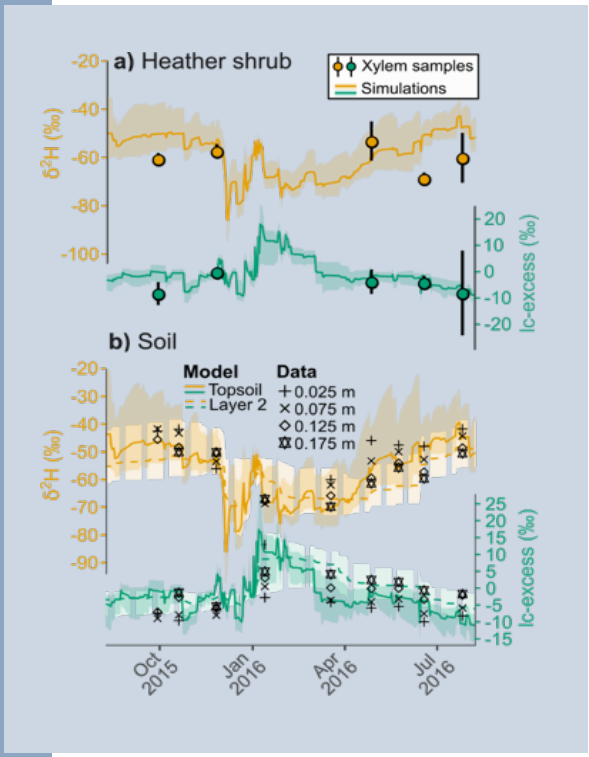


Fig 2 Example of comparison between simulated and observed isotopic composition at one hillslope location, in heather shrubs (a) and the underlying soil (b).

convening and chairing the session 'Ecohydrological, Hydropedological, and Hydrometeorological Insights from Spatiotemporal Patterns', which lasted the whole Monday: posters in the morning and two oral slots in the afternoon. Indeed, we were very happy with the quality and diversity of contributions our inter-disciplinary theme attracted, and with the general turnout in the audience (including a few 'big names'). Although we regretted the absence of one invited speaker because of a last-minute visa denial, I hope that the ideas and people gathered on that occasion will facilitate networking, future collaborations and, why not, putting together a similar session in the coming years.

Another privilege is the possibility to listen to cutting-edge geoscience research not remotely relevant to my work, but most welcome for personal interest (and sometimes simply when feeling the need for a short break!) An example this year was the great Sagan Lecture by Jonathan Lunine on the "Exploration of the Solar System's oceanworlds as a scientific (and societal) imperative". In addition, the convergence of so many people also favours meetings of all sorts, in my case including a great discussion with the collaborators of my current research project, getting involved in the AGU technical committee 'Ecohydrology', and a meeting of CUAHSI regarding collaborations for advancing hydrology in Earth Systems Models.

Finally, reporting this year's AGU would not be complete without giving justice to the location: New Orleans!! Contrasting with its lengthy convention center where walking distances made AGU exploration somewhat demanding, the city itself was very welcoming – true to its reputation as a cultural Mecca for jazz/blues (and live music at large), beautiful architecture, handcrafting, and good food.

In a nutshell, a great AGU event,now let's sort out all the ideas and associated challenges it fostered!

Sylvain Kuppel
University of Aberdeen

Recent PhD theses

The (welcome) expansion in tertiary education in recent decades has led to many more academic departments able to offer research degrees. As hydrology is such a cross-cutting subject it is sometimes difficult to keep track of new developments so, mindful of BHS's remit to link science and pratical application, we thought it would be helpful to trawl through the British Library's ETHOS data base.

The following titles are listed as published in 2017. Please contact me if there are others that have been missed which also seem likely to be relevant to members' interests which we can then list in the next issue

Author	*Title*	*University*
Wyness, Adam James	The influence of sediment characteristics on the abundance and distribution of E. coli in estuarine sediments uk.bl.ethos.703473	St Andrews
Basic, Tea	Applied ecology and management of a European barbel Barbus barbus population of a lowland river uk.bl.ethos.707679	Bournemouth
Elayouty, Amira Sherif Mohamed	Time and frequency domain statistical methods for high-frequency time series uk.bl.ethos.712646	Glasgow
Jomes, Nicholas David	A participatory modelling approach to developing a numerical sediment dynamics model uk.bl.ethos.720544	West of England
Coleman, Martin	Analysis of fluvial dissolved organic carbon using high resolution UV-visible spectroscopy and Raman spectroscopy uk.bl.ethos.726712	Glasgow
Leathard, Alex	A water grid for the UK uk.bl.ethos.728324	Newcastle
Manouseli, Despina	Evaluation of residential water efficiency programmes in the UK uk.bl.ethos.719256	Loughborough
Hoolohan, Claire	Reframing water efficiency : towards interventions that reconfigure the shared and collective aspects of everyday water use uk.bl.ethos.719310	Manchester

Book Review

"Climate Change in Practice"

by Robert L. Wilby

(Cambridge University Press, 351 pp).

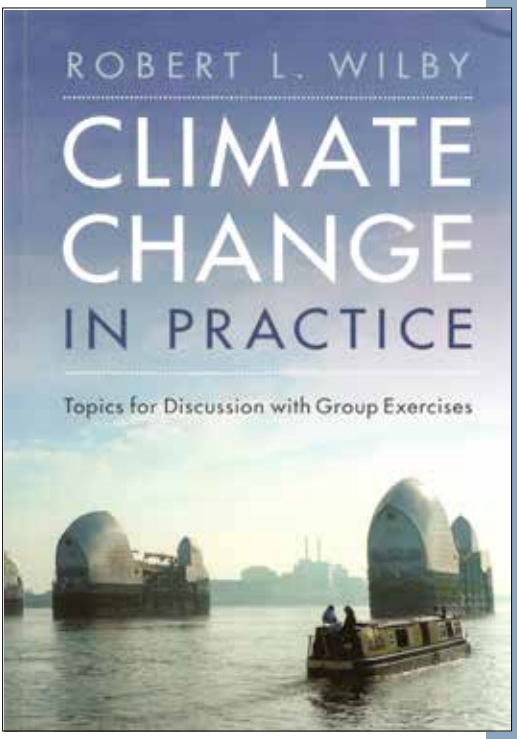
The book, based on a Climate and Society undergraduate course taught by its author, is sub-titled "Topics for Discussion with Group Exercises". It is "... not intended to be a core text but is best regarded as a supplementary handbook". Its range is remarkable. Chapter headings include "How Trustworthy Are Climate Models?", "How to Decarbonise Economies?" and "Could or Should Humankind Geoengineer Earth?". The book includes suggestions for group exercises. Complementary online resources (not reviewed here) are available to those who register for them.

Blocks of standard text (with copious citations – often at the end of each of two or more consecutive sentences) are interspersed with Tables, Figures, photographs, text panels (with headings like Topic Summary, Background Reading, Notes, Group Exercise, Learning Outcomes), etc. This structure, and the use of colour in many of the Figures, gives the physical book an attractive look. However, it is not an easy read, partly because of its structure but also because of its stated overall purpose as a resource for tutors. A reader interacting alone with the book might find it prohibitively difficult to get more than a flavour of some of the issues covered by the book, unless they delve deeply in the literature cited. As a resource for use by already-well-informed tutors, or by highly-motivated students with access to the research literature, the book will undoubtedly be extremely valuable.

This reviewer, whilst appreciating the book's value as a teaching aid, is not so sure it is the publishing success it might have been. The text embedded in many of the Figures is too small, e.g. some text in Figs 2.1 and 2.2 could be read only by taking the book to bright light and, even then, squinting very hard. Many of the Figures are from other publications, reports, etc, (sources are scrupulously acknowledged) and are presented without having received sufficient attention to make them fully suitable for the book. Several Figure captions are mini essays in their own right, in some cases extending to nearly half a page of reduced-size text. What is the point (to a reader) of photographs like those in Fig. 7.7, which are too small and/or have such poor definition that the reader has to take it as a matter of faith that what they (try to) show matches their captions? Many of these perceived publishing

deficiencies (if not all of them) can be observed in some other modern books, journal papers, etc. Perhaps it's time for the consumer to say a bit more about such things?

There are issues of language mis-use that the book exposes very well, either inadvertently or, to its author's great credit, explicitly. For example, of the first kind the book says "... global mean temperatures for land areas ..." (p7). The word global must be one of the most over- and mis-used words in hydrology and climate science (and more generally). Of the second kind, in an interesting section headed "Ethical Climate Services" (Chapter 17, "Who Are Climate Experts?") something is highlighted that many have probably been thinking for a long time, namely that "... hyperbole is on the rise in climate research papers ...". Fig. 17.2 indicates an approximate doubling between 1991 and 2015 of the percentage of words (in the title, abstract or keywords of relevant papers) like "amazing, ..., astonishing, ..., excellent, ..., groundbreaking, ..., remarkable, ..., spectacular, ..., unprecedented". The author makes the excellent point that "Whether climate change sceptic or mainstream climate scientist, we would all benefit from a dose of humility when it comes to recognising our own knowledge limitations ... This means presenting climate science as no more or less than it is." I agree wholeheartedly.



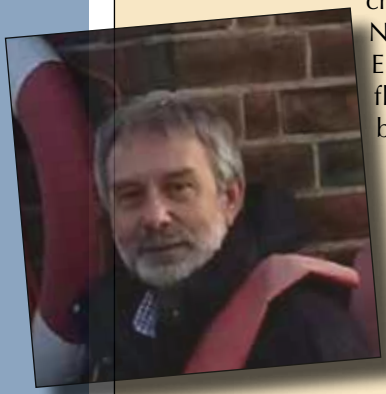
The book is a distillation of Prof Wilby's extensive and deep knowledge of a wide range of issues related to global warming within the context of climate change, its possible consequences and what might be done about it. At £29.99, the book must surely be good value as a supplementary handbook, where the target audiences "... are university students and their instructors, postgraduate students and researchers, as well as climate service providers".

Ian Littlewood
December 2017

News from Members

Congratulations to Peter Spencer

for his MBE for services to flood hydrology and the economy.



Peter started work in the water sector in 1974 for a consulting engineering firm, which included periods overseas. He became a chartered civil engineer in 1982. He joined the National Rivers Authority (a predecessor of the Environment Agency) in late 1990, to set up a flood modelling team in the north-west. He has been an operational flood forecaster since 1991.

Peter said: "Flood hydrology, flood modelling, and the base hydrometric data have improved tremendously in the last 30 years, and I have been fortunate in working in these fields at such exciting times. The changes have significantly improved our service to communities through a range of aspects including our flood maps, flood alleviation schemes, and flood forecasts. I expect the major floods in recent years will continue to provide exciting challenges and opportunities.

Weather radar

The Met Office and Environment Agency have been upgrading the UK weather radar network to dual polarisation. This has been an ambitious engineering project which has resulted in a high-quality operational network of instruments, providing real-time rainfall data over the UK. The project started in 2011, and at the end of last year, the final two radars returned to the network after their upgrade to dual polarisation.

Note: A National meeting on this topic is being planned .

Changes to BHS Statutes

As you will see from the announcement on the separate flier enclosed with your copy of Circulation, we propose some changes to the Statutes. We have already notified our founding partners, CEH and ICE of our intention which also needs to be endorsed by the membership. Please do make your return - by post or electronically - within the time-frame allowed, i.e. by **16th March**.

.....and a 'feel good' comment from a member recently retired from Atkins

As an engineer/ modeller, I've been using rainfall data for years but not knowingly paying a great deal of attention to hydrology. It's only as models have become more detailed and comprehensive that I've had to get to grips with hydrology, and the data that hydrologists provide me with. When it was all urban catchments, it was easy enough, but integrating urban and rural elements complicates the issue, especially when we need to run long time series to understand fluvial, groundwater, sewer and surface water flooding all in the same models. And with climate change on top of that ……

In my 40 years' involvement with sewers, I've gone from manual spreadsheets using the Modified Rational Method and its simplistic approach to intensity, duration and runoff to sophisticated computer models using temporally and spatially varying rainfall, radar rainfall data even, and multiple runoff models in the same network – and to getting frustrated when I don't get results for the whole of a massive catchment within minutes! What would have seemed far-fetched to my starting-out self is now commonplace, and I'm not sure that I haven't become a bit spoilt by it! What we can do now is so damned clever, and that will only improve with time.

BUT – and there's always a but – we do have to recognise that however clever we are at manipulating it, we always need more data to work with, to calibrate our various models, and that takes time and doesn't come cheap. More raingauges, more rainfall radar, more flow gauges in open and piped networks will be needed, and we – you, now that I'm retiring – will have to keep urging the government, water companies, EA and others to fund this essential long-term exercise. And speaking of the government, you might want to consider voting next time for a party that takes investment in social benefits seriously, and is more likely to make resources available.

And now that we understand so much more about climate change to date, we need a better way to define current return periods from long-term averages and projecting them into the future – as our records don't represent a static baseline, long-term averages won't be a reliable guide to flood (or drought) frequency over recent years, let alone into the future. As much as the statistics, we need to find better ways of presenting the data so that decision makers and the general public (and engineers like me) understand what the risks and the uncertainties are. And yet again, your vote matters when it comes to dealing with climate change.

All the best to all of you for an interesting and exciting future. I've enjoyed it no end, and I hope you do too.

Regards
Kristian Ravnkilde

Register of consultants

I hope it is fair to say that the professional hydrological community — researchers, consultants, regulators — know how and where to go for appropriate specialist advice. This is not the case for many individuals such as house-holders inadvertently caught up in the aftermath of the vagaries of our turbulent climate.

We try to be helpful in responding to telephone enquiries, including referring to the Consultants Register on our web site. This is therefore an unashamed plea for more registrations: the present listing seems rather sparse and surely does not represent the full extent of expertise available from our members for those in need of environmental/ hydrological surveys to meet the requirements of planning or insurance submissions.

Celia Kirby

CBHE

There's not been much traffic recently in registrations on the Chronology of British Hydrological Events database. But maybe as this is the time of the year when a few more interesting events will find their way onto the site, I'm being churlish in making such comments.

Don't forget that there is a direct link on our web site, and for those of you who are already logged in, it couldn't be easier to do your bit to expand this invaluable archive. [Think of future hydrologists!]

Travel grants for EGU

Anyone wishing to apply for a travel grant to attend the EGU meeting this year, needs to get a completed application to the Hon Treasurer, Ian Littlewood, no later than the **16 February** 2018. For more information on eligibility and an application form to download are available on the website.

Events Calendar 2018

Date	Title	Venue	Type
01 Feb	Bringing flood modelling to your local community	Newcastle Univ	BHS Pennines Region workshop
01 Feb	Managing flood risk in Oxford	ICE London	BHE SE Region
12-15 Feb	SnowHydro 2018	Heidelberg	Conference
22 Feb	Flood Modeller Pro Workshop	Birmingham	BHE SE Regional
05 March (tbc)	Groundwater	Warrington	BHS Peninnes Region
08 March	Low flows: water co. perspective	ICE London	BHE SE Regional
14 Marh	'About Drought' Showcase	Birmingham	NERC symposium
14 March	Working with natural processes: natural flood management	Edinburgh	CIWEM Conference
22 March	Groundwatrer 2018	London	Brownfield Conference
?? March	Reservoir hydrology revisited	York/Durham	BHS Pennines Region
19 April	International water resources	ICE London	BHS SE Region
08-10 May	Remote sensing and hydrology	Cordoba	IAHS sympsoum
24-28 June	IEMSs 2018	USA	Conference
18 July	Diffuse pollution: policy, practice, investment	London	CIWEM Conference
12-13 Sept	BHS NATIONAL HYDROLOGY	Westminster Univ	BHS National SYMPOSIUM

Is this simple listing of forthcoming events useful, or do you all use the web site?.—Ed.

2018 Peter Wolf Symposium

This year's event is in the planning stage but as dates and venue are not yet finalised, please simply note that it will be taking place late spring/early summer.

Full details will be circulated ASAP

UK Hydrological Bulletin: November 2017 – January 2018

Rainfall for the November 2017 to January 2018 period was moderately above average at the national scale but, as is often the case, with considerable regional contrasts. The late autumn saw the onset of seasonal recoveries in river flows in western and northern catchments but substantial soil moisture deficits remained across the English Lowlands where groundwater levels and some reservoir stocks continued to fall, and drought conditions intensified in Kent. This water resources stress eased during late December and through January as the focus of hydrological concern switched decisively to flood risk. The latter half of January saw sustained high flows and widespread flood alerts — on occasions, snowmelt was a significant contributory factor. By month end, overall reservoir stocks for England & Wales were appreciably above average for the time of year and groundwater levels were generally in the normal late-winter range.

Regional rainfall totals for November were mostly below average, particularly in the South East where, in many catchments, the October–November period was the driest since 1978. This is directly reflected in the runoff for the Great Stour in Kent where during the second week flows fell below the previous minimum for November (in a 52-year series), see Fig. 1. In addition, the sustained meagre inflows to Bewl reservoir left end-of- November stocks at a third of capacity (the lowest for at least 25 years) whilst several wells in the Chalk of the South East were dry. In contrast, parts of northern and western Britain experienced a wet month. During the fourth week a sequence of active Atlantic fronts brought sustained heavy rainfall. 24-hr rainfall totals of over 80 mm were recorded at both Capel Curig (north Wales) and Shap (Cumbria), falling on already wet catchments. Correspondingly, flood warnings were common and road and rail transport disrupted, particularly in Lancashire. Some landslides were reported in Scotland and, in Cumbria, the River Eden registered a new maximum daily flow for November in a series from 1964. The associated

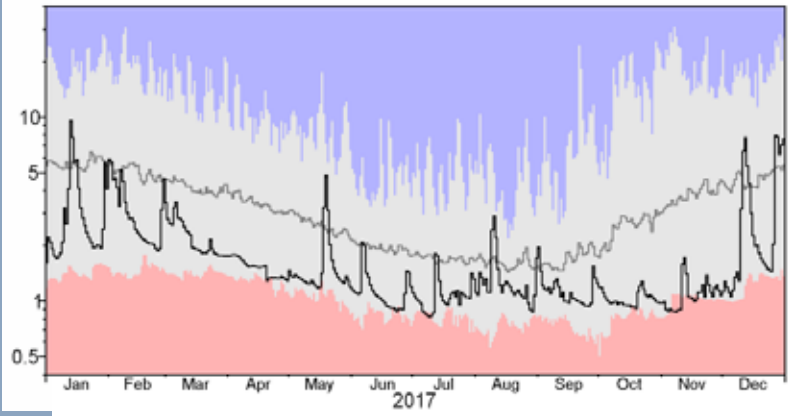


Fig 1 Daily mean flows ($m^3 s^{-1}$) for the Great Stour at Horton. The blue and pink envelopes are the pre-2017 daily max. and min.; the grace trace is the long term daily mean

heavy groundwater recharge resulted in notably high groundwater levels in the Permo-Triassic sandstones of Dumfries and Galloway.

The December rainfall total for the UK was close to the long term average but, generally, southern regions were wetter than average – East Anglia particularly so. By contrast, north-east Britain was drier than average with a substantial rainfall deficiency across the Grampian region. Vigorous cyclonic conditions early in the month resulted in notable precipitation totals in north-west Scotland: during the 6/7th a 24-hr total of 73 mm was recorded at Cluanie Inn. Of greater general significance was the exceptional recovery in river flows through the month across much of southern Britain.

By the final week, over 100 flood alerts were in operation across England & Wales and, in Kent, flows in the Great Stour (see above) rose to well above the late-December average. Importantly also, reservoir stocks at Bewl increased by around 10% during the month and aquifer recharge was heavy in most southern outcrop areas.

Despite the notable December river flows, estimated runoff from England & Wales for 2017 was appreciably below average (Fig. 2). In judging the significance of the moderate increase in runoff since 1960 it is important to note the exceptional dryness of the 60s and 70s; if pre-1960 runoff figures were available the trend would be rather more muted.

January was a very unsettled month, with a sequence of deep Atlantic low pressure systems causing significant wind damage and triggering many further fluvial and tidal flood alerts – and a few landslips. Floodplain inundations were mostly moderate but excess surface water caused significant transport disruption. Following the passage of Storm Eleanor (on the 3rd) flood alerts were widespread and had extended to a cluster of rivers in the English Lowlands (e.g. the Thames and Little Ouse). With catchments near-saturated and snowmelt contributing to runoff rates in many catchments, most rivers remained in spate, particularly during the fourth week when moderate floodplain inundations were common (e.g. in York). On the positive side, the continuing abundant infiltration ensured that groundwater level recoveries gained further momentum in most parts of the country. This, together with a high proportion of index reservoirs being within 15% of capacity, makes for a generally healthy water resources outlook.

Terry Marsh
27/1/2018

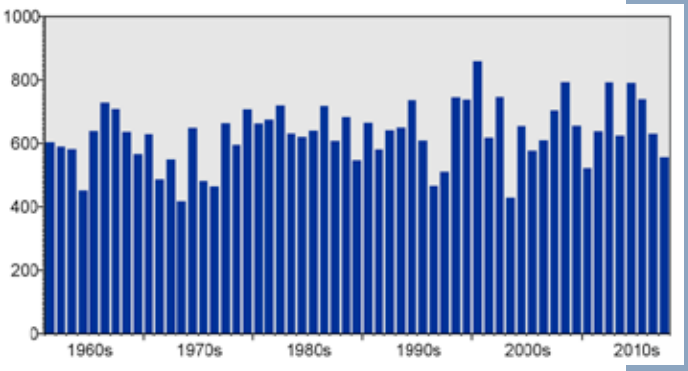


Fig. 2 Annual runoff totals (mm) for England & Wales – based on a representative network of gauging stations across the country



"About Drought — maximising the impact of UK research on drought and water scarcity"

— see page 10