

Circulation

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The Newsletter of the British Hydrological Society

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President's Perspective

Transdisciplinarity and working together for change – reflections from COP26

This is my first President's piece! I would firstly like to thank Nick Chappell for doing such a great job at the helm of the British Hydrological Society for the last two years; I am very much looking forward to working with you all over the next three years, as President and then Past President.

I've just spent the last week in Glasgow at COP26 and it has been an emotional rollercoaster. At times I have felt despondent but I did leave with an optimism that parties have now accepted the science and realise the urgency of the situation, even if they have not gone far enough in terms of ambition and commitments this time. Going into COP26, climate adaptation was still very much the poor man to mitigation – reducing our greenhouse gas emissions. Only 20% of climate financing is committed to adaptation or the 'Race to Resilience', with the rest committed to supporting the 'Race to Zero'. However, we will not get to Net Zero without significantly increasing our investments to increase resilience through climate adaptation. Adaptation is a pressing need everywhere but particularly in developing countries where climate resilience is lower. Ironically, much of the research exists to solve our adaptation needs. It was noted at COP26 that transdisciplinary science plays a key role in meeting the adaptation needs of people, with co-developed solutions key – the same approach as taken in the Centre for Climate and Environmental Resilience at Newcastle University, and our ONE Planet DTP – **https://research.ncl.ac.uk/one-planet/**– that I direct. Top-down approaches to science are one reason for the gap between science and solutions – and the reason that science is not utilised by practitioners. The launch of the Adaptation Research Alliance at COP26 will bring hopefully start to bring science into practice through a participatory approach and enable the development of tools and solutions for increased resilience that are based on stakeholder needs. This will strengthen the coping capacity of local communities to extreme weather.

The Adaptation Research Alliance will fund the development of better information on risks, better decision-making tools and better solutions. It will ensure the development of locally-conceived, locally-tested and locally-owned science. These investments

must leverage and strengthen the expertise that exists in the global south, making sure they have the knowledge and expertise to drive local changes, engaging youth and women in particular in driving global action.

As Maarten van Aalst, Director of the international Red Cross Red Crescent Climate Centre, stated at the launch of the ARA, "Climate change is a long-term environmental, but also a humanitarian, issue yet research has not found its way into local communities where decision-makers need information. Research must provide solutions working with decision-making, answering questions that matter."

But for this we need strong leadership. We need to bring innovations together, finding and sharing best practice, data and tools, and making research comparable, to provide a strong body of evidence; the approach taken by much of the EA's new Flood Hydrology Roadmap. People on the ground already know what needs to be done to adapt and we cannot continue to ignore approaches from the Global South. We can learn about effective flood warning systems for example from Bangladesh where flooding disasters are common but few die, yet hundreds died recently in Germany.

We need a pathway to resilient Net Zero with adaptation going hand-in-hand with mitigation. There is a strong need for multi-disciplinary teams to address these challenges – with meaningful partnerships fostered over time to develop the work. We need to work together to make a more resilient world.

My presidency aims to foster some of these ideas, firstly by working more closely with other key organisations such as the Royal Meteorological Society, the British Society for Geomorphology, the Royal Geographical Society and others to enable more interdisciplinary meetings. Secondly, I would like to better support initiatives like the Flood Hydrology Roadmap which is key to ensuring UK water resilience and, to be successful, needs to be transdisciplinary, bringing the community together across academia and practitioners alike.

Finally, I would like us to be less competitive and more collaborative as a community; sharing data, models and best practice is needed for us to rise to the grand challenges we face, including climate change and the biodiversity crisis, and to co-develop the transdisciplinary solutions we need.

Hayley Fowler
BHS President
November 2021

39th Annual General Meeting
7th September 2021
held on-line via Zoom

The 39th Annual General Meeting of BHS was held virtually on Zoom as part of the Innovation in UK Hydrology Conference on Tuesday 7th of September 2021. There were no apologies for and no corrections were needed for the report of the 38th BHS AGM published in *Circulation 147*.

Presidents Report

Dr Nick Chappell opened the session thanking all BHS members over the last water year for maintaining our water supply, sewerage and hydrometric systems, delivering flood forecasts and flood schemes, sustaining world-leading research, adapting teaching, as well as continuing participation in BHS activities.

During 2020/2021, BHS meetings continued to be held on-line with a second series of webinars organised by the BHS main committee with great success. These webinars, plus those organised by BHS Pennines section and from the *Innovation in UK Hydrology* meeting and *Peter Wolf Early Career Webinar* (in addition to those held in 2019/2020) have been added to the BHS YouTube channel (**https://www.youtube.com/channel/UCQ3xxpdbW_AhS4Ht6bLbbDQ**) which can be watched at your leisure.

The 'Innovation in UK Hydrology' meeting was organised for the week in which we should have been enjoying our 14th BHS National Symposium at the University of Lancaster which, due to the ongoing Coronavirus situation, has again been postponed to 12th–14th September 2022. All themes and sessions that have been proposed previously have been carried forwards, with abstracts opening in the New Year. Watch out for forthcoming information on the Symposium, with some information already available here: **www.lancaster.ac.uk/lec/graduate-school/professional-training/bhs2022**

Circulation continues to be one of the main ways we as a society have to communicate with our members, Nick thanked BHS Technical Secretary Celia Kirby for all her efforts in putting together *Circulation* each quarter. Members are encouraged to discuss and submit content for *Circulation* with Celia at any time.

The BHS Social Media accounts continue to be active with members of the Communications sub-committee (Lucy Barker and Michael Pollock) running the LinkedIn page and group, and the BHS Twitter account (@britishhydrosoc), as well as managing the YouTube channel. We now have over 2500 followers on Twitter, and our official LinkedIn page set up in 2019 has 485 followers.

Formal partnerships with ICE and UKCEH continue. The Institute of Civil Engineers (ICE) provide support with financial and membership management, committee and meeting support. UKCEH continue to contribute to society activities and meetings as well as to the running of the society with David Boorman formally representing UKCEH on the committee. In January 2020 *Hydrology Research*, the official journal for BHS, was made open access and all papers are now freely available on-line. Some universities are able to submit to *Hydrology Research* for free due to institutional agreements (**https://iwaponline.com/open_**

access/pages/institutional_agreements). For those having to pay the open access charges BHS, has been able to secure a number of fee waivers for BHS members in 2021 – please contact Editor-in-Chief Nevil Quinn for more information (**Nevil.Quinn@uwe.ac.uk**). There is strong BHS membership on the Editors and the Editorial Board, with the number of Editors expanding this year.

BHS members are reminded that they are eligible to apply to the Exeter Fund to support travel to overseas IAHS meetings. After several years without travel, the Exeter Fund is healthy so members are encouraged to apply; a timely reminder, as abstracts are still being accepted for the IAHS XIth Scientific Assembly held 29th May-3rd June 2022 in Montpellier, France. Find out more about the assembly here: **http://www.iahs2022.org/**

The BHS Working Group on the Future of Hydrological Research led by Prof. Keith Bevan published a second paper in June 2021 led by Thorsten Wagener in *Hydrological Processes*, "Knowledge gaps in our perceptual model of Great Britain's hydrology" (**https://doi.org/10.1002/hyp.14288**). Discussion also remains open on the BHS website (**https://www.hydrology.org.uk/bhs-working-group-future.php**).

BHS has made a number of awards this year. Supported by the Environment Agency and the JBA Trust, BHS awarded 10 MSc Studentships of £1500 each for the 2021 academic year': see more information in the Treasurers Report below. The BHS Undergraduate Dissertation Prize – judging panel chaired by Liz Lewis – had 11 excellent projects to consider this year; thank you to all the university staff for submitting entries. First prize was awarded to **Josh Worman** from the University of Bristol for an outstanding piece of work in the field of hydrological modelling: "Improving the representation of fluvial flood defence schemes in hydrodynamic flood modelling: A study implementing an advanced algorithm for identifying hydraulically significant features within the River Severn catchment". Runner-up prizes were awarded for excellent pieces of work by **Seren Peregrine** from the University of Bristol in the field of hydrological analysis and to **Emma Bramley** from Durham University in the field of hydrochemistry.

Honorary Secretary Report

Lucy Barker summarised society activities over the past year. BHS events continued despite the pandemic and we would like to thank everyone who helped organise webinars, agreed or volunteered to speak, participated in and attended our meetings. Each webinar was extremely well attended with participants from around the world. In March we had to temporarily upgrade our Zoom account to enable us to host over 500 attendees for the Flood Hydrology Road Map webinar, which was hosted by **Sean Longfield** (EA), **Rob Lamb** (JBA Trust, Lancaster University), **Nick Reynard** (UKCEH) and **Hannah Cloke** (University of Reading). Other webinars in February on the role of citizen science in hydrology and April on a hidden cycle in UK water resources were given by **Wouter Buytart** (Imperial College) and **Will Rust** (Atkins, Cranfield University), respectively.

Unfortunately due to the ongoing coronavirus situation, the 14th National Symposium was again delayed until 2022. In its place however, a meeting on 'Innovation in UK Hydrology' was organised by Nick Chappell on the 7th September, with six talks covering innovations in a range of hydrological topics including: water resources and

droughts, catchment planning, hydrological modelling and data archival and analysis. The speakers were: **Geoff Darch** (Anglian Water Services), **Chris Soulsby** (University of Aberdeen), **Andrew Johnson** (UKCEH), **Chris Evans** (UKCEH), **Jola Miziniak** (Thames Water), **Lucy Barker** and **Katie Muchan** (UKCEH). The meeting also included a discussion session run by the BHS working group on the 'Future of UK Hydrology'. The national meeting was followed on 8th September by a Peter Wolf Early Career Webinar. Four speakers were invited to discuss hydrological innovation for the climate emergency in the context of their career development: **Sean Harrigan** (ECMWF), **Linda Speight** (then University of Reading), **Charles Rougé** (University of Sheffield) and **Mark Franklin** (SEPA). This was followed by a panel discussion with **Hayley Fowler** (BHS President, Newcastle University), **Giuseppe Degan Di Dieco** (University of Bristol, BHS Early Career Representative) and **Anita Asadullah** (Environment Agency, BHS Diversity and Inclusion Sub-committee). Recordings of the talks from both meetings, as well as the 2021 webinars, can be found on the BHS YouTube channel.

As a society, we are looking forwards to resuming in-person meetings in 2022. The first of which is the delayed Peter Wolf Symposium for Early Career Hydrologists to be held at the University of Strathclyde. Registration for the Symposium is open now, see page 30 for more information. As noted above in the President's report, the 14th National Symposium has been rearranged for 12th–14th September 2022. Other meetings, both on-line and in-person, will be arranged for the coming year so please watch out for more information in *Circulation*, via Mailbase, Twitter and LinkedIn.

Do you have a good idea for a BHS meeting? Would you like to host a meeting or webinar? Get in touch with Lucy Barker (**lucybar@ceh.ac.uk**) to discuss your idea and plans. You can find out more about organising BHS meetings on the website: **https://www.hydrology.org.uk/Organisation_of_BHS_Meetings.php**

Honorary Treasurer Report

Scott McGrane (University of Strathclyde) presented the financial activities of the Society. Overall the finances remain healthy, although income has dropped slightly from 2020. This was a result of a drop in membership (–39), in combination with no donations or income from in-person meetings. However, advertising via the website continued to bring in money to the Society.

The loss of income from meetings was quite considerable, but it is hoped this will change as we start to hold in person meetings again in 2022, such as the Peter Wolf Symposium in March and the 14th National Symposium in September. The Exeter Fund remains extremely healthy with an increase of £10,872 on last year. As reported in the Presidents report, we encourage BHS members to apply to attend overseas IAHS meetings. The Exeter Fund is also open to IAHS members. More information can be found on the BHS website: **https://www.hydrology.org.uk/Travel_Grants.php**

The lack of in-person meetings has however meant that expenditure has also remained minimal, as there have been no in-person BHS Committee meetings or travel grants. It has meant that we were able to continue to invest in our digital capabilities by renewing the Zoom licence to use for national and regional meetings. We plan to retain the Zoom licence post-pandemic to enable people to attend meetings virtually that they may otherwise

not able to attend in person.

The largest expenditure has been the publication of *Circulation*, a vital resource to share Society activities and for the hydrological community to keep in touch.

We also continue to invest in the future of hydrology with the support of the Environment Agency and the JBA Trust, as rewcorded in the Presidents report with the award of10 BHS MSc Studentships. The recipientsa are: **Hannah Roe** (University of Birmingham), **Thomas Burgess** (University of Leeds), **Hannah Champion** (Lancaster University), **Jack Bethwaite** (University of Birmingham), **Jonathan Mells** (Newcastle University), **Maria Dancel** (University of Birmingham), **Adam McCue** (Queen Mary University, London), **Gemma Shaw** (University of Birmingham) and **Aaron Williams** (Plymouth University). Congratulations to all the recipients!

Committee Membership

BHS would not run without its committee of volunteers who keep the society going alongside their day jobs, so thank you everyone for working so well together for another productive year despite all the challenges of working from home and more on-line meetings. We are particularly grateful or those completing their terms of office on the Main Committee and in the regional sections, including **Mason Durant** who chaired the Diversity and Inclusion Sub-committee and contributed to the Meetings sub-committee, and **Nick Chappell** as President and who will now serve as Past President for 2021/2022.

We are pleased to welcome **Hayley Fowler** (Newcastle University) as our new BHS President, **Giuseppe Degan Di Dieco** (University of Bristol) as the Early Career Representative (see *Circulation 150)* and **Chris Skinner** (Environment Agency) as an elected Ordinary Member. **Scott McGrane** (University of Strathclyde) has been re-elected as Honorary Treasurer, and **Michael Pollock** and **Anita Assadullah** will continue on the 2021/2022 committee as co-opted members.

Lucy Barker
BHS Honorary Secretary



New Committee Member

Chris Skinner



I am a Senior Hydrologist at the Environment Agency, part of the Flood Hydrology Improvements Programme. Our team is delivering against actions from the 25-Year Flood Hydrology Roadmap for the Agency and my role is overseeing the methods strand. My background is from academia, especially numerical modelling, having worked across the modelling chain from hydrometeorology to landscape evolution. My most recent work concerned understanding the input and parameter sensitivities of the CAESAR-Lisflood model, with an interest in its use operationally.

I'm also very interested in game-based research and engagements. I founded the SeriousGeoGames and Earth Arcade projects at the University of Hull, producing the virtual reality activity Flash Flood! among others, and run the Games for Geoscience sessions at EGU. Numerical models and videogames share many elements and in some sense are the same thing, they just have different ideas of what is useful, and I think there's a lot of potential there. In my free time I've been learning about 3D printing, including printing out real river scenes.

BHS Undergraduate Dissertation Prize



Congratulations to this year's prize winner –**Josh Worman,** University of Bristol, with "Improving the representation of fluvial flood defence schemes in hydrodynamic flood modelling: a study implementing an advanced algorithm for identifying hydraulically significant features within the River Severn catchment"

ABSTRACT

Hydrodynamic modelling is an essential tool for predicting flood risk and planning mitigation measures. Several input parameters are required, including a digital elevation model (DEM). For the sake of computational efficiency, hydrodynamic models are often run at significantly lower spatial resolutions. Such coarse resolutions produce acceptable predictions of flood inundation extent for the most part, however they often have disastrous consequences for the representation of flood defences. During the resampling process, the peaks of flood levees are flattened, resulting in significant reductions in accuracy where levees are located. This study implements an advanced algorithm in the UK for the first time that identifies flood levee-like features in a high resolution DEM and then preserves their height during the resampling process. The impact of these newly preserved levees was assessed along the River Severn when simulating the summer 2007 floods and confirm that flood defences do indeed make a significant difference to flood risk projections and that it is of paramount importance that modellers take account of such structures in future assessments.

NRFA Peak Flow Dataset
Version 10 released

The National River Flow Archive has released an update to its peak flow dataset, including the files for use in the WINFAP software for flood estimation. The dataset includes Annual Maxima (AMAX) and Peaks over Threshold (POT) data for 939 gauging stations which have been updated with an additional water year of data (October 2019 to September 2020) in England, Northern Ireland, and Wales. No update was available for sites in Scotland due to issues with the hydrometric archive.

New AMAX1 records were set at 39 stations during water year 2019/2020 with the majority in Wales and northern and central England as a result of successive large rainfall events, most notably in November 2019 and February 2020 (Sefton *et. al.*, 2021).

As well as the additional water year of data, a period-of-record review was undertaken at 94 stations across England, Scotland and Northern Ireland – around 3,500 years of data! In Wales, pncluding reviewing AMAX/POT comments and photographs for all peak flow sites.

The NRFA's peak flow dataset provides flood data for 939 river flow gauging stations around the UK. The data can be used with the flood estimation methods set out in the Flood Estimation Handbook (FEH), which is the industry standard for current flood estimation in the UK.

The peak flow dataset has been shown to provide net economic benefits of almost £5.4 million per year in terms of costs saved by environmental consultants and regulators.

The peak flow data provided through this service originate from gauging stations operated by a range of UK hydrometric measuring authorities as is the case with other NRFA data. Maintenance of the NRFA peak flow dataset, including the latest update, is carried out under a collaborative project between the Centre for Ecology & Hydrology, the Environment Agency, Natural Resources Wales, Northern Ireland's Department for Infrastructure – Rivers, and the Scottish Environment Protection Agency.

The updated NRFA peak flow dataset was released on 26th August 2021 and reflects the NRFA data holdings at this time. Version 10 of the NRFA Peak Flow Dataset is the seventh version released since the NRFA took over the stewardship of the national peak flows database.

Updated peak flow time series and metadata are now available to view on the NRFA website and can be found using the NRFA's gauging station search tool.

Download the NRFA Peak Flow Dataset V10:https://nrfa.ceh.ac.uk/peak-flow-dataset

ON TREND – My journey into non-stationarity

Inspired by Will Rust's excellent BHS Webinar on 7-year cycles[1], I felt moved to take another look at long-term rainfall trends for the UK. There is nothing quite a like a good, long data set to reawaken the "researcher" in me. Many years ago, David MacDonald had provided me with some long period rainfall data so I had some form here. Also, for a recent legal case, I revisited the excellent summary of the summer floods of 2007 by Terry Marsh and Jamie Hannaford that included a teasing graph of seasonal rainfall from 1766 to 2007[2].

There are numerous, talented researchers out there that do this sort of thing for a living and for whom my crude investigations may be of limited value. Apologies to you if you are in this category. This article is intended for the design hydrologist – challenged, as I have been throughout my career, to deliver design flood estimates. It has never been easy and it is getting harder with each passing year.

I turned to the same time series as Terry; the monthly precipitation series for England & Wales (EWP), dating from 1766[3]. This valuable resource provides monthly time series from 1766 and daily series from 1933. I salute the many individuals and organisations that have contributed to this record; numerous observers plus those who have applied quality control and consistency checks to ensure that the time series is as reliable as it can be. This huge endeavour provides a valuable resource for the research community to access. That said, one should still treat the early data with some caution, for a host of reasons such as the likely lack of standardisation and uncertain adjustments for snow which contributed a higher proportion of precipitation at the start of the record.

My investigations inevitably started with a spreadsheet:

- I plotted 10-year running means for annual and seasonal totals. I used two 6-month seasons (October to March and April to September) in contrast to Terry who had used Dec, Jan and Feb for winter and June, July and August for summer.
- I extracted annual averages for specific time periods
- Finally, I added simple trend lines for the full period of record.

The results are shown in Figure 1; the standout features in relation to trend are:

- Trend in winter rainfall of +0.4 mm/yr and representing an increase of around 100 mm over the period of record;
- Weak trend in summer rainfall of –0.2 mm/yr (an overall decrease of around 50 mm);
- These seasonal patterns lead to a weak trend in annual rainfall of around +0.2 mm/yr (an overall increase of around 50 mm).

1 Unearthing a hidden cycle in UK water resources. BHS Webinar presented by Will Rust, 28th April 2021.

2 The summer 2007 floods in England & Wales – a hydrological appraisal. Terry Marsh & Jamie Hannaford, 2007.

3 Wigley, T. M. L. and P. D. Jones (1987) England and Wales precipitation: a discussion of recent changes in variability and an update to 1985, J Climatol, 7, 231-246). https://www.metoffice.gov.uk/hadobs/hadukp/

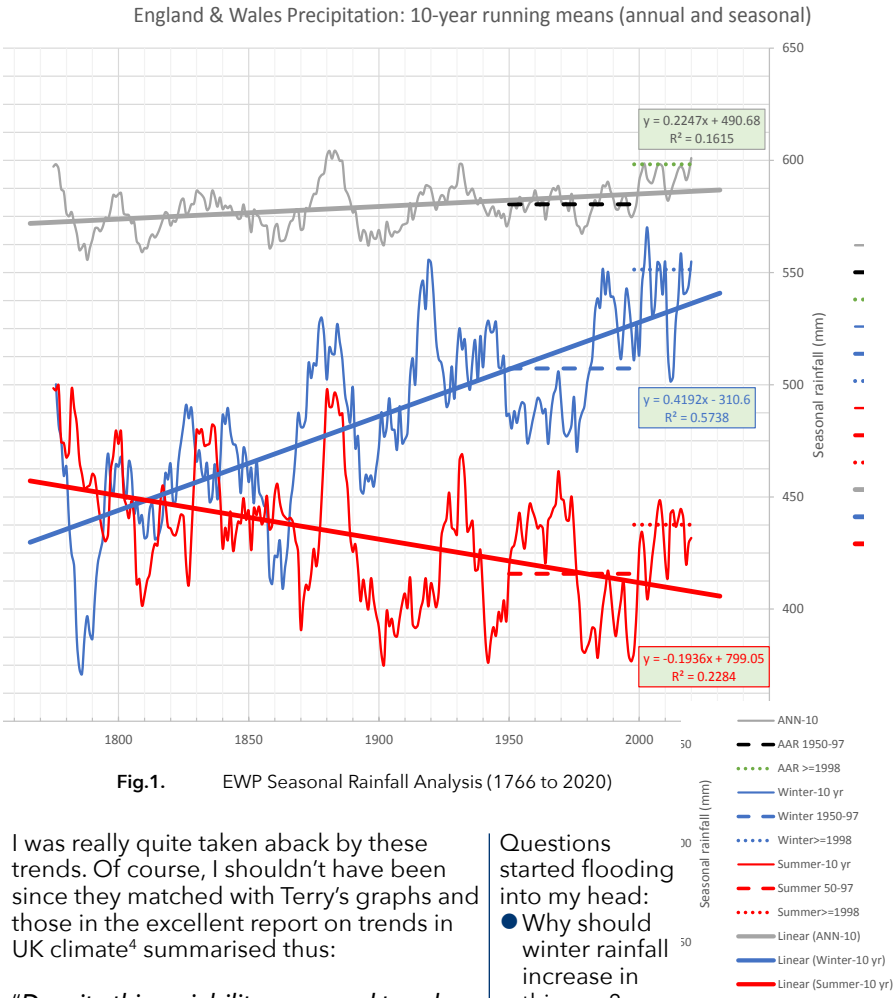


Fig.1. EWP Seasonal Rainfall Analysis (1766 to 2020)

I was really quite taken aback by these trends. Of course, I shouldn't have been since they matched with Terry's graphs and those in the excellent report on trends in UK climate[4] summarised thus:

"*Despite this variability, a general trend can be seen of decreasing precipitation in summer, although this is difficult to quantify robustly as it depends on the period used. In winter, an increasing trend can be observed, although there has been little change over the past 50 years. There is no discernable trend in annual mean England & Wales precipitation.*"

Since the results had emerged from my own analysis, they took on an enhanced value (to me!), even though I was essentially reproducing the work of others.

Questions started flooding into my head:

- Why should winter rainfall increase in this way?
- Why should summer rainfall decrease in this way?
- What happened in the late 1970s that triggered a sharp decrease in summer rainfall and increase in winter rainfall?
- What triggered the increases in winter and summer rainfall in the late 1990s?

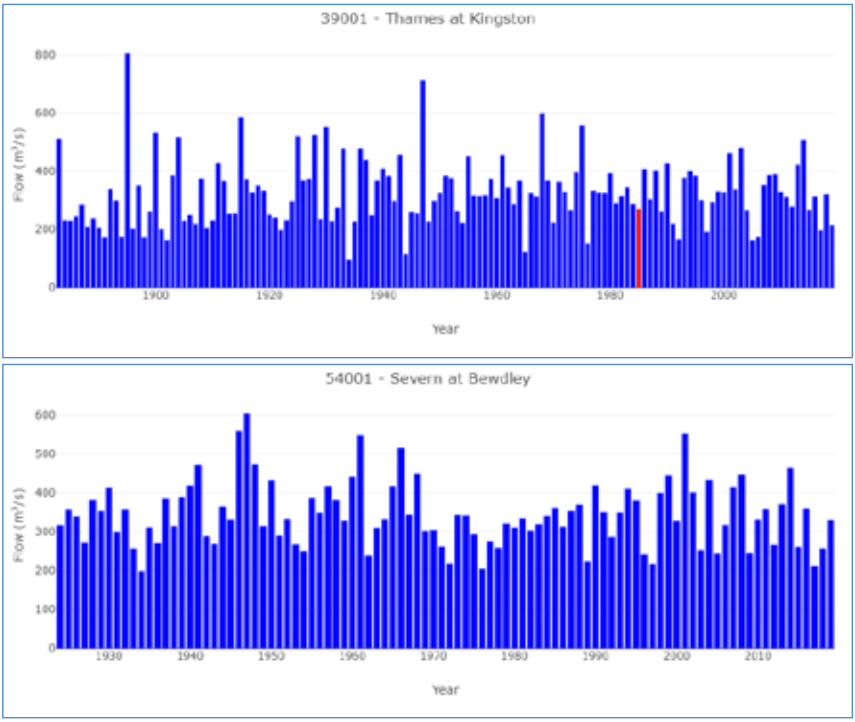
4 The climate of the UK and recent trends, Geoff Jenkins, Matthew Perry and John Prior, Hadley Centre, Met Office, Exeter. Revised edition, January 2009

Whilst struggling with these questions, I also reflected on the impact that this has on my work, of delivering flood estimates and guidance in an increasingly complex world.

- That there is **non-stationarity** is self-evident; what is unclear is what we do about it. Current Environment Agency guidelines[5] offer a progressive increase in rainfall and river flow in the coming century. Whilst the implied precaution is understandable, it assumes a progressive change in these parameters. That may pan out but the long rainfall series shows that there may be many bumps along the road! The annual maximum series for the River Thames at Kingston has bucked the trend; using a threshold of 500 m^3/s, there were nine exceedances in the first half of the record and just three in the second half (Figure 2). That we live in a country that is becoming warmer and wetter is clear; however, this does not seem to translate in extreme flood occurrence.

- T**hursday 9th April 1998** is a date of some significance for me. I spent the afternoon at home, recuperating after a minor operation watching the rain come down. That rainfall triggered the Easter 1998 floods which was the start of the

5 https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances



https://nrfa.ceh.ac.uk/data/station/peakflow/

Fig. 2:. Annual maximum flow series for the River Thames at Kingston and River Severn at Bewdley

"flood-rich" epoch that we are still in. I have shown the post 1998 average annual values on Figure 1, which confirms what we all knew anyway! This recent epoch is full of record-breaking floods and just to cap it all has some decent droughts embedded within it too.

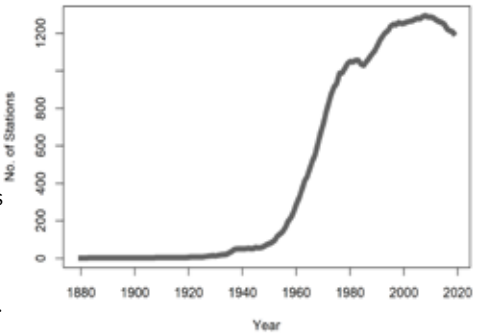


Fig. 3. Gauging stations contributing daily flow

- **Seasonality** is such an important subject in hydrology. It used to be so simple; heaviest rainfall in summer falling on 'dry catchments' meant that urban and small catchments were 'summer critical'. Lower rainfall extremes in winter falling on 'wet' catchments meant that the remaining catchments were 'winter critical'. Seasonality has continued to underpin some of our design flood tools. The seasonal trends that are shown in Figure 1 should reinforce that notion of seasonality with drier summers and wetter winters. However, the summer floods of 2007 and then 2012 have undermined all that; these events had clearly not been reading the textbook.

- We have appreciated for some time that the **formal observational records** from UK river gauges are dominated by the period from around 1960 (Figure 3). The pattern of 10-year running means for rainfall in Figure 1 shows that the annual EWP series exhibited limited variation over this period. That said, the seasonal series show more volatility and most notably the change in the late 1970s referred to above. The annual maximum series for the River Thames and that for Bewdley (Figure 2) suggest that the last few decades of the 20th Century were relatively benign for hydrological extremes. Clearly, this has profound implications for the hydrological design tools that are rooted in historical data analysis. If a large proportion of our time series data are unrepresentative, then our analyses are undermined, unless we make some adjustment.

Still struggling with these issues, I turned to another simple but highly effective tool, namely double mass analysis. Firstly, I plotted cumulative summer rainfall *vs* cumulative winter rainfall. The resulting mass curve in Figure 4 shows that winter and summer rainfalls exhibited a similar trend up to the 1860s. However, there was a progressive and steady divergence from then to the present. Recognising that this may be linked to changes in temperature, I undertook a further mass analysis of cumulative seasonal rainfall differences *vs* cumulative mean temperature for central England[6]. The result in Figure 5 showed a remarkably consistent association between changes in seasonal rainfall and changes in temperature – but only from the 1860s. Whilst temperature is likely to be implicated, there are clearly other factors at play.

Where does that leave me? Confused, for sure, about the patterns of UK rainfall data. Concerned too, about how we

6 https://www.metoffice.gov.uk/hadobs/hadcet/data/download.html

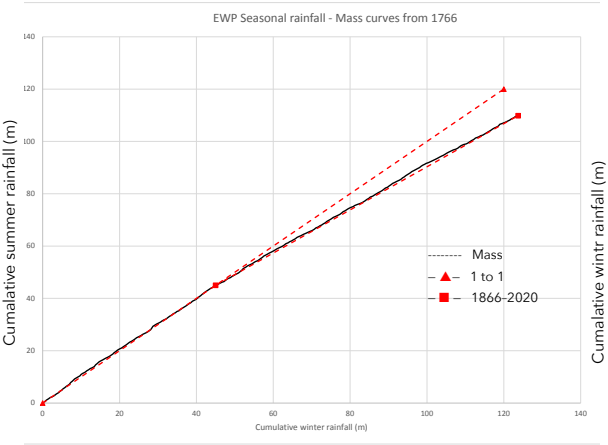


Fig. 4. Double mass analysis summer *vs* winter rainfall

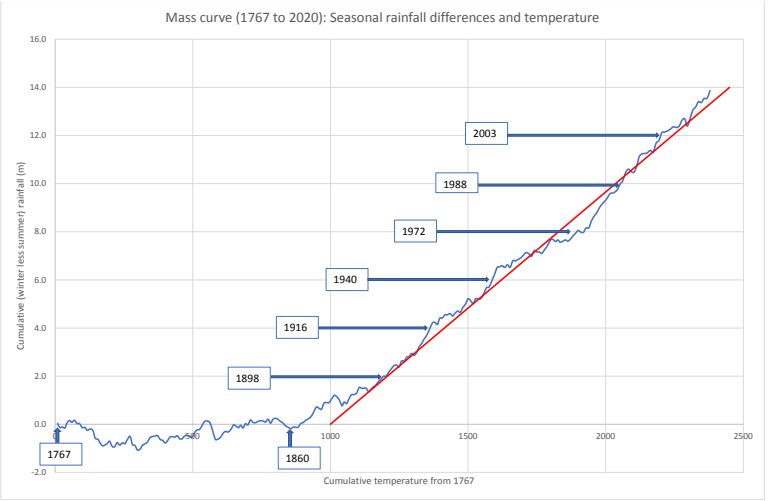


Fig.5. Double mass analysis Seasonal rainfall difference vs mean temperature

deal with these difficult issues in design flood estimation. Mostly, just intrigued about what happened climatically in the 1860s that triggered the progressive changes in seasonal rainfall that are still in train.

Paul Webster
Corylus

Acknowledgement:
I would like to acknowledge Terry Marsh's review of an earlier version of this article – as well as his fascinating and informative reviews of UK Hydrology in each issue of Circulation!

New BHS publication !

BHS Ocasional Paper – OP No. 15
"Unit Hydrographs and United Kingdom hydrology 1990–2020: IHACRES rainfall – streamflow modelling"
by Ian Littlewood

will be available shortly to download from the BHS Publications Archive on our website

Abstract

A history is given of the application of two types of Unit Hydrograph (UH) for UK hydrology, from 1990 to 2020. The Paper outlines the UH-based rainfall–streamflow modelling methodology known as IHACRES, which was introduced in 1990, then summarises and discusses its contributions to several types of environmental hydrology study, including: hydrograph separation; analysis of droughts; rainfall–streamflow model regionalisation; extending streamflow records, investigating data timestep issues; quantifying the effects on streamflow of environmental change (land-use, climate); and characterising Chalk stream flow regimes. Advantages are discussed and illustrated of the IHACRES UH, which is for total streamflow, over the UH introduced in 1975 and still being used for UK engineering hydrology in 2021, which is for a poorly defined (unmeasurable) direct flow component of streamflow. The Paper argues that inertia to substantial change continues to effectively prevent UK engineering hydrology practice from progressing beyond using a UH for direct flow, although a demonstrably superior type of UH (for total streamflow) exists. This inertia appears to have influenced reviews of standard procedures for UK design flood hydrograph estimation, e.g. for reservoir dam spillway safety assessments, which do not mention the advances that have been made in UH identification and application over the past 30 years or so. A short Section gives an overview of three generations of free-to-use IHACRES software; a final Section provides concluding remarks.



BRITISH HYDROLOGICAL SOCIETY

Unit Hydrographs and United Kingdom hydrology 1990-2020: IHACRES rainfall – streamflow modelling

by

Ian G. Littlewood

BHS Occasional Paper No.15

Exceptional rainfall at Brettenham, 25 July 2021

Meteorological Background

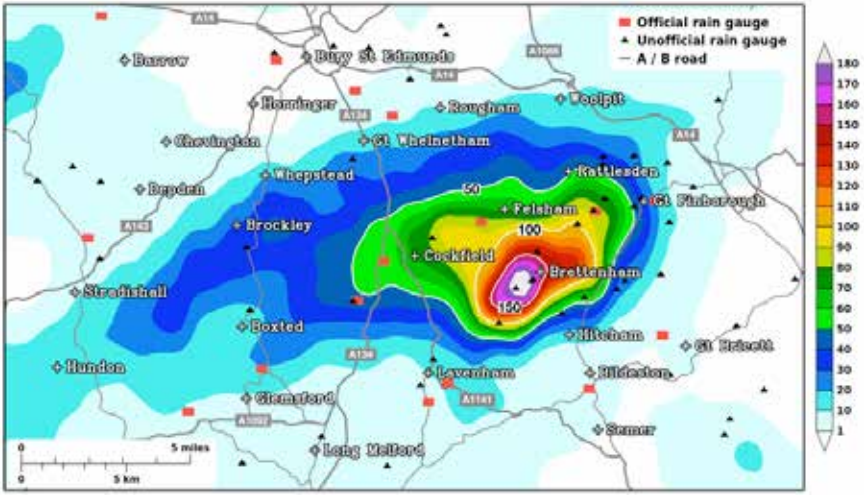
Slow-moving thunderstorms affected parts of East Anglia, London, southeast and central southern England on Sunday 25 July 2021, resulting in localised flash flooding. The storms were focused along marked low-level convergence zones, where light winds of opposing directions met creating forced ascent, and in some areas enhanced by sea breezes. The slow storm movement, high precipitation efficiency and back-building of convection and uplift, resulted in prolonged torrential downpours in places. Particularly extreme rainfall occurred over the small village of Brettenham in mid-Suffolk, where over 180mm of rain was recorded in less than 2 hours by a rain gauge operated by a former voluntary observer for the Environment Agency. Maximum rainfall intensity of over 100mm/hr persisted over for 45 minutes during the peak of the storm.

At least 28 properties in the village were flooded, and the heavy rain and small hail resulted in significant damage to standing crops at what was the beginning of the grain harvest. The rainfall observed, especially when considering the relatively short duration, is unprecedented in the local area and potentially challenges some UK records.

Hydrological Response

The very intense and localised rainfall described above produced a marked response in the River Brett and the River Gipping. Fortuitously the upper catchment of both rivers have Environment Agency river gauges at Cockfield and Stowmarket, and the central, most intense part of the storm event occurred in parts of both catchment areas.

Given that the rainfall



Estimated rainfall accumulations (mm) for the 24h ending 0000 UTC 26 July. Unofficial rain gauge data derived from many sources, including WU home AWS and numerous farmers who kindly submitted readings for the purpose of this study.

Maximum 15-minute discharge, time of peak and maximum specific discharge. (From 15-minute data provided by the Environment Agency)

Station Name	Maximum 15-minute discharge (m^3/s)	Time/date of maximum	Maximum specific discharge ($m^3/s/km^2$)
Cockfield	1.67	19.45 25/7	0.064
Hadleigh	2.59	04.15 27/7	0.016
Higham	1.79	00.00 28/7	0.001
Stowmaket	3.43	03.30 26/7	0.027

was so localised, of a relatively short duration and high intensity and, that growth, development and decay took place with very little locational movement, a very simplified, almost classical response hydrographs were recorded at Cockfield and Stowmarket. Another small un-gauged headwater of the river Brett rising close to Brettenham, and joining the main river at Chelswoth, was most severely affected by the storm. with overtopping of the river and flooding of gardens reported by residents of houses near the bridge in the village. This and the inflow by other tributary streams are incorporated into the river discharge hydrographs, with attenuation of the flood peak as it moved downstream to Hadleigh and Higham.

The eastern part of the storm occurred over the upper reaches of the River Gipping, and was recorded at its highest flow gauging point at Stowmarket. The elapsed time between the time of the event, concentrated between 15.30 and 17.00 on 25 July and the times of peak flow at various sites, is indicative of the lowland and rural nature of the countryside which was covered at that date by fully mature arable crops. Thus the peak flow at the nearest river gauge at Cockfield occurred some 3.5 hours after the central time of the storm, and the flood peak did not reach Hadleigh for a further 32.5 hours.

Flows from the 25 July event are all markedly less than the historic maxima at local gauges, the record flows all being recorded in the winter months, and in most years winter flood maxima are greater than the flood peaks recorded. The limited volumetric flood response from this event is affected by two main reasons, a) the limited areal extent of the storm, and b) the dryness of the ground antecedent to the rainfall event. The Hydrological Summary for July 2021 (ceh.ac.uk) showed that in the days preceding the event, river flow and groundwater conditions in East Anglia had been close to average for the time of year. This means that soil moisture deficits were quite large, (in the range 90–110mm, and the COSMOS data for Elmsett, the nearest station to the storm location, was recording soil moisture content of about 25 to 30%. Thus there was considerable capacity for rainfall to be taken up as initial losses and infiltration.

Storm rarity, maximisation, and depth area analyses

The lack of widespread flood impacts should not detract from the importance of the severity of storm rainfall, total and intensity, which have significant impacts on design storm considerations, as discussed in the next section. Since the storm depth was 181mm and the maximised rainfall estimated at 219mm, the storm efficiency which is the ratio of the storm rainfall to the precipitable water (estimated from vertical analysis), i.e. a

measure of how much recycling of atmospheric moisture took place, is 181/ 42.3 = 4.28. This result is the second highest short term storm value recorded in the UK, the highest being the Hewenden (1956) storm reanalysed by Collinge *et al*. (1992) of 4.95, as compared with the value of 3.50 for the same storm in the Flood Studies Report (NERC, 1975). The higher efficiency came through the analysis of more station data for the event than would normally be available from EA and Met Office networks. The maximised value of 219mm is close to the PMP estimate using Clark & Dent (2021) and Clark (2009) of 207mm. All these estimates are much higher than the Flood Studies Report estimate of 1.75hr PMP of 164mm.

There are implications for design storm guidance. Over 80 years ago the Institution of Water Engineers (1937) produced a table of recommended raingauge densities for use in catchments with reservoirs, the aim being to make sure that as much local data be used in assessing the safety of dams. Although Floods and Reservoir Safety (1978) advised the use of local data, this was abandoned in the 4th edition (ICE, 2015).

In view of the small area of catchments with reservoirs, the potential increase in the PMF indicated by the Brettenham storm suggests rates of runoff close to the Extreme Catastrophic Flood of Allard *et al*. (1960). Although this standard has never been adopted for design purposes, discussion between one of the present authors and Peter Wolf, co-author of the Allard *et al*. 1960 study, showed that it was his personal intention that it should be applied as an upper limit of the rate of runoff.

A full report of the event and findings is under review for *Weather* and *Journal of Geoscience and Environmental Protection*.

Dan Holley (Weatherquest)
James Dent (Retired Consultant)
Colin Clark (Chalton Hill Research Station)

New members

Sarah Littlewood.....Aecom, Marlborough
Brogan Mccawley.....Camberley
Clare Burnell.....Abergavenny
Tess O'hara.....University of Newcastle
Brian Rawlins.....University of Zululand, South Africa
Alejandro Duisillant.....London
Matthew Cowdell...JBA Consulting, Newcastle upon Tyne
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Colin O'flynn.....Newcastle upon Tyne
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David Mindham.....University of Lancaster
Robbie Clinkscale.....Dunfermline
Sarah Lowe.....Nantwich
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A short-cut method for uncertainty estimation in FEH single site analysis: the GLO distribution

This note presents a short-cut method to evaluate the uncertainty of T-year design flood events derived from a Flood Estimation Handbook (FEH) single site analysis based on the Generalised Logistic (GLO) distribution.

When conducting a single site analysis using the FEH methodology (Institute of Hydrology, 1999) is common to adopt the GLO distribution. In this case the T-year design flood is given as:

$$Q_T = QMED \times [1+\beta/\kappa \{1- (T - 1)^{(-\kappa)}\}]$$

where QMED, β and κ are the location (the index flood), normalised scale, and shape parameter, respectively. Consider an AMS series containing *n* observations: $q_1, q_2, \ldots, q_n$ and the corresponding L-CV (t_2) and L-skewness (t), then the three parameters are estimated according the FEH as:

$$QMED = median[q_1, q_2, \ldots q_n]$$

$$\beta = \frac{t_2 \kappa \sin(\pi\kappa)}{\kappa\pi(\kappa + t_2) - t_2 \sin(\pi\kappa)}$$

$$\kappa = -t_3$$

The uncertainty of the design flood, Q_T, originating from trying to estimate its value from a limited number of AMAX data can be expressed measured by its variance, $Var(Q_T)$, and the corresponding 95% confidence interval which is approximately:

$$[Q_T - 2\sqrt{(Var(Q_T)}\,;\, Q_T + 2\sqrt{(Var(Q_T)}\,] \qquad (1)$$

A numerical estimate of the variance, $Var(Q_T)$, can be obtained using a variety of methods, including: Monte Carlo simulations, non-parametric bootstrapping, or analytical approximations. For the GLO distribution, these methods all require some degree of computational sophistication to either generate stochastic samples or numerical evaluation of specialised mathematical functions.

Based on an extensive set of Monte Carlo simulations, Kjeldsen (2021) presented a short-cut method allowing the variance to be calculated using a polynomial approximation of the general form:

$$Var(Q_T) = \frac{(QMED \times \beta)^2}{n} exp[a_0 + a_1 y_L + a_2 y_L^2 + a_3 y_L^3] \qquad (2)$$

where *n* is the record length, the parameters: a_0, a_1, and a_3 are constants and y_L is the Logistic reduced variate recommended by the FEH for use with the

GLO distribution and defined as:

$$y_L = Ln(T - 1)$$

The numerical values of the three parameters depend on the *L*-skewness, t_3, of the of the AMAX data and are defined for values of t_3 in the interval $-0.45 < t_3 < 0.45$ and with record length in excess of 20 years ($n>20$) as shown in Table 1:

Table 1 *Parameter values for use in Eq. (2) to derive variance of T-year design gevent (adopted from Kjeldsen, 2021).*

	L-skewness, t_3									
	-0.45	-0.3	0.25	-0.15	-0.05	0.05	0.15	0.2	0.35	0.45
a_0	1.2888	1.3441	1.3668	1.3805	1.3757	1.3348	1.2970	1.2819	1.2903	1.2831
a_1	-0.4104	-0.4287	-0.3687	-0.2282	-0.0464	0.1785	0.4152	0.6006	0.7375	0.9136
a_2	0.2114	0.2172	0.2082	0.1885	0.1760	0.1684	0.1607	0.1743	0.1928	0.1901
a_3	-0.0181	-0.0177	-0.0164	-0.0146	-0.0139	-0.0140	-0.0137	-0.0150	-0.0161	-0.0155

-

Example of application:
Consider a series of n=51 AMAX events available from gauging station 57005 River Taff @ Pontypridd covering all water years from 1967 to 2017. Adopting a GLO distribution with the FEH single site analysis gives the model parameters shown in Table 2

Table 2 *Median, L-CV, L-skewness and GLO parameters as estimated for 57005 Taff @ Pontypridd.*

Median (m^3/s)	L-CV	L-skewness	QMED	Scale β	Shape κ
353.3	0.1578	0.0835	353.3	0.1594 -	.0835

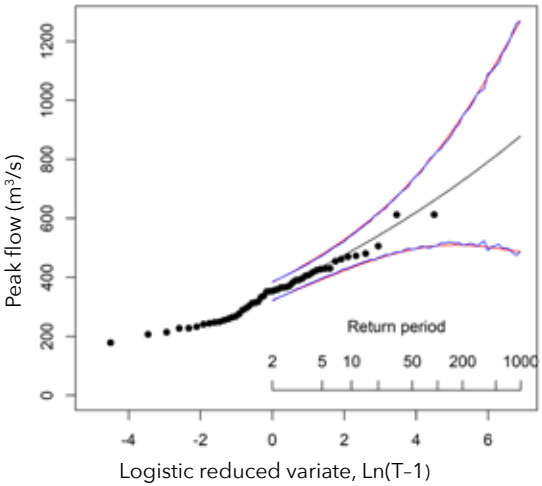
Numerical values of the three parameters a_0, a_1, a_2, and a_3 can be obtained from simple linear interpolation between the two columns in Table 1 on either side of the value of $t_3=0.0835$ as demonstrated in Table 3

Table 3 *Linear interpolation of model parameters from Table 1.*

	t_3=0.05	t_3=0.0835 interpolated	t_3=0.15
a_0	1.3348	1.3221	1.2970
a_1	0.1785	0.2578	0.4152
a_2	0.1684	0.1658	0.1607

For return periods in the range T=2 up to T=1000, the standard deviation of the estimated design flood can be estimated by combining Eq. (2) with the parameter values reported in Table 2 and 3.
The estimated variance can now be used to derive the approximate 95% confidence intervals via Eq. (1) as shown in Figure 3. The figure also includes confidence limits calculated from 10,000 Monte Carlo simulated AMAX series based on the GLO parameters listed in Table 2. There is a good correspondence between the two sets of confidence intervals, supporting the usefulness of short-cut method presented here.

$$Var\{Q_T\} = \frac{(353.3 \times 0.1594)^2}{51} exp[1.3221 + 0.2578y_L + 0.1658y_L^2 - 0.0139y_L^3]$$



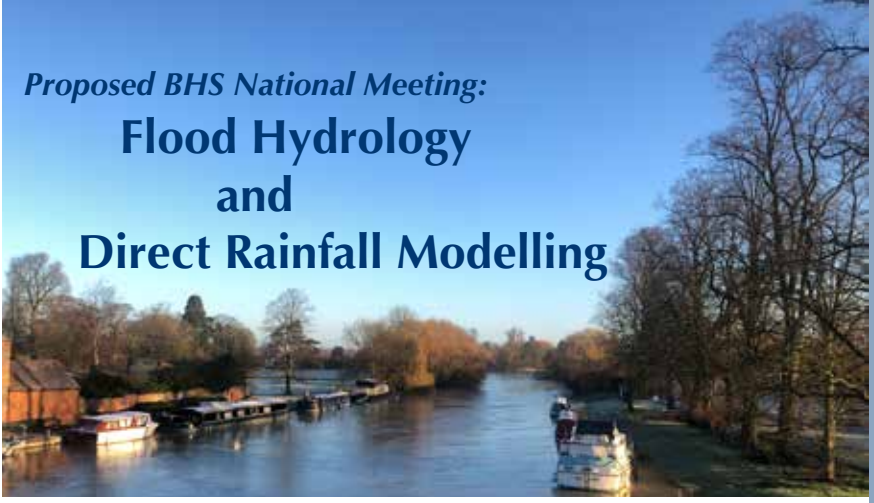
Fig, 1 GLO flood frequency curve (solid line) fitted to AMS from 57005 Taff @ Pontypridd. 95% confidence interval calculated using Eq. (3) shown in red, and the corresponding 95% confidence interval derived from 10,000 Monte Carlo generated AMS shown in blue.

Note of caution: The short-cut method presented here is applicable only for FEH single site analysis based on the GLO distribution. Records lengths should generally be longer than 20 years, and the L-skewness t_3 in the interval between -0.45 to 0.45.

Thomas Rodding Kjeldsen
Department of Architecture and Civil Engineering, University of Bath

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Proposed BHS National Meeting:

Flood Hydrology and Direct Rainfall Modelling

Direct rainfall modelling involves the application of rainfall to a hydraulic model grid, which routes runoff overland using the shallow water equations. This type of modelling has become increasingly popular over recent years, particularly for surface water flood mapping applications. However, their acceptance for fluvial flood estimation in operational hydrology has been limited by concerns over their assumptions and applicability to UK catchment processes.

This meeting aims to bring together practitioners, software developers and research hydrologists to consider whether direct rainfall modelling approaches can and should be adopted more widely for fluvial flood modelling in the UK.

Ideas for possible speakers and topics are requested (self-nominations welcome). Possible topics could include:

- Field observations of rainfall-runoff processes and their implications for choice of modelling methods
- Advances in software capabilities for direct rainfall modelling
- Case study applications of direct rainfall modelling in the UK, in different settings (e.g. urban, rural, permeable, pumped)
- Comparisons between direct rainfall models and other physically-based distributed models
- Theoretical assumptions and input data availability
- Advantages and disadvantages of direct rainfall models compared to industry-standard unit hydrograph methods
- Quantifying uncertainties in direct rainfall models, including the impacts of rainfall loss, infiltration, surface roughness and grid resolution assumptions
- Calibration and verification of direct rainfall models

We are currently gauging interest in this topic for a meeting, to consider length and format. If you are interested in this topic, would like to be involved in planning this meeting or contributing (presentations, posters and opinion pieces all welcome), please contact us by the end of January 2022.

Thank you

The Environment Agency National Flood Hydrology Team FloodHydrology@environment-agency.gov.uk

BHS Symposium Discussion on the Future of Hydrology

This session was chaired by Keith Beven, who had also led the BHS Working Group on the Future of Hydrology. Keith started the session by giving a short summary of the history of the working group and also pointing towards the briefing notes for the discussion that were available online (see also the BHS Working Group pages at **https://www.hydrology.org.uk/bhs-working-group-future.php** where comments can still be added).

The briefing notes presented some potential questions for discussion on observational needs, model/theory needs, and water management needs, as well as noting to the outcomes from the working group, including a report to BHS and two commentaries in ***Hydrological Processes.*** He also wondered whether the Working Group had been the best mechanism for generating a discussion in the BHS Community. Hence this Symposium session to allow more people to comment.

Within the hour available a wide range of topics were brought up. Keith started by encouraging people to think about the catchment water balance, and the issue of how difficult it was to 'close' the water balance given current observational limitations. In particular, he pointed to event runoff coefficients in the Kent catchment evaluated as part of the Q-NFM project where for Storm Desmond the apparent runoff coefficient was over 1.2. The implications for forecasting and model evaluations can be important.

To save your reading time, rather than provide a detailed summary of the discussion, the following is a focused set of bullet points that suggest points of departure for future initiatives.

1. If we want to improve observational data what should the priorities be? While recognising that it can be difficult to prioritise, that priorities might be different for different purposes, and that improvements might require significant development and resource, if we are not proactive in deciding on what is really needed, and demonstrating the potential impact, then there will be little or no progress (Keith used the analogy of the timescales required for satellite development).
2. It is surprising, particularly given the sequence of recent extreme events, that hydrology does not have a higher profile. What can be done to improve this (ideas included a TV series, a YouTube channel, weather forecasters talking more hydrology, more involvement of BHS members in local management groups, …). Is there a need for a BHS communication strategy?
3. The highest and lowest flow events are often of greatest interest. It is more difficult to generate interest between extremes. Change in the extremes is already happening – can this be used to bring a wider community together (e.g. in revisiting

the concept of the 100-year flood, in communicating the expected consequences)? Better communication with policy makers and short term adaptation strategies are as important as longer term aims.

4. Hydrology is also important as a driver for other processes, in water quality and pollution, ecohydrology and biodiversity, health issues, agricultural production etc., in ways that are affected by anthropogenic feedbacks (a particular point was raised in terms of inadequate regulation and monitoring of compliance on construction sites). These linkages also need to be communicated and reflected in decision making.
5. Monitoring is often given less attention than modelling (including in University courses). This need not be the case – recent developments in monitoring are really exciting. Modelling and monitoring come together in important ways when it is necessary to evaluate model or process hypotheses given uncertain data. Are recent developments enough to make progress in distinguishing hypotheses that are improving decision making (see point 1)?
6. Data technologies can be as important as observational techniques in improving practice. It is important to ensure that relevant data are made available in an open and timely way.
7. Can the communication of research progress into practical applications be improved? In some cases (e.g. local flood forecasting using cheap sensors) this does not seem to be happening. In other cases (e.g. use of stochastic sequences in the latest AMP round) it may be happening too quickly without adequate testing. [There was also a discussion about checking and explicitly recording assumptions of models and analyses in ways that can be audited at this point].
8. The future of hydrology is not only a question for UK hydrology, but there are many parts of the world that are more at risk from future change than the UK. Can BHS find improved ways of communicating knowledge to other countries.

All these points may be summarised into the general question of 'How to do better?' The BHS community are invited to make additional suggestions for consideration by the BHS Main Committee. This can be done by adding comments through the BHS Working Group pages (see 1), where a recording of the September discussion can also be found.

Thanks are due to Lucy Barker for ensuring that a discussion with 70 people online worked pretty well flawlessly and to all those who directly contributed to the discussion on the day (Alejandro Dusaillant, Chris Skinner, David Boorman, David Faulkner, David Hannah, Gareth Old, Hayley Fowler, Jill Labadz, Louise Parry, Miranda Foster, Nick Everard, Rebecca Passmore). Apologies to those whose comments in the chat did not get picked at the time – they were recorded and have been incorporated here. Finally, thanks to all the members who contributed to the outcomes of the BHS Working Group.

Keith Beven

A new Potential Evapotranspiration dataset for England*

The recent hot dry spells of 2018 and 2020 remind us all of the underlying changes which we are experiencing within the context of a warming world. Beyond changes to our rainfall patterns, accompanying changes to evaporative demands will have significant impacts upon the water environment. Our ability to respond to the Climate Emergency relies upon fit for purpose observational networks from which we are able to derive spatially and temporally homogeneous datasets. With this at the forefront of our thinking, we have developed a 1km Daily Potential Evapotranspiration (PET) dataset for hydrologists to use.

The Environment Agency and water industry make significant investments in developing both hydrological and groundwater models. These models underpin our management of water resources ensuring there is enough water for people, business and the environment, both now and in the future. The new PET datasets have been developed from a new set of daily spatially and temporally homogeneous input datasets derived at 1km grid square resolution.

Use of these new datasets will lead to improved model calibrations and less resource spent trying to calibrate models with poorer quality input datasets.

How has the new dataset been derived?
The new dataset has been developed from the latest science developments in homogenisation, the gridding of input variables and in the calculation of PET.

The project started in 2016 and has been delivered in two phases.

Within Phase 1 of the project, climate station records back to 1961 were obtained from the Met Office MIDAS system (Met Office Integrated Data Archive System) and homogenised using the MASH methodology (Szentimrey, 2014). Interim findings from this work were published in Shelton *et al*. (2017) with final results published in 2018 (JBA, 2018).

Within Phase 2, radiation and sunshine records were integrated to utilise the growth in network coverage in the former to offset the decline in the latter. Existing gridding methodologies used by the Met Office for monthly time step data (Hollis et al., 2019) were adapted and enhanced for daily time step data required for the calculation of PET. Methodologies for the inclusion of interception (water intercepted by the canopy), PETI, were reviewed and the recommendations incorporated within our implementation of the Centre of Ecology and Hydrology - Climate, Hydrology and Ecology research Support System (CEH-CHESS) FAO56 methodology (Allen et al., 1998, Robinson et al., 2017, JBA, 2020).

What is the new EA-PET dataset?
The new PET datasets (PET and PETI) comprise the following:

- Daily data from 1st January 1961 covering England*

* *The datasets also cover Wales*

- PET and PETI for a reference crop (short well-watered grass)
- 1km grid which aligns with the Met Office HadUK grid
- Three levels of data quality
  - o MASH QC - from homogenised data produced during Phase 1 of the project.
  - o Full QC - from data which has undergone full QC within the Met Office MIDAS system.
- Updated each month with provisional climate data (flagged as minQC) and final climate data (flagged as fullQC) 4 months in arrears to that. Full QC data will supersede min QC data.

The Figures shown overeaf illustrate changes in PET for selected catchments since 1961 using the new datasets.

How can I access the EA-PET dataset?

The dataset was initially made available to water companies in summer 2020 to utilise within their work on the National Framework for Water Resources.

The datasets are now Open Data and are available to download (in netCDF format) through the Defra Data Services Platform (DSP).

Richard Davis
Senior Advisor (Hydrology), Water Resources Assessment, Environment & Business, Environment Agency

Acknowledgments
Technical advice was kindly provided by both UKCEH and the National Climate Information Centre at the Met Office. JBA were our consultants on Phase 1 and Phase 2 of the project.

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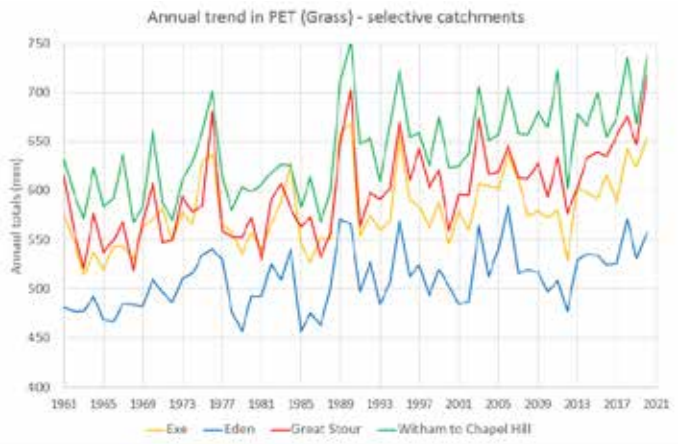
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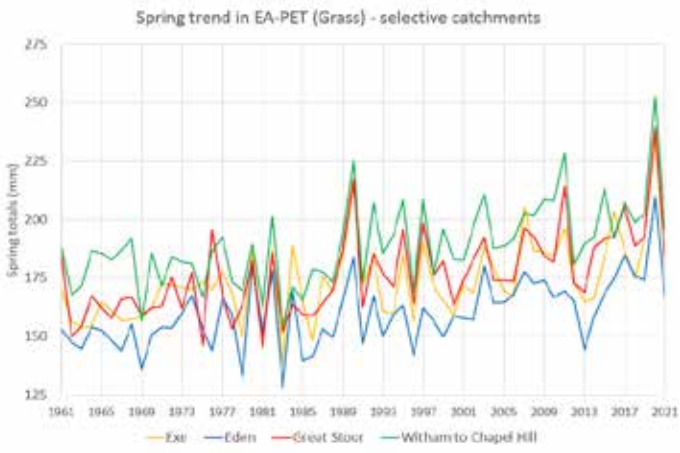
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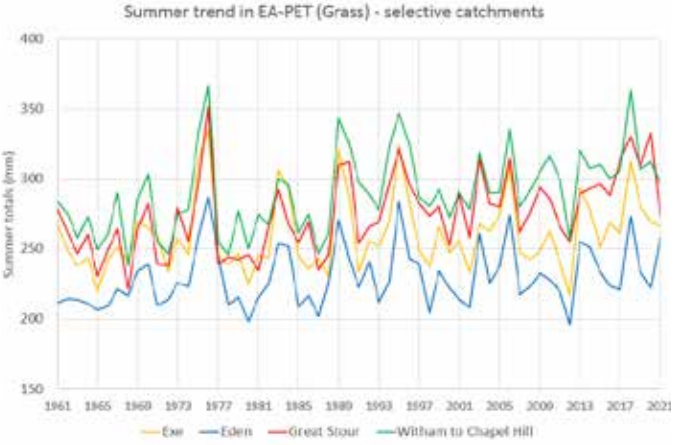
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Annual trend in PET (Grass) - selective catchments
Annual totals (mm)
750
700
650
600
550
500
450
400
1961 1965 1969 1973 1977 1981 1985 1989 1993 1997 2001 2005 2009 2013 2017 2021
Exe
Eden
Great Stour
Witham to Chapel Hill


Spring trend in EA-PET (Grass) - selective catchments
Spring totals (mm)
275
250
225
200
175
150
125
1961 1965 1969 1973 1977 1981 1985 1989 1993 1997 2001 2005 2009 2013 2017 2021
Exe
Eden
Great Stour
Witham to Chapel Hill


Summer trend in EA-PET (Grass) - selective catchments
Summer totals (mm)
400
350
300
250
200
150
1961 1965 1969 1973 1977 1981 1985 1989 1993 1997 2001 2005 2009 2013 2017 2021
Exe
Eden
Great Stour
Witham to Chapel Hill



PETER SPENCER retires

Peter Spencer is retiring this November. Many of you will know him and may want the opportunity to send him a message, though I hope and somehow expect he will remain an involved member of BHS.

I think those that know him will agree that hydrology and flood modelling is just what Peter does

For those of you who don't know him or would like to know more...

With a Geography course at Manchester University, then an MSc in Engineering Hydrology at Birmingham, Peter Spencer joined the Hydrology team at Halcrow's in 1974. He was there for 16 years covering a range of subjects – flood hydrology (particularly for reservoir studies and scheme design), water resources, irrigation, hydrometry, urban hydrology and sewer design, and later river hydraulics and modelling. He spent over 4 years overseas – more than 2 years in Pakistan on small-scale arid-zone irrigation, 18 months in Hong Kong on hydrometry, and shorter stays in Indonesia and Somaliland. For much of the time his long-term boss was Mike Hall, who ended his career as Professor of Hydrology at Delft IHE. He became a chartered civil engineer in 1982 and a senior engineer in 1989, both managing projects and having technical input.

In 1990 he joined the National Rivers Authority (which later became the Environment Agency) as River Modelling Manager to setup the North-West flood modelling team in Warrington. Section 105 floodplain mapping began in 1999, and he managed the first (and large) NW project. He wrote the specification jointly with the Area client, and this became the basis of the national specification.

He was one of those who reviewed the Flood Estimation Handbook (FEH) in 1999. The FEH is data-based, yet there were no plans to improve data and keep it up-to-date. He secured £1.07M from a government initiative (the Capital Modernisation Fund) to do this, and led this project (HiFlows-UK) for the UK (including Wales, Scotland and Northern Ireland) from 2001 until delivery in summer 2005. HiFlows-UK is now the NRFA Peak Flow Dataset, which is core to nearly all UK flood estimation.

The NW modelling team was disbanded through structural changes in 2005 and Peter joined the regional flood forecasting team, where his main role was the building and improvement of hydraulic flood forecasting models so that they were fast and stable. He was also involved in improvements to ratings of stations in flood forecasting models, and scheme design after the floods of 2005 and 2009 in the North West.

His post was transferred to the NW modelling and hydrology team in 2012 and into the national flood hydrology team in 2012. Throughout, he continued work in flood forecasting, including managing flood forecasting projects, technical input into scheme design and other studies by Consultants (e.g. Croston, Carlisle, Liverpool Land

Drainage). R&D input continued in long-period rainfall and small catchment flood hydrology and support the Area and the NW modelling team after the December 2015 floods (including the operation of Thirlmere Reservoir), and also flood hydrology of the Medway in Kent. This was followed by a national project (with Wales), and national guidance was released in November 2020.

Peter has also been a dedicated leading Monitoring and Forecasting Duty Officer for the Agency's flood incident response service from 1991 to 2020 and has trained and guided many others.

He was awarded an MBE (Christmas 2017) for services to flood hydrology and the economy.

In preparing the case I spoke to many people about Peter, many of whom were members of the BHS. Not only was I struck by how fondly people spoke of him but, again and again, I heard people say we would not be where we are today without him. So Peter, from all of us, thank you and best wishes for your new life . We will miss you at work but hope we will still see you at BHS events (or perhaps poking around a gauging station somewhere!)

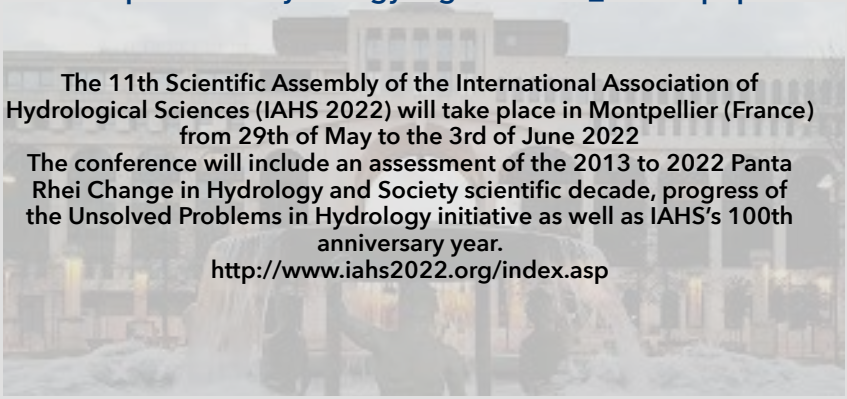
Anita Asadullah,
Flood Hydrology Improvements Manager @ EA

If you'd like to send him a message and do not have his contact details, please send to anita.asadullah@environment-agency.gov.uk floodhydrology@environment-agency.gov.uk and we'll pass them on.

A reminder:

Any BHS member intending to go this event may wish to apply for a travel grant from the Exeter Fund: we suggest that your get your application in early, noting the conditions as found at:

https://www.hydrology.org.uk/Travel_Grants.php



The 11th Scientific Assembly of the International Association of Hydrological Sciences (IAHS 2022) will take place in Montpellier (France) from 29th of May to the 3rd of June 2022
The conference will include an assessment of the 2013 to 2022 Panta Rhei Change in Hydrology and Society scientific decade, progress of the Unsolved Problems in Hydrology initiative as well as IAHS's 100th anniversary year.
http://www.iahs2022.org/index.asp

UK Hydrological Bulletin: August – October 2021

After a warm and generally dry late summer — parts of southern England excepted — river flows continued to decline through most of September, with very depressed runoff in responsive rivers during the fourth week. A major synoptic change then heralded a steep recovery in flows with widespread flood warnings in October. Floodplain inundations were generally modest but surface flooding incidents were common, repetitive and disruptive — particularly in south-east England where the vulnerability of transport in London to intense downpours was heavily underlined. Elsewhere, the meagre late summer and early autumn rainfall was reflected in modest reservoir inflows; stocks were particularly depressed across parts of northern Britain. A wet October eased the water resources concerns but the passage of a sequence of deep Atlantic low-pressure systems triggered further flooding which was particularly severe in parts of southern Scotland and northern England.

Overall, August was a dry month – the UK rainfall total was 75% of the long-term average – but regional variations were substantial (Fig. 1). Above average rainfall for Northern Ireland contrasted with monthly totals below 50% for much of East Anglia; western Scotland was very dry also. There were however some exceptional downpours.

On the 1st/2nd Bonchurch (Isle of Wight) reportedly registered >100 mm of rainfall triggering a landslide and severe local transport disruption. A week later a storm total of 67mm was recorded at Spadeadam in Cumbria. However, many rivers in Wales, northern England and western Scotland registered less than half of the average August

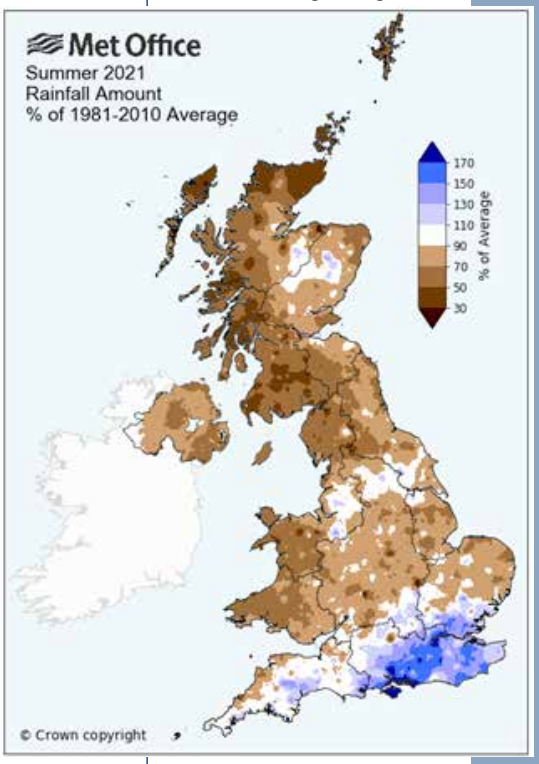


Fig. 1 UK rainfall for summer 2021

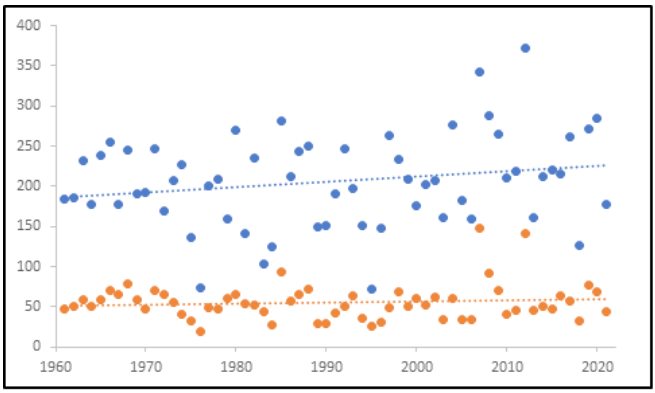


Fig. 2 England & Wales rainfall and runoff (mm)with linear trend lines

runoff. Correspondingly, reservoir inflows were generally meagre, particularly in Scotland where Lochs Katrine and Thom registered their lowest end-of-August stocks on record. Groundwater levels were depressed in Northern Ireland and south Wales but aquifer storage remained healthy in many less responsive boreholes across the UK.

Notwithstanding the wetness of south-east England, the UK recorded its driest June–August since 2003 with western Scotland registering its lowest summer rainfall since 1869. For England &Wales, summer rainfall was well below average but the trend over the last 60 years has been positive; in the same timeframe runoff from England & Wales shows virtually no overall trend (Fig.2).

September was the second warmest in the UK Met Office national temperature series which begins in 1884. Nationally, rainfall totals were around 85% of average but with large regional and local variability – heavy downpours, in mid-month particularly, resulted in significant surface flooding in parts of south-east Britain, London particularly. This contrasted with continuing aridity in western Scotland – contributing to its 2nd lowest June-September rainfall in a series from 1862. In Northern Ireland, runoff for the River Annacloy fell below 20% of the monthly average, and very modest flows characterised many rivers draining from the Pennines and Scottish Highlands. Recessions continued throughout much of the month but the passage of several deep depressions in the final week triggered a rapid recovery in river flows. Nonetheless, stocks remained notably depressed in a number of major reservoirs in Scotland and northern England (including Haweswater and Thirlmere). By contrast, groundwater levels remained above average in many Chalk & Upper Greensand aquifer units in England. In West Dorset, groundwater levels were close to the highest on record for the time of year in the Lime Kiln well where records extend back to 1969 (Fig. 3) and estimated overall storage in the Chalk aquifer was the fifth highest since 1983, reflecting heavy recharge through the winter of 2020/21.

October was another seasonally warm month but with rainfall above average in all regions of the UK and nationally ranking amongst the 15 wettest in the UKMO series from 1862.

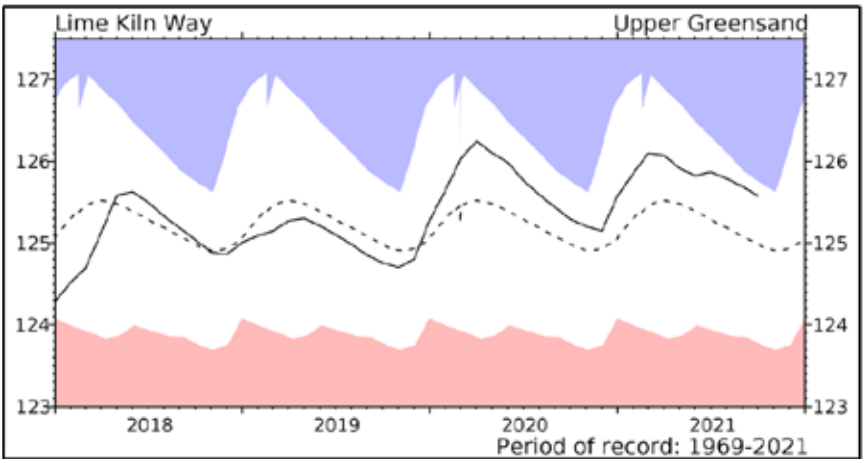


Fig. 3 Groundwater levels for the Lymn Kiln Way well. The black trace is recorded levels, the broken trace the long-term average and the blue and pink envelopes the long-term max. and min. levels.

A sequence of deep Atlantic low-pressure systems ensured that flood warnings were common and widespread. Surface flooding was particularly extensive in London on the 3rd and, generally, river flows increased steeply across much of the UK. Two days later further storms – including a 25mm deluge in an hour at St James's Park, London –– saw an increase in Flood Warnings and many catchments vulnerable to further storms. After a dry interlude, a moist Atlantic airflow brought heavy and sustained rainfall to much of the northern half of Britain during the final week. The Met Office reported a 361.6 mm rainfall total over 36 hours at Honister Pass (Cumbria) over the 28/29th: equivalent to around 40% of the annual average rainfall for England. Flooding was widespread and sustained in much of the Scottish Borders and northern England and, in the Lake District, exceptional water level rises resulted in Bassenthwaite Lake and Derwentwater briefly merging into a single body of water. This episode did help to underline the value of flood defenses and another positive aspect of the exceptional rainfall was a notable rise in reservoir stocks across much of the UK. In Cumbria, stocks in Haweswater and Thirlmere reservoir increased by over 20% in the final week alone and, entering November, overall reservoir storage for England & Wales was close to the average for the time of year.

Terry Marsh
9/11/21

Statement to the BHS Membership

The eagle-eyed among you may have noticed that we released the latest edition of Circulation on Wednesday to the BHS Mailbase and then immediately withdrew it from Twitter and the BHS Website. The reason for this was that it was brought to my attention that we had published a personal view from one of our membership that climate change was not a real phenomenon. These personal views are widely available on YouTube for anyone interested but we do not think it is appropriate to provide them with a forum under the BHS logo.

The British Hydrological Society (BHS) was formed in 1983 in response to a clear need for a new, broad-based national society for the advancement of hydrology. The Society caters for everyone interested in the inter-disciplinary subject of hydrology. We aim to encourage good practice and scholarship in scientific and applied aspects of hydrology and to foster the involvement of members in national and international activities. We also strive to provide a voice to all our membership and a forum for sharing opinions and views through our Regional and National meetings programmes and our quarterly newsletter Circulation.

Given the strength of scientific evidence from the series of six published reports from the Intergovernmental Panel on Climate Change, with the latest Sixth Assessment Report released this year stating that, "It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred" and "Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since the Fifth Assessment Report (AR5)," we do not want to be seen as endorsing the "climate sceptic" viewpoint put forward by the member. We do not believe that this represents good scholarship in science and will be reviewing our Governance procedures to make sure that members voices can still be heard but through the lens of good science. This review will consider all aspects of BHS governance and policies, with the Society statutes updated in consultation with membership as is appropriate.

Anthropogenic activities have unequivocally modified Earth's climate, causing increasingly disruptive socio-economic and ecological impacts. Changes to large scale climate patterns have resulted in increasingly frequent and intense examples of extreme weather events that have had devastating consequences for societies, economies and ecosystems alike, while future projections of change suggest that such changes will soon impact all regions of the planet. The scale of recent changes across the climate system as a whole and the present state of many aspects of the climate system are unprecedented over many centuries to many thousands of years.

Global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered. Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in carbon dioxide (CO2) and other greenhouse gas emissions occur in the coming decades. In an effort to limit these impacts, the recent COP26 event hosted in Glasgow and Milan pledged to limit the increase in global temperature by curbing future greenhouse gas emissions, which if fully implemented would hold the average planet temperature to 1.8°C above pre-industrial levels by 2100.

[1] https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/
[2] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WG1_Headline_Statements.pdf

Yet there is a need for society, economies and Governments to adapt to living with extreme climate events, as limiting future temperature increases will not reduce exposure to the extreme events and changes that many countries are already experiencing. Implementation of strategic and equitable solutions for all nations will be necessary to limit the consequences of future changes, with the alternative being continued inaction, which would have profound consequences for all life on the planet.

The Evidence Base for Climate Change

Since the Industrial Revolution, consistent burning of fossil fuels have resulted in a sustained increase in the concentration of greenhouse gases in the atmosphere (namely carbon dioxide, methane, nitrous oxide and fluorinated gases). Global networks monitoring the concentration of such gases in the atmosphere have documented subsequent changes in global temperatures on air, in the ocean and in the atmosphere, with current temperatures approximately 1.1°C above pre-industrial levels according to the most recent IPCC report. The evidence is unequivocable, and highlights the scale of the challenge facing humanity to limit further increases and the associated harms.

The consequences of these changing atmospheric concentrations of greenhouse gas and temperatures are all around us. Many changes in the climate system become larger in direct relation to increasing global warming. They include increases in the frequency and intensity of hot extremes, marine heatwaves, and heavy precipitation, agricultural and ecological droughts in some regions, and proportion of intense tropical cyclones, as well as reductions in Arctic sea ice, snow cover and permafrost.

Extreme heat records have all been broken in the last decade, with many areas experiencing their hottest ever temperatures being recorded in the last two or three years. Increasing occurrences and intensities of wildfires have had devastating global impacts, with places like California, Australia, Turkey and even Siberia experiencing substantial damages and losses to devastating events. Significant reductions in Arctic sea-ice cover and retreat of major glaciers in cryosphere environments have completely altered the way these dynamic environments function, threatening ecosystems and societies resident in areas that are vulnerable to such changes: for example, many societies that rely on meltwater dynamics from glacial systems for water security now find themselves at risk of limited supply also impacting food and energy security.

It is the within the hydrosphere where the most profound impacts of climate change will pose the greatest risk to Earth's biomes, and the flora and fauna that reside within them, and indeed, there is already substantial evidence of this occurring. Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events. Increasing megadroughts (such as those that have impacted places like Australia, South Africa, India, and California) have had devastating consequences for societies, ecosystems and economic activities alike. Conversely, we are witnessing demonstrably more intense, damaging flood events from intensifying storm events all across the world. Based on extensive scientific evidence accumulated over decades, we know that a warmer atmosphere can store more moisture, and as a result, extreme precipitation events are much more likely, increasing the potential for flash-flood events.

Hayley Fowler
BHS President

