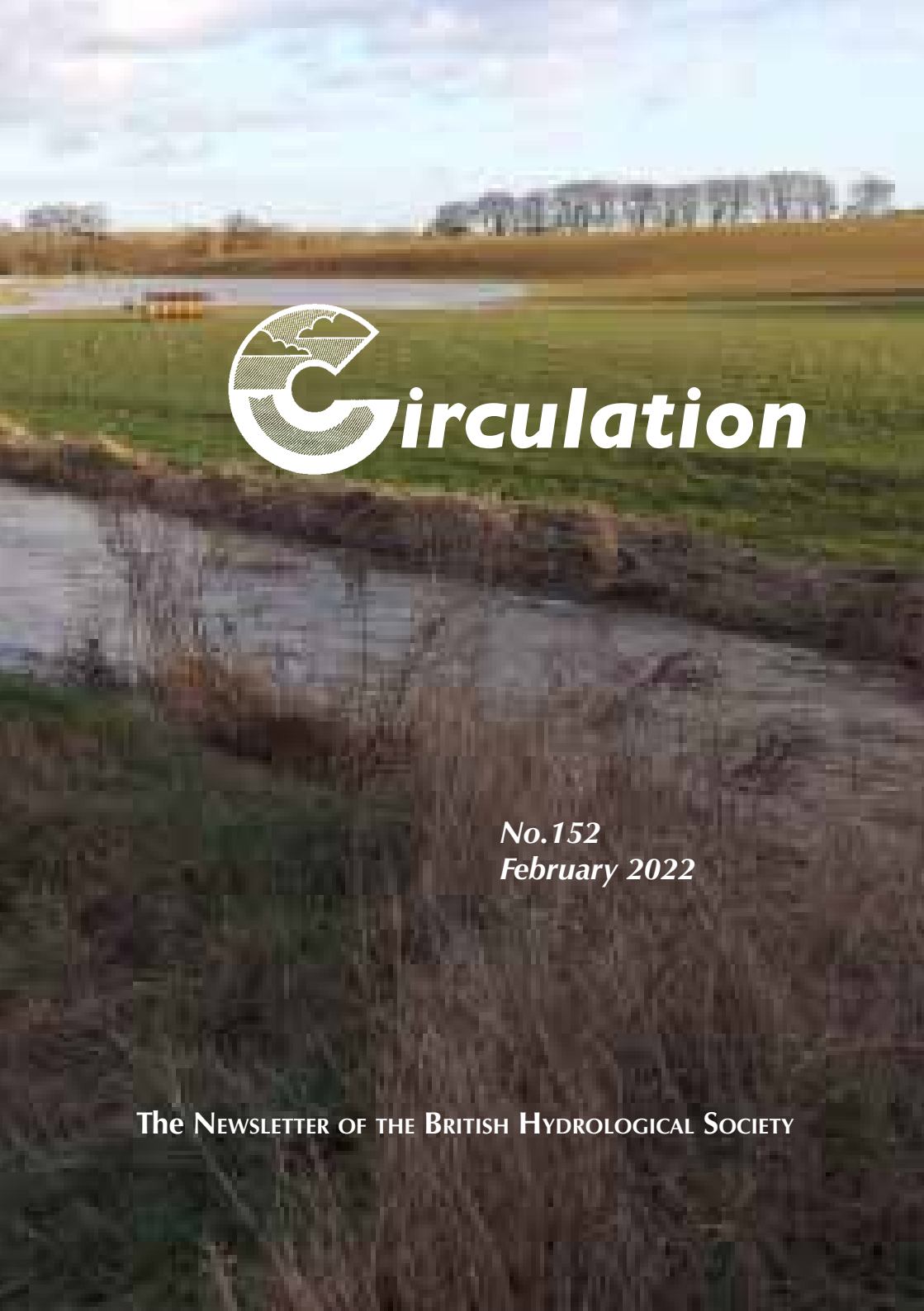


Circulation

No.152
February 2022

The Newsletter of the British Hydrological Society

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Conference website:

https://www.lancaster.ac.uk/lec/graduate-school/professional-training/bhs2022/

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President's Perspective

Scepticism and climate change science

Well, it has certainly been an interesting introduction to being President of the BHS. The BHS has always been a lively society, with many issues up for debate and discussion, but last issue's *Circulation* certainly drew a response from the membership – both those strongly in support of the statement we issued on the evidence for climate change, and from those who remain sceptical. We should be sceptical in our views. There is a need for critical evaluation and assessment of the evidence and scientific theories can never really be proven, only falsified. I am certainly a sceptical scientist. However, I will reiterate again here the view of the Intergovernmental Panel on Climate Change, in the latest Sixth Assessment Report, an unbiased review of the scientific literature in this area, which is extensively peer-reviewed by experts and governments from around the world: "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…Human-induced climate change is already affecting many weather and climate extremes in every region across the globe." The evidence is clear that global warming is happening and the latest WGII report, released only this week, further emphasizes the urgency of immediate and more ambitious action to address climate risks.

In a personal capacity, I was involved in a private round-table with the Joint Committee on the National Security Strategy (JCNSS) during COP26 who are currently hosting an inquiry on "Critical national infrastructure and climate adaptation"[1]. The inquiry is considering the resilience of UK CNI, including the water sector, to the effects of climate change, which is predicted to result in an increase in extreme weather events such as flooding, droughts, wildfires and heatwaves, as well as rising sea levels and is a direct response to the devastating floods seen in Germany last summer. We have seen severe wind storms and widespread flooding across the UK a number of times in the last few months. They are accepting evidence until 30 March 2022 and I would encourage members to contribute.

There have been many contributions to *Circulation* for this issue on climate change – from articles on the science, to personal views that we now host in our new 'Letters to the Editor' section where people can write short letters to Celia on their opinions on any topic of relevance to BHS members. I do hope you enjoy reading these articles and the more personal views and that you take the time to respond to these if you feel the need.

[1] https://committees.parliament.uk/work/1659/critical-national-infrastructure-and-climate-adaptation/

BHS meetings, Peter Wolf Symposium and Lancaster BHS Symposium

In my last President's Piece I talked about the need for us to work 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, providing different perspectives as well as new networks and partnerships. We have started to make plans for some joint national meetings with these organisations but would welcome ideas from the membership for meeting topics as we start to reconnect in-person after the pandemic. We'd also be keen to restart our popular lunchtime webinars so please get in touch if you would be keen to offer one.

The year seems to be flying past and I, for one, am really looking forward to our postponed Symposium, due to happen at Lancaster University on 12–14th September 2022. The BHS Symposium will consist of a series of networking events and sessions organised in five themes across the three days. These themes are: (a) Future hydrology, (b) Floods & droughts, (c) Natural flood management & partnership working, (d) Ecohydrology & water quality, and (e) International hydrology. The symposium will also include field visits, demonstrations and talks in the Lake District (Cumbria) on the 14th. Please do consider attending and meeting your fellow hydrologists in person. We are still accepting abstracts so please do submit soon.

The organising committee had to make the difficult decision recently to postpone the Peter Wolf Symposium from March to 20–21 September 2022. Those that have already submitted abstracts and/or registered, will automatically be carried over to the new dates in September. The theme remains Hydrological Innovation for the Climate Emergency and will be run over two days in Glasgow. It will include a mix of oral and poster sessions from the early-career delegates, invited keynote speakers, and a site visit. There will also be an evening dinner/social event on the Tuesday. Please see the Symposium website for more details and register if you would be interested to attend.

BHS and the Flood Hydrology Road Map

The BHS is a supporter of the Flood Hydrology Roadmap and a member of its Governance Board. The FHRM sets out a vision for flood hydrology for the next 25 years. The FHRM is key to ensuring UK water resilience and, to be successful, needs to be transdisciplinary, bringing the community together across academia and practitioners alike. Many of its priorities are around increased community collaboration; sharing data, models and best practice. The FHRM has now been approved and is due to be released soon. The BHS will be helping with some of the FHRM priority actions, particularly through access to our membership, so do watch out for surveys etc coming through the mailbase, twitter etc and please engage with these if you can. The EA are keen to engage across the UK and internationally in relation to the FHRM initiatives.

Hayley Fowler
BHS President,
February 2022

Mike Mansell-Moulin

MIKE M-M, THE FOUNDER AND FIRST PRESIDENT OF BHS died earlier this month. Reading his entry in the History-of-Hydrology wiki it is obvious that he was very much a pioneer in our subject: one of the students on the first Peter Wolf post-graduate course at Imperial College, then embarking on field-work and water resource surveys all over the world culminating as Chief Hydrologist for Binnie & Ptnrs. His range of expertise included the safety review of fourteen major international dams to the protection of chalk streams from groundwater abstractions. He served on the Steering Committee for the UK Flood Studies carried out by NERC. The important event in his career for BHS hydrologists was at an International Hydrological Assembly held in Exeter University in July 1982 where the idea of forming a Hydrological Society was discussed and an Initial Planning Group of eight members was elected with Mike as Chairman. Intensive discussions, studies and a questionnaire over a year led to a report which showed that 489 individuals (91%) supported the idea of an independent society. This would be concerned with both the scientific and applied aspects of hydrology. The British Hydrological Society was launched at the Royal Society in London on 1st November 1983. He was elected as the Founder President and, later, the first Honorary Life Member.

Scottish Hydrometric Data is back and better!

On 24 December 2020, SEPA were subject to a serious and complex cyber-attack, displaying significant stealth and malicious sophistication, which significantly impacted our organisation, our staff, our public and private partners, and the communities who rely on our services.

The attack had a significant impact on our systems and since then we've been unable to fulfil Environmental Information Requests for hydrometric data.

As part of building back better SEPA has launched a new service which allows anyone to freely access and download our hydrometric data, which includes river, tidal, ground water levels and rainfall data.

This new service is designed for computer literate users such as web developers, consultants, partners and academics to access this information through an Application Programming Interface (API) available on SEPA's website. The data is delivered through the API, by generating calls or queries.

Guidance has been written, which will help everyone to access the information more easily. This guidance will continue to be improved and developed over time based on user feedback.

The guidance can be accessed at https://timeseries.sepa.org.uk/. If you would like any more information, or to let us know what hydrometric data you would like us to make available next, then please get in touch.

Mark Franklin

I believe in climate change but ….

As pointed out by our President, and some of the comments following the James Dent opinion piece in the emailed version of Circulation No. 151, there is a general scientific consensus that humans are having a significant impact on the global climate. I believe that climate change is revealed in the observational record so would certainly not wish to question that consensus here, but as a member of BHS since the very beginning of the Society, it has never (to my knowledge) been a problem for members to express their opinions. There have certainly been other times when I have personally not agreed with opinions expressed in Circulation. I wonder why this should have generated such a fuss this time.

I do believe that we are changing the climate but I also think that there are still important issues that have not received enough discussion. The IPCC Consensus is heavily conditioned on the results of model projections as a means of extrapolating beyond the observational period; models that are subject to very important epistemic uncertainties and which have many parameters that can be tuned. Indeed, they have been tuned to give something of a consensus in the model outputs. Those projections are traditionally presented in terms of anomalies (as % changes) which neatly draws attention away from the limitations of their predictions when compared with past observations. But, as hydrologists, should we not be worried about the fact that those models predict precipitation patterns poorly in many parts of the world. And if they cannot predict precipitation patterns and precipitation extremes well, they cannot get the energy partitioning right at the land surface which will then have feedback effects on predictions in the atmosphere (something that will only become even more important as "hyperresolution" and "convection permitting" models become more widely used and local surface conditions become more important).

There is much about climate models that remains obscure. There was a time when the general scientific community were not aware of the latitudinal "flux corrections" that were needed by atmospheric models to make climate change projections (for perfectly good reasons as a necessary approximation). They only became apparent when ocean models were coupled to the atmosphere so that it was announced that they were no longer necessary (I was at a meeting when the Hadley Centre announced this success). But given the complexity of the current generation of models there are still some very strong assumptions in the grid-scale parameterisations required to make the models operational. Look at the treatment of hydrology in the land surface parameterisations; it may be improved in the future with the outcomes of the HydroJules and other projects but that will still have limitations in its process representations and will remain dependent on rainfalls provided by the model. As with any model, however carefully programmed, there may also still be bugs in the code. UKCP18 state that the local probabilistic projections had to be updated in September 2020 because of a correction to the code. Their site also suggests that they give the "broadest range" of potential future change – but (elsewhere) not all possible future outcomes. The probabilistic projections provide "an indication of how much the evidence from models and observations taken together in our methodology support a particular future climate outcome" as "conditioned on methodological choices and

expert judgement"[1] . Advice is also given about how to use the probabilistic projections but there appears to be little or no information on the assumptions that underlie the methodological choices and expert judgements (apart from a very simple explanation of a perturbed parameter ensemble – a full list would, of course, make for rather a long document).

There have also been studies that have shown that when tested at the decadal scale against recent observations, data-based models of change can perform somewhat better than the climate models on temperature and other variables. I asked about a comparison with observations when UKCP09 was released. I was told this was not possible because the observations had already been used in bias-correcting the model outputs. I am now told that this is not the case in UKCP18: the available projections are not bias corrected but there are still aspects of the observed climate that are not being well simulated. As hydrologists, we have certainly been more aware of the various downscaling techniques and bias corrections that have been necessary in post-processing to make use of the outputs of climate models for impact studies at catchment scales. This is rather convenient to fulfil the remit of impact studies but, as hydrologists, should we not be worried about some of those bias corrections? It is these approximations and epistemic uncertainties that also make me wary of the various attribution studies that have been published.

My conclusion (or rather opinion) is that change is occurring but that the future remains really rather uncertain in ways beyond the current probabilistic projections. That suggests that we should not rely only on model projections in adapting to the future (see my opinion piece in Hydrological Processes of a decade ago[2]). My worry is that change might be much faster than the models are projecting and that the occurrence of extremes will lead to increasing global insecurity (does UKCP18 really give the broadest range of projections? nobody ever took the much wider range of climateprediction.net projections seriously because there were much "better" models available, and yet those have certainly not been explored in the same way). COP26 demonstrated that the case for change has convinced many (but as with COVID vaccinations, clearly not all) but that, despite the evidence, real action is really difficult to achieve.

Being a responsible scientist involves discussing and critically evaluating assumptions, testing potential hypotheses that might constrain some of those epistemic uncertainties, and presenting credible evidence to inform policy. Even if the majority might already be convinced (including myself) that the climate system is being changed by human activities, there are clearly still issues to be resolved and a need to consider the epistemic uncertainties in planning for the future. It could still be a convenient choice to rely on the outputs from UKCP18 (in the same way as we use an AEP of 0.01 as a convenient standard for fluvial flood defences), but that is not necessarily the only option and warrants more discussion. There should surely be ways of allowing that discussion within the Society without appearing to endorse opinions outside the consensus. But that is only my own opinion, of course.

Keith Beven

[1]Sections 4 and 5 in https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---caveats-and-limitations.pdf

[2] Beven, K J, 2011, I believe in climate change but how precautionary do we need to be in planning for the future?, *Hydrological Processes* (HPToday), **25**, 1517–1520, DOI: 10.1002/hyp.7939.

Letters to the Editor

Dear Editor

I enjoyed reading Jim Dent's contribution to Circulation. Of course it wasn't 'in' our newsletter because the committee decided to overrule editorial judgment and pulled it as described by our President. Like most members, I could see many flaws in his arguments and I certainly don't agree with him. However, he gave voice to some of the pauses for thought which must surely have entered the minds of every thinking hydrologist at some point in the last 40 years during which we have been trying to separate the various signals (natural variability, periodicity, trends) present in all climate and weather variables. Whilst there is little doubt now that some recent extreme events can conclusively be laid at the door of rapid climate change caused by man, it's nowhere near as simple to understand and express as some pretend. Perhaps it is inevitable that such simplification and forceful expression is absolutely necessary to persuade politicians to make things happen. I understand and support this degree of emphasis but I do not support the emergence of a cancel culture whereby a fellow practitioner should be denied the chance to put forward a different view. Such cancelling would only be defensible if the arguments had been inflammatory and dangerous (e.g. Andrew Wakefield and his MMR-autism thing). With all due respect to the Society's influence and to Jim Dent himself, I doubt whether any such reaction would have followed printed publication of his piece. All that would have been required was a simple statement to the effect that a) the Society fully supports the conclusions of the IPCC and backs all International efforts to hold down global warming and b) that Jim Dent's views are personal and should in no way be interpreted as those of the Society or the vast majority of its members.

Mike Lowing
Group Leader, UK Flood Studies 1970-75;
BHS Past President 1991-93
22 December 2021

Dear Celia

The last pages of the latest Circulation caused me a lot of disquiet. Given the size of the BHS membership, is it so surprising that there may be one or two who doubt the accepted narrative surrounding climate change? I should hasten to add that that doesn't include me.

Not being a great Twitter user and being quite able to contain myself until the printed issue comes through the letterbox, I have only a very hazy idea what the offending article said and none about its author. The impression, however, is that the article cast doubts on the accepted view that human activities are largely responsible for climate change. But why it wasn't felt that this could safely be left to readers of Circulation to decide whether to accept or reject the arguments put forward is a mystery. The history of

human progress is largely a result of people who have challenged, often at great personal cost, deeply held accepted views. Think Galileo. Think Darwin. So rather than applauding the author's bravery, BHS seems to have decided to suppress the article and only allow the now-conventional narrative in the pages of Circulation.

Whilst the article may be putting forward erroneous arguments, some of the issues raised, so long as they are not mere assertions, may well be worthy of debate and perhaps help to shake people out of what looks increasingly like groupthink, exemplified rather well by the explanation for removing the article from the magazine.

David Cooper
6 January 2022

Dear Editor

IS RE-WILDING/RE-GREENING AN ENTIRLY BENEFICIAL AIM FOR HYDROLOGY?

Superficially the ideas of re-wilding or (re-greening) presents a win-win situation for water management. It is a concept widely espoused by environmentalists and also taken up by many local authority and charitable bodies. Re-wilding has been given a boost by announcements that beaver populations have become established small pockets on the River Otter in Devon and also in Scotland. Beaver habits of building dams across rivers are thought to be beneficial as they will reduce river spates in their upper reaches. A recent feature in t e country could perhaps offer one of a number of cautionary views.

Coypu as a source of a fine fur, Nutria, were 'farmed, - mostly in East Anglia. During and after the War, fur items became less fashionable, and fur farming declined. As a consequence many coypu escaped or were simply let loose to the wild. By the 1950s and 60' they had become pests, because of their destructive behaviour. They dug into river banks and ate riparian vegetation, which weakened banks and made them prone to collapse and erosion. Coypu were very unpopular with farmers, as they had a voracious appetite for potatoes and sugar beet which are widely grown in East Anglia. In the late 1960's the then Ministry of Agriculture, Fisheries and Food brought in an extermination programme, which continued until the late 1980s. Could beavers be seen in some quarters as pests?

Some aspects of re-wilding appear to be of benefit, mostly on the catchment scale. Increasing catchment storage through vegetation, reducing runoff, gives the opportunity for water to infiltrate to soils and aquifers. The slowing of run-off helps decrease sediment loss, and in general ameliorate flash flooding. But it must be borne in mind that these ameliorating effects only apply at the lower end of the flood severity spectrum. Like many other structural flood design interventions, they will have little or no effect with rare, more damaging floods. One has only to witness how wet it can be in upland areas in a prolonged frontal rainfall event. Rewinding experiments have generally focusses on non-drainage of uplands, in-field run-off control

measures, vegetation of channels sides and use of marshland storage. (In) famously, the latter ideas were taken to their extreme by a former head of the Environment Agency who, after the numerous flood events of 2000-02, opined that she would like to see all pumping station in the Fens and Somerset Levels blown-up! There are some downsides to re-wilding, and these relate to problems that in some cases are inadvertently happening due to many recent changes in operational practice.

Over the last 20 to 30 years, river channel maintenance has markedly decreased, as a result of cost economies in river management agencies and changed environmental aims. This trend has become most apparent, especially to the public perception, in cessation of dredging and the lack of vegetation clearance of banks and channels. As river capacity is decreased, out of bank flooding has increased in frequency and flood waters infiltrate into the flood plain. Farmers and residents of low lying area might not be as pleased as the environmental lobby! Concurrently there has also been a decline of land drainage and road drainage maintenance, which only exacerbates the problems of localised flooding.

Progressive reduction in physical river inspection and operational maintenance of structures such as locks and flood gates has taken place in recent years, as part of a perceived need to economise on travel and manpower. Automation and remotes sensing are favoured, but these have a habit of breaking down at critical times, and is especially for control gates and pumps. There are no staff able to go out at critical times to see what is happening at the key points on rivers and management structures. CCTV cameras are notoriously unreliable: there is limit to what can be done in monitoring a real-time event from a computer terminal.

Re-greening will inevitably affect the agricultural sector. It is obviously that farmers are interested in maintaining their land drainage and flood protection to a good standard, but imposition of further limits, controls and legislation requirements will inevitably leads to more costs. The agricultural sector has become very active in soil and water conservation through numerous regulations, especially water, abstraction licensingIt seems unfair to keep applying the 'user-pays' principle for the benefit of a minority of those with a somewhat rosy tinted view of 'wilderness' and who may not appreciate the amount of water and land management involved in areas like Minsmere and Wicken Fen in order to preserve a 'natural' wetland.

I can envisage a time when in most winters flooding will be significant obstacle to road traffic in many areas. During the period of widespread flooding in 2000-02, when I was working for the National Flood Warning Centre, I was struck by the similarities of the areas seriously affected by previous major events, especially the floods of 1851. Going back further, I am concerned that we are in danger of returning to pre-industrial conditions of travel where roads are impassible and land stays flooded for several months in winter. The last few weeks have seen much concern with transport limitations, commodity shortages, etc: just imagine a time when such things become a regular seasonal occurrence. Re-wilding is hardly going to help.

James Dent
25th January 2022

Dear Celia,

When I was at school the science teacher told us that Science is the search for the truth: fine words which I accepted. But the process of finding truth has in recent times, I regret, become marred in evidence being ignored or suppressed, misinterpretation, and even falsified.

I have been reading the account by Nicholas Copernicus of his evidence showing that the earth is a sphere and goes round the Sun. At the time in 1543 it was a touchy subject, as have been since Continental Drift, Glaciation or Biblical Flood, Smoking and health, Badgers and TB in Cattle. However, these have one thing in common and that is that present day evidence can be used to settle the argument. In contrast, the Climate Change dispute is different: it cannot be proven until for example we get to 2050, all else being equal. So for the time being it is an unscientific theory. I do not know what the rainfall and temperature will be in 2050, or 2030 for that matter.

Some people say that they do know. But variability and change are hard to separate and the past is littered with wrong predictions. I have recently asked the authors of a paper on non-stationarity how they can produce an estimate of the 1 in 100 year flood using data at the start of their record. I get no answer. Similarly I have asked authors of a Journal of Hydrology paper on PMP in India how they reckon that maximum rainfall estimates have increased since 1970, and the lead author of an Australian bushfire paper, on the merits of Native Land Management (see Bill Gammage, 2012: The Biggest Estate on Earth). I have not had a reasonable answer to both questions.

More recently I have queried whether the authors, reviewers and editors of some 100 or so papers which show a much lower Climate Sensitivity than some current thinking are wrong. I have no axe to grind and take sides with no-one and make no predictions of future temperature or rainfall: I stick to the Science and report:

1. That the Vostock Ice core data show that temperature controlled Co2 levels by the process of respiration and decay.
2. That a graph in a New Scientist paper shows that at a concentration of 600ppm the temperature will rise by about 0.5 deg C, and if increased to 6000ppm would rise by 7 deg C. Forecasts of 600ppm by the end of the century or even earlier depend, amongst other factors on a population forecast of 11 billion people in the world by that time.
3. That our temperature records in East Somerset for the past 33 years have shown no trend.
4. A paper in Nature Climate Change 2014 states that warm days increase the Belief in Global Warming.
5. National weather forecasts on BBC Radio 4 always report maximum temperatures but seldom report minimum temperatures.
5. Work by Rosenthal, Oppo, and Liley (Science, 2013, 617-621) showed that the Little Ice Age, and Medieval Warm Period were global events, and that during the Post Glacial Climatic Optimum the temperature was about 2 deg C higher than now.
6. Birth rates are falling well below replacement levels in the USA, Europe and Japan. The UN has recently reduced it's forecast of global population from 11 to 9 billion. Some people have forecast a drop in world population by 2070: it could be much earlier.

I have no funding for climate research from either side.

Colin Clark
20th February 2022

'On Trend' Postscript

This is a follow up to my article on non-stationarity that appeared in *Circulation 151*. It has been prompted by feedback from readers and especially from Richard Davis who referred me to a fascinating paper by Conor Murphy *et al.* entitled "Multi-century trends to wetter winters and drier summers in the England and Wales precipitation series explained by observational and sampling bias in early records" (*Int J Climatol.,* 2020; **40**:610–619).

The paper describes how England Wales Precipitation (EWP) seasonal precipitation were reconstructed using multiple linear regression. Predictors are based on available long-term observed and reconstructed sea level pressure (SLP), temperature and wind direction series. The reconstructed series are then compared with the observed EWP time series.

The key findings are:

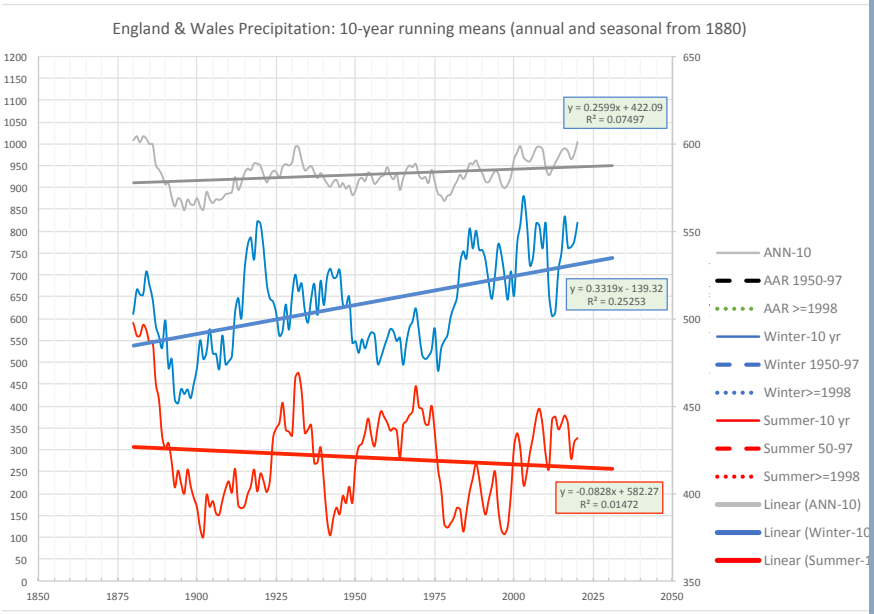
- Significant discrepancies are revealed between reconstructed and observed EWP time series in the pre-1870 record. For winter, the timing of divergence aligns with the introduction of the Snowdon Pattern Rain Gauge. The paper shows that the widely accepted trend to wetter winters in observed series is likely an artefact of measurement practice and (probably) higher occurrence of snowfall in early winters.
- For the summer series, the divergence between observations and reconstructions coincides with a reduction in network density prior to 1820, together with a period of uncertain data in key constituent series at Oxford and Kew.

The closing sentence of the paper is a reminder to us all when dealing with data. "Our work is a reminder of the importance of revisiting the quality of established long term records as new evidence and data sets become available."

The paper has at least provided an answer to the discontinuity that I had observed around the 1860s. However, it also paved the way for repeating the analysis for the post 1870 data that had been found to be reliable. I excised the data prior to 1880 and replotted the time series of 10-year running means for annual and seasonal (2 seasons each of six months' duration) rainfall.

The results are shown in the Figure opposite, from which the following inferences can be made:

i. There remains a clear upward trend in the winter rainfall series amounting to around 40 mm over the 140 year period.
ii. The increase is not a smooth one, however, being marked by steep changes, such as from 1975.
iii. For the summer series, the fitted trend line shows a weak downward trend; however, this is likely influenced by the very wet period at the start of the plotted data. Exclusion of data from the start of the record would likely remove any apparent trend. In their more thorough analysis, Murphy et all noted that the trend to drier summers in



observed series is not robust with significance depending on start/end year and predictors used in model reconstructions.

iv. The summer series is also characterised by a more systematic "switching" between above and below average periods. There are low turning points at around 1900, 1940 and 1980; the high turning points are not so clear. There is clearly no sign of one for 2020!

v. Unsurprisingly, the annual series shows an upward trend that largely results from that for winter. Visually, the series is less volatile, reflecting the smoothing effect of the summation.

vi. However, it is interesting to note the way in which the sustained periods of "above average" seasonal rainfall can at times be out of phase. The period from 1950 to 1975 is characterised by high summer but low winter rainfall; that from 1975 to 2000 by high winter but low summer rainfall. This led to a generally benign period in terms of flood extremes. In contrast, post 2000 is a period of high summer and high winter rainfall with well documented consequences.

It is of course a good sport of identifying trends and other features of long time series; the difficult part is to build and test hypotheses to explain them. That leads inevitably to seeking an understanding of how those processes may evolve over time – a more challenging endeavour.

Paul Webster

Puzzling non-stationarity – the late nineteenth century

This note is not to question the validity of the link between carbon emissions and climate change, elegantly described by Hayley in *Circulation 151* and supplemented by thousands of worldwide researchers and physical science. However, we wish to draw attention to periodicities, variability and anomalies in climate and flood responses which are little related to carbon emissions (though they may interact with it). These climate changes are not fully understood, relatively little researched or adequately incorporated in our predictions and projections.

Paul Webster's article in *Circulation 151* notes seasonal trends, particularly to the fall in summer rainfall since 1850 – withdrawn on further evidence by Paul (Murphy *et al.*, 2019). However, there were also two decadal periods when the rainfall was higher than at present, notably the period towards the end of the nineteenth century when summer rainfall was more than 10% higher than at present. Winter rainfall during this period was also high, resulting in the annual rainfall being at its highest level in 100 years. The graph also shows an apparent periodicity between consecutive peaks and troughs of summer rainfall of about 40 years. Paul notes an increase in summer rainfall over the last 50 years – the period of gauged flow records which have conditioned our perception of change –see Figure on previoujs page.

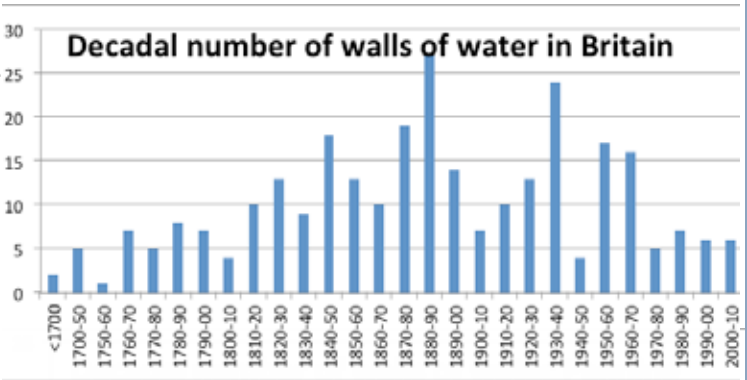
Attention is drawn here to some of the consequences in terms of summer flooding from intense rainfall and associated occurrences of large hail.

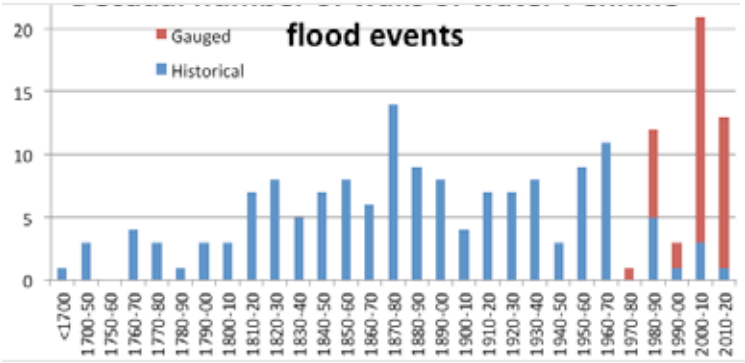
Over the last few years I have compiled a chronology of flash floods for the whole of Britain from about 1700. The chronology includes occurrences of 'walls of water' where the river rises so rapidly as a result of intense rainfall that it is a hazard to river users, more severe than the occurrence of the peak level. Now these events are rare and hydrologists may not have experienced a single one in their region during their career. Yet nearly 300 of these events have been found, mainly in upland Britain but extending into neighbouring lowlands since 1700. Figure 1 shows considerable correspondence with the time series of summer rainfall; the sharp increase in numbers after 1870; the decline to a minimum in 1900 to 1910 and a new peak from 1930 to 1940.

The small numbers registered over the last 50 years may partly be explained by reduced number of newspaper sources in the British Newspaper Archive. However, a more detailed examination based on local newspapers and professional reports of flash floods for Pennine catchments in northern England shows a similar reduced number of events. A further investigation of gauged records of rate of rise in Pennine catchments does show additional events where the water rose abruptly from a low level by more than 0.75 metres between 15-minute observations but few over 1 metre. These had rarely received any press description or even rainfall records. It is likely that many events during the historical period have also been unrecorded; only those major events which have caused loss of life or a threat to life have been reported in the press.

Besides the time series of walls of water, another damaging climate event – the occurrence of large hail – also shows a similar

high level of occurrence at the end of the nineteenth century and a significant decline since then (Webb *et al.,* 2009: Clark, 2020). A regional time series of large hail was prepared for Northeast and Southwest England as part of the Sinatra project





and these also show maxima at the end of the 19th century and a striking decline since then (Archer, 2016).

Since the occurrence of sufficiently intense convection and rainfall to cause both walls of water and large hail is associated with high summer temperatures it seems anomalous that more frequent events have occurred in a period of lower average temperatures. Model projections indicate an intensification of precipitation with increase with temperature, according to the thermodynamic Clausius–Clapeyron (CC) relation (a rate of ~6–7%°C^{-1}) – a warmer atmosphere being capable of holding more moisture.

This analysis leads only to further questions. What are the physical reasons for the trend and variability? Is there any reason why this large upswing in summer rainfall and associated flash floods and hail could not recur at present? If they did is it likely they would be ascribed by both professionals and the press as solely the result of the upswing in carbon emissions? My message to climate scientists and hydrologist is not to ignore inconvenient observations – explain, refute, but don't ignore.

A further point should be made with respect to methods of flood risk assessment. If the last 50 years has been a period of lower summer rainfall and associated lower frequency of summer floods (at least) then single site flood estimates are likely to be lower than if historical data could be included. This also applies to pooled data which may also underestimate. In analysis carried out in northeast England for seven catchments

(Archer, 2010), estimates of the 100-year flood on series including historical data exceeded the pooled analysis in every case by amounts ranging from 6% to 54%. Where it has not been possible to include historical information in the estimates should there be a standard increase in the 100-year estimate for past climate as well as for future projections?

Terry Marsh

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POW Symposium

Sadly, its been necessary for the organising committee to make the difficult decision to postpone the Peter Wolf Symposium from March to 20-21 September 2022. While the COVID-19 situation is undoubtedly improving, the organising committee is aware that many would-be attendees may not yet be willing to travel and/or be in large groups, especially since many of us (in Scotland at least) are not yet back working in our offices. As such, by postponing to September we are allowing for normality to (hopefully) return, enabling us to run the in-person Symposium as intended.

For those that have already submitted abstracts and/or registered, these will automatically be carried over to the new dates in September. If, however, the date change presents issues for anyone, please email: peterwolf2022-conf@strath.ac.uk.

Other than the date change, the other details of the symposium remain unchanged. The theme is Hydrological Innovation for the Climate Emergency and will be run over two days (Tuesday 20 and Wednesday 21 September 2022) in Glasgow. It will include a mix of oral and poster sessions from the early-career delegates, invited keynote speakers, and a site visit. There will also be an evening dinner/social event on the Tuesday. Abstract submission (for oral or poster presentations) and registration costs also remain unchanged – £80 for BHS members and early-bird registrations, and £110 for full registration, with early-bird registration (non-BHS members) now closing 26 August 2022. Please see the Symposium website for more details. Note that the ICE booking page is in the process of being updated.

Easy methods for quantifying the uncertainty of FEH pooling analysis

In *Circulation 151* there was an article, written by Dr Thomas Kjeldsen about an easy to apply method to quantify uncertainty for single site design flood estimation. Leading on from that article and the uncertainty work that preceded it, this short note presents two easy to apply equations for quantifying uncertainty for FEH pooling; one for ungauged estimates and one for gauged (enhanced single site).

Ungauged

Previous work (Kjeldsen, 2015) led to the quadratic equations of Dixon *et al.* (2017) for calculating the factorial standard error (fse) of flood estimates, from which confidence intervals can be obtained:

$$Confidence\ intervals = \begin{cases} \left(\frac{q}{fse}, q\ fse\right), 68\%\ intervals \\ \left(\frac{q}{fse^2}, q\ fse^2\right), 95\%\ intervals \end{cases} \quad (1)$$

where q is the extreme flow estimate. Based on bespoke bootstrapping methods undertaken for FEH analysis (Hammond, 2021), the factorial standard error was derived for 545 UK catchments (suitable for pooling) across a range of return periods. Instead of using single site estimates for comparison to derive the fse, the sampling distribution of the flow estimate, based on the pooled annual maximum samples, was approximated by the bootstrapping. For a range of return periods the fse for the cases of no QMED donor, one donor, and two donors were tabulated (see table Table 2 in Hammond (2021)). If these three sets of fse's are standardised by dividing the range of fse's by the associated fse for the two-year estimate (see Table 1 below), there is no significant difference between them, and a standardised quadratic can be established for the growth curve fse. There is no significant difference because they are derived from the same 545 pooling groups and any difference is only due to the random aspect of the bootstrapping. This standardised quadratic can be multiplied by the QMED fse. In which case one equation will suffice for quantifying uncertainty in the ungauged case. This is a flexible approach where QMED fse may be considered on a case-by-case basis (including when QMED is drived from the gauged record but the growth curve is not). Where y is the Gumbel reduced variate which is -ln(-ln(1-1/T)), and T is the return period, then:

$$fse = QMED_{fse}\ (0.0069y^2 - 0.0099y + 1.0039) \quad (2)$$

The following table provides the fse of the growth curve which can be multiplied by the QMD fse.

Table 1: The factorial standard errors for the ungauged growth curve

RP	**5**	**10**	**20**	**50**	**100**	**200**	**500**	**1000**
fse	1.005	1.018	1.036	1.070	1.102	1.142	1.207	1.265

The practitioner can multiply the QMEDfse with the associated fse of the return period in Table 1. For return periods in between, Eqn. 2 can be used (note they will differ slightly). For example, assuming the QMED fse is 1.41, the 100-year fse is 1.41*1.102 = 1.55. Using catchment 58006 (Mellte river at Pontneddfechan) as an example, the ungauged 100-year flow estimate is 186m3/s*. The 68% confidence intervals are therefore 186/1.55 = 120, and 186*1.55 = 288.

Fig. 1 provides the confidence intervals for the growth curve, plotted with the growth curves from the pooling group. The outer dotted lines are the 95% interval and the inner dotted lines are the 68% interval.

*using two QMED donor stations (58002 and 57015), the default pooling group, and the generalised logistic distribution.

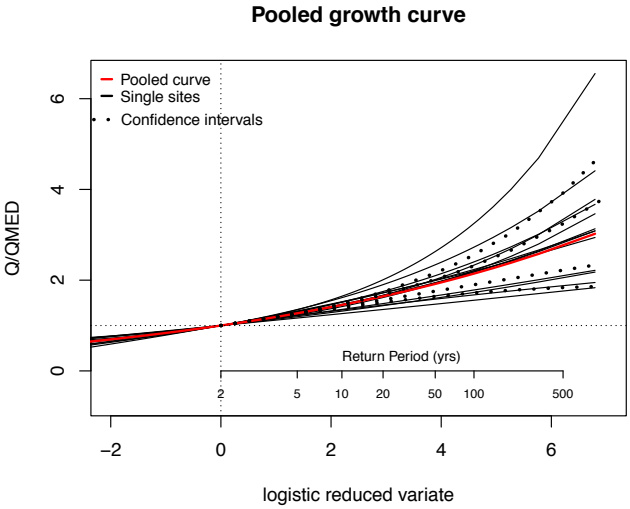


Fig. 1. Pooling growth curves with uncertainty for the central estimate

Gauged

For gauged estimates, Hammond (2021) calibrated a quadratic to calculate variance, similar to that developed for single site estimates by Kjeldsen (2021) – although a third order polynomial was applied in the latter case. Here, the QMED, the linear coefficient of variation (LCV) and the sample size (N) of the site under investigation are required.

$$Var_{ESS} = \frac{(QMED \times LCV)^2}{N} \exp(1.3125 + 0.599y + 0.00399y_l^2 \qquad (3)$$

Where y_l is the logistic reduced variate (ln(RP – 1)). The square root of the variance is then the standard error of our estimate and confidence intervals can be obtained accordingly. In the case of catchment 58006, the sample size of the annual maximum record (available from the National River Flow Archive) is 49, the median annual maximum flow (QMED) is 87m3/s and the LCV is 0.18. The enhanced single site 100-year flow estimate is 190m3/s

(using the default pooling group and the generalised logistic distribution). The variance is therefore

$$Var_{ESS} = \frac{87 \times 0.18^2}{49} \exp(1.3125 + 0.599 y_l + 0.00399 y_l^2 = 317 \quad (4)$$

The 95% confidence intervals are then

$$\begin{aligned} 95\%\ \text{intervals} = (190 - 2\sqrt{317}=154), & \quad \text{lower} \\ (190 + 2\sqrt{317}=226), & \quad \text{upper} \end{aligned} \quad (5)$$

Figure 2 shows the associated 95% intervals for the enhanced single site estimate. In this case the enhanced single site curve is practically identical to the single site curve.

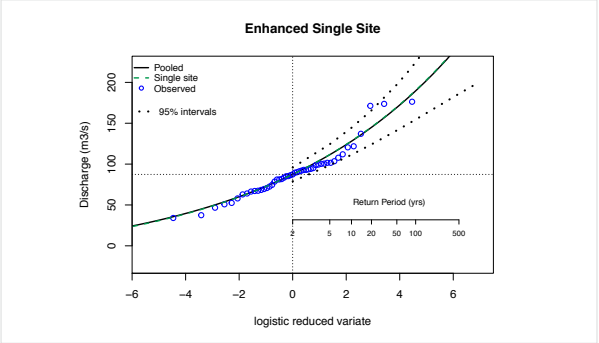


Fig. 2. Enhanced single site frequency curve with confidence intervals

These intervals can be compared to the single site intervals (derived by bootstrapping) as seen in Fig. 3.

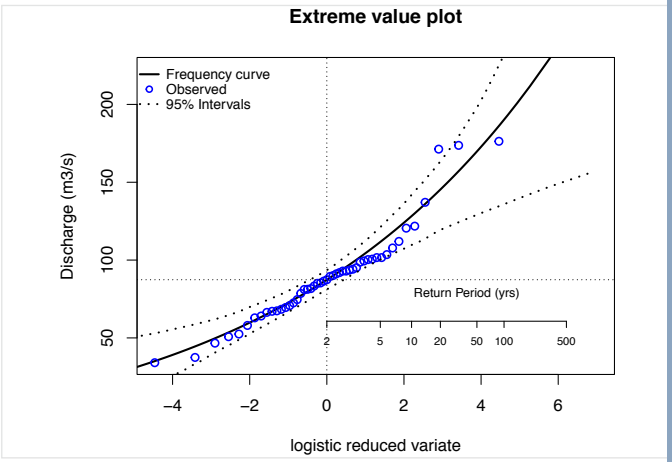


Fig. 3. Single site uncertainty for catchment 58006

Summary
Two equations can be applied to quantify the FEH pooling uncertainty. Eqn. 2 can be applied in the ungauged case, and Eqn. 3 in the gauged (enhanced single site) case. Eqn. two provides the fse which can be divided and multiplied by the flood estimate to derive lower and upper intervals. Eqn. 3 provides th e variance, the square root of which can be subtracted and added to the flood estimate to derive lower and upper intervals. Applying these methods, the UKFE 'R' package now provides estimates of uncertainty as a default for pooled flood frequency estimation.

Anthony Hammond
JBA

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Dixon H., Faulkner D., Fry M., Kral F., Lamb R., Macklin M., Prosdocimi I., Reed D., Rogers P., Sefton C., Stewart L. & Vesuviano G. 2017. Making Better Use of Local Data in Flood Frequency Estimation. Report – SC130009/R. Environment Agency, Bristol, UK.

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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

REMINDER: There are funds for available for BHS and IAHS members to attend and participate in international meetings (outside of the UK) of the International Association of Hydrological Sciences (IAHS) but get your Travel Grant application in soon.

Congratulations to the Pennines Group for their successful run of on-line meetings

Much as (some) of us are not so keen on 'screen' encounters, there's no denying the fact that they have allowed our expected exchange of technical information to continue when many othrs have fallen by the wayside. May we remind the committees of the other regional groups that we have a central Zoom account to be tapped into plus there is money in the central BHS kitty to help you with doing similar events.

Recent PhD theses

Author	*Title*	*University*
Cooke Olivia	Assessment and mitigation of storm-water runoff in an informal settlement uk.bl.ethos.834168	Bath
Dallison Richard	Climate change and Welsh catchments: implications for hydrological regimen, water quality and water abstraction uk.bl.ethos.831301	Bangor
Houghton-Foster Helen	Learning fom the past: exploiting archives for historical water management reseach uk.bl.ethos.842970	Liverpool
Freeman Caroline	Upland flood mitigation by managing infiltration uk.bl.ethos.8341681	Aberystwyth
Lane Rosie	National-scale hydrological modelling of high flows across Gt. Britain: multi-model structures, regionalisation approaches and climate change analysis with uncertainty uk.bl.ethos.828420	Bristol
Pearson Eleanor	Modelling the interactionsbetween geomorphological processes and NFM uk.bl.ethos.839145	Leeds

Managing wastewater using smart networks

Every year in the UK there are over 400,000 pollution incidents recorded from overloaded sewers, where millions of cubic meters of sewage, laden with plastics and microplastics spill into our streams, rivers, and oceans via thousands of Combined Sewer Overflows [CSOs] and sewage treatment works storm bypasses. Furthermore, hydraulic overload within the network causes sewer flooding that affects tens of thousands of properties per annum. After many decades of lobbying, delays and deliberation there is now a new Environment Bill that mandates the eventual eradication of pollution and flooding from our sewage networks and treatment plants.

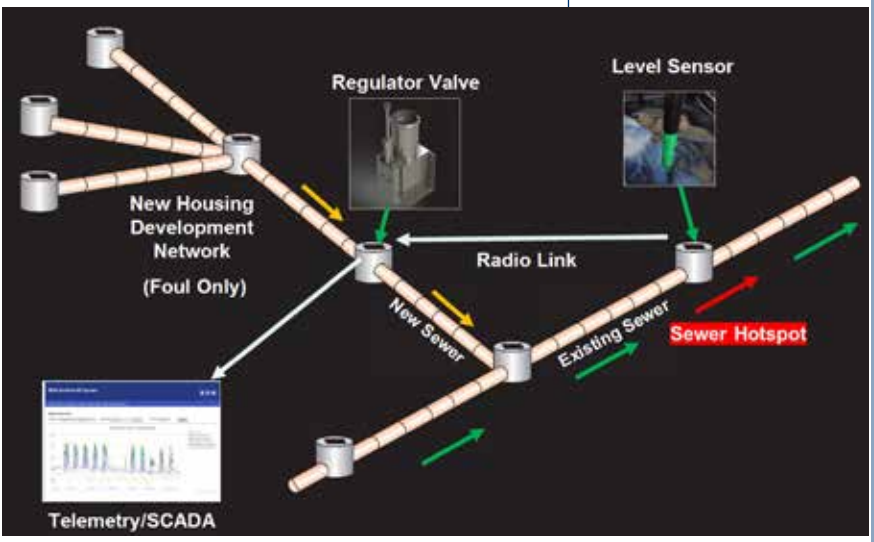
A primary cause for this delay is cost, with estimates varying wildly from £40bn to £400bn and the fear of the knock-on effect on water bills.



However, need it all be implemented using concrete, pipes, storage tanks and decades of disruption to highways, plus with the emission of millions of tons of CO_2 in the process?

The good news is that pollution and sewer flooding reduction has been achieved through the creation of retrofit smart networks within the existing network. A retro-fit 'smart network' in its simplest form is to add an up-stream flow control device, a down-stream level sensor and a feedback path between the two, to create a closed loop control system that harnesses up-stream storage to implement peak flow control / flow modulation to reduce overloads. In sewers, what you can be certain of is a lack of power and if you want power, it will be costly and come with many safety implications due to the presence of potentially explosive and highly corrosive atmospheres. Hence the need for smart sensors and wireless combinations that are ultra-low power and battery operated and comply with the new UKEx standards (ATEX no longer legal in the UK). The accompanying illustrations show the hardware involved. A retro-fit 'smart network' in its simplest form is to add an up-stream flow control device, a





An innovative sewer flow regulator1 design

down-stream level sensor and a feedback path between the two, to create a closed loop control system that harnesses up-stream storage to implement peak flow control / flow modulation to reduce overloads. The accompanying illustrations show the hardware involved.

However, low carbon, cost and minimal disruption can only be delivered if the smart network design is created around the exiting sewer network, rather than the existing network having to be modified to accommodate the smart network upgrade.

Neverthelss, the viability of any sewer flooding or CSO overflow reduction scheme will ultimately be determined by the benefit delivered *vs* its cost which now has to factor in imbedded carbon.

Brian Back
Radio Data Networks

New members

Ilona Szabo.....Mott MacDonald, Clacton-on-Sea
Clarissa Rizzo.....Wallingford HydroSolutions
Helen Hooker.....Reading University

Sir David Roxbee Cox (1924–2022): A Personal Tribute

David was a colossus in the field of statistics, and I was privileged to be able to collaborate with him a little when I was at Imperial College (IC), and indeed I learned much of my statistics and time series modelling through him and one of his colleagues. When I joined the small Hydrology Group at IC as an assistant lecturer in 1968, I was given responsibility for teaching Statistical Hydrology to the MSc students, and for research in the then burgeoning field of time series modelling and synthetic hydrology. Terence O'Donnell, the head of the Group, introduced me to David early on; he was softly spoken and modest in his demeanour, but always authoritative, and could demolish something that was not rigorous or right in a brief sentence. At that time, he was at the height of his productivity, turning out a book every year or two plus numerous papers, editing *Biometrika*, supervising a cohort of PhD students etc, and statisticians came from around the world to work with him. I don't think he found much time to eat, sleep or comb his hair – it always looked tousled!

I attended a course on time series analysis given by David which was delivered with his usual clarity, and which greatly reinforced my theoretical knowledge of the subject. When I developed my first time series model of daily flows, I went, in some trepidation, to discuss it with David, and he was very encouraging and constructive with his comments. He arranged for me to make a presentation on it at an ISI/IASPS meeting in London that he was involved in organising. More trepidation followed about facing all those statisticians, but I survived it! That led on to two PhD student projects which we jointly supervised.

Mandelbrot introduced fractional Gaussian noise (fGn) in 1968 as an explanation of the Hurst Phenomenon which was based on a power law covariance function. I found an alternative explanation based on approximating the covariance with an ARMA model which was much simpler than fGn. I went along to discuss this with David, and he was helpful and constructive as always. He rummaged around in his papers and found an old report from his days at the Wool Research Institute where he had used a power law covariance function to describe a property of wool yarn, but made little of it. The sphere of influence of his work was huge.

After I moved to Newcastle in 1984, an opportunity came up to develop a rainfall time series model for the water industry and Paul Cowpertwait developed the Neyman Scott point process model of rainfall. This was further developed in a number of directions by Aidan Burton, Chris Kilsby and Hayley Fowler, and owed much to the seminal work of David and Valerie Isham on point processes, particularly their Proc Roy Soc A paper with Ignacio Rodriguez-Iturbe. Some healthy competition developed in this field between us and the Imperial Hydrology group led by Howard Wheater, with David and Valerie providing formidable support. The many resulting publications had a significant impact on the field, with several applications in flood hazard estimation and climate change impact assessment.

Apart from the huge contributions which David made to many spheres of theoretical statistics, he left a defining legacy in many areas of applied statistics. We are fortunate that hydrology was one of those fields, and I will always remember the personal excitement and inspiration my contact with David created in those early days of my career.

Enda O'Connell

UK Hydrological Bulletin: November 2021– January 2022

Over most of the UK, the November–January period was exceptionally mild: 14 of the 18 warmest such periods in the Met Office national series now cluster in the 21st century. The three-month period was also characterised by an exaggeration in the normal NW/SE rainfall gradient across the UK. Particularly heavy precipitation in north-west Britain contributed to moderately above average November–January rainfall for Scotland whilst England & Wales registered its second lowest rainfall total since 1962. The meagre rainfall impacted directly on reservoir stocks and river flows over wide areas — in a few rivers draining impermeable catchments late-January flows closely approached, or eclipsed, previous minima for the time of year. By contrast many groundwater-fed streams remained within the normal range albeit with a contraction in their headwater extent. Several episodes of very boisterous weather conditions, mostly in December and again impacting predominately on the northern half of Britain, were both damaging and disruptive. Tidal and fluvial flood warnings were widespread, the latter exacerbated on occasions by rapid snowmelt; transport disruption was widespread and substantial. Despite modest January precipitation reservoir stocks at month-end were generally typical for the time of year.

Following heavy late-October rainfall, most catchments were close to saturation entering November and, with flood warnings in many areas, vulnerable to further significant rainfall. In Northern Ireland, water levels in Lough Neagh were notably high. Throughout the month however most low-pressure systems tracked to the north of the UK; correspondingly rainfall totals were substantially below average — England & Wales registered its lowest November rainfall since 1956. Particularly arid conditions extended across much of southern Britain; most of Sussex and Kent registering less than 20% of the monthly average rainfall. This, together with seasonally high temperatures, ensured that river flow recessions were both protracted and steep, particularly in impermeable catchments. River flows – and groundwater levels – were particularly depressed in South Wales. By contrast, in Scotland a cluster of active Atlantic low-pressure systems brought substantial rainfall with snow on high ground. During the third week, Resallach (Highland Region) recorded a three-day rainfall total in excess of 130 mm. Subsequently the passage of Storm Arwen caused further extensive transport disruption with significant snow accumulations in the Pennines – where the TanHill pub was cut-off for three days – and a light dusting to parts of southern England.

December rainfall totals were well within the normal range across almost all of the UK. Heavy overnight rain on the 1st, particularly in northern Britain and Wales, triggered widespread flood alerts. Snowmelt was an aggravating factor in some northern catchments. The passage of Storm Barra on the 7th generated further alerts - extending to rivers across southern England. Tidal alerts were common also and the associated erosion resulted in a few minor coastal realignments

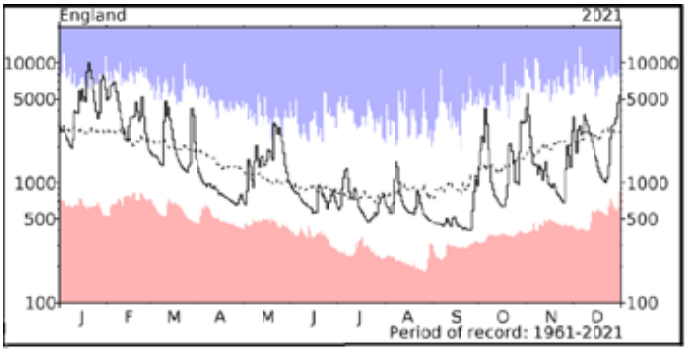


Fig 1 .
the highest and lowest flows for each day; the dotted trace is the daily average.

(e.g. near Berwick). Sustained high pressure, extending for a fortnight in many areas, then resulted in steep river flow recessions. Subsequently a sequence of Atlantic low-pressure systems generated strong recoveries in river flows (Fig. 1). These were particularly steep in Northern Ireland and North Wales; in Snowdonia, Capel Curig registered 90mm of rain in 24hrs (30/31st).

At year-end groundwater levels were generally typical for time of year, albeit with a few deep Chalk wells still in recession. The wet spell also ensured that end-of-year stocks in index reservoirs across the UK were almost all within 10% of the long-term average for the time of year.

To place the 2021 water balance in a broader historical context, Fig. 2 illustrates the trends in annual rainfall, runoff and losses (rainfall–runoff) for England & Wales over the last 60 years (gauging station density before 1961 was insufficient to characterise runoff at the national scale effectively). Over a period when average temperatures have increased by an exceptional 1.7C, rainfallhas increased by around 12%, with very modest increases in both runoff and losses.

January was generally a seasonally mild month, particularly in northern Scotland. It was also notably dry; provisionally the 4th driest since 1964 for the UK as a whole with very arid conditions in many eastern and southern catchments. The second week

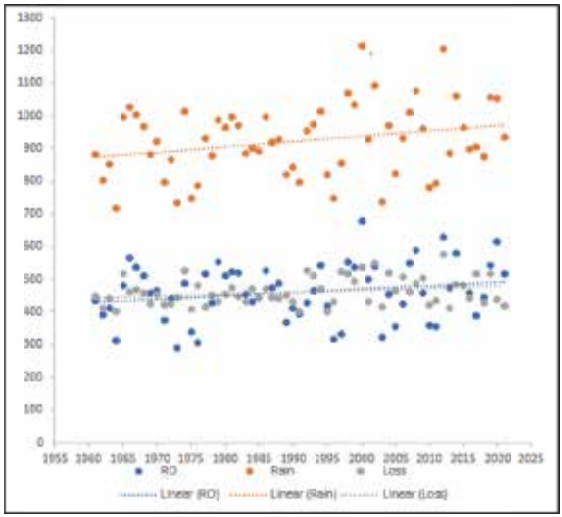


Fig. 2 UK rainfall pattern in June

was, however, unsettled — a sequence of Atlantic frontal systems brought significant rain to many areas with moderate snow accumulation on higher ground. Meltwater from the latter contributed to the subsequent flood risk, for example on the 9th when Flood Alerts were common in the South West and Wales. Subsequently, high pressure became dominant and in many areas precipitation was largely restricted to fog-drip. Correspondingly, river flow recessions were steep and sustained. During the final week river flows were approaching the lowest on record for the time of year – for example in the Yorkshire Ouse and the Torridge (Devon).

Contrary to the normal seasonal pattern, reservoir stocks declined through January but the benefit of heavy replenishment last October is still evident. For England & Wales overall stocks are just short of 90% of the long-term average (Fig. 3) and most individual index reservoirs are within 10% of capacity. Whilst aquifer characteristics and well depths made for substantial spatial variability, groundwater levels – South Wales apart – generally remained within the normal January range. At Stonor Park, in the Chilterns, the benefit of abundant recharge – over the 2019/20 winter half-year in particular – remains evident (see Fig. 4). and stocks in most index reservoirs remained within 10% of the end-of-January average. Similarly for groundwater resources, levels in most index wells were below average but with a few exceptions (in Wales for example) remained within the normal late-winter range.

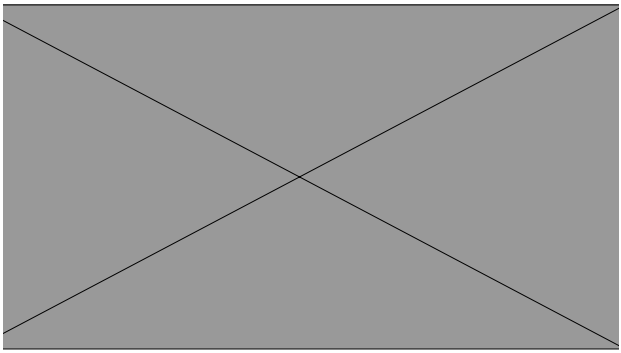


Fig. 3. An index of monthly reservoir stocks for England & Wales

Terry Marsh
14/02/22

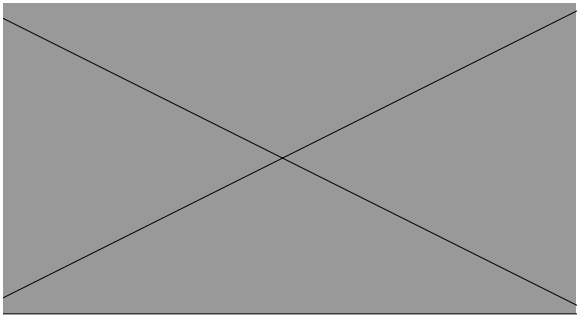


Fig. 4 Groundwater levels for Stonor Park - black trace, the blue and pink envelopes are the max. and min. levels; the dotted trace represents the long term average.



"February fill-dyke" – north Lincolnshire
© Barry Barton