Circulation

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The Newsletter of the British Hydrological Society

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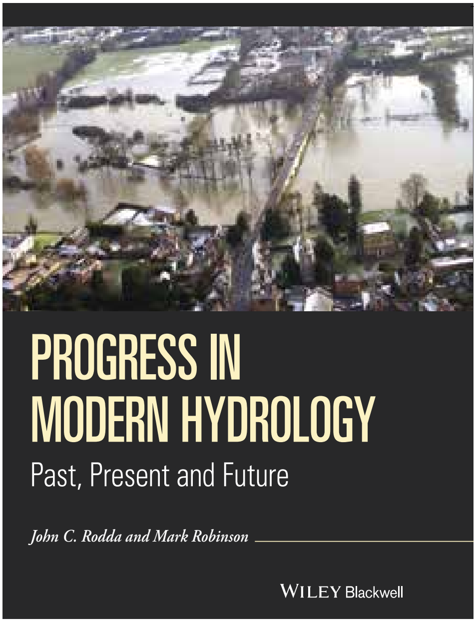


We are delighted to renew our thanks to the editors and individual chapter authors for the generous donation of royalties from this book. So far, nearly two years from its publication date, the society has already received over £1000, a most welcome and timely contribution to our continued support for young hydrologists in their careers thrrough Travel Grants and Burseries for MSc courses.

This record of the advances in hydrological research and practice achieved over the previous 50 years at the Centre for Ecology and Hydrology at Wallingford is a vital addition to the literature and was and is greatly welcomed .

[If you haven't already got your copy, please note that special rates apply to BHS members.]

President's Piece

In July 2016 I reported on our survey of the membership which demonstrated a diversity of expertise and interests. Practitioners (52%) and academics and researchers (35%) dominated the membership but 15% of members worked for the Environment Agency, SEPA or Natural Resources Wales. The majority of members identified with catchment hydrology, flood hydrology and hydrometeorology/ hydroclimatology. Water resources, hydrometry and groundwater hydrology remained significant themes but growth involved links with related disciplines: ecology, biochemistry, and geomorphology. Indeed, joint meetings with the British Society for Geomorphology and the Freshwater Biological Association were a feature of the BHS during our early years.

A transformation of hydrology from a theoretical and technical engineering-based discipline to an empirical 'environmental' science one was catalyzed by the International Hydrological Decade, launched by Unesco in 1965. When I went up to university in the early 1970s, Ven Te Chow's '*Handbook of Hydrology*' (McGraw-Hill, 1964) was on permanent loan from the library. It contained a wealth of information presented in a matter-of-fact style. Roy Ward's 'Principles of Hydrology' (McGraw-Hill, 1967), although less technical, complemented Chow's tome and provided an engaging conceptual framework for aspiring hydrologists. In 1970, Noel Hynes published his '*Ecology of Running Waters*' (Liverpool UP) and then in 1973 and 1974, respectively, Ken Gregory and Des Walling published '*Drainage Basin Form and Process*' (Arnold) and '*Fluvial Processes in Instrumented Watersheds*' (IBG). Over the next four decades 'Hydrology' became embedded in the core of a range of interrelated environmental sciences concerned with surface water and groundwater systems. But when the grand challenges of the future include a focus on 'extremes' and 'exceptional' events, when the past is not the key to understanding the future, are we giving appropriate training for the next generation of hydrologists? Will they need more physics and less biology?

This year's National Meeting and AGM on September 13th will explore the change in the UK's hydrological skills base, assess it's perceived decline, and discuss the skills needs of the hydrologists of the future. The need for this review was discussed at the UK Committee for National and International Hydrology and we shall be inviting a cross-section of academics, practitioners and stakeholders to present their views. Full papers and short presentations will be welcomed and the notes of the meeting will be reported in *Circulation*. The meeting will be hosted by Loughborough University.

Please contact: Ian Pattison (i.pattison@lboro.ac.uk) if you would like to be involved.

Professor Geoff Petts
President

Bourassa palm at the edge of Lake Malawi 1974 where it could not have germinated and grown

Drought in Africa – which drought?

asks Dave Archer

Reports in the popular press of recent droughts in various parts of Africa have asserted that "it was never like this in the past" and that the drought is the result of climate change driven by CO_2 emissions. Based on the many years I have spent in Africa and especially the three years spent at Karonga at the northern end of Lake Malawi in the mid 1970s, I have seen ample evidence of past droughts much more severe than those that have occurred in recent decades — and uninfluenced by recent increases in carbon emissions.

The first line of evidence was from older residents who pointed out into the lake and remarked "I was born out there" – an indication that the lake level was now so much higher than in the past that it swamped villages and houses. A walk on the lakeshore revealed trees growing at the water's edge that could not have germinated and grown there – see photo above.

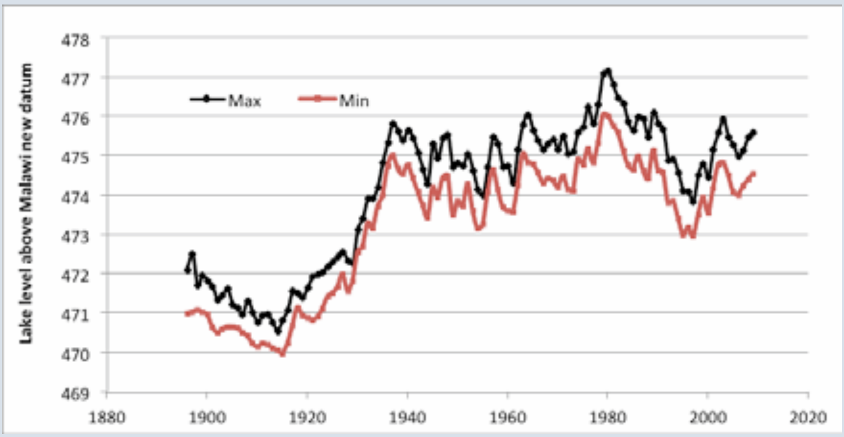
Further historical evidence was provided by War Graves from World War I. In an early battle of World War I, German forces in Tanganyika attacked Karonga in what was then Nyasaland on 9 September 1914 and were driven off in the ensuing battle. The six British soldiers that were killed were buried near the then lakeshore whilst the German graves were at a higher level. As the lake advanced, the British graves were relocated adjacent to the German war graves.

Observations of lake level and outflow back up these observations; the lake was at its lowest level in 1914 of 470.5 m. Lake Malawi is a large lake (conveniently 365 miles long and a maximum of 52 miles wide). Its catchment area of 36500 km^2 is 23% of its total catchment area in Malawi, Tanzania and Mozambique. There is a fine balance between inflow and evaporation such that there is considerable variation in the volume of outflow to the River Shire (and thence to the River Zambezi). The levels fell steadily from the beginning of the record in 1896 such that outflow ceased entirely by 1915 and did not recommence until 1935 when sandbars which had formed during the low flow period were breached (Drayton 1984).

Since then the annual maximum lake level has fluctuated between about 474 and 477 metres, reaching a maximum in 1980, falling to 1997 but rising again thereafter (Fig 2). Thus over the last century the drought severity implied by lake level fluctuations was far more severe and persistent during the early twentieth century than during recent decades. Evidence from early travellers indicates that the lake level was also very low in 1830 but very high in 1857 to 1863 when David Livingstone ascended the Shire Valley and sailed up the lake (Pike and Rimmington, 1965).

Evidence of early droughts extends much further than Malawi. Lake Tanganyika also shows a rapid fall in levels around the beginning of the twentieth century but also low levels during the first half of the nineteenth century and very high stands, especially in the late 1870s (Nicholson 1999). Lake Rukwa , a shallow lake in southwest Tanzania, was relatively high in mid-19th century, reached its maximum around 1880, then fell rapidly in the last decade or so of the century. Nicholson (1999) also notes that this pattern of rapid fall to twentieth century levels is ubiquitous throughout eastern Africa and is apparent in numerous other lakes, including Victoria, Naivasha, Stefanie and Turkana.

Nicholson, in a remarkable series of more than a dozen papers since 1979, has chronicled historical climate change using documentary, proxy and gauged data over the whole of the African continent, culminating in a synthesis in Nicholson (2014) in which she creates a continental-scale data set from 1800. Using principal components analysis she shows the dominance of a small number of spatial patterns, one of the most common being anomalies of the same sign over most of the continent but weaker in the equatorial region. This analysis confirms the severity and widespread distribution of the droughts in the early nineteenth century and early 20th century in both southern and northern subtropics. The early twentieth century drought is mirrored in the north by a sharp downturn in the flow in the Nile after 1900 (Hurst *et al.*, 1965) whilst Kraus (1955) noted a decrease in tropical rainfall around 1900 in phase with the Nile flows.



The persistence and severity of Nile droughts has been known from ancient times as chronicled in the Bible in the story of Joseph (~1700 BCE)(Genesis, Chapter 41). Such deviation from a random process in the Nile time series has been statistically codified as the Hurst Phenomenon (Hurst, 1951) and the Joseph Effect (Mandelbrot and Wallis (1968).

Even without the added uncertainty of changes brought about by increase in carbon emissions, the African continent has been dealt a cruel hand with respect to climate variability. Such natural variability must be understood and factored into global climate models to have any security in projected future rainfall patterns.

Currently, intermodel agreement is often quite low with respect to precipitation over parts of Africa (IPCC, 2013). Nicholson (2014) has investigated large-scale factors governing historical rainfall regimes and has so far achieved modest success, especially with associations with large-scale wind regimes, but more remains to be researched.

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Keith Beven elected to US National Academy of Engineering

Professor Keith Beven was has been elected as one of just 22 foreign members, announced by the NAE which cited his 'contributions to the understanding of hydrological processes and development of the foundations of modern hydrological modelling."

Keith's work has been cited more often in international research journals than the work of any other hydrologist and his contribution to his field has been described as 'unparalleled'. He has published ten books and over 40350 journal articles and retaining close links to the Lancaster Environment Centre following his recent retirement, after nearly 30 years at Lancaster University.

Keith says that its a particular honour to be recognised by an Academy outside the UK and, in fact, rather a surprise since his background is much more in research to understand and represent hydrological processes than in engineering.

Extreme Climate Events on Aquatic Biogeochemical Cycles and Fluxes

San Juan, Puerto Rico
22-27 January 2017

This AGU Chapman conference was created to bring together multiple disciplines with the aim of summarising the current knowledge of the subject, exploring new directions and areas for research and experiments, and exploring how the research being undertaken can help with the mitigation, management and restoration of aquatic systems experiencing such events. With an increase in the frequency and intensity of extreme events expected in the future, the meeting was a timely opportunity to bring together experts from a variety of fields to address these issues.

From a personal point of view, as a second year PhD student, the conference also provided me with an excellent opportunity to meet experts from across the world, with many leading biochemistry scientists present, though meeting post-doctoral researchers and fellow students also provided very useful networking opportunities and the chance to hear about the methods being undertaken by people doing similar work in different locations. The conference provided numerous new perspectives and ideas from a mixture of scheduled talks and poster sessions, whilst the breakout discussions held at the end of each day ensured lively debate. I went into the conference hoping to broaden my horizons to all things biogeochemistry, given that it is easy to forget while doing a PhD that of necesssity you only focus on a small part of the spectrum: by the end of the week this had certainly been achieved.

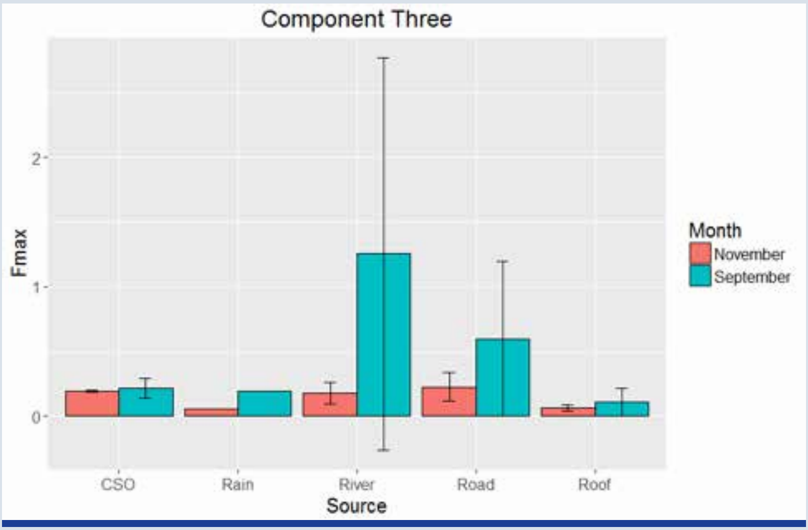
I was also able to present the early stages of my work on "Characterising Dissolved Organic Matter during Extreme Events within an urbanised, headwater catchment in Birmingham, UK" in a poster presentation during a session on differences in extreme climate event (ECE) impacts across forested, agricultural, and urban landscapes.

Characterisation of Organic Matter (OM) from sources within urban catchments during storm events has largely been unexplored until now. However storm events constitute the main flux of OM into streams for headwater catchments, particularly in urban environments where catchment surface run-off tends to be much higher than from natural catchments. Furthermore urban catchments contain a wide variety of potential OM sources, and there are numerous pathways for OM to enter the stream during storm events. There therefore exists a need to characterise the OM produced within urban environments to identify the main sources of OM that lead to degradation of the biological and chemical quality of urban streams, and this is the research gap the research for my poster sought to address.

Although data collection is still at the early stage, water samples were collected for a variety of road, roof and Combined Sewage Overflow drains, whilst in-stream OM is also monitored. The research has so far covered two storms, with samples analysed for fluorescence and absorbance. From this, various fluorescence and absorbance indices were calculated, and Parallel Factor Analysis (PARAFAC) was undertaken to identify distinct fluorophores within the dataset. Initial results indicate a differing response in fluorescence by storm type and that within-source variation in OM characteristics was extremely high for road samples (see figure below), highlighting the fact that local land-use activities are highly influential on the character of OM in the drain sampled.

For example, proximity to petrol stations appears to be the main predictor of high Tryptophan (which represents the 'polluting' aspect of OM) loads in samples. The comments received in the poster session were very helpful in guiding the future direction of my work, where I would like to look further at the main land-use predictors of varying OM components within drains, and the effects of antecedent weather conditions on OM character, while numerous attendees suggested new ideas and methods I can incorporate into the future stages of the research.

The relatively small scale nature of the conference, meant that I was able to attend every seminar and poster session and the resultant group discussions which provided ample opportunity to hear and speak with specialists from a wide variety of fields. Of all the sessions, the talks and posters in the "Export, Transport, and Transformation of C, N, and P Through the Fluvial/Aquatic Network From the Source to the Sea" session most closely echoed my work and as such provided me with new perspectives and outlooks for analysis of my own work, whilst listening to Peter Raymond's 'pulse-shunt hypothesis' talk was



Fluorescent Maxima values for PARAFAC derived component three, which has Tryptophan-like fluorescence which tends to degrade the chemical quality of rivers. High variability between storms, and within road and in-stream samples can be observed.

particularly enlightening.

The session on land use effects where my poster was presented was similarly very useful in terms of direct relation to my own research, while the sessions relating to defining ECEs, and watershed restoration practices to mitigate ECEs provided insightful and helpful background knowledge, raising interesting questions over what exactly defines ECEs, and how exactly the research presented in the conference may aid future restoration efforts.

On the Wednesday of the conference, a field trip to an urban watershed in Rio Pedras and then to the Bisley experimental watersheds in the El Yunque rainforest to investigate the impacts of ECEs provided a welcome break from sitting in the conference rooms all day. From the perspective of my work, seeing the extremely polluted urban site identified new challenges I do not see within my sites in the UK, for example regular inputs of untreated sewage are prominent within the catchment yet, intriguingly, the river remains relatively ecologically healthy despite such regular pollution inputs. The Bisley experimental watersheds meanwhile offered a unique chance to observe the challenges and strategies put in place there to monitor ECEs at varying scales.

Overall, the chance to get directed feedback and comments on my work from experts in the field probably proved the highlight of the trip, though secondary to this, I also very much enjoyed the general chance provided at the conference to explore areas and fields that I've yet to have the opportunity to look at in much depth. As such, the conference has proved very useful for the future direction of my research, and I believe will aid the future of my PhD greatly, for which I am very grateful to the BHS for providing me with a grant to help attend the conference.

Links to future papers published from the meeting will be found here: **https://sites.google.com/a/udel.edu/chapmanece/home**

Danny Croghan
University of Birmingham

New members

Stamatios-Christos Batelis ....University of Bristol
Josie Baulch ....University of Southampton
Huzefa Haji Egis ....Eau Nairobi, Kenya
Anthony Hammond ....Environment Agency, London
Briony McIntosh ....JBA Consulting, Edinburgh
Liam Nicholson ....Mott Macdonald, Leeds
Aaron Smith .... University of Aberdeen
Ian Struthers ....SWECO, Edinburgh
Natasha Vaughan ....Reading
Nikolaos Vavlas ....CEH, Wallingford
Victoria Venn ....Nantwich
Beth Waring ....Atkins, Epsom
Hazel Wilson ....Queen Mary's ,London
David Wright ....Natural Power Consultants Ltd, Stirling

Measurements of actual evaporation: the friend or the foe?

I have just read the piece in *Circulation 132* by David Evans and Jim Dent's comments (*Circulation 131*) that evapotranspiration (AE or 'actual evaporation') could be a friend or a foe, according to who you believe, which in the present case is either a model output or field measurements. Following on from my schoolmate Tim Burt and J. McDonnell's concern on the demise of fieldwork in hydrology (Burt & McDonnell, 2015), and having caught up with some of Vit Klemes's earlier papers such as on putting carts before horses (Klemes, 1997), I would like to respond to Jim's suggestion that I be drawn into the debate.

I began making measurements of potential evaporation from a sunken pan in 1985. The first 25 years' results have already been published (Clark, 2013) and there are now 31 years' observations made on a daily basis. In 1995 one, then two, weighing lysimeters with short rooted grass were installed at CHRS and there are 21 complete years of data from these. Lysimeters are cheap to make, install and maintain, and provide the following data:

1. Daily AE which can be aggregated up to whatever time period is needed.
2. Soil moisture deficit (mm) which is very useful for real time flood warning (Clark, 2004, 2017).
3. Drainage volume which is a very good indicator of when surface runoff takes place in the upper Brue in East Somerset. It has been found that there is a non-linear relationship between SMD and runoff potential as the summer progresses.

Early comparison of the SMD from the lysimeter and MORECS (Clark, 2002) showed that the latter was giving values which were far too high. The worst case of this was for the 16th August 2004 when the UKMO suggested that the SMD for the Valency catchment near Boscastle was about 100 mm. The lysimeter measurement was about 30 mm and when an allowance for the difference in rainfall between the two sites is made, a more sensible value is about 10 mm. Comparisons with MOSES did not fare much better (Clark, 2009). It seems as though people have forgotten that the equation produced by Howard Penman was partly based on lysimeter readings. A much bigger data set would have told us much.

Taking up the invitation from Jim Dent, I have analysed the relationship between rainfall and AE. Before the results are described it is worth pointing out that the losses in the water balance for the upper Brue at Lovington gauging station compared well with the results from the Bruton based lysimeter (Clark, 2013). Figure 1 shows the relationship between annual rainfall and AE. Since there are errors on both variables the Reduced Major Axis line (RMA) has also been calculated. The results are the opposite to those that David has described.

Since he showed the model-based results for the summer six months – here defined as April to September – Figure 2 has been produced which also shows a positive correlation. Both results suggest that if there is less rain then the grassed lysimeter uses less water. It follows that there will be no excessive theft of water by an increase in AE: plants are good at water conservation. Clearly

AE depends upon temperature as well as rainfall. Therefore I carried out a partial correlation between AE and rainfall with temperature held constant. The result was r = 0.68 sig. 1% which is a big increase on r = 0.59 for the summer observations, and strengthens the idea that AE will not go up with a decrease in rainfall.

In contrast to this finding, during dry spells PE (pan) will increase since water is not limiting or limited by the stomata on plant leaves. This apparent paradox is an illusion since pans and lysimeters are responding to temperature and rainfall in different ways. A detailed discussion is out of place here*.

I was sorry to read of the mixed success of lysimeters in Belfast and Sussex. Our lysimeters are open for inspection by arrangement. More recently a fourth lysimeter higher up in the Brue valley at North Brewham has been installed, and three other open sunken pans with a range of nearly 200 m in altitude are being monitored daily. The data gathered at all four sites will be of great value for many aspects of hydrology.

I only hope that those followers of the IPCC will go and gather similar data and put hydrology back to where it belongs – in the field.

Colin Clark
CHRS Somerset

* *A pity: cue for a future contribution? – Ed.*

Fig 1 Relationship between annual rainfall and actual evaporation 1996-2010

Fig 2 Relationship between summer (April-September) rainfall and actual evaporation 1996-2010.

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Using local data to reduce uncertainty in flood frequency estimation

The Environment Agency have recently published some new research on making better use of local data in flood frequency estimation. Examples of local data include short or uncertain flow records, long-term flood history* (documentary and palaeoflood records), river level records and information obtained from field visits.

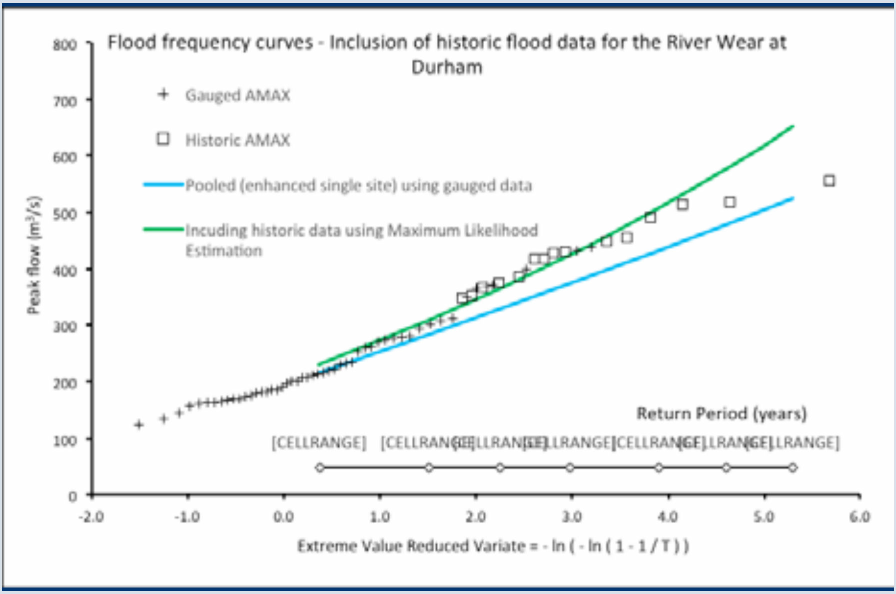
The technical report reviews existing scientific evidence and good practice, and also describes the development of new procedures for incorporating local data in to flood estimation.

The full report can be accessed at

https://www.gov.uk/government/publications/making-better-use-of-local-data-in-flood-frequency-estimation

and for more information please contact **Sean Longfield** at sean.longfield@environment-agency.gov.uk

* *nice plug for the BHS CBHE? – Ed.*



British Hydrological Society,
JBA Trust
Environment Agency

MSc Studentship Award Scheme 2017

Now in its seventh year, this award scheme supports talented students wishing to pursue development of their academic experience and qualifications in hydrology and catchment management. Graduates of MSc courses play a vital part in the future management of the water environment.

The studentships will be awarded to a small number of British students to help towards Master's degree tuition costs at UK Higher Education Institutions. Awards are anticipated to be between £1,500 and £2,500 depending on the number and quality of applicants.

Applications should be made using the dedicated online application website:
http://BHS-studentships.jbatrust.org
The closing date for application is 16 July 2017.

Candidates will need to upload the following information:

- Contact details
- Details of tertiary education
- Details of the proposed MSc course
- Any prizes or awards which the applicant is applying to or has already accepted
- A personal statement of up to 250 words stating why the applicant wishes to undertake the course and the significance of receiving funding from the BHS, JBA Trust and Environment Agency
- Two references, preferably at least one from an academic

UK Hydrological Bulletin: February – April 2017

Following an exceptionally dry four months for the UK as a whole, the February–April period was generally very mild and featured a hydrologically very valuable wet spell in late February and early March. However, a remarkably dry episode lasting until late April then increased long term rainfall deficiencies in most regions and initiated sustained river flow recessions. It probably also signalled the termination of the groundwater recharge season across much of southern Britain. Whilst late-March reservoir stocks were generally healthy, a subsequent dry late-spring and summer could potentially be accompanied by localised water supply, agricultural and ecological stress, in South East England especially.

Anticyclonic synoptic patterns which had been dominant through much of the late autumn and early winter began to break down in late January and February rainfall totals were close to the average for the UK as a whole. Some parts of northern and southern Britain were however particularly dry (Dartmoor for example) and, in Northern Ireland, moderate February rainfall contributed to the driest September–February period since 1933/34. Most of the UK was notably dry in this timeframe also.

Modest spate conditions characterised many rivers in early February but sustained recessions ensued, with well below average runoff generally in the third week when especially depressed flows were reported in Northern Ireland (see Fig. 1). Thereafter a very mild Atlantic airflow dominated synoptic patterns. The associated frontal rainfall – particularly that resulting from the passage of Storm Doris on the 23rd – generated a smart recovery in runoff rates with some flood alerts (e.g. in Wales and northern England) and, in a few southern areas, initiated a belated recovery in groundwater levels. Nonetheless, despite the February spates, the winter (Dec–Feb) runoff total for the UK was the lowest since the extreme drought of 1975/76, with a significant minority of index rivers reporting less than half their average winter runoff.

The wet interlude continued into March – often a transformative month in terms of the water resources outlook. Eight-day rainfall totals in excess

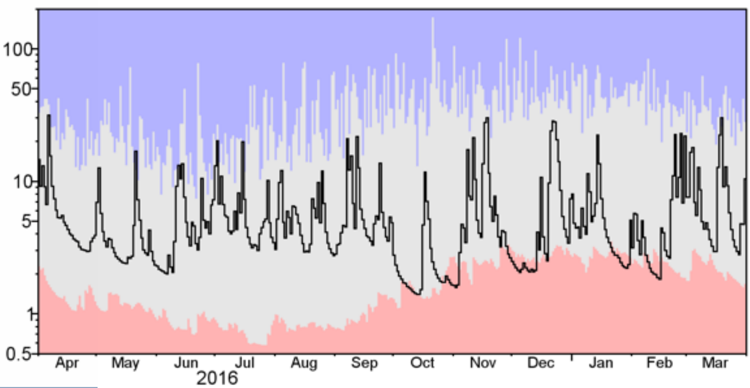


Fig 1 Daily mean flows for the River Faughan (Northern Ireland). The blue and pink envelopes show the long term min. and max. for the pre-2016 record.

of 200 mm were reported in parts of Snowdonia and very wet conditions characterised the Sperrins in Northern Ireland also. Flood alerts were common during the first week and again around mid-month. Correspondingly, replenishment of many major reservoirs in Wales and northern England was substantial, ensuring that stocks in most index reservoirs across the UK were marginally above the late-March average. Roadford (Devon) and Bewl (Kent – see Fig 2) were exceptions but stocks remained considerably above drought minima for the time of year.

However, March rainfall totals were below average in much of Scotland and, importantly, much of southern and eastern England. Correspondingly, groundwater recharge to much of the Chalk aquifer was modest — at a time when increasing soil moisture deficits threatened an early termination to the 2016/17 recharge season (e.g. in the South East). In the Chilterns groundwater levels in the Chalk remained well below the early spring average but considerably above drought minima (Fig 3).

A remarkably arid and exceptionally warm episode, began in the fourth week of March and continued throughout most of April. Rainfall accumulation of less than 2 mm over the sequences of 30 days or more were registered in some southern areas (including at the Centre for Ecology & Hydrology's Met Station). This, following the second driest October–March since 1975/76 for Great Britain as a whole, testifies to a very notable rainfall deficiency. It's impact has been moderated by the cluster of preceding wet winters — with associated very healthy reservoir stocks and groundwater resources — in many areas and the general resilience of water resources in the UK to single-year drought episodes. Nonetheless, a dry late spring would very likely foreshadow very moderate summer river flows, particularly in spring-fed rivers and streams and a concern for the water resources outlook if rainfall totals through the autumn are modest also.

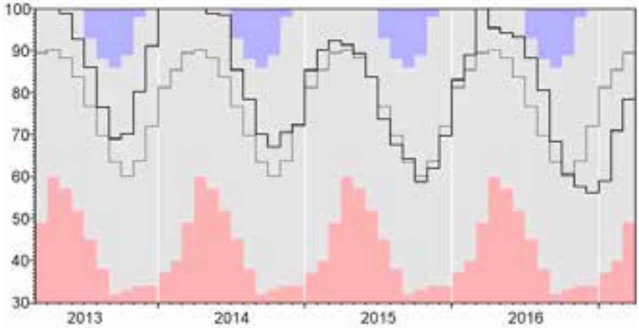


Fig 2 End-of-month stocks for Bewl Reservoir (black trace). The grey trace is the long term monthly average, the blue and pink traces show the long term max. and min. for the pre-2016 record

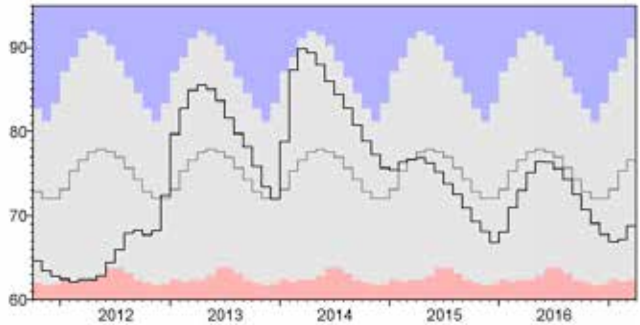


Fig 3 Monthly groundwater levels in the Chalk at Stonor Park (black trace). The grey trace is the long term monthly average, the blue and pink traces show the long term max. and min. for the pre-2016 record.

Terry Marsh
26/4/17

Diary

PLEASE CHECK OUR WEB SITE FOR MAJOR FORTHCOMING HYDROLOGICAL EVENTS AND FURTHER DETAILS

18-23 June 2017
HydroEco 2017
University of Birmingham,
"Ecohydrology on the edge: ecology-hydrology-human interactions in a changing world".
http://www.birmingham.ac.uk/generic/hydroeco2017/index.aspx

10-14 July 2017
IAHS 2017 Scientific Assembly
Port Elizabeth, South Africa

13-14 July 2017
Weather and Climate Impacts: From research and services to application and policy
Royal Meteorological Society Annual Conference
University of Exeter

27 July 2017
Early careers, fine sediment and hydroecology: supporting good ecological status through research
Workshop run by the British Ecological Society Aquatic Group
Environment Agency, Reading.
martin.wilkes@coventry.ac.uk

13th September 2017
BHS Annual General Meeting

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- **Web pages: http://www.hydrology.org.uk/**

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Editorial

You'll see that we have flagged up the date of the forthcoming AGM. Part of the official business is to note the changes in the membership of our Management Committee. There is a view that the present committee structure does not always reflect the best 'use' of members' attributes and commitments and we are considering some changes. Please think hard about your willingness to stand and respond accordingly when the ballot papers come round.

Celia Kirby

President Geoff Petts presents Tim with a film membrship ticket (we learned that Tim is a film buff!)

Best wishes to Tim Fuller, our ICE Secretary, who retiried at the end of April after 17 years with the Civils. Probably not many members have had actually met Tim but we all know his name as the contact point for admin. dealings with Great George Street. Tim has looked after us well and we shall miss **him.**