Report on BHS Working Group on Future of Hydrology meeting on Observational Needs
Birmingham University
10th January 2020

Present: Paul Bates, Keith Beven, Eleanor Blyth, Nick Chappell, Simon Dadson, Nick Everard, David Hannah, Thorsten Wagener, Geoff De Villiers (Physics & Astronomy, U. Birmingham), Joining on Skype: Rob Lamb, Louise Parry
Apologies: Anita Asadullah, Stuart Child, Hannah Cloke, Jim Freer, Hayley Fowler, Kate Hepple

1. Review of Priorities

KB introduced the document circulated prior to the meeting, summarising the priorities arising from the Royal Society Meeting. He noted that only one person had commented on the Report of that meeting on the BHS web site. Getting community involvement in the initiative clearly remains an issue. There had been a number of expressions of interest from both within the group (and 2 from outside) to take some of the priorities forward – but the mechanism for doing so needed to be discussed, at this meeting this will be focused on observational needs.

2. Discussion of priorities

NE emphasised the difficulties in deciding priorities when budgets are limited but that there was a real opportunity when water would be such an important issue in the 'climate emergency'. The sums spent on improving hydrological observation are small and hydrometric and water quality observations are often not aligned. We also need to do better in evaluating the benefit of such investment. Both floods and limited water supplies during drought periods can have extremely high cost impacts relative to the investment in observations. There are new methods already promising better flow measurements, especially under high flow conditions, based on velocimetry and 3D surface patterns (possibly even from satellite imaging) and automated dilution gauging - the question was partly a matter of who could provide the leadership to move towards product development and utilisation.

DH noted that there were other opportunities and drivers in digital environments and the internet of things that should be taken advantage of. There had not been too much application of data science methods in environmental science, though such methods do depend on having adequate data available for specific purposes (a difficulty in hydrology in defining catchment characteristics as in evident in some of the current NFM microcatchment work).

Discussion of specific priorities (and potential Champions for those priorities) then gave way to a wider discussion of defining 'why' questions and a potential strategy for moving forward, particularly in the context of the forthcoming NERC Catchment Observing Systems initiative.

3. Discussion of future strategy

DH gave a summary of the discussions at the workshop to frame the NERC Critical Infrastructure Bid to UKRI on Catchment Observing Systems. That had attracted a lot of interest with over 100 bids to join the meeting. There would be a scoping study that would be led by UKCEH with a view to reporting at the end of the year with a UKRI bid of the order of £25m. That investment might provide a basis for other thematic programmes but he noted that £25m is not a large sum, especially compared to the TERENO project in Germany and NEON in the US. This also faces challenges of wider community involvement (not yet clear) and of defining properly what are the questions to be answered in making a transformational change in hydrological research.

TW noted that it was not only new and better observations and techniques that were important – we could make more of existing data if it were more readily available and more aligned when collected for different purposes to give added value. Administrative structures often do not allow such alignments and access for advancing the science. NC added, along with the relevant QA information). The questions of transferability of information and the ungauged catchment problem remained important ones and could be formulated into relevant hypotheses to be addressed.

SD added that he had been asked by NERC to consider model/theoretical developments under the HydroJULES project but intended that as wide a group as possible should be consulted in that process. TW/SD are preparing draft documents on future model/theory needs for the Working Group to consider that includes a consideration of a perceptual model of UK hydrology and future model building for the UK community.

GdV outlined the progress that has been made in the Quantum project to provide gravity gradient observations. This was still in a development stage, and currently cost of the order of hundreds of thousands of pounds but seemed to show great potential for integrated storage evaluation, leak detection, down-borehole and other applications. The cost would come down, and the project was interested in working with potential applications.

There was some discussion about why the hydrological community was not well organised compared with some others [and why the UK did not have the same reputation for global leadership in hydrology as before]. KB suggested that this was in part because most of what was important in hydrology was controlled by unknowable boundary conditions, as well as the difficulty of reducing uncertainty in closing the water balance at catchment scales. This was what made generalisation and transferability difficult, and necessarily limited the more general benefits of past research programmes such as LOCAR and CHASM, and the possibility for community focus on common questions and hypotheses. A transformational change in hydrological research requires leadership and finding ways of overcoming these limitations, or finding a way of working within such constraints. TW commented that there was also a problem of the past focus on catchments at management scales in hydrological research. It might be necessary to pose hypotheses at larger regional scales, with observational networks that allow testing at such scales. There is an opportunity, however, to create a narrative about the importance of water in a time of expected future change.

EB noted the lack of attention paid to evapotranspiration in recent decades. There had been the promise of the global Fluxnet network, but the UK had seen limited benefit. KB asked also about the benefits from the investment in the UK COSMOS network, since this did not really address the important issues in subsurface hydrology.

[Kate Heppell in a comment before the meeting also noted the lack of continuous water quality and isotope data in the UK with a view to understanding residence times and flow pathways]

There was some discussion about other relevant communities both in terms of sensors (auto industry, microwave detection of rainfalls, satellite companies looking for applications), and potential users, such as local authorities (recent Birmingham city council project on surface water flooding) and fitting in to the EA Flood Road Map. An outward looking approach is needed. Given that observational tools sit at the interface between science and technology it will be necessary to engage with the technology leaders in other disciplines.

There was some consensus that there needed to be more demonstration of the benefit of better or new observations. LP suggested that this should not be so difficult in the area of flood hydrology since we need to: (1) quantify factors controlling future changes in flood incidence and (2) increase confidence in estimating the amount of freeboard needed to avoid over-engineering already costly flood defences.

One way of demonstrating benefit is to use existing models to show how much difference the availability of more accurate or new types of observation might make, including an extension to decision theory. There may be existing models that could be used to do so (e.g Bristol UK model; NFM project models) but a more extensive evaluation would require a funded collaborative project. There are limitations of such an approach, in terms of the specific assumptions of a model and its calibration (ensemble of model runs required?), commensurability issues of model variables and hypothetical observations, whether a model is fit for all purposes (e.g. for failure of connectivity in drought situations) and the definition of benefit for different practical applications. Such an approach is commonly used in defining benefits for satellite sensors (see SWOT example in HP Observational Needs Commentary) and should perhaps be part of the NERC scoping study. KB undertook to draft a discussion document on a framework for this type of analysis that might serve as an input from the Working Group to the forthcoming NERC scoping study.

It is not necessarily so easy to demonstrate benefit when observation needs are defined more in terms of gaining scientific understanding. It would be useful to define the observational needs that relate to the most important questions of hydrological understanding, albeit that they might have importance to hydrological practice only in the longer term. An example might be some means of getting more direct evidence of subsurface hydrological pathways (with implications for example of the impact of climate change on water quality and biodiversity). There was some discussion as to how this might relate to the IAHS “23 unsolved problems” paper which was a summary of suggestions from a much wider community. It was felt that this could perhaps be the starting point for a

more UK specific definition of observational needs. KB will again try to formulate a discussion document for the observational aspects of such needs.

4. Summary

We moved from considering specific near-term or long-term priorities to a more general strategy of defining questions to be addressed and evaluating the benefit of different types of observations (and their spatial coverage and availability) for those purposes. This is more straightforward where benefit can be demonstrated in terms of decision theory and better water and quality management; it is more difficult to define in terms of the potential for improving scientific understanding. UK Hydrology needs to move forward on both fronts We need to bring the UK hydrological community together to define the observational needs for different purposes. In doing so we need to inform the UKRI-NERC scoping study and associated UKRI bid (mostly near-term investment) while demonstrating the need for longer-term development of methods that are not yet available.

Overall conclusions:

1. We want to bring the UK hydrological community together around the two topics of future Floods and Droughts in the UK in a way that provides ambitious leadership for our science. We must recognise the critical role of water to society but never more so than during a time of unprecedented environmental change that will impact all aspects of life in coming years. If we fail to spot and address the challenges relevant to our science, we fail the nation.
2. We want to influence the design of the Catchment Observing System project through a) a series of commentary papers and b) through the use of a model experiment to quantify the data needs for near and far future of hydrological research.
3. We want to build a case for a bigger programme of UK Hydrological Science Research at a time of unprecedented environmental change that will impact all aspects of life.