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Journal Article review - Huntingford, C. et al. 2014 **Potential Influences on the United Kingdom's floods of winter 2013/14**, *Nature Climate Change*

To: All Chief Executives, Main Contacts and APSE Contacts

1. Introduction

In July 2014, Dr Chris Huntingford, a climate modeller at the Centre for Ecology and Hydrology, spoke at the APSE Flooding and Water Stewardship seminar in Oxford. The first part of his talk was on the scale and significance of the winter December 2013 – February 14 floods (hereafter, "DJF1314"). This was then followed by a review of current research in to analyzing if there is any possibility of a human influence on weather events of the type experienced – that is, a response to the burning of fossil fuels.

At the time of the seminar, Chris was leading the authorship of a peer-reviewed paper titled: 'Potential Influences on the United Kingdom's floods of winter 2013/14', which appeared shortly afterwards in the journal, Nature Climate Change*. This briefing document draws on some of that paper's key messages.

2. Historical context

Period DJF1314 saw a rapid series of low pressure weather systems cross the Atlantic, and the related storms caused heavy rainfall across much of the UK. This in turn contributed to a sustained period of water runoff and high river flows especially in the south of the UK. Ultimately this became exacerbated as the ground became increasingly saturated, and less able to absorb additional rainfall.

What was particularly remarkable is that in general, records of instantaneous peak river flows were not broken. However, what was special is the length of time at which generally high river levels occurred for. The River Thames, which drains the largest catchment in the UK, recorded its highest flow since year 1974 (a value of $524 m^3 s^{-1}$)., More significantly, it sustained a rate of flow of above $250 m^3 s^{-1}$ for 76 consecutive days, which far exceeds the longest such period within records of 30 days in 1947.

As another measure of high river runoff totals (i.e. the amount of water leaving through estuaries in to the sea), for months DJF1314 exceeded previous records in 31 out of 64 records of national index catchments. The total flow for England and Wales, as a whole, was the highest recorded for a 3 month period in records stretching back to 1961.

Besides river floods due to heavy rainfall upstream, there were also concerns regarding the UK's coastline. In the early part of this three month period, in December 2013, the highest tidal surge since 1953 caused coastal erosion, especially along western coast lines. Further erosion resulted in one of the most iconic aspects of period, the loss of the railway line through Dawlish. Elsewhere, very heavy ground saturation resulted in cliff failures, land slips and the appearance of sink holes. Towards the end of the DJF1314, a more dominant flood type became that of groundwater flooding, caused by exceptional aquifer recharge

3. Meteorological Events

During Chris's talk, he emphasised that the initial priority, and especially by the UK Meteorological Office, was to gain a fuller understanding of the events leading to the heavy rainfall. Maybe highlighting how remarkably interconnected the planet's weather and climate systems are, the starting point was believed to have been unusually heavy rainfall over the west Pacific, Indonesia and the eastern Indian ocean. This is then thought to have driven high pressure in the northeast pacific, which draw exceptionally cold air down from the Arctic and over many parts of the USA (during DJF1314, many USA states suffered exceptional levels of cold and snow). These USA weather patterns, and strong temperature gradients then forced a downstream strengthening of the Atlantic Jetstream, which was the main driver of the UK DJF1314 storms. There was possibly an additional factor, whereby wind patterns were such that a phenomenon called a "westerly duct" allowed perturbed wind patterns over the Pacific to reinforce the Jet Stream strength across the Atlantic. The Meteorological Office in particular is currently making a more complete analyses of these events.

4. An influence of fossil fuels?

As might be expected during such remarkable events, the question as to whether a human influence on climate could be to blame was frequently asked. Chris in his talk restated the point that no single extreme weather event can be directly attributed to raised levels of carbon dioxide in the atmosphere. However, much research is being undertaken to understand if carbon dioxide enrichment could trigger higher probabilities of unwelcome meteorological occurrences. In Chris's paper – which is predominantly a review of possible influences in DJF1314 rainfall patterns – he reviewed the literature as extensively as possible.

One re-occurring theme in much climate research is the impact of rapidly decreasing levels of Arctic sea-ice, as observed in a warming world. Although Arctic sea ice extent changes are often cited as an influential driver of Winter UK climate, many computer projections suggest less Arctic sea ice loss would favour easterly flow and abnormally cold winters. Interestingly the previous three UK winters were marked by quite major cold snaps – and this also highlights that in a climate system that is getting warmer, paradoxically there could be a few regions of the world where the impact is to have periods of slightly cooler conditions. DFJ1314 was, though, characterised by warm, westerly winds suggesting it to be unlikely that that sea-ice decrease was a driver for this pattern of weather events. Chris's review paper discusses many other factors which could be a cause, such as warmer oceans placing more water in the atmosphere through evaporation, a higher atmospheric "holding capacity" of water at higher temperature. In particular, has the probability of the sequence of events outlined above (i.e. events starting in Indonesia) be expected to occur more often?

One feature of climate research is that it reports collectively at roughly 7-year intervals to the United Nations, via an Intergovernmental Panel on Climate Change (IPCC). So in slightly more general terms than the specifics of DJF1314 events, the 4th IPCC assessment finds over 90% of climate model simulations project an average increase in rainfall, under unmitigated greenhouse gas emissions for December – February, for decade 2090-2099. The 5th IPCC assessment report notes similar changes for the nearer period of 2046-2065. Within the mid-latitudes, backing such model-based trends, then rainfall measurements do indicate an increasing frequency of intense rainfall. Huntingford *et al* (2014) notes, however, that there is little suggestion of emerging trends in high magnitude UK floods at present – some research papers suggest this mismatch is because the influence of more intense rainfall is offset (in terms of flooding), by less snow in a warmer world, which when melting can cause spikes in river levels.

The UN report does touch on economic costs, and references other research suggesting under a "business-as- usual" emissions scenario (that is, a world where little development and use of "green" technologies occurs), then computer projections indicate that economic loss due to flooding in Europe could increase from 4.2 billion euros per year in the 2000-2012 period to 23.5 billion in the 2050s. More locally, of 1120 gauged catchments in England and Wales, 35% are categorised as having an enhanced flood risk, i.e. should monthly winter rainfall increase, this would lead to a larger increase (proportionally) in flood peaks.

However, also of particular interest in the EU study is that the majority of the expected increase in flood risk is due to expected socio-economic development rather than changes in atmospheric conditions, highlighting the importance of careful planning of housing and business developments when near to flood-risk areas.

Major changes in the frequency of storm –driven surge frequency on the UK coastlines are unlikely in the coming years (based on UKCP09 regional climate model predictions). However more robust across climate models (i.e. more model agreement) are projections that in a warmer world, sea levels can expected to rise over the next 100 years. Hence, this can exacerbate the impact of storm-surges. Again, a paper cited in the UN reports (and in Huntingford et al, 2014) place the increase in frequency of extreme coastal events resulting from increases in the time-mean sea level at a factor of 10 in many places and by a factor of 100 in some locations around the UK over the next century.

5. Further Research

Although Chris's talk and paper feel extensive in scope, what is apparent is that there remain some unknowns, despite significant research in to how the world's climate system operates. These unknowns exist in particular at the finer geographical scale and refer to how changes which could influence average storm-track positions might occur. To find out more about the unknowns requires activity along three strands of development.

First, computer model parameterisation, that describes the physical, chemical and biological attributes of the Earth's climate system, needs on-going refinement. Second, a step-change in resolution of climate models is needed down to smaller scales. This is a challenge, as despite modern computers, a full global climate model is slow to operate, and finer resolutions are ever more demanding and dependent on computer speed. Third, the climate system is inherently chaotic, and to sample changes in extreme events – which are by definition rare – then thousands of model years are needed, and for each prescribed and different level of carbon dioxide concentrations. Again a challenge for computer availability. However, being optimistic that these things are possible, then this can all lead to creating a single statistic for extreme event (such as UK flooding), and its expected change. The Fractional Attributable Risk (FAR) is a single number designed to capture the extent to which raised levels of greenhouse gases (GHGs) have altered the likelihood of a weather event. This compares, as a ratio, estimates of the likelihood of a weather event if the Industrial Revolution and consequent GHG emissions had not occurred, against an estimate of the likelihood of the event with contemporary levels of atmospheric carbon dioxide. The comparison then allows a quantification of the impact of anthropogenic emissions.

6. APSE comment

Predictions of increases in time-mean sea level which may lead to an increase of extreme coastal events by a factor of 10 in many places and a factor of 100 over the next century place into sharp focus the need for long-term efforts to redesign communities to cope with these disasters.

Homes and businesses may need to be relocated on higher ground/away from flood plains, flood defences ensured and community flood resilience groups established and equipped to help each other through flood incidents.

The APSE Flooding seminar also featured Peter May's presentation on developments in property level food protection, Paul Hendy's presentation on supporting communities and the launch of Local Water, an APSE research publication, detailing case studies and examples of how Local Authorities are dealing with the challenges related to floods. APSE will continue to explore these themes in the context of Advisory Groups and with partners, through briefings and seminars and also support our members to achieve their aims in the delivery of flood defence and resilience schemes.

In view of the long-term picture, we re-state the recommendation in Local Water that the National Planning Policy framework be rebooted to include that all new commercial and residential buildings in water sensitive zones are required to be flood and drought resilient and that all budgets and job-roles related to flood or drought defence are ring-fenced in the event of any re-structuring of environment agencies or other support organisations.

The paper clearly takes a global perspective and although local authorities aren't in a position to act in a global manner (as well as bearing in mind the current financial position) they are in a position to influence the practical elements of people's day to day lives. As such they need to focus on their place shaping role and how they can influence the impacts of climate change both in their locality and over the short and longer term.

Council Leaders and Chief Executives, in the light of flood risk and other issues, have you considered

'What you locality will look like in 10, 50 or 100 years' time?'

'What your council needs to do now to ensure it will look that way?''

'What is the role of the Ensuring Council towards making this happen?'

Addressing the challenges that flood risk and other impacts of climate change pose will require long term action plans, which in turn will require cross- party support and collaboration between various sectors in the local, regional and national arena. Although there is global agreement (at least amongst the vast majority of informed parties) over the scale of climate change and the need for action, acting to abate climate change is partially a unilateral decision because similar actions by others cannot be guaranteed. Those local authorities brave enough to take tough decisions should see themselves as being at the vanguard of an inevitable process. The alternative of sitting back and agreeing to act only when others have agreed to do the same is a far more ineffective and expensive option.

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* The full research paper the article above refers to is:

Chris Huntingford, Terry Marsh, Adam A. Scaife, Elizabeth J. Kendon, Jamie Hannaford, Alison L. Kay, Mike Lockwood, Christel Prudhomme, Nick S. Reynard, Simon Parry, Jason A. Lowe, James A. Screen, Helen C. Ward, Malcolm Roberts, Peter A. Stott, Vicky A. Bell, Mark Bailey, Alan Jenkins, Tim Legg, Friederike E. L. Otto, Neil Massey, Nathalie Schaller, Julia Slingo and Myles R. Allen (2014) **Potential influences on the United Kingdom's floods of winter 2013/14**. Nature Climate Change, DOI:10.1038/NCLIMATE2314