Review of

Climate change increases the probability of heavy rains like those of storm Desmond in the UK – an event attribution study in near-real time

by
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This study looks at the likelihood of one-day and two-day precipitation events over Northern England and Southern Scotland for current day conditions and the influence that anthropogenic climate change had on these likelihoods. The methodology consists of analysing historical observed trends, coupled climate model simulations and ensembles of regional climate simulations. The authors conclude that "the effect of climate change is positive, making precipitation events like this 40% more likely" with an uncertainty estimate ranging from 5-80% likelihood.

I see several difficulties with this study listed below. The paper is not well written (perhaps a consequence of the tight timing) in that it is confusing in several aspects, see points below, and lacks the scientific rigour expected from a contribution to HESS. As a result, I cannot recommend the manuscript for publication.

1. The manuscript aims to analyse the probability of heavy precipitation events in NW England and S Scotland similar to storm "Desmond" of 4-6 Dec 2015. As two of the three methodologies use dynamical circulation models the immediate question arises of how well these models are able to correctly simulate the event in the first place. It is well known that precipitation, and in particular heavy precipitation events are difficult to simulate for models on a range of horizontal resolutions. A major problem here is the substantial underestimation of the rainfall intensities compared to observations, even with numerical weather forecast models. The ECMWF 24-hour analysis which is used in this study also greatly underestimated the rainfall intensities for "Desmond". As discussed in the paper, this is to be expected from models that cannot resolve the local orography sufficiently. Given these inherent problems with rainfall magnitudes in models, what can be reasonably expected to be said with any confidence about extreme events that fall outside the range of the model worlds? Are these models adequate tools to quantify (relatively small) changes of observed extremes that inherently come with large uncertainties? This is a difficult question to answer positively, and unless any evidence (e.g. synoptic studies) is presented to convince ourselves that the models indeed are able to simulate structures that are reminiscent of storm "Desmond", we have to assume that the answer is No.
2. The definition of the extreme event for this study is confusing and perhaps misleading. In most parts of the paper one-day rainfall amounts are used; in some other parts it is argued that two-day rainfall amounts

should be used (selection bias?). While the text mentions observed one-day rainfall amounts of 341mm at one station in Northern England and of 77mm in Southern Scotland, the event definition seems to be based on the area averaged ECMWF analysis (which is a 24-hour forecast) of 36.4mm. There is confusion here what analysis was used to derive 36.4mm – was it the operational analysis (as suggested by Fig 1 and text in Section 2) or the ERA-Interim analysis (as suggested by the text in Section 4)? The return time definition of the event is similarly confusing. A 1-in-100 year event is assumed but I cannot see much observational evidence for this assumption. From Fig 3c) and d) I'd rather think the observed return times are less than 5 years. What is the return time of the 36.4mm in the ECMWF analysis?

3. I am left confused with the issue of mode biases and how the presented analysis takes them into account. The Introduction talks about the need for careful bias correction while mentioning at the same time that this was not available at the time of writing. What does this imply for the presented quantitative analysis? Section 5 mentions the dry model bias again but I cannot see how this problem has been solved or addressed adequately.
4. The authors argue in the Introduction that internal low-frequency variability plays a minor role. What is the basis for this statement? The discussion of Section 4 saying that "very low frequency natural variability could also cause the results to diverge" seem to suggest differently.
5. It is found that the regions of NW England and S Scotland show a very different behaviour in terms of precipitation trends even though they are geographically very close and one would expect similar large-scale dynamic influences. How does the discrepancy between these two neighbouring regions impact the findings of this study? Observations of NW England show no trend whereas those in S Scotland indicate a positive trend. I don't understand the sentence in Line 24, p13201: "the trends in the two regions are compatible with each other…". I also don't understand the comments on the natural variability in this context.
6. Why is the framing of the attribution question different in the coupled climate model EC-Earth and the observations? As far as I understood a very similar methodology based on trends and GEVs has been applied to the coupled model data, no matter what forcings were used in the model runs.
7. The abstract mentions a change in return times of 1.4 with a confidence interval of 1.05-1.8. How is this derived when the three individual methods give values of 1.3-2.8 for the observations, 1.1-1.8 for EC-Earth and 1.05-1.8 for the regional model?

Minor points

- Fig 2 is not very informative – what is the motivation for showing it? Why are there two seasonal cycles shown in the plot?
- The subplots of Fig 3 are very small (too small)
- Fig 4 is not discussed in the text.
- Several places in the text where reference to wrong figures are made.

- Why have only the two recent winters instead of a more representative climatology been included in the analysis of the regional model?
- The discussion of floods in the last paragraph of Section 6 is misleading as this study is about rainfall.