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Interactive Comment

Interactive comment on "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* van Oldenborgh et al.

van Oldenborgh et al.

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Reply to Interactive comment #1.

General comments

This paper concerns the possible relationship between the heavy precipitation in NW England and S Scotland associated with Storm Desmond, and anthropogenic climate change. It consists of an observational analysis, and two model studies that give very similar results. My main issue is with the alleged connection between the analysis presented here and that particular extreme event (and, especially, with the flooding in

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Cumbria, which is what generated the most media attention). It seems to me that the different analysis components really say nothing more than that we can expect heavy wintertime precipitation in high northern latitudes to increase under climate change, which of course is well established in general. In particular I fail to see how this analysis differs from general (non-event-specific) analysis of what we can expect from climate change, and how much of that change is already affecting extreme-event risk.

We disagree that this analysis does not add anything over the well-known expectation that "heavy wintertime precipitation in high northern latitudes to increase under climate change". The increase is not uniform in the climate models (see attached figure 1), so it depends on the location. This is partly due to the change in circulation that affects (extreme) precipitation changes next to the increase in potential water vapour pressure. In the observations this is quite pronounced due to the strong historical increase in westerlies in winter in Europe, with increases in heavy precipitation concentrated on the west side of mountains, such as Scotland (attached figure 2, see also van Haren et al, 2012, doi:10.1007/s00382-012-1401-5).

Secondly, the increase in extreme precipitation is only well-known for soft extremes like Rx1day, the annual maximum of daily precipitation. Here we are looking at much more rare events with a return time of $\mathcal{O}(100\,\mathrm{yr})$. In particular the Weather@Home ensemble does not make any assumptions on how the PDF scales with global warming, leaving open the possibility that extremes do not scale with the mean.

We recently saw an example of these two effects, circulation changes giving rise to spatially inhomogeneous changes and extremes not necessarily scaling with the mean, when looking at Central England precipitation. Extreme precipitation in this region does not show the increase that northern England precipitation has (see attached figure 3). Extreme event attribution studies are therefore needed to investigate whether extreme events do not scale with the mean or a change in the atmospheric circulation leads to a stronger increase, no change or even a decrease in the likelihood of the extreme events to occur over the expected thermodynamic response. Examples for the latter two cases are Schaller et al., 2014 (BAMS, 95, S69–S72) and Delworth and Zeng, 2014 (Nature Geosci. 7, 583–587.).

Much more extensive scientific analysis (see comments below) would be needed to connect these results to Storm Desmond. Thus I am unable to recommend this paper for publication in its present form.

We agree completely that further analysis is needed (and are indeed working on that). This paper was intended to show that a preliminary, fast analysis can yield useful information on the media time scale, which is otherwise dominated by generalities that are not as informative for the public. The limitations of the present study are clearly noted.

Specific comments

p.13199, line 8

You say that Clausius-Clapeyron may not be the only factor affecting heavy precipitation, but it seems to me that the C-C-based estimate would fall safely within your estimates. Is there really any evidence that your results are reflecting anything other than C-C? This really ought to be discussed.

Over western Europe, both the observations and the models show a shift to more frequent westerly circulation types over western Europe in winter. This has been shown to increase mean winter precipitation in Europe (van Haren et al, 2012, doi:10.1007/s00382-012-1401-5), winter precipitation extremes over the Rhine basin (van Haren et al, 2013, doi:10.1088/1748-9326/8/1/014053) and over southern England (Schaller et al, Nature Climate Change, to appear). The origin of this shift has been diagnosed to be the increase in temperature contrast between the warming hole in the North Atlantic associated with the weakening AMOC (Drijfhout et al, 2012, doi:10.1175/JCLI-D-12-00490.1) and the increase in tropospheric temperatures that is advected from the upper tropospheric heating in the tropics with the Hadley circulation (Haarsma et al, 2013, doi:10.1007/s00382-013-1734-8).

We agree that this ought to be discussed and added this paragraph to this section.

In the observational analysis, what should we make of the fact that the observations show no trend in NW England, but a big trend in nearby S Scotland? Are there plausible physical reasons for this? Do the models suggest anything like this? Otherwise it seems that you are just averaging over the two regions to obtain a larger signal-to-noise ratio (since the wintertime precipitation gets much stronger at higher latitudes), which completely removes any association with the recent heavy precipitation event in NW England (where there seems to be no evidence of a long-term trend).

As far as we can see there is no physical reason for this, just natural variability. Both regions are on the (south)western side of mountains and should respond similarly to changes in circulation. As can be seen from our Fig. 1, winter precipitation extremes are similar in size to these regions. As first-oder assumption we assume that previous extremes just happened to hit Scotland more than Northwest England. As we mention, the two trends are well within each other's uncertainty intervals. We average them to obtain an estimate of the region that had the heaviest precipitation during Storm Desmond. We reformulated this section to

"The Northwest England region shows no trend in the maximum daily precipitation over October–February, with a 95 % uncertainty margin on the change in return times of these extremes of a factor 0.3–2.1 (1 indicates no change). In South Scotland there is a strong positive trend in precipitation, giving an increase in probability of 1.8–4 times what it used to be at the beginning of the series, 1931. This is due to large extent to a heavy precipitation event in 2005. However, even without that year the trend is positive. The trends in the two regions are compatible with each other: the difference is not statistically significant. We therefore assume that the difference in trends is mainly due to natural variability. This is supported by the observation that the maxima in these two regions are uncorrelated. Averaging them gives the best estimate for the observed trend in the region affected by Storm Desmond. This gives an increase in probability of a factor 1.3–2.8 (95 % confidence interval)."

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p.13201, lines 16-17:

The horizontal line in Fig. 3 shows the ERA-Interim precipitation, which would correspond to about a 1-in-4 year event in NW England, and practically an annual event in S Scotland (in present climate). Are these values believable?

No, these are not believable, as we indicate in the text. At the time we estimated the return time to be of order 100 years. As the United Kingdom does not have an open data policy the only reliable information we had was the Eskdalemuir station series with a very roughly 50 year return time. Since then, the Northwest England and South Scotland series have been made available. These give return times of 5 and 7 years for the event on these two area averages. (Locally the return times are larger.) This indicates that the ERA-interim / ECMWF analysis value was in fact not as bad as we thought.

More generally, why should we trust ERA-Interim for heavy precipitation? What sort of validation can you provide in this region?

This is a good point that we neglected while writing the paper. From a physics point of view, the model is a weather forecast model that has been optimised for these kind of situations. A straight validation against observations is difficult, as the UK Met Office only makes 9-9 data available and we only have 0-24 reanalysed precipitation. The nearest country with an open data policy is the Netherlands, where we consider ERA-interim precipitation averaged over the country (200×200 km, similar to the region of precipitation in Storm Desmond) and a straight average over the 32 0-24 stations. Daily precipitation is correlated at $r = 0.95$ with an RMS error of 1.1 mm/dy, a bit more at the high extremes of 20–30 mm/dy. This shows that ERA-interim is useful for a first approximation of winter precipitation in this area. We added a sentence to this effect when ERA-interim is introduced.

p.13201, line 24:

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What do you mean by 'The trends in the two regions are compatible with each other'? Since the trends in NW England are basically zero, this would seem to suggest that the trends in S Scotland are compatible with zero; is that really what you mean? If that really is the case, then the conclusion of the study seems vastly over-stated.

See above. Note that the assessed range of return times was taken from the modelling studies only, among others based on the zero reult for NW England making the S Scotland trend unlikely.

In the modelling analysis, the use of the large area (54–57N, 6W–2E), especially one extending so far north, must greatly increase the anthropogenic signal, but to be relevant to the flooding in Cumbria, some connection must be established between heavy precipitation in that larger region, and heavy precipitation in mountainous areas in Cumbria. Moreover such a connection has to be established not only for year-to-year variability, but for the effects of climate change. Is there any evidence for such a connection?

This region was based on the area of highest precipitation of Figure 1 excluding the orographically-driven maxima. A correlation map of De Bilt daily precipitation with ERA-interim over Europe shows that the decorrelation scale is of this order of magnitude, so synoptically the rainfall is quite homogeneous over the larger region. We cannot study the complex effects of orography on the sub-grid scale with these models, as we state in the text. The only evidence we have for this is the observational analysis, which is based on station data. Within the large uncertainties this agrees with the model analysis.

It should be noted that the fact that most of the flooding took place in England and not in Scotland may well be due to different flood protection levels between the two, see for instance Crichton, 2005, "Flood Risk and Insurance in England and Wales: Are there lessons to be learned from Scotland?"

p.13202, line 25:

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Picking the 1-in-100 year event for the large region as the 'Desmond storm' in the coupled model simulations seems to be purely a result from model world. Have you analysed that event (for either model) to see whether the synoptic situation looked anything like Desmond?

As mentioned before, the return times for these large-area averages turn out to be lower than this. As we write, the increase in probability is not very sensitive to the return time.

No, we did not have time to look at the synoptic situation in the models. The Weather@Home model has been extensively validated for precipitation extremes in southern England for Schaller et al, 2016. An in-depth study of the ability of the w@h model to simulate the large scale circulation in the winter months over Europe has just been submitted (Mitchell et al., Climate Dynamics) and shows a remarkably good representation in particular of the jet latitude compared to state-of-the art CMIP5 models. The EC-Earth model forms the basis of the KNMI'14 scenarios, downscaled with the regional climate model RACMO2. In winter the precipitation from the driving GCM and RCM are very similar. The atmospheric component of EC-Earth is also very similar to the model used to generate ERA-interim.

A quick look at the two highest events in EC-Earth indeed show the same synoptic situation as the situation with Storm Desmond: a controlling low near Iceland causes a frontal rain system to pass over northern England.

p.13205, line 27:

It says '1.05 to 1.4' on line 10, so this value of '1.05 to 1.8' seems to be incorrect. How does that affect your overall confidence intervals?

The second is indeed a typo. It does not affect our assessment of overall confidence interval, as we took the union of the Weather@Home and EC-Earth ranges. This agrees well with the observational analysis except that it allows higher values.

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A small point, but why do you say 6W–2E rather than 6–0W as there seems to be no land over 0–2E anyway (for 54–57N)?

Thank you for noticing this. The region was selected on the basis of Figure 1. Later we decided to concentrate on precipitation over land, and none of the authors noticed that the eastern boundary could be moved in that case. As you say, it makes no difference in the results.

Technical corrections

p.13201, line 15: "Fig. 2" -> "Fig. 3"

The figure numbers were indeed not all updated correctly after we inserted an extra figure. Fixed.

p.13202, line 13: "Fig. 2" -> "Fig. 1"

Fixed.

p.13203, line 2: I do not understand what is meant by "a shift in intensity . . . of such an event in intensity" Thank you, deleted the second intensity.

p.13204, line 20: "Fig. 5" -> "Fig. 6"

Fixed.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 13197, 2015.

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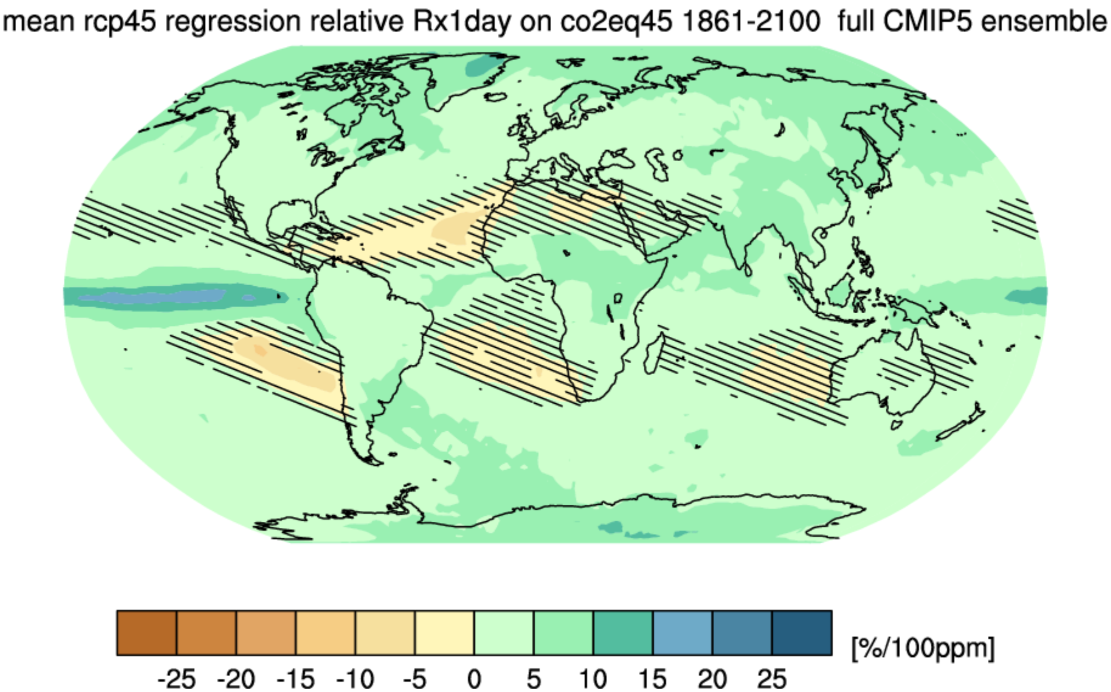

Fig. 1.

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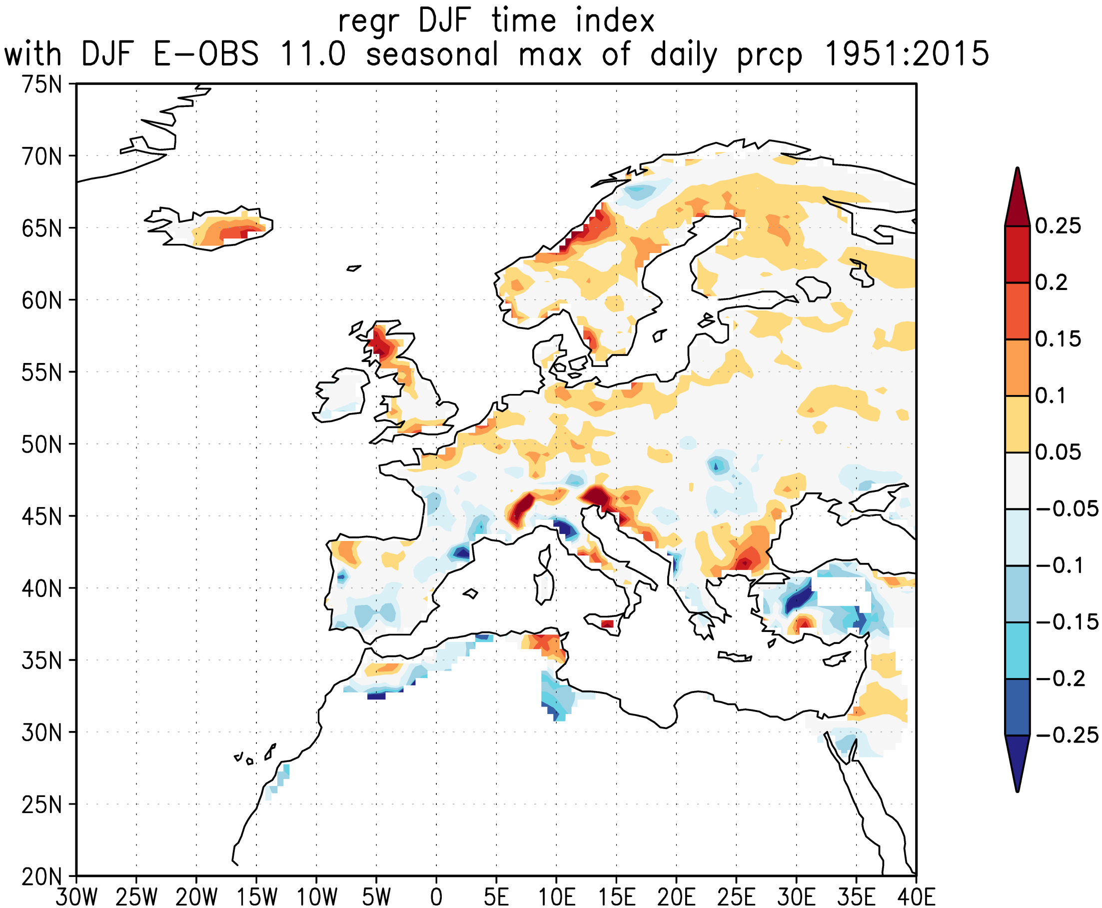
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with DJF E-OBS 11.0 seasonal max of daily prcp 1951:2015
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Fig. 2.

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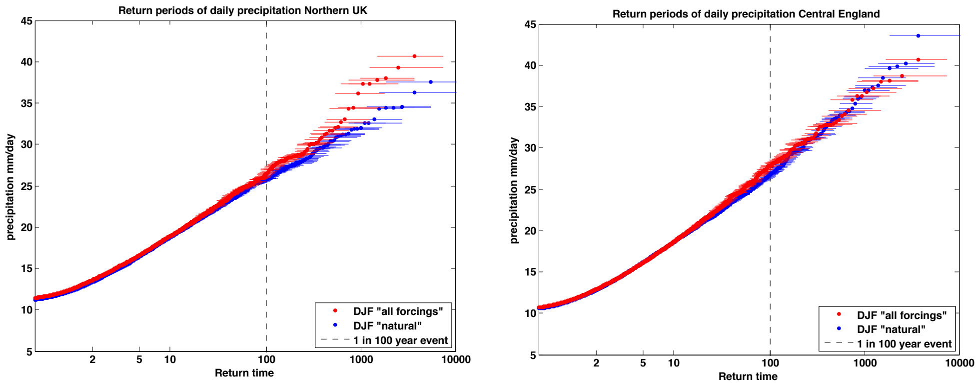

Fig. 3.