

Reply to Referee comment #2

Wood uses a method to attribute changes in the probability of extreme events to either changing mean climate or climate variability. This is applied at a high-resolution regional scale, to explain changes to short-duration (3hr-72hr) precipitation extremes. The results are very interesting, and give an insight into the mechanisms of climate change in Europe.

I expect the results to be of interest to the readership of ESD. The manuscript is generally well written, though needs some clarifications and credits in places. I thus recommend acceptance after revisions.

General point

The analysis leans heavily on the calculation of probability ratio and specifically the separation in two contributing parts. This method was developed in Van der Wiel & Bintanja 2021. This study should therefore be cited in a few key locations in the manuscript, to inform the reader of the origin on the method, and to show on what background you built out with very useful insights on the drivers of changing short-duration precipitation extremes, and to give credit where it is due. I list the locations in the manuscript here, where a reference to the paper should be added:

- *Line 75 - Add in this short summary of the paper that you will follow the Van der Weil & Bintanja (2020) methodology, rather than noting you will use 'the probability risk ratio'.*
- *Line 116 - Start the Methods section with the correct information.*
- *Line 487 - Again, in your conclusion section give credit and help the reader find the relevant reference.*
- *Figure 1 - After looking up the original paper, I noted that this figure is very close (copied from?) their figure 1. I believe you have to add "Taken after their figure 1" or something, and please check if there are copyright issues (maybe not because you replotted?, I'm no expert).*

Very valid points and thank you for suggesting locations for appropriate referencing. I have checked rights and permission of the original figure, and there should be no issue. In the figure description I will place a "(adapted from van der Wiel and Bintanja (2021))".

Major points

Line 33 - I don't understand the addition of 'mean state' here. The magnitude of an extreme precip event is the total volume of water in a time period/for an event. Please clarify what you mean (or remove the bit between brackets).

The information in brackets (i.e., mean state) will be removed.

Figure 5 - Maybe add a note in the text on whether you have an idea on whether the trend you see, between different warming levels, is a significant one. In some regions it is steady, but e.g. in IP the lines seem to spread and come together again. I don't think there is necessarily a dynamic/circulation reason to expect this? This is useful here, but also in other

places. Are the changes you note, between warming levels, extremeness, aggravation, physically in origin?

Some of these differences could potentially be explained by the absolute values of PRtotal. Figure 5 as well as other figures you are pointing at show the relative contributions. This means that if the PRtotal is small, then also small differences between PRvar and PRmean seem larger in the relative context. Specifically in the context of Figure 5, this could be valid for the current warming level (1°C) in several subregions (e.g., Eastern Europe, Mediterranean, Mid Europe, France). I will add one or two sentences on this in the manuscript.

Minor points

Line 26,27 - maybe remove one of the 'devastating' ?

Good idea.

Line 39- 41 - Add more clearly at the beginning of the sentence that you are talking about global mean here. The next sentence came as a surprise to me.

Will add "global" before "mean precipitation".

Line 48 - The statement about changes in distribution does not at all follow from the sentence about occurrence. Maybe put the first sentence of this paragraph with the previous, and start here about the distribution/mean and variability etc.

This is a good suggestion.

Line 86 - 'All 50-members', add the s

Line 190 - Somewhere in this paragraph you might (if you'd like) add that there is no obvious spatial pattern in Fig 2 to be distinguished.

Good idea.

Line 231 - What is Prudence?

A reference will be included. PRUDENCE was a predecessor of Euro-CORDEX and defined the European subregions. These regions are widely used since in the European Regional Climate Model context and have been used in this study.

Figure 4/5 - I'm not sure what AMAX is in the legend?

AMAX stands for Annual Maximum. I will add the appropriate explanation in the figure caption

Figure 4/5 - Given all your PR values are positive (i.e. above 1, or above 0), you might cut the subplots at $y=1$. This would give more details on the values and differences between warming levels.

The idea was to have consistency among the different figures regarding the axis, but I see your point and will adjust figures.

Line 346 - for the change in sign, refer to figure 7?

Yes, that is the appropriate figure reference. I will include this.

Figure 7/9 - probably too many lines to be useful/interpretable? Maybe when comparing seasons, don't show the warming levels? Then you can use the x-axis for seasons maybe.

Visibility could, as you also suggested elsewhere, be improved by adjusting the limits of the y-axis.

Figure 10 - most of your y-axis is useless, consider cutting it off at -0.4 C ?

I will check the figures again and will adjust the y-axis extents where appropriate. For individual Figures I will however keep the axis limits homogenous throughout all subplots within.

Line 423 - You note that more extreme events, have a larger variability contribution? Do you think this is due to a physical process (if so, can you hypothesise which?) or is decreased sampling here an issue?

The latter could potentially be the case. There are grid cells where a 3-sigma event is not reached in the pre-industrial simulations and/or in the ALL simulations.