

Review nhess-2023-224

Based on a radar-based precipitation dataset (2001 to 2022) of the German Weather Service, counterfactual studies on flash flood events in Germany are carried out. Counterfactual studies show what happens when an extreme event occurs under different conditions (e.g. at a different location) and can help disaster risk management to better prepare for such events. First, the ten most severe precipitation events in Germany are identified, which then serve as the basis for the counterfactual studies. In particular, the prominent case (floods in July 2021) is discussed in more detail. The TOP10 events are then shifted (depending on the distance from the point of origin) and the potential hydrological response to rare heavy precipitation events is analysed using a hydrological model. One aim is to determine how close the actual historical events are to the worst-case scenarios.

I find it a very nice paper with interesting results. However, these could be presented in a slightly more structured way, some detailed explanations for non-experts would be helpful and some of the highlights could be explained in more detail (especially part 2 of the results).

Major:

- Regarding our case study “Flood 2021/Ahr”:
Be careful... The flood event in July 2021 is a prominent example – but it is not a flash flood event (see title of your paper)? You need to discuss (or argue) this carefully.
- Section 4.1:
Please discuss your TOP10 results in more detail. How severe were these events? Did these events have a relevant impact (damage, deaths)? Or were the events (or their effects) in the end not so bad? Please put your TOP10 in context with other work. Were these results also identified as “exceptional” by others? See also TOP-list by Ludwig et al. (2023): A multi-disciplinary analysis of the exceptional flood event of July 2021 in central Europe - Part 2: Historical context and relation to climate change, Nat. Hazards Earth Syst. Sci., 23, 1287-1311, <https://doi.org/10.5194/nhess-23-1287-2023>, 2023.
- In some passages, I would wish more context for readers who are not familiar with the topic (or from other disciplines). (More complex) figures could be better introduced: what is the motivation of the figure or what exactly does the figure show before starting the interpretation (e.g. Fig 3, 4, 6). In addition, the authors do not take international readers into account – for them a figure with relevant names (cities, mountains) would be very helpful; this figure should also contain the orography that is relevant for the interpretation of Figure 5.
- Please reflect your structure of the section 4. I had to read it twice to understand it. Please try to introduce everything before you start the interpretation (e.g. introduce complex figures before you discuss them). A clear sentence at the beginning (motivation for the following section, aim or scientific question to be investigated) could help the reader to understand more quickly what you are trying to achieve. You have nice results, but could discuss them in a more structured way.
- L321f: “The dataset can also be an helpful asset to identify flash flood hot spots in Germany.”
And what exactly would the hot spots be? Somehow the result is missing? Please work out better which regions would be particularly affected. At the moment you remain rather abstract. Maybe you should think about reducing the high resolution of Figure 5? Would a figure based on the “factors” be an idea (to show which postcode areas have been “too little” affected so far or where the danger could currently be underestimated too much due to the “missing” history)?

Minor comments:

L68f: Suggestion: Here you can again clearly define or clarify the study area for the reader.

Sect. 2.1. Prec data

Which season? The whole year or just the summer half-year?

L105ff: What are the advantages/disadvantages of xWEI compared to CatRaRE; again emphasise in writing exactly what is considered in xWEI that is not considered in CatRaRE (soil moisture is indirectly implied but clearly communicated).

L117: "...high, if the rainfall in the 3 km x 3 km neighborhood was extreme at multiple durations (between 1 h and 72 h)."

Perhaps add an example to make it easier for the reader to understand?

L128: "The study area is Germany."

Suggestion: Define this already at the beginning of section 2.

L1334: "The median basin size is 11.55 km²."

Idea/Suggestion: Add a histogram of all catchments; including quartile value (25%/75% percentile).

L135: "case study 1"

Do you have one case study or more? (because you write "1")

L167 "SCS-CN" method

Reference? References for "established"

L206: Suggestion: Include the table in results section 4 (or 4.1) (together with the spatial results) and only refer to this section here.

L209: "within the HPE's bounding box (not just for the aligned subbasin)".

Can this be better explained what is meant by this?

L212: "By following this procedure, we generated approximately 230,000 QR data sets across Germany of counterfactual run off data sets."

Can the calculation of the value 230,000 be better explained to the reader?

Table 1: "The ID was constructed from an acronym that specifies the federal state"

A non-German wouldn't understand this, let alone that the names of the cities mean anything to them; could the spatial allocation be better explained to the international reader?

Table1: Ranking (1, 2,) is not given; not all dates have been transformed into English.

L216: "unit peak discharge (UPD)"

Reference?

L228f: "events with a large bounding box"

Please specify what you mean by this.

L229: "a large xWEI are likely to include smaller event clusters"

Do you mean: "a large xWEI **value** are likely to include **some** smaller event clusters"?

L241/Figure 3: Please introduce the figure better in the main text (more explanation) before going into the result (as the figure is quite complex).

L247: "the QR peak can vary by a factor of 2."

Can you give a reason (or hypothesis) why this is the case?

Figure 4: Can you explain one or two sentences about "stream order" for the reader who is not so familiar with hydrology?

L254: Location of NWJul21_b events? How far away?

258f: "In our model, the catchment consist of 37 subbasins (Fig. 2a)."

This information would be helpful to the reader before.

L259f: "Using the same approach, we are also able to take the other nine events from Table 1 and compare the resulting QR flood peaks"

Please be more specific; you mean that you apply the other observed cases to the Ahr area to see that...

L263f: "have apparently caused even higher QR peaks in Altenahr"

Can you hypothesize why this is the case?

L266f: "Among these, there are no counterfactuals of the events BW/May16, BB/Jun17, LS/Jul17, HS/May19 and BB/Jun20"

Why?

L288f: "Mountain and low mountain ranges such as the Harz mountains, Ore mountains, the Black Forest" International readers need a figure that contains relevant location information; this could also include the orography so that the relationship is clear to them.

Figure 6: I don't understand the figure; please provide a more precise caption. A caption should first explain the figure (in a scientific paper). You start with results.

Table 3 & LL314ff: "Table 3 shows which events caused the highest discharges for sub-basins all across Germany: the counterfactuals of the event SNJun/13 have caused the highest QR peaks in 82 % of the subbasins. Out of the ten HPEs, this is also the event with the highest hourly precipitation rates (see Tab. 1). Only in two subbasins, the highest QR peaks were caused by NW/Jul21 counterfactuals. In only one case, the worst case scenario was caused by an original event."

And what does that mean; can you elaborate on the highlight of this statement? Can you be more specific? What do we learn from this finding?

Section 5:

A brief introduction and motivation for the section would be helpful to the reader.

Perhaps rename section 5 to "Discussion" or "Discussion and Limitations"?

L342ff: This section seems misplaced here; suggest moving it to 4.1.

L356: "Together with the expected underestimation of rainfall (see section 5.1)"

What order of magnitude are we talking about here?