

What made the June 2013 flood in Germany an exceptional event? A hydro-meteorological evaluation

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Reply to comments of Christian Reszler

First of all we want to thank the Christian Reszler for his valuable and thoughtful comments. Following, we will reply to each of the comments made.

General comments

Referee Comment:

The paper by Schröter et al. evaluates the June 2013 flood in Germany from a hydro-meteorological perspective and compares this flood with two large flood events in the past. They build on a very nice data base of gridded daily precipitation and a compilation of large scale flood events in Germany. They point out the main driver for the exceptional flood, the high soil moisture status in the catchments prior to the event, and illustrate the importance of the antecedent soil moisture for high return periods.

The valuable data base using different spatial indices makes this well written paper a valuable contribution to flood event and flood risk analysis. It is worth being published. However, what would even increase the strength of the conclusions are implications regarding design flood estimation. The Authors' address the importance of scenario definition (“unusual combinations”) for flood risk analysis, i.e. pronounced precipitation and high antecedent soil moisture, but, in the light of the large floods in recent years and the comprehensive flood data

base they could try to refer their conclusions to the usual statistical measures in design flood estimation.

Authors' response:

The introduction and conclusions have been overworked. We now also refer to advanced approaches for flood frequency analysis and design flood estimation.

Specific comments

I have a few comments that should be considered before publishing.

Referee Comment:

P. 8128, line 1: "... hypothesis is contrary to ..." This is a rather strict formulation, also in the next sentence "... only secondly ..."

Authors' response:

We reformulated the sentence: "This hypothesis is of interest in the context that the influence of initial catchment wetness is seen to be of decreasing importance..."

Referee Comment:

P. 8132, Sect. 2.4.3: What is the role of evapotranspiration (summer events) for the antecedent moisture status? Can other data sources be used to confirm API? (e.g. DWD actual soil moisture maps, remote sensing data, hydrological models in operational use).

Authors' response:

API is used as a proxy for soil moisture depending on rainfall in the period before the onset of the flood. The potentiation of k with the number of days corresponds to the assignment of continuously decreasing weights to rainfall that has occurred earlier. This relation approximates the decrease of soil moisture due to evapotranspiration and percolation to deeper soil layers. We complemented these details to the text.

Alternative data sources are available as for instance the soil water index (SWI) of TU Vienna which is based on Metop ASCAT remote sensing data. However these data and also other data sources such as hydrological models are not available continuously for a 50 years period, such as our reference period from 1960 to 2009, to draw consistent comparisons for May/June 2013 and the floods of the event set.

The extraordinary soil moisture situation in May/June 2013 is confirmed by a map of ranked soil moisture values provided by BfG (2013).

BfG: Länderübergreifende Analyse des Juni Hochwassers 2013, Bundesanstalt für Gewässerkunde, Deutscher Wetterdienst, Koblenz., 2013.

Referee Comment:

P. 8137, Sect. 3.1: There are a lot of meteorological details given, please clarify some very specific parts (e.g. weather types), or, since it is a hydrological paper, I propose to shorten this part, also in the light of "... cannot explain the extraordinary situation in 2013", as mentioned previously in the text (p. 8130, line 10).

Authors' response:

We shortened this paragraph and clarified or deleted some very specific details. Furthermore, we deleted the mentioned paragraph (p. 8130) with the large-scale weather patterns because it provides no useful insight.

Referee Comment:

P. 8137, Sect. 3.2 and further pages: Please clarify the date of the event in August 2002 used in this study. On p. 8140, line 1 the 24 hour sum from 7 to 8 Aug. 2002 is given, but at the Danube and the Elbe the second flood from 12 to 17 Aug. caused the higher flood peak. Is this peak - showing high return periods with high antecedent wetness - incorporated in the study?

Authors' response:

This was a mistake, sorry. The period of the 24-h maximum, which triggered the second flood peak (considered in our study), was 12-13 August. We corrected this.

Referee Comment:

P. 8143, line 28: Are there other factors? To what extent could this be the effect also of the shape of the hydrograph, i.e. the large volume of the (single) flood wave, as illustrated e.g. by Blöschl et al. (2013) for the Danube? Furthermore, did flood protection measures, possibly installed after the 2002 flood, affect wave propagation in 2013?

Authors' response:

The shape of the hydrograph, superposition of flood waves in the river network and flood protection measures are important factors that may aggravate a flood. Similarly, dike breaches may alleviate the flood level downstream. During the flood in June 2013 the superposition of flood waves played an important role at the confluence of the Inn and Danube (also shown by Blöschl et al., 2013) as well as in the Elbe catchment at the confluence of the Saale and Elbe

ivers. However these hydraulic issues were not within the focus of this paper. Anyway, these effects were not important for the upstream parts of the Saale, Werra and Main rivers. We restricted our statement to the *'upstream parts of the Saale, Werra and Main catchments'*

Technical comments

There are not many typing errors I found in the text:

Referee Comment:

P. 8228, line 11: possibly set a comma after "Germany, ..."

Authors' response:

We overworked this paragraph and this sentence does not longer exist.

Referee Comment:

P. 8228, line 15: events of Uhlemann ...

Authors' response:

This has been changed ("event set of Uhlemann...").

Referee Comment:

P. 8142, line 15: increased

Authors' response:

This has been changed.

Referee Comment:

P. 8146, line 21: Why put "antecedent" in quotes?

Authors' response:

This indeed does not make sense. We deleted the quotes.

Referee Comment:

P. 8159 and following pages: see above: please clarify the date of the 2002 flood in the Figures (or in the text)

Authors' response:

The date of the 2002 flood has been clarified, see comment above.