

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

**Kai Schröter<sup>1,3</sup>, Michael Kunz<sup>2,3</sup>, Florian Elmer<sup>1,3</sup>, Bernhard Mühr<sup>2,3</sup>, Bruno Merz<sup>1,3</sup>**

[1]{Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Section Hydrology, Potsdam, Germany}

[2]{Karlsruhe Institute of Technology, Institute for Meteorology and Climate Research, Karlsruhe, Germany}

[3]{CEDIM – Center for Disaster Management and Risk Reduction Technology, Germany}

Correspondence to: K. Schröter (kai.schroeter@gfz-potsdam.de)

## **Reply to Short Comment of Michel Lang**

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

**Principal Criteria    Excellent (1)    Good (2)    Fair (3)    Poor (4)**

**Scientific Significance:**        X

Does the manuscript represent a substantial contribution to scientific progress within the scope of Hydrology and Earth System Sciences (substantial new concepts, ideas, methods, or data)?

**Scientific Quality:**        X

Is the scientific approach and applied methods valid? Are the results discussed in an appropriate and balanced way (consideration of related work, including appropriate references)?

**Presentation Quality:**        X

Are the scientific results and conclusions presented in a clear, concise, and well-structured way (number and quality of figures/tables, appropriate use of English language)?

1. Does the paper address relevant scientific questions within the scope of HESS?

The paper presents a hydro-meteorological comparison of three major flood events that occurred in Germany these last decades: July 1954, August 2002 and June 2013. It addresses several components that can explain the severity of these events: meteorological conditions, initial wetness conditions and rainfall intensity. This is a valuable contribution to the analysis of past flood events and the improvement of the understanding of the physical mechanisms of extreme floods.

2. Does the paper present novel concepts, ideas, tools, or data?

The paper provides very clear maps on the spatial variability of different indexes: 3days maximum rainfall - cumulated amount and return period; antecedent precipitation index - cumulated amount and return period; initial flow condition - normalized ratio and return period; peak discharge - return period. It gives also interesting information on the weather conditions, the repartition of the areal rainfall during the rainy period, the date of the maximum of the rainfall, the position of the three flood events within a 2D graph (wetness index and precipitation index).

All these information provide a very valuable insight of the characteristics of flood events.

3. Are substantial conclusions reached?

Yes, the paper shows clearly the importance of antecedent soil moisture conditions for the height return period of the June 2013 flood.

4. Are the scientific methods and assumptions valid and clearly outlined?

Yes

5. Are the results sufficient to support the interpretations and conclusions?

#### **Referee Comment:**

There is one possible improvement related to the role of snowmelt contributions. This point is addressed (end of section 3.5) in one sentence. I wonder if some index could be added (analysis of snow cover plus air temperature).

#### **Authors' Response**

We agree that snowmelt can play an important role in the generation of floods. However, in the case of summer floods in Germany as in July 1954, August 2002 and June 2013 this was not an important factor. On the contrary, both in June 2013 and in July 1954 snow was accumulated above elevations of 800 m in the Alps (Blöschl et al., 2013) and attenuated runoff generation. Likewise in August 2002 snow did not play an important role. As the focus

area of our analysis is Germany we decided to exclude the aspects of snow melt and accumulation. The derivation of a snow-melt index for the set of historic flood events would be interesting, yet reliable data for a consistent comparison are not available.

6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?

**Referee Comment:**

One point could be highlighted: I didn't understand how the event start dates were selected (see section 2.4.1). Is it related to the date when the flow does significantly increase? The sentence is easy to write, but we need some mathematical criteria to define what is a significant increase (we can have some secondary peaks).

**Authors' Response:**

Actually, we have two different event start dates. One is related to the onset of large-scale floods which form the data base of large-scale floods, the other one is based on the maximum precipitation that triggers the flood.

We overworked subsection 2.4.1 (now 2.2.1) and added further explanations.

7. Do the Authors' give proper credit to related work and clearly indicate their own new/original contribution?

Yes

8. Does the title clearly reflect the contents of the paper? Yes
9. Does the abstract provide a concise and complete summary? Yes
10. Is the overall presentation well-structured and clear? Yes
11. Is the language fluent and precise? Yes
12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?

**Referee Comment:**

Please give comment of the value of 0.9 in equation (1). Is it a well-known planetary invariant coefficient (??) or something specific to the time-autocorrelation of rainfall in Germany? Add some references on this point.

**Authors' Response:**

There are several suggestions in the literature to use a value between 0.8 and 0.98 (which depends especially on climate and season). Since the purpose of our study was to compare past flood events with the same methods, we decided to use a constant value between, thus we selected 0.9. The implications of varying  $k$  within the range are now examined within a sensitivity analysis.

In the manuscript we added some references and explained the use of this value for the depletion constant. Further we examined the sensitivity of the Wetness-Severity-Index with regard to this factor. See new section.3.6 Sensitivity analysis.

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?

**Referee Comment:**

Section 1: The sentence “This hypothesis is contrary to the notion that the influence of catchment wetness is greater ...” is somewhat overstated. The main idea of flood frequency analysis based on rainfall information is that the extreme tail of distribution is driven by the extreme tail of the rainfall distribution. It is characterized by an asymptotic parallelism between the two distributions (see for example the Schadex method, Paquet *et al.*, 2013). But these methods clearly account that flood hazard is a combination of antecedent moisture conditions and rainfall intensities. That is to say that all possible combinations are possible for specific flood events.

**Authors' changes:**

We reformulated the introduction: “...On the one hand, catchment wetness state is an important factor for the generation of floods (Merz and Blöschl, 2003). As such it is a useful indicator in flood early warning schemes (e. g. Van Steenbergen and Willems, 2013; Alfieri et al. 2014; Reager et al. 2014) and is also incorporated in procedures for extreme flood estimation (e. g. Paquet et al. 2013). ...”

The issues raised by the referee in reference to Paquet et al., (2013) are also included in the conclusions.

**Referee Comment:**

Page 8128, line 22: “Section 4”

**Authors’ response:**

This has been corrected.

**Referee Comment:**

Page 8138, line 26: “(pw)”

**Authors’ response:**

This has been changed.

**Referee Comment:**

Page 8139; line 10: The sentence is not clear. I understand that the Authors’ do not want to extrapolate beyond the 200 year return period. It means that the estimated values of return period have been upper-bounded to 200 years (and not neglected).

**Authors’ response:**

We followed this suggestion and reformulated the sentence: “The estimated values of the return periods have been truncated to 200 years...”

**Referee Comment:**

Page 8144, line 6: “(see Fig. 11, middle and right panels)”

**Authors’ response:**

This has been corrected.

**Referee Comment:**

Page 8148, line 30: paper of Bloschl *et al.* (2013) has been published in HESS (no more in HESSD).

**Authors’ response:**

This has been corrected.

14. Are the number and quality of references appropriate?

Yes

15. Is the amount and quality of supplementary material appropriate?

No relevant