
hess-2020-605
Responses to anonymous referee 2

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January 11, 2021

Dear Anonymous Reviewer 2,

thank you very much for reviewing our manuscript. We are very grateful for your comments and suggestions. In the following, we provide detailed responses to all your comments.

On behalf of all authors,

Sincerely,

Erwin Rottler

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1 General Comment

Overall quality of the preprint: A well-structured paper that supports earlier results and adds additional insights into the shifts of flood genesis under climate change. The latter could be highlighted a bit more in the abstract and other parts of the text (suggestions under "specific comments"). Principle review criteria (scientific significance, scientific quality, and presentation quality) are generally evaluated as "good". Suggest to accept with revisions.

We will revise our abstract and corresponding paragraphs in the discussion and conclusion and focus more on the additional insights rather than already known results.

2 Specific comments

2.1 Comment 1

Page 1, Abstract - change request: The abstract describes basic mechanisms of the flow regime of the Rhine River in a warmer climate. This is neither new – cf. e.g. to Kwadijk Romans (1995; <https://link.springer.com/article/10.1007/BF01093854>) - nor the core of the study presented here. It is suggested (a) to highlight a set of change signals of the hydrological characteristics you evaluated (number of years with snowmelt fraction above a threshold or lift of "melt elevation" etc.) and/or (b) focus more on the hypothesized new flood type superimposing rainfall- und snowmelt-induced runoff.

Thank you for pointing at this. We will revise the abstract and focus more on the specific changes in hydrological characteristics we detect.

2.2 Comment 2

Page 1, line 16 - suggestion: The term "current climate crisis" has a political flavor.

Indeed. We will think about a better term and get rid of any political flavor.

2.3 Comment 3

Page 2, lines 1ff - suggestion: Add reference to IPCC SROCC

Yes, we will include this reference.

2.4 Comment 4

Page 3, lines 9ff - change request: Please add here, that hydrological processes are modelled at 5 km grid resolution (referring to page 5). Otherwise the reader waits for a final downscaling step of met. data to the 500 m grid of mHM.

We will add this information.

2.5 Comment 5

Page 3, line 16 – change request: The quoting used here reads like the authors do not understand what this part of the procedure/sentence means. Is that the intention here? The bias correction procedure is important when dealing with peak flow analyses (and heavy precipitation). Please rephrase.

We agree. The bias correction is a very important step. We will rephrase this paragraph and include additional information on the downscaling and bias correction of the climate model data.

2.6 Comment 6

Page 3, line 22ff – change request: Please explain how you treated the catchment upstream of Basel. As it reads now you would end up with two parameter sets; one from the calibration of Basel, one from the calibration of Lobith (also containing the catchment upstream of Basel). Please clarify, which parameter set you used for the overlapping part of the catchment or if you used individual model set ups for each gauging station.

During the multi-basin calibration, we attain one parameter set, which we use for the entire basin. We use one model set up. We will rephrase this paragraph to make it more clear.

2.7 Comment 7

Page 6, line 17f – change request: Please add some details on your experience concerning the 14-day time window for snowmelt and evaporation. Is it based on investigations of historical floods? Or on model simulations?

You are right. We need to explain this better. We will extend this section and add more information on the selection of the window width we used.

2.8 Comment 8

Page 6, line 25f – change request: The flow regime at gauge Cologne is usually regarded as "complex" regime containing "nival" and "pluvial" characteristics. This should be added here. Now, the gauge is described as another pluvial example.

We will add this information here.

2.9 Comment 9

Page 7, Figure 3 – change request: The map shows the Rhine River basin up to Lobith, not the entire Basin. This should be added in the scheme and/or caption.

You are right. In Fig. 2 we still explicitly mention it, but in the scheme in Fig. 3 this information is missing. We will update manuscript accordingly, to eliminate this confusion.

2.10 Comment 10

Page 7, Figure 4 – suggestion: For reasons of consistency it is suggested not to introduce an additional reference period here (1971-2016). The period 1971-2000 should be chosen here as well.

In order to illustrate the long-term runoff seasonality of the gauges observed, we decided to use the 100-year time window 1917-2016. Yes, the usage of the period 1971-2000 would make it more consistent with the other analyses so we will change this during the revision.

2.11 Comment 11

Page 8, line 11ff – suggestion: For some readers it may be interesting to note that according to your results there will still be some snowmelt at gauge Cochem even in a 3 °C warmer world. Suggest to add this point.

We will add this specific information into our revised manuscript.

2.12 Comment 12

Page 8, line 13 – suggestion: The units of the variables could be changed to give a better "grip" of the results. For example, "the number of streamflow maxima having an estimated runoff contribution of snowmelt of more than 20

We will improve this formulation and rephrase the sentence accordingly.

2.13 Comment 13

Page 8, line 21 – change request: "Decreases in solid precipitation are most prominent in winter" ← That's not surprising because according to your results the historical period shows is no solid precipitation in summer. Rephrase, e.g. referring to meteorological seasons (DJF, MAM, JJA, SON).

We will rephrase this section of the text as suggested.

2.14 Comment 14

Page 9, lines 3 – suggestion: Suggest to repeat here that the timing of the highest annual flow remains unchanged.

We will do so.

2.15 Comment 15

Page 10, lines 6f – suggestion: The role of evaporation simulated under climate change conditions strongly depends on the evaporation approach used and the area of interest. Suggest to transport this uncertainty of hydrological modelling by formulating more carefully. For example: "With the approach used here, evaporation seems to play a minor role . . .".

Thank you for pointing at this. Yes, the evapotranspiration approach used is a crucial point. We will rephrase this part.

2.16 Comment 16

Page 11, line 6f. – suggestion: It would be also interesting to state already here that snowmelt-driven flooding is possible despite of rising temperatures. At least in low warming levels there may still be relevant snowmelt events. This follows only two pages later.

Yes. That is a good idea. We will add this information here.

2.17 Comment 17

Page 11, line 11 – change request: The hypothesis mentioned in the introduction was on flood risks resulting from the overlap of nival and pluvial peak flows. Here, the focus is on snow-melt driven floods only. Check consistency.

The idea of earlier snowmelt-driven floods is part of the hypothesis of a possible overlap of nival and pluvial peaks. We will rephrase this sentence to make it more clear.

2.18 Comment 18

Page 12, figure 8 – suggestion: Add the range that is displayed by the boxes.

We will improve this figure and its display ranges.

2.19 Comment 19

Page 12, line 1f – suggestion: Suggest to stay focused on floods and skip low flows.

Yes, we should focus of floods and be careful talking too much about low flows.

2.20 Comment 20

Page 12, line 3ff – change request: In this paragraph it is advisable to be very clear about (a) the statistics (e.g. to avoid confusion between monthly and annual stream flow maxima) and (b) the gauge/regime that is discussed. Otherwise the reader will be lost. For example the statement that "with rising temperatures, most flood events will occur in winter" does obviously not relate to Basel/nival regimes. This has to be more transparent.

Thank you for pointing this out. We need to improve this paragraph. We will rephrase this paragraph and also look at other parts of the result and discussion section.

2.21 Comment 21

Page 14, line 7 – change request: In how far are peak elevations (here: 1300 m a.s.l.) and the related processes interpreted here reflected in the hydrological model, given the 5 km grid resolution? Please add this to the method description (page 3f.).

We will include further information on this in the method section.

2.22 Comment 22

Page 14, line 30ff. – suggestion: cf. comment on abstract. Suggest to refocus this paragraph in the same way.

Following your suggestions on how to improve the abstract, we will also rewrite this paragraph.

2.23 Comment 23

Page 15, line 14f. – suggestion: Suggest to stay focused on floods and skip low flows. Lakes and reservoirs play an important role for high flow, too. If they are not yet implemented in the model, this should be mentioned in the methods chapter (page 3f.)

We will include this information into the method section.

3 Technical correction

3.1 Comment 24

General comment: It was difficult to print the pdf. Presumably one of the graphs is oversampled – please check.

Yes. Thank you for hinting at this. The problem is Fig. 7 itself. We will export the figure in a different format to ensure its accessibility.

3.2 Comment 25

Page 8, line 5 – change request: Figure 5b contains no information on the timing of runoff maxima. Wrong reference. Please correct (-> 5d?) and repeat the reference to "Basel" in the text/line 5.

Yes, the reference is not correct. We will change this.

3.3 Comment 26

Page 8, line 13 – change request: "more the" -> "more than"

Agree. Needs to be "more than".

3.4 Comment 27

Page 9, Figure 5 – change request: The horizontal grid lines do only occasionally match the tick marks. Please correct.

We will correct this in the figure.

3.5 Comment 28

Page 10, Figure 6 – change request: The horizontal grid lines do only occasionally match the tick marks. Please correct.

We will correct this in the figure.

3.6 Comment 29

Page 11, line 6 – change request: Replace "Smax14" by plain text.

Yes, using plain text here is better. We will rephrase the sentence.

3.7 Comment 30

Page 12, Figure 8 – change request: The horizontal grid lines do only occasionally match the tick marks. Please correct.

We will correct this in the figure.

3.8 Comment 31

Page 13, Figure 9 – change request: The horizontal grid lines do only occasionally match the tick marks. Please correct.

We will correct this in the figure.

3.9 Comment 32

Page 24, Figure B1 – change request: The horizontal grid lines do only occasionally match the tick marks. Please correct.

We will correct this in the figure.

3.10 Comment 32

Page 25, Figure C1 – change request: The horizontal grid lines do only occasionally match the tick marks. Please correct.

We will correct this in the figure.