Response to reviewers
Manuscript for Hydrology and Earth System Sciences
Manuscript number: HESS-2018-164
Title: The potential of global re-analysis datasets in identifying flood events in Southern Africa
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Referee #1:

General Comments

This paper assesses the potential of using re-analysis datasets with hydrological models to identify flood events in the Limpopo River basin. They evaluate climatological forcing's at 0.5 and 0.25 deg spatial resolution, and different hydrological and land surface models of the WRR datasets. While it is a model intercomparison paper, the objective is to identify timing and magnitude of floods. The novel aspect of the article is a flood detection comparison with reported observed flood damaged, which tries to link what is modeled to the actual impacts. The analysis focus on evaluating coarse spatiotemporal resolution dataset and models, which are not the most up to date and appropriated to assess local scale floods in small catchments. As the current generation of land surface and hydrological models are currently available at much higher resolution (i.e., 5-10-5 km), these models could potentially be more appropriated and yield better skill in detecting floods. Nonetheless, I understand that the authors are constrained by the data and models available at the WRR dataset. However, WRR could have been updated for a more novel study. The paper is clear and concise, and the authors acknowledge limitations on data, models, and analysis, and well as listed aspects for improvement. Despite the limitations, this study intended to inform the scientific community on the potentials and limitation of currently available data and model for flood applications.

We thank the referee for taking the time to review our manuscript thoroughly and for his/her constructive comments. We are pleased that the referee values our work and is generally positive. The referee provided helpful comments in order to improve our manuscript. We have considered each of the comments carefully, which we will address here in detail. For the ease of reading we have copied the referee comments (in bold), and respond to each of the comments below.

Specific comments

1. Page 2 Line 19 and Page 3 line 8: Can you expand the explanation of the term "spatially symmetrical"?

We thank the referee for pointing out that this was not clear. By observational data being "spatially symmetrical" we mean that the data is evenly distributed across the study area. In the case of the Limpopo River Basin most of the available data as well as resources (financial, institutional) are located in South Africa, thus the data is not spatially symmetrical, which is mentioned in the next sentence (page 2 lines 19-20). We will change this in our revised manuscript to "not evenly distributed across the riparian countries, with most gauges in South Africa".

2. Page 3 Line 21: I would say … managing floods at the regional and basin scales …. I'm not sure to what extent forecasting at 0.25deg resolution is aiding flooding management at local scales.

We thank the referee for the comment. As the scope of our paper is to assess the scale up to which global models are able to provide useful information for small-scale flood risk management in areas with insufficient observational data, we used the word "local". As this was not completely clear, we will modify the text to "… managing floods at the regional and sub-basin scales.".

3. Section 2.3.2 Disaster Data: I understand flood damage data is scarce and has its several limitations, which leads to data aggregation as an alternative to consolidate a standard analysis.

However, it would be interesting to see few point results for maybe one or two cases where the location and time of the flood events are reported, and how do the models perform regarding flood timing, magnitude, and detection. This additional analysis would bring more meaningful insights on the potential use of these models for flooding management and flood detection, rather than a sub-basin aggregation.
Indeed, we agree that it indeed would be highly interesting. We will investigate the possibilities for adding this aspect in our revised manuscript.

4. Section 3.1: The models, in the context they were applied in this study, were not designed to evaluate discharge and floods at small catchments with < 4km2, as the grid size is of at least _625 km2 (0.25deg). As an (expected) result, the timing, magnitude, and flood detection are poorly captured. As these models are not appropriated to be applied in small catchments, can you expand on what is the purpose of evaluating the small catchments in this study, why is it a reasonable approach, and which knowledge/information do you expect the scientific community will gain from it?
Many thanks for this thought-provoking point. The reason we have decided to include the smallest sub-catchments as well, is because part of the scope of our paper is to determine the area up to which the models are still able to represent the hydrological behaviour. As shown in the results presented in Section 3.1 (page 8 line 25), the models were shown to capture the hydrology of the river for sub-catchments that are larger on the order of 520 km^2 for WRR2, which is on the order of the 625 km^2 of the cells size of the 0.25 degree models . Including the smaller catchments provides information about the scale up to which we can use such models that are included in the WRR dataset. This has, to our knowledge, not been studied before it is valuable for the scientific research community. Particularly since there are many regions that have to rely on such global data as the observational data is insufficient for localized models. Furthermore, as is for instance shown by Figure 3 where we analyse the Spookspruit river, with a sub-catchment area of only 252 km^2, global-scale models do actually have skill in capturing the variability (indicated by MM1 and MM2), even though the actual values are indeed overestimated. We will, however, rephrase this in our revised manuscript as this was not entirely clear. Since both referees raised this point, we are nevertheless willing to disregard the smallest stations from our analysis. We are therefore interested in the opinion of the editor regarding this issue. We also consider of scientific interest that for both the coarser and the finer resolution models, the threshold is on the order of the cell size. This holds promise for the continuing effort of modelling research groups in developing increased resolution (global models).

5. Section 3.1: Coefficient of determination could be used instead of linear Pearson to represent how much of the variability can be represented by the proposed models.
Indeed, we agree that the coefficient of determination could have also been used, as they both describe the degree of collinearity between the modelled and observed data, though in a different way. The coefficient of determination describes the proportion of the variance in the measured data explained by the model, whereas Pearson's correlation coefficient is an index of the degree of linear relationship between observed and simulated data. We were interested in this linear relationship, in addition to the NSE and PBIAS, which is why we chose for Pearson's correlation coefficient above the coefficient of determination.

6. Page 11 Line 11. Can you expand on why do you think LISFLOOD perform worst using higher resolution forcing's data? I'd guess something related to model calibration.
We thank the referee for raising this interesting point. We have greatly looked into the reason why LISFLOOD could be performing worse in a higher resolution. There are a number of factors that could contribute to this. First of all, the models in WRR2 had further modifications in respect to WRR1, apart from the different forcing and higher resolution. For LISFLOOD the modifications include an increased number of lakes and reservoirs, improvement of irrigation water demand and groundwater abstraction and an increased number of soil layers (Arduini et al., 2017; Dutra et al., 2017). This could be part of

the answer as to why the improved forcing and higher spatial resolution did not result in an improved performance. Secondly, we agree with the referee that it could indeed also be related to the model calibration. LISFLOOD was somewhat calibrated for WRR1 using eleven parameters for 24 large catchments (Dutra et al., 2015), but LISFLOOD was not calibrated for WRR2 (Dutra et al., 2017). Instead, the parameterisation of WRR1 was also used for WRR2, even though the alterations to the model require an updated calibration (Arduini et al., 2017; Dutra et al., 2017). We will include the reasons for the worse performance of LISFLOOD in WRR2 in our revised manuscript.

7. This study was conducted considering data and models at daily time resolution, can you comment about the implications of temporal resolution on the forcing's data and modeling on the identification of short flashy floods. To what extent does it play a role in correctly identifying the flood category in places like southern Africa where rainfall if general driven by short and intense convective cells.
The forcing data of MSWEP is actually available at a 3-hourly resolution. However, as most models operate at the daily timestep (in the WRR dataset LISFLOOD, PCR-GLOBWB, W3RA and WaterGAP3) and since the output is also at the daily step, the forcing data with a sub-daily resolution is generally not used. Furthermore, sub-daily data is generally not available in these areas. Some of the rain- and discharge gauges report hourly values, but most only at the daily timestep. In order to analyse the short flash floods, even shorter reporting time-steps (every minute or 5-minutes) would be preferred. Apart from the high resolution data a very high resolution local model is also needed to model the short flash floods (López et al., 2016). For these models, the forcing data used in the WRR dataset would be insufficient. Our scope, however, is to look at the potential of available datasets at the global scale, and not to model at the high resolution the occurrence of flash floods. Indeed, these flash floods are likely not well captured in the data, and most research does not take this kind of flood events into consideration. That is the exact reason why we are also interested in including this in our research.

Technical Corrections / Minor Points
1. Page 2 Line 32: … determine climatic extremes as well as its uncertainties at global…
We thank the referee for pointing this out, the sentence will be altered.

2. Page 3 Line 20: as an illustration, I'd list some examples of currently available flooding forecast systems currently available.
The suggestion is highly appreciated, we will look into it.

3. Page 4 Line 15: it would be nice to see the location of dams and reservoirs mapped in Figure 1., as it expands our sense about the basin dynamics and importance of representation of lake and reservoirs in hydrological models.
We agree with this comment, we will add this in the revised version of our paper.

4. Page 14 Line 22: …whereas flood events occur at the basin or finer scales…
We assume the referee is referring to Page 13 Line 22: "whereas flood events occur at the basin scale". In this case, we agree with the referee and will modify this sentence text accordingly.

5. Page 15 Line 4. I'd say there is a critical need for both higher resolution re-analysis supporting data and flood forecasting systems to properly capture timing, intensity, and location of flood impacts.
We agree with the referee that there is a critical need for both the re-analysis data as well as flood forecasting systems. Such global models as used in this re-analysis are also employed in global forecasting systems, such as GloFas (Alfieri et al., 2013). GloFas uses the HTESSEL model which is also considered here, but then at a resolution of 0.1 degrees. We will include this in our revised manuscript.

6. Page 15 Line 22. I would change to something like: "This shows that some largescale models (i.e., WaterGAP3) have some skill in capturing observed and reported damaging floods, while others

perform poorly. The finds here presented, highlights the importance of model intercomparison and evaluation studies to inform the scientific community on model's strengths and weakness as well as plausible applications".

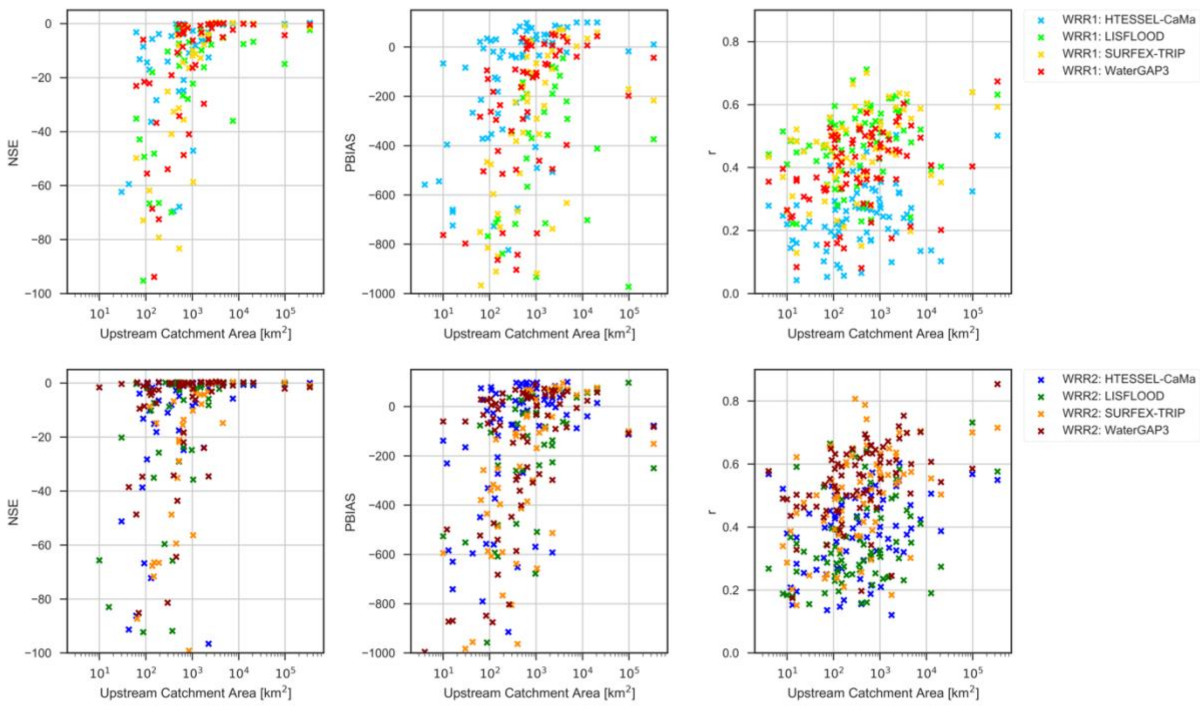
Many thanks for this comment, however, we do not fully agree here. In this particular study that focussed on the Limpopo basin WaterGAP3 performed better, but it is not sure if this is a general conclusion. There are many instances possible where other models would perform better. For instance, if this study would be repeated elsewhere, or if the discharge outputs of other models would be compared, or if the models would have had another forcing, or if all models would have been calibrated.

7. Figure 1: Use a different color for the basin delineation; include the other river tributaries of a lower order, especially the ones where gauges were evaluated; use a different color for the circle and square.

We thank the author for the suggestions to improve this figure, we will alter the figure where possible to include these points, as well as add the dams and/or reservoirs (as was pointed out in the Technical Corrections / Minor Points 3).

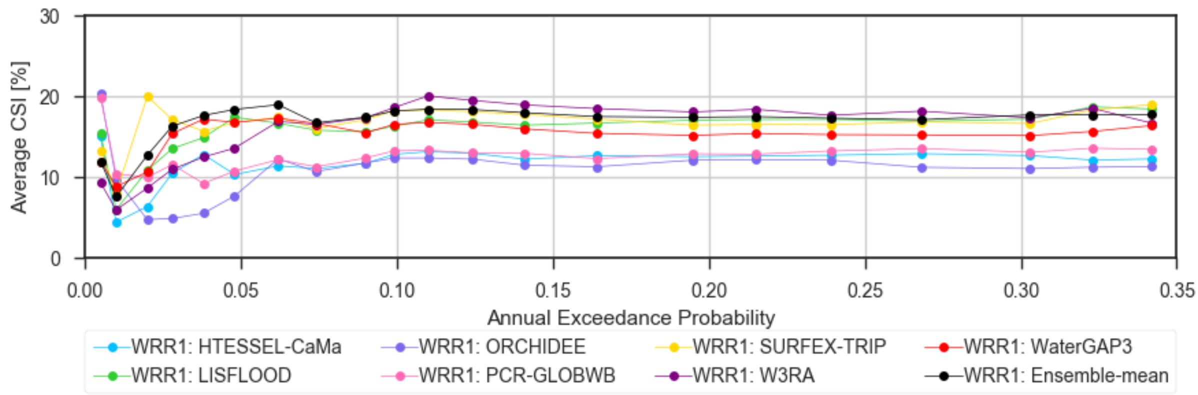
8. Figure 2: Maybe you can check if a log scale in the y-axis of the NSE plots would improve the representation of the values around zero.

Thank you for your comment, which was also raised by the second referee. We will take a closer look at improving the graphs for the NSE in this figure.



9. Figure 4: The 'X' points are very confusing and hard to follow through, maybe consider dots with a light line connecting them in the background.

Thank you, we have modified this figure, see below for WRR1. This indeed makes the figure clearer.



10. Figure 5: Full name of POD and FAR in the figure caption.
Thank you for pointing this out, we will include the full name in the paper.

11. Figure 6: Improve the figure quality regarding dpi. Change color scheme to opposite colors (i.e., red and blue) rather than light and dark (i.e., light blue and dark blue). Otherwise it's hard to see the differences.
Thank you for raising this issue, which was also mentioned by the second referee. We will change the figure in the revised version of the paper.

References used in this revision response:

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