R: We thank the reviewer for the suggestions/comments/feedback that helped us improve our manuscript and for tacking time to read and review our paper.

Rivers in the Sky, flooding on the ground
Reviewer 3 Report Round 1

This article analyzes the role played by atmospheric rivers in some of the most important flood events in the lower part of the Rhine River basin. Overall, the paper is well written, and the inclusion of the perspective of the hydrological extremes –floods– rather than the simple extreme precipitation is always an added value. The authors find most of the more important flood events over the region were preceded by an AR event, and this is an interesting result that could be valuable for the region. The quality of the figures is acceptable, but it could be improved. I suggest the authors improve some of them if that is not very problematic.

I believe that the title is a bit pretentious. It is a very catching title that would be probably the best choice for a review paper or a paper intended to get conclusions on a global scale. This manuscript is focused on a very particular region of Inland Europe, and I think that this should be reflected in the title somehow. I would perfectly understand if the authors would like to keep the "Rivers in the sky, flooding on the ground" –I would have done the same–, but I suggest that this title should be extended with a citation to the region of interest somehow.

R: We agree with this comment. We will change the title of our manuscript as follows: "Rivers in the sky, flooding on the ground: the role of atmospheric rivers for the inland flooding in central Europe"

I have already read the comments made by the other reviewers, and I mostly agree with them. Reviewer 2 suggests to extend the 10-events composites. I will not put that condition as necessary to give my full recommendation to publish, but I think that it could be a good improvement for the paper if the authors are willing to do it.

R: Although we fully agree with this comment/suggestion, our aim was to focus on the most extreme floods in the lower Rhine. For the current study we will keep just this 10 flood events, but in the future we want to make another study in which we want to include more floods events and also analyzed the floods and their triggers in the upper Rhine area. If we extend the current study to more flood events, it means changing almost substantially the structure and the outcome. We want to regard this study as a starting point for more in-depth studies regarding extreme inland flooding and their large scale driver, with a special emphasis on ARs.

Also, this colleague suggests the authors include a discussion about Helen Dacre's (and others) perspective of the importance of local convergence of moisture in ARs development. He/She is right, but I would like the authors to take into account –when they discuss this point– that there is also a huge bunch of articles of all kinds pointing out to the essential role played by the large scale advection of tropical and subtropical moisture. I do not think that the authors should take sides with any of those perspectives –actually, I believe that both mechanisms are necessary, and the relative importance between them changes among the events–, but both may be included in the discussion.

R: We agree with both reviewers comments. Thus, we will try to change the text in the revised manuscript to be able to properly discuss and integrate the aforementioned comments (the importance of local convergence of moisture in ARs development and the role played by the large scale advection of tropical and subtropical moisture).

I will not suggest major changes, however, some of my comments (particularly those regarding the very likely explosive nature of some of the involved cyclones and also those regarding the role played by NAO) will take some time from the authors to be replied. I would like to read and discuss the answers in an eventual second round of the review process.

R: We will try our best to improve the revised manuscript tacking into account the reviewer's suggestions/comment.

Minor Comments
L.43 I suggest the authors consistently arrange the citations by chronological order. It is not only fairer for our colleagues, but also the result is more elegant. For example, in this case, I would start from Lavers and finish by DeFlorio or Guan and Waliser.

R: The references will be modified accordingly.

L.54 Please, leave a blanck space between "50" and "km".

R: The text will be modified following the reviewer's suggestion.

L.57 The beneficial aspects of ARs are not restricted to arid/semiarid areas at all. Most ARs are beneficial even in mid-latitudes.

R: The text will be modified following the reviewer's suggestion.

This idea is well discussed in Ralph (2019), and I think that should be included somehow in the text. Ralph, F. M., Rutz, J. J., Cordeira, J. M., Dettinger, M., Anderson, M., Reynolds, D., ... & Smallcomb, C. (2019). A scale to characterize the strength and impacts of atmospheric rivers. Bulletin of the American Meteorological Society, 100(2), 269-289.

L.65 There are some other important analyses relating ARs and extreme precipitation and floods in Europe that the authors did not take into account. (e.g. Eiras-Barca et al.; 2016, 2017).

R: We will integrate the aforementioned references in the revised version of the manuscript.

L.87 I think that section 2 must be included in the methods section. However, this is just my opinion and I let this decision to the authors.

R: We agree with this suggestion and we will move section 2 in the data and methods section.

L.116 If the authors had SLP, why did they start the vertical integration at the level of 1000 hPa instead of SLP, which would the most correct option?

R: We start the vertical integration at 1000 hPa due to the limitation for the wind and specific humidity data. The SLP data is used to look at the large scale circulation. For the vertical integration we are actually using the surface pressure.

L.130-134 I don't see the need to describe with words what the equations are already saying.

R: The manuscript will be modified following the reviewer's suggestion.

L.135 The algorithm (and database) developed by Guan at UCLA is one of the most commonly used in our field, and I am not going to call it into question. However, did the author consider the possibility that the detection thresholds could have substantially changed in these almost 200 years that they are considering in the analysis?

R: We appreciate this interesting question. Fundamentally, this relates to the question whether the definition of ARs should change as the climate changes, and we think it could be argued either way. In the current study, we chose to use a fixed AR definition – similar approaches have been used for studying AR changes between the current and future climates (e.g., Espinoza et al. 2018; Massoud et al. 2019) and have proved useful. This is also consistent with the study of other types of extremes. For example, a hurricane a century ago is still a hurricane today.

L.136 Please, replace the asterisks by ·

R: The text will be modified following the reviewer's suggestion.

L.152 How well is performing EOBS over Germany? Some analyses pointed out the fact that EOBS may not be the best option over continental Europe...

R: The new EOBS version (v21.e) is rather robust over Germany, mainly because in the E-OBS database the highest number of station are the German ones. The E-OBS data was included in the supplementary figures mostly to show that the precipitation was not located over Germany, but it was stretching From France towards Germany in a rather narrow band (Figure S6).

L.164 Please, leave a blank space between 27 and mm. Take this into account throughout the rest of the article.

R: The text will be modified following the reviewer's suggestion.

L.320 The presence of both the high pressure over the Iberian and the low-pressure north of the British isles will be both almost mandatory requirements for a strong AR to landfall in the region of interest. However, I am not sure that the plots in Figure 11 are really catching the importance of the low-pressure system, which is essentially the one that is carrying the warm conveyor belt and the AR in its pre-frontal region. Particularly, I would be interested to know how many of those 10 systems were explosive cyclogenesis. There is a recent article (Eiras-Barca et al., 2018) analyzing the important correlation between explosive cyclogenesis and strong ARs over Europe, and it would be interesting to know how many of those 10 systems leading to the 10 highest flood peeks were explosive cyclones. Additionally, I think that there is room here for a brief discussion about the role played by the NAO in all this. I suggest the authors include a brief discussion on the matter.

R: Following the reviewer's suggestion/comment we have actually checked if some of the extreme floods analyzed in our study (e.g. 1988, 1993 and 1995) are also associated with explosive cyclones. We have used the database kindly provided by Jorge Eiras-Barca (https://esd.copernicus.org/articles/9/91/2018/esd-9-91-2018.html). For the aforementioned 3 extreme flood events no explosive cyclones have been recorded during the flood peaks or prior to them.
For the whole analyzed period (1836 – 2019) it has been shown that the NCEP-20C reanalysis dataset as well as ERA-20C data are not optimal datasets for extratropical cyclones and windstorms analysis (Befort

et al., 2016) (https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/asl.694). In their study Befort et al. (2016) have show that the use of the long-term reanalysis dataset (NCEP- 20C and ERA-20C) is hampering a reliable analysis of real long-term trends of cyclone and windstorm activity. In a similar study Wang et al. (2013) (https://link.springer.com/article/10.1007/s00382-012-1450-9) have shown that the use of NCEP – 20C ensemble-mean is found to be unsuitable for accurately determining cyclone statistics. Thus, we cannot make a proper analysis regarding explosive cyclones and extreme flood events over Lower Rhine over the whole length of our dataset. Nevertheless, we will insert a brief discussion of this topic in the conclusion part in the revised version of the manuscript.

Figure 1 Is not clear what "euro_dem" is.

R: The text will be modified following the reviewer's suggestion.

Figures 3,4,6,7,9,10,11 Please include the units in the color bars or the arrows.

R: The units will be added for all the figures in the manuscript in a proper manner.