Interactive comment on “The importance of model resolution on simulated precipitation in Europe –from global to regional model” by Gustav Strandberg and Petter Lind

Anonymous Referee #2

The paper “The importance of model resolution on simulated precipitation in Europe –from global to regional model” by Strandberg and Lind assesses the ability of a large set of climate models in simulating precipitation (particularly extremes) in European subregions. The authors find that models with coarse grid spacings underestimate the amount and frequency of extreme precipitation but that the variability between models can be larger than the sensitivity to grid spacing. The novel contribution of this study is the inclusion of global climate model data in their analysis since very similar and more detailed analyses have been done with regional models over Europe. I have two major concerns with this manuscript.

We thank the reviewer for making the effort for reviewing our paper and for all comments. Responses follow below in red. In the markup version of the revised manuscript substantial changes are also marked in red.

First, it does not account for the spatial dependence of extreme precipitation. I argue that the authors can obtain the same results by first aggregating E-Obs observations to a coarser grid and then comparing the aggregated extreme precipitation with the original E-Obs data. They would also see that the coarser version of E-Obs “underestimates” extreme frequency and magnitude. Coarse-resolution models should not reproduce the magnitude of extreme events on local scales since they model aggregated rainfall over large areas (e.g., 100x100 km).

The main objective of the paper is not really to focus in precipitation extremes but rather the full distributions (which includes aspects of extremes). We are aware that extremes may not always be well represented in observations, depending on multiple factors including the spatial and temporal character of such events, and we try to acknowledge these weaknesses in the observations in the discussions of the results. As you say the model grid resolution sets limits to what the model can actually resolve but we argue that it is still important to show to what extent different models, from GCMs to RCMs, exhibit similarities and differences in the full precipitation distributions for different regions and seasons.

My second concern is the use of E-Obs for this analysis. E-Obs has very low station density over large parts of Europe and heavily underestimates extreme precipitation. There are other observational datasets available that are far more appropriate for the presented analysis. More details on these comments including relevant literature is provided below.

It is true that E-OBS is inherently associated with uncertainties and the quality is highly dependent on the underlying station density as you say. We intended here to keep the model-observation comparison consistent for all sub-regions by using the same observational data set and hence constrained the comparison to E-OBS solely. We have included a separate section (Sec 2.2) with a discussion of observations and related uncertainties. Furthermore, to highlight the importance of high-quality data sets, we have included in one of the ASoP analyses a regional high-resolution data set (Nordic Gridded Data set, NGCD) that covers the Scandinavian region (see Fig. 3 in Supplementary material). It is seen that NGCD has higher contributions for both low and high precipitation intensities, providing more confidence in especially the RCMs (at least over this region).

General Comments:

1.I have major concerns with your approach to compare extreme precipitation. Extreme precipitation is strongly scale dependent and largest on point scales (e.g. measured by precipitation gauges) and decreases on larger spatial-scales. E-OBS for example has way weaker extreme precipitation than other regional datasets in Europe that feature higher resolution and a higher station density (e.g. Prein and Gobiet 2017). If you compare extreme precipitation on the model native grid, you mix the model ability in simulating extreme precipitation with the spatial scale on which the model simulates extremes. E.g., extreme precipitation in a 100 km grid spacing model should not match observed extreme precipitation on a 25 km grid. In this case the only way to do a fair comparison is to aggregate the 25 km grid observations to the 100km model grid. This aggregation does not introduce large biases such as you state for interpolation (in Line 127-128).

We have now also included analyses where all data are regridded to a 0.5°×0.5° and a 2°×2° grid. This makes it possible for us to separate the effect of model physics from the effect of just having more data points.

2. E-Obs should be used with care for extreme precipitation (Haylock et al. 2008). There are other/regional datasets in Europe that are much better suited for the assessment of extreme precipitation (see Prein and Gobiet et al. 2017).

As mentioned in the response above we have included one other regional data set for the region of Scandinavia (the NGCD data set, see Fig. S3 in Supplementary). However, we would like to emphasize again that extreme precipitation is not the main focus of the study, rather a more holistic approach in the investigation of the model's representation of precipitation over Europe.

3. You are missing to discuss and to refer relevant literature on the ERUO-CORDEX simulations that performed very similar analysis as you present. Kotlarski et al. (2014), Casanueva et al. (2016), and Prein et al. (2016) address similar questions and come to fairly similar conclusions. The novelty of your analysis is that you also include GCM data, which is a valuable contribution but does not change the major conclusions. You should also take a look at Thackeray et al. (2018) who show a highly relevant analysis of model grid spacing and extreme precipitation on a global-scale.

The Introduction has been expanded with a paragraph discussing Demory et al., and Iles et al., as well as other similar studies using CORDEX data:

A few studies have been made investigating how model resolution affects the simulated precipitation in the CORDEX ensembles, comparing 50 km and 12.5 km grid spacing. A clear result is that precipitation generally increases with higher resolution, which sometimes means that the bias increases when precipitation is added to already wet models (Kotlarski et al., 2014; Casanueva et al., 2016); something that is also seen in simulations with global models (e.g. Thackeray et al., 2018). An overall improvement of mean precipitation is not seen the high resolution CORDEX simulations, except for regions with complex topography (Korlarski et al., 2014; Casanueva et al., 2016; Prein et al., 2016). Prein et al. (2016) looked at local precipitation on short time scales. They find that 12.5 km simulations better represent extreme and mean precipitation, also when simulations are aggregated to 50 km. They note, however, that the results are highly dependent on which observations the simulations are compared with. They also note that improvements are on the ensemble as a whole, and not necessarily for each individual model. In similar studies as the present Iles et al. (2019) and Demory et al. (2020) compare CORDEX simulations with simulations from CMIP5 and Primavera. They see that precipitation increases with resolution so that CMIP5 underestimates precipitation amounts and CORDEX overestimates it, when compared to E-OBS, and that the effect of resolution is largest in complex topography. They also find that Primavera performs similarly to CORDEX when run on the same resolution, which is interesting regarding that the Primavera models are developed for low resolution. Iles et al. (2019) also find considerable inter-model differences meaning that improvements are seen on the ensemble level rather that for individual models.

4. Please be careful with the use of model resolution. In most cases you refer to model grid spacing. Model resolution depends on the numeric diffusion in the model and models with the same grid spacing can have different resolutions. The effective resolution of a model is typically 4-8 times its grid spacing (e.g., Skamarock 2004).

Thanks for reminding us about this. We tried to straighten up the terminology so that we use "grid spacing" when talking about distances in km and "resolution" in more general statements, like "comparing high and low resolution models".

5. There are many typos and grammar errors in the document. Please consider using a proofreader before resubmitting the document.

Typos are corrected. We apologise for the lack of proof reading, as a reviewer it's annoying to have to correct typos.

Literature:

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