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Interactive comment on "The benefits of increasing resolution in global and regional climate simulations for European climate extremes" *by* Carley E. Iles et al.

Anonymous Referee #2

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In the manuscript "The benefits of increasing resolution in global and regional climate simulations for European climate extremes" Iles et al. assess the dependence of simulating extreme event intensity on model resolution and model strategy (regional vs. global) over Europe. They show that higher resolution simulations have generally stronger extremes with higher sensitivities for precipitation and wind extremes than for temperature extremes. Their results generally confirm previous studies and for me, the greatest value of this paper is the combination of a large range of models and investigating three extreme events, which provides a good overview. I also like the upscaling analysis although it is kept fairly brief. However, I have concerns in how the team compared models with different resolutions and would like to see a more careful usage of the word model bias especially in the context of precipitation and wind analysis for which the used observational datasets are of questionable quality. Below is a more detailed description of my major/general and minor comments.

Major/general comments:

1. I have concerns with using nearest neighbor remapping for extreme value analysis. This remapping method will artificially increase extremes in high-resolution data particularly in situations with strong gradients. For instance, precipitation extremes are typically very localized and have strong spatial gradients. You are remapping the 0.11 EURO-CORDEX simulations to a 0.5deg grid. This means that you pick the closest 0.11deg grid cell to each 0.5deg cell and assume that it rains ass much on the 0.5deg area than on the 0.11deg area. This is certainly not the case and by doing this, you violate mass conservation of precipitation. I strongly recommend using a conservative remapping method that conserves mass and energy while remapping. This will affect many of your results since you generally find that extremes are more intense in the high-resolution simulations. Using conservative remapping will dampen this effect and might change your conclusions.

2. Along coastlines, you have to be careful that you only consider land grid points in your evaluation against land-based observations. As you mention in your wind speed analysis, there is a sharp gradient in wind speed but also for temperature extremes between ocean and land. I am not sure if your interpretation that high wind extremes propagate further inland in coarse-scale models is correct. Could it be that you include ocean grid cells in your analysis, which cause a high bias in low-resolution models?

3. Please use a lapse rate adjustment when comparing temperature extremes between model grid spacings. Your finding that heat extremes are less overestimated in high-resolution simulations in topographic regions is trivial since the coarse resolution models have lower topography and therefore higher temperatures. You could simply use the topography of E-OBS and correct the model temperature with a climatological

average lapse rate (e.g., 6.5 deg C per km).

4. Please avoid writing about model biases when you compare extreme precipitation to E-OBS. You mention that E-OBS underestimates precipitation extremes, which means that you would like a model to be wetter than E-OBS. Evan the MESAN precipitation extremes are likely too low. I suggest being very careful how you use the word bias and rather use difference when comparing to precipitation but also wind datasets.

5. The separation of CMIP5 and CORDEX results from the UPSCALE results make the paper unnecessary long and harder to read. I recommend combining sections 4.1 and 4.2 since I do not see a good reason to separate the UPSCALE ensemble from the other datasets. Also, combining figures 1, 3, and 4 with 5, 7, and 8 would be beneficial. You could do this by not showing the results for all and common ensemble members but only one of the two. They are very similar anyway.

6. Also, the summary and discussion section could be combined. After the summary section you again briefly summarize results in the discussion. You would lose very little information by removing the summary section.

7. I am concerned with how different the three wind observations are. Are they all equally likely? Looking at the big differences between these observations makes me wonder if you can/should evaluate the models at all. Just looking at your fields in Fig. 4 (c,f,i) makes me wonder if these datasets can even capture topographic effects. The low wind extreme minimum over the Alps looks very unrealistic and event he models seem to do a better job capturing these effects that the observations. Would the use of MESAN winds be a better option?

8. Please be careful when you use the term model resolution and do not confuse it with model horizontal grid spacing. The model resolution is typically 4 to 8 times the model horizontal grid spacing (Skamarock 2014)

Minor Comments:

L37-8: Please explain what a long-standing anticyclone is? Do you mean a stationary anticyclone?

L41: I would say "flash floods" here since river floods involve large-scale processes.

L43: I suggest "poorly resolved" since some of these processes can be resolved at fairly large grid spacings.

L50: Could you please be more specific than "small-scale processes and features involved"

L89: What do you mean with "their" in "to their information"?

L136: E-OBS has quite high station density in some regions (e.g., Slovenia, Germany) but low density in others (e.g., Austria, Spain)

L168L: "us to identify"

L173: Are these daily maximum surface wind speeds based on model time step wind speed or hourly maxima of instantaneous wind, or something else?

L174: "Those consist of"

L192: What is this alternative dataset for SST?

L203: Performing your analysis on a 0.5deg grid is fine but you have to say that this will deteriorate the skill of the coarser grid spacing simulations.

L228: Temperature can have strong gradients along coastlines and in orographically complex regions that you mention quite a lot in your results. Therefore, using bilinear interpolation might also not be the best choice here.

L228: I agree that these are rare events but you should mention that you decrease your sample size by looking at rare events, which makes robust statistics more challenging.

L251: I am not familiar with this method of pooling extreme values from an ensemble. You correct the models for a mean bias but you do not correct for the shape and scale

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of the tail of the distribution. Does this not mean that you base your high return values mainly on the models that have a very long tale? Is there a reference for this method?

L283-7 & 304-8 & 318-9 & 364-8: This information does not have to be duplicated here since it is already mentioned in the figure caption.

L332-3: Gauge under catch could not only contribute it definitively does. This can be substantial especially for extreme precipitation that are associated with high wind speed (northern latitudes) and in snow-dominated regimes.

L474: I can also see this in the N96 simulation but the Alps are much wider at this grid spacing.

L481-3: A model's grid spacing is always higher than its resolution (see e.g. Skamarock 2014). L559: Did you detrend your 500 hPa geopotential height before you did the analog analysis. There is a high chance that the 500 hPa geopotential increased during your simulation period, which might affect your analog analysis.

L542-73: This should go into the methods section.

L696-7: Getting benefits from upscaling might demand convection-permitting climate simulations (Hart et al. 2018).

L715: This is not true in Ban et al. (2015). They show very similar increases in extreme precipitation between their 12 km and 2 km model results.

Literature:

Skamarock, W.C., 2004. Evaluating mesoscale NWP models using kinetic energy spectra. Monthly weather review, 132(12), pp.3019-3032.

Hart, N.C., Washington, R. and Stratton, R.A., 2018. Stronger local overturning in convectiveâĂŘpermitting regional climate model improves simulation of the subtropical annual cycle. Geophysical Research Letters, 45(20), pp.11-334.

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