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Hydrology and Earth System Sciences
Discussions

Interactive comment on "An evaluation of the importance of spatial resolution in a global climate and hydrological model based on the Rhine and Mississippi basin" *by* Imme Benedict et al.

Anonymous Referee #1

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The study 'An evaluation of the importance of spatial resolution in a global climate and hydrological model based on the Rhine and Mississippi basin'Âăby Benedict et al evaluates the effect of increasing resolution in a global climate model and a global hydrological model on the mean, seasonal cycle and extreme river discharge in the Rhine and Mississippi basins. I find this study very original. I particularly like the idea of cross-resolutions (high GCM - high GHM, high GCM - low GHM, low GCM - high GHM, low GCM - low GHM), and I think that the findings are well suited for the HESS journal.

The figures are clear. The paper is well written, but it could gain in clarity. Some

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sections are not well organised, some important information (about the models for example) is missing. I also think that a few additional analyses could be added to better see the benefits of running high-resolution GCMs, compared to the low-resolution and particularly compared to observations.

Moreover, it is only in the discussion section that we learn that horizontal transport is switched off in the GHM. This is probably why there is no improvement between the low and high-resolution GHM, which probably biases the findings of this study. It would have been essential to see the impact of such improved representation of river flow on the mean and extreme discharge. See my detailed comments below.

Detailed comments:

- Page 2, L10: could you expand this sentence to specify which parameters are unknown or not easily quantifiable? Also in Page 5 L3 and L4: which parameters are remapped? Which method is used to remap them?

- Section 3.2: it is not mentioned whether there is horizontal transport in W3RA or if it is only vertical through the soil layers. According to the discussion section, the high-resolution version could have horizontal transport but it was switched off for better comparison with the low-resolution model. It seems to me that this should have been kept on for a more realistic representation of the moisture flow. Why can't the low-resolution GHM have it on as well? If horizontal transport was on in both versions, we would certainly see an impact of resolution, due to the slopes of orography for instance. Here the authors conclude that resolution does not play a role in the GHM, while (to me) a very important aspect of the model is left out.

If feasible, it would improve the study to have an extra simulation using the low-resolution GCM and low- and/or high-resolution GHM with horizontal transport. If not possible, then this aspect needs to be highlighted much more in the abstract, model description, and discussion.

- Page 5, L14-15: is one year enough for spinup? Is soil moisture in equilibrium? How deep are the soil layers?

- Section 3.4: The authors use the term ‘coupling’ between the GCM and GHM but the right term should be forcing/driving, as their is no interactions/feedbacks involved.

At which frequency are the forcing fields used?

- Page 6, L3: GHM forced with ERAI data: how long is the simulation? Is it 1 simulation of 30 years, or 6 simulations of 5 years?

- Page 8, L14-15: Is it really an improvement due to the storm track? Could it be also that the high-resolution GCM simulates precipitation over orography more accurately, as well as the dry shadow at the lee of the mountains (as shown on Fig 4)? To verify the hypothesis of better moisture transport, the authors could do a map of precipitation and moisture fluxes (as arrows) using a larger domain that includes part of North Atlantic.

It would be good also to add the convective part on this panel to determine if the peak in June is mostly convective.

- Page 9, Fig 5: evaporation panels: are solid lines GCM only, and dashed lines GHM at 0.5d forced by low and high-resolution GCM? If so, this needs to be made clearer in the caption.

- Page 11, section 4.1.2: why is the high-resolution GCM worse than the low-resolution for the most extreme precipitation events in SON, while the discharge is better?

Moreover, the high-resolution model shows much higher precipitation extremes but Fig 5 shows a similar mean seasonal cycle between low- and high-resolution models. So what is the contribution of extreme precipitation to the mean over the Mississippi?

- Fig 7: it is hard to see any difference. Do instead a difference plot. CPC, low-res minus CPC, high-res minus low-res. It could even be more informative to split it into seasonal means.

- Section 4: I find it difficult to have to jump back and forth between the different figures, read about the Rhine, then the Mississippi, then the Rhine again, etc. To facilite the understanding of the results and connect the processes together, it would be easier to have a whole section on the Rhine, then a whole one on the Mississippi, and modify the Figures accordingly.

- Fig 10: how do the models compare with observations? Is the distribution at high-resolution closer to observations?

Moreover, would these distribution look the same in the high-resolution GHM? If horizontal transport was allowed, how would these distributions look like?

- Page 20, L15-16: high-resolution is needed for such an extreme event, but is it realistic compared to observations? Adding observations would be useful here.

Moreover, if you select an extreme event in the low-resolution simulation, what does the large-scale circulation look like? The low-resolution model is probably able to simulate the large-scale pattern right but does not precipitate over the right location because of orography, or does not transport enough moisture across the ocean. It would be useful to have an extra case using the low-resolution model, look at the circulation, moisture transport and precipitation.

Minor comments:

- Page 2, L20: Replace Table 1 by Fig 1

- Page 2, L28-31: Add references for the Mississippi basin, as done for the Rhine basin before.

- Page 3, L2: replace ‘empties’ by ‘discharges’

- Page 4, L13: replace ‘medium’ by ‘low’ for consistency

- Page 5, L7-8: instead of writing ‘which means that there are no extra processes resolved at the higher resolution’, which is vague (what extra processes? Horizontal

transport? Others?), add that differences between low and high-resolution GHM only come from better representation of orography and vegetation.

- Page 5, L9: replace Table by Fig

- Page 5, L12: what is ldd? (also page 17, L8)

- Section 3.3: replace title by a more explicit one, such as 'Observational datasets for model validation'

- Page 5, L29: replace ERA-Interim LAND by ERA-Interim/Land.

- Page 6, L2: replace Table by Fig

- Page 15, L26: replace where by are.

- Page 17, L5: replace but by and.

- Page 17, L18: replace weather by climate.

- Page 17, L23: replace arrow by words, for example: 'in the T799 GCM forcing the 0.5d GHM'.

- Fig 10: it looks like the selected events are annual means, as it is difficult to see the triangles. To see the events better, use larger triangles for example.

- Fig 10 caption: 'The different seasons are indicated with the colours and regression line and correlation value': be more descriptive: DJF (purple), etc. Be more descriptive on the plot as well: AM 10TP, AM Q?

- Page 20, L1: replace 'First, we show' by 'Fig 10 shows'

- Page 20, L3-4: repetition of caption, delete.

- Section 4.4: use subsections for the Rhine and the Mississippi.

- Page 21, L14: remove the term coupling

- Page 22, L6: replace ‘experiments’ by ‘model simulations’

- Page 22, L32-33: cite previous studies, as this finding is not new.

- Page 23, L26: replace ‘by the author’ by ‘to the authors’

- In many places in the manuscript, the word ‘run’ is used. I think ‘simulation’ is better in a scientific context, while ‘run’ pertains to the technical aspect of the simulation.

- Some acronyms are not defined: CMIP5, ISI-MIP, FAO

- I found a large number of typing errors in the manuscript. I suggest the authors to carefully check their manuscript. For example, there are many words in singular while they should be plural.

A few examples:

- title: use plural: models

- Page 2, L22: use plural: models

- Page 2, L24: use plural: basins (also in other places in the text)

- Page 2, L29: typo: Caribbean

- Page 2, L30: typo: precipitation

- Fig 2 caption: use plural: basins, stations

- Page 5, L5: typo: conclude

- Page 5, L14: typo: timeseries

- Page 11, L2: typo: particularly

- Page 11, L3: typo: overestimation

- Page 17, L15: use plural: resolutions

There are many others.

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