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Hydrology and Earth System Sciences
Discussions

Interactive comment on "South Asia river flow projections and their implications for water resources" *by* C. Mathison et al.

Anonymous Referee #3

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Summary: This paper presents an analysis of changing annual river flows projections for two major basins in South Asia based on two GCMs (HadCM3 and ECHAM5) downscaled to 25km using HadRM3 RCM and TRIP river routing scheme. Robustness of the downscaling is presented by comparing it with downscaled ERA-interim and observed river flows at selected GRDC gauges. A major conclusion is that the region will plausibly witness increased high flow events.

Comments: This is an interesting study and publication worthy. I have neither looked into previous comments on the manuscript nor the response of the authors. Hence, my comments/concerns in the following may overlap with prior comments and the authors may already have proposed how to respond to some of them. My major concern is with the downscaling methodology. I list my concerns in the following.

1) How is downscaling performed? The authors state that GCMs and ERA-interim drive the RCM but the details are missing. I assume GCMs provide coarse scale inputs to the RCM but the RCM perhaps requires finer scale forcing to produce 25 km outputs. Perhaps the RCM resolves the finer scale details but which details and how is not clear. A clear description of this downscaling strategy is needed in a step by step manner. Further, a justification for why driving RCM by a GCM can be called a downscaling exercise is needed.

2) I assume a comparison of streamflow at selected gauging stations based on 'downscaled' GCM via RCM with the observed (and ERA-interim-RCM derived streamflow) is supposed to be a validation of the performed downscaling exercise. However such a comparison is not convincing enough for it to be called validation. The authors may want to provide evidence that supports the robustness of the downscaling performed, perhaps based on better datasets available elsewhere (not limited to South Asia). Such validation need not be on observed streamflow but on other variables that the RCM simulates. Nonetheless, this does not disqualify the validity of the downscaling exercise itself – it appears (based on my limited understanding of 'downscaling' implemented here) that RCMs introduce physics based constraints on the process of disaggregating coarse scale variables to finer scale 25 km resolution.

3) It is not clear if ERA-interim drives the same RCM as the GCMs? – should be HadRM3?

4) Figure 3, cannot clearly see ERA-interim.. Need a different color

5) Page 5801 – not clear why the units of total annual precipitation is mm/day? Needs further clarification.

6) Figure 4, ERA-interim appears to be the same as GCMs while it is difficult to compare the 3 with the observed in Figure 5. I think the RCM constrained downscaling needs to be compared with a statistical/naïve downscaling method for example rule based or statistical disaggregation of coarse scaled GCM variables to 25 km and using

it to drive a hydrological model. In addition, these should then be compared with a control simulation of no downscaling, i.e. the case of driving the hydrological model with the outputs of GCMs/ERA-interim. This can then highlight the value that RCM adds to the downscaling exercise. This will then also highlight whether we need RCM based (or any other) downscaling to arrive the conclusion that the region will see more high flow events in the future.

7) Page 5803: Why 1.5 stdev for GCM is used for the uncertainty bound? Why not the same of the observed? There may be other ways to further define these uncertainty bounds, e.g. based on a-priori knowledge about measurement errors etc.

8) Line 20, page 5803: Ganges/Farakka gauging station is also sufficiently downstream in a basin where there is heavy GW extraction. Why is the same pattern not seen as in the Kotri gauge, where higher than observed simulations of GCMs and ERA-interim are attributed to the lack of extraction scheme in MOSES?

9) Page 5806, figure 7: How about a similar figure for rainfall, i.e. precipitation climatology both for downscaled and coarse scaled (original) products. This and comment 6 will clarify the role (and the value) of downscaling in revealing the pattern of increasing high river flows.

10) Figure 5 should be split into two. One which shows past to present and the other which shows future projections for the two GCMs for clarity sake.

11) Do future streamflow projections incorporate plausible land cover land use change as well as socio-economic scenarios? – if not then the produced annual river flow projections via a complex MOSES land surface model are perhaps as good as downscaling climate projections and using them to drive a simple water balance model in representing plausible futures. This also touches upon comment 9. The authors may again want to clarify the value added of using HadRM3 while responding to this comment-why do I need such extravagant downscaling when it does not incorporate aspects of changing socio-hydrology of the basins – perhaps it provide an upper bound of sorts

but I doubt it.

12) Figure 9 and elsewhere: Need to state in the caption that the counts for the two GCMs appears in the upper right corner of the figures.

13) Implications of river flow projections for regional water management: How confident can we be of stated water management implications when the RCM used is weak in terms of incorporating plausible socio-hydrological trajectories in the region? MOSES does not incorporate GW extractions, plausible land cover and landuse futures, regional land surface-atmosphere feedbacks, plausible socio-economic futures such as population, demography and economic growth etc. These implications are probably as good as those that one would arrive at if only downscaled precipitation and temperature variables are used and run through a simple and static water balance model (by static I mean that its parameters that correspond to landcover etc. do not change). Please see comment 11 as well. Perhaps another control simulation may need needed for comparison where in downscaled climate variables are used to force a very simple water balance model (for example a single bucket model with a threshold).

14) Page 5815, line 22: The authors mention that increasing variability poses a challenge for the region but no analysis is provided to justify the claim that river flow will be become more variable in the future.

15) Page 5816, lines 16-17: Same as the above. The authors mention temperature and variability in precipitation but no analysis is provided to back the claim. The paper will be stronger if additional analysis for variables that are downscaled and its variability is provided. This also connected to comment 1, where the need for clarifying the downscaling process through a detailed description of various involved variables (in addition to other) has been expressed.

16) Towards the conclusion, I am unable to see what the comparison between ERA and GCM downscaling tells us about the robustness of downscaling and simulation of river flows.

17) I often encountered too long sentences, the authors may want to break them into smaller more digestible sentences.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 5789, 2015.