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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Climate change alters low flows in Europe under a 1.5, 2, and 3 degree global warming" *by* Andreas Marx et al.

Anonymous Referee #2

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General comments

This manuscript explores the impact of climate change on low river flows in Europe using a multi-model GCM and hydrological model (HM) ensemble under three global warming scenarios. The use of this ensemble allows the authors to assess the range of uncertainty in projections and the relative contributions of GCMs and HMs. Overall, it is an interesting and informative study, well-written and clear, supported by appropriate figures and references. There are some questions surrounding catchment selection for model validation and the general omission of smaller catchments, as well as the extent to which conclusions can be drawn on drought when analysing only flow percentiles. However, once these and some other interpretational aspects are addressed, I would recommend this study for publication.

Specific comments

Evaluating model performance (Page 4, line 30 to Page 5, line 4): I think more interpretation is required of Fig 1. There are only nine lines devoted to this, and I am not sure that I entirely agree with the assessment that "results show a good agreement" without some caveats. Low flows for PCR-GLOBWB and median flows for Noah-MP are systematically over-estimated across almost all catchment sizes, and there is a systematic under-estimation of low flows for Noah-MP. Whilst no-one is expecting perfect model results, there should be more attention given to the validation, as well as additional text in the discussion on the potential influence of model performance on the conclusions drawn.

Catchment selection for validation (Figure 2): There is no information on how or why these catchments were selected for validation. It would appear that a number of nested sub-catchments of relatively few large rivers have been selected (i.e. multiple downstream stations on the Rhone, Loire, Ebro, etc.) There is also no information on from where the river flow data were sourced. Data are freely available for some regions where the models are not evaluated but for which results are presented.

Omission of catchments <10,000km2 (Page 8, lines 13-15): Perhaps this argument explains the selection of catchments in Fig 2? I am not convinced that modelled data at 5km spatial resolution cannot resolve the river flow network of catchments <10,000km2. The authors highlight the "unprecedented" (Abstract) 5km spatial resolution and on a number of occasions highlight the "spatially explicit information" in this study, but removing smaller catchments seems not to capitalise on this. This section also says that such catchments will be removed, but the maps displayed in Fig 3 onwards all feature a river flow network which contains routed flows for catchments less than 10,000km2, in which the network appears to be relatively well defined. All of this is relevant also in relation to the comment above on model performance at the lower end of the flow regime across all HMs (Fig 1). Catchments <10,000km2 also omitted from Fig 4; are the results similar?

Drought or low flows (throughout manuscript): There is some inconsistency between the use of 'drought' and 'low flows'. This paper analyses changes in median annual Q90 flows, which allows conclusions to be drawn on climate change impacts on low flows but not necessarily drought. The authors use low flows and drought at times interchangeably, including in the research questions and conclusions.

Robustness (Page 10, line 6): There is detail on the hotspots of changes in low flows, but in the end the low robustness means that for the Mediterranean / Atlantic, changes are not 'likely' (as defined by the authors) for most of these areas for either 1.5K or 2K. In fact, the signal for the Mediterranean might be stronger than that for the Atlantic, but it is less robust than the Atlantic. Statements like "Nevertheless, these results are not robust" (Page 13, lines 17-18) could be useful here.

Uncertainty from GCMs or HMs: There are a number of statements on Page 18 that need to be clarified in relation to Table 4. "HMs are the major source of uncertainty in the Alpine region" – GCMs and HMs are closer together in Alpine compared with other regions, but the numbers in Table 4 are similar for GCMs and HMs across all warming levels, and GCMs are higher for 1.5K. "The Northern area shows a nearly similar contribution in GCMs and HMs" – so does Alpine (see above), and GCMs and HMs are even more comparable for 2K and 3K in Alpine than in Northern. "In the Mediterranean, the uncertainty due to the HMs rises with increased warming" – this is true for all regions. It is also strong to say that GCMs "dominates" total uncertainty for Europe (Page 18, line 33), especially given the negligible differences between GCMs and HMs for two of the five regions.

Technical corrections

Page 2, line 32: "differ- ent" to "different"

Page 4, line 11 - Page 5, line 4: Very lengthy paragraph could be better structured and split into multiple shorter paragraphs.

Figure 1: Useful to have a legend for colour based on GCM as there are some systematic patterns.

Page 11, line 9: "Q10" should be "Q90"?

Page 11, line 11: "to a large extent"

Page 15, line 11: Mediterranean should be "(-16%)" not "(-24%)", reading off Table 3 for 2K to 3K?

Page 17, line 1 (and throughout): "Targus" should be "Tagus"?

Table 4: It's more editorial, but Fig 6 discussed before Table 4 despite being featured afterwards.

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