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Interactive Comment

Interactive comment on "Future hydrological extremes: the uncertainty from multiple global climate and global hydrological models" *by* I. Giuntoli et al.

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Anonymous Referee 2 Received and published: 2 March 2015

This paper is a concise analysis of the potential consequences of projected climatic conditions on low-flow and high-flow frequencies globally. On the whole, the paper is very clearly written, and I only have a few concerns.

Answer We thank the reviewer for the positive review and helpful suggestions.

Comment-1 As Section 4 of the paper correctly notes, there are several sources of error not investigated in this study, such as bias correction, CO2 and vegetation dynamics, emission scenarios, and internal variability. In view of these sources of uncertainty, the abstract (line 21) should not state that using multiple GCMs and GHMs is sufficient to envelop the overall uncertainty range.
Answer We agree, the use of multiple models alone does not allow embracing all of the uncertainty. We will edit the text accordingly.

Comment-2 Page 4, lines 8-15 also bear on the issue raised in my first comment. Prudhomme. et al. (2014) and Davie et al. (2013) are reported to find that biome models which include effects of varying CO2 produce more runoff than purely hydrologic models. This implies that using GHMs without a varying CO2 effect not only will not envelop the overall uncertainty range, they may also bias the results toward less runoff. So some runoff possibilities may be missed by a set of hydrological GHMs, and at the same time some erroneously low runoff solutions might be improperly included within the uncertainty range.
Answer We agree, this is a critical point. The aim of including a rich set of GHMs in order to capture a representative uncertainty range had to come into terms with the applicability of the method. During our analysis the two biome models available through ISI-MIP have shown the presence of large pools of zero values in their time series that caused heavy land masking, thereby hampering the global comparison assessment. As shown in Fig.1 index extraction was vetoed over large parts of the globe leaving only 61% for JULES and 20% for LPJmL of land gridcells after masking (with the veto rules described in Appendix B). Note that the masking applied to the mamuscript's ensemble is formed by superimposing masking from each of the GHM-GCM combinations.
The unavailability of historic simulations with the same GHMs to evaluate the GHMs' ability to represent the different aspects of runoff regime (e.g. high, medium and low flows) lead us to adopt the pragmatic approach of using the largest possible ensemble

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of models common to both high and low flows. Another option could have been to use one ensemble for low flows and one for high flows (with JULES, though posing limitations with resolution and masking), but we would loose consistency in the global comparison of projections of changes and ANOVA across flows.
We are aware of the potential underestimation of the uncertainty or bias towards non-biome GHMs, and this is not confined to CO2 processes in plants but also include spatial resolution (as the reviewer mentioned below), internal variability in GCMs, GCMs and GHMs parameterization, and lack of detailed processes such as e.g. surface and groundwater exchanges or glacier in GHMs. However, our results demonstrated that, even excluding biome models and other model structure differences in the ISI-MIP ensemble, large uncertainty in the signal of changes in high and low flows is attribuatble to GHMs and not only on GCMs. We will amend the abstract and extend the discussion to highlight this important point. We will also attach to Appendix B a table of gridcell availability per GHM-GCM combination for high and low flows.

Comment-3 A related issue not mentioned, but which should be mentioned, is that the mere inclusion of multiple models is insufficient to fully scope the uncertainty associated with models. Structural model errors are not all random; some structural errors, such as insufficient resolution, are common across all models. Using multiple models does not help with this aspect of model uncertainty.
Answer We agree, we will refer to this aspect of the difficulty to fully scope the models uncertainty in our revised manuscript (as in our reply to Comment-1).

Comment-4 Page 5, bottom should include mention of which (if any) GHMs include varying CO2 effects. At present, the reader is left to wonder until near the end of the manuscript.
Answer Yes, as suggested, we will state in the Data and methods Section that none of the GHMs used in our ensemble include varying CO2.

Comment-5 Page 6, lines 21-25 are written incorrectly. As written, for HFD, a cell exceeding the Q95 value may be assigned a value of either 0 or 1, while the assignment for a cell that doesn't exceed the Q95 value is undefined. The same applies to LFD. Lastly, the reference to the Appendix should be to Appendix B.
Answer Yes, actually the value of 1 is assigned only if the cell exceeds the Q95. We will rephrase: "For HFD, a value of 1 (high flow) is assigned to each cell if the cell's runoff exceeds the Q95 value, otherwise a value of 0 (no high flow) is assigned"; and similarly for LFD.

Comment-6 Page 8, line 24 to Page 9, line 4: Seasonal differences are to be expected, but there seems to be no obvious reason why the NH in boreal winter should behave like the SH in austral summer, or why the NH in boreal summer should behave like the SH in austral winter. Yet, by discussing globe-wide variations in terms of DJF and JJA, this is what you are implying. To better frame the discussion, and to see whether this surprising possibility is borne out by the data, create separate Fig. 2 charts for each hemisphere.
Answer Approximately 80% of landcells are located in the NH, while 20% in the SH (not considering masked areas). Therefore, global results are dominated by boreal seasonality (high flow changes dominant in DJF, and low flow changes dominant in JJA). Splitting the manuscript's figure into three latitude ranges (Fig.2): North (Lat>23.5); Tropics (23.5<Lat<-23.5); and South (Lat<-23.5); the North still accounts for the majority of land (65%) with results that are broadly similar to the global ones. With three latitude bands, we can notice PDF shifts of e.g. DJF towards decreased changes for high flows and increased changes for low flows.

Interactive comment on Earth Syst. Dynam. Discuss., 6, 1, 2015.

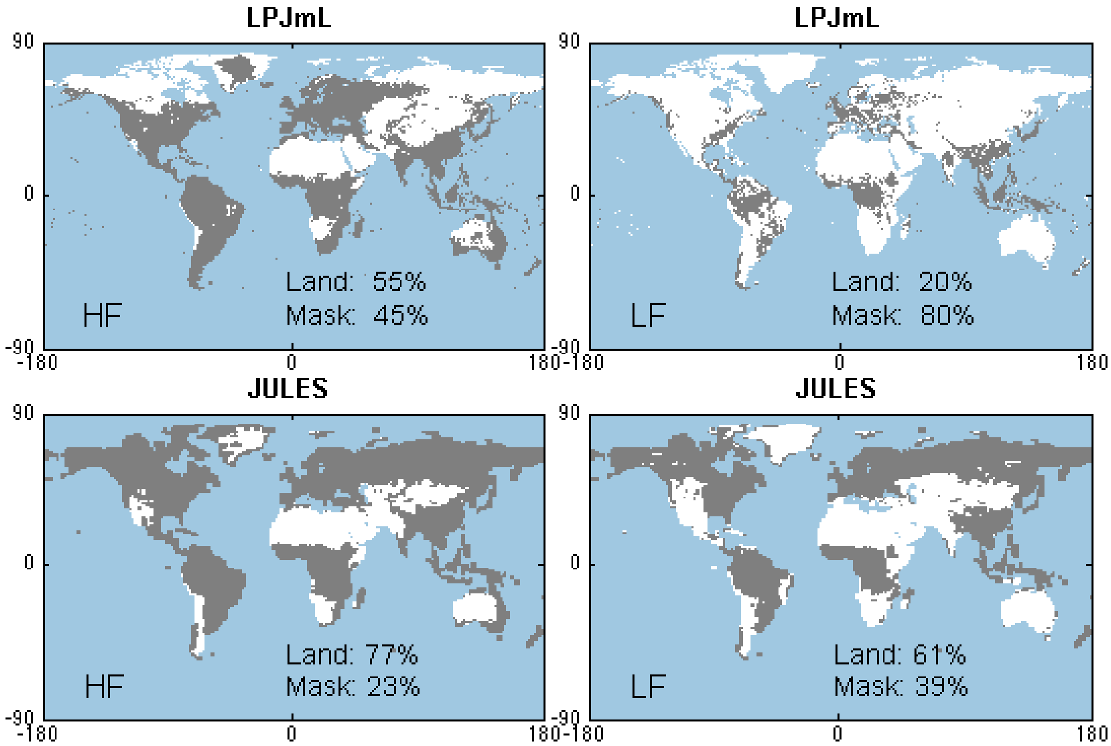

Fig. 1. Land masking upon HFI and LFI index extraction for the biome-model GHMs (not included in the ensemble): LPJmL and JULES (top and bottom panels respectively).

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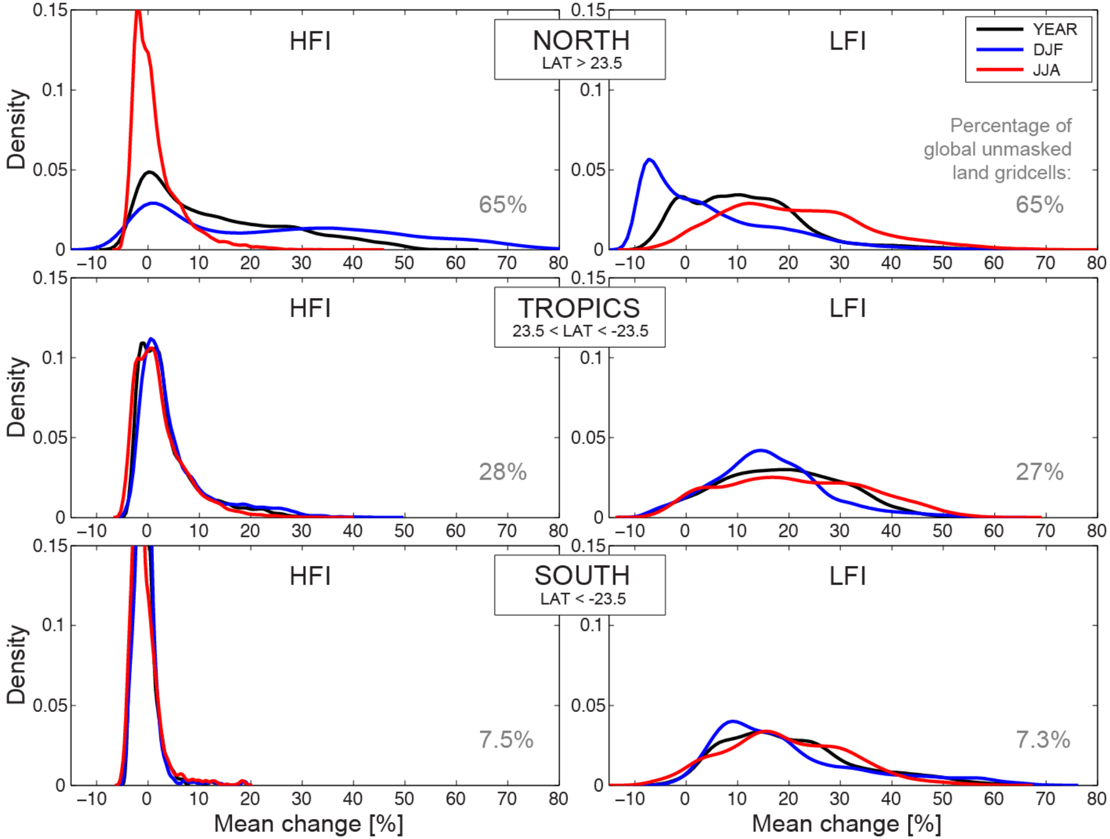

Fig. 2. PDFs of mean changes in high (HFI) and low (LFI) flows, annually and per season (DJF and JJA) referring to North, Tropics and South latitude bands.

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