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

I. Giuntoli et al.

ixg282@bham.ac.uk

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Referee 3 Antonio Speranza Received and published: 2 March 2015

Comment-1 The addressed topic is interesting and quite a bit of performed work is reported in the paper; in particular, I appreciated the effort in assessing the relative contribution of GCMs and GHMs to "uncertainty". I think, however, the reader could be helped in forming his own judgement if some more information was provided here and there; for example, by showing specific examples (giving an idea of the nature of analysed fields) of runoff fields for different models.

Answer We thank the reviewer for the positive and helpful suggestions. As suggested, we could provide in Annex a specific example of mean annual runoff from the control period for five representative gridcells (Fig.1) i.e. one per main Koppen Geiger region (A-Tropical, B-Arid, C-Temperate, D-Cold, E-Polar) for the different global model combinations i.e. GCMs-GHMs.

Comment-2 At some points I had problems in following the proposed reasoning:

- The proposed analysis suggests major impact of GHMs on polar and arid areas, where the runoff component is minor. Doesn't this go without saying?
- In Fig. 1 to the observed increase in the percentage of HFI days in high latitudes in the northern hemisphere (Fig. 1a) values of signal-to-noise ratio less than 1 correspond; only in some regions - Alaska, north-west America, north China - S2N>1 (model agreement): what motivates, then, the conclusion "...exhibit a number of robust large-scale features. Increases in high flow days were found at northern latitudes, with a strong signal over..."? Similar considerations hold for seasonal maps.

Answer 1st point: True, however, in that instance we thought it was worth specifying it to contextualize how GHMs, which are ultimately responsible for simulating runoff over land (unlike GCMs), are the ones associated with large uncertainties in those areas where runoff is scarce and/or ephemeral - and therefore its simulation is difficult to achieve.
2nd point: We feel the S2N>=1 regions over northern latitudes are quite large and well clustered together, although we realize there are areas where regional agreement is weak (S2N<1) as in e.g. northern Russia or western North America.

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Comment-3 I share with Referee 1 doubts concerning the “novelty” of proposed work, but I leave to him evaluation of answers proposed by the Authors.
All in all, I believe the paper is in line with similar literature and it can be published with the suggested amendments.

But, just for the sake of scientific discussion, let me raise a general question concerning the specific use of observations over threshold proposed in this paper.
The authors mention at pag. 12, lines 15–29 that “The identification of high and low flows over long time series, and particularly over climate projections, is non trivial. As an illustration, van Huijgevoort et al. (2014) in their multi-model ensemble study on droughts, report that applying the threshold level method to the future period using a threshold derived from the control period can lead to spurious pooling of drought events. They suggest that future changes could be counted for by linking the drought threshold to adaptation scenarios like Vidal et al. (2012) did over France. Wanders et al. (2014) used a transient threshold level method for a moving reference period, in order to reflect the changes in hydrological regime over time, finding that the non-transient threshold method projected larger shares of areas in drought (except in snow dominated regions).”.
Now, use of very low (because of trend) thresholds for the selection of “extremes” generates problems typical of “fat distributions”: the sets of events over threshold are rich in number, but include non extreme events! Use of different models further complicates the situation. As a consequence, even under conditions allowing application of Gnedenko (“three type”) theorem*, the distribution of the selected events is non- parametric and the reliability of the statistical inference is very poor (in particular for what concerns the “tail events”). But, at the same time, “central limit” conditions are not fulfilled and the distributions cannot be considered normal*. Geographical non-uniformity further complicates the picture.
As a consequence, the inferred statistical estimators are presumably characterized by

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(very) weak reliability (in particular for what concerns “real extremes”) and have, at most, a qualitative meaning: I would not base any relevant decision on them!
*Note that in the specific case in question even a simply linear trend would introduce an additional dimension to the parametric space of the distribution.
*By the way, isn’t normality a necessary requisite in ANOVA?

Answer The discussion you raise is very interesting. The problem of fat distributions upon selection of low flows extremes is well known when dealing with hydrological time series. A study on a global scale has to come into terms with a threshold selection (in our study Q10 was selected over 34 years on a 5-d basis) that will have to be universal and serve many hydrological regimes and climate regions at once i.e. geographical non-uniformity. A threshold selection resulting from this trade off, will describe low flows but will inevitably pool events that are not truly extreme. Nevertheless, we simply looked at if the threshold was crossed more or less often in the future with respect to the past, therefore the technical issues of poor reliability of statistical inference should not be as pressing as in the context of frequency analysis (i.e. fitting extreme value distributions).
With regards to the ANOVA we carried out in our study, we tested the residuals for normality, and, although not always, this condition was met by 78% and 88% of unmasked land gridcells for HF and LF respectively (Appendix C).

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

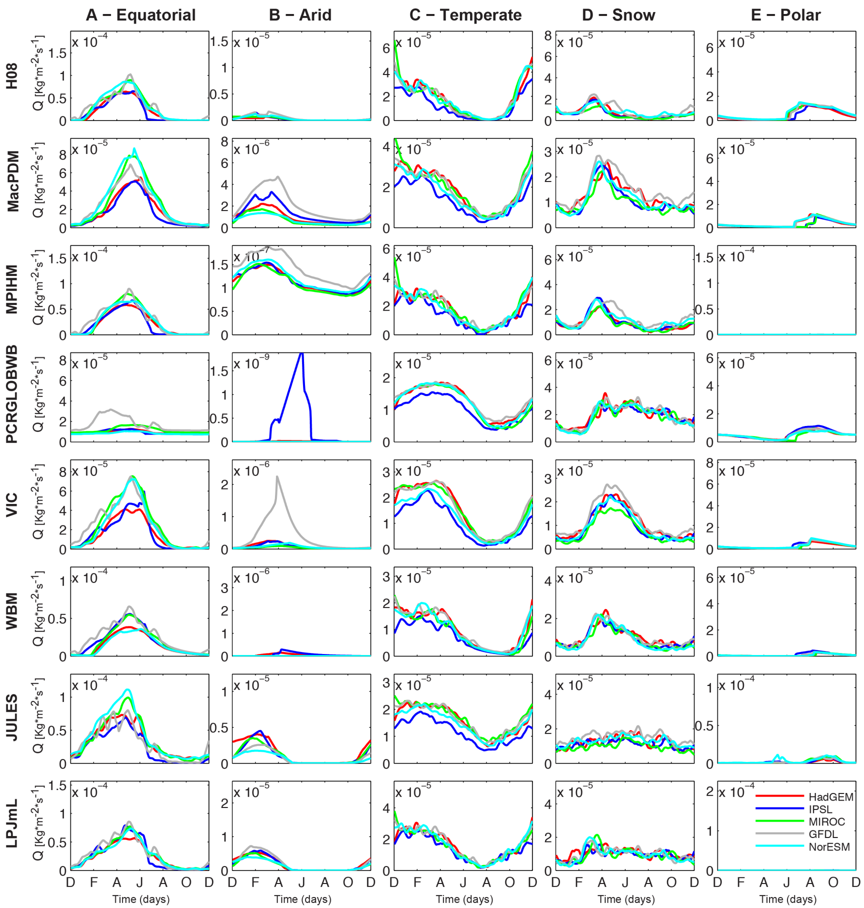

Fig. 1. Mean annual daily runoff (1972-2005) per GHM (in row) for selected gridcells (Lat,Lon): A-Tropical (-2.25,-53.25); B-Arid (-20,25); C-Temperate (43.75,11.25); D-Snow (41.65,-91.5); E-Polar (65,165).

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6, C108–C112, 2015

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