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Hydrology and Earth System Sciences Discussions

# *Interactive comment on* "The ability of a GCM-forced hydrological model to reproduce global discharge variability" *by* F. C. Sperna Weiland et al.

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We would like to thank the second reviewer for the useful comments which helped us to improve the manuscript. All comments were considered carefully and included in the text and the revised manuscript will be uploaded soon. Please, find our response below.

1)" The reference for all model runs should be observed river discharge. It is not sufficiently justified why to use the ERA-40 based model as a reference, given the limitations of this reanalysis data set for hydrological purposes (e.g., Hagemann et al.



2005, Validation of the hydrological cycle of ERA 40). ERA-40 may result to be superior to the GCM-based models, but if so this should be an independent result of this study instead of setting it a priori."

Indeed ERA-40 data has its limitations for application in hydrological studies, still this re-analysis dataset provides one of the best representations of historical meteorological conditions on a daily time-scale. The monthly CRU time-series downscaled to daily values with ERA-40 data is the best representation we have of the past climate, so we need to validate PCR-GLOBWB using this dataset. We adjusted the study according to the reviewers advise. More attention has been paid to the limitations of the ERA-40 and CRU datasets. The performance of the run based on the ERA-40 dataset is tested in a similar way as the GCM datasets. In a next step results of the GCM based model runs are compared with both observations and model results of the ERA-40 runs.

2)"With the approach for bias correction applied in this study (i.e., correcting to mean monthly values of the CRU data set), differences in the discharge simulation results of the PCR-GLOWB model can mainly be expected to be due to (a) the different sub-monthly climate variability of the different GCM data sets, and (b) differences in the inter-annual variability in the GCM data. From this perspective, it is not clear at all why single GCM-based model runs show up with completely different mean monthly river discharge regimes for some river basins (Fig. 2), i.e., 'deviating regime curves' (page 701, line 21), although they are driven with input data with similar monthly climate regimes. Thus, the conclusion that 'few deviating GCMs can bias the discharge statistics ...' (page 705, line 18) is not well founded or at least not sufficiently explained. Also Chapter 3.2.2 on the differences in (monthly) timing of discharge peaks is unreasonable in view of similar monthly climate forcing."

The bias-correction for the GCMs with 360 days has been revised, regime curves and timing of peak are improved.

3) "Derivation of potential evaporation, Chapter 2.2.1, page 694. It is not clear how

potential evaporation for this study could be calculated based on CRU TS2.1 data and using the Penman-Monteith equation, given that the CRU data do not include wind speed and net radiation as required for Penman-Monteith."

Because net radiation and windspeed are not provided in the CRU TS 2.1 timeseries, we were forced to use the monthly CRU climatology CLIM 1.0. The description is improved in the revised manuscript.

4)"Information on PCR-GLOWB model performance relative to observed river discharge is shortly given in an appendix only. This part is insufficient and poorly written."

Extended in main text of the revised manuscript.

"From a general perspective, the approach of this study avoiding to 'focus on the correct reproduction of mean discharge or river regimes' (page 689, line 20) is questionable if the authors want to study in a sound way 'the influence of deviating GCM variability on the resulting hydrological variability' (page 689, line 26). I doubt whether this can be achieved with a model that does not properly represent the mean hydrological behavior of the studied river basins."

It is not our intention to avoid to 'focus on the correct reproduction of mean discharge or river regimes'. Since several studies already focused on the correct reproduction of the mean we want to study the seasonal and inter-annual variability in more detail, variables that are also of relevance for water management. There are indeed differences between the model results and observed discharges. Still for most basins, regimes and seasonality of regimes are reasonably well represented. To investigate GCM variability in a wide variety of basins one needs a relatively large scale low resolution hydrological model which may not perform as well as detailed hydrological models for smaller study-areas. However, in table 3 we show that continental discharges calculated with PCR-GLOBWB show little deviation from continental discharges found in previous model studies. This test-case with PCR-GLOBWB can be considered exemplary for other macro-scale hydrological model studies. We extended the validation of



PCR-GLOBWB in the manuscript and the results of the GCM based runs are analyzed using the information obtained from the model validation.

"More specifically, 4.1) using a logarithmic scale for comparing simulated and observed river discharge (Figure 9) is not adequate to evaluate model performance as errors may likely be several tens of percent without proper graphical representation."

We included a bar-chart with percentual deviations, a logarithmic scale was used to combine all rivers in one graph.

4.2) "using the sum of observed river discharge and water demand as a proxy for 'natural flow' as computed by the model is a misconception because actual water use (withdrawal water use) can be expected to be considerably lower than water demand."

Indeed water demand will, especially in dry regions, be higher than actual water use. We added an extra comment on this simplification in the manuscript and reduced the conclusions drawn from this short analysis. Still, to our opinion it provides useful information. At least for the Murray, Rhine and Danube the sum of water demand and observed discharges illustrates that overestimation of observed discharge can originate from lack of water use inclusion in the hydrological model.

4.3) "The description of Figure 9 is imprecise, e.g., what is CRU_ERA; where are the deviations mentioned in the figure caption; the figure does not contain regimes contrary to what is mentioned in the text (page 707, line 7)"

Adjusted in revised manuscript.

5) "The conclusion that 'after bias correction the spread between regimes calculated with the 12 corrected GCM data sets is decreased' (page 705, line 10) is not justified as not results of simulation runs without bias correction are shown in the study"

To illustrate this, regime curves of the non-bias corrected GCM datasets have been included as well.

6)” The results of this paper are discussed and concluded without any reference to previous studies in this field (Chapters 3 and 4).”

Several references have been included in the revised manuscript.

7)” The discussion of lag-1 inter-annual autocorrelations in river discharge may gain from comparing with autocorrelation of basin-average precipitation time series. This may result in more concrete clues on whether (missing) autocorrelation is due to climate forcing, model errors, or the hypothesis of reservoir storage impact (page 704, line 20).”

Although we realize that the lag-1 correlation of precipitation time-series may give a better representation of persistent droughts, ENSO effects etc, we restricted ourselves here to an analysis of the discharge timeseries, since the focus of this study is reproduction of discharge variability and inter-annual discharge variability can differ significantly from inter-annual precipitation variability. Even in a comparison with lag-1 correlation coefficients of precipitation data one can still not distinguish the influence of hydrological model deficiencies from the influence of realistic reservoir and groundwater storages. Because of the large differences between modelled and observed lag-1 concentration and the difficulties in deriving both the source of these differences and the resulting hydrological meaning of the lag-1 correlations obtained, we decided to leave the lag-1 correlation out of the new version of the manuscript.

8) “How has the CRU CLIM 1.0 climatology (page 697, line 7) been used within the approach taken in this study?”

CRU CLIM 1.0 climatology windspeed and radiation fields have been used to derive potential evaporation.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 687, 2010.