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Hydrology and Earth System Sciences Discussions

Interactive comment on "The relationship between climate forcing and hydrological response in UK catchments" *by* N. W. Arnell

Anonymous Referee #1

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General Comments

With 21 different climate models and different emission scenarios, most impact assessment studies usually chose a set of GCMS and emission scenario in order to decrease the computational burden. Either the most and least dramatic simulations are used in order to represent the full spectrum of changes, or the conservative or medium simulations are used, all depending on the applications. The author here tries to oversee this confusion in having to choose from the different GCMS and emission scenarios by trying to quantify the hydrological responses of 6 catchments over the UK to prescribed changes in global temperature. It results in an original way to present the hydrological impacts due to climate change based on this global temperature change. The author

also evaluates the cascade of uncertainties into the hydrological simulations by assessing the uncertainties in climate forcing (ensemble of GCMS), the difference between climate change and natural multi-decadal variability, and hydrologic model parameter uncertainties and finds that the hydrological uncertainties resulting from the ensemble of GCMS is greater than any of the other uncertainties. Therefore, the full ensemble of GCMS should always be used in order to better communicate the uncertainties of climate change impacts.

I would suggest accepting the paper after MAJOR revisions in order to clarify the paper but most important the paper needs to better support the results (parameter uncertainty), and further discuss the overall conclusions with respect to the communication of the results to decision makers, the added uncertainty to the results, the implications of showing the results this way rather than the traditional way (emission scenario vs. prescribed temperature change – added value?, full GCM histograms rather than mean and standard deviation).

Specific Comments

- Overall confusion in the term "scenario" widely used in the paper; the emission scenarios, climate model scenarios (i.e. simulations) and set of scenarios (set of rescaled future climate GCM simulations for a prescribed change in global temperature). The paper would benefit from a clarification of the terms used at the beginning of section 2.4.

- In my understanding, the parameter uncertainty is the acknowledgment that different sets of model parameters could be used for a similarly well calibrated hydrology. In the paper, the model parameter uncertainty is assessed over one basin, and is based on parameters that randomly vary between + and – 10%. The author claims that none of the simulated hydrology is poor but the performance statistics decreased to a bias of 20% and a NSE less than .6, which is really low for monthly hydrology. I would disagree that this is a fair representation of the parameter uncertainty because some of the sim-

ulations do not represent reasonably well the catchment hydrology. The assessment of the parameter uncertainties could be done by using a single or multi objective function calibration procedure and using the resulting set of parameter combinations that fall into the Pareto Optimum for example.

- The conclusion on parameter uncertainty being negligible with respect to climate change scenarios is not properly supported by the analysis and results (one gcm, one prescribed temperature change, and inappropriate parameter combinations). The parameterization uncertainty should be compared to the full GCM ensemble (climate change uncertainty). This would help for a fair comparison rather than using only one GCM and one prescribed temperature change in order to support the conclusion that the parameter uncertainty is negligible w/r to climate change uncertainties (which includes uncertainties in GCMS and prescribed temperature changes). In particular, a 30% change in relative runoff due to parameter uncertainty for a 2 degree prescribed temperature change seems significant to me with respect to climate scenario uncertainty when looking at Figure 4 for the relative change in summer runoff.

- Clarify how the natural multi-decadal variability is simulated

- The paper would also benefit from a discussion section about the overall conclusions of the paper;

o The paper conclusion is that all GCMs should be used in climate change analysis because results show clusters that are not well represented by ensemble mean and standard deviations usually used. However the author does not consider the fact that the climate models are not fully independent and use, by clusters, similar equations to represent some processes. In this respect, clusters are expected and do not necessarily mean that they better represent the truth but only that several models use the same empirical/physical processes. Using the mean and standard deviation *may* be a way to smooth this inter-model dependence and to display results that are not dependent on the number and types of GCMs used but rather on the different existing represen-

tations of physical processes. I am also not sure how the information carried by the histograms (to show the clusters), can be used by decision-makers.

o Since the author was mostly able to present results for a 2 degree prescribed temperature change, I wonder how the communication of the results is that much simplified to decision-makers. It seems relatively equivalent to displaying results for one emission scenario. There is more uncertainty (regression analysis) but it may still be a simpler way for decision makers to make the link between climate change “simplified scenario”, i.e. a prescribed global temperature change, and the hydrologic impact. A small paragraph could assess this point and valorize what the author intends to do.

Technical corrections

P 7636, lines 2-4: the sentence in unclear. Do you mean that most studies use a set of global climate model simulations to force a catchment-based hydrology model in order to simulate both the baseline period and the future periods?

P7635, line 18: change 18 to 21 GCMs.

Figure 1 would benefit from displaying: the delineation of the catchments, the GCM grid (2.5 degree I believe), and maybe also some soil characteristics (chalk / non chalk) in order to explain the different impact on the hydrology later on.

P7638, line 1. Move the description of the input to the model (lines 11-13) here before the description of the model processes and parameters. And add that temperature is an input, as mentioned later in the paper.

P7638, line 8: are those monthly or daily biases and NSE? Table 2: one of the basin displays a low performance

P7638, line 10; define CMIP

P7638, line 10: was A2 chosen arbitrarily? or was it chosen for a particular reason over A1, A1B, B1, . . .? Is it better for the regression fit?

P7638, line24: start a new paragraph at " Scenarios representing . . .".

P7638, line 25 : add "spatially" for "spatially downscaled".

P7638, line 26; many climate change impact studies had to temporally and spatially downscaled the GCM simulations to the scales of the hydrology models and it can be elaborated (Maurer et al. 2007, Salathe et al. 2010 for example, or choose a "delta method"). Here the author choose a simple interpolation and then a "delta-method"-like approach for the temporal disaggregation. I would suggest adding a sentence here about how others do (references) and why this approach is appropriate here. In particular, since the hydrology model uses a basin average forcing values, a simple interpolation is appropriate.

P7638, line 28: do not go the next paragraph.

P7639, 1st paragraph: did the author create those new 30-year daily time series for different prescribed changes in global temperature?

P7639, last paragraph:

- Please clarify why those additional climate forcing are used (additional uncertainty assessment?),

- define UKCIP98.

- It is also unclear how you get 7 new scenarios?

- Why use HadCM2 and not a rescaled baseline period as done for the climate change ensemble. Could this affect the magnitude of the uncertainty in the natural variability?

P7640, first paragraph: did you mean -5 to +10%?

P7640, line 16: UKCIP98 or 02 has been used?

P7640, RESULTS SECTION: Clarify that most results are presented for a prescribed change in temperature or 2 degree C, and why.

P7641, line 5. The non linearity is expected when using a physically-based hydrology model and non-linear processes. I would just add that this finding was expected.

P7642, line 24: HadCM3 or HadCM2? Please coordinate with what has been used for the natural variability experiment.

Figure 5: it is difficult to compare the uncertainty due to the parameterization from this figure. It should be combined in Figure 4, the same way the natural variability uncertainty was assessed.

P7643, last paragraph. Some of the simulations have used a parameters combination that is not representative of the hydrology of the basin. And they should not have been used for the parameter uncertainty assessment. A +/-5% annual bias during the calibration period would be reasonable. If the runoff percentage change should only use certain parameter combinations with a representative bias during the calibration period, it should also include all GCMs and all prescribed temperature changes and see by how much it changes your percentage change. That would better support your conclusion. Finally, and most important, a 30% change in runoff seems significant to me with respect to climate scenario uncertainty when looking at Figure 4. It seems to me that Figure 6 is not appropriate for comparing and evaluating the summer runoff relative change ranges due to either climate scenario or parameter uncertainties.

P7646, line 7: is this runoff percentage change for the full GCM spectrum? It does not match the results mentioned on page 7643.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 7633, 2010.