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Hydrology and Earth System Sciences Discussions

Interactive comment on "The influence of constrained fossil fuel emissions scenarios on climate and water resource projections" *by* J. D. Ward et al.

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We thank Richard Mackey for his positive comments on our paper and for his suggested improvements.

Mackey notes that Koutsoyiannis et al. (2008) and Anagnostopoulos et al. (2010) both argue that GCMs are not yet ready for use in hydro-climatological predictions, due to their demonstrated lack of performance in reproducing observed temperature and precipitation at sub-global scales. However, notwithstanding these critiques, GCMs are indeed currently being (widely) used to generate regional and local predictions of long-term climate change impacts. Kundzewicz et al. (2008) provide a detailed review

of research into hydrological impacts from global climate change, summarising chapter 3 of Working Group II in the IPCC's Fourth Assessment Report (Kundzewicz et al., 2007). Similar studies have continued to be published since then, such as the recent Kirono et al. (2011), where GCMs forced by the A1B (medium) and A2 (high) emissions scenarios were used to predict long-term (i.e. 2070) changes to drought severity and frequency across Australia.

In our paper, we have noted that a controversial discussion (i.e. whether or not GCMs are appropriate for use in hydrological projections) is currently taking place in the scientific literature. However, apart from noting it, we have deliberately chosen to not engage with that discussion in this paper, and Mackey acknowledges that we "need not get into the politics and ideology of the IPCC's output". Instead, we have taken what we see as a constructive position by noting that (a) many of the GCM model predictions are being forced by unrealistic emissions scenarios, and (b) the degree of change and the uncertainty surrounding the modelled future climate are both likely to be overstated (as a result of using these inappropriately high emissions scenarios). As we show in our case study, if more realistic fossil fuel constrained emissions scenarios are used, then both the relative change and the model spread are significantly reduced.

In his review, Mackey suggests that we extend our description of Koutsoyiannis' stochastic approach, as distinct from more commonly-assumed descriptions of stochasticity. We can see some benefit in such an extension to our paper, and we thank Mackey for the suggestion.

We would add the following paragraph in the Introduction (around lines 18-25 of page 2629, as suggested):

Koutsoyiannis (2010) demonstrates that a stochastic approach using a deterministic dynamic model within a Monte Carlo framework (to account for inherent lack of precision and accuracy in values such as initial conditions) can be considered an "all-times solution", providing a useful explanation of uncertainty over short and long timeframes.

Meanwhile, a deterministic dynamic model that is not implemented within a stochastic (e.g. Monte Carlo) framework will give "misleading results and a dangerous illusion of exactness" over long timeframes. Even with the very slightest uncertainty (e.g. on the order of 10^-6) in initial conditions, the toy model of Koutsoyiannis (2010) showed complete divergence in the stochastic simulation over the long timeframe.

We would then add the following paragraph at the end of the Introduction (line 19 of page 2632):

The scope of the current paper is primarily to investigate the opportunity to constrain emissions scenarios using published fossil fuel production estimates, and to study the possible influence this may have on hydrological predictions. However, in the case of rainfall, an argument could be made that we are unable to discern much at all from GCMs regarding climate change impacts, and that natural chaos will continue to dominate the long-term pattern. This may be highly relevant under low emissions scenarios, where we will show that the severity and the uncertainty surrounding the predicted change are both reduced, relative to high emissions scenarios.

Finally, we would add the following sentence in the final paragraph of the Conclusions & Recommendations (page 2646-47):

If the severity and uncertainty surrounding emissions scenarios can indeed be reduced, then a sound approach to long-term hydrological planning may involve a stochastic framework based on the statistical interpretation of historical data, with any deterministic modelling of future climate change to be carried out within the stochastic framework as recommended by Koutsoyiannis (2010).

Once again we thank Mackey for the constructive input to our paper, and we hope that the proposed changes will strengthen the manuscript.

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