

***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 Antonis Christofides for his strongly positive comments and useful recommendations.

Although Christofides has kindly said that our manuscript is publishable as-is, we would seek to make changes in accordance with his suggestions.

**On uncertainty**

Christofides takes issue with our treatment of uncertainty, and carefully explains the

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nature of intrinsic and epistemic uncertainty in a practical sense. He notes that we have cited Koutsoyiannis (and others) in our introduction to the topic, but suggests we have not properly dealt with the intrinsic uncertainty inherent in climate. His/their argument is that the climate system is so chaotic that recent observed trends cannot necessarily be attributed to increasing “forcings” such as atmospheric greenhouse gas concentrations. They provide evidence by way of a deliberately simple model with constant “forcings”, and show that even this model displays chaotic behavior and long-term trends / departures from the mean, which cannot possibly be attributed to any change in forcing (as there is no such change made in the model). Hence, they argue, the far more complex general circulation models (GCMs) with various coupled processes (such as ocean-atmosphere exchanges, and even dynamic vegetation processes) cannot be used to attribute changes in the world’s climate to increasing greenhouse gas emissions – such changes may simply be the product of intrinsic uncertainty in the model. If this position was accepted, it would follow that one cannot claim (as we have done) that a reduction in prediction (i.e. epistemic) uncertainty is possible by constraining emissions scenarios, because there is doubt that any observed climate trends are associated with greenhouse gas emissions in the first place.

Notwithstanding the above discussion on intrinsic uncertainty and the resultant questioning of the attribution of climate change to greenhouse gases, the “mainstream” (IPCC) climate science community continues to uphold that GCMs are reproducing important physical characteristics of the climate, including trends that are attributed to increasing greenhouse gas concentrations, and they conclude that the future climate is critically dependent on greenhouse gas emissions. Such conclusions have led to an explosion of long-term climate change impact studies, with wide-ranging projections exacerbated by the use of wide-ranging emissions scenarios. Such wide-ranging projections are of limited use to water resource managers who are charged with long-term risk assessment.

In the present discussion paper, we prefer not to “choose sides” in the debate over the

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reliability / usefulness of GCMs, as we feel this would be a distraction from the main point of our research. With that in mind, we are offering our review of the fossil fuel literature to mainly assist those climatological and hydrological modelers who are attempting to operate within the mainstream, i.e. where GCMs are seen as a reasonable tool for projecting possible impacts, but where there has traditionally been little formal guidance for narrowing the large spread of scenarios. This study is therefore intended to present a sound basis for constraining emissions scenario inputs to the low or low-medium range, in order to reduce some of the spread in projected impacts. We feel that this usefully informs long-term risk assessment, by eliminating extreme scenarios and improving model agreement. Meanwhile, we will continue to watch the GCM debate unfold with interest, and will seek ways to contribute to it in the future.

We will clarify and add detail to our section on uncertainty in the Introduction, along the lines of the above discussion.

### Other issues

P2632L24: we agree with Christofides' recommendation to include the phrase "what the IPCC consider to be" before the word "plausible" (in quotes).

P2633L17: Christofides has drawn attention to our claim that Nakicenovic Swart (2000) explicitly attribute equal likelihood to all scenarios. Indeed, quoting Nakicenovic Swart (<http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=13>): "As in the case of the storylines, no single scenario - whether it represents a modeler's choice or harmonized assumptions - was treated as being more or less "probable" than the others belonging to the same family." Christofides questions the scientific credibility of such a claim (by Nakicenovic Swart). To address such a question would require an in-depth review critique of the modeling techniques, data quality, model calibration and validation behind each of the 40 future socio-economic scenarios used in the IPCC's SRES, in order to determine whether or not it was truly valid to simply assume all were equally (im)plausible. Instead, we are taking a relatively crude approach to the issue,

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by qualitatively evaluating the likelihood that the world will follow any of the medium to high emissions trajectories based on post-SRES studies of fossil fuel production. In conducting our literature review, we have found that the recently published projections of fossil fuel production are tending to converge around the lower range of emissions scenarios, and as such, irrespective of any differences in modeling approaches behind the various SRES scenarios, there is now a scientific basis to at least eliminate the upper scenarios, as they were based on unrealistic assumptions about accessible fossil fuel resources.

P2640L20: Christofides suggests that our statement "It is important to note that low emissions do not guarantee a future free of significant climate change" is a moot point, as nobody could/would make such a guarantee. He also questions what we mean by "significant" climate change. We will change this sentence to the following: "It is important to note that some models predict large changes in climate (relative to recent observations) even under low emissions scenarios."

P2639L4: Christofides recommends that in our Conclusion, we should repeat the important observation (reported by Rutledge, 2011) that in the SRES, Nakicenovic Swart (2000) cited a figure for estimated coal reserves from WEC (1998) that has been very significantly reduced in subsequent assessments (e.g. WEC, 2007) by the same group. We will take his suggestion and make this point again in our Conclusion.

Christofides finishes his review by suggesting that we end our paper with a stronger final paragraph. We are grateful for this advice (and for the affirmation of the paper's "message") and we will re-word the paragraph to end the paper in a stronger way.

## References

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