Earth System
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Discussions

Interactive comment on "On the meaning of independence in climate science" *by* J. Annan and J. Hargreaves

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Thank you for the comments, to which we here provide a partial reply.

We think it is important to separate out several ideas which are, we believe, conceptually separate. Model duplication (and near-duplication) can be in our view considered separately from model performance. It is just as easy to tweak parameters or structure of a "good" model (however this is defined), and add this near-replicate to the CMIP ensemble, as a "bad" one. Thus it is not obvious to us how or why model performance could be a useful indicator in assessing model duplication. We emphasise that we certainly consider assessment of model performance to be important, especially when predictions are being made (and have published several papers relating to this). However, it is not clear that this can be usefully linked to the question of model

independence. A challenge that our manuscript presents is to discover whether and how the concept of probabilistic independence can be applied to measures that do take account of performance (presumably in addition to inter-model differences). It may be possible to do so, and this would be useful in explaining what the terms of this (conditional) independence actually are. We consider that a significant achievement of the paper is its presentation of a mathematically sound foundation for the discussion of model dependence which can be built on in future work.

We can certainly discuss in more detail the effect of model dependence on prediction, and present some analysis of this. It is amenable to a relatively straightforward theoretical analysis. For example, if we have 15 independent models (according to our definition) and then 5 of these (selected at random) are replicated once each, the effective ensemble size is reduced to around 13, just a little smaller than if the 15 independent models had been used (though more markedly smaller than the apparent ensemble size of 20). This will be expected to have a very small effect on ensemble performance, e.g. as suggested by Figure 3c,d of Knutti et al (2010) where it is shown that the ensemble mean of 20 or 21 randomly-selected models typically has a very slightly worse performance than when all 23 are used. If, on the other hand, a future CMIP ensemble contained a massive ensemble from one modelling centre alone, then this could have a much more significant effect, reducing the effective ensemble size to one or two. Again, Figure 3 c,d of Knutti et al indicates the likely effects of this on the ensemble mean, with an increase in expected RMS error of up to about 50%. In this case the ensemble spread would also collapse, leading to additional problems. Of course most researchers already limit themselves to a single ensemble member from each model when performing multi-model analyses, but the principle here applies also to near-replication through dissemination of a model to multiple modelling centres. A new paper bears this out, with Leduc et al (2016) finding very little different in mean projections when "institutional democracy" is imposed (though the differences in spread are more marked, especially when the ensemble is reduced most severely). Therefore, we expect that accounting for model dependence (as defined and demonstrated

in the manuscript) will have very little effect on predictions, but it could potentially have a larger effect in future iterations of CMIP.

Specific comments

p3 l26 - yes, this is correct. The approach presented here does not account for model performance as discussed above.

p5 l7 This is possible, but we do not expect to have contradictory evidence. The point about always expecting to learn from new evidence is mathematically derivable, and is not contradicted by there being some occasions where we "unlearn". Such events must however be expected to be relatively rare (expectation here being used in the formal probabilistic sense).

References:

Knutti et al 2010 "Challenges in Combining Projections from Multiple Climate Models" Journal of Climate

Leduc et al 2016 "Is institutional democracy a good proxy for model independence ?" Journal of Climate, in press

Interactive comment on Earth Syst. Dynam. Discuss., doi:10.5194/esd-2016-34, 2016.