Earth System Dynamics Discussions

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Comment on esd-2021-8

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Community comment on "Balanced estimate and uncertainty assessment of European climate change using the large EURO-CORDEX regional climate model ensemble" by Guillaume Evin et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2021-8-CC1, 2021

Evin et al. present an impressive and extensive study involving the ANOVA method and data augmentation to estimate balanced mean change with an approach called 'QUALYPSO' and to distinguish between sources of uncertainties: RCPs, GCMs, RCMs and internal variability. This is a contribution to progress in terms of understanding downscaled model projections and the use of ensembles.

I nevertheless have some suggestions concerning the background and introduction to this study. My impression is that there are many papers presenting RCM results that ignore related work done through empirical-statistical downscaling (**ESD**). I think that acknowledging such work in many cases would strengthen them. Here for instance, the statement "*the largest MME of regional climate projections ever produced*" is not quite correct since ESD efforts for a while have produced larger Multiscenarios Multimodel Ensembles (MME). For instance, a total of 254 downscaled simulations, each for 200 years, provided a basis for new ways to present large ensembles in Benestad et al. (2017; DOI: 10.1016/j.cliser.2017.06.013).

I would also argue that any effort to provide a robust estimate of total uncertainty in connection with downscaling should involve *both* RCMs as well as ESD, because these two approaches have different strengths and weaknesses independent of each other. They draw on different sources of information. For instance RCMs may be biased because of inconsistencies with the driving global climate model (GCM or ESM - here I use GCM referring to both). E.g. using different parameterisation schemes than the driving GCM, or there may be differences in outgoing longwave radiation (OLR) at the top of the atmosphere because the RCMs produce different rain/cloud climate to the driving GCM. Furthermore, *both* RCMs and ESD rely on the link between large and small scales being stationary, but *in different ways*: ESD in terms of the calibration of historical predictors and predictands; RCMs in terms of their parameterization schemes that provide a large-scale aggregation of unresolved small-scale processes.

A comment on "*the Arctic warming amplification and to the regional snow-albedo positive feedback*" is that the Arctic amplification is even more pronounced at the high latitudes, during winter, when there is no sunlight (during the polar nights). It's not so obvious that

this is due to an albedo effect because it's dark (and there is also often a cloud-cover present).

It's a bit surprising that the internal variability converges to zero at 2100 as it seems like in Figure 2 - column 5 when the total temperature change only is a few degrees C (especially for northern Europe). I suggest checking the calculations. Also see Deser et al. (2012; DOI: 10.1038/nclimate1562).

GCM uncertainty over sea may be a result of incorrect sea-ice cover since the temperature shoots up in the air where it retreats, as mentioned in the discussion. This has been interpreted as a known shortcoming in the past, and it's a bit surprising if the models with sea-ice in this region also are considered among the most trustable CMIP5 GCMs concerning the wintertime sea-ice cover. I suggest checking this.

Uncertainties should probably not exclude the possibility of tipping points. In this case, it could be a reversal of the thermohaline circulation.

One suggestion: when it comes to precipitation, two key parameters are also the wet-day mean precipitation and the wet-day frequency. They are useful because they provide more actionable information than just the seasonal totals (their product with the number of days is the total precipitation amount).

Another suggestion is that methods from ESD can be used to study the connections between features provided by the driving GCM and the response simulated by nested RCMs. For instance, ESD calibrated with one GCM-RCM pair may be applied to a different GCM to compare with its RCM. This is a bit like 'hybrid downscaling'.

Finally, ESD can be regarded as a way to test the uncertainties connected with GCMs and decadal variability, and results by Mezghani et al (2019; DOI: 10.1175/JAMC-D-18-0179.1) may seem to suggest that internal variability plays a bigger role on a regional scale than the GCM (is didn't use 30-year smoothing, however). These results also highlight the limitation posed by 'the law of small numbers'. One nice aspect of ESD is that it can incorporate a quality evaluation of GCMs.