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Can we beat climate model democracy in ensemble projection?

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To effectively plan adaptation to climate change we need climate projections which cover all potential outcomes. At the same time we need projections to be as narrow as possible, to be able to adapt to these potential outcomes. Uncertainties in climate projections are a result of natural variability, scenario uncertainty and model uncertainty. Model uncertainty can potentially be decreased by giving more weight to those models in multi-model ensembles that are more skillful and realistic for a specific process or application.

We compare multiple approaches on how multi-model ensemble averages can be calculated; an arithmetic multi-model mean as in IPCC AR5, a weighted multi-model mean taking into account performance and independence (*Knutti et al.* 2017) and the average of the ten best models based on Root Mean Squared Errors over the historical period. We further test whether simple statistical extrapolation (e.g. a simple linear regression over the historical time period) outperforms the physical models. We investigate how the different approaches influence the projection of annual maximum temperature (TXx) over Central Europe and test the skill of the physical models and linear regression in a perfect model test. The perfect model test assumes one of the model runs to be the truth and tests if the rest of the ensemble is able to predict this ”truth”.

We find that the differences between the projected changes in TXx and the ”truth” are close to zero for the near future (1975–2024) for all multi-model means as well as the statistical extrapolation. For the end of the century the average difference is still close to zero for the physical models while it is around -5°C for the linear extrapolation. On average, the difference in the projection between weighted multi-model mean and ”truth” stays closest to zero, followed by the method only including the ten best models and the arithmetic multi-model mean. So, the difference between the linear regression estimate and the ”truth” moves further away from zero with time while the physical models on average are able to maintain their skill into the future. Therefore, a naive linear extrapolation of changes in TXx for the near future will only slightly underestimate this change, but this error will become larger and larger further into the future. When using the weighted multi-model mean the average error in the projection does not increase with time.

References

Knutti, R., J. Sedláček, B. M. Sanderson, R. Lorenz, E. M. Fischer, and V. Eyring (2017), A climate model projection weighting scheme accounting for performance and interdependence, *Geophys. Res. Lett.*, 44, 1909–1918, doi:10.1002/2016GL072012.