EGU2020-5777
https://doi.org/10.5194/egusphere-egu2020-5777
EGU General Assembly 2020

Quantifying uncertainty in projections of future European climate: a multi-model multi-method approach

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Political decisions, adaptation planning, and impact assessments need reliable estimates of future climate change and related uncertainties. Different approaches to constrain, filter, or weight climate model simulations into probabilistic projections have been proposed to provide such estimates. Here six methods are applied to European climate projections using a consistent framework in order to allow a quantitative comparison. Focus is given to summer temperature and precipitation change in three different spatial regimes in Europe in the period 2041-2060 relative to 1995-2014. The analysis draws on projections from several large initial condition ensembles, the CMIP5 multi-model ensemble, and perturbed physics ensembles, all using the high-emission scenario RCP8.5.

The methods included are diverse in their approach to quantifying uncertainty, and include those which apply weighting schemes based on baseline performance and inter-model relationships, so-called ASK (Allen, Stott and Kettleborough) techniques which use optimal fingerprinting to scale the scale the response to external forcings, to those found in observations and Bayesian approaches to estimating probability distributions. Some of the key differences between methods are the uncertainties covered, the treatment of internal variability, and variables and regions used to inform the methods. In spite of these considerable methodological differences, the median projection from the multi-model methods agree on a statistically significant increase in temperature by mid-century by about 2.5°C in the European average. The estimates of spread, in contrast, differ substantially between methods. Part of this large difference in the spread reflects the fact that different methods attempt to capture different sources of uncertainty, and some are more comprehensive in this respect than others. This study, therefore, highlights the importance

of providing clear context about how different methods affect the distribution of projections, particularly the in the upper and lower percentiles that are of interest to 'risk averse' stakeholders. Methods find less agreement in precipitation change with most methods indicating a slight increase in northern Europe and a drying in the central and Mediterranean regions, but with considerably different amplitudes. Further work is needed to understand how the underlying differences between methods lead to such diverse results for precipitation.