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## Calibrating large-ensemble European climate projections using observational data

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In this study methods of calibrating the output of large single model ensembles are examined. The methods broadly involve fitting seasonal ensemble data to observations over a reference period and scaling the ensemble signal and spread so as to optimize the fit over the reference period. These calibration methods are then applied to the future (or out-of-sample) projections. The calibration methods are tested and give indistinguishable results so the simplest of these methods, namely Homogenous Gaussian Regression, is selected. An extension to this method, applying it to dynamically decomposed data (in which the underlying data is separated into dynamical and residual components), is found to improve the reliability of the calibrated projections. The calibration methods were tested and verified using an “imperfect model” approach using the historical/RCP8.5 simulations from the CMIP5 archive. The verification indicates that this relatively straight-forward calibration produces more reliable and accurate projections than the uncalibrated (bias-corrected) ensemble for projections of future climate over Europe. When the two large ensembles are applied to observational data, the 2041-2060 climate projections for Europe for the RCP 8.5 scenario are more consistent between the two ensembles, with a slight reduction in warming but an increase in the uncertainty of the projected changes.