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Separating internal variability and forced response in multi-member ensembles

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Obtaining reliable estimates of the forced response in climate model projections is important for many applications in climate science. Depending on the variable it is, however, challenging to separate the forced signal from internal variability, particularly for seasonal to daily and regional to local scales. Various methods have been suggested in the literature, ranging from simple linear or polynomial fits, utilizing initial-condition members to machine learning approaches such as dynamical adjustment.

Based on a large initial-condition ensemble we develop and test a novel, straight-forward yet reliable approach to separate internal variability and forced response based on LOWESS filtering. It estimates the forced response from climate projections making use of all initial condition members available as well as the pre-industrial control simulations. Our approach hence utilizes the information provided by multiple initial-condition members but is also applicable for models with only one realization.

We demonstrate that our approach can reliably isolate the forced response on different spatial scales and for different variables using the ensemble mean of a large initial condition ensemble as reference. We show results for global and regional temperature and precipitation and compare our approach to other methods previously suggested in the literature. Overall, our approach aims to optimize between complexity, a priori parametrizations, and efficient use of all initial condition available for a given model.