# Objective method for building a reduced ensemble for climate change projections

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**Abstract**

Climate change is one of the biggest challenges facing humankind. Thus, the problem of global climate change forced by anthropogenic emissions of greenhouse gases has to be addressed throughout the whole society, including mitigation and adaptation measures. Several governments have established national adaptation plans, where the planning and implementation of adaptation measures have steadily gained importance over the course of recent years.

Climate change projections are subject to uncertainties that are caused by 1) the chaotic character of the climate system, 2) the underdetermined state of the climate system, 3) the simplified model description of complex physical processes, and 4) the assumptions on the future development of global societies and economy. In order to consider these uncertainties in adaption planning, an ensemble of climate projections covering the whole range of uncertainties is created by taking advantage of different ensemble generation strategies (initial and boundary conditions perturbation, multi-model ensembles, use of different scenarios).

In recent years the number of available climate projections has increased significantly. The compilation of all climate projections leads to a so-called ensemble of opportunity since it is not constructed in a systematic way. For that reason, the analysis of a larger ensemble is not always beneficial (Knutti et al. 2010). Furthermore, there can be computational restrictions that, for some applications, impede the use of the full ensemble, suggesting a reduction of the ensemble size. To still make optimal use of the information inherent in the full multi-model ensemble, a careful selection of projections to be further processed in a study is crucial. It has to be assured that a reduced ensemble still represents the desired characteristics of the full ensemble. Here, the question arises of what the desired characteristics of an ensemble are.

Interdependence between climate models, caused by common assumptions on the climate system and shared observational data for model tuning, as well as replication of code and shared model components across seemingly different models developed by independent institutions, results in similarities between the outputs (and correlation between the errors) of different models (e.g., Knutti et al. 2010).

Sanderson et al. (2015) applied a Principal Component Analysis (PCA) prior to defining a measure of similarity between each pair of models. From this measure, an independence score is calculated for the whole ensemble that is then maximized by excluding highly dependent models. As an additional criterion, Sanderson et al.’s (2015) method can incorporate model performance with respect to observational data (i.e., model bias) such that a combined independence–performance score (called independent ensemble quality score) is optimized. Knutti et al. (2017) recently applied Sanderson’s independent ensemble quality score to construct a climate projection weighting scheme for the study of Arctic sea ice and temperature evolution.

Following the study by Delalane et al. (2018), here we present the method and its application to a reduction of the number of ensemble members of the regional climate projection ensemble for Europe, reducing interdependencies in the ensemble with the objective of preserving relevant information on potential future climate states. For this, the procedure proposed by Sanderson et al. (2015) was applied, which consists of two main steps: 1) a dimension reduction realized by a PCA and 2) the reduction of the ensemble with the objective of maximizing the independent ensemble quality score. A similar analysis will be performed in the near future for Australia as part of the NESP ESCC program.

**References:**

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