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Exploring perturbed physics ensembles of a regional climate model

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Evaluation of climate model uncertainties has received much attention in recent years, as it is a key element to study the impact of climate change. Typically uncertainties are assessed using multi-model ensembles (MME) and single-model perturbed physics ensembles (PPE). The projects provided estimates for the uncertainty of climate sensitivity and parametric uncertainty in current state-of-the-art climate model. However, studies using PPEs have so far mainly been using global climate models, and little work has been conducted with regional models.
This study discusses the parameter uncertainty of the regional climate model COSMO-CLM with two PPEs for present-day climate over Europe. The PPEs consist of 30 simulations for the period 1990-2000 and 106 simulations for the year 1990 driven by ERA-40 re-analysis. The COSMO-CLM is the climate mode of a non-hydrostatic limited area model developed by the German weather service and the COSMO consortium. In the evaluation of the simulations we consider the variables 2m temperature, precipitation, total cloud cover and soil moisture, with a focus on the annual cycle, inter-annual variability and selected extremes.
We show that the simulated range spanned by the parameter uncertainty encompass the observations at a regional level for the annual cycle and the inter-annual variability, taking into account observational uncertainty. The consideration of observational uncertainties is particularly important for precipitation intensity and total cloud cover. The parameter uncertainty of selected extremes is large for temperature and precipitation, with strong spatial variability.
In order to rank the PPEs we propose a new skill metric, which takes into account observational uncertainty and natural variability. The metric is an extension of the climate prediction index (CPI, Murphy 2004) and is compared to metrics used in other studies. The sources of error are further decomposed into bias, correlation and variability errors and related to the comparison of the different metrics and the driving boundary data. The skill framework is additionally used to identify important model parameters of the model, which are interesting for comprehensive model calibration.