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Natural variability in RCMs: single model 50-member-ensemble (ClimEx) results to better understand variability in multi-model ensembles of CORDEX

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Multi-model ensemble RCM approaches are very common in climate sciences and impact studies to account for the full range of possible future conditions. The ensemble approach is often applied with all available model data and the variability in the results is usually associated with model structural uncertainty. Less attention is drawn to the possibility of varying future conditions in model results due to internal model variability, which is also often induced by only one member of a GCM-RCM combination being available. Complementary knowledge is drawn from single model large ensembles, in which only the initial conditions of the same GCM-RCM combination are changed to gain insights into the internal variability of models, then interpreted as natural variability and source of irreducible uncertainty.
Within the ClimEx project (www.climex-project.org), an ensemble of 50 members of the GCM CanESM2 (RCP 8.5) is downscaled by the RCM CRCM5 to the CORDEX 0.11° grid for a European and Northeastern North American domain (280x280 pixels each). The 50 CanESM2 members run from 1950-2099 each, resulting in about 7500 years of climate data. This enables us to better quantify the role of intra-model variability, e.g. natural variability, in past, present and future. In this study, the change of natural variability in the ClimEx ensemble is first analyzed for the European domain, and then compared to the climate change signals of the 13 EURO-CORDEX models sharing the same grid (EURO-CORDEX), resolution (0.11°) and scenario (RCP 8.5). We compare seasonal temperatures and precipitation as well as some climatological indicators. Results show that the variability in signals of the CORDEX ensemble is usually significantly larger than the variability of the ClimEx ensemble. Nevertheless, for some regions and seasons/indicators, the spread in ClimEx is comparable or larger than the CORDEX spread, even for the far future (2070-2099). Thus, natural variability can play a major role in climate projections, and therefore uncertainty in multi-model ensembles is not always (only) connected to the differences in models, but also due to natural variability. The study highlights the role of single model large ensembles for a better understanding of the uncertainties in climate projections; it contributes to overcome existing weaknesses in the application of climate data in hydrological impact studies.