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Resolution dependence of precipitation in a state-of-the-art atmosphere only general circulation model

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Long climate model simulations have necessarily been run at coarse spatial resolutions. Downscaling techniques are typically applied to general circulation models (GCMs) to obtain details at a finer resolution. Dynamical downscaling is done by embedding a high resolution regional climate model within a coarse resolution global model, allowing for a better representation of orographic and coastal effects, as well as more resolved model physics.
In this study, we use two sets of 5-year 6-member ensemble simulations of a state-of-the-art atmosphere only GCM (AGCM, EC-Earth) to investigate the effect of GCM spatial resolution on modeled precipitation over Europe. The objectives of the analysis are to determine whether climate models have sufficient spatial resolution to resolve the physical processes affecting precipitation. We investigate if there is a significant statistical difference in modeled precipitation between a low-resolution and a high-resolution AGCM ensemble, and if either of the ensembles gives a better representation of precipitation in the actual climate system.
We find that the high resolution ensemble gives a more accurate representation of European winter precipitation than the low-resolution ensemble, both in the mean-state and in the extremes. The low resolution ensemble has more precipitation in most of the northern half of Europe and less precipitation in the southern half. Our results suggest that synoptic systems are better simulated in high resolution GCMs, providing for a more accurate horizontal moisture transport and moisture flux convergence. High resolution regional climate models may have a too small spatial domain to capture this effect. Our findings may be valid for other GCMs as well, showing the necessity to analyze other GCMs that may become available in the future with such high horizontal resolutions.