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Calibrating regionally downscaled precipitation over Norway through quantile-based approaches

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Abstract. Dynamical downscaling of earth system models is intended to produce high-resolution climate information at regional to local scales. Current models, while adequate for describing temperature distributions at relatively small scales, struggle when it comes to describing precipitation distributions. In order to better match the distribution of observed precipitation over Norway, we consider approaches to statistical adjustment of the output from a regional climate model when forced with ERA-40 reanalysis boundary conditions. As a second step, we try to correct downscalings of historical climate model runs using these transformations built from downscaled ERA-40 data. Unless such calibrations are successful, it is difficult to argue that scenario-based downscaled climate projections are realistic and useful for decision makers. We study both full quantile calibrations and several different methods that correct individual quantiles separately using random field models. Results based on cross-validation show that while a full quantile calibration is not very effective in this case, one can correct individual quantiles satisfactorily if the spatial structure in the data are accounted for. Interestingly, different methods are favoured depending on whether ERA-40 data or historical climate model runs are adjusted.

1 Introduction

The intensification of climate research over the past decade produces a steadily increasing number of data sets combining different global circulation or earth system models, CO_2 emissions scenarios and downscaling techniques. Turning future projections into robust and reliable information available at a local scale is imperative for the successful modelling of impacts of climate change in nature and society. The comprehensive financial and safeguarding challenges of mitigation and adaptation call for thorough validation, improvement and extensions of current downscaling techniques.

The comparison of climate models to weather data raises interesting statistical problems. For a statistician, the most natural definition of the climate is that it is the distribution of weather (and other earth system variables) over multi-decadal timescales (Smith et al., 2010; Guttorp, 2014). A climate model (general circulation model or more generally earth system model) describes the distribution of observable variables based on physical principles. Because some of the processes (e.g. convection, clouds) occur on scales smaller than the large grid squares needed to approximate a solution to the Navier–Stokes equations, such processes are often calculated using simple approximations (or parameterizations).

A multitude of models have emerged for projection of future climate change at different spatial (and temporal) scales. Essential in the process of going from the coarse resolution of the global models to finer spatial scales are the regional climate models (RCMs). Such models propagate information from a coarse-scale model along the boundary of a higher-resolution area of interest, using a more detailed terrain description, model solutions using finer resolution, and