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The curse of the law of small numbers haunts regional climate modelling

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Natural variations have a non-predictable nature for example in terms of the timing and location of regional warm, cold, wet or dry periods. Such variability is particularly pronounced at mid-latitudes where the dynamics are strongly non-linear, and its chaotic nature makes the natural variability non-deterministic and for all intents and purposes random. We suggest that the chaotic nature of natural variability on regional scales results in random states, and that together different simulations with climate models capture a large part of the range of variability. Hence, an ensemble of climate model simulations can be approximated as a "pseudo-sample" and a basis for the estimation of statistical properties such as probability. In an ideal case, for which an ensemble was to provide a true statistical sample, there is a severe limitation to statistical description known as the "law of small numbers". The estimates of statistical parameters are often misleading if they are based on a small sample, and a minimum size is often taken to be at least 30 data points. For regional climate modelling, it is the boundary conditions from the global climate models that define the regional climate variability, and it is the number of global climate model simulations that defines the real size of the sample. A major limitation with regional climate models is their high computational demand. This limits the size of the ensembles of regional climate simulations and forces the modeller to decide (often subjectively) which global models to downscale. Empirical-statistical downscaling, on the other hand, is well-suited for downscaling large multimodel ensembles of global climate model simulations. Drawing on strengths from both fields this can help to put regional modelling results in perspective, making results more robust.
We present some examples where a small sample of regional climate models is compared with empirical-statistical downscaling applied to the same driving global models as well as a larger ensemble to demonstrate how the law of small numbers can produce a cold bias in the estimated future warming.