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Do regional climate models represent regional climate?

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When using climate change scenarios - either from global climate models or further downscaled - to assess localised real world impacts, one has to ensure that the local simulation indeed correctly represents the real world local climate. Representativeness has so far mainly been discussed as a scale issue: simulated meteorological variables in general represent grid box averages, whereas real weather is often expressed by means of point values. As a result, in particular simulated extreme values are not directly comparable with observed local extreme values.

Here we argue that the issue of representativeness is more general. To illustrate this point, assume the following situations: first, the (GCM or RCM) simulated large scale weather, e.g., the mid-latitude storm track, might be systematically distorted compared to observed weather. If such a distortion at the synoptic scale is strong, the simulated local climate might be completely different from the observed. Second, the orography even of high resolution RCMs is only a coarse model of true orography. In particular in mountain ranges the simulated mesoscale flow might therefore considerably deviate from the observed flow, leading to systematically displaced local weather. In both cases, the simulated local climate does not represent observed local climate. Thus, representativeness also encompasses representing a particular location.

We propose to measure this aspect of representativeness for RCMs driven with perfect boundary conditions as the correlation between observations and simulations at the inter-annual scale. In doing so, random variability generated by the RCMs is largely averaged out. As an example, we assess how well KNMIs $RACMO_2$ RCM at 25km horizontal resolution represents winter precipitation in the gridded E-OBS data set over the European domain.

At a chosen grid box, RCM precipitation might not be representative of observed precipitation, in particular in the rain shadow of major moutain ranges. Here, the simulated windward weather does not cross the mountains to the extent it does in reality. As a consequence, using the local simulated precipitation time series to drive impact models might lead to a completely wrong representation of the resulting impact, such as the variability of river runoff in small mountaineous catchments. The good news are that in most cases, simulated precipitation from a distant grid box is representative of the chosen observed precipitation. In other words: if one needs to provide an input time series for an impact study in the southern slopes of the Alps, it might be advisable not to use locally simulated precipitation, but instead to use bias corrected precipitation from the north-western slope of the Alps. We show that this non-local correction can also improve the representation of climate change trends.

Our findings also have implications for bias correction. If the local grid box simulation is representative, a classical bias correction can in principle be applied. If a non-local grid box simulation is representative, a non-local bias correction can be applied. If representativity could not be established, bias correction is in general not justified and should only be carried out based on stringent physical reasoning.