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To what extent is climate change detection at the local scale 'clouded' by internal variability?

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Internal variability, i.e. the natural variability of the climate system, has been shown to be an important source of uncertainty in climate change projections of mean and (especially) extreme climate events, next to model uncertainty and uncertainty in projections of greenhouse gas emissions. To quantify the internal variability and get a robust estimate of the forced climate change response, large ensembles of climate model simulations of the same model provide essential information.

For global climate models (GCMs) a number of these single model ensembles are indeed available. So far however, the size of single model ensembles for regional climate models (RCMs) has been limited to only a few members, relatively short periods or small modeling domains. Here, we use a 16 member ensemble generated with the RCM KNMI-RACMO$_2$ driven by the GCM EC-EARTH. The initial atmospheric state of EC-EARTH was perturbed in 1850, after which each member was run until 2100 assuming the historical emission scenario until 2005 and the RCP8.5 emission scenario from 2006 onwards. Each of the EC-EARTH members was then downscaled on a 12-km resolved domain covering Western Europe including the Alps for the period 1950-2100.

For this ensemble we show the climate change signal, the noise due to internal variability and the signal-to-noise ratio, and how these depend on parameter, season, location and projection period. Using an aggregated spatial probability perspective similar to Fischer et al. (2013) we also examine whether spatially aggregated responses yield more robust changes and earlier detection times of climate change.

This information is particularly relevant when the output of RCMs is applied in impact studies. Firstly, with this information we can identify which of the two – internal variability or climate change - is more important for a certain timescale, requiring potentially different coping strategies. Secondly, the internal variability can be a cause for the discrepancy between RCM output and observations, and should thus be considered in the RCM output bias correction when applied in impact models.