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Quantifying the effect of varying GHG's concentration in Regional Climate Models

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Regional Climate Models (RCMs) are driven at the boundaries by Global Circulation Models (GCM), and in the particular case of Climate Change projections, such simulations are forced by varying greenhouse gases (GHGs) concentrations. In hindcast simulations driven by reanalysis products, the climate change signal is usually introduced in the assimilation process as well. An interesting question arising in this context is whether GHGs concentrations have to be varied within the RCMs model itself, or rather they should be kept constant. Some groups keep the GHGs concentrations constant under the assumption that information about climate change signal is given throughout the boundaries; sometimes certain radiation parameterization schemes do not permit such changes. Other approaches vary these concentrations arguing that this preserves the physical coherence respect to the driving conditions for the RCM. This work aims to shed light on this topic.

For this task, various regional climate simulations with the WRF model for the 1954-2004 period have been carried out for using a Euro-CORDEX compliant domain. A series of simulations with constant and variable GHGs have been performed using both, a GCM (ECHAM6-OM) and a reanalysis product (ERA-20C) data. Results indicate that there exist noticeable differences when introducing varying GHGs concentrations within the RCM domain. The differences in 2-m temperature series between the experiments with varying or constant GHGs concentration strongly depend on the atmospheric conditions, appearing a strong interannual variability. This suggests that short-term experiments are not recommended if the aim is to assess the role of varying GHGs. In addition, and consistently in both GCM and reanalysis-driven experiments, the magnitude of temperature trends, as well as the spatial pattern represented by varying GHGs experiment, are closer to the driving dataset than in experiments keeping constant the GHGs concentration.

These results point towards the need for the inclusion of varying GHGs concentration within the RCM itself when dynamically downscaling global datasets, both in GCM and hindcast simulations.