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Simulated and reconstructed climate in Europe during the last five centuries: joint evaluation of climate models performance and the dynamical consistency of gridded reconstructions

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This study jointly analyses European winter and summer temperature and precipitation gridded climate reconstructions and a regional climate simulation reaching a resolution of 45 km over the period 1501-1990. In a first step, the simulation is compared to observational records to establish the model performance and to identify the most prominent caveats. It is found that the regional simulation is able to add value to the driving global simulation, which allows it to reproduce accurately the most prominent characteristics of the European climate, although remarkable biases can also be identified. In a second step, the simulation is compared to a set on independent reconstructions. The high-resolution of the simulation and the reconstructions allows to analyse the European area for nine sub-areas. An overall good agreement is found between the reconstructed and simulated climate variability across different areas, supporting a consistency of both products and the proper calibration of the reconstructions. However, biases appear between both datasets, that thanks to the evaluation of the model performance carried out before, can be attributed to deficiencies in the simulation. Although the simulation responds to external forcing, it largely differers with reconstructions in their estimates of the past climate evolution for European sub-regions. In particular, there are deviations between simulated and reconstructed anomalies during the Maunder and Dalton minima, i.e. the simulated response is much stronger than the reconstructed. This disagreement is to some extent expected given the prominent role of internal variability in the regional evolution of temperature and precipitation. However the inability of the model to reproduce any warm period similar to that recorded around 1740 in the reconstructions indicates fundamental limitations in the simulation that preclude reproducing exceptionally anomalous conditions. Despite these limitations, the simulated climate is a physically consistent dataset, which can be used as a benchmark to analyse the consistency and limitations of gridded reconstructions of different variables. Comparison of the main variability modes of surface air temperature and precipitation indicates that reconstructions present too simplistic variability modes. This can be attributed to the linear techniques employed in the reconstructions. Particularly the precipitation reconstruction exhibits patterns that are simpler than the simulated ones. These are in turn too simple compared to observations. The co-variability among variables is investigated through Canonical Correlation Analysis in both datasets and compared to observations. The simulation is roughly able to capture the co-variability, whereas independent reconstructions for different variables show a very low correlation, indicating a lack of dynamic consistency that reduces the confidence in such subcontinental European reconstructions.