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Added value of a regional climate model simulation of historical times over Europe

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A simulation with the regional climate model (RCM) CCLM is analysed for the historical period 1645–2000 AD over the European-Mediterranean region. The regional simulation was driven with the output of the Earth System Model (ESM) of the MPI in Hamburg including transient changes in orbital parameters, solar activity and volcanic aerosols. As a novelty the ESM uses a model for the interactive simulation of the carbon cycle and also changes in land use are implemented.

The horizontal resolution of the regional model is 0.44° x 0.44°, whereas the atmospheric model in the ESM has a resolution of 3.75° x 3.75°. The increased spatial resolution of the RCM is also reflected in the simulated climatic fields of near-surface temperatures and precipitation. Especially, the structure of the RCM-simulated mean precipitation pattern resembles the observations better than the direct ESM output. However, precipitation biases in the RCM are partly larger than in the ESM due to the overestimation of precipitation by the RCM, especially at the windward sides of mountain chains. Also the RCM temperature bias is larger than the ESM bias, especially over the Baltic region.

The comparison between the ESM and RCM for near-surface temperatures reveals that the RCM largely follows the evolution of the driving ESM in different European (sub)regions. This is even the case for regions showing complex terrain. Periods with marked changes in external (solar and volcanic) and internal (greenhouse gases) forcing parameters are reflected in regional temperature changes, for instance related to a temperature decrease during the Maunder Minimum (1675–1715 AD) and an increase in the 2nd half of the 20th century. Although the amplitude of temperature changes is mostly pronounced during wintertime, temperature changes related to forcing changes are primarily evident during summertime when solar incoming radiation is largest and changes in atmospheric circulation do not mask the externally controlled temperature variability over Europe.

The added value of the regional climate simulation can be seen primarily for hydrological variables like precipitation. For example, the spatial variability patterns simulated by the RCM over the Iberian Peninsula are more consistent with observed patterns compared to those simulated by the ESM. For comparisons with empirical proxy data like local lake level changes or tree rings this is of specific importance, because hydrological gradients may change within only a couple of 10th of kilometres quite profoundly. A second example relates to the presence of coastal orographic boundaries resolved by the RCM around the Mediterranean area like the Pyrenees, the European and the Dinaric Alps and the valley systems intersecting these barriers. These coastal orographic features posses an important influence also on atmospheric mesoscale circulation properties, for instance induced by a more realistic representation of the absolute height of mountain chains as well as windward and leeward effects. The more realistic simulation of these mesoscale circulation systems also influences the hydrological long-term evolution and variability. Therefore it is important to use the downscaled output of ESMs in order to establish a better basis for comparisons with existing hydrological-sensitive proxies in these regions. In the future results of the RCM simulation will be compared with empirical reconstructions based on new statistical reconstruction approaches related to bayesian hierarchical modeling.