Climate dynamics investigations for the Carpathian Basin with the REMO regional climate model

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Abstract

The main objectives of the research were (i) to adapt the REMO regional climate model (RCM) developed by the Max Planck Institute for Meteorology (in Hamburg) at the Hungarian Meteorological Service (OMSZ); (ii) to validate its applicability over the Carpathian Basin and (iii) to estimate the main climate change features of Hungary.

Firstly, the REMO model was adapted to the supercomputer of OMSZ and some short technical and scientific tests were performed. Then it was concluded that the optimal horizontal resolution of REMO is at 18-25 km range and its spin up period is 4 years. After the preparatory testing phase, a model simulation was conducted over a domain covering Central and Eastern Europe on 25 km horizontal resolution for 1957–2000 using observation-based (i.e., considered as quasi-perfect) ERA-40 re-analyses as lateral boundary conditions. The temperature and precipitation results were validated against the E-OBS and CARPATCLIM gridded observational datasets for 1961–1990 and 1971–2000, respectively. REMO produced systematically higher past temperature values in comparison to the measurements. For Hungary the overestimation reached 3 ºC in summer and autumn, while it was lower in spring and winter. The precipitation was exaggerated at some areas of the model domain, though the mean amounts over Hungary had slight error in summer and autumn.

After validation runs a climate change simulation was carried out for 1951–2100 using the same integration domain. The lateral boundary conditions were taken from the ECHAM5/MPI-OM coupled global climate model run forced by A1B emission scenario. REMO with ECHAM drivings produced good past temperature estimations only with minor departures from the observations, whereas precipitation was overestimated except summer. The projection results were evaluated for the periods of 2021–2050 and 2071–2100 with respect to 1961–1990. For Hungary, REMO provides the largest temperature increase in summer and autumn (around 1.5 and 4 ºC for 2021–2050 and 2071–2100, respectively). The number of warm (tropical) nights, summer and hot days is projected to enhance with 10-20 days for the near-future and with more than 30 days for the far-future, at the same time the frequency of frost and extremely cold days will likely reduce. Only slight annual precipitation change is foreseen, however, its seasonal distribution is going to change: 26 % summer decrease and 31 % winter increase for 2071–2100. The reduction of precipitation events is projected in every season except in winter, the days with daily precipitation exceeding 10-20 mm will increase apart from summer, at the same time longer dry periods are simulated by the end of the century, especially over the southern and eastern regions of Hungary.

The outcomes are compared to RCM results available in Hungary and Europe. REMO produced similar model errors and simulated same temperature tendencies for the Carpathian Basin as the investigated RCMs. Furthermore, results of the ENSEMBLES project confirm that summer precipitation decrease is likely to be compensated mainly by winter increase. Finally, two – an optimal and a practical – examples are shown for quantifying the uncertainties of meteorological modelling and applying them into impact studies.