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Temporal characteristics of heat waves and cold spells and their links to overly persistent atmospheric circulation in EURO-CORDEX RCMs

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We study links between atmospheric circulation and summer heat waves/winter cold spells in an ensemble of EURO-CORDEX RCMs in Central Europe. Evaluation of 23 model simulations allowed us to analyse the influence of the RCM formulation as well as of the driving data (the ERA-INTERIM re-analysis and 4 different GCMs), and the role of the spatial resolution (0.11deg and 0.44deg). Model results were compared against observations over the reference period of 1980–2005. Atmospheric circulation was represented by circulation indices derived from daily gridded mean sea level pressure data, and by circulation types/supertypes derived from the indices. We examine observed and simulated temporal characteristics of hot and cold days (defined as days with temperature anomaly above/below the 90th/10th quantile of their empirical distributions in summer/winter) and heat waves and cold spells (defined as periods of at least three hot/cold days in summer/winter), focusing on their links to the persistence of atmospheric circulation, especially those circulation types significantly conducive to heat waves and cold spells.

Although the RCMs reproduce the frequency of heat waves and cold spells relatively well, they have a tendency to produce longer than observed heat waves and cold spells, with some simulations leading to extremely long heat waves or cold spells. The RCMs have a tendency to cluster cold days together, and to produce more days in cold spells per season than observed. All models simulate a winter season with a larger number of cold days/days in cold spells than in any season observed, which indicates too high interannual variability of winter conditions. The RCMs reproduce in general the observed circulation significantly conducive to heat waves and cold spells. Zonal flow reduces the probability of temperature extremes in both seasons, and more easterly flow days in a season are linked to a higher number of cold spell days. Prolonged temperature extremes (both heat waves and cold spells) are primarily linked to easterly/southeasterly circulation. Because of these links, the RCM simulation of temperature extremes is strongly affected by biases in atmospheric circulation. For almost all simulations and all circulation supertypes, there is a significant overestimation of the mean length of sequences of supertypes in summer. Model simulations also strongly overestimate the mean length of westerly flow in winter. We also detected biases in reproducing the observed distributions of temperature anomalies from the annual cycle leading to an overestimation of the 10th quantile (used in the definition of cold days/cold spells) by up to several degrees of Celsius.