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Ranking and projection of CMIP6 based on Climatic Extremes performance over Central Europe

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This study explores future projections of climate extreme indices in Central Europe and examines the impact of performance-based subsetting of Global Climate Models (GCMs). To achieve this, we evaluated CMIP6 GCMs based on their accuracy in replicating the observed mean, spatial correlation, and variability of selected climate extreme indices. We analyzed simulations from all available CMIP6 models under four socio-economic scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5), using two baseline periods (1961-1990 and 1981-2010) and two future periods (2021-2050 and 2070-2099). The study considered three air temperature indices: (i) the number of days with daily maximum temperature over 34 °C (Su34), (ii) the number of days with daily maximum temperature over 25 °C (Su25), and (iii) the number of tropical nights with daily minimum temperature over 20 °C (TN). Additionally, we analyzed four rainfall indices: (i) number of days with very heavy precipitation over 20 mm (R20mm), (ii) number of days with heavy precipitation over 10 mm (R10mm), (iii) consecutive dry days (CDD), and (iv) consecutive wet days (CWD) for precipitation thresholds of 1 mm and 2 mm. Our ranking method assigned scores to the models from 1 to 39 for each climate extreme index based on three evaluation metrics: Pearson's correlation coefficient, the ratio of the mean, and the ratio of the standard deviation. The total rank for each GCM was determined by summing these scores across all indices and metrics.

The median of the multi-model ensemble (MME) indicates an important increase in the number of days with very heavy and heavy precipitation, especially towards the end of the century, while the number of consecutive wet days shows minimal change. Consecutive dry days are projected to increase significantly by the late 21st century. There is also a marked rise in the number of summer days and tropical nights, with more pronounced changes in the southern regions of the study area.

We selected the top ten models ensemble (BME) based on their performance ranking. For historical periods, the BME showed improved accuracy for the mean of all indices except Su34. For future projections, the BME indicates greater positive changes in very heavy precipitation and consecutive wet days compared to the MME. Conversely, the BME shows smaller changes for Su34 and Su25 indices, particularly for the far future period. The interquartile range (IQR) of R10mm and R20mm is higher for the BME than for the MME. The BME's IQR for CDD is also higher, except under SSP585, where it narrows in both future periods. The IQR for CWD remains similar between the BME and MME, with a higher IQR only under SSP126. For Su25 and Su34, the BME exhibits a higher IQR under all scenarios except SSP585 in the near future. Regarding tropical nights, the BME reduces the IQR across all scenarios while maintaining the MME medians.