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Improved northern hemispheric atmospheric blocking properties in two storm-resolving climate models

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Atmospheric blocking and its associated extreme phenomena, such as hot and cold spells represent a risk to society. Current climate models struggle to simulate the atmospheric blocking properties, making it difficult to understand the underlying physical processes and raising uncertainty about their evolution under warming. Today, several climate models attempt to better resolve small-scale processes and have demonstrated their ability to convincingly simulate them; however, few studies have evaluated the impact of these tunings on large-scale flow.

Here, we investigate the representation of Atmospheric blocking characteristics in the two new generations of storm-resolving Earth-system models (nextGEMS), consisting of the Icosahedral Nonhydrostatic Weather and Climate Model (ICON) and the ECMWF Integrated Forecasting System (hereafter only IFS). These models are run at high horizontal resolution, ICON at 5 km (convective parameterization off) and IFS at 4.4 km and 28 km (convective parameterization on). Both models are fully coupled models with eddy-resolving ocean models. The five years of simulations are compared with the reanalysis ERA5 and one CMIP6 model (MPI-ESM1-2-LR). Atmospheric blockings are identified and tracked using a Lagrangian approach based on the geopotential height anomaly at 500 hPa. Properties such as intensity, size, and zonal speed are evaluated.

The nextGEMS showed an increased skill in reproducing atmospheric blocking at the system scale. Firstly, the Atmospheric blocking intensity, spatial extension, and zonal speed are closer to the ERA5 than the CMIP6 model. However, the block intensity and size in the IFS model are simulated better than in the ICON model, and its improvement increases at the finest resolution, 4.4 km. This improvement at higher resolution coincides with more precipitation upstream to the block center than at lower resolution during the onset phase. The latter is consistent with recent studies, indicating that increased moist processes contribute to stronger and bigger blocks. Thus, we provide insights into how the large-scale flow can benefit from the storm-resolving climate models by increasing their skill to simulate atmospheric blocking characteristics and the diabatic processes at higher resolution in a fully coupled system. A more comprehensive evaluation of the large-scale flow in the nextGEMS models will be performed with longer runs.