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Using a nested single-model large ensemble to assess the internal variability of the North Atlantic Oscillation and its climatic implications for Central Europe

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The ClimEx-project ("Climate change and hydrological extreme events"; www.climex-project.org) provides a single-model initial-condition ensemble that is unprecedented in terms of size, resolution and domain coverage: 50 members of the Canadian Earth System Model version 2 (CanESM2 Large Ensemble, 2.8° spatial resolution) are downscaled using the Canadian Regional Climate Model version 5 (CRCM5 Large Ensemble, 0.11° spatial and up to hourly temporal resolution) over two domains, Europe and northeastern North America. The high-resolution climate information serves as input for hydrological simulations to investigate the impact of internal variability and climate change on hydrometeorological extremes.

This study evaluates the downscaling of a teleconnection which affects northern hemisphere climate variability, the North Atlantic Oscillation (NAO), within the nested single-model large ensemble of the ClimEx project. The overall goal of this study is to assess whether the range of NAO internal variability is represented consistently between the driving global climate model (GCM, i.e., the CanESM2) and the nested regional climate model (RCM, i.e., the CRCM5).

The NAO pressure dipole is quantified in the CanESM2-LE; responses of mean surface air temperature and total precipitation sum to changes in the NAO index are evaluated within a Central European domain in both the CanESM2-LE and the CRCM5-LE. NAO–response relationships are expressed via Pearson correlation coefficients and the change per unit index change for historical (1981–2010) and future (2070–2099) winters.

Results show that statistically robust NAO patterns are found in the CanESM2-LE under current forcing conditions, and reproductions of the NAO flow pattern present in the CanESM2-LE produce plausible temperature and precipitation responses in the high-resolution CRCM5-LE. The NAO–response relationship is more strongly evolved in the CRCM5-LE than in the CanESM2-LE, but the inter-member spread shows no significant differences: thus internal variability expressed as inter-member spread can be seen as being represented consistently between the GCM and RCM. NAO–response relationships weaken in the future period in both the CanESM2-LE and CRCM5-LE, suggesting that the NAO influence on Central European temperature and precipitation decreases.

The results stress the advantages of a single-model ensemble regarding the evaluation of internal variability. They also strengthen the validity of the nested ensemble for further impact modelling using RCM data only, since important large-scale teleconnections present in the driving GCM propagate properly to the fine scale dynamics in the RCM.