Resolution sensitivity of European extreme precipitation and its response to large-scale atmospheric circulation variability

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The effects of atmospheric modes of variability, such as the North Atlantic Oscillation (NAO), on the spatiotemporal distribution of European mean precipitation are relatively well-documented, but less is known about their impact on precipitation extremes. It is important to determine how well GCMs represent relationships between extremes and large-scale modes of atmospheric circulation variability, particularly for understanding the implications of a given medium-range or seasonal NAO forecast for extreme precipitation. Here, we evaluate the resolution sensitivity of European extreme precipitation in gridded observations (ECA&D E-OBS) and in an ensemble of both atmosphere-only and coupled global simulations, compiled as part of the EU Horizon2020-funded PRIMAVERA project, where mid-latitude horizontal resolution is increased from ~135 to ~25km. The global models comprising this study are HadGEM3-GA3, -GA6, -GA7, and EC-Earth3.1 (atmosphere-only), and HadGEM3-GC2, EC-Earth3 and CNRM-CM5 (coupled). We adopt a multi-metric approach to model evaluation by (*i*) computing extreme quantile composites for NAO+ and NAO- regimes; (*ii*) applying generalised extreme value analysis to daily precipitation and aggregating results over large European river basins (>50000 km^2); and (*iii*) determining the contribution to extreme precipitation by Euro-Atlantic sector cyclones. For example, the 95th percentile of daily winter precipitation was composited (NAO+ - NAO-) and zonally averaged (see figure). The large-scale pattern – wet north-western Europe and dry southern Europe – is reproduced by HadGEM3-GA3. However, the response of extreme precipitation between ~40-50°N to NAO phase is overestimated across the resolution hierarchy and the variability between 58-65°N is captured only at N512 resolution, likely due to its better representation of Norwegian topography. Our complementary statistical and process-based model evaluations attempt to characterise and evaluate the resolution sensitivity of links between European extreme precipitation and large-scale atmospheric variability.

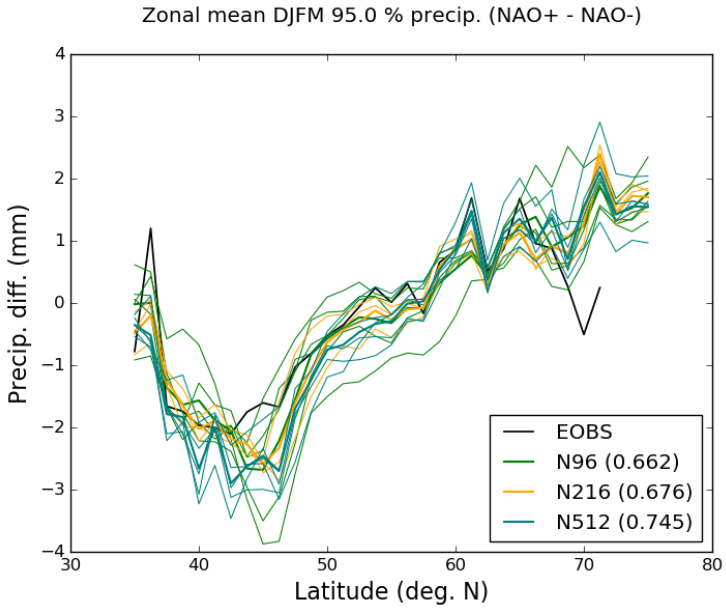

Figure: Zonal mean (-40-60 °E) difference between European extreme (95th percentile) winter precipitation (December-March) under NAO+ vs NAO- in gridded observations (EOBS) and HadGEM3-GA3.0 simulations (UPSCALE campaign), with horizontal resolutions of ~130km (N96), ~60km (N216) and ~25km (N512). Precipitation over land only. Values in legend give ensemble mean root-mean-square error (model-EOBS).