Supplement of Earth Syst. Dynam., 12, 457–468, 2021
https://doi.org/10.5194/esd-12-457-2021-supplement

Supplement of

Weather extremes over Europe under 1.5 and 2.0 °C global warming from HAPPI regional climate ensemble simulations

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SUPPLEMENT

Comparison with observations

This supplement describes a comparison of the annual cycle of temperature and precipitation regional ensembles with the global ensembles and observations. Figures S-1, S-2, S-3 and S-4 show the annual cycle based on monthly mean data in near-surface temperature and precipitation of the GCM and RCM ensemble for the current decade (2006-2015) compared to the E-OBS (Haylock, et al., 2008) gridded observational dataset for the eight PRUDENCE regions (Christensen and Christensen, 2007). We use version 17.0 of the E-OBS dataset, because it is the last version that provides data on a rotated 0.44° grid, which is the same as the REMO grid and makes horizontal interpolation between E-OBS and REMO results unnecessary. Due to different representations of orography, a correction using a lapse-rate with 0.0067 K m^{-1} has been performed for temperature. The GCM data was horizontally interpolated to the E-OBS grid and the same vertical interpolation method for temperature was used. Annual cycles are computed for each ensemble member individually and shown as a range is the minimum/maximum ensemble member for that particular month. For the E-OBS data a multi-year (2006-2015) monthly mean value is presented.

For most of the regions, the GCMs as well as the RCM ensembles are performing well in terms of temperature (Figures S-2 and S-4). One striking feature is a warm bias especially during summer over the Mediterranean in all ensembles. A possible explanation might be the poor representation of air-sea interactions over the Mediterranean. Another interesting but not surprising feature is that the RCM ensembles are often closer to the observational dataset than the GCM ensembles. This can be explained by the better representation of regional climatic features due to a better horizontal resolution in the RCM. In terms of precipitation, the performance is generally less good (Figures S-1 and S-3). While the models simulate precipitation well in the Iberian Peninsula and the Mediterranean, they tend to overestimate precipitation compared to E-OBS in other areas, but no general conclusion can be drawn from the Figures in terms of precipitation. The RCM ensembles show an improved performance over the GCM ensembles the Alps. For other areas the benefit of an RCM would show up in spatial patterns and not in highly aggregated measures that are shown here. It is not a straightforward comparison, but similar features in terms of biases can be found in historical climate change simulations with REMO (Teichmann et al., 2013; Remedio et al., 2019). A more in-depth analysis of the briefly discussed features would be needed for more comprehensive explanations, which is beyond the scope of this paper.

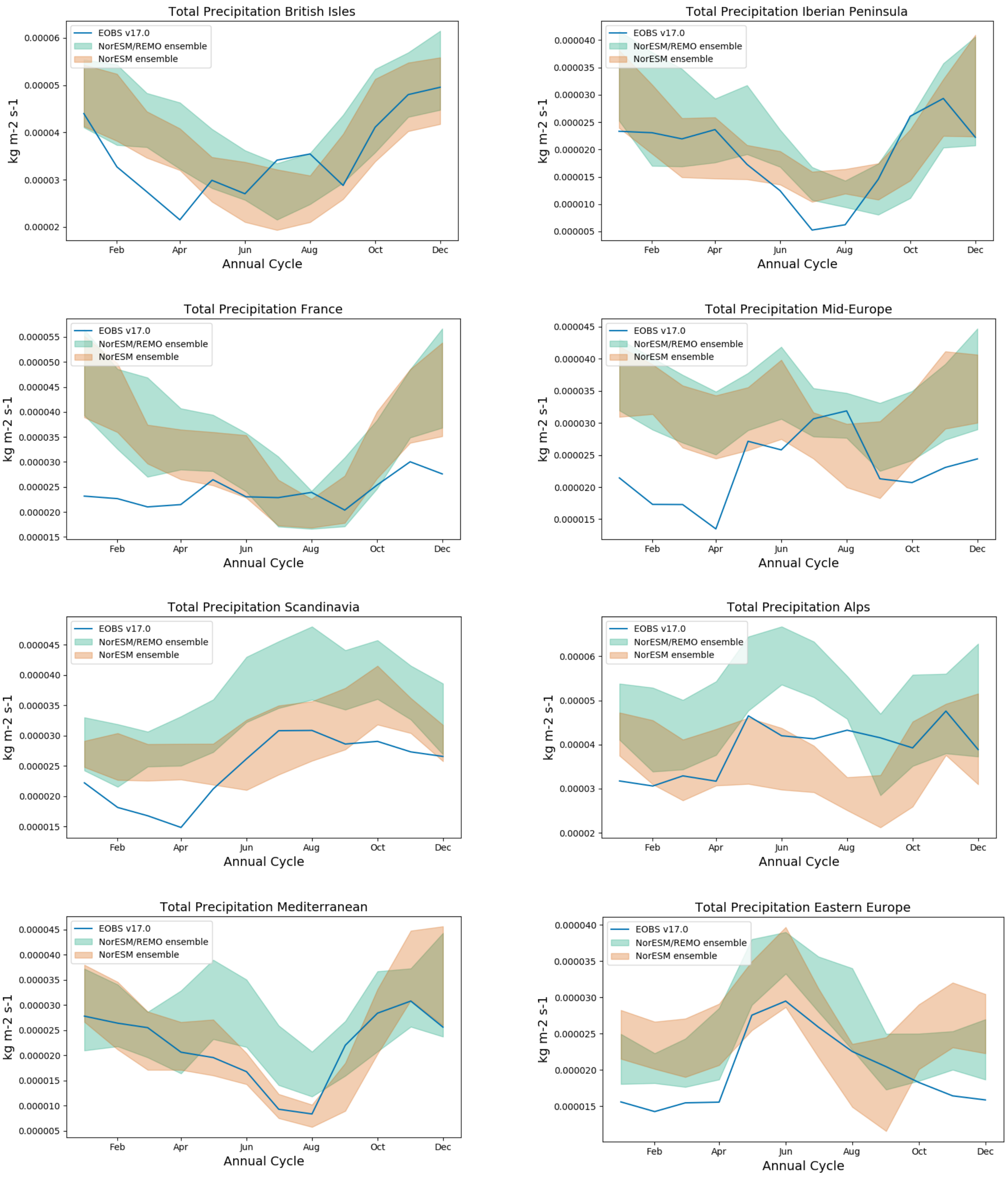

Figure S1. Precipitation for the NorESM-REMO simulations, compared to the NorESM GCM simulations and E-OBS observations.

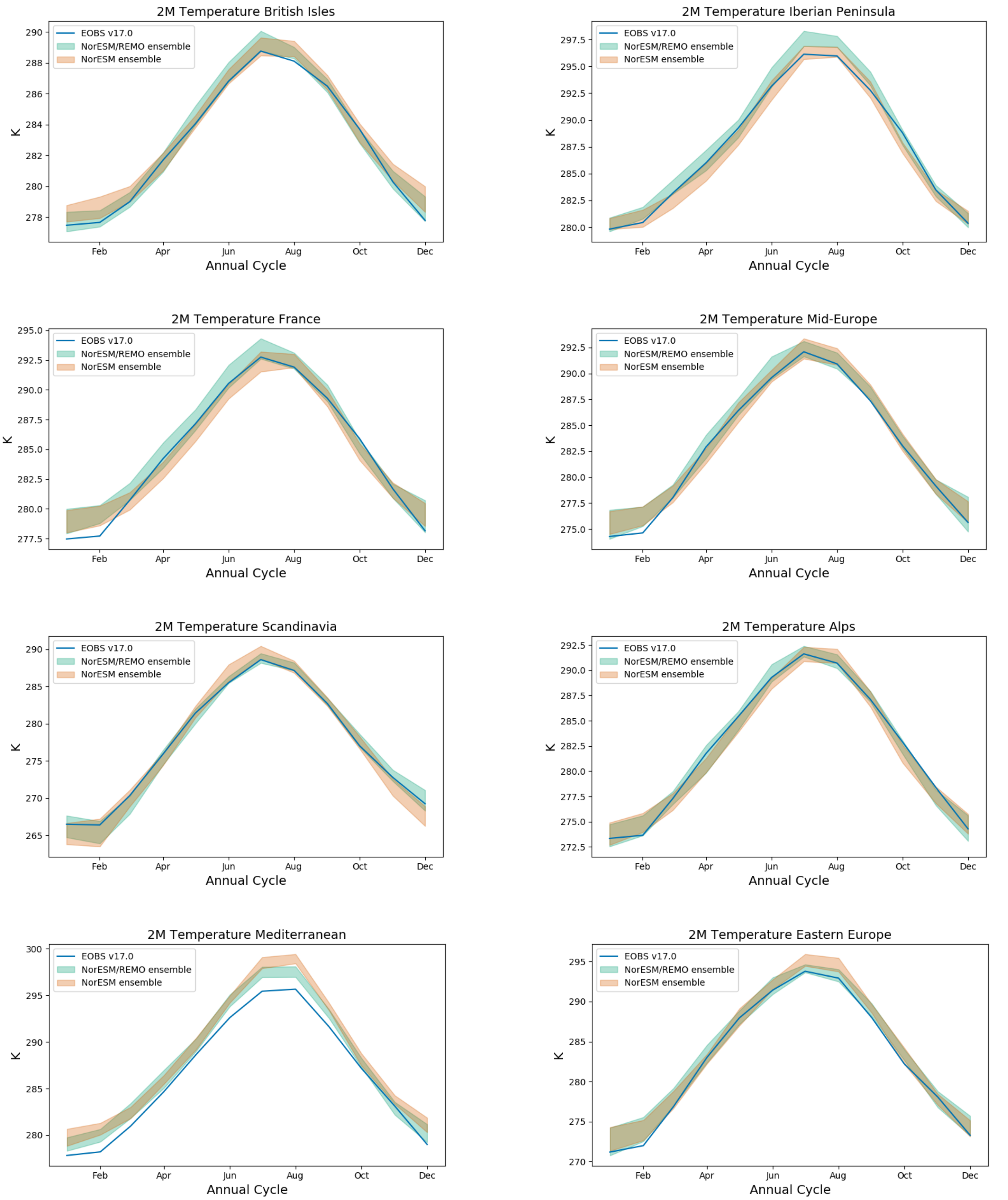

Figure S2. Temperature for the NorESM-REMO simulations, compared to the NorESM GCM simulations and E-OBS observations.

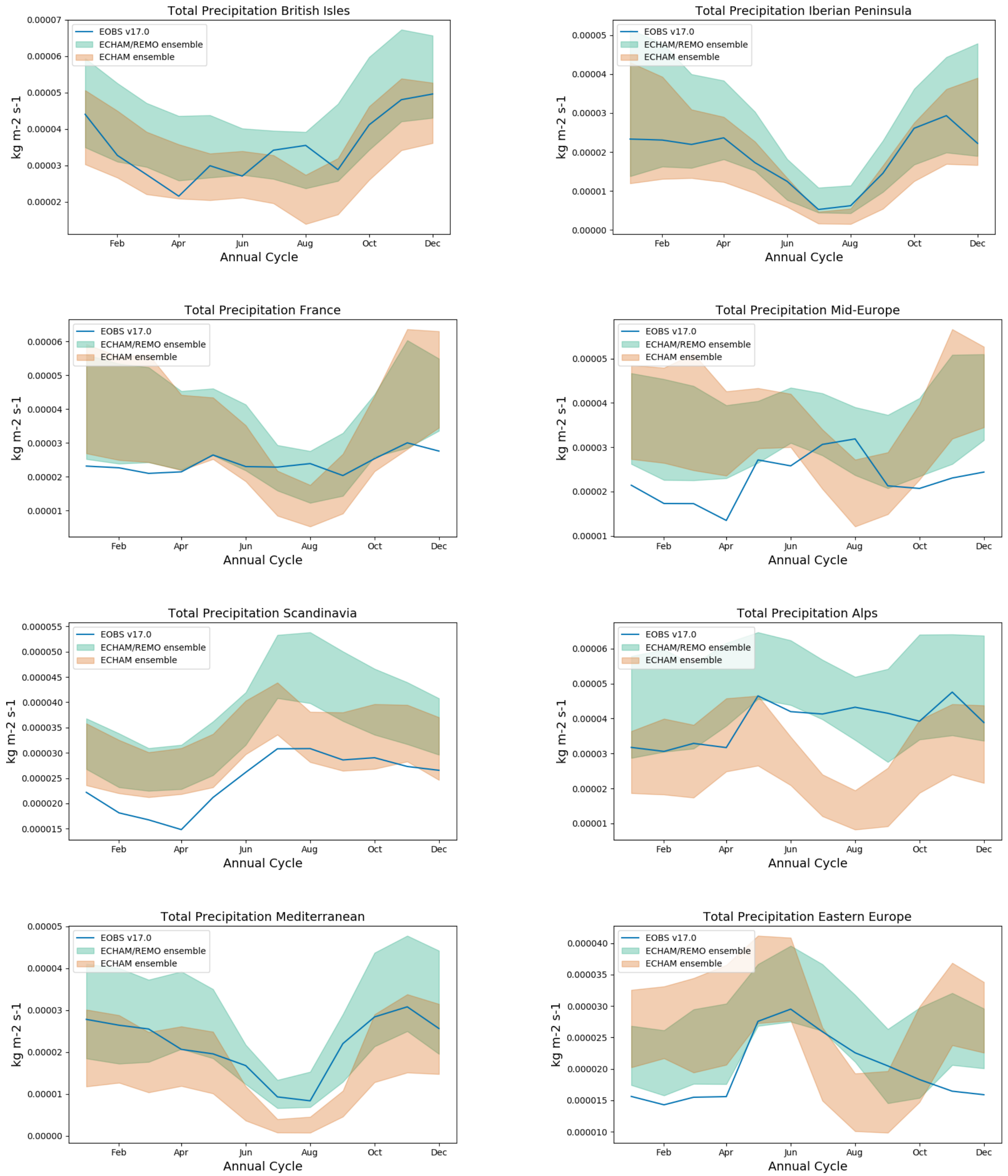

Figure S3. Precipitation for the ECHAM-REMO simulations, compared to the ECHAM GCM simulations and E-OBS observations.

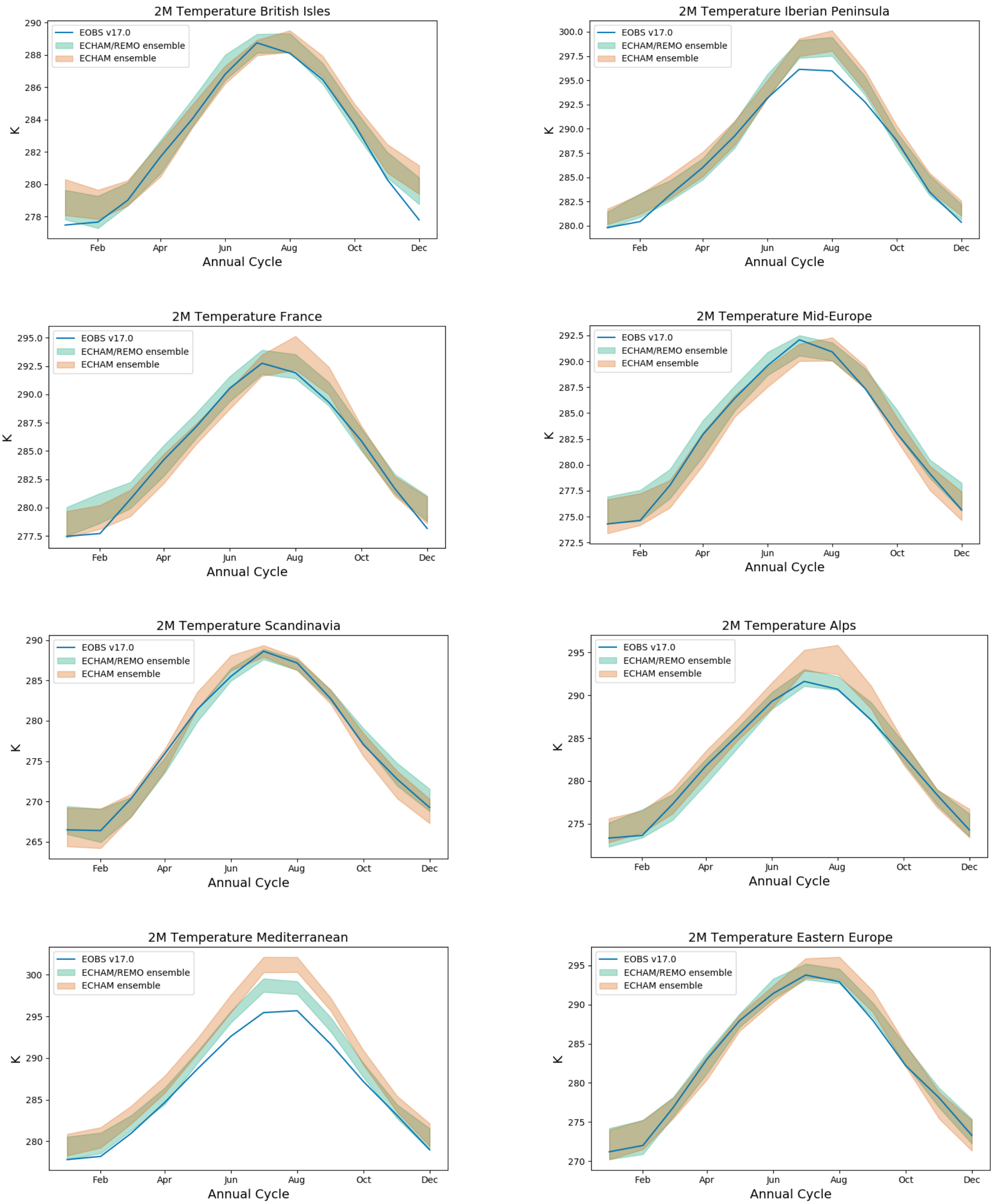

Figure S4. Temperature for the ECHAM-REMO simulations, compared to the ECHAM GCM simulations and E-OBS observations.

Spatial pattern of RX5day with a reduced member ECHAM6 ensemble

This supplement examines the influence of different sized ensembles on the RX5day index. In order to confirm that the more noisy patterns of the NorESM compared to ECHAM6 driven ensemble in Figure 4 are at least partly related to the number of ensemble members, we computed the same plots as in Figure 4 but with a randomly picked 25-member ECHAM6 driven REMO ensemble instead of the NorESM driven ensemble (Figure S-5). It can be clearly seen that the reduced member ensemble shows a noisier pattern with less significant grid boxes compared to the full ensemble.

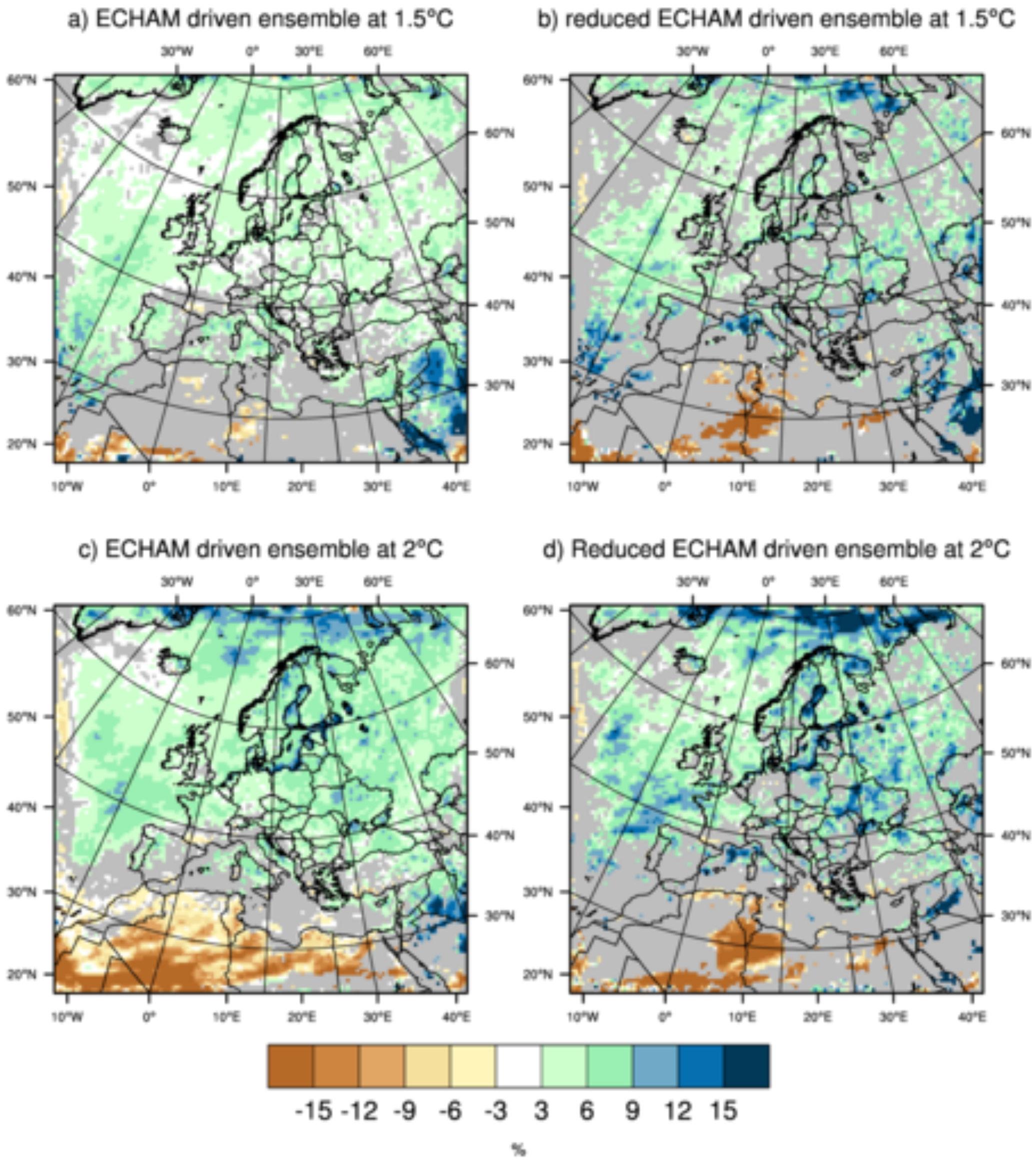

Figure S-5. Changes in RX5day with a reduced member ECHAM6 ensemble.

Available variables from the REMO HAPPI dataset

Table S1: List of variables following CORDEX data standards that are available as daily, monthly and seasonal means upon request to the authors (happi-data@hzg.de). Additional variables can be made available upon request.

Variable Short Name	Variable Long Name	Unit
hurs	Near-Surface Relative Humidity	[%]
huss	Near-Surface Specific Humidity	[1]
pr	Precipitation	[kg m-2 s-1]
prsn	Snowfall Flux	[kg m-2 s-1]
ps	Surface Air Pressure	[Pa]
psl	Sea Level Pressure	[Pa]
rlds	Surface Downwelling Longwave Radiation	[W m-2]
rsds	Surface Downwelling Shortwave Radiation	[W m-2]
sfcWind	Near-Surface Wind Speed	[m s-1]
tas	Near-Surface Air Temperature	[K]
tasmax	Daily Maximum Near-Surface Air Temperature	[K]
tasmin	Daily Minimum Near-Surface Air Temperature	[K]

Acknowledgments

We acknowledge the E-OBS dataset from the EU-FP6 project ENSEMBLES (http://ensembles-eu.metoffice.com) and the data providers in the ECA&D project (http://www.ecad.eu).

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