Supporting Information for "The role of the North Atlantic for heat wave characteristics in Europe, an ECHAM6 study"

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1. Figures S1 to S9

Introduction

Here we include additional figures in support of the main manuscript. Figure S1 shows the monthly averaged SST forcing difference in the North Atlantic ocean between the NEUTRAL and the COLD experiment as described in the main manuscript. The largest differences are to find in summer. All other figures (Figures S3 to S9) focus on the JJA season only.

Figure S2 is equivalent to Paper Figure 1 but depicts the results of a non-parametric significance test, the Mann-Whitney U-test to account for non-normally distributed data.

Figure S3 depicts the difference in GPH between the COLD and the NEUTRAL experiment at different pressure levels. The difference in GPH over the continents and north of Scandinavia is largest in the upper troposphere and decreases in strength towards the surface. The differences over the North Atlantic Ocean, on the other hand, are only significant in the lower troposphere.

Figures S4 and S7 show the JJA mean values for the NEUTRAL experiment, in accordance to the differences between COLD and NEUTRAL depicted in the Paper Figures 1 and 2.

Figure S5 shows the heat wave statistics for the COLD and the NEUTRAL experiment. Apart from magnitude and duration, which are already shown as differences in the main manuscript, Fig. S5 also depicts the average number of heat wave days per summer season for the COLD and the NEUTRAL experiments. While over the easternmost part of the European continent the number of heat wave days is much larger in the COLD experiment, over Scandinavia and the British Isles slightly more heat wave days occur in the NEUTRAL experiment.

Figure S6 shows the JJA mean of meridional wind at 300 hPa for the COLD and the NEUTRAL experiment as well as for ERA5 data. For the ERA5 climatology we used data from 1979 to 2019. Although the general summer wave pattern looks quite well represented in our model simulations there are a differences to the reanalysis data that (could) influence the exact location of the downstream response of our SST experiment (see also Fig. S9). Namely, the northward wind over Scandinavia is too large in amplitude and shifted toward the east in our model while southward wind east of the Caspian Sea

is too large in amplitude and shifted toward the west in ECHAM6 at T63.

Figure S8 depicts the JJA mean for cloud cover and zonal wind at 300 hPa for the NEUTRAL experiment along with the difference between the COLD and the NEUTRAL experiments. It shows enhanced cloud cover over the North Atlantic ocean in the COLD experiment compared to the NEUTRAL experiment along with a poleward shift of the tropospheric jet stream.

Figure S9 shows the JJA 300 hPa meridional wind difference between the different experiments and ERA5 as well as between the 2018 experiments (COLD and NEUTRAL) and a historical ensemble. The historical ensemble (HIST) consists of three AMIP-like simulations that were, similarly to the 2018 experiments, forced with daily SST and SIC derived from ERA5. But in this case, the forcing was transient, from 1980 to 2019. For the atmospheric forcing the CMIP6 historical and subsequently SSP5-8.5 scenario were used. Model biases are similar between the 2018 and historical experiments, whereas the amplified wave over the European continent is only visible in the COLD experiment.

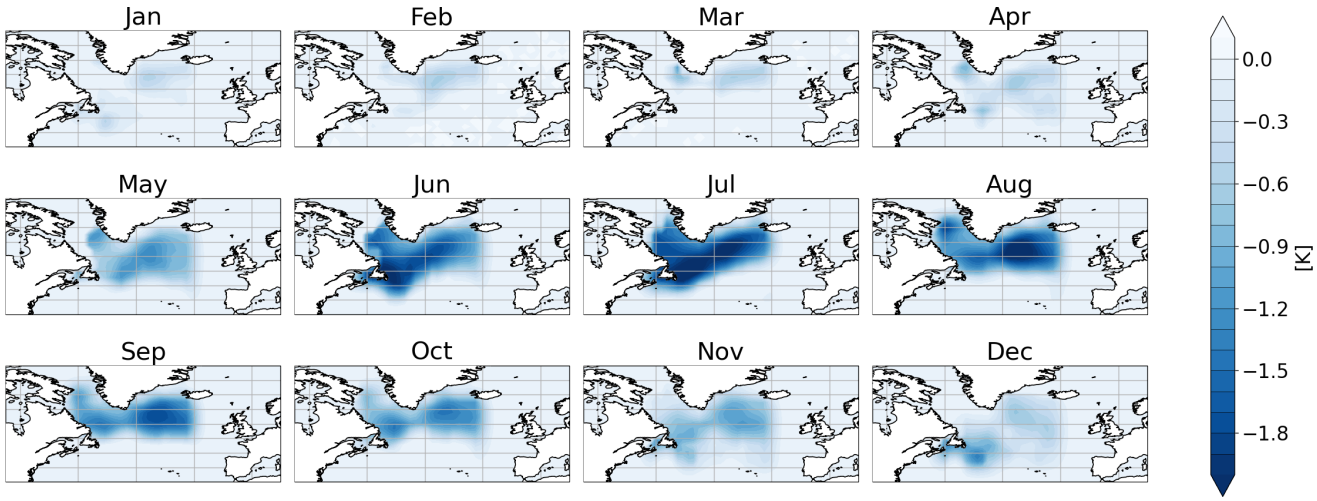

Figure S1. Monthly averaged difference between the SST forcing for the COLD minus NEUTRAL experiments in the North Atlantic region.

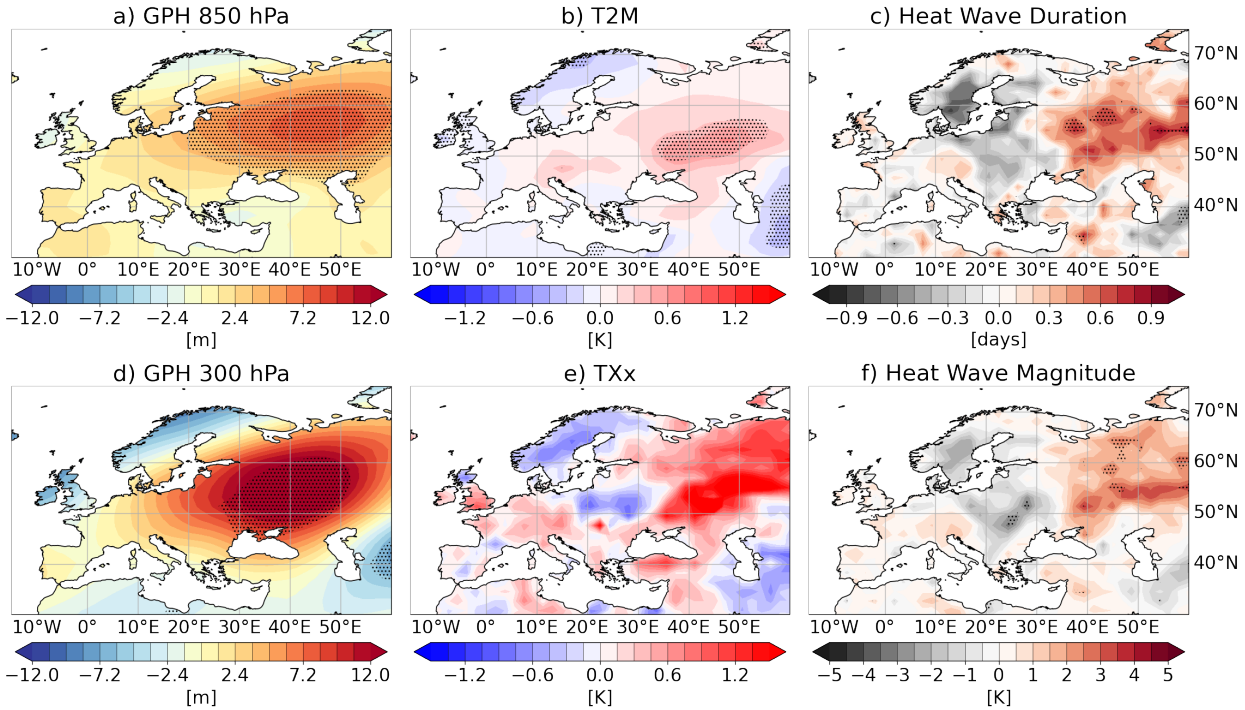

Figure S2. JJA mean values for the COLD minus the NEUTRAL experiment: GPH at 850 hPa (a) and 300 hPa (d), air temperature at 2 m (T2M, b) and 20 year return values of maximum daily maximum temperatures (TXx, e), as well as heat wave duration (c) and magnitude (f). Significant differences between COLD and NEUTRAL ($p - value < 0.05$ based on a Mann-Whitney U-test) are stippled.

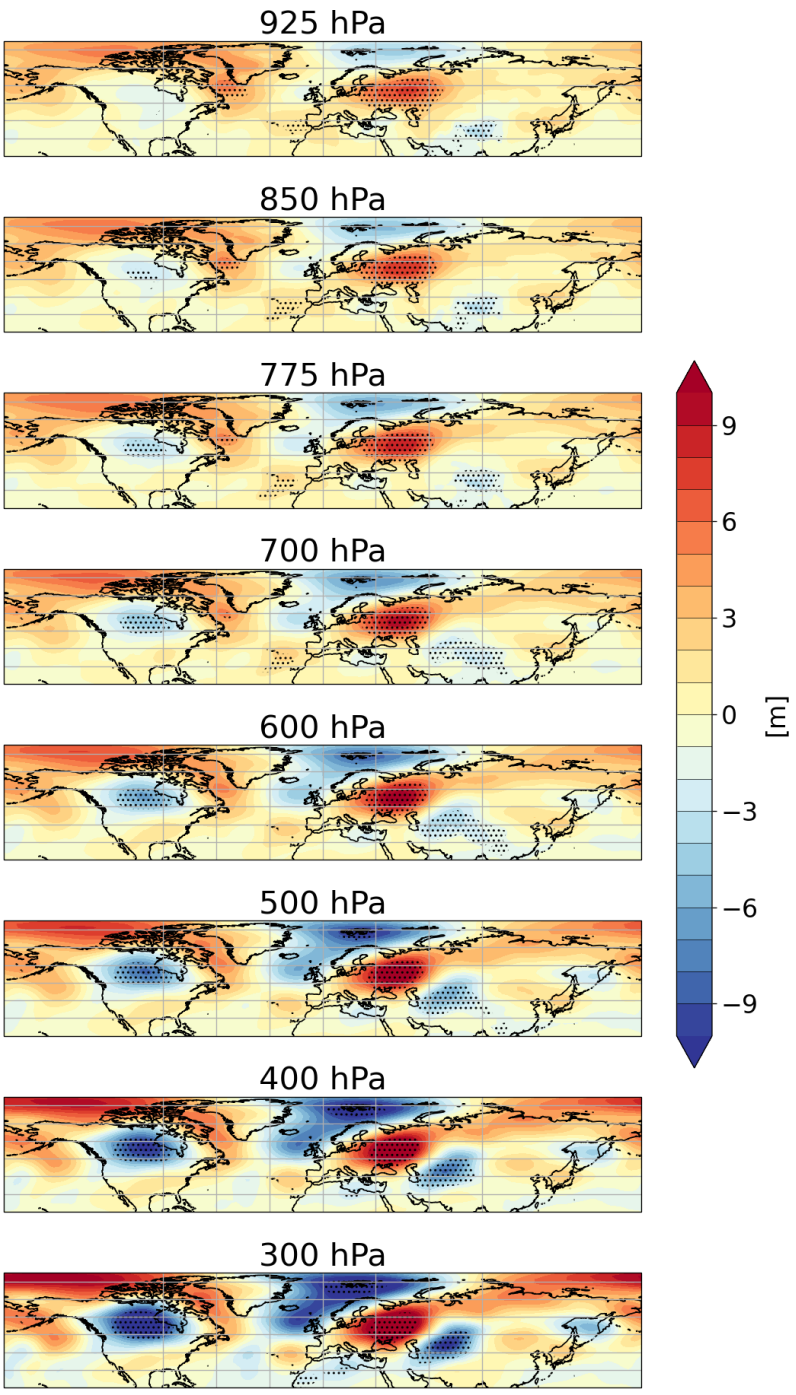

Figure S3. Difference between COLD minus NEUTRAL experiment for GPH at different pressure levels for the JJA season. Significant differences (p-value < 0.5) are stippled.

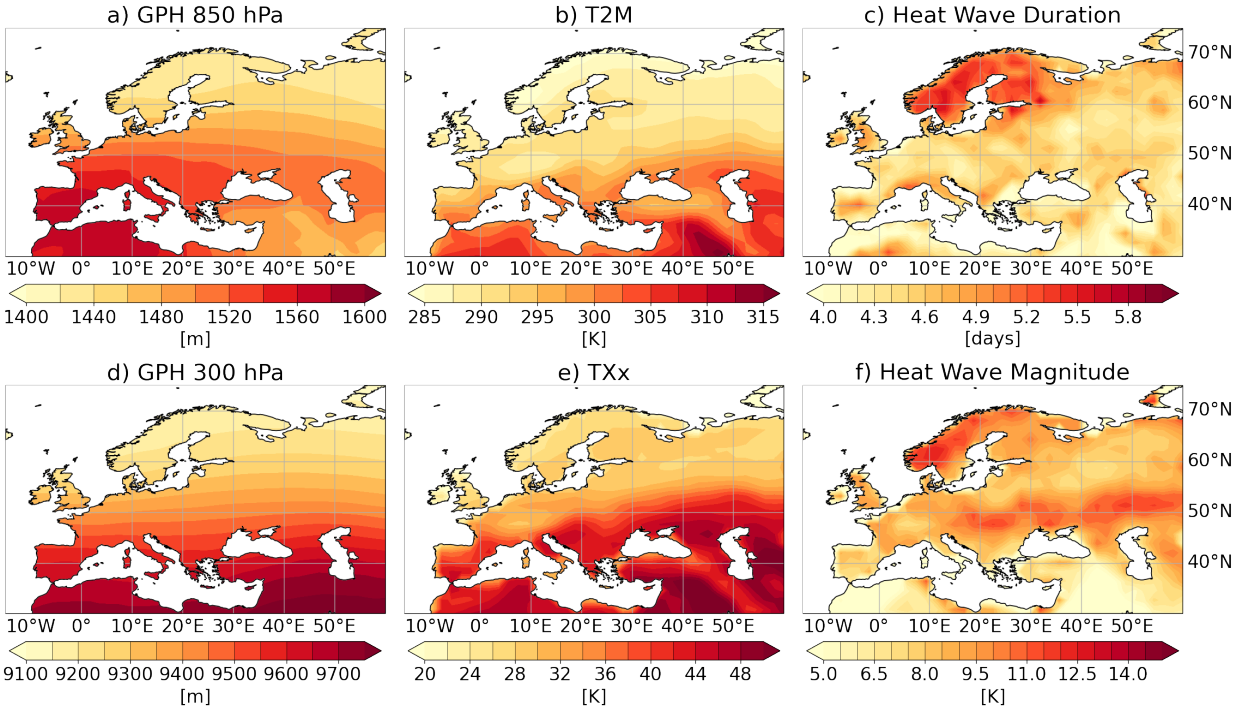

Figure S4. JJA mean values for NEUTRAL experiment: GPH at 850 hPa (a) and 300 hPa (d), air temperature at 2 m (T2M, b) and 20 year return values of maximum daily maximum temperatures (TXx, e), as well as heat wave duration (c) and magnitude (f)

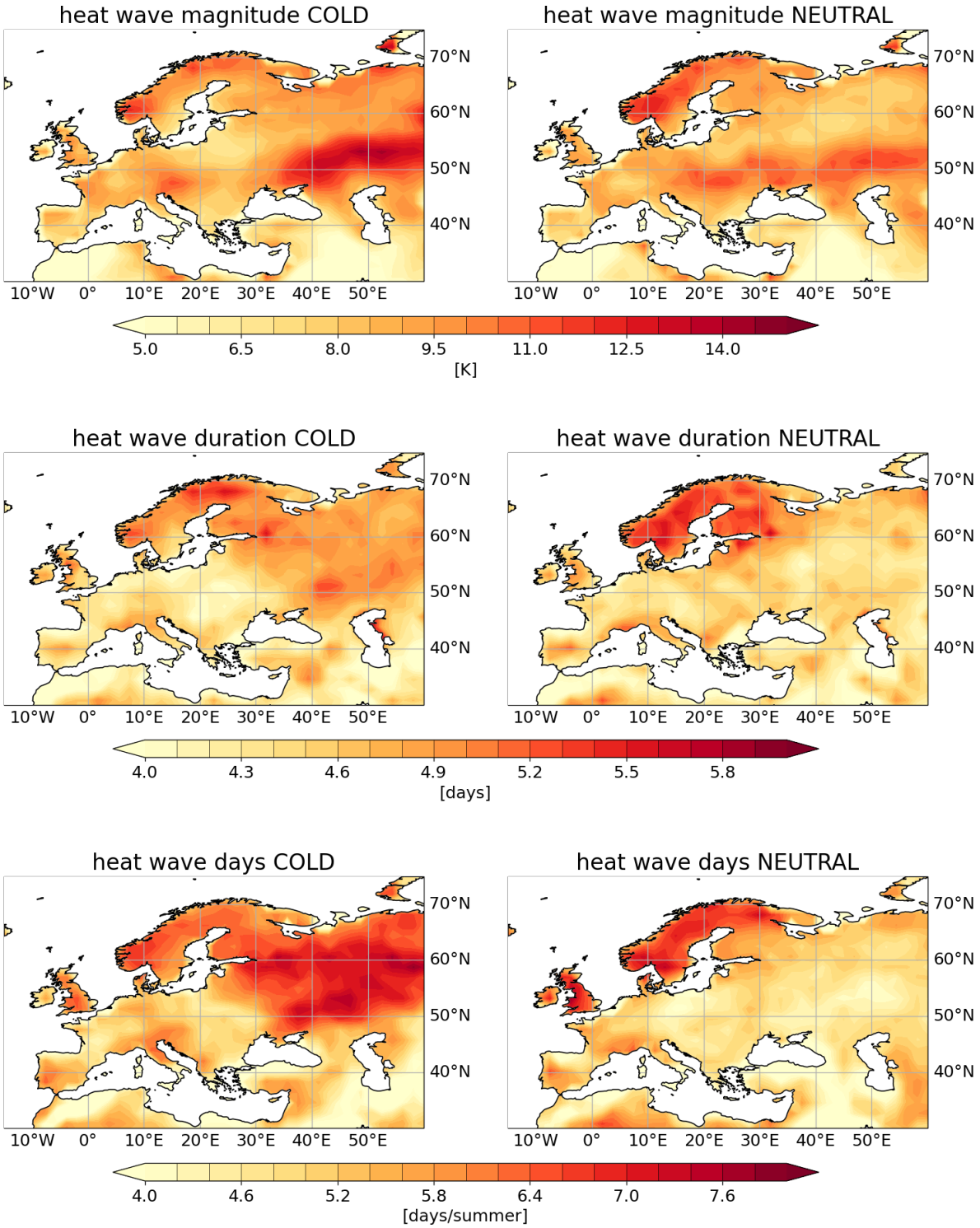

Figure S5. Heat wave magnitude, duration and heat wave days per season for the COLD and the NEUTRAL experiments for JJA.

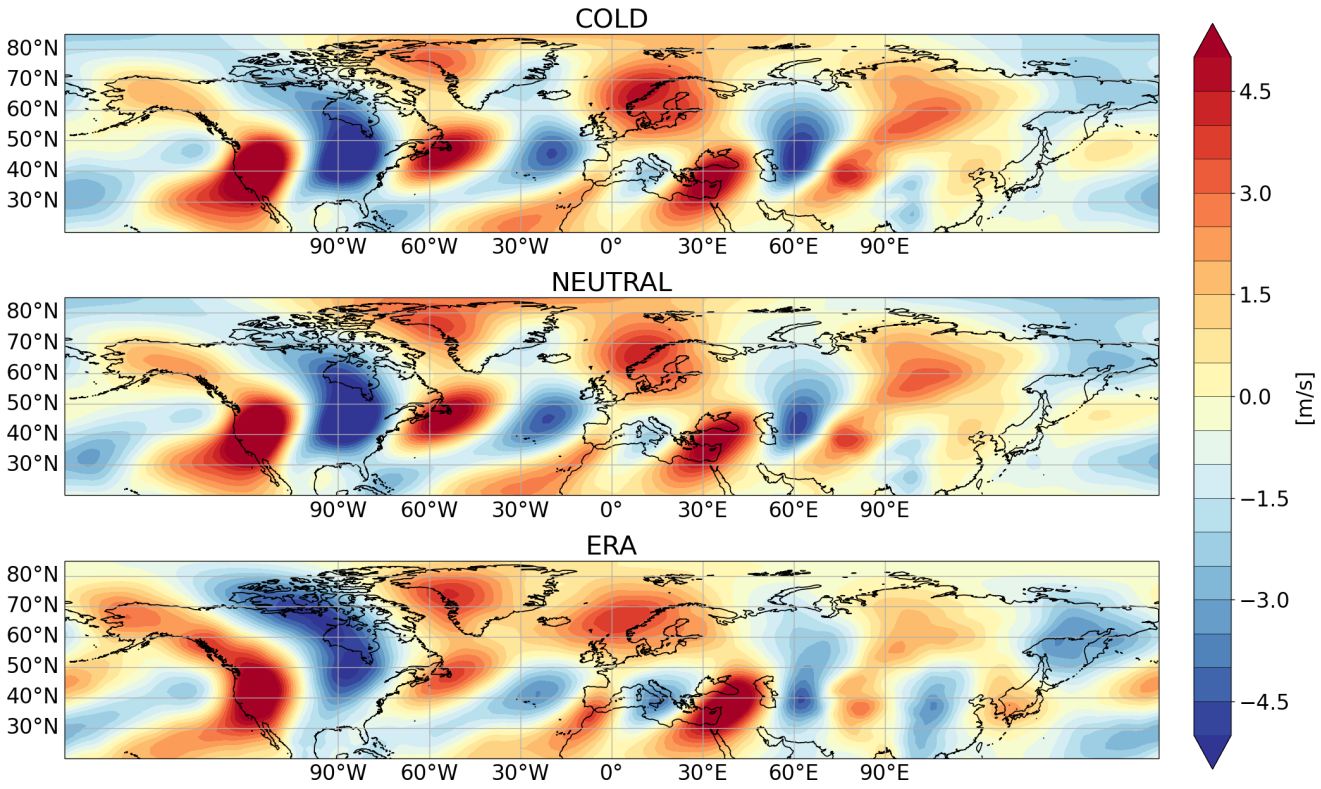

Figure S6. V-wind at 300 hPa averaged over JJA. Top to bottom: for the COLD and the NEUTRAL experiment as well as for ERA5 data covering the period 1979 to 2019.

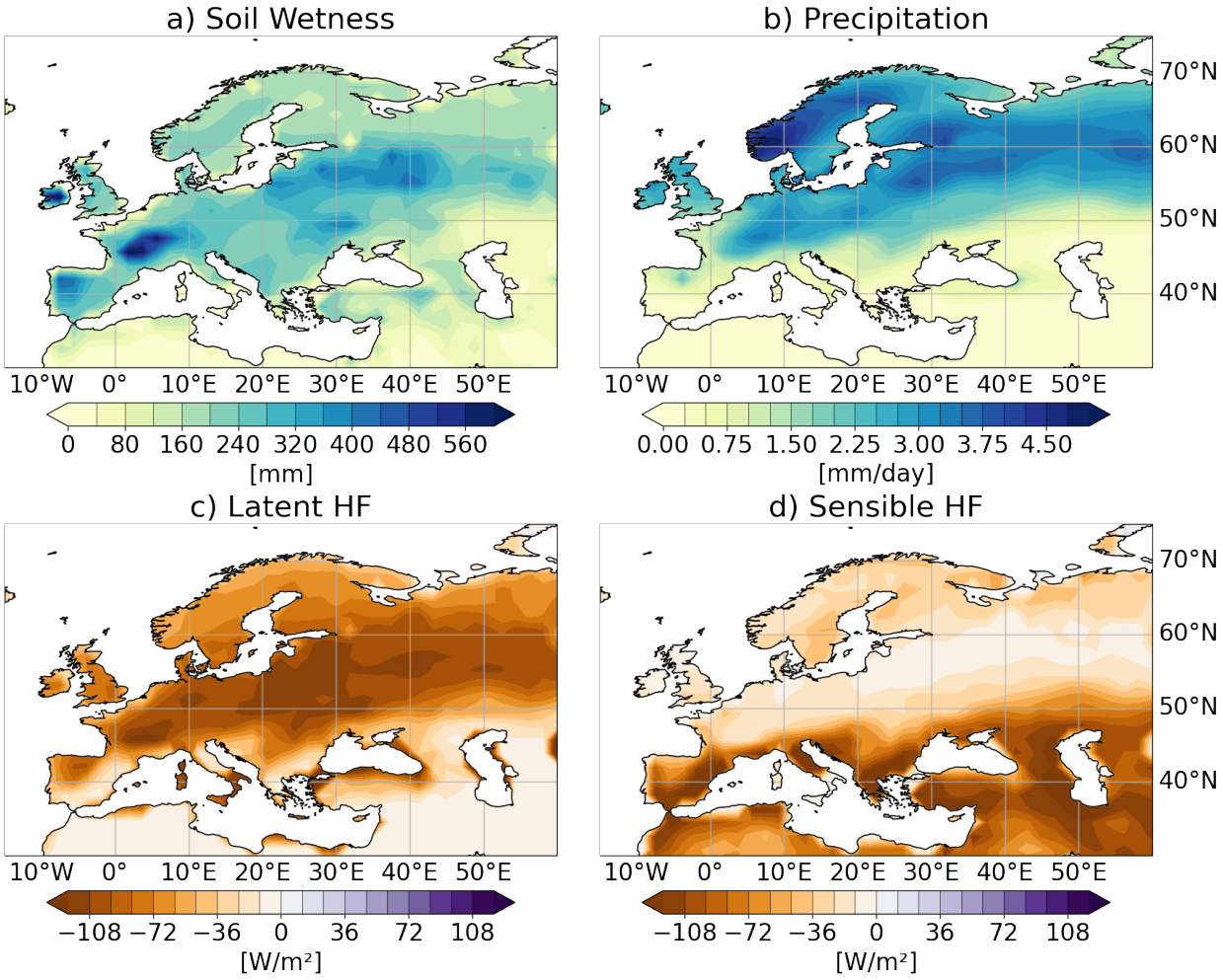

Figure S7. JJA mean values for the NEUTRAL experiment: soil wetness (a), precipitation (b), latent (c) and sensible heat flux (d). Heat flux is positive downward.

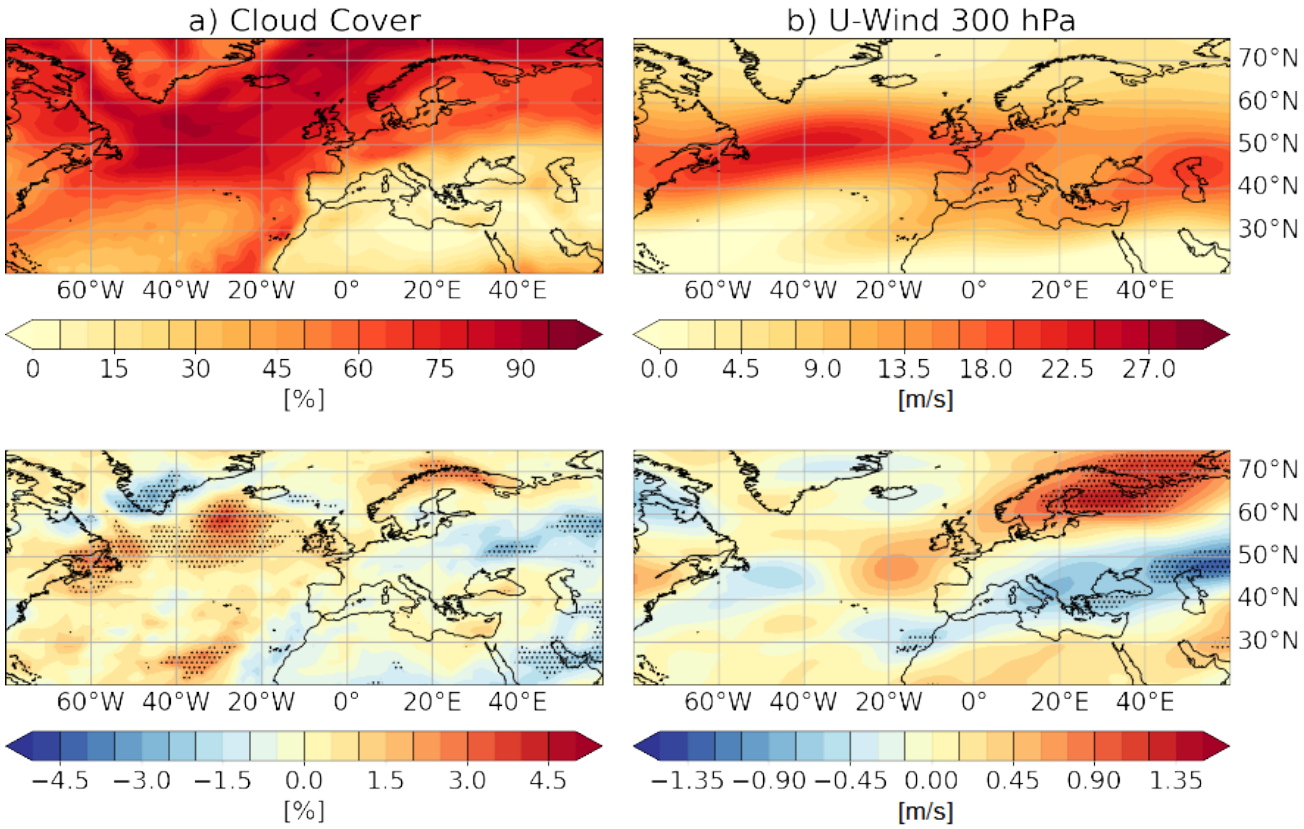

Figure S8. JJA cloud cover in [%] (a) and u-wind at 300 hPa in [m/s] (b). Top for the NEUTRAL experiment and bottom for the difference COLD minus NEUTRAL. Significant differences (p-value < 0.5) are stippled.

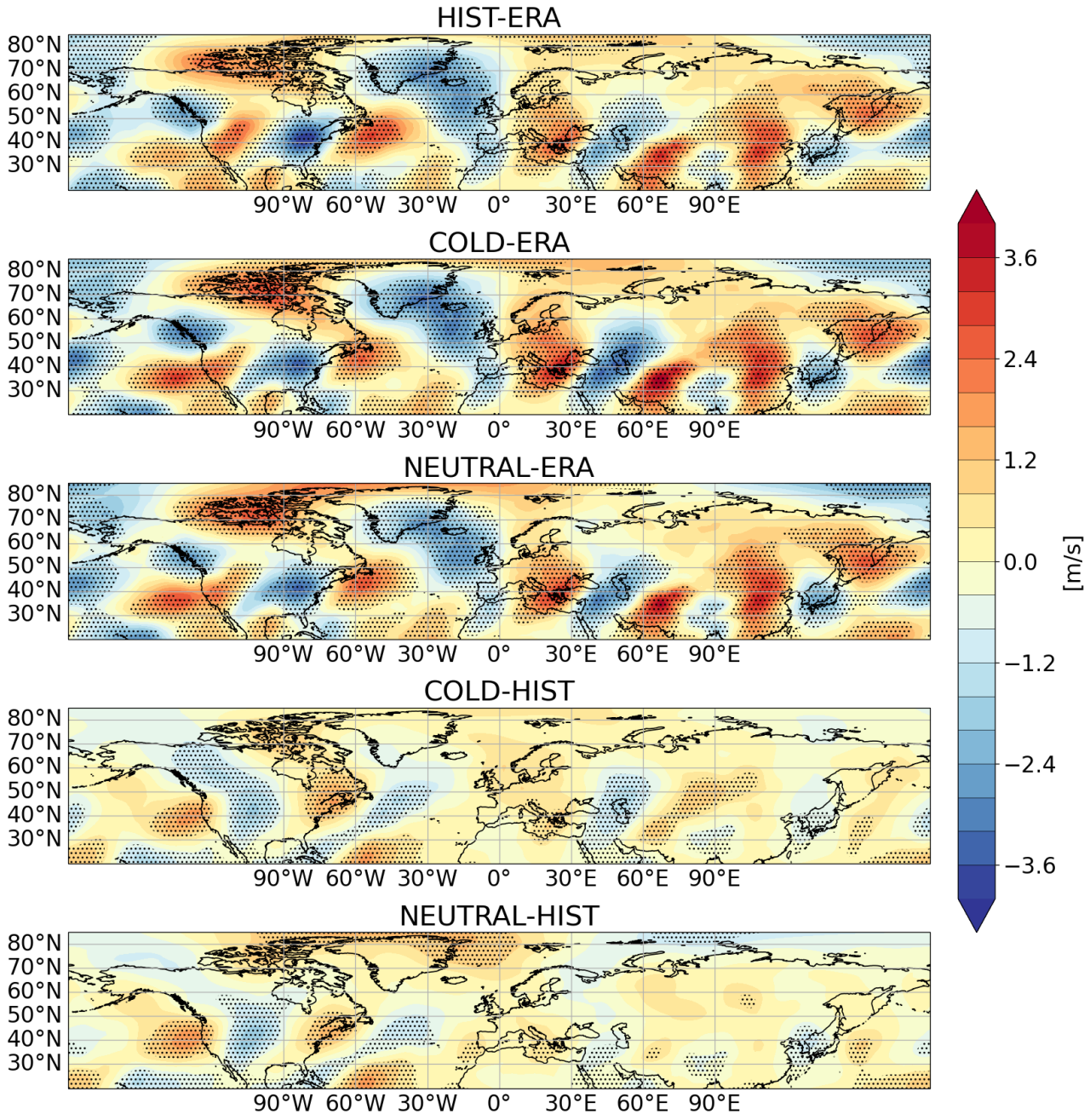

Figure S9. Differences in v-wind at 300 hPa averaged over JJA for different model simualtions and ERA5 data. Top to bottom: HIST minus ERA, COLD minus ERA, NEUTRAL minus ERA, COLD minus HIST and NEUTRAL minus HIST. ERA5 and HIST data cover the period 1980 to 2019. Significant differences (p-value < 0.5) are stippled.