Supplementary Information: Everyday weather in a warmer world

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S1 Surface heat budget

The surface heat budget is calculated as:

$$Q_{net} = DLWRF - ULWRF_{sfc} + DSWRF_{sfc} - USWRF_{sfc} - LHTFL - SHTFL, \tag{S1}$$

where $DLWRF_{sfc}$ and $ULWRF_{sfc}$ are the downward and upward longwave fluxes at the surface, respectively; $DSWRF_{sfc}$ and $USWRF_{sfc}$ are the downward and upward shortwave fluxes at the surface, respectively; and $LHTFL$ and $SHTFL$ are the surface latent and sensible heat fluxes, respectively.

The budget is calculated locally for each (lat, lon, day) in a given region. Then, paired differences in the local budget terms are calculated between the +2K and 20CRv3$^+$ experiments. The differences are binned according to the 2m-temperature (T2m) percentile in 20CRv3$^+$ of that (lat, lon, day). Note that the sign convention of the differences shown in Fig. S3 is consistent with equation S1: for example, a positive value for the $DLWRF_{sfc}$ difference term in Fig. S2 indicates greater surface *warming* due to downward longwave radiation in the +2K experiment. Similarly, a negative value in the $LHTFL$ difference in Fig. S3 indicates greater surface *cooling* from evaporation in the +2K experiment.

Flux terms were not archived for the +2K+CO2 experiment, hence only differences in the +2K experiment are shown.

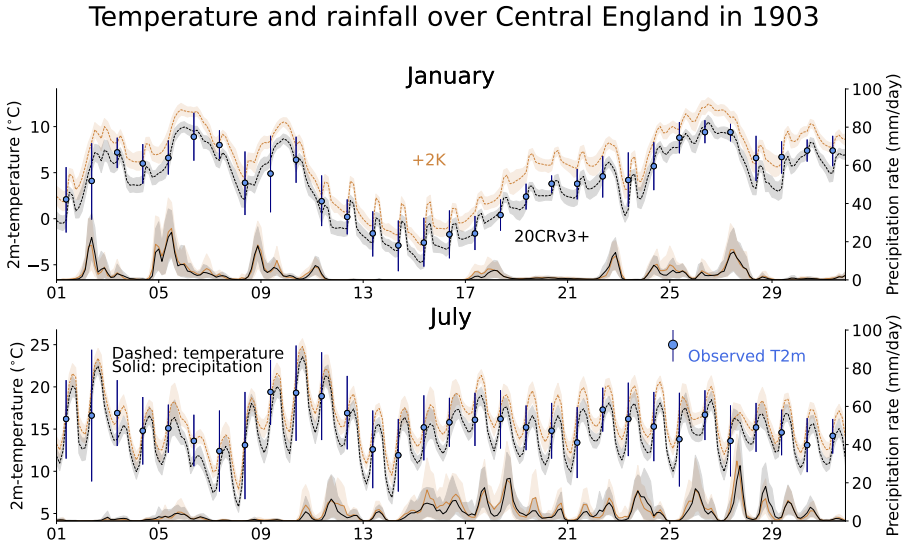

Figure S1. As Fig. 2, but showing the +2K experiment. Time series of 3-hourly 2m-temperature (dashed line) and precipitation rate (solid line) averaged over central England (3-0°W, 51.5-54.0°N, see boxed region in Fig. 8). The 20CRv3$^+$ experiment is in black and the +2K experiment is in yellow. Lines show the ensemble means and shading denotes the 10-90% range across the ensemble. Blue markers show daily mean temperatures from the Central England Temperature (CET) series (Legg et al. 2025), plotted at 9am each day. Vertical bars on each marker indicate the CET daily maximum and minimum temperatures.

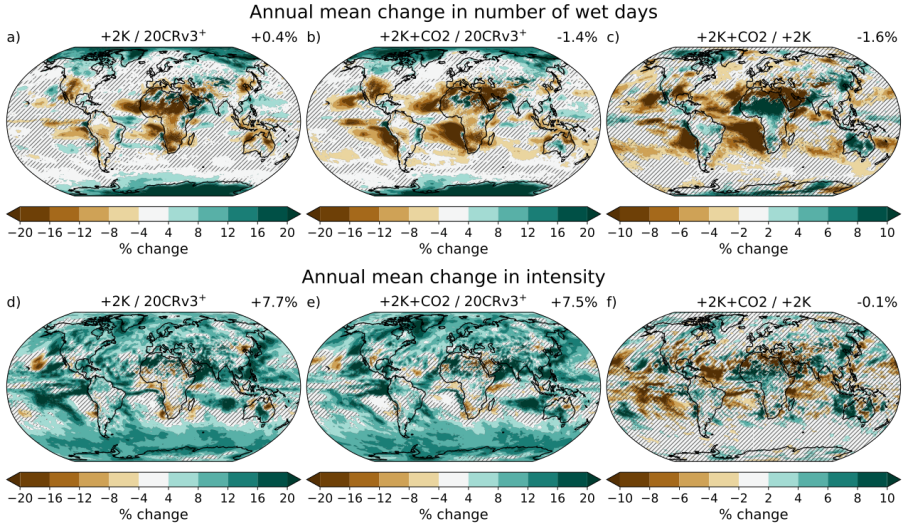

Figure S2. Percentage changes in precipitation (a-c) frequency (number of wet days) and (d-f) intensity in the warmer world experiments. The wet day threshold is 1mm/day. Precipitation intensity is the mean precipitation on wet days. The value at the top right of each plot is the global (area-weighted) average of the changes at each gridpoint, as in Fig. 4. Hatching hides non-significant changes at the 5% level using a two-tailed Student's t-test.

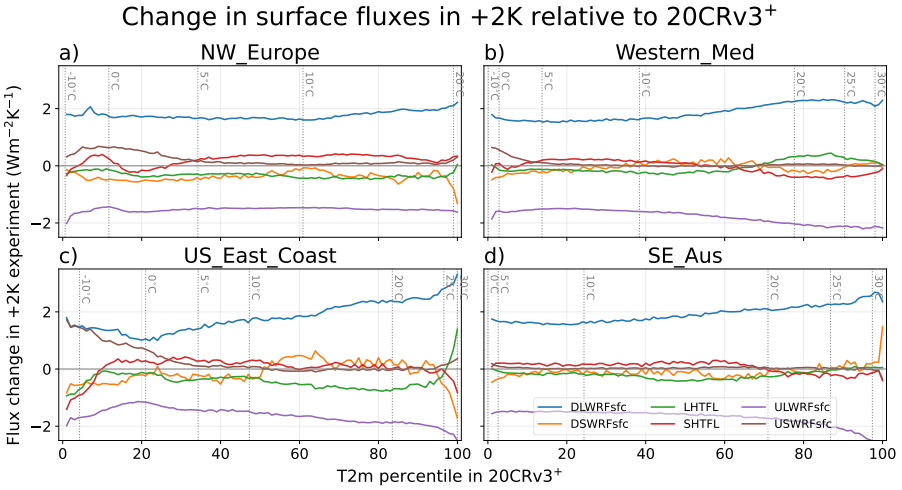

Figure S3. Change in surface fluxes in +2K experiment vs 20CRv3$^+$, as a function of 20CRv3$^+$ temperature percentile. Flux changes are calculated in the same way as the temperature differences in Fig. 5, i.e. paired differences (+2K minus 20CRv3$^+$) at each (lat, lon, day) are binned according to the 20CRv3$^+$ temperature at that (lat, lon, day). Fluxes are defined as downward positive, so that a positive value indicates increased surface heating in the +2K experiment.

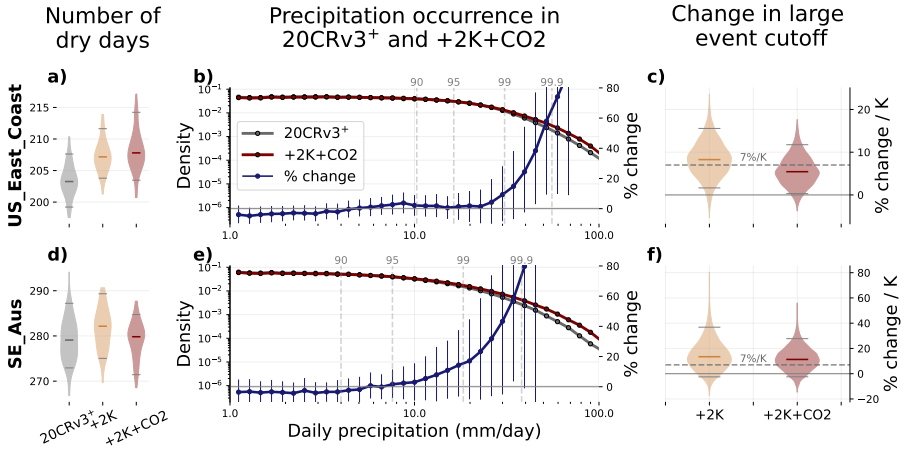

Figure S4. As Fig. 7, but for the US_East_Coast and SE_Aus regions. (a, d): Number of dry days in each experiment (daily precipitation less than 1.04mm). The median is shown by the horizontal line and the violin shows the distribution of ensemble members. (b, e) Daily precipitation occurrence in 20CRv3$^+$ and +2K+CO2. The blue line shows the percentage change in each bin in +2K+CO2. Error bars show the 10-90% range through sampling all combinations of ensemble members, and vertical dashed lines show percentiles of the precipitation distribution in 20CRv3$^+$. (c, f) Ratio of large event cutoff s_L in +2K+CO2 vs 20CRv3$^+$ (see main text). Only land gridcells are used for all calculations. Bins in (b) and (e) are logarithmically distributed with the smallest nonzero bin centred at 1.11 mm/day and successive bin widths increasing by 14.7%.

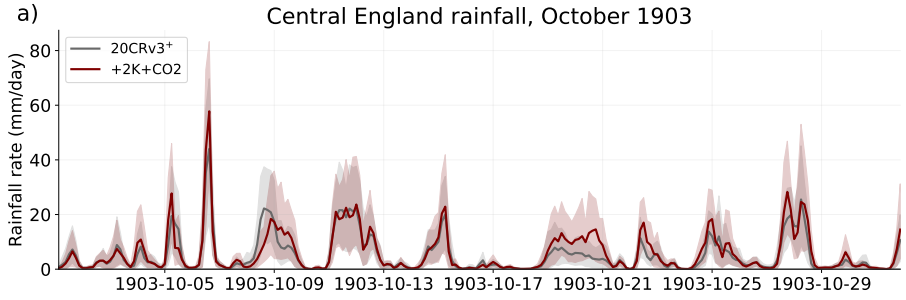

Figure S5. As Fig. 8e, but showing 3hr rainfall. Rainfall over Central England (see the red boxed region in Fig. 8). Shading shows the 10-90% range across the ensemble.