# Changes in event soil moisture-temperature coupling may intensify very extreme heat beyond expectations

## Supplementary information

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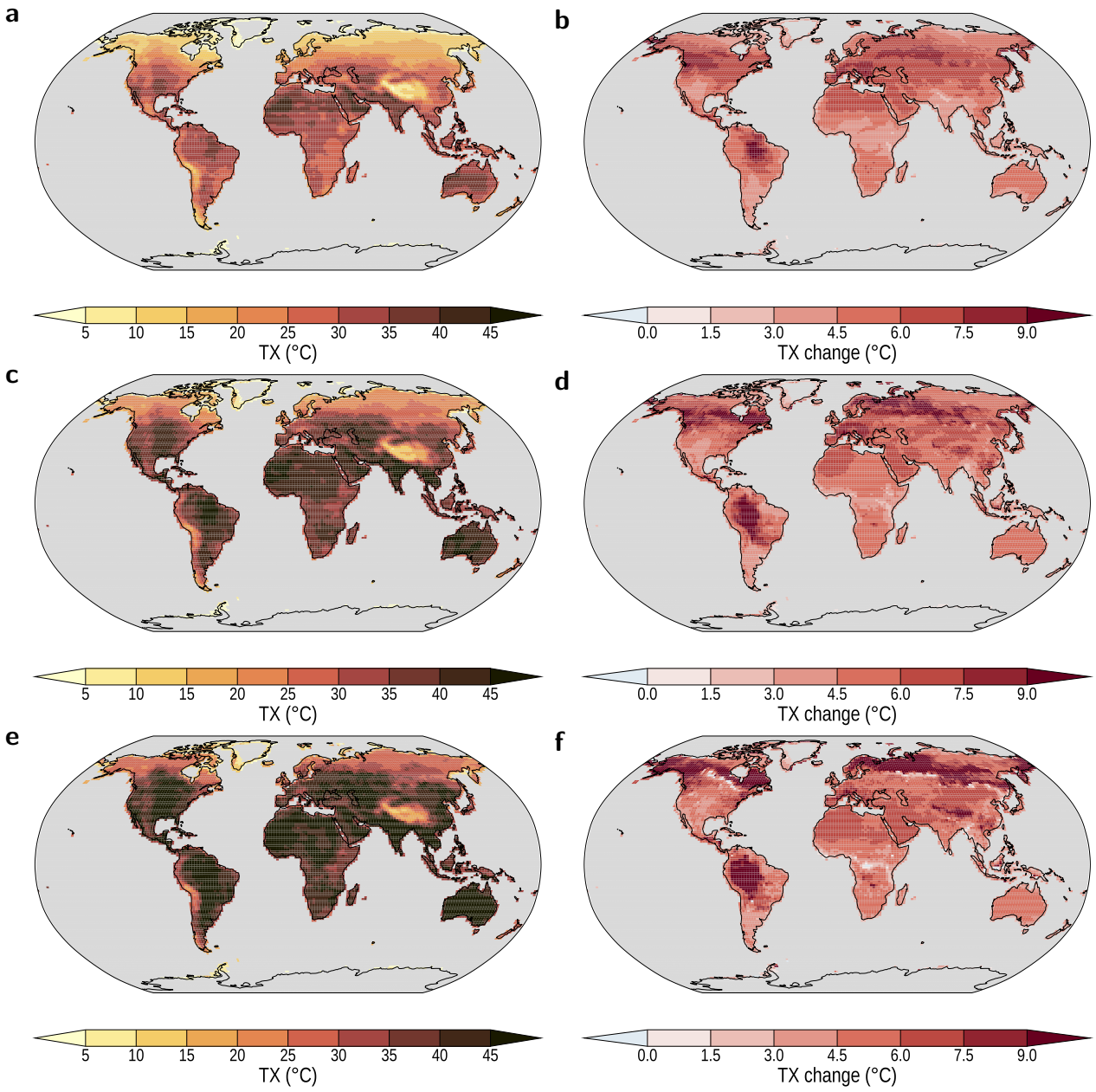


**Figure S 1: Daily maximum temperature and its changes for ACCESS-ESM1-5.** **a** Present day (1990-2014) warm season (annual mean for 20S to 20N) daily maximum temperature and **b** its projected changes (2076-2100 vs. 1990-2014) under the SSP5-8.5 scenario. Corresponding present day values and changes for the 2-year (**c,d**) and 200-year (**e,f**) return levels of daily maximum temperature $T_X$.

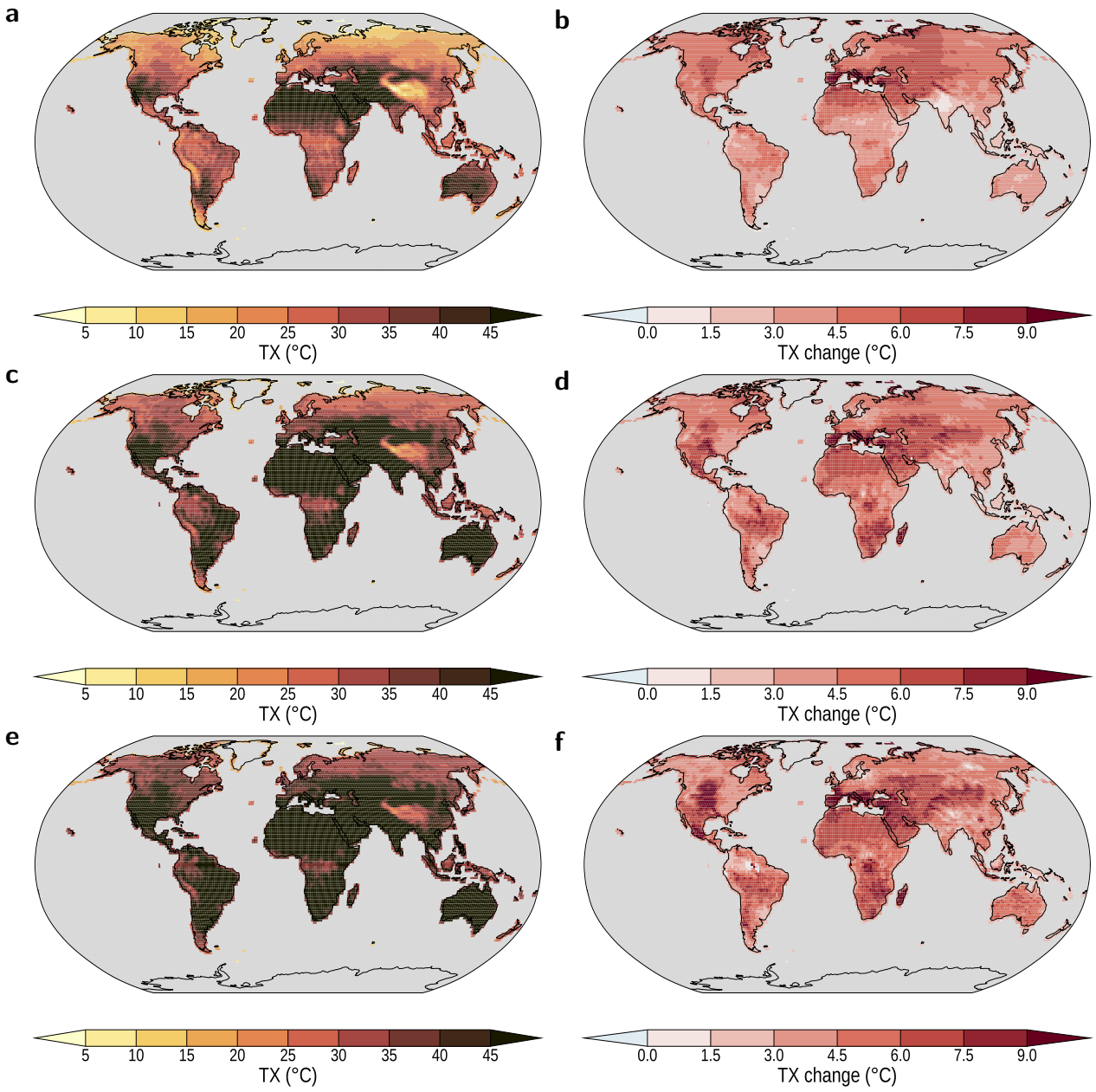


**Figure S 2: Daily maximum temperature and its changes for MIROC6. a** Present day (1990-2014) warm season (annual mean for 20S to 20N) daily maximum temperature and **b** its projected changes (2076-2100 vs. 1990-2014) under the SSP5-8.5 scenario. Corresponding present day values and changes for the 2-year (**c,d**) and 200-year (**e,f**) return levels of daily maximum temperature $T_X$.

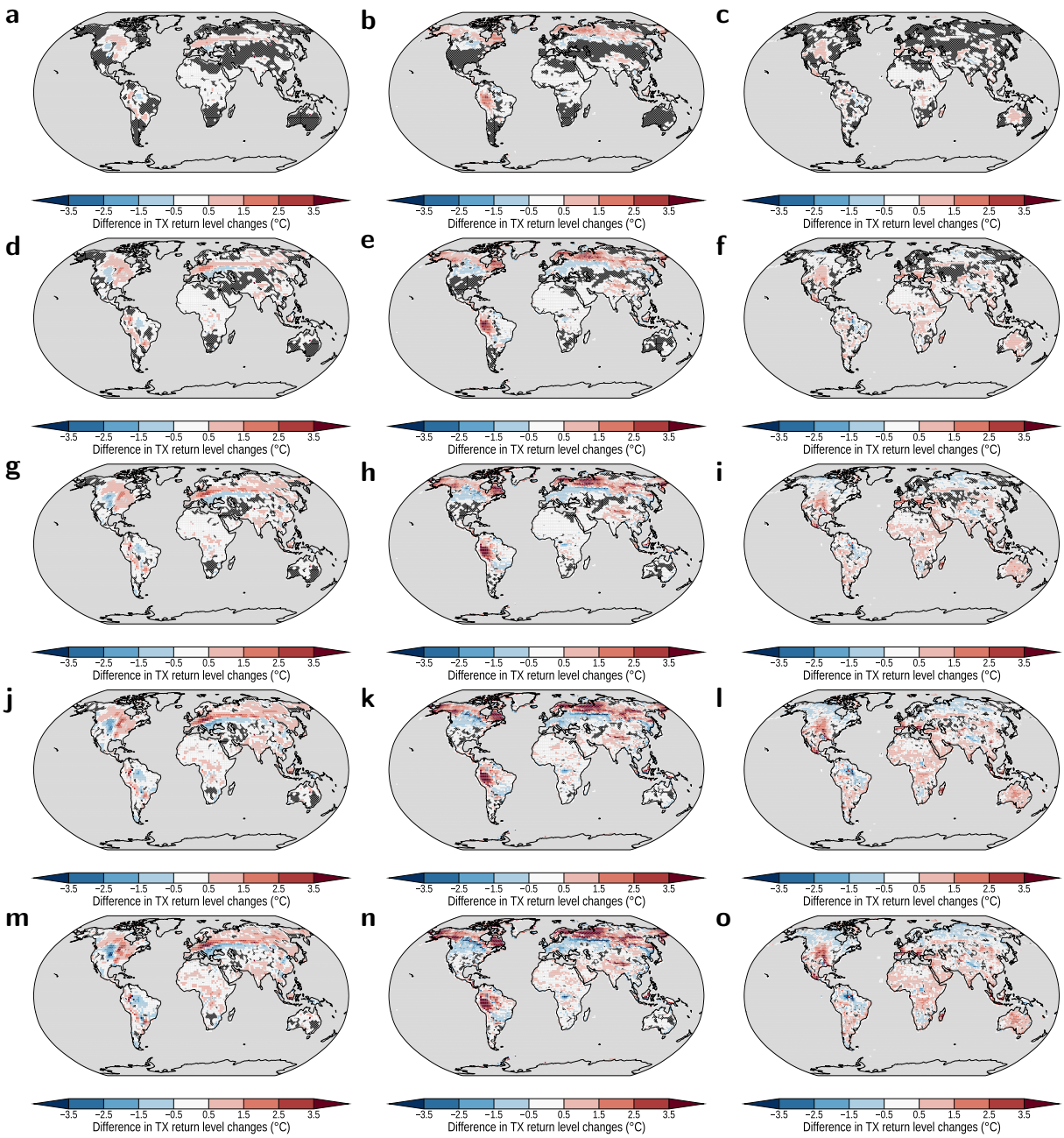


**Figure S 3: Difference in changes of moderate to extreme temperature return levels.** Changes (2076-2100 vs. 1990-2014) in 5- **(a-c)**, 10- **(d-f)**, 20- **(g-i)**, 50- **(j-l)** and 100-year **(m-o)** return levels minus changes in 2-year return levels of daily maximum temperature $T_X$ for MPI-ESM1-2-LR **(a,d,g,j,m)**, ACCESS-ESM1-5 **(b,e,h,k,n)** and MIROC6 **(c,f,i,l,o)**. Differences in hatched regions are not significant at the 95% level (see Methods for detail).

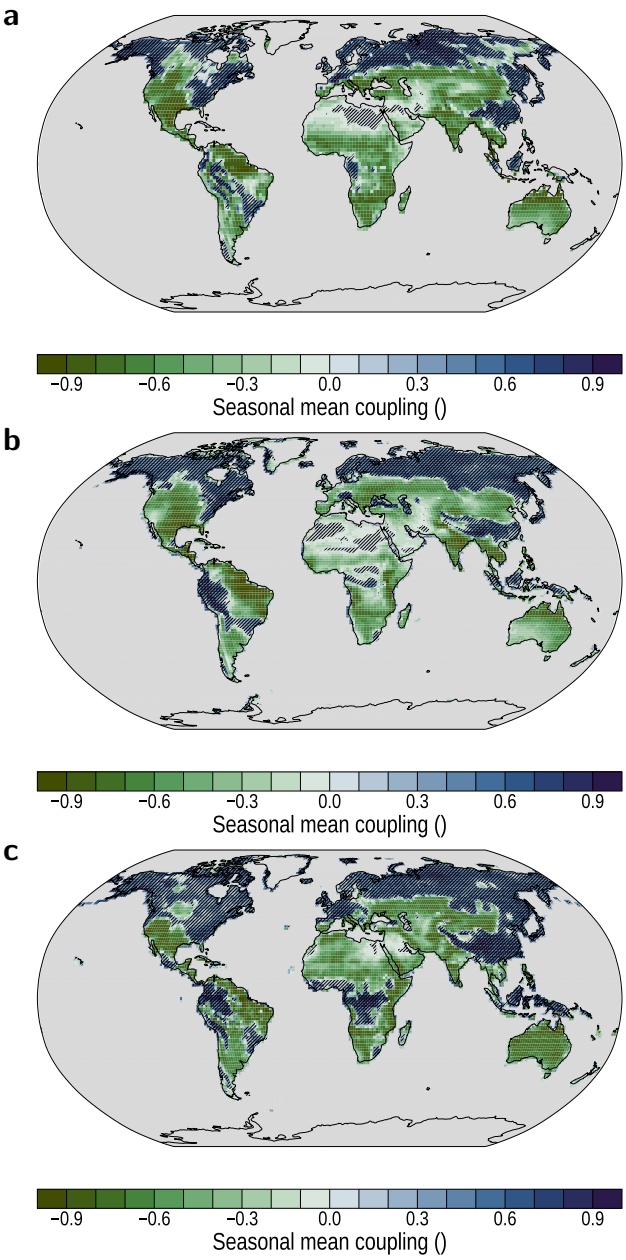


**Figure S 4: Present day seasonal mean coupling.** **a** MPI-ESM1-2-LR, **b** ACCESS-ESM1-5 and **c** MIROC6.

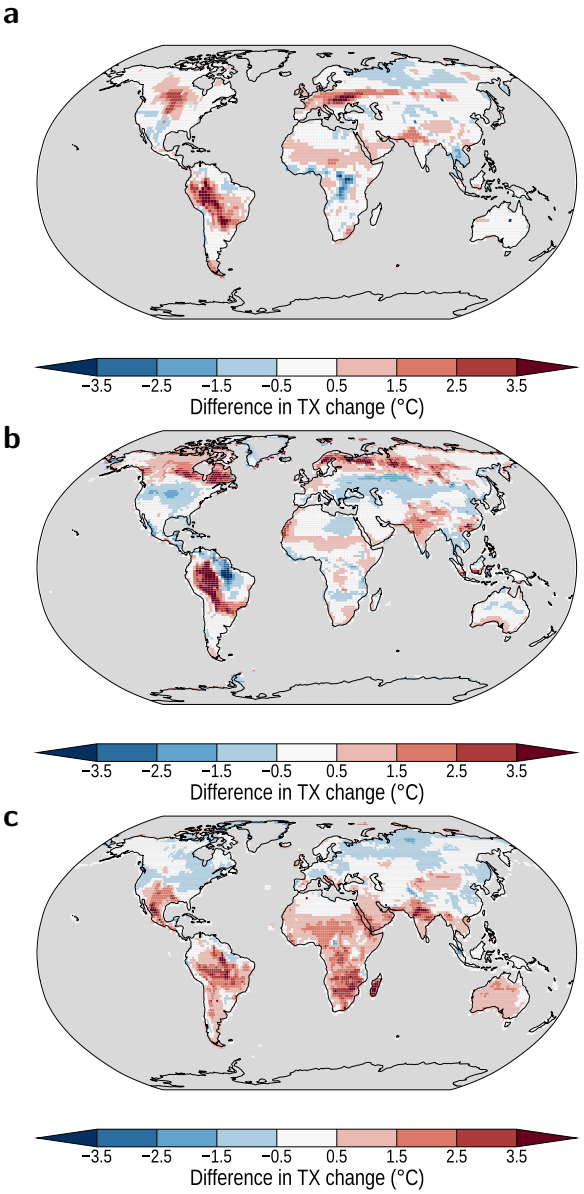


**Figure S 5: Differences in changes between moderate and mean heat events** Difference in changes (2076-2100 vs. 1990-2014) of 2-year return values and seasonal mean of daily maximum temperature $T_X$ for **a** MPI-ESM1-2-LR, **b** ACCESS-ESM1-5 and **c** MIROC6 under the SSP5-8.5 scenario.

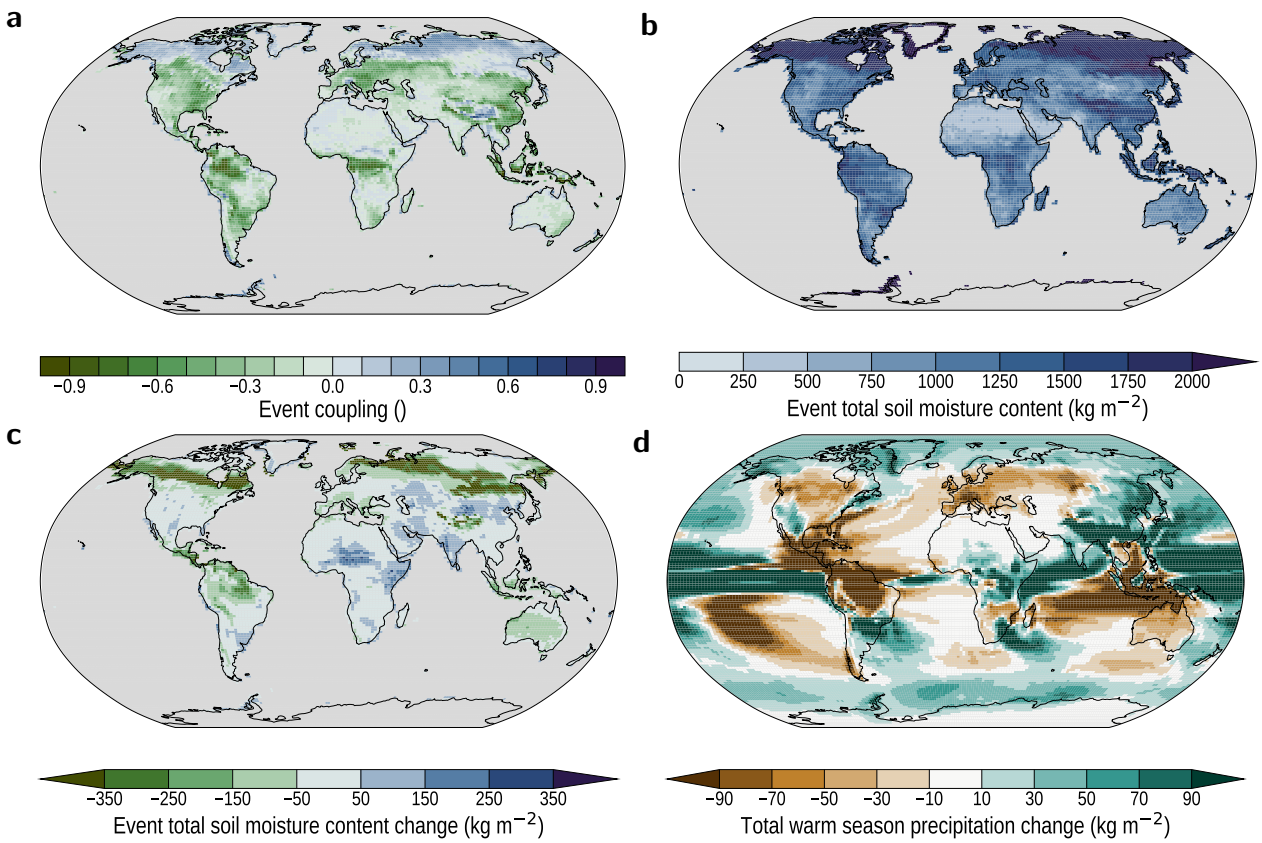


**Figure S 6: Driving processes for ACCESS-ESM1-5.** **a** Present (1990-2014) soil moisture temperature coupling strength (strong negative values indicate strong coupling), **b** present (1990-2014) event soil moisture, **c** event soil moisture changes **d** and warm season (annual mean for 20S to 20N) precipitation changes (2076-2100 vs. 1990-2014).

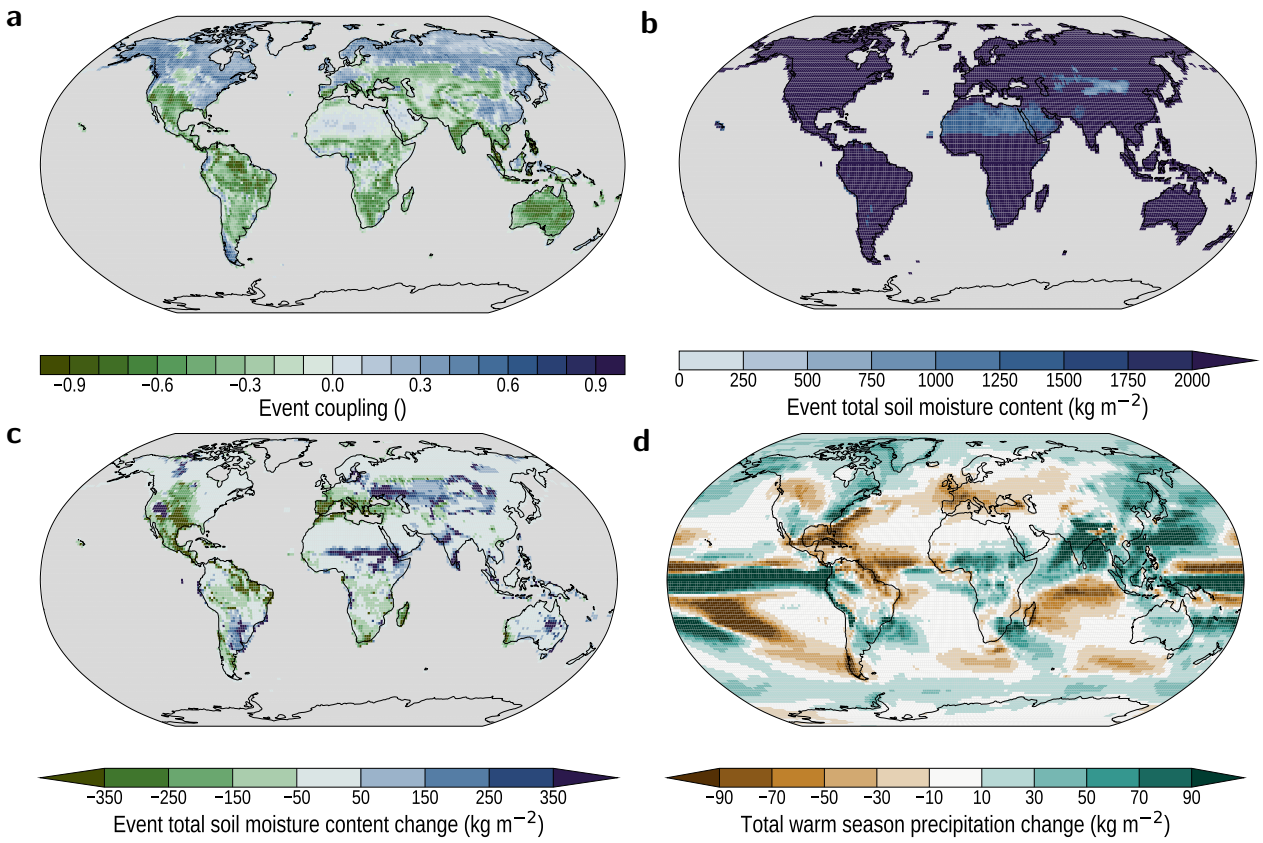


**Figure S 7: Driving processes for MIROC6.** **a** Present (1990-2014) soil moisture temperature coupling strength (strong negative values indicate strong coupling), **b** present (1990-2014) event soil moisture (note the different color scale compared to the two other models), **c** event soil moisture changes **d** and warm season (annual mean for 20S to 20N) precipitation changes (2076-2100 vs. 1990-2014).

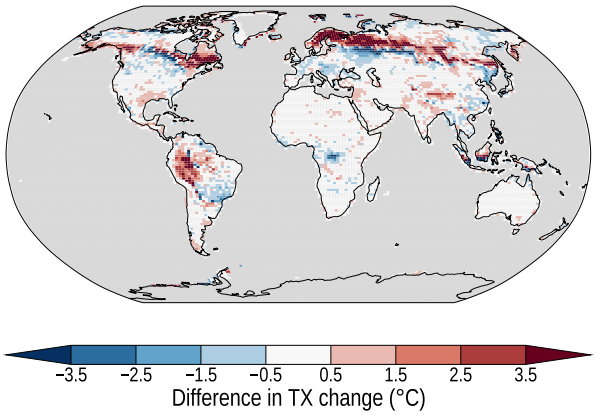


**Figure S 8: Difference in changes of extreme temperature return levels for near future projections for ACCESS-ESM1-5.** Difference between changes in 200-year and 2-year return levels of daily maximum temperature $T_X$ for near future climate (2036-2060 vs. 1990-2014).

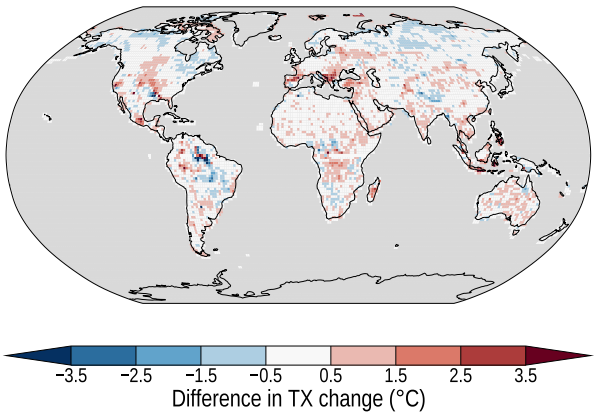


**Figure S 9: Difference in changes of extreme temperature return levels for near future projections for MIROC6.** Difference between changes in 200-year and 2-year return levels of daily maximum temperature $T_X$ for near future climate (2036-2060 vs. 1990-2014).