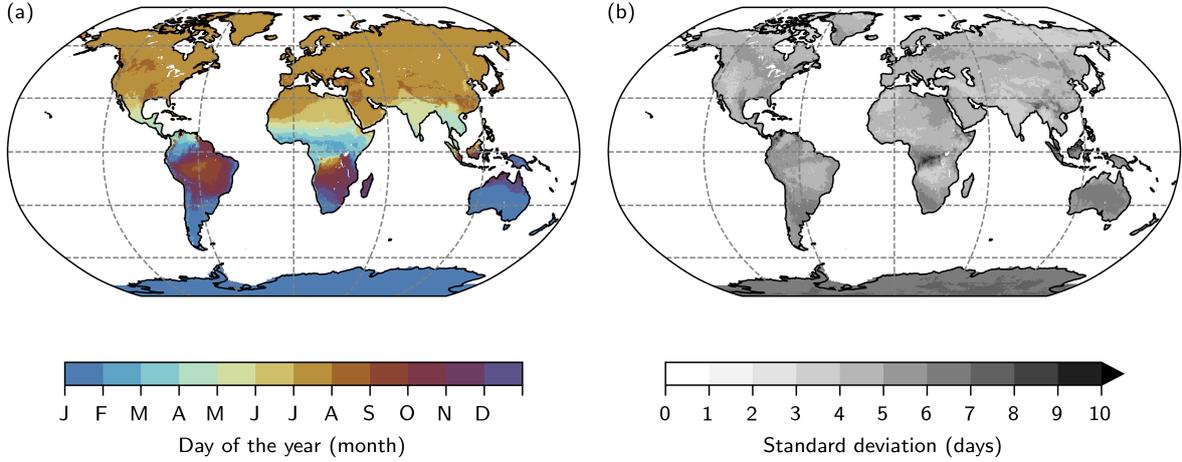*Supplement to*

Global characterisation of the vertical temperature anomaly structure of heat extremes over land in ERA5

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# 1 Mean calendar day of the year during TXx events

Figure S1. Global distribution of **(a)** the month of the mean calendar day of the year during TXx events from 1951 to 2023 at each grid point, and **(b)** the corresponding standard deviation. The mean calendar day of the year for the 73 TXx events at each grid point is computed using a circular mean over 365 days.

# 2 Sensitivity analysis of the clusters to choices of the vertical profiles
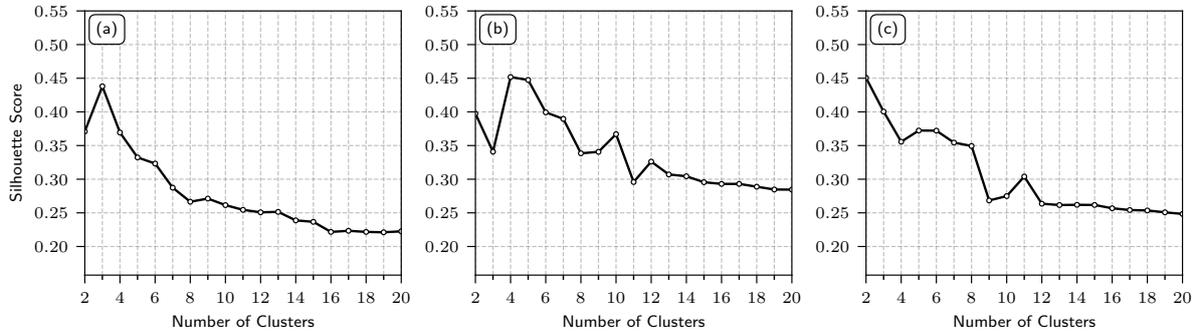
Figure S2. Silhouette scores for finding an optimal number of clusters of the median *scaled T'* profiles over land grid points with the k-means clustering approach, using **(a)** the eight retaining principle components of all hybrid sigma-pressure levels (40–137) without area-weighting, **(b)** the five retaining principle components of only the lowermost model levels (90–137) with area-weighting, and **(c)** the six retaining principle components of the vertically adjusted profiles, which are linearly scaled between the surface pressure and pressure of the dynamical tropopause, including area-weighting.
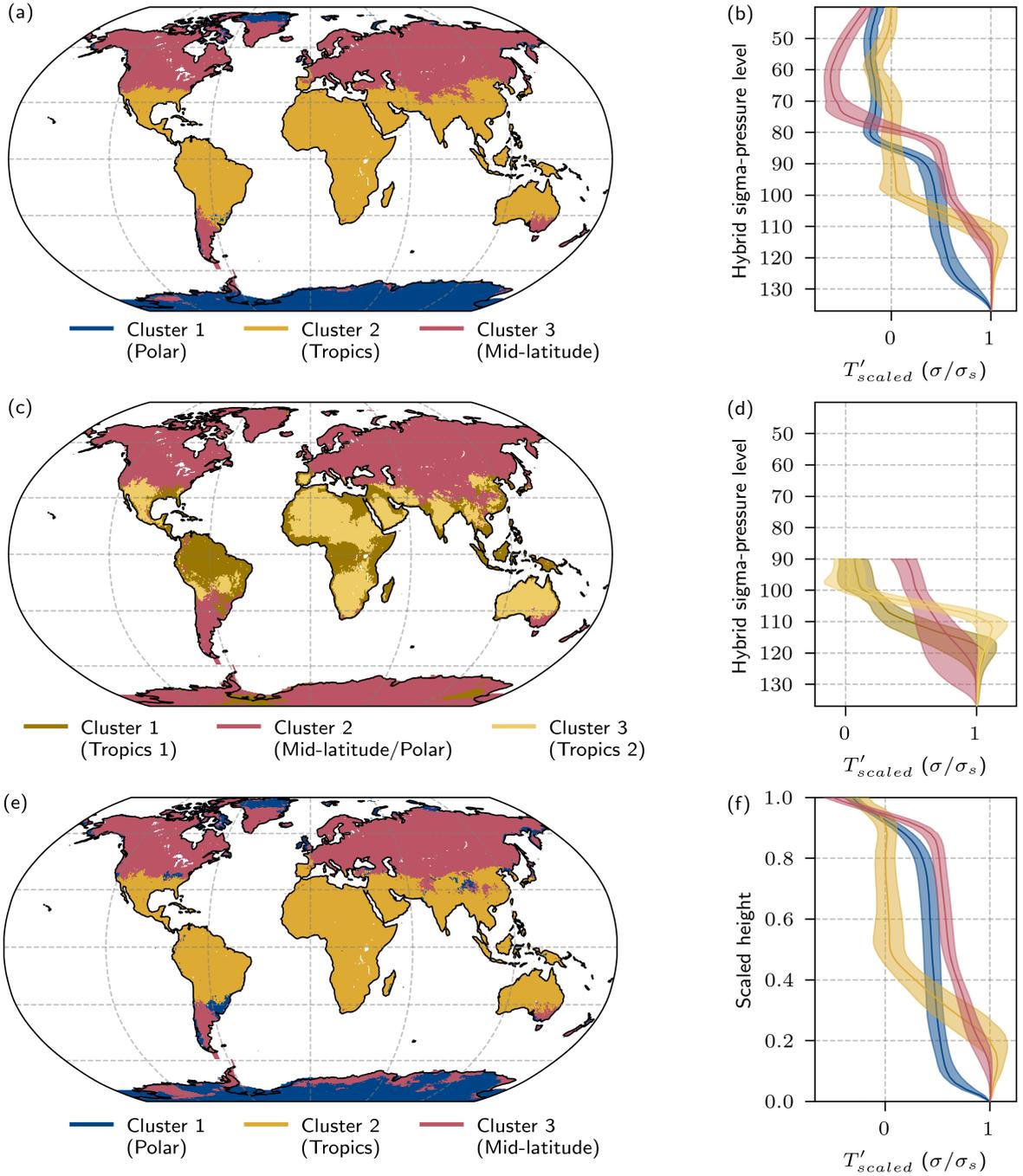
Figure S3. K-means clustering with three clusters over land using **(a, b)** without area-weighting the eight retaining principle components of full vertical profiles on the hybrid sigma-pressure levels 40 to 137 (Cluster 1: $N = 29'202$, Cluster 2: $N = 27'321$, Cluster 3: $N = 31'626$), **(c, d)** with area-weighting the five retaining principle components of restricted to the hybrid sigma-pressure levels 90 to 137 (Cluster 1: N=15'920, Cluster 2: $N = 58'932$, Cluster 3: $N = 13'297$), and **(e, f)** with area-weighting the six retaining principle components of the vertically linear pressure scaled profiles, where zero denotes the surface pressure and one the dynamical tropopause height (Cluster 1: $N = 14'212$, Cluster 2: $N = 55'730$, Cluster 3: $N = 17'487$). The colours (left) show the distribution of the clusters. The vertical profiles (right) denote the median (line) and interquartile range (shading) of the median vertical T'_{scaled} profile of all the grid points within each cluster.

3 Inter-cluster variability and the variance of individual TXx events
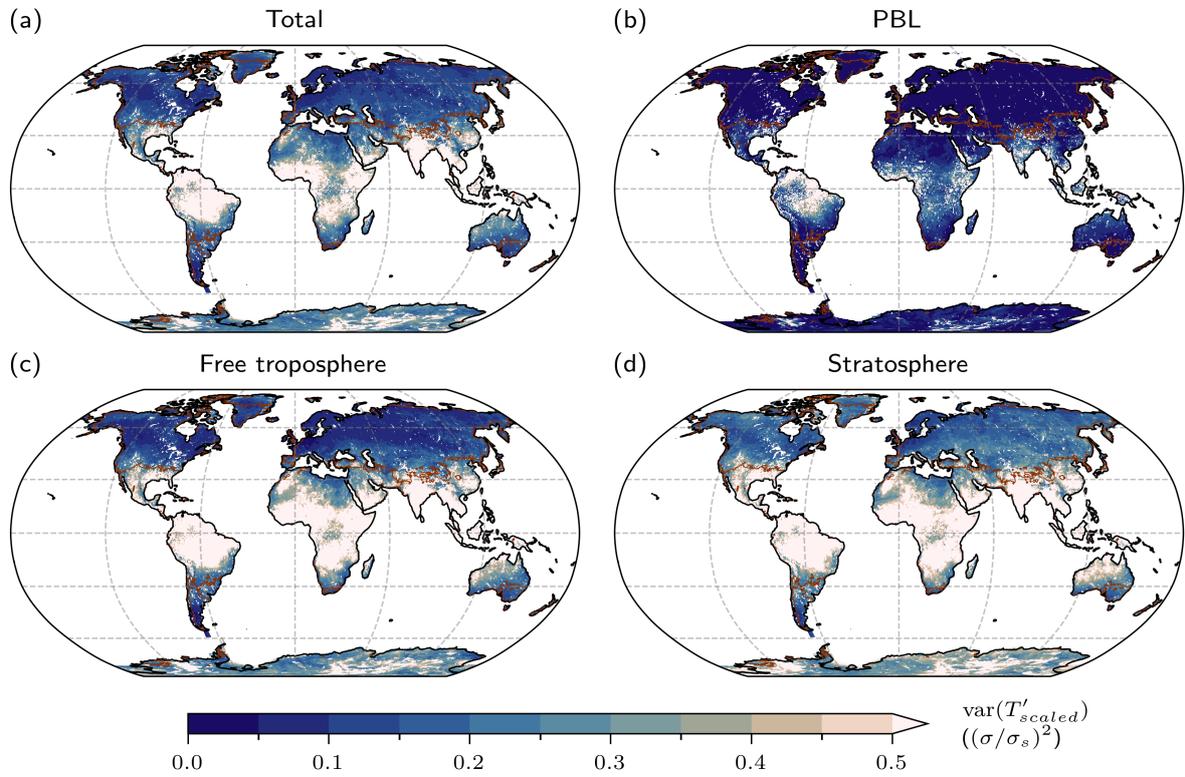
Figure S4. Variance of the TXx events T'_{scaled} profile to their median T'_{scaled} for all TXx events $(\mathrm{var}(T'_{scaled}))$, vertically averaged over **(a)** all hybrid sigma–pressure levels, **(b)** the PBL, **(c)** free troposphere, and **(d)** stratosphere. The brown lines denote the boundaries between the three clusters.
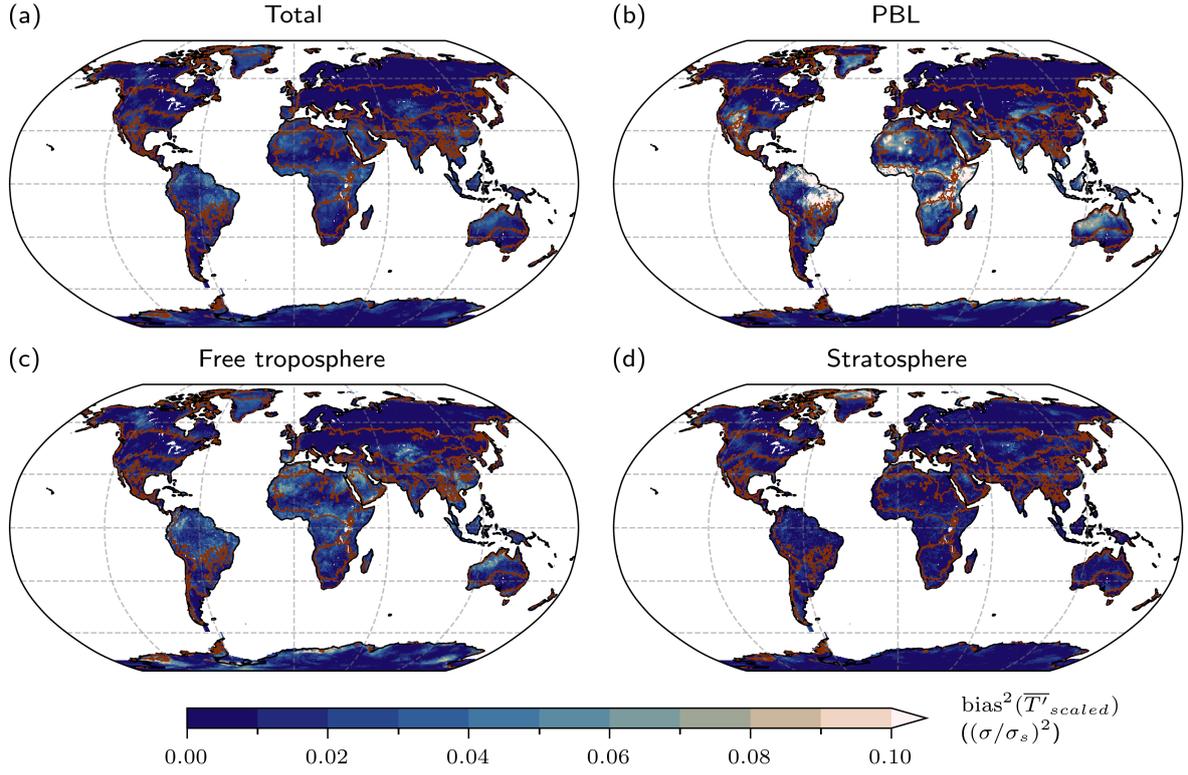
Figure S5. Distribution of squared bias of the grid point's median *scaled* temperature anomaly ($\overline{T'}_{scaled}$) and the corresponding cluster median profile ($\overline{T'}_{cluster}$) of the six clusters ($\mathrm{bias}^2(\overline{T'}_{scaled})$), vertically averaged over **(a)** all hybrid sigma–pressure levels, **(b)** the PBL, **(c)** free troposphere, and **(d)** stratosphere. The brown lines denote the boundaries between the six clusters. The coldest 10 TXx events are excluded at each grid point.