Supplement of

Understanding the vertical temperature structure of recent record-shattering heatwaves

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1 CAPE and CIN during record-shattering heatwaves (Fig. S1)
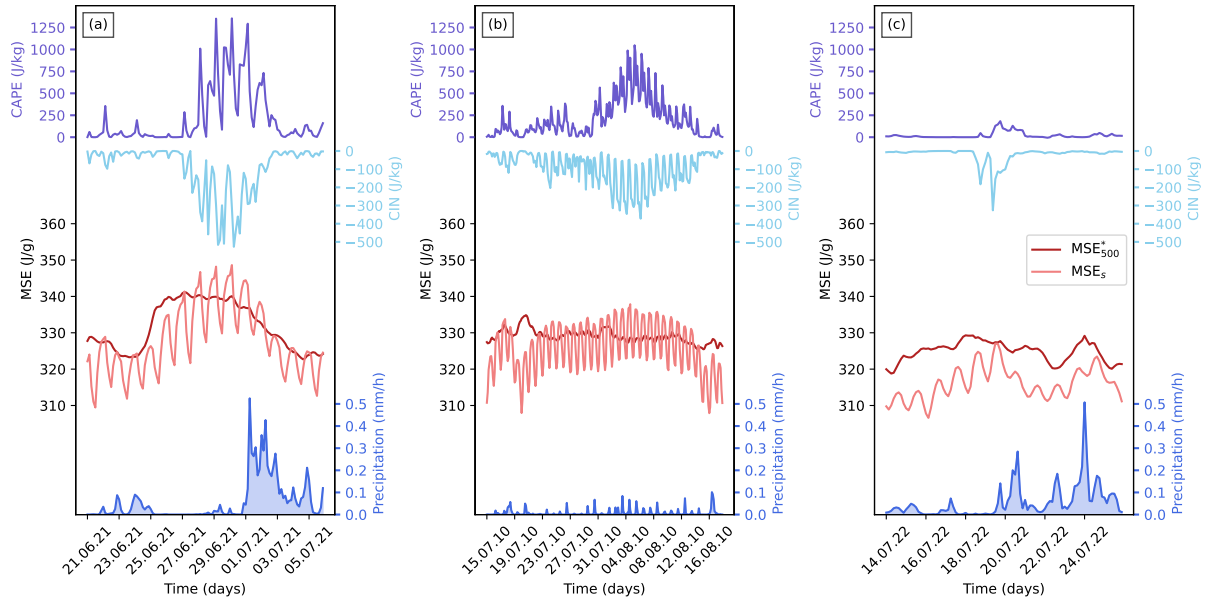
Figure S1: CAPE (purple, left y-axis) and CIN (light blue, right y-axis) evolution during the (a) PNW heatwave, (b) RU heatwave, and (c) the UK heatwave computed for the lowest model level. Further shown are surface moist static energy (MSE$_s$; light red) and free tropospheric saturation moist static energy at 500 hPa (MSE$_{500}$; dark red). The dark blue line and shading depict precipitation (right y-axis). All values have been calculated at each grid point and then averaged over land points of the respective 10.5° latitude by 10.5° longitude boxes indicated in Fig. 1.

2 Lagrangian T' decomposition before and after reaching the minimum pressure during the PNW heatwave (Fig. S2)

The WCB signature during the PNW heatwave suggests that air parcels ending up between 500 and 300 hPa experienced a strong ascent before contributing to the heatwave. Therefore, the adiabatic T' undercut -13 K at these altitudes. However, from this consideration alone, it remains unclear whether air parcels at these altitudes subsided within the anticyclone after their initial ascent. To clarify this, we divide the T' along each kinematic trajectory into contributions before and after reaching the minimum pressure, indicating the end of the ascent and the beginning of a possible descent. These disentangled net T' contributions are shown in Fig. S2.
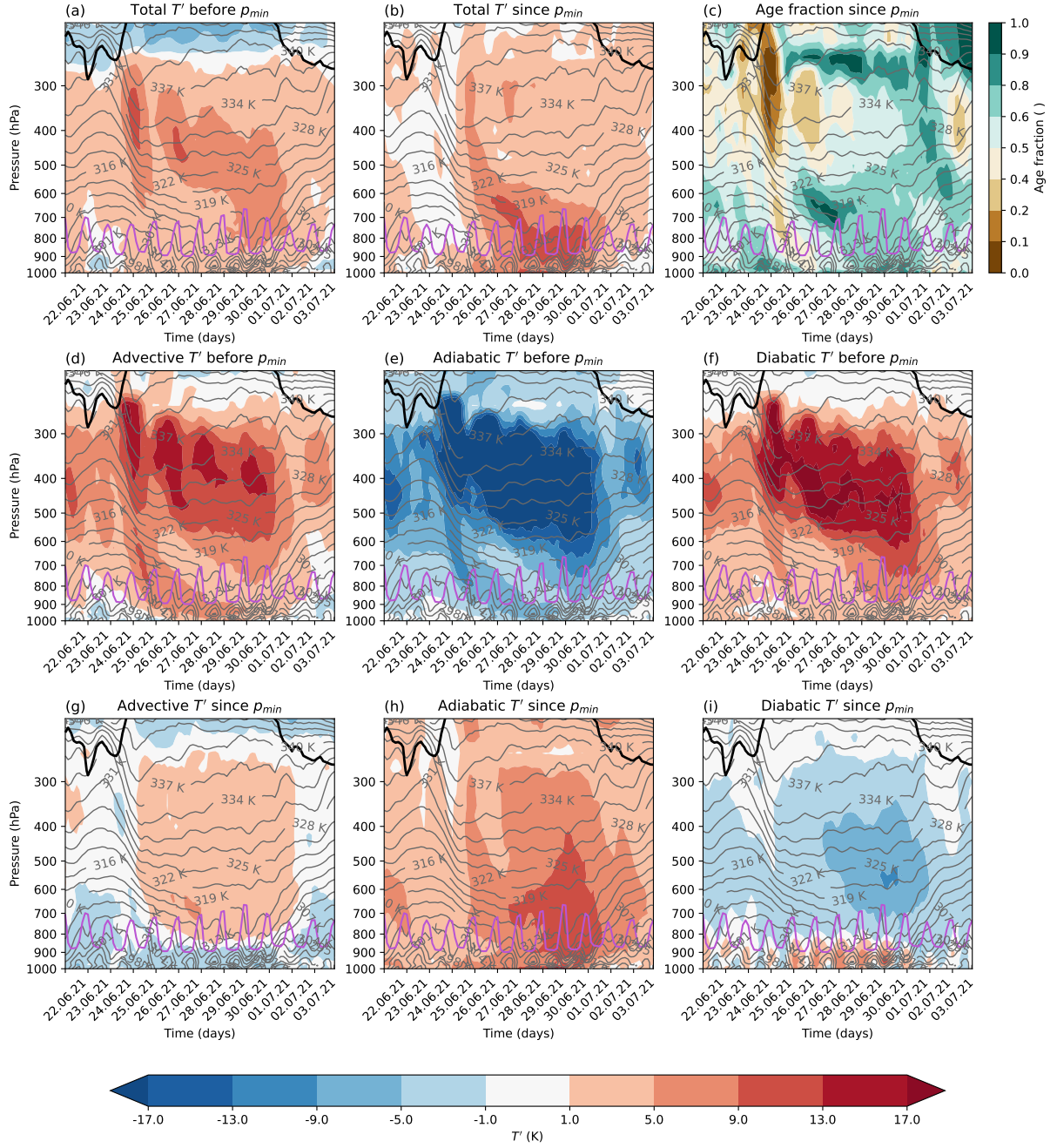
Figure S2: Time-height plots of T' and its contributions during the PNW heatwave spatially averaged over land grid points in the 49–59° N by 115–125° W box divided into the contribution (a, d–f) before and (b, g–i) after the respective air parcels reached their minimum pressure p_{min} since t_g between 22 June and 3 July 2021. The panels show (a, b) T', (c) the "age fraction" after reaching the minimum pressure, (d, g) the advective T', (e, h) the adiabatic T' and (f, i) the diabatic T' of the air parcels since the generation of T' in colour. The black line shows the dynamical tropopause (2 PVU contour), the grey contours depict the potential temperature, and the purple line indicates the planetary boundary layer height.