Supplement of Weather Clim. Dynam., 6, 211–230, 2025
https://doi.org/10.5194/wcd-6-211-2025-supplement

Supplement of

Synoptic perspective on the conversion and maintenance of local available potential energy in extratropical cyclones

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S1 Reference state schematic

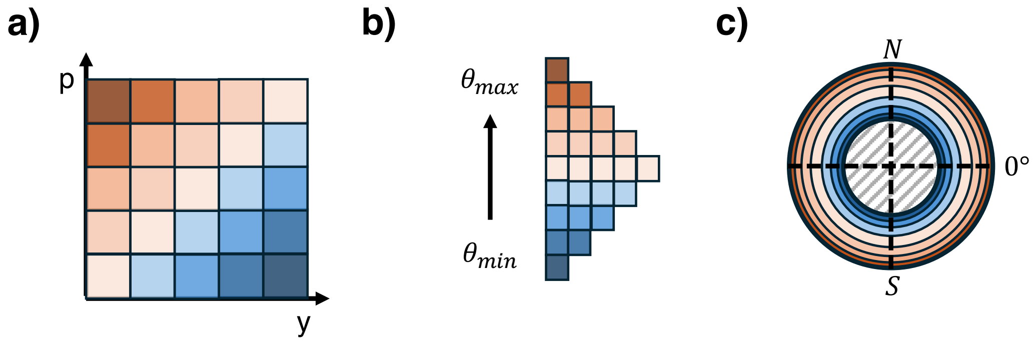

Figure S1: Schematic illustration of the computation of the reference state. (a) Meridional cross section of an idealized baroclinic zone composed of air parcels, represented by boxes. Color indicates potential temperature of the air parcels, increasing from blue to red. (b) Sorting of air parcels by increasing potential temperature. (c) Construction of the reference state from sorted air parcels illustrated by a section through the solid Earth (hatched) and the atmosphere (color, not to scale). The dashed lines indicate Earth's rotation axis and the equatorial plane (0° latitude). The atmosphere is assumed to be shallow such that each circle has the same circumference.

S2 QGω forcing from lower levels

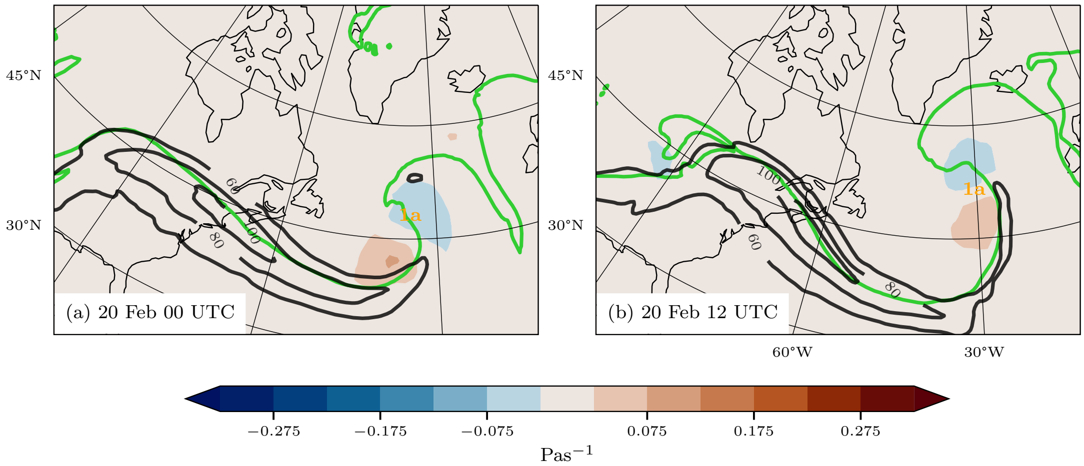

Figure S2: Low-level quasi-geostrophic ω on 500 hPa (color shading) for two time steps. Also shown are the 2-PVU contour on the 315 K isentrope (green) and wind speed on 300 hPa (black contours; 60, 80 and 100 m/s).

S3 APE evolution along forward trajectories

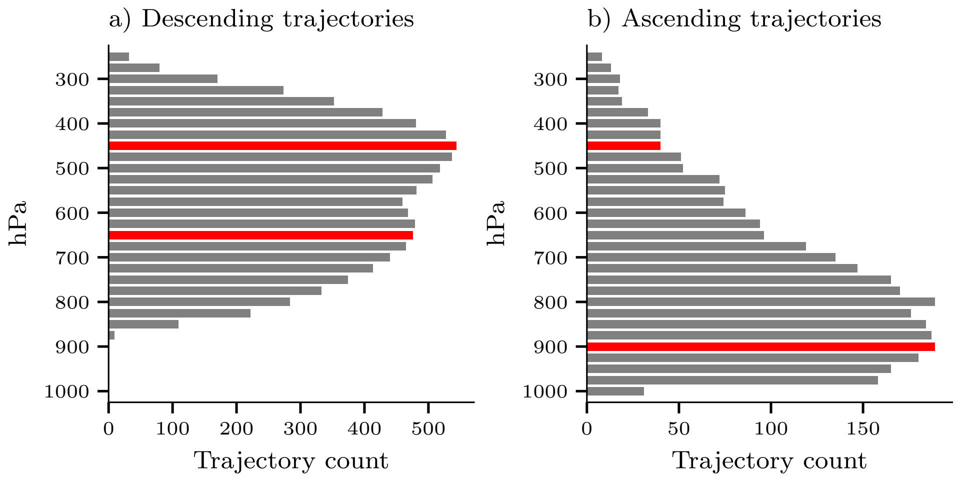

Figure S3: Vertical distribution of starting positions of trajectories in Fig. 5 for (a) descending trajectories, and (b) ascending trajectories. The vertical levels shown in Figs. S4-5 are highlighted in red.

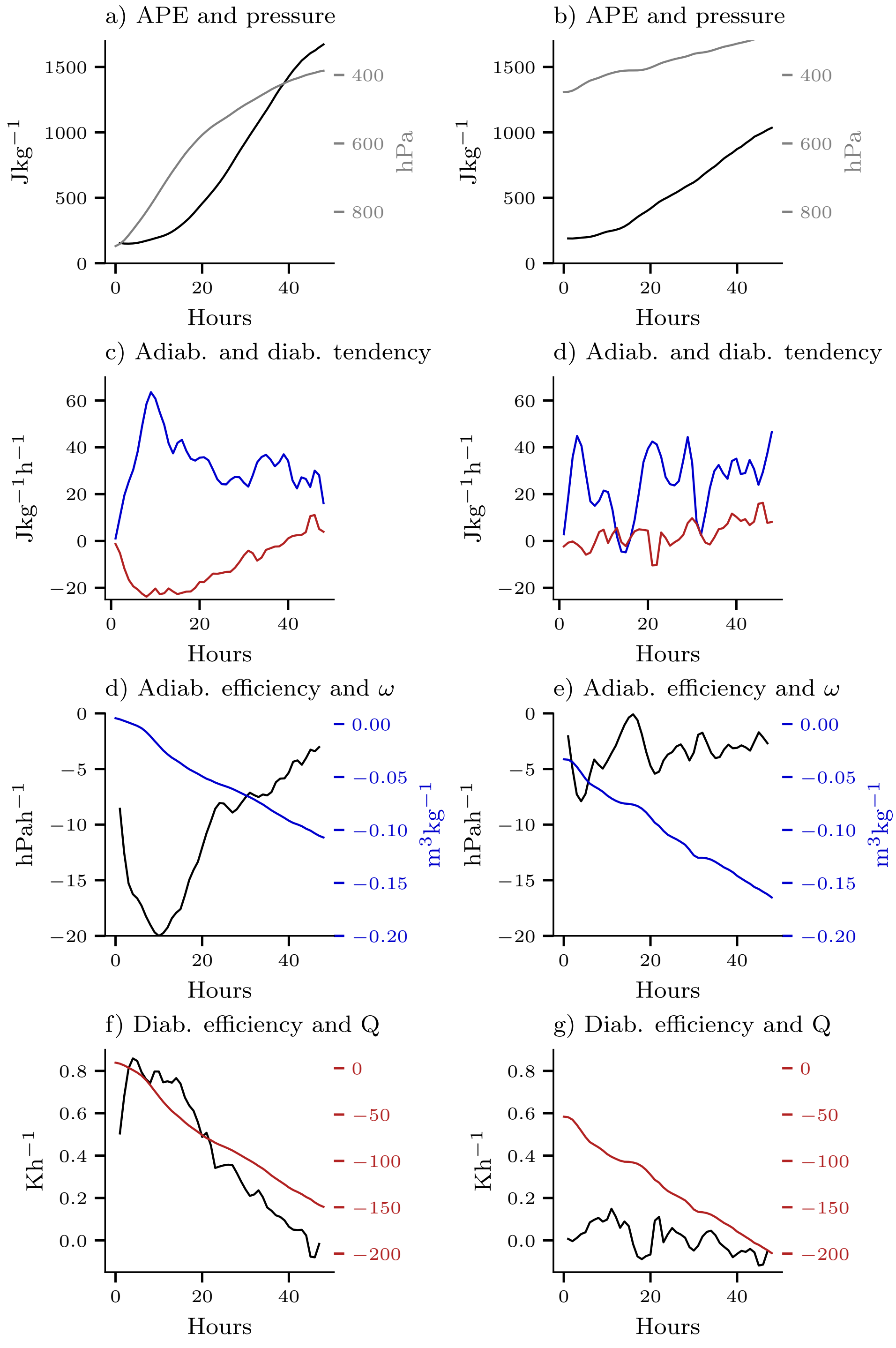

Figure S4: APE evolution along selected 48 h ascending forward trajectories from Fig. 5. Shown are averaged time series for trajectories ascending from 900 hPa (left column) and 450 hPa (right column). Shown are (a),(b) APE density (black) and pressure (grey); (c),(d) adiabatic (blue) and diabatic (red) APE tendency; (d),(e) vertical pressure velocity (black) and adiabatic efficiency (blue); (f),(g) diabatic heating rate (black) and diabatic efficiency (red, dimensionless).

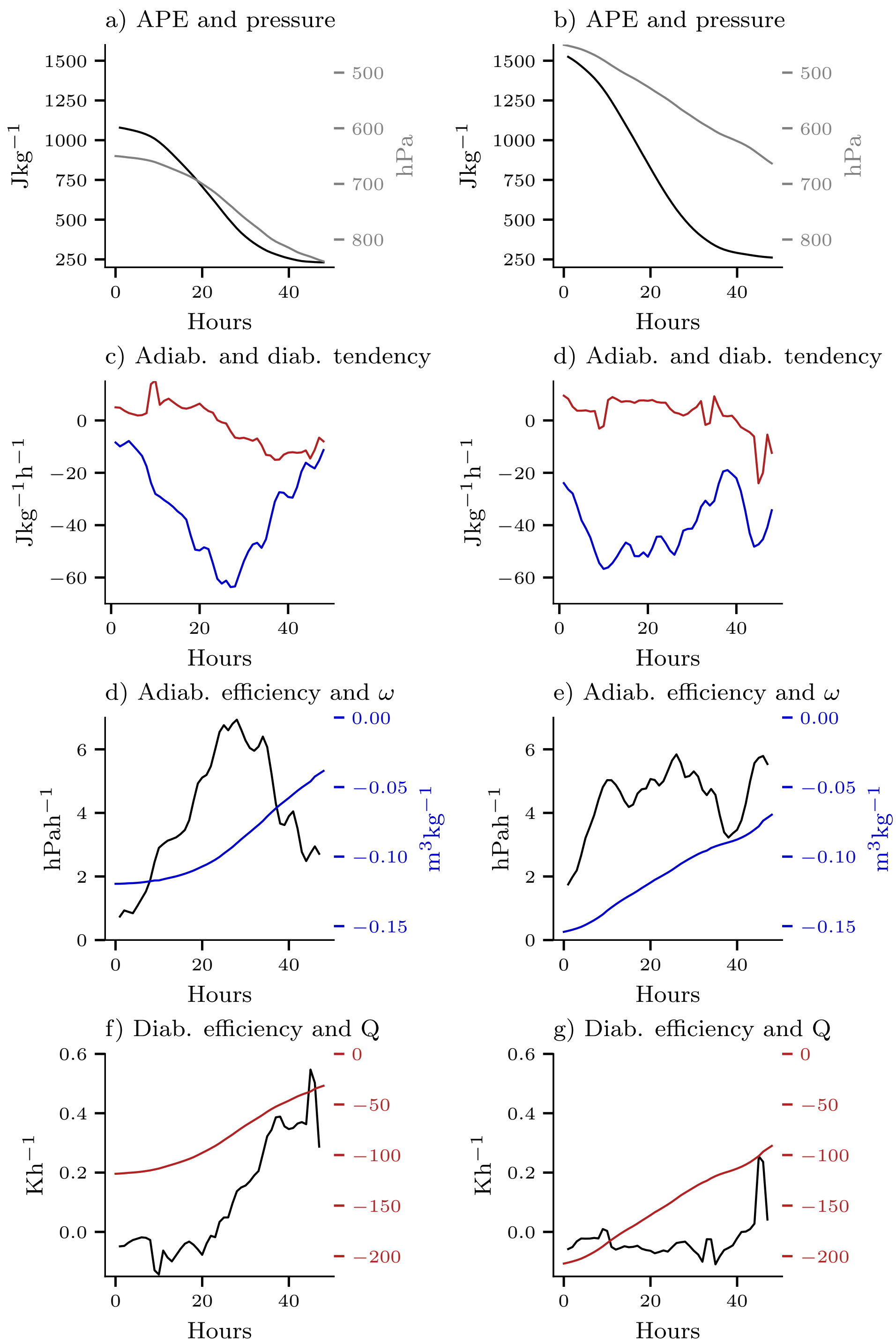

Figure S5: Same as Fig. S4, but for descending trajectories from 650 hPa (left column) and 450 hPa (right column).

S4 Enlarged cyclone-relative composites

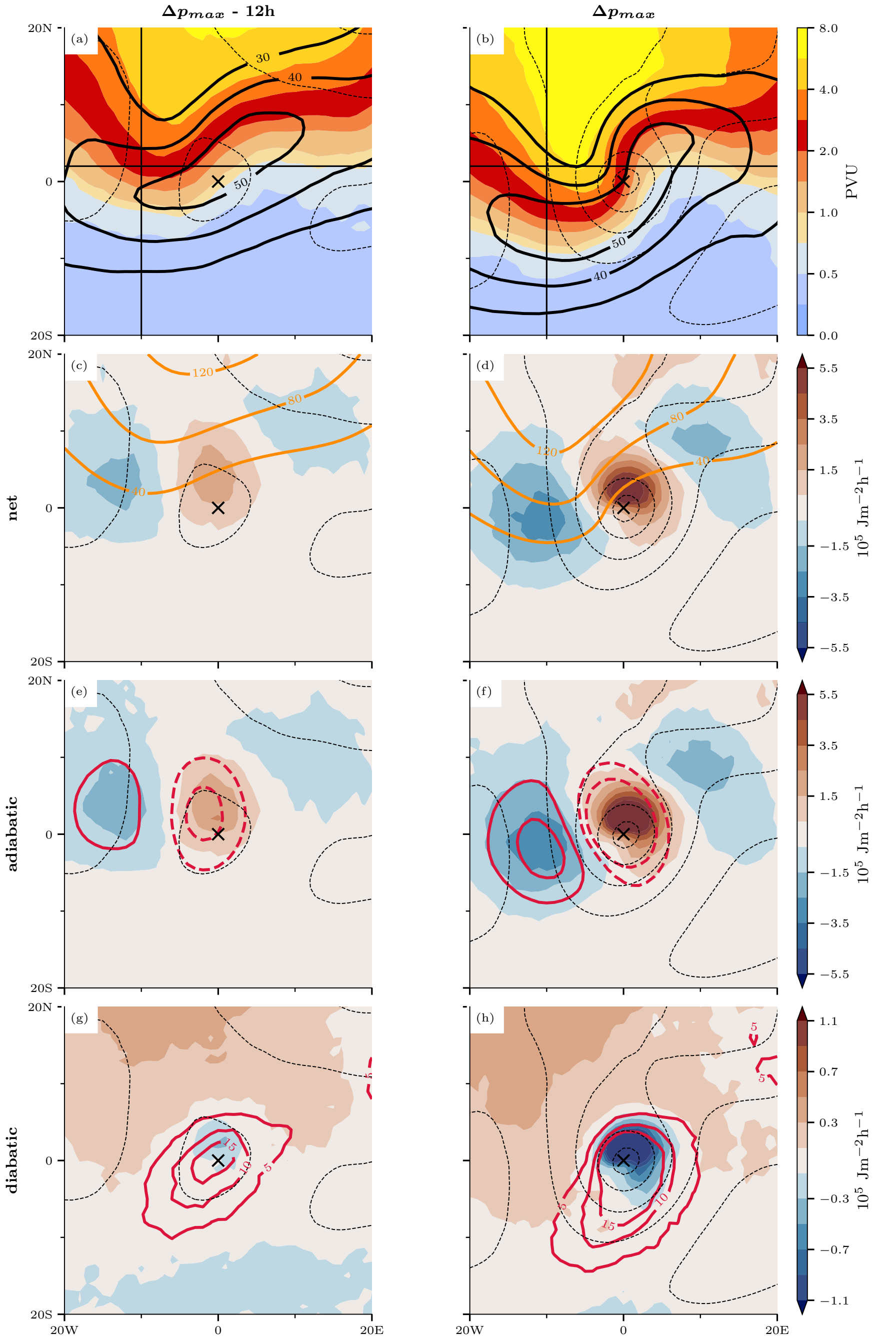

Figure S6: Cyclone-relative composites 12 h before time of maximum intensification (Δp_{max} - 12 h) and at time of maximum intensification (Δp_{max}). Black dashed contours indicate mean sea-level pressure (every 8 hPa). (a)-(d) isentropic PV at 315 K (shading) and wind speed on 300 hPa (every 10 ms^{-1}). (e)-(h) net APE tendency (shading) and the distribution of vertically integrated APE density (orange contours; 40, 80, 120 $\cdot$ 10^5 Jm^{-2}). (i)-(l) adiabatic APE tendency (shading) and upper-level QGω on 500 hPa (red contours; -0.1, -0.05, 0.05, 0.1 Pas^{-1}). (m)-(p) diabatic APE tendency (shading) and one-hour accumulated precipitation (red contours; every 5 mm). Note the different color scales for the APE tendencies.

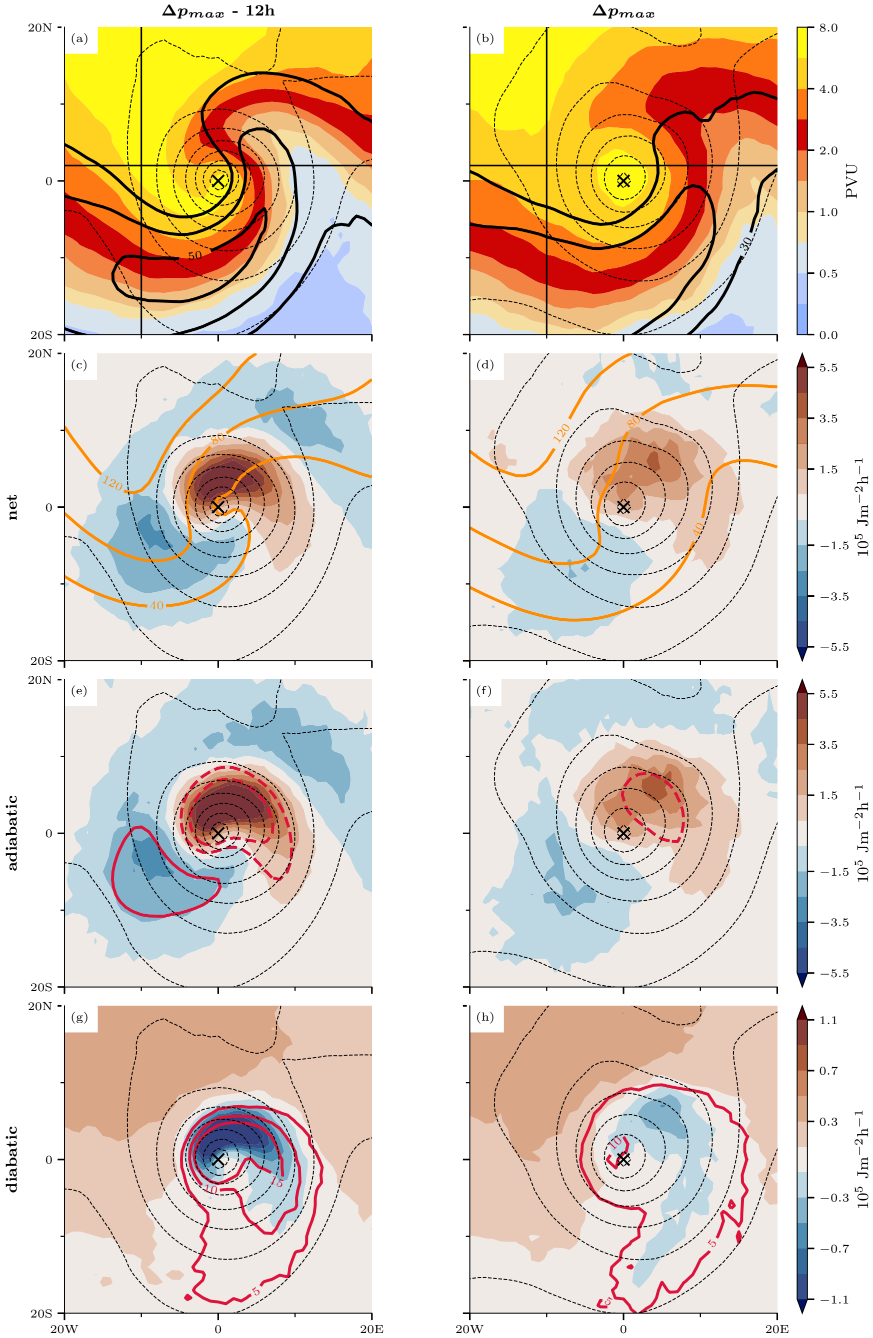

Figure S7: Cyclone-relative composites at time of maximum depth (d_{max}) and 12 h after time of maximum depth (d_{max} + 12 h). Black dashed contours indicate mean sea-level pressure (every 8 hPa). (a)-(d) isentropic PV at 315 K (shading) and wind speed on 300 hPa (every 10 ms^{-1}). (e)-(h) net APE tendency (shading) and the distribution of vertically integrated APE density (orange contours; 40, 80, 120 · 10^5 Jm^{-2}). (i)-(l) adiabatic APE tendency (shading) and upper-level QGω on 500 hPa (red contours; -0.1, -0.05, 0.05, 0.1 Pas^{-1}). (m)-(p) diabatic APE tendency (shading) and one-hour accumulated precipitation (red contours; every 5 mm). Note the different color scales for the APE tendencies.

S5 Sensitivity to the choice of radius for APE tendency integrals

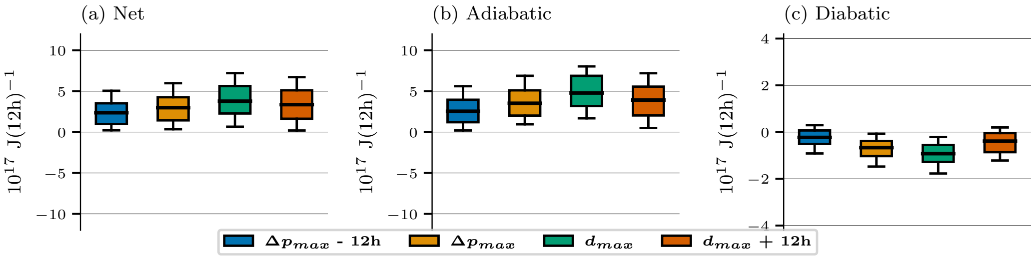

Figure S8: (a) Distribution of minimum mean sea-level pressure of the 285 selected cyclones, averaged +/- 6 h around the four life cycle stages. The (b) net, (c) adiabatic and (d) diabatic APE tendency is integrated in a 1000 km radius around the cyclone center within a +/- 6 h window around the four life cycle stages. Whiskers show the 10th-90th percentile range.

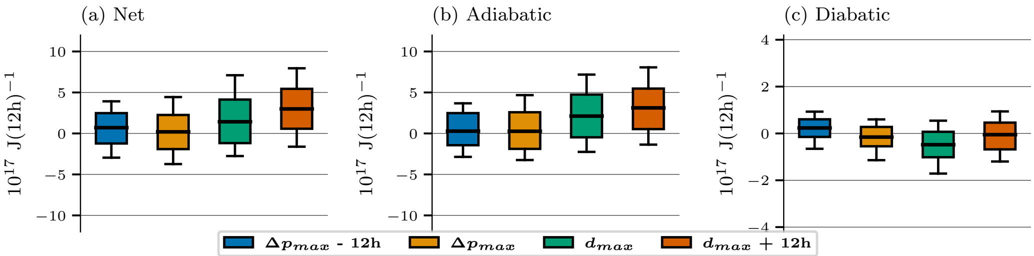

Figure S9: Same as Fig. S8, but for an integration radius of 1500 km.

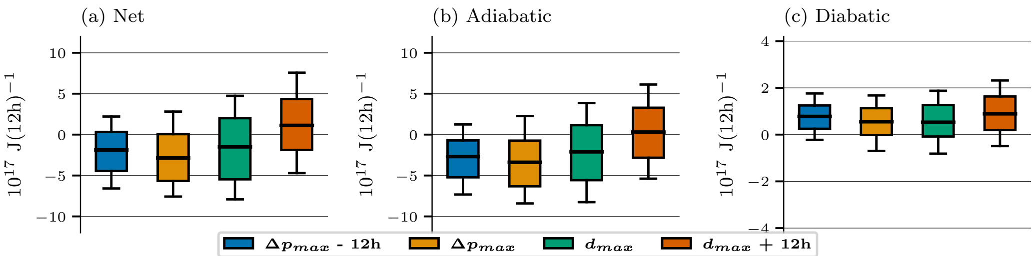

Figure S10: Same as Fig. S8, but for an integration radius of 2500 km.