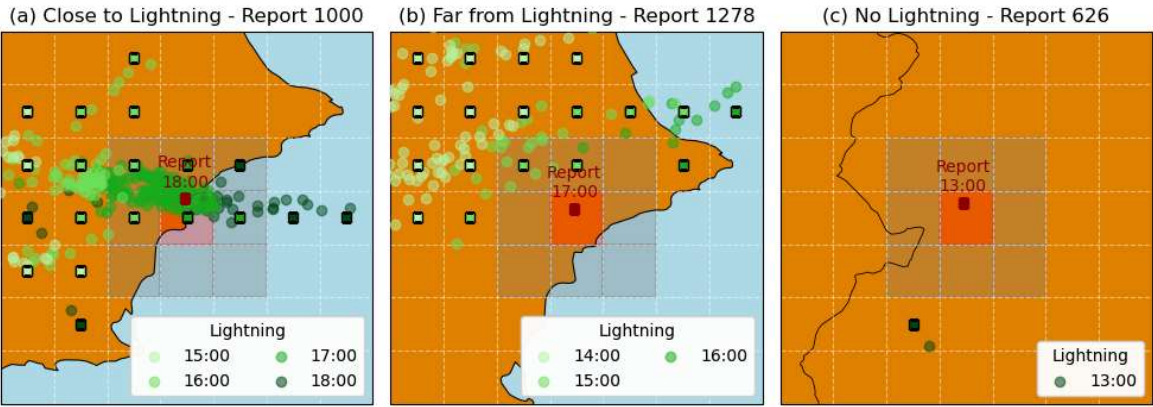
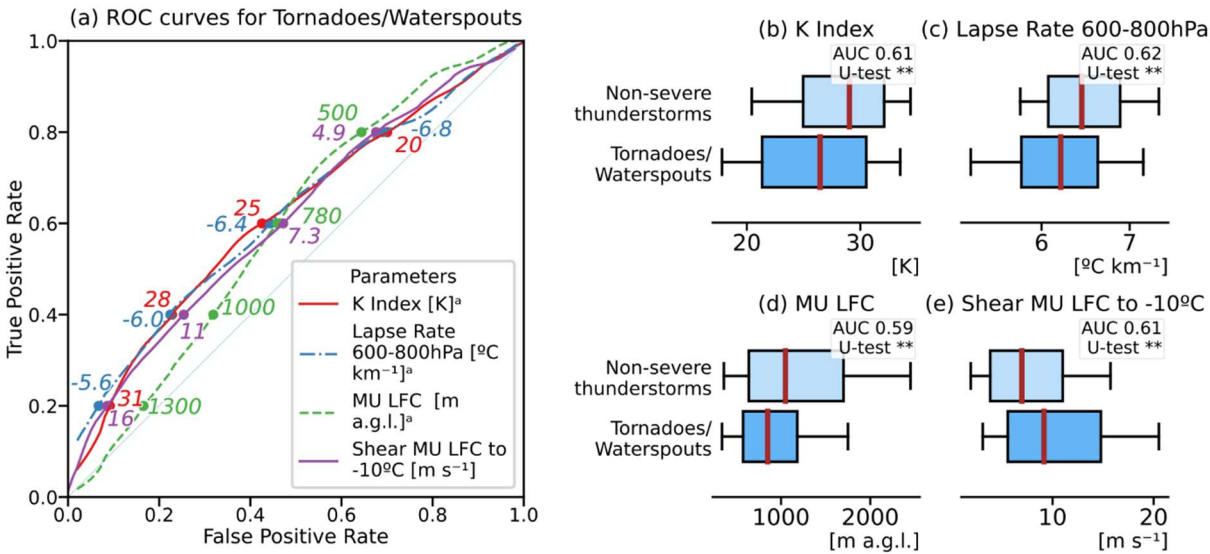


1 **Supplementary Material**



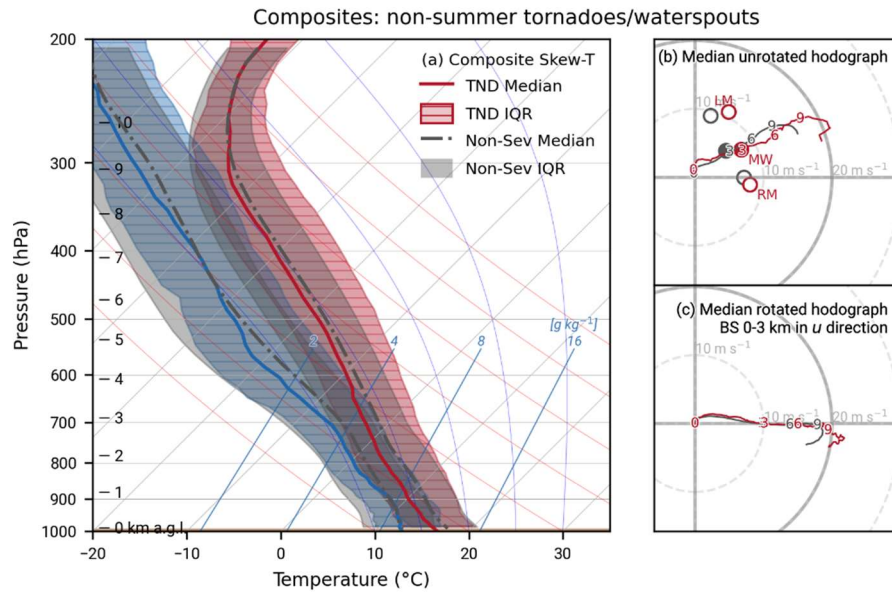
Supplementary Figure S1: Examples of the downburst subclassification and the time selection for profiles. All subfigures show the 0.25° ERA5 grid with lightning observations overlaid. Squares indicate the hour of the first lightning in the grid using the same color. In (a) it can be inferred from lightning flashes that convection occurred over the report location at least 1 hour prior to the report and, according to our criteria, the selected profile would be chosen at 16:00. In (b) no lightning was found on the report grid but lightning flashes were present at 15:00 in neighbor grids so, according to our criteria, we choose 14:00 to avoid contamination of the profile. In (c), lightning flashes are far from the reported grid cell (~60-70 km) and we select 12:00, the hour previous to the report, for the profile.

2



Supplementary Figure S2: Convective parameters that best classify summer tornadoes against non-severe thunderstorms. (a) Receiver Operating Characteristic curves of selected parameters. The numerical values annotated correspond to the thresholds in each convective parameter that are exceeded (^a not exceeded, for MU LFC) by 80%, 60%, 40% and 20 % of tornadoes (i.e., true positive rates). (b-e) Distributions of the parameters. Mann-Whitney U-tests evaluate if both distributions differ for various confidence levels (ns: below 0.95; **: 0.99). ML: mixed-layer parcel. MU: most-unstable parcel. LFC: level of free convection. SRH: storm-relative helicity. RM: right-mover motion.

3



Supplementary Figure S3: Composite profiles for non-summer tornadoes/waterspouts (TND; colored lines) and non-severe thunderstorms (Non-Sev; grey lines). (a) Composite skew-T diagram. (b) Median hodograph with 3, 6 and 9 km altitudes annotated, also including motion vectors of right-mover supercells (RM), left-mover supercells (LM) and the mean 0–6 km wind (MW). (c) Shear-relative composite hodograph, with the origin of single profiles shifted to the center of the hodograph and 0–3 km bulk shear (BS) aligned with the wind *u*-component (i.e., eastward).