Supporting Information for "A statistical model for isolated convective precipitation events"

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This supplementary information contains further text and figures that are not crucial for the understanding of the main text. However, this material may be useful for those readers who are interested in the details, which were mainly summarized in the text in the main manuscript.

Supplementary discussion S1: The effect of θ

In Fig. 1 we give a general overview of the different track types and how their weight is affected by the parameter θ. As might be expected, the total precipitation contribution of solitary tracks monotonically increases for increasing θ (Fig. 1, from ca. 25% to ca. 75% for *P2K*, and from ca. 10% to ca. 75% for *P4K*), while the contribution of mergers monotonically decreases. At $\theta = 0$ the contribution of mergers is 32% for *P2K* and somewhat larger (42%) for *P4K*. At $\theta = 1$, the contribution of the mergers is essentially zero, as identical areas of the merging or fragmented cells would be required. The track

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that is treated as continued is always the merging or fragmentation result, respectively, and therefore no new track initialization happens. The contribution of fragmentation also decreases with θ, but is generally small. Also the contribution of other track types monotonically decreases with θ, but remains finite even at $\theta = 1$. For values of θ between 0 and 0.5 the main contribution is clearly from solitary tracks and mergers, therefore we will, in the following, often focus on those two track types.

We mention a few minor technicalities: Tracks that are only one time step long are neglected, however, in Fig. 1 their contribution is included into the track type *other*. Their contribution decreases somewhat when varying θ from 2.3% to 0.3% in *P2K* and from 5.8% to 0.4% for *P4K*. However, even at $\theta = 1$ their contribution is still non-zero. For instance, it may occasionally be the case that an object splits off from one track and merges into another, larger track at the next time step. Such an object would initiate a track that would be terminated immediately and therefore would be only one time step long, track at $\theta = 1$.

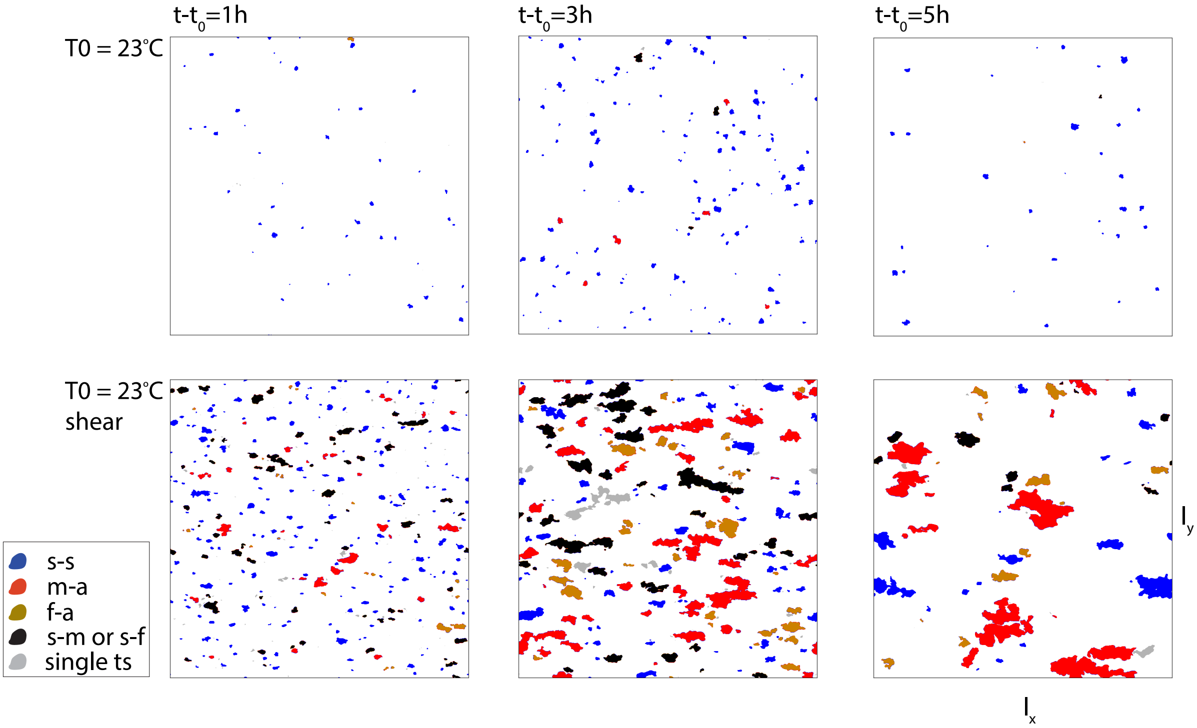


Figure S1. Time sequence of tracked objects. Precipitation objects one hour, three hours and five hours after the onset of precipitation for $T_0 = 23°C$ without wind shear (*CTR* simulation, upper row) and $T_0 = 23°C$ with large-scale wind shear (*OMEGA* simulation, lower row), as labeled, for $\theta = 0.5$. Legend, coloring and remaining model parameters as in Fig. 2. Objects are colored by their track type as indicated in the legend. Note the pronounced merging effect caused by large-scale advection.

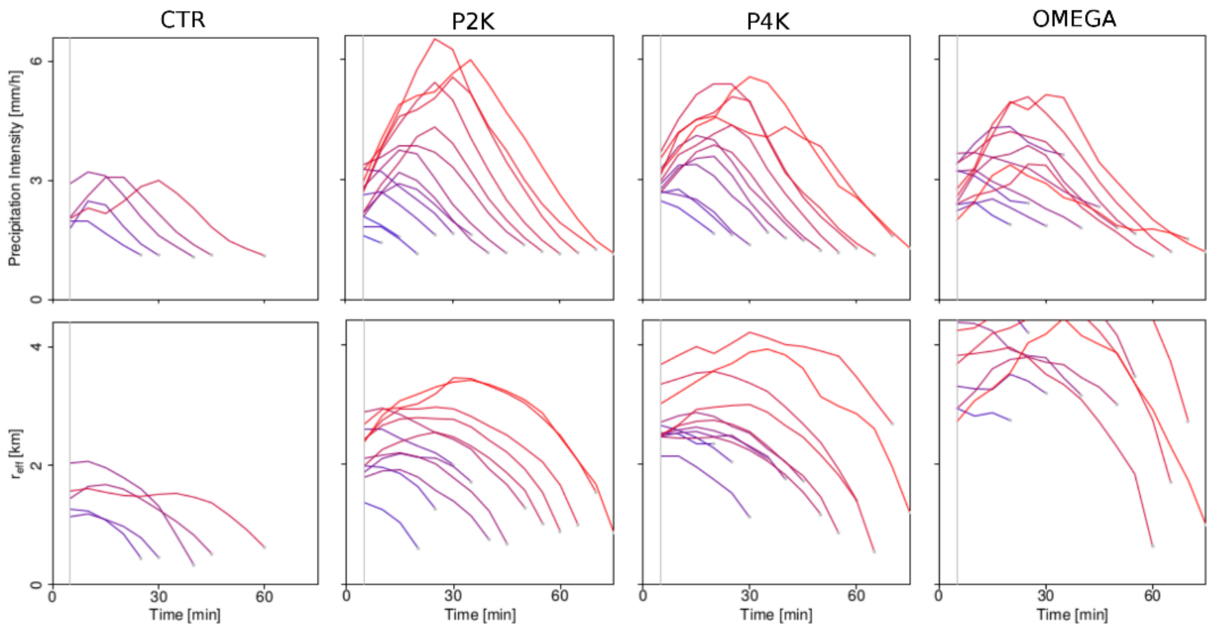


Figure S2. Time dependence across track duration (mergers). Similar to Fig. 5 but for tracks initiated as mergers (track types *m-a*): Intensity (top row), and effective radius (bottom row). Columns from left to right: CTR, P2K, P4K, and OMEGA simulation, each with $\theta = 0.5$.

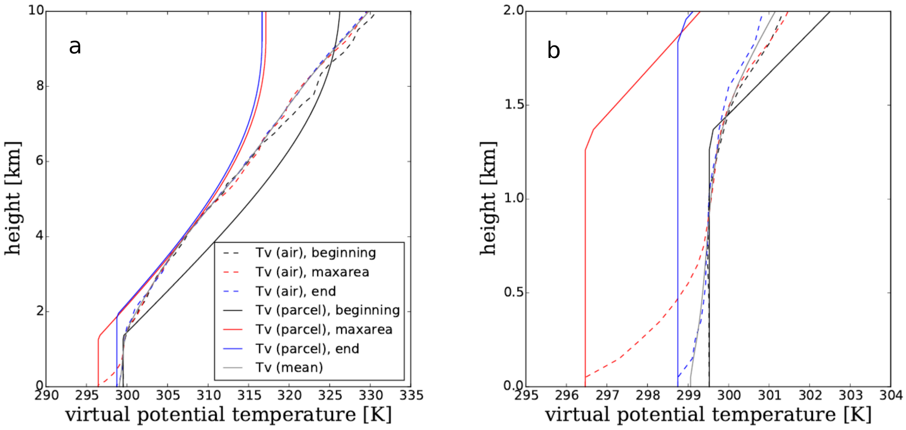


Figure S3. Vertical profiles of virtual potential temperature θ_v for a selected solitary track. Dashed curves show the profile of θ_v at the column of the center of mass of the event, while solid curves show the profile of an idealized air parcel that follows a pseudo adiabat $\theta_{v,palcel}$, at the beginning of the event, after 30 min when the track reaches its maximum extent, and after 70 minutes at the time when surface rain ends, up to 10 km height (a), and zoom up to 2 km height (b). The area between both curves where $\theta_{v,parcel} > \theta_v$ represents CAPE, while the area close to the surface, where $\theta_{v,parcel} < \theta_v$, represents CIN. Left panel: Profiles from surface up to a height of 10 km; right panel: Zoom into boundary layer up to a height of 2 km. While at the beginning of the events CAPE is large and CIN is small, after 30 min CAPE is large, mainly because of the drop in surface temperature due to the cold pool, while CAPE completely vanishes (note that this is the case only for a part of the tracks). At the end of the track, the cold pool has already weakened and a drop in CIN is visible. Note also that the change in atmospheric profile above the boundary layer (i.e. the dashed lines) is relatively small, and therefore contributes only weakly to the change in CAPE. There, local profile of θ_v even does not strongly deviate from the horizontal mean profile (solid gray line).

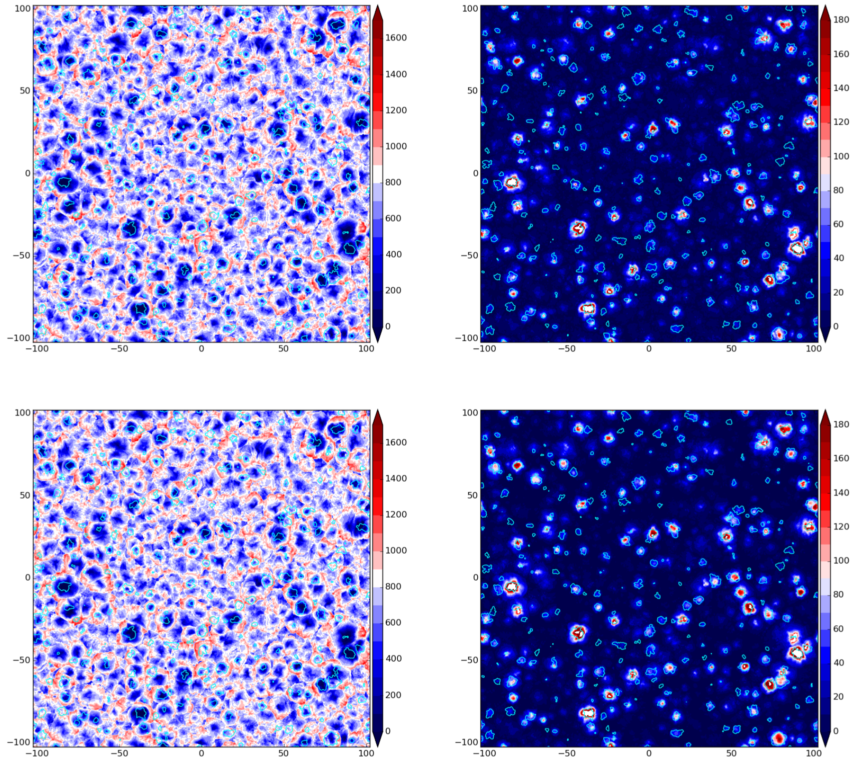


Figure S4. Horizontal snapshot of local CAPE and CIN. CAPE (left) and CIN (right), given in $[J\,kg^{-1}]$, at 16:00 UTC in the P2K simulation, calculated from the equations 1 and 2. In the top panels, the local T_v at each column have been taken, while in the bottom panels, the horizontal mean profile of T_v way used. Note the relatively small differences between both cases.

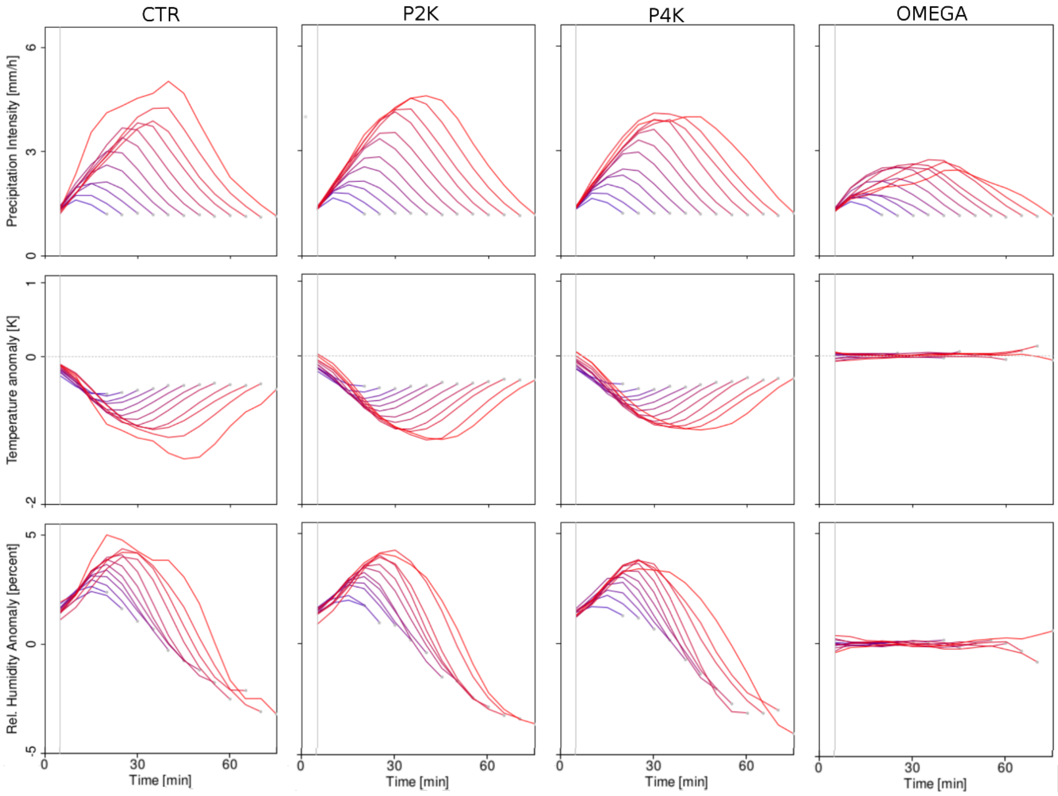


Figure S5. Auxiliary field time dependence. Intensity (top row), near-surface temperature (center row), and relative humidity (bottom row) as function of time. Columns from left to right show solitary tracks for CTR, P2K, P4K, and OMEGA, each for $\theta = 1.0$.

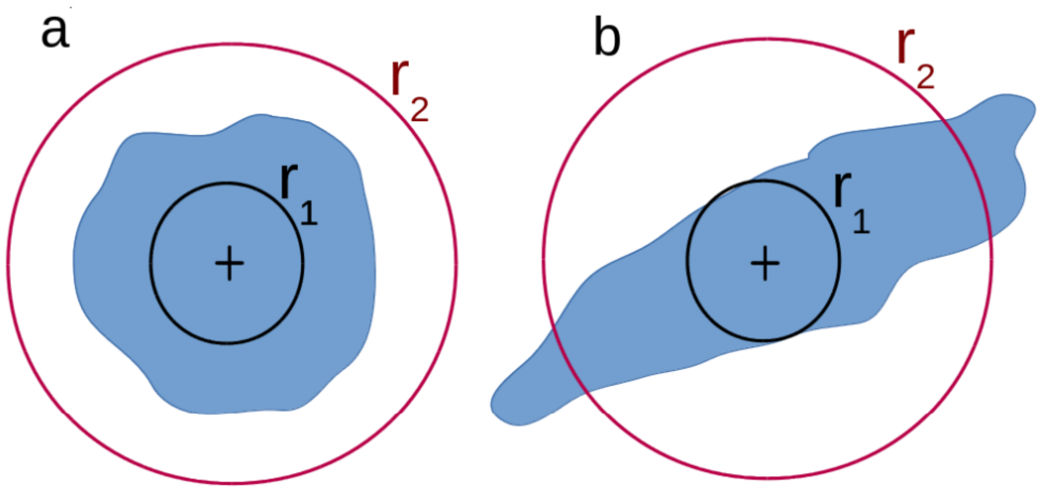
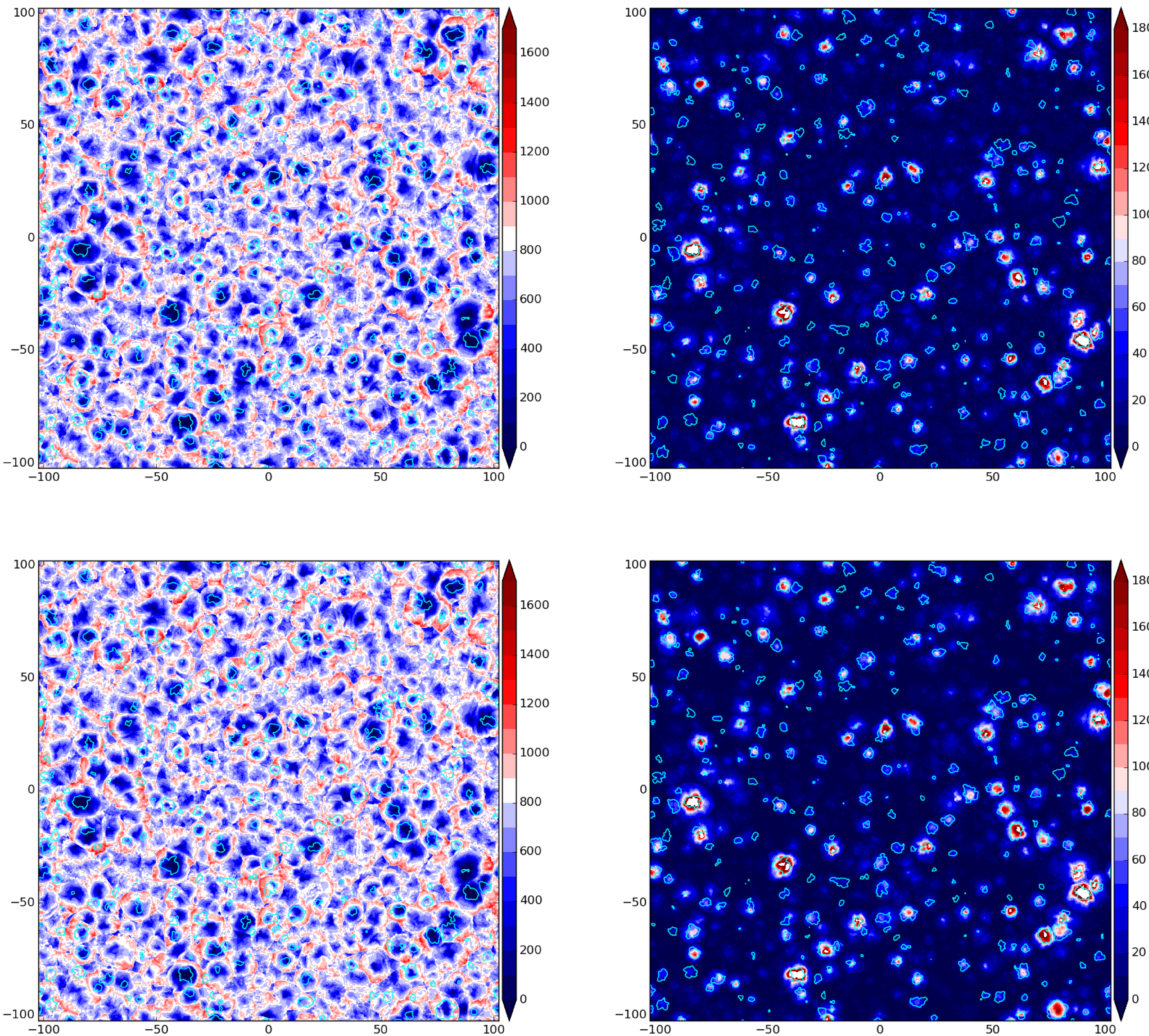
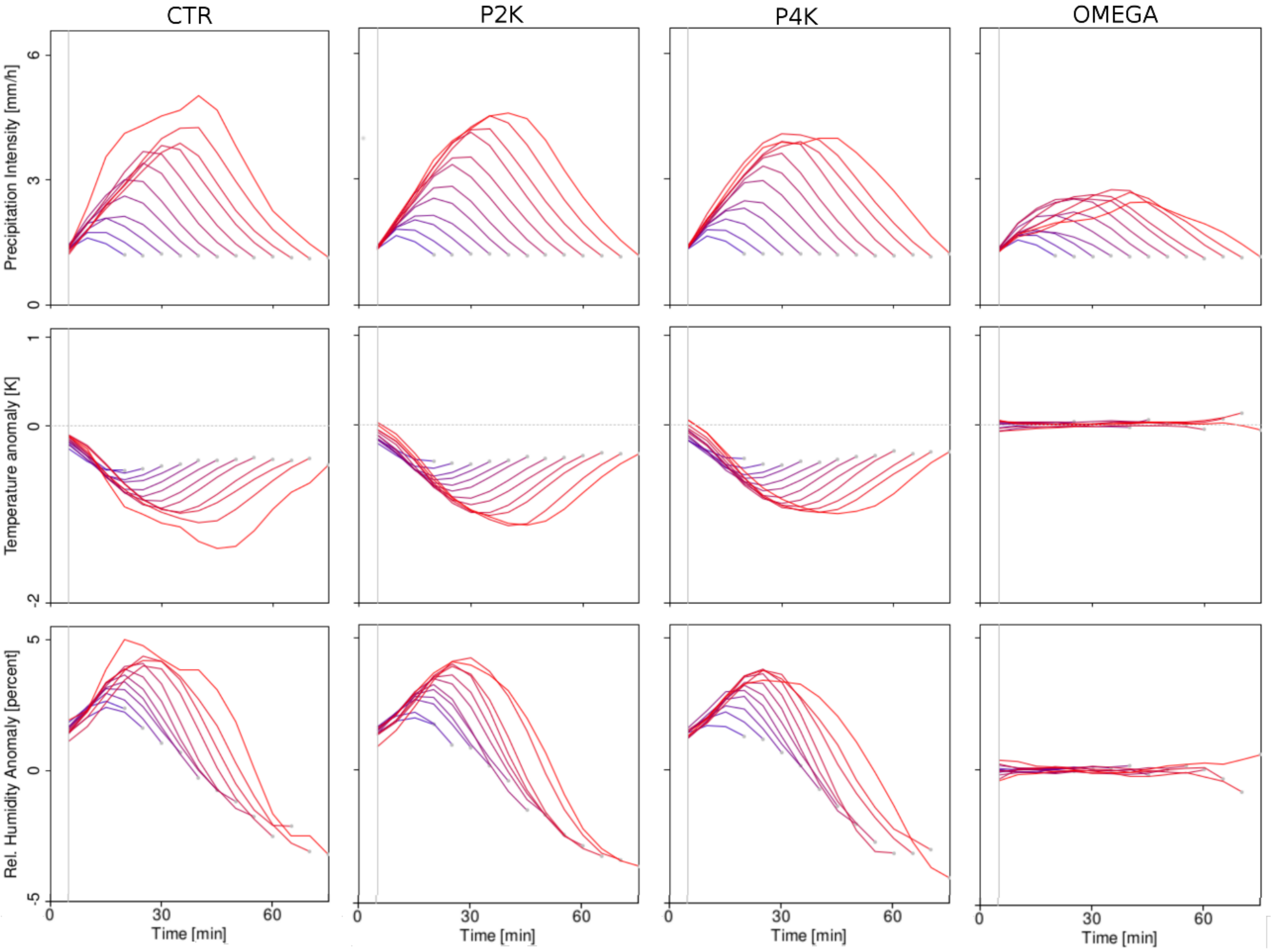
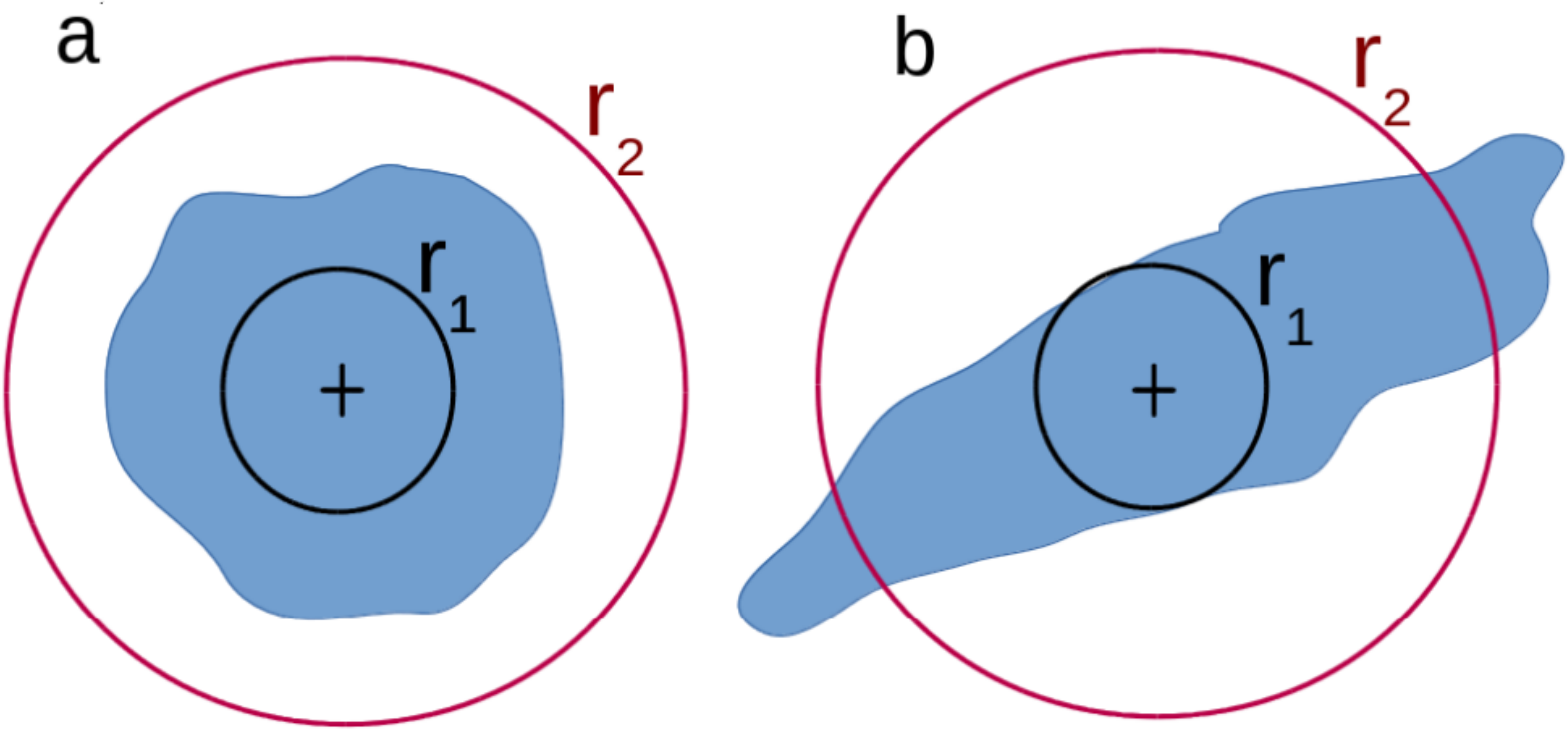


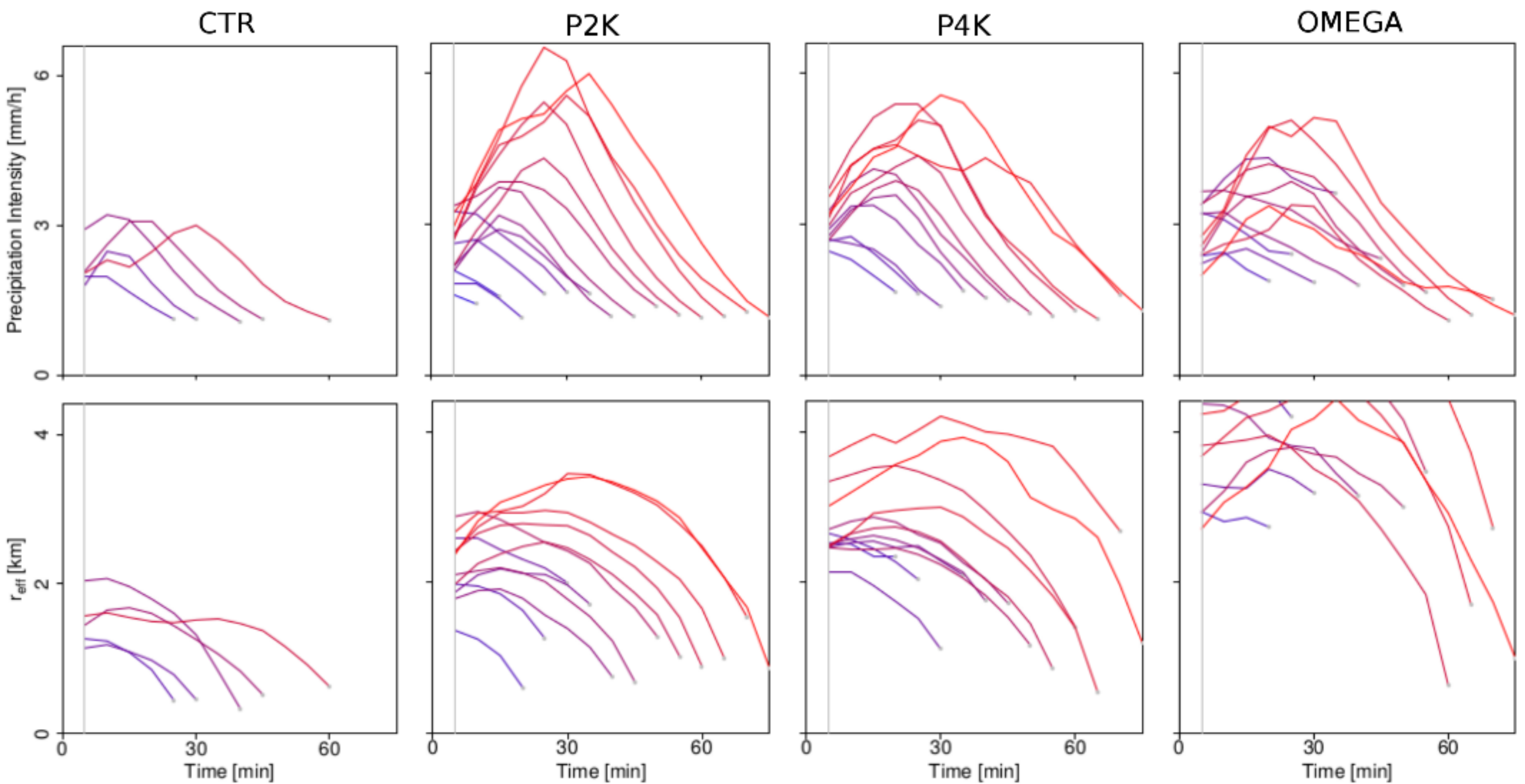
Figure S6. Sketch to illustrate the tails of the radial profiles seen in Fig. 9. Consider two precipitation objects of comparable size, one which has nearly circular shape (a) and one that strongly deviates from a circular shape (b). The black circles with small radius r_1 around both cell centers lie completely inside the rain areas, so the mean intensity at this radius will be averaged around the entire circle. However, the red circle with large radius r_2 is completely outside the object (a), such that the intensity there will be zero, while in (b) the red circle partly intersects with the objects. Outside this intersection the intensity is by definition zero, such that an averaging along this circle will lead to a small mean intensity and thus contribute to the tail. Averaging over many circular shaped objects of type (a) and few longer objects of comparable size of type (b) leads to the tail of the profiles, especially for larger areas.


100
50
0
−50
−100
−100
−50
0
50
100
1600
1400
1200
1000
800
600
400
200
0
180
160
140
120
100
80
60
40
20
0

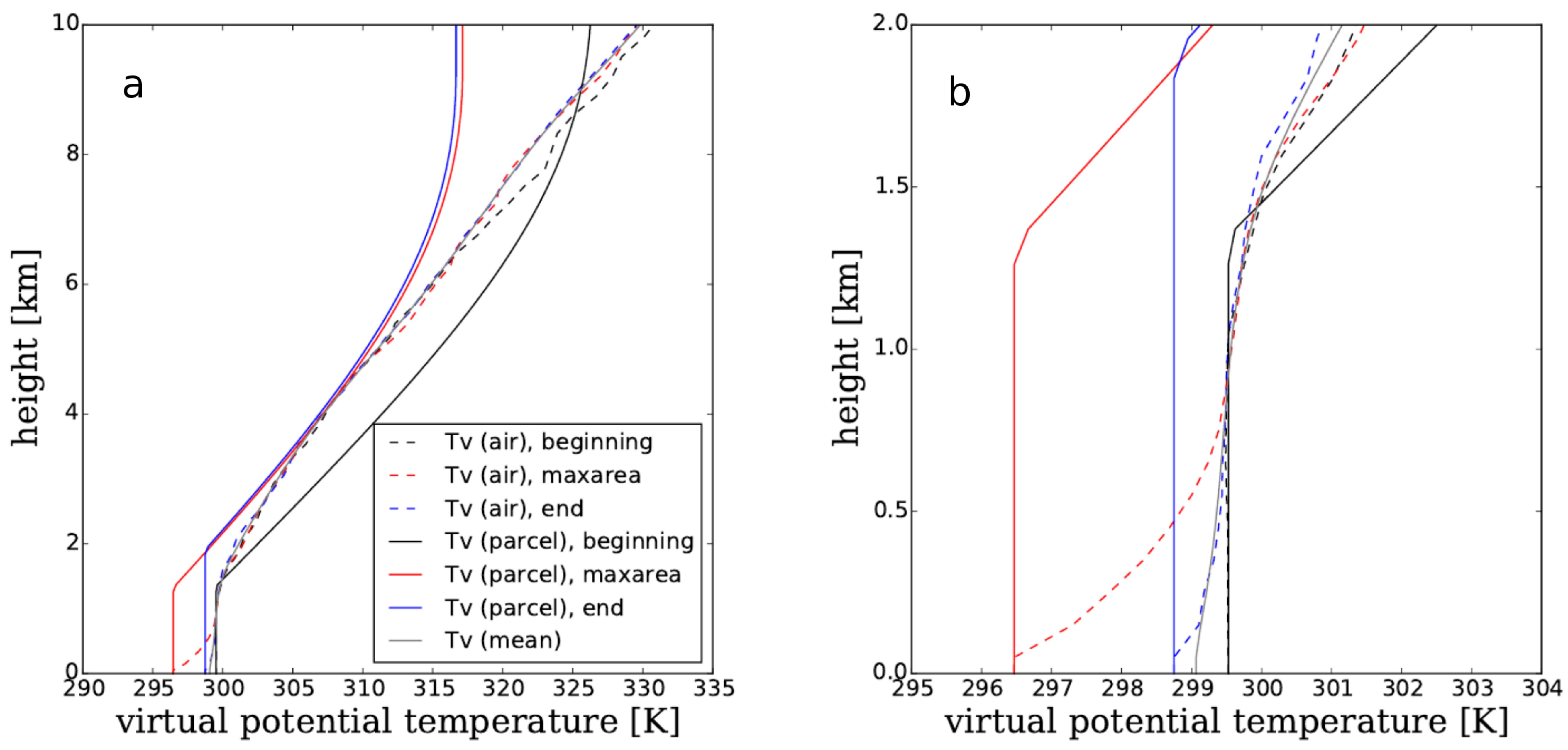


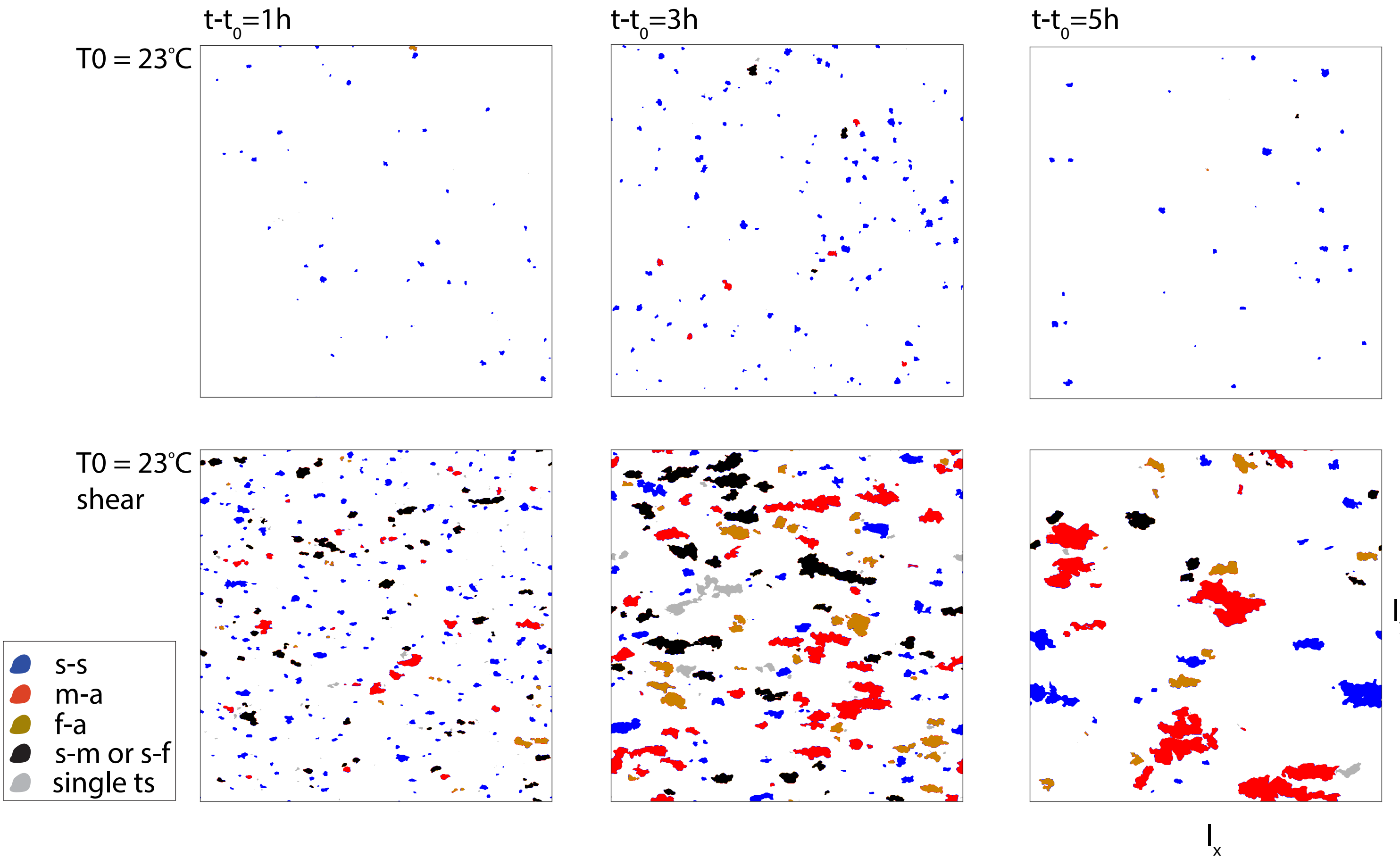
CTR
P2K
P4K
OMEGA
Precipitation Intensity [mm/h]
Temperature anomaly [K]
Rel. Humidity Anomaly [percent]
Time [min]
0
3
6
1
0
-2
5
0
-5
0
30
60


a
r2
r1
b
r2
r1



CTR
P2K
P4K
OMEGA
Precipitation Intensity [mm/h]
0
3
6
r_{eff} [km]
0
2
4
0
30
60
Time [min]


a
b
height [km]
virtual potential temperature [K]
Tv (air), beginning
Tv (air), maxarea
Tv (air), end
Tv (parcel), beginning
Tv (parcel), maxarea
Tv (parcel), end
Tv (mean)



t-t0=1h
t-t0=3h
t-t0=5h
T0 = 23°C
T0 = 23°C
shear
s-s
m-a
f-a
s-m or s-f
single ts
ly
lx