

Supporting Information for ”Numerical diffusion and turbulent mixing in convective self-aggregation”

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Introduction This material starts by providing supporting information on the small domain simulations which are used to initialize the large domain simulations of the main paper. **Text S1** describes the numerical setting of SAM and WRF for such simulations and the differences between the two RCE equilibrium conditions reached by the two models. Such conditions are further examined by looking at the averaged vertical profiles of small domain temperature and specific humidity in **Figure S1**, and the initial sounding for the large domain simulations in **Figure S2**.

Figure S3 shows energy spectra for the main experiments (WRF, SAM, WRF0, SAM0) on the lowest 2 km. These figures are reported here to show how the reduction of turbulent

mixing decreases the dissipation at small scales in the boundary layer and increases the convective activity there. This is connected with smaller humidity perturbations.

Figure S4 shows the effect of different initial conditions on the reduction of mean updraft size and the large-scale variability of convection.

Figure S5 shows the vertical profiles of temperature and relative humidity for experiments with different Pr number, in order to demonstrate its importance for the triggering of CSA, especially in the WRF model.

Text S1. SAM small domain simulations (SAMs) are performed in a doubly periodic domain with the same physics and model setting as the SAM large domain simulation in the main paper. The only differences are the domain size ($96 \times 96 \text{ km}^2$) and the horizontal grid resolution (1 km). The initial sounding is taken from (Cerlini et al., 2023) a previous run of the same model in RCE configuration. The simulation is run for 100 days and the equilibrium sounding is obtained by averaging hourly output over the last 20 days. The initial and final profiles can be seen in Figure S1

WRF small domain simulations (WRFs) are performed in a doubly periodic domain with the same physics and model setting as the WRF large domain simulation in the main paper. The domain size is ($100 \times 100 \text{ km}^2$) and the horizontal grid resolution is 1 km. The initial sounding is the standard sounding which is found in the RCE setup of WRF ideal cases, but imposing the same SST and surface pressure as that of SAM. The initial and final profiles can be seen in Figure S2. Over the first 400 meters, the initial profile of WRFs is moister than that of SAM of about 0.8 g/kg (on average). Also the temperature of WRF is slightly larger overall vertical layers.

References

Cerlini, P. B., Saraceni, M., & Silvestri, L. (2023). Competing effect of radiative and moisture feedback in convective aggregation states in two crms. *Journal of Advances in Modeling Earth Systems*, 15(2), e2022MS003323.

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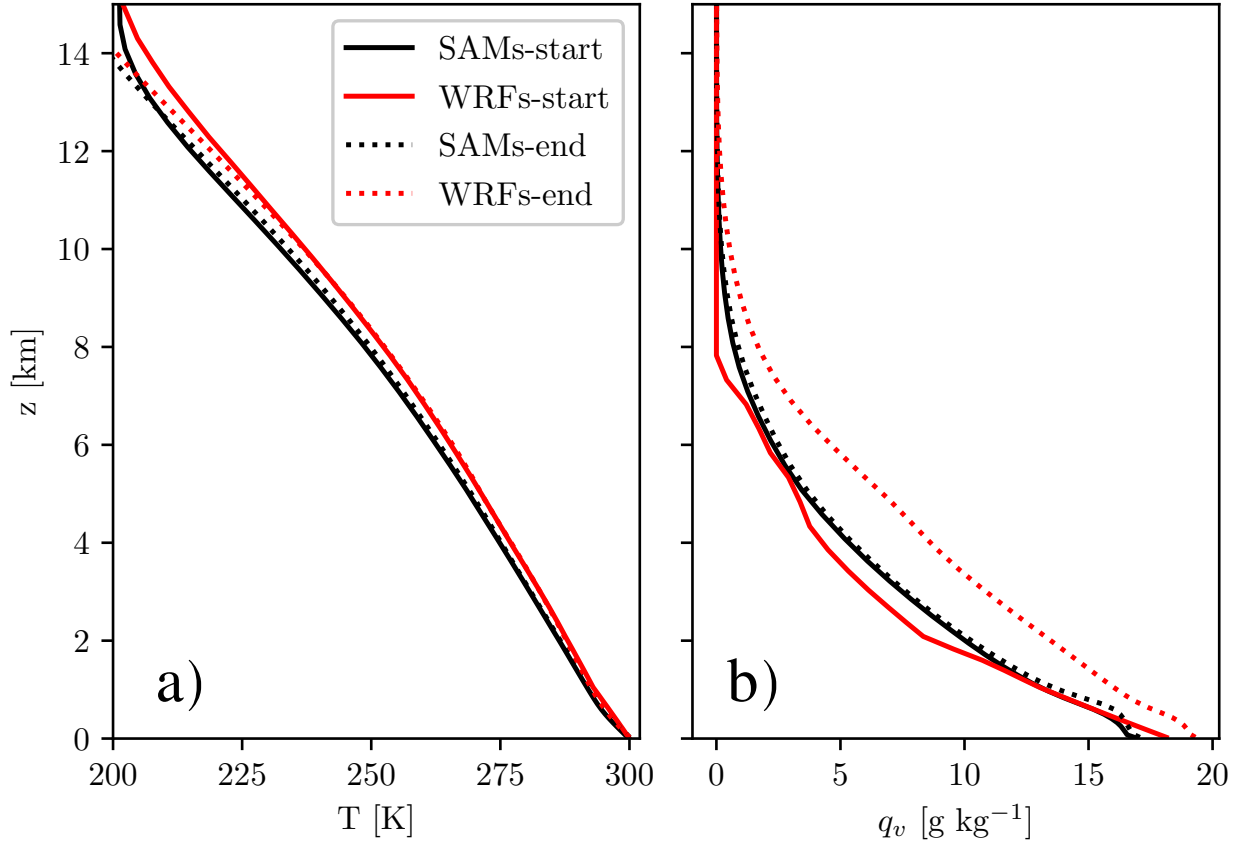


Figure S1. Initial (first time step, solid lines) and final (last 20 days, dotted lines) equilibrium profiles of Temperature (a) and specific humidity (b) for SAMs (black lines) and WRFs (red lines) small domain simulations.

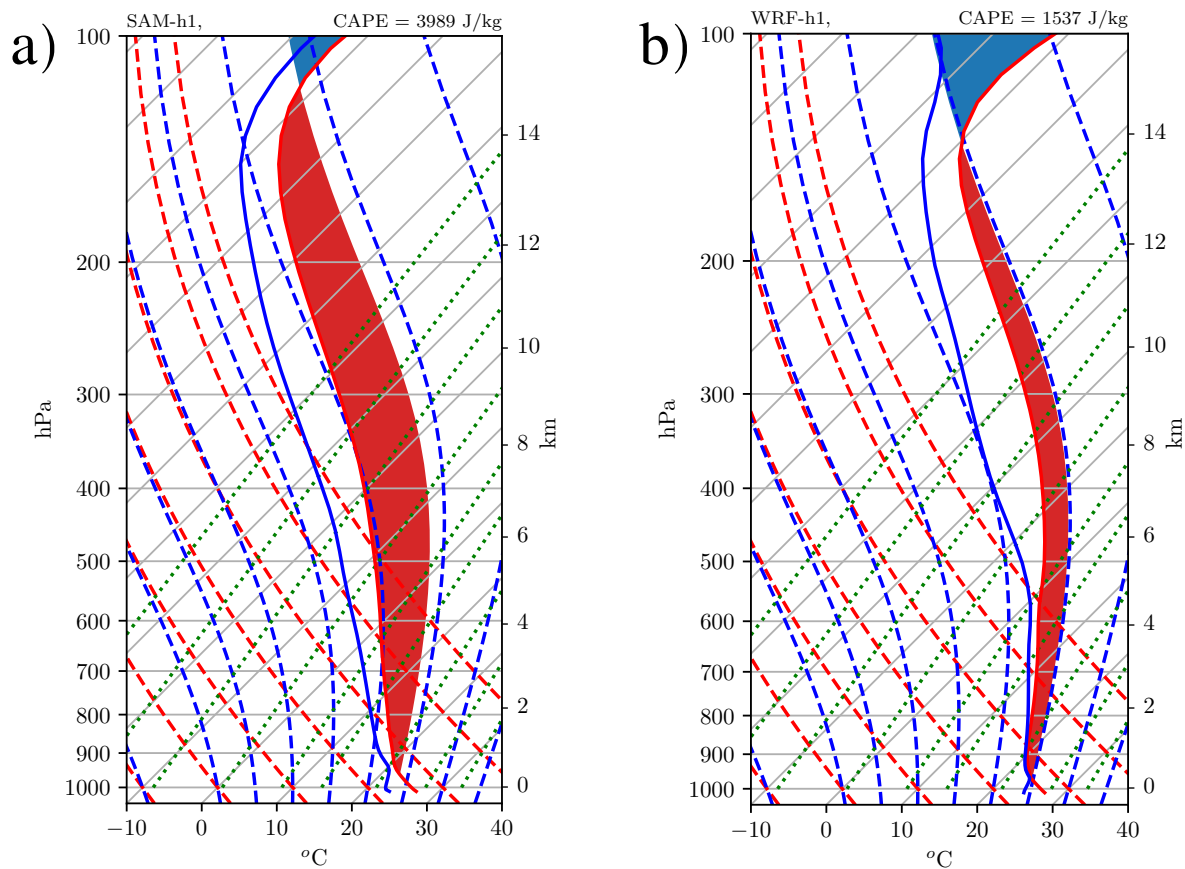


Figure S2. Initial (first hour) skewT diagram for SAM (a) and WRF (b) simulations. On the top right corner corresponding CAPE values are reported.

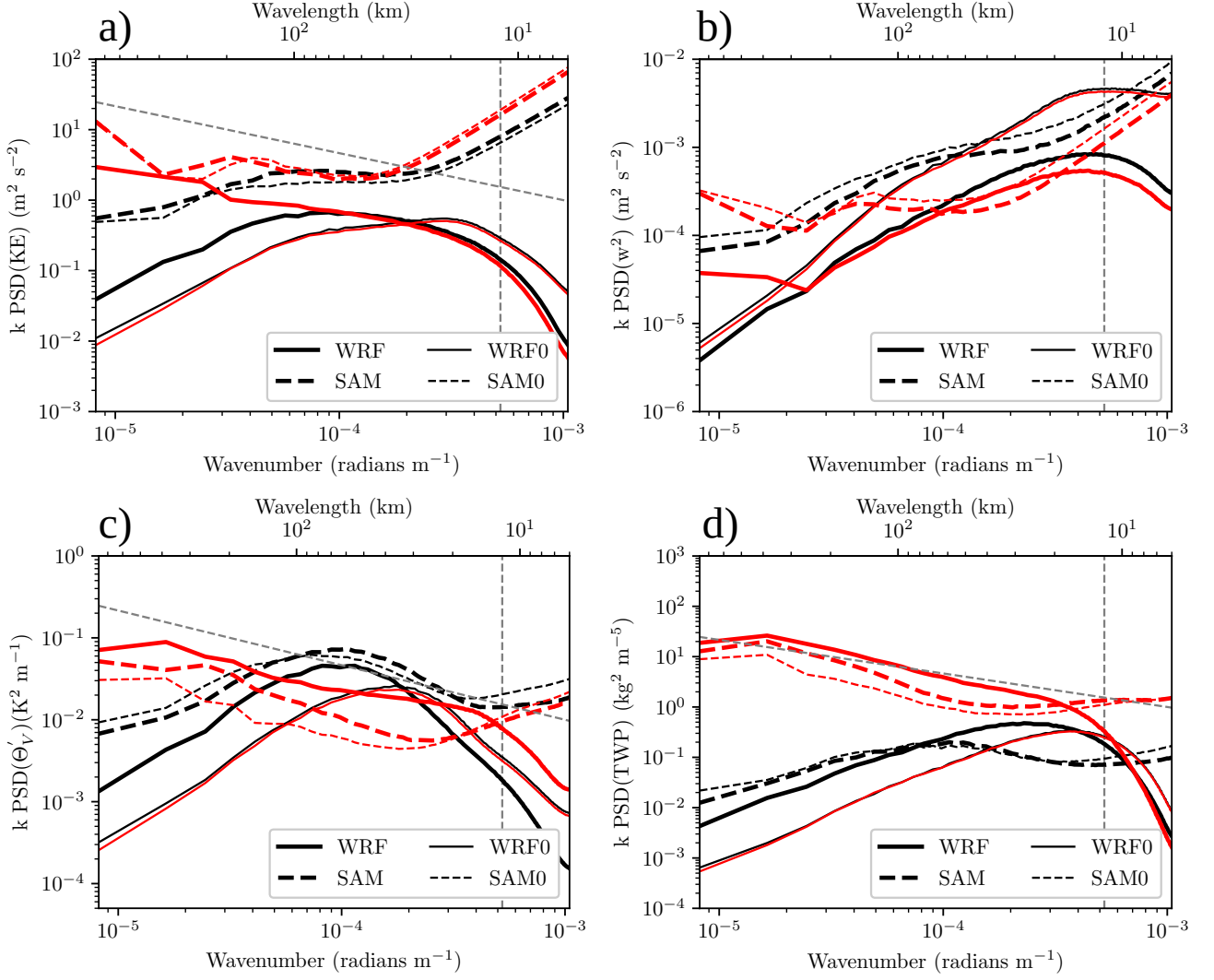


Figure S3. Power spectral densities of horizontal Kinetic Energy, KE (a,b) and vertical velocity, w (c,d), averaged over boundary layer (between 0 and 2 km). The reported values are time-averaged at the initial 5 days of simulation (a,c) and the last 20 days (b,d). The PSD is multiplied by the corresponding wavenumber to have a direct correspondence between the variance of the variables and the areas underneath the curves. The oblique gray dashed line represents the $k^{-5/3}$ power law, while the vertical gray dashed line marks the effective resolution of the model, taken as $4\Delta x$.

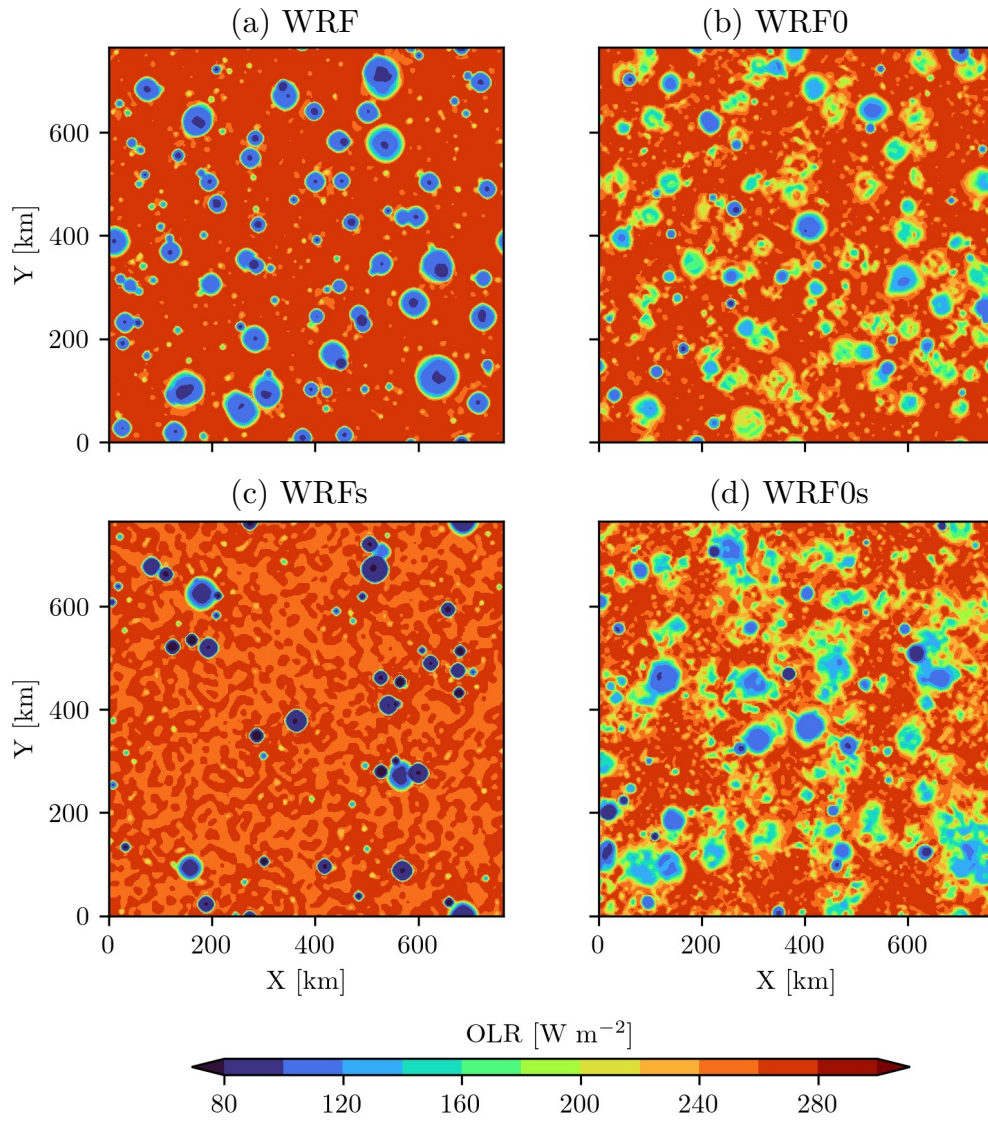


Figure S4. OLR instantaneous snapshots at midnight after 12 hours for a) WRF, b) WRF0, c) WRFs, d) WRF0s.

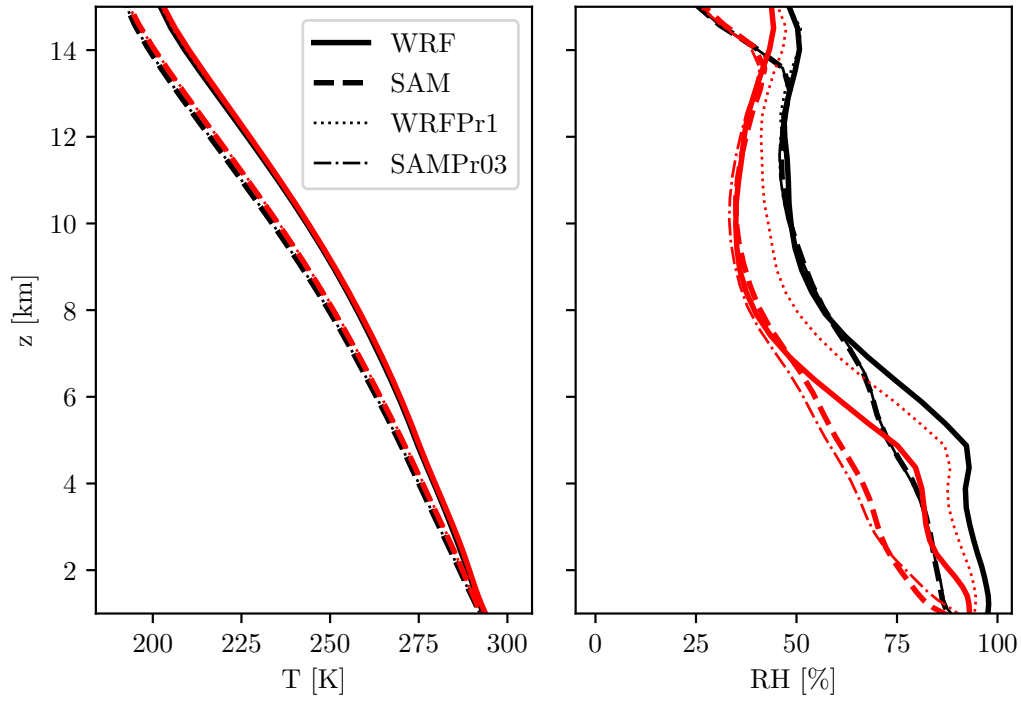


Figure S5. Vertical profiles of a) absolute temperature and b) relative humidity for the simulation WRF, SAM, WRFPr1 and SAMPr03. Black lines show the average on the first 6 hours. Red lines show the profiles averaged over day 10.