Contribution ID: **8** Type: **Talk**

Links between spatial organization and plume rooting in a decentralized framework for convective transport

Monday 16 May 2022 10:05 (15 minutes)

In this study a spectral model for convective transport is coupled to a thermal population model on a horizontal microgrid. Thermals interact under simple rules, reflecting pulsating growth and environmental deformation. Long-lived thermal clusters thus form on the microgrid, exhibiting scale growth, spatial organization and memory. Size distributions of cluster number are diagnosed from the microgrid through an online clustering algorithm, and provided as input to a spectral multi-plume eddy-diffusivity mass flux (EDMF) scheme. This yields a decentralized transport system, with the thermal clusters acting as independent but interacting nodes that carry information about spatial structure. The main objectives are to i) provide proof of concept of this approach, and ii) to gain insight into impacts of spatial organization on convective transport. Single-column model experiments demonstrate satisfactory skill in reproducing two observed cases of continental shallow convection at the ARM SGP site. Metrics expressing self-organization and scale growth match well with large-eddy simulation results. We find that in this coupled system, spatial organization impacts convective transport primarily through the scale break in the size distribution of cluster number. The rooting of saturated plumes in the subcloud mixed layer plays a key role in this process.

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Session Classification: Convective concepts