EGU21-785
https://doi.org/10.5194/egusphere-egu21-785
EGU General Assembly 2021

A modelling perspective on anvil evolution differences between day and night

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Geostationary satellite observations of tropical maritime convection indicate an afternoon maximum in anvil cloud fraction that cannot be explained by the diurnal cycle of deep convection peaking in the night. This implies that the daytime anvils must be more widespread and/or long lived compared with the anvils that are formed during the night.

We study the decay of anvil clouds in an idealized cloud resolving modelling setup in which a cloud is initialized in the middle of the model domain to identify what causes differences in the evolution depending on the time of the day in which the cloud is detrained from a deep convective core. We show that daytime anvils are both longer lived and more widespread. The main reason for their longevity is the heating due to absorption of shortwave radiation, which leads to a mesoscale ascent within the cloud, helping to loft and spread the cloud further than the nighttime anvils. The nighttime anvil cloud top is dominated by longwave radiative cooling, which drives a circulation that erodes the cloud top by entrainment of drier environmental air and leads to a cloud descent and shorter lifetime.

Additional simulations in radiative convective equilibrium setup with a realistic diurnal cycle of insolation confirm the crucial role of shortwave heating in increasing the daytime anvil cloud top and anvil longevity. In addition, the mesoscale ascent also modifies daytime anvil properties, leading to an increased ice water content, higher ice crystal number concentration and larger ice crystal radius near cloud top.