Metre-Scale Radiative Effects on the Development of Stratocumulus-Topped Boundary Layer

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High-resolution simulations such as direct numerical simulations (DNS) are required to resolve the metre-scale variability in the stratocumulus-topped boundary layer (STBL). To simplify the expensive radiative transfer calculations, previous research has been considering the liquid water path (LWP) as a proxy for the longwave radiative transfer. However, the contribution to the radiative fluxes from the absorptive gases is thereby neglected. By using a line-by-line radiative transfer model ARTS, we show that the cloud top radiative cooling is underestimated by 30% in previous simulations using the LWP parametrisation. Furthermore, we discover a layer warming at 1 K/h with thickness of merely about 5 m directly above the cloud top, in which the warming is attributed to clear sky radiative effect, i.e., the absorptive gases. By parametrising the absorption of water vapour and carbon dioxide into three representative absorption bands, we sufficiently represent the longwave radiative transfer in the stratocumulus, particularly the warming layer, in the DNS, without compromising the computational efficiency. Using the band model, we perform a sensitivity study to investigate the effect of the warming layer on the STBL. It is found that the warming layer facilitates cloud dissipation by detraining warm air into the STBL and evaporating the cloud. Moreover, convective instability is also suppressed through compensation of the cloud top radiative cooling, which reduces the moisture transport through turbulence to sustain the cloud.

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Conference Room, 3/F, Mong Man Wai Building

Zoom Link (Mixed-mode)

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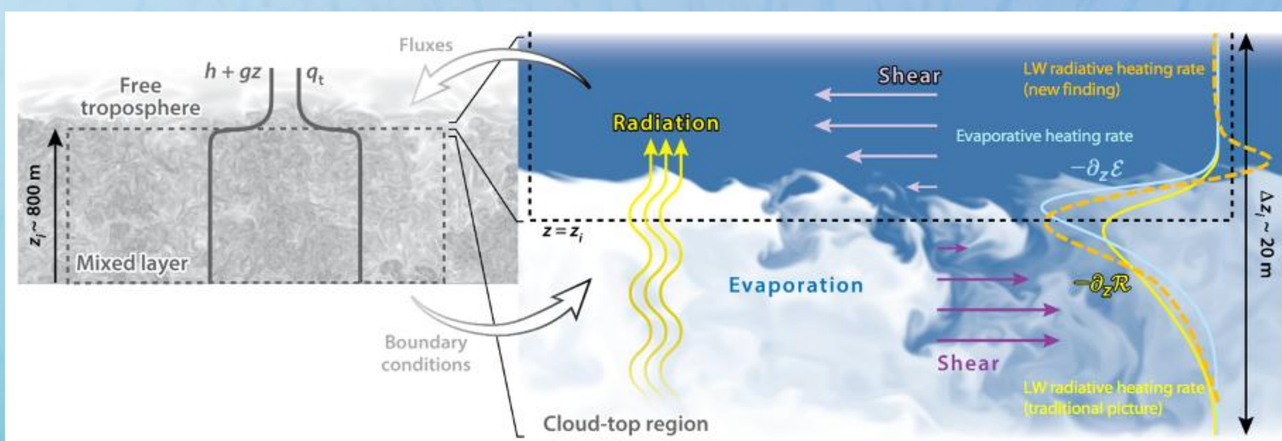

Cloud top metre-scale processes in the stratocumulus-topped boundary layer
Diagram adapted from Mellado (2017)

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