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LES study of convective mixing and evaporative cooling in shallow convection

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Numerical simulations of shallow convection are used to investigate the role of convective mixing and evaporative cooling in the vertical transport of mass, heat, and moisture in non-precipitating shallow cumulus convection. Evaporative cooling is found to increase mass flux and the magnitude of heat and moisture fluxes, comparing twin large-eddy simulations with either suppressed or active evaporative cooling. Nonetheless, subsiding shells transport mass downward even when evaporative cooling is suppressed, emphasizing that evaporative cooling is not the primary cause of existence of subsiding shells and buoyancy reversal. Instead, convective mixing across vertical levels is found to be the primary reason of buoyancy reversal. Evaporative cooling yet accelerates downdrafts (updrafts) in the shell (cloudy) regions as well as increases the cloud cover in the lower cloud layer. The cloudy regions are more humid and the liquid water potential temperature is lower compared to the evaporative-cooling-suppressed experiment. The primary effect of evaporative cooling is thus to increase the updraft core anomalies, thus enhancing vertical turbulent transport.