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Comparison of a global-climate model simulation to a cloud-system resolving model simulation for long-term thin stratocumulus clouds

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Abstract. A case of thin, warm marine-boundary-layer (MBL) clouds is simulated by a cloud-system resolving model (CSRM) and is compared to the same case of clouds simulated by a general circulation model (GCM). In this study, the simulation by the CSRM adopts higher resolutions which are generally used in large-eddy simulations (LES) and more advanced microphysics as compared to those by the GCM, enabling the CSRM-simulation to act as a benchmark to assess the simulation by the GCM. Explicitly simulated interactions among the surface latent heat (LH) fluxes, buoyancy fluxes, and cloud-top entrainment lead to the deepening-warming decoupling and thereby the transition from stratiform clouds to cumulus clouds in the CSRM. However, in the simulation by the GCM, these interactions are not resolved and thus the transition to cumulus clouds is not simulated. This leads to substantial differences in liquid water content (LWC) and radiation between simulations by the CSRM and the GCM. When stratocumulus clouds are dominant prior to the transition to cumulus clouds, interactions between supersaturation and cloud droplet number concentration (CDNC) (controlling condensation) and those between rain evaporation and cloud-base instability (controlling cloud dynamics and thereby condensation) determine LWC and thus the radiation budget in the simulation by the CSRM. These interactions result in smaller condensation and thus smaller LWC and reflected solar radiation by clouds in the simulation by the CSRM than in the simulation by the GCM where these interactions are not resolved. The resolved interactions (associated with condensation and the transition to cumulus clouds) lead to better agreement between the CSRM-simulation and observation than that between the GCM-simulation and observation.

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