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Insights into low-latitude cloud feedbacks from large-eddy simulations

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Cloud feedbacks are a leading source of uncertainty in the climate sensitivity simulated by global climate models (GCMs). Low-latitude boundary-layer and cumulus cloud regimes are particularly problematic, because they are sustained by tight interactions between clouds and unresolved turbulent circulations.

Large-eddy simulations (LES) using sub-100 m grid spacings better simulate such cloud regimes without need for complex models of subgrid variability of cloud and turbulence. Recently, multiday LES over small computational domains have elucidated marine boundary layer cloud response to specified aspects of greenhouse warming and the associated changes in large-scale dynamics and atmospheric radiative heating. The focus will be the CGILS LES intercomparisons and subsequent related work. Four primary contributing mechanisms of subtropical low cloud response are implicated, all with observational support. These are (1) thermodynamic: cloudiness reduction from warming and moistening of the atmosphere-ocean column, (2) radiative: cloudiness reduction from CO_2 and H_2O-induced increase in atmospheric emissivity aloft, (3) stability-induced: low cloud increase from increased lower-tropospheric stratification, and (4) dynamical: low cloud increase from reduced subsidence. LES as a group robustly suggest that the cloudiness reduction mechanisms typically dominate, giving positive shortwave cloud feedback in the subtropics consistent with the range simulated by conventional global climate models. Finally, a possible approach for better bridging the scale gap between LES and global models will be noted.