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# Impact of Cloud-Scale Radiation Variability on the Marine Stratocumulus to Trade Cumulus Transition and Implications for Parameterization in Atmospheric Models

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Weather and climate models typically have been designed with a modular structure for parameterizations that simplifies development and permits substitution of particular model components with alternative formulations. For example, parameterizations for radiation, convection, and turbulence are often developed independently and can be interchanged with competing schemes within each category. An outcome of this type of model infrastructure is that the parameterizations interact with each other solely via the grid-scale resolved meteorological state, i.e. the grid box mean temperature, moisture, winds, etc., even when the schemes internally contain representations of subgrid variability. An example of this is the use of subgrid cloud fractions in the radiation parameterization to account for subgrid cloud variability when calculating radiative heating tendencies. However, the resulting radiative tendencies represent the grid-box mean heating rates and do not contain information about the variability of this rate within the cell, which in theory could be deduced, at least in part, from the cloud fraction information. If this subgrid heating variability were communicated to the boundary layer turbulence parameterization, it could provide useful information for calculating a more accurate turbulent kinetic energy.

We present a series of large eddy simulations demonstrating the impact of neglecting the subgrid radiative heating variability on the scale of regional and global climate model grid columns in the context of marine clouds. The evidence suggests that one reason the stratocumulus-to-trade cumulus transition for these clouds can be too abrupt in climate models because of the coarse nature of the interactions between the radiation and boundary layer parameterizations. Small-scale spatial variability in the heating rates from clouds impacts cloud-top entrainment and mixing, and helps sustain the stratocumulus cloud features. When this variability is removed the cloud field more quickly develops convective characteristics.