Physical Controls on the Cellular Organization of Stratocumulus Clouds

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Résumé

Satellite observations show that stratocumulus-topped boundary layers exhibit a robust mesoscale cellular morphology, with characteristic cell diameters consistently scaling as 25–35 times the boundary-layer depth, largely independent of the specific organization regime. Given the diversity of shallow boundary layers and the strong temporal variability of the meteorological conditions that govern them, the persistence of such a well-defined aspect ratio is striking. The physical mechanisms controlling this mesoscale organization, however, remain poorly understood, with major uncertainties surrounding the roles of phase changes, cloud-top entrainment, and vertical stability. In this talk, we review recent advances in understanding the cellular organization of stratocumulus clouds. First, we analyze the temporal variability of cellular aspect ratios using satellite observations and demonstrate the key role of diurnal boundary-layer decoupling. We then investigate the physical processes driving upscale cellular growth using high-resolution simulations performed with the French Meso-NH model. These simulations reveal the presence of inverse turbulent cascades, through which energy injected at small, vertically driven scales is transferred to the largest horizontal scales. Finally, we assess the extent to which canonical Rayleigh–Bénard convection can serve as a conceptual framework for interpreting cellular organization in shallow atmospheric layers, using a suite of idealized numerical simulations.

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