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Process-oriented analysis of what controls the vertical structure of low clouds and their warming response in CMIP5 models

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In the latest-generation climate models (CMIP5), cloud-radiative feedbacks continue to dominate the intermodel spread of climate sensitivity. The complexity of climate models and the large number of processes potentially involved make the analysis of cloud-radiative feedbacks difficult. In a previous study, we showed that how models represent the vertical structure of low clouds in the present climate is linked to the models' surface energy budget and climate sensitivity. Additionally, whether tropical boundary-layer clouds deepen or shallow in response to warming exerts an important control on a model's climate sensitivity.

Different parameterizations of boundary layer dynamics, shallow and deep convection, and cloud fraction in CMIP5 models lead to the intermodel differences in the low-cloud response to warming. For instance, it was previously shown that how turbulent boundary layer mixing is represented influences tropical low-cloud changes under both interannual variability and global warming. Here we identify the fundamental differences among parameterized processes that underlie the spread of the low-cloud vertical structure and low-cloud feedbacks in CMIP5 models. Our goal is to understand the physical origins of sub-tropical biases among climate models (e.g., the warm temperature bias in eastern ocean basins, the mid-tropospheric humidity bias, and the weak inversion bias). This gives insights in how models can be improved and how the spread of climate sensitivity can be reduced.