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SST dependence of convective aggregation in three General Circulation Models

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Studies using cloud-resolving models or simple models have shown that under certain conditions, the radiative-convective equilibrium state becomes unstable to large-scale overturning circulations, and leads to the phenomenon of self-aggregation of moist convection. Modeling and observational studies suggest that the degree of aggregation of moist convection can influence the large-scale atmospheric state (e.g. humidity, clouds) and its energy budget. The question thus arises as to what extent the aggregation of convection may rectify the Earth's climate, including the large-scale atmospheric circulation, hydrological sensitivity and climate feedbacks.

We explore these issues by running three General Circulation Models (IPSL-CM5A-LR, ECHAM6, CAM5) in radiative-convective equilibrium, i.e. a non-rotating aqua-planet configuration forced by a globally-uniform insolation and sea surface temperature (SST). We show that in these conditions, all three models can predict the spontaneous emergence of a large-scale convective organization and overturning circulation, and that the equilibrium aggregation state depends on SST and cloud-radiative effects. We will explore the reasons why the equilibrium aggregation state depends on temperature, and the impact of convective aggregation on the global mean state. Robust behaviors will be highlighted, as well as inter-model differences. The implications of these results will be discussed.