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Role of Moist Static Energy Advection in Evolution of Convective Aggregation in Observations

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Organization of convection in tropics exhibits a wide range of spatial and temporal scales on account of a complex maze of interactions between clouds, circulation, radiation, and moisture. Somewhere in that maze are also present the mechanisms responsible for the phenomenon of convective self-aggregation in idealized simulations. However, the exact role played by these self-aggregation mechanisms on organization of convection in the real world remains unclear including understanding when convection will aggregate further and when convection will disaggregate. Cloud radiative feedbacks have been found to be important for initiation and maintenance of self-aggregation in idealized modelling studies. In observations too, it has been shown that radiation varies linearly with convection across different regions in the tropics. This implies that radiative feedbacks add moist static energy (MSE) to the already moist columns (that is it favors aggregation). However, the question comes up then, why does convection disaggregate in observations despite the support from radiative feedbacks? We hypothesize that advection of moisture and moist static energy (MSE) instead is important for determining when convection aggregates or disaggregates in the real world.

We utilize a moist static energy (MSE) variance budget-based phase plane as a process oriented diagnostic tool to test our hypothesis. The phase plane is formed by taking the variance of MSE on the x-axis and time tendency of variance of MSE on the y-axis. Then, cycles of aggregation and disaggregation show up as elliptical orbits on this plane. Contributions to the MSE variance tendency from the advective terms and radiative terms can be explicitly analyzed on this phase plane. Data from idealized simulations is used to understand how self-aggregation mechanisms show up on the phase plane. The results are compared with reanalysis data to understand the differences between self-aggregation mechanisms in models and mechanisms that favor aggregation in the real world. Data from different regions is also analyzed to determine whether it's the variations in advective terms or the radiative term that govern when convection aggregates or disaggregates in observations.