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The Role of Mesoscale Cellular Convective Cloud Morphologies in Low Cloud Feedbacks

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Mesoscale cellular convective (MCC) clouds occur in large-scale patterns over the ocean, are prevalent in sub-tropical cloud regions and mid-latitudes, and have important radiative impacts on the climate system. On average, closed MCC clouds have higher albedos than open or disorganized MCC clouds for the same cloud fraction which suggests differences in micro- and macro-physical characteristics between MCC morphologies. Marine cold air outbreaks (MCAOs) influence the development of open MCC clouds and the transition from closed to open MCC clouds in the mid-latitudes. A MCAO index, M, combines atmospheric surface forcing and static stability and can be used to examine global MCC morphology dependencies. MCC cloud morphology occurrence is also expected to shift with sea surface temperature (SST) changes as the climate warms. Analysis of MCC identifications (derived from a neural network classifier applied to MODIS satellite collection 6 liquid water path retrievals) and ECMWF ERA5 reanalysis data shows that closed MCC cloud occurrence shifts to open or disorganized MCC within an M-SST space. Global climate models (GCMs) predict that M will change regionally in strength as SSTs increase. Based on our derived MCC-M-SST relationship in the current climate, closed MCC occurrence frequency is expected to increase with a weakening of M but decrease with an increase in SSTs. This results in a shift to cloud morphologies with lower albedos. Cloud controlling factor analysis is used to estimate the resulting low cloud morphology feedback which is found to be spatially varied and between ±0.15 W m^{-2} K^{-1}. Because the morphology feedback is estimated to be positive in the extra-tropics and is not currently represented in GCMs, this implies a higher climate sensitivity than GCMs currently estimate.