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Climate Implications of the Moist-convective Diurnal Cycle

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This idealized modeling study is provoked by recent observations from the tropical Indian Ocean (the DYNAMO field campaign), which demonstrate the high degree to which column humidity is modulated by the diurnal cycle of clouds. Under suppressed large-scale conditions, shallow convection prevails, and the diurnal cycles of shortwave radiative heating and sea surface temperature (SST) are at their strongest. In turn, the diurnal cycle of clouds is prominent, which is manifest in daytime cloud deepening and tropospheric moistening in response to boundary layer warming (bearing resemblance to the diurnal cycle over land). An idealized modeling study is performed to 1) assess the driving processes in the diurnal cycle (i.e. SST vs. radiative forcing) and 2) assess whether or not this diurnal cycle rectifies onto longer timescales. A cloud-resolving model framework is employed with the CM1 model (Bryan and Fritsch 2002), wherein a diurnal cycle of SST is prescribed, fully-interactive radiation varies diurnally, and the weak temperature gradient (WTG) approximation is invoked to simulate the feedbacks between the moist convection and large-scale circulation. The results suggest that the diurnal cycle is highly nonlinear, in that the diurnal fluctuation of clouds strongly rectifies onto longer timescales. The diurnal cycle must therefore be regarded as a "forcing mechanism" to the climate system. The vitality and quality of the moist-convective diurnal cycle in climate models may in turn be important to the accuracy of their simulations.