



Role of Cloud Evolution in the Madden-Julian Oscillation

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It has been known that clouds undergo a systematic evolution through the life cycle of the Madden-Julian Oscillation (MJO). But the exact role of each type of cloud at each phase of the MJO is still a subject of debate. In this study, long-term cloud radar observations at the ARM western Pacific site of Manus and the CINDY/DYNAMO field campaign were diagnosed and used to constrain and validate cloud-permitting model simulations to investigate possible roles of different types of clouds in the MJO. Shallow clouds and their moistening effect are almost perpetual through the life cycle of the MJO. They serve as an important source of low-level moisture in general. But they do not contribute directly to the observed increase in low-level moisture during the convective development stage of the MJO, which is mainly due to large-scale advection. Eddy transport of congestus and deep convective clouds contributes to moistening at mid and upper levels. Stratiform clouds have a net drying effect because of an imbalance between their ice deposition and weak eddy transport. Drying by precipitation formation of both shallow and deep convective clouds is mostly balanced by vertical moisture transport in response to the corresponding latent heating. Nonprecipitating clouds contribute to the moisture tendency through their effects on radiatively induced vertical moisture transport.