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A Machine Learning Assisted Development of a Model for the Population Dynamics of Clouds

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Traditional conceptual models underpinning parameterizations of the interaction between convection and the environment have relied on an assumption that slowly varying large-scale environment is in statistical equilibrium with a large number of small and short-lived clouds. Thus they fail to capture non-equilibrium transitions such as the diurnal cycle and formation of meso-scale convective systems. Informed by analysis of radar observations, cloud-permitting model simulations, theory and machine learning, this work presents a new cloud population dynamics model. 12 winters of observation of convective and stratiform clouds by a C-band radar at Darwin, Australia and a machine learning algorithm are used to close a set of coupled equation that relate large-scale forcing, mass flux, convective cell sizes and stratiform areas. The coupled model shows that, by favoring small shallow clouds, stratiform area imposes a damping feedback on mass flux fluctuations. On the other hand, the growth rate of stratiform area is found to be approximately linearly related to convective area. The maximum size of stratiform area is sensitive to the frequency of the variability of forcing, with lower frequency forcing favoring larger stratiform area. Implementation of the model in large-scale models as a non-equilibrium alternative to traditional mass flux cumulus parameterization schemes will be discussed.