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Improving simulation of the feedback between radiation, convective clouds and rainfall over the Maritime Continent

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This paper presents work that improves regional climate simulations over the Maritime Continent using the Regional Climate Model Version 3 (RegCM3) coupled to the Integrated Biosphere Simulator (IBIS). A comprehensive evaluation of the RegCM3-IBIS model system was undertaken using observations from multiple sources, including the Tropical Rainfall Measuring Mission (TRMM), the Surface Radiation Budget project (SRB) and the International Satellite Cloud Climatology Project (ISCCP). This assessment identified significant model errors associated with processes that occur on diurnal timescales, especially convective-radiative feedbacks and the role of cumulus clouds in mediating the diurnal cycle of rainfall. Significant improvements to the performance of RegCM3-IBIS have been achieved by focusing our efforts on these diurnal-scale processes.

In particular, we present two new pieces of work: 1) a new formulation for the fractional coverage of convective cloud within a model grid cell, and 2) a new parameterization for the production of convective rainfall from convective cloud liquid water. These new formulations only contain parameters that can be directly quantified from observational data, are independent of model user choices such as domain size or resolution, and explicitly account for subgrid variability in cloud water content and non-linearities in rainfall production. The new formulations are more physically-meaningful than the existing methods within RegCM3 and can be quickly and easily implemented across convection schemes with no increase in computational burden.

With the new formulations, the performance of RegCM3-IBIS is greatly improved across multiple evaluation metrics, especially surface radiative and turbulent heat fluxes, cloud cover and rainfall. These results therefore indicate a consistent improvement in physical realism throughout the simulation. The results of this work illustrate the complex feedback mechanisms that exist between surface fluxes, radiation, cloud cover and rainfall, and emphasize the need to appropriately capture these feedbacks within large-scale climate models.