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Maritime Continent rainfall features in a convection-permitting model

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The Maritime Continent is a major active convective area and one of the most challenging regions in terms of atmospheric modelling. Rainfall in the Maritime Continent is driven by both large-scale phenomena such as the Madden-Julian Oscillation and ENSO, and fine-scale processes such as land-sea breeze and tropical convection. In combination, they produce very particular precipitation regimes that models consistently fail to reproduce across spatial resolutions, regardless of their dynamic formulation.
Climate simulations at convection-permitting scales are now becoming possible. Rather than simply increasing spatial resolution, these experiments constitute a conceptual advance since they no longer rely on many of the assumptions of convective schemes. Here, we use the Weather Research and Forecasting model operating at multiple resolutions (32, 16, 8, 4 and 2km) to determine the role of the spatial resolution and the representation of convection on the realism of precipitation in the Maritime Continent. We show that the key aspect to better simulate precipitation in the region is the explicit representation of deep convection, while the benefit of increasing spatial resolution is limited.
Both explicit convection and parameterized shallow convection produce precipitation at the right time of the day because they do not transform CAPE as readily as the deep convection scheme. Thus, not only precipitation but also other processes linked to convective circulation such as land-sea breeze are better represented when deep convection is explicitly resolved. In spite of generating a diurnal cycle that better matches the observations, there are features that remain a challenge even at the kilometre scale, such as the land/ocean distribution of total precipitation amounts. Explicitly resolving deep convection has implications for the lower atmosphere mixing, specially over the ocean, where the model does not generate enough energy to trigger convection and produce rainfall. As such, the microphysics and the planetary boundary layer take on particular importance in the challenge of simulating tropical convective precipitation in very high-resolution experiments.