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Precipitation scaling in the tropics with a convection-permitting model

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The Maritime Continent is a major convective area and precipitation processes in the region pose great challenges to atmospheric models. A combination of large-scale drivers, such as the Madden-Julian Oscillation and ENSO, and fine-scale processes, such as orographically-forced precipitation, land-sea circulations and tropical convection, governs rainfall in the Maritime Continent. The use of convection-permitting models in the region has shown improved performance in the simulation of precipitation characteristics that are key for the region (i.e. diurnal cycle).

Most of the rainfall occurring over land is concentrated in the late afternoon and precipitation extremes often occur over short periods of time. The availability of water vapor in the lower troposphere and the high water-holding capacity of a warm atmosphere favors very intense precipitation events, according to the Clausius-Clapeyron relationship. In a warming climate, a full understanding of the so-called precipitation scaling with temperature is thus crucial. However, this potential generally requires the atmosphere be saturated and convection be initiated to become effective. Using a regional climate model operating at convection-permitting scales over 3 consecutive wet seasons, we investigate the response of intense precipitation to temperature.

In this presentation, we examine different approaches to relate precipitation extremes to near-surface temperature and dew-point temperature. We show that the relationship breaks at certain thresholds that are relatively uniform across islands. The region is well supplied with water vapor and the break is not explained by a deficit in water vapor, unlike previously proposed for other water-limited regions. We identify possible reasons for this behavior, such as the lack of environmental conditions that trigger convection. In this context, we explore the sensitivity of the modelling system to the convection representation (explicit vs. parameterized) and discuss the implications for future changes in intense precipitation events. Finally, we put forward the use of specific variables, such as temperature and equivalent potential temperature integrated in the vertical. These variables not only are coherent with the CC equation but also acknowledge the different warming rates near the surface and at higher tropospheric levels, where precipitating processes actually occur.