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Extreme Precipitation in Tropical Squall Lines

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Squall lines are the consequence of the interaction of low-level shear with cold pools associated with convective downdrafts. Beyond a critical shear amplitude, squall lines tend to orient themselves at an angle with respect to the low-level shear. While the mechanisms behind squall line orientation seem to be increasingly well understood, uncertainties remain on the implications of this orientation. Roca & Fiolleau 2020 show that long lived mesoscale convective systems, including squall lines, are disproportionately involved in rainfall extremes in the tropics. One may then question whether the orientation of squall lines has an impact on rainfall extremes, and if so, why.

Using a cloud-resolving model, we perform idealized simulations of tropical squall lines by imposing a vertical wind shear in radiative-convective equilibrium. Our results show that precipitation extremes in squall lines are 40% more intense in the critical case and remain 30% superior in the supercritical regime. With a theoretical scaling of precipitation extremes (Muller & Takayabu 2019), we show that the condensation rates control the amplification of precipitation extremes in tropical squall lines, mainly due to its dynamic component. The critical case is not only optimal for squall line orientation, but also for the cloud base velocity intensity of new convective cells.