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Plain Language Summary: Tropical waves influence equatorial weather but remain difficult to simulate. This study tests how model resolution (120 km to 3.75 km) and convection treatment (parameterized vs. explicit) affect wave realism. The 3.75-km explicit run best reproduced observed wave structures and rainfall but paradoxically performed worst on wave speed. This highlights both the progress of global km-scale models and the challenges that remain for tropical prediction.

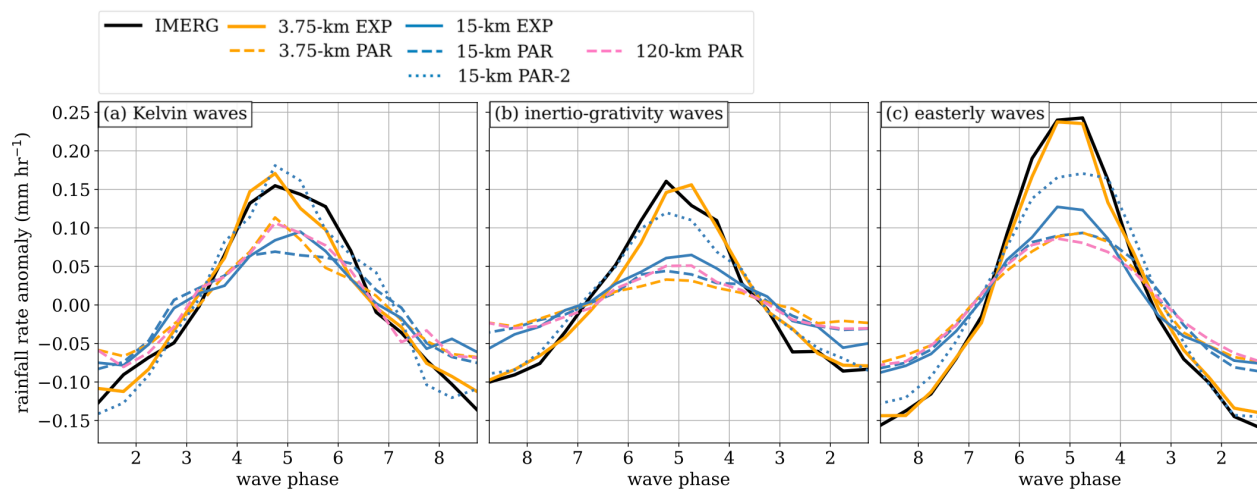


Figure 1. Rainfall rate anomalies induced by (a) Kelvin waves, (b) inertio-gravity waves, and (c) easterly waves. IMERG “observations” are shown in black. Solid lines represent simulations where the overwhelming amount of precipitation is explicit, dashed lines indicate runs where most of the precipitation is parameterized, and dotted lines correspond to the 15-km PAR-2 run (which has nearly an equal split between explicit and parameterized precipitation). The 3.75-km runs are shown in orange, the 15-km runs in dark blue, and the 120-km run in pink.

- The highest-resolution (3.75 km) simulation with explicit convection most realistically represents the three-dimensional structure, rainfall, and physical consistency of tropical waves.
- A paradoxical trade-off emerges: simulations that best capture wave structure show the largest errors in propagation speed, while structurally poorer runs reproduce speed more accurately.
- Explicit convection proves effective only at truly convection-permitting scales (~ 4 km), as the 15-km explicit run performs worse than the 3.75-km version.
- An alternative convection scheme at 15 km produces realistic wave structures but introduces a large precipitation bias, underscoring the effect compensating errors in numerical models.