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Differences in the regional response of rainfall to convectively coupled Kelvin waves over tropical Africa

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The representation of convection remains one of the most important sources of bias in global models and evaluation methods are needed that show that models provide both the correct mean state and variability; both for the correct reasons. Convectively coupled Kelvin waves (CCKWs) enhance and suppress rainfall during their passage across equatorial Africa but CCKWs simulated by climate models generally have weaker wave amplitudes than observations and significant regional biases.

We present a novel approach for evaluating rainfall variability due to modelled CCKWs. A phase cycle was defined for the CCKW cycle in OLR and used to composite rainfall anomalies. We characterise the observed (TRMM) rainfall response to CCKWs over tropical Africa in April and evaluate the performance of two pan-Africa regional climate model (RCM) simulations: a parameterised convection simulation and the first pan-Africa convection permitting simulation (CP4).

TRMM anomalies in mean rainfall, extreme rainfall, and dry days are associated with the CCKW phase. Focusing on regional differences we show that: there is a dipole between West Africa and the Gulf of Guinea involving onshore/offshore shifts in rainfall; and the transition to enhanced rainfall over west equatorial Africa occurs one phase before the transition over east equatorial Africa. The global model used to drive the RCMs simulated CCKWs with mean amplitudes of 75%-82% of observations. The RCMs simulated coherent responses to the CCKWs and captured the large-scale spatial patterns and phase relationships in rainfall although the simulated rainfall response is weaker than observations and there are regional biases which are bigger in regions away from the equator. The parameterised simulation produced a closer match to TRMM rainfall anomalies than the convection permitting simulation with stronger spatial correlations and smaller root mean square errors. The response in dry days was more closely simulated by the convection permitting simulation.

These results highlight the need to improve both parameterised convection and convection permitting climate models, evaluate convective responses to other tropical wave modes, and develop further understanding of the physical mechanisms for the variations seen, and why these are, or are not, captured in the models.