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Dynamical propagation and growth mechanisms for convectively coupled equatorial Kelvin waves over the Indian Ocean

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Convectively coupled equatorial Kelvin waves (CCKWs) are tropical weather systems that can lead to extreme precipitation. A vorticity budget for CCKWs over the Indian Ocean is presented, to identify the basic mechanisms of eastward propagation and growth. The budget is well closed, with a small residual. In the lower troposphere, CCKWs behave like strongly modified theoretical equatorial Kelvin waves. Vortex stretching, from the divergence of the Kelvin wave acting on planetary vorticity (the −f D term), is the sole mechanism by which the vorticity structure of a theoretical Kelvin wave propagates eastward. In the lower and middle troposphere, this term is also the key mechanism for the eastward propagation of CCKWs but, due to subtleties in its structure and phasing linked to a combination of modal structures, it also contributes to growth. Unlike in the theoretical Kelvin wave, other vorticity source terms also play a role in the propagation and growth of CCKWs. In particular, vortex stretching from relative vorticity (the - zeta D term) is the largest source term, and this leads strongly to growth, through interactions between the background and perturbation vorticity and divergence. Horizontal vorticity advection by the background flow contributes to propagation, and also acts to retard the growth of the CCKW. The sum of the source terms in this complex vorticity budget leads to eastward propagation and growth of CCKWs. The structure and vorticity budget of CCKWs in the upper troposphere is quite unlike that of a Kelvin wave, and appears to arise as a forced response to the lower-tropospheric structure.