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Propagation and growth mechanisms for convectively coupled equatorial Kelvin waves

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Convectively coupled equatorial Kelvin waves (CCKWs) are tropical weather systems that bring high impact weather and flooding, particularly in the Maritime Continent. They are a key component of the tropical climate system through scale interactions with other phenomena such as the Madden--Julian oscillation (MJO). CCKWs share many key features with theoretical, dry, linear equatorial Kelvin waves, such as a predominantly zonal component of their horizontal wind anomalies, and eastward propagation. Here, a vorticity budget for CCKWs is constructed using reanalysis data, to identify the basic mechanisms of eastward propagation and the observed growth. The budget is closed, with a small residual. 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. This term is also the key mechanism for the eastward propagation of CCKWs, but its different phasing also leads to growth of the CCKW. However, unlike in the theoretical wave, other vorticity source terms also play a role in the propagation and growth of CCKWs. In particular, vortex stretching from the divergence of the CCKW acting on its own relative vorticity (the -ζ D term) is actually the largest source term, and this contributes mainly to the growth of the CCKW, as well as to eastward propagation. Horizontal vorticity advection (and to a lesser extent, vertical advection), counters the vortex stretching, and acts to retard the growth of the CCKW. The tilting of horizontal vorticity into the vertical also plays a role. However, the meridional advection of planetary vorticity (the -β v term, the main mechanism for westward propagation of Rossby waves), is negligible. The sum of the source terms in this complex vorticity budget leads to eastward propagation and growth of the CCKWs. The implications for numerical weather prediction, forecasting and climate simulations are discussed.