Data-driven extraction and classification of convectively coupled equatorial waves

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ABSTRACT

We extract patterns of convective organization using a recently developed technique for feature extraction and mode decomposition of spatiotemporal data generated by ergodic dynamical systems. The method relies on constructing low dimensional representations (feature maps) of complex signals using eigenfunctions of the Koopman operator. This operator is estimated from time-ordered unprocessed data through a Galerkin scheme applied to basis functions computed via the diffusion maps algorithm. Koopman operators are a class of operators in dynamical systems theory that govern the temporal evolution of observables. They have the remarkable property of being linear even if the underlying dynamics is nonlinear, and provide, through their spectral decomposition, natural ways of extracting intrinsic coherent patterns and performing statistical predictions.

We apply this approach to brightness temperature data from the CLAUS archive and extract a multiscale hierarchy of spatiotemporal patterns on timescales spanning years to days, including dominant intraseasonal mode of tropical variability (MJO) but also traveling waves on temporal and spatial scales characteristic of convectively coupled equatorial waves (CCEWs). In particular, we examine if the activity of these coherent structures is modulated by low-frequency atmospheric and oceanic variability. We discuss various properties of waves in our hierarchy of modes, focusing in particular on their across-scale interactions and temporal evolution. As an extension of this work, we discuss the deterministic and stochastic aspects of the variability of these modes.