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Covariance Structure of a Fluctuating Midlatitude Jet

Principal Component Analysis (PCA) is a standard technique used in ocean/atmosphere physics to look for structure in large multivariate datasets; mathematically, PCA involves finding the eigenstructure of the covariance matrix. Individual PCA basis functions are often assumed to represent distinct physical "modes" of variability. In this talk, we will develop analytic expressions for the covariance structure of an idealised midlatitude jet that can vary in strength, width, and position. Through a systematic perturbation analysis, we can read off the leading few eigenvectors (PCA modes) of the covariance matrix.

This analysis demonstrates that even in this idealised system, many of the assumptions commonly made in interpreting PCA structures are false. In particular:

(1) the PCA time series are uncorrelated, but not independent,

(2) individual PCA "modes" do not represent individual physical processes, and

(3) PCA structures arising due to individual processes alone can be mixed, or "hybridised", when these processes occur simultaneously.