Contribution ID: **58** Type: **Poster**

The structure of predictability in an intermediate-complexity atmospheric model: covariant Lyapunov vectors and finite-time Lyapunov exponents

Tuesday 8 October 2024 15:02 (6 minutes)

A comprehensive investigation of the predictability properties in a three-level quasi-geostrophic atmospheric model with realistic mean state and variability is performed. The full spectrum of covariant Lyapunov vectors and associated finite-time Lyapunov exponents (FTLEs) is calculated. The statistical properties of the fluctuations of the FTLEs as well as the spatial localisation and entanglement properties of the covariant Lyapunov vectors are studied. We look at correlations between the FTLEs by means of a principal component analysis, identifying modes of collective excitation across the Lyapunov spectrum. We also investigate FTLEs conditional on underlying weather regimes. An advanced clustering algorithm is employed to decompose the state space into weather regimes associated with specific predictability properties as given by the FTLEs. Finally, the extreme value properties of the FTLEs are studied using generalised Pareto models for exceedances above a high and below a low threshold. Return levels as well as upper and lower bounds on the FTLEs are determined and extremely unstable or stable atmospheric states are identified.

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Session Classification: Postersession & Coffee