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Lyapunov Analysis applied to multiscale dynamics : the Lorenz 96 model

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We propose an analysis of perturbation growth in a modified version of the 2-level Lorenz 96 model, where external forces are active on both scales. The aim is to build a consistent scenario of the role of the interactions between scales on the error dynamics, from both geometric properties of the so-called Covariant Lyapunov Vectors (CLVs) and direct perturbations of the system, using Finite Size Lyapunov Exponents (FSLEs). On the one hand, we show that there is a central band of nearly-zero Lyapunov Exponents (LEs) whose associated CLVs have a significant projection on the slow variables – a possible signature of the existence of Hydrodynamics Lyapunov Modes – and investigate how the coupling between scales affects this property. We address the question of the origin of this central band and its scaling with system size. On the other hand, we show the presence of two plateaus in the FSLEs spectrum, hinting at the existence of collective chaos in the system. We find that the second plateau seems to correspond to the first LE in the central band, thus giving strong bases to the study of collective chaos through other properties of CLVs and FSLEs.