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A toy model to investigate stability of AI-based dynamical systems

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The development of atmospheric parameterizations based on neural networks is often hampered by numerical instability issues. Previous attempts to replicate these issues in a toy model have proven ineffective. We introduce a new toy model for atmospheric dynamics, which consists in an extension of the Lorenz'63 model to a higher dimension. While neural networks trained on a single orbit can easily reproduce the dynamics of the Lorenz'63 model, they fail to reproduce the dynamics of the new toy model, leading to unstable trajectories. Instabilities become more frequent as the dimension of the new model increases, but are found to occur even in very low dimension. Training the neural network on a different learning sample, based on Latin Hypercube Sampling, solves the instability issue. Our results suggest that the design of the learning sample can significantly influence the stability of dynamical systems driven by neural networks.