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A comparison of generalized Lorenz models to the Boussinesq model and investigations into chaotic properties

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Abstract

The Lorenz '63 system is a three-dimensional system of ordinary differential equations, originally derived as a minimal model for chaotic and intermittent atmospheric motions by considering the lowest order of harmonics in the two-dimensional Rayleigh–Bénard convection problem. Despite its seeming importance in meteorology and beyond, it is not clear whether the much-discussed chaos in the Lorenz system is in fact representative of the dynamics of even the two-dimensional Rayleigh–Bénard convection, let alone that of the atmosphere. In this study, we take a look at a few different generalizations of the Lorenz '63 system derived by relaxing some of the simplifying assumptions, namely, consideration of higher-order harmonics in the vertical [1], additional physical considerations [2], etc. The exploration of the parameter space leads to some interesting observations involving chaos, intermittency, and their coexistence. Lastly, we derive a fully generalized Lorenz system having an arbitrary number of harmonics in both the vertical and horizontal directions [3]. The numerical solutions of these higher-order generalizations of the Lorenz systems are then compared order-by-order against the solutions of a two-dimensional direct numerical simulation.

References

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