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Error dynamics in shell models for turbulence

Lesley De Cruz and Stéphane Vannitsem
Royal Meteorological Institute, Brussels, Belgium (lesley.decruz@meteo.be)

A deep understanding of the error dynamics in turbulent systems is crucial to estimate the horizon of predictability, and to quantify the impact of initial-condition (IC) and model errors on the statistical characteristics of ensemble prediction systems.

We present a study of the dynamics of combined IC and model errors in a turbulent system. We use the Sabra shell model [1], a spectral model which captures the characteristic properties of a turbulent system using a low number of variables (of the order of 50). The analytical properties of the short-term error dynamics in the Sabra shell model are investigated using the methodology described in Ref. [2], and compared to numerical results. Of particular interest is the property of a dissipative system that the mean squared error (MSE) reaches a minimum shortly after the introduction of an IC error. The distribution of the minimum-error times is investigated, and the spatial-scale dependence of the error dynamics is discussed. At longer time scales, our simulations confirm the well-known fact that an arbitrarily small error in the initial conditions contaminates the integral scale in a time that is independent of the scale of the initial error. Finally, we report on the error dynamics in the presence of a crossover between 3D and 2D turbulence, known to characterise the atmosphere.

References

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