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Stochastic closure for local averages in a finite difference discretization: an application to the forced/inviscid Burgers equation

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The development of numerically efficient models for atmospheric flow is a topic of ongoing research. Need for such models arises wherever the interest is predominantly in the dynamics of a coarse-grained flow which is, however, interacting with small-scale structures not to be resolved explicitly. Typical applications are, e.g., the parameterization of meso-scale or synoptic-scale eddies in large-scale climate models or the treatment of the impact of small-scale turbulence on the larger turbulent structures in large-eddy simulations. We present a systematic framework for the development of a stochastic closure for local averages of various atmospheric quantities. The parameterization is derived from the finite difference discretization of the full model equations by utilizing stochastic mode reduction techniques [1]. It includes linear and nonlinear corrections, as well as additive and multiplicative noise terms. The new parameterization is implemented for the Burgers equation, where we consider a stochastically forced case as well as the inviscid case. In order to assess the performance of the closure, it is compared with two benchmark parameterizations: a Smagorinsky sub-grid scale model and a purely empirical linear stochastic parameterization. The new parameterization improves the representation of the inertial energy range (forced case) and higher order statistical moments (inviscid case).

References

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