Simulating homogenous isotropic turbulence with deterministic and stochastic forcings using a dimensionally reduced model

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Numerical simulations of Homogenous Isotropic Turbulence (HIT) typically employ Fourier space formulations, limiting forcing to low wavenumber modes, which poses challenges for practical applications in physical space. A promising alternative for physical space implementations, proposed by Lundgren [1], introduces a linear forcing proportional to the local and instantaneous velocity.

In this study, we investigate the application of a linear forcing within dimensionally reduced flow models, specifically One-Dimensional Turbulence (ODT) [2] [3]. We build upon recent work by Giddey *et al.* (2018) [4], utilizing a deterministic forcing that incorporates a time-dependent forcing coefficient as previously proposed by Basenne *et al.* [5]. The goal of the work is the study of passive scalar mixing within HIT, and the evaluation of the nature and consequences of the suggested forcing in the selected turbulence model. We reproduce the results from [4] and recover an inertial scaling in the energy cascade with the exponent $-5/3$. We investigate the spectra and temporal evolution of spatially averaged kinetic energy and other derived quantities. Additionally, we scrutinize control parameters influencing the forcing method and assess their impact on spectral characteristics. To further stress issues arising from the suggested forcing, we also implement an alternative stochastic force injecting turbulent kinetic energy; an alternative forcing method specifically designed for ODT, initially proposed by Fistler *et al.* [6].

Overall, our research compares the deterministic and alternative stochastic forcing approaches for high-fidelity reduced order modelling of turbulent momentum and multiple scalar mixing.

References

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