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Fractal and multifractal reconstruction of sub-grid scales in large eddy simulation of atmospheric turbulence

Emmanuel O. Akinlabi[1], Marta Waclawczyk[1], Szymon P. Malinowski[1]
[1] Institute of Geophysics, Faculty of Physics, University of Warsaw, Warsaw, Poland
E-mail: emmanuel.akinlabi@fuw.edu.pl

ABSTRACT

We implement a fractal and multifractal sub-grid scale models for large eddy simulation (LES) of atmospheric flow. The fractal model reconstruct sub-grid velocity field from the knowledge of its filtered values on LES grid, by means of fractal interpolation, proposed by Scotti and Meneveau [2]. The characteristics of the reconstructed signal depends on the (free) stretching parameters, which is related to the fractal dimension of the signal. In [2], the stretching parameters was assumed to be constant in space and time. To account for its variability, we calculate the probability distribution of the stretching parameter from direct numerical simulation (DNS) data of stratocumulus-top boundary layer (STBL) [1] (courtesy of Prof. J.-P. Mellado from the Max Planck Institute of Meteorology) using the geometric method proposed by Mazel and Hayes [5].

The multifractal subgrid scale model evaluate the subgrid velocity components from a multifractal representation of the subgrid vorticity field [4]. Since the enstrophy field exhibits multifractal scale-similarity on inertial range scales, we use multipliers distribution calculated from DNS of STBL to reconstruct the enstrophy subgrid scale for LES as described in [4].

We implemented both subgrid models into 3D anelastic semi-Lagrangian/Eulerian finite difference model EULAG [3] to simulate STBL. We aim to test which approach provides better results of the subgrid velocity field, as compared to DNS statistics. Our final goal is to simulate motion of heavy particles in atmospheric turbulence and model the effect of subgrid scales on their disperision.

References

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