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Letter to the Editor: On the evolution of dissipation rate and resolved kinetic energy in ALDM simulations of the Taylor–Green flow

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ABSTRACT

We correct a data processing error in the article "Construction of explicit and implicit dynamic finite difference schemes and application to the large-eddy simulation of the Taylor–Green vortex" by Dieter Fauconnier, Chris De Langhe and Erik Dick published in the Journal of Computational Physics 228 (2009), pp. 8053–8084.

In order to validate implementations of the dynamic Smagorinsky model and the multi-scale Smagorinsky model, Fauconnier et al. [1] conducted pseudo-spectral large-eddy simulations (LES) of a transitional Taylor–Green vortex and compared the evolution of dissipation and resolved turbulent kinetic energy with data for the Adaptive Local Deconvolution Method (ALDM) taken from Ref. [2]. Fauconnier et al. came to the conclusion that the three methods lead to modeling errors with similar magnitudes but opposite signs, which gives an erroneous impression about the implicit subgrid-scale modeling

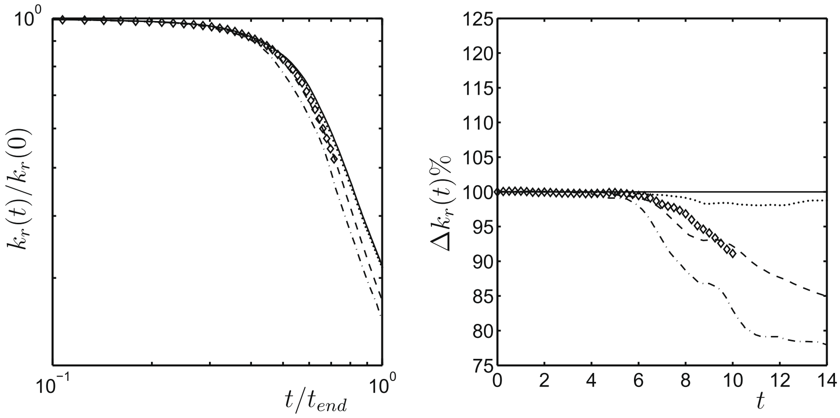

Fig. 1. Temporal decay of resolved turbulent kinetic energy k_r (left) and percentage of resolved turbulent kinetic energy $\Delta k_r = k_r/k_{exact}$ (right) for Taylor–Green flow; — reference DNS, ⋯ filtered DNS solution, pseudo-spectral LES [1] using ·–·–·– the dynamic Smagorinsky model and –––– the multi-scale Smagorinsky model, and ◇ implicit LES with ALDM [2].

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effect of ALDM. Private communication with the authors revealed that for ALDM the amount of resolved turbulent kinetic energy was reconstructed from the dissipation, as given in Ref. [2, Fig. 13], through

$$k_r(t) = k_r(0) - \int_0^t \varepsilon_r(t)dt.$$

This identity, based on the equilibrium hypothesis for homogeneous isotropic turbulence in a periodic box, holds for fully resolved simulations but not for LES, where also the dissipation due to the subgrid-scale model has to be taken into account, i.e.

$$k_r(t) = k_r(0) - \int_0^t \varepsilon_{total}(t)dt = k_r(0) - \int_0^t \varepsilon_r(t) + \varepsilon_{SGS}(t)dt.$$

We reproduce Fig. 9 of Ref. [1] using the archived original data, see Fig. 1. It becomes clear that the LES models do not show opposite but equal trends. The resolved turbulent kinetic energy is under-predicted which is consistent with the dissipation being overestimated. We note that the error for ALDM is significantly smaller than suggested by Fig. 9 of Ref. [1]. Fauconnier's results for the multi-scale Smagorinsky model agree very well with ALDM, whereas the dynamic Smagorinsky model is somewhat inferior. This also confirms similar findings in Ref. [2]. We emphasize that Fauconnier's conclusions remain fully valid as far as they concern the proposed dynamic finite difference schemes.

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Stefan Hickel
Nikolaus A. Adams
Technische Universität München,
Institute of Aerodynamics,
D-85747 Garching, Germany
Tel.: +49 89 289 16140; fax: +49 89 289 16139
E-mail addresses: sh@tum.de, stefan.hickel@gmx.net (S. Hickel)

J. Andrzej Domaradzki
University of Southern California,
Department of Aerospace and Mechanical Engineering,
Los Angeles, CA 90089-1191,
USA