

University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

NASA Publications

National Aeronautics and Space Administration

2019

High-order finite-difference nonlinear filter methods for subsonic turbulence simulation with stochastic forcing

Alexei G. Kritsuk

Dmitry Kotov

Bjorn Sjögren

Helen C. Yee

Follow this and additional works at: <https://digitalcommons.unl.edu/nasapub>



Part of the [Astrophysics and Astronomy Commons](#)

This Article is brought to you for free and open access by the National Aeronautics and Space Administration at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in NASA Publications by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

High-order finite-difference nonlinear filter methods for subsonic turbulence simulation with stochastic forcing

Alexei G. Kritsuk^{a,*}, Dmitry Kotov^c, Björn Sjögren^b, Helen C. Yee^c

^a*University of California, San Diego*

^b*Lawrence Livermore National Laboratory*

^c*NASA Ames Research Center*

Abstract

Numerical stability of high-order filter schemes developed by Yee & Sjögren is tested on three-dimensional turbulence simulations with stochastic forcing and their performance is compared with that of TVD and WENO schemes. The best-performing filter method employs an eighth-order central base scheme with the Kennedy & Gruber skew-symmetric splitting of the inviscid flux derivative, a wavelet-based local flow sensor, a nonlinear filter utilizing the dissipative portion of seventh-order WENO scheme, and an explicit third- or fourth-order Runge-Kutta time integration. We show that the filter scheme is more computationally efficient and provides a wider spectral bandwidth compared to the seventh-order WENO scheme. The method also demonstrates robust long-time integration for moderately compressible turbulence. In contrast, the the fifth- and seventh-order WENO schemes show non-trivial evolution of the velocity and density power spectra over a few dozen dynamical times, where both TVD and filter schemes recover a solid statistically stationary turbulent state.

Keywords: L^AT_EX, Elsevier, template

2010 MSC: 00-01, 99-00

*Corresponding author

Email address: akritsuk@ucsd.edu (Alexei G. Kritsuk)