University of Groningen

On restraining the convective subgrid-scale production in Burgers' equation

Helder, Joop; Verstappen, Roel

Published in:
ADVANCES IN TURBULENCE XI

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2007

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Helder, J., & Verstappen, R. (2007). On restraining the convective subgrid-scale production in Burgers' equation. In JMLM. Palma, & AS. Lopes (Eds.), *ADVANCES IN TURBULENCE XI* (pp. 737-737). (SPRINGER PROCEEDINGS IN PHYSICS; Vol. 117). Springer.

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

On restraining the convective subgrid-scale production in Burgers' equation

Joop Helder and Roel Verstappen

Institute of Mathematics and Computing Science, University of Groningen,
P.O.Box 800, 9700AV Groningen, The Netherlands;
J.A.Helder@math.rug.nl, R.W.C.P.Verstappen@rug.nl

Most turbulent flows cannot be computed directly from the Navier-Stokes equations, because the convective term $\mathcal{C}(\mathbf{u}, \mathbf{v}) = (\mathbf{u} \cdot \nabla) \mathbf{v}$ produces too many scales of motion. In quest of a dynamically less complex mathematical formulation, we consider regularizations $\mathcal{C}_n(\mathbf{u}, \mathbf{v})$ of the nonlinearity. Hereby, the regularizations conserve the energy, enstrophy (2D) and helicity by construction. This yields $\mathcal{C}_n = \mathcal{C} + \mathcal{O}(\epsilon^n)$, where ϵ is the filter length, and $n = 2, 4, 6$. The regularized system is more amenable to approximate numerically, while its solution approximates the large-scale dynamical behavior of the Navier-Stokes solution. The evolution of the vorticity $\boldsymbol{\omega}$ is given by the usual equation, where the vortex stretching term becomes $\mathcal{C}_n(\boldsymbol{\omega}, \mathbf{u})$. By analyzing the regularized interactions, the filter length is determined such that the production of smaller scales by means of vortex stretching stops at the grid-size δ .

As a first step, the method is applied to Burgers' equation with $\text{Re} = 50$. Here, the analysis is relatively easy, while important aspects of 3D Navier-Stokes remain. To illustrate the results, energy spectra are shown below for $n = 4$. Clearly, without the model the physics are not captured correctly, as the energy is not dissipated enough at the high wavenumbers. With the model, a power law of k^{-20} for small scales is found, for different values of δ .

Fig. 1. Left: Steady state energy spectra, with and without the model. Right: Steady state energy spectra for different values of the grid-size δ .