Introduction and recent results for LANS-alpha, the Lagrangian averaged Navier-Stokes alpha model of turbulence

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Abstract

We used geometrical mechanics to derive, analyze and test a new class of equations for turbulence modeling, with potential applications in global ocean circulation and in other GFD problems. The new models are based on Lagrangian averaging (averaging following the fluid parcels) which preserves nonlinear coherent structures, instead of diffusing them.

Lagrangian averaging also preserves the geometrical link among fluid dynamics, geodesic flows on smooth invertible maps the Kelvin circulation theorem (an important property of rotating geophysical flows) and Lagrangian invariants. For example, the new models preserve potential vorticity and helicity of three-dimensional ideal flows. The new turbulence models have been tested by comparisons with:
(1) Experimental data in pipe flows, for physical realism at high Reynolds numbers;
(2) Large-scale direct numerical simulations of the Navier-Stokes equations in periodic domains, for relative speed up and proper numerical solution properties;
(3) Other competing models, especially the dynamic model of Large Eddy Simulations, in turbulent mixing layers, for speed and accuracy; and
(4) Rotating shallow water flows, for proper behavior in geophysical fluid problems, whose large-scale behavior is dominated by rotation.

These new turbulence models are now being implemented as the subgrid-scale parameterization in the Los Alamos Parallel Ocean Program (POP). POP computes high resolution global ocean circulation, an important component of Earth's climate.

C. Foias, D. D. Holm and E. S. Titi, The Navier-Stokes-alpha model of fluid turbulence. *Physica D* **152** (2001) 505-519. http://xxx.lanl.gov/abs/nlin.CD/0103037.