Geophysical Research Abstracts
Vol. 20, EGU2018-10738, 2018
EGU General Assembly 2018

Identification of coherent structures in the turbulent Couette flow

Andrei Dernov (1) and Evgeny Mortikov (2)

(1) Moscow State University, Computational Mathematics and Cybernetics, Russian Federation (dernovaw@gmail.com), (2) Scientific-Research Computing Center of Moscow State University, Russian Federation (evgeny.mortikov@gmail.com)

Experimental studies of geophysical media, conducted with the help of various measuring tools, allow to detect the existence of coherent structures. A.S. Monin and A.M. Jaglom [1] define a coherent structure as a nonrandom nonlinear stable superposition of large-scale turbulence components. At present, attention is paid to the study of this phenomenon. Coherent structures play an important role in the processes of energy, momentum, and substance transfer. [2]

To identify coherent structures, it is proposed to use Eulerian methods.

For this aims, velocity gradient tensor ∇v is divided into the symmetric S and antisymmetric components Ω:

$$\nabla v = S + \Omega,\ S = \frac{1}{2}\left[\nabla v + (\nabla v)^T\right],\ \Omega = \frac{1}{2}\left[\nabla v - (\nabla v)^T\right],$$

Eulerian methods:

- $Q - criterion$ [3]:

$$Q = \frac{1}{2}\left(|\Omega|^2 - |S|^2\right), \quad |\Omega|^2 = tr[\Omega\Omega^T], \quad |S|^2 = tr[SS^T]$$

Coherent eddies are defined as regions with positive values of Q. The Q-criterion identifies regions where the vorticity is stronger than the rate of strain.

- $\Delta - criterion$ [4]:

$$\Delta = \left(\frac{Q}{3}\right)^3 + \left(\frac{\det \nabla v}{2}\right)^2$$

Coherent eddies are defined as regions where ∇v has complex eigenvalues. Coherent structures are defined as regions with positive values of Δ.

- $\lambda_2 - criterion$ [4]: If the eigenvalues of the symmetric tensor $\Omega^2 + S^2$ are ordered as $\lambda_1 \geq \lambda_2 \geq \lambda_3$, criterion requires $\lambda_2 < 0$.

In this paper, the turbulent Couette flow is considered. The fields of the criteria are constructed with the aim of identifying possible regions with coherent structures. Numerical experiments are carried out for various values of the Reynolds number and Richardson to study the influence of various conditions on the behavior of structures. The DNS (Direct Numerical Simulation) model, developed at the Moscow State University [5], is used.

References:

1. Monin A.S., Yaglom A.M.: Statistical hydromechanics. Vol.1.:1965; Vol.2.:1967.

2. Drobinski, P., R. A. Brown, P. H. Flamant, and J. Pelon: Evidence of organized large eddies by ground-based Doppler lidar, sonic anemometer and sodar, 1998.

3. Hunt, J. C. R., Wray, A. A. &Moin, P.: Eddies, stream, and convergence zones in turbulent flows. Center for Turbulence Research Report CTR-S88, 1988, pp. 193–208.

4. Jeong, J. & Hussain, F.: On the identification of a vortex. J. Fluid Mech. 285, 1995,pp. 69–94.

5. Mortikov E.V.: Numerical modeling of the motion of the ice keel in a stratified fluid. Izvestiya of the Russian Academy of Sciences. Physics of the atmosphere and ocean. — 2016. — Vol. 52, 1. — pp. 120–128.