Lund University
Department of Energy Sciences
Division of Fluid Mechanics

Turbulence - Theory and Modelling

Computer exercise 3

Model anisotropy

Introduction
In this exercise you will investigate how several turbulence models handles anisotropy.
Please hand in a short (max 4 pages) report on your findings latest 13 December by email to johan.revstedt@energy.lth.se. The report should include comparisons of the models in accordance with the task below..

Preparations
Read about the Lumley triangle, Pope Ch 11.3.2 + lecture notes.

Tasks. The Lumley triangle
Download the case-file from the course web-page (same case file as the previous exercise, right click on the link and choose 'save link/target as'). Download the matlab-script "Lumleytriangle.m" if your computer matlab version is below 2016b, otherwise download "LumlegyTriangle_matlab2016Above.m".
This task is let you explore how different turbulence model give different prediction of turbulence anisotropy, which will be *visualized* by following one line across the domain and viewing its trajectory in the Lumley-triangle (ξ – η) plot, where $6\xi^3 = b_{ij}b_{jk}b_{ki}$ and $6\eta^2 = b_{ij}b_{ji}$, and $b_{ij} = \left(\overline{u'_i u'_j} - \frac{2}{3}k\delta_{ij}\right)/2k$. To calculate a point in the Lumley triangle one will, hence, need values of all 6 components of the stress tensor. While RSM directly provides this, some postprocessing is required for 2-equation models, such as k-ε, k-ω etc. In that case we utilize the Boussinesq hypothesis accordingly: $b_{ij} = \frac{\upsilon_T \overline{S_{ij}}}{k}$

A.1) Run the case as is, i.e. the standard k-ε with a Reynolds number of 10000.
Create a line from x=-5 to x=10 at y=0.2. To export the data to Matlab `file` → `write` → `profile`. In the left panel of the dialog, make sure to **only select** the name of previously extracted line, and in the right panel, select (1) "density" (2) "turbulent kinetic energy" (3) "turbulent viscosity" and (4-7) "dX-Velocity/dx", "dY-Velocity/dx", "dX-Velocity/dy", "dY-Velocity/dy"
Save to the same folder as the matlab script is stored in, name the file `p5.prof`.

A.2) Now open the Matlab script, and press F5 to run and view the trajectory alongside with Lumley triangle. If you accidently saved file with another name than `p5.prof`, modify the Matlab line of: **fileID = fopen('p5.prof');**

B) Change turbulence model to Realizable k-ε, run the simulation until it converge. Repeat the steps in A1 and A2 and examine the trajectory in the Lumley triangle , did you notice the difference compared to (A) , why?
C) Repeat, using the SST k-ω model

D) Change to RSM model and run. At `file` → `write` → `profile` you should now mark (1) “turbulent kinetic energy” (2) “UU-Reynolds stress”, (3) “UVReynolds stress” , (4) “VV-Reynolds stress”, (5) “WW-Reynolds stress” instead, and save to the file “p5.prof”. Run matlab, what changed?