Computing Turbulent Flows

In this section we address methods that might be used to compute turbulent flows. Of course, the most obvious approach would be to discretize or enmesh the entire region of the flow and to solve numerical approximations to the Navier-Stokes equations. This is known as the DNS or Direct Numerical Simulation method. However to be thorough it would rely on the mesh being substantially finer than the smallest eddies in order to accurately resolve the flow. The problem with such an approach, as discussed at the end of section (Bkf), is that even for quite small Reynolds numbers this requires a very refined mesh and very large computer storage and run times. Moreover those demands increase substantially as the Reynolds number of the desired fluid flow increases.

At the other end of the spectrum of methods is the RANS or Reynolds Averaged Navier Stokes equation approach in which no effort is made to compute the unsteady flow eddies. Instead the method focusses on models of the Reynolds stress terms in the averaged Navier Stokes equations. These models attempt to relate the Reynolds stress terms to the mean flow and spatial gradients of the mean flow. We will focus on these RANS methods here since they are the commonest methods used in computing turbulent flows. But it is also worth mentioning that a hybrid approach is also widely used in which one attempts to model the large eddies but then uses a model to include the averaged effect of the smaller eddies. One such version of this is called LES or Large Eddy Simulation.

One of the commonest elements in RANS methods is the original model suggested by Prandtl and called Prandtl's mixing length model.