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Progress in subgrid-scale modelling for large-eddy simulation of wall-bounded shear flows

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Conventional numerical predictions of engineering or geophysical turbulent flows are based on the Reynolds-averaged Navier-Stokes (RANS) equations for which statistical turbulence models are needed. Such computations can only give statistical information about turbulence, and severe limitations of existing turbulence models in non-standard situations represent a major obstacle to reliable predictions.

Alternative turbulent flow simulation approaches are direct numerical simulations (DNS), in which all relevant length and time scales down to the Kolmogorov scales have to be resolved, and large-eddy simulations (LES), in which only the large-scale, energy-carrying vortices of the flow are accurately resolved on the numerical grid whereas the small-scale fluctations are taken care of by a subgrid-scale (SGS) model. The application of LES is promising as LES can provide reasonable accuracy at a fraction of the computational cost of DNS. LES of simple turbulent flows are now quite well established and a variety of SGS models have been proposed in the literature. However, successful LES for non-standard flow conditions is not straightforward. For example, laminar-turbulent transition, which is important in a variety of technical applications, is difficult to predict and its refined modelling has obtained increased attention only recently.

In the talk, recent advances with large-eddy simulations (LES) of transitional and turbulent incompressible wall-bounded shear flows will be presented with focus on the prototype problem of plane channel flow at low grid resolutions. A variety of SGS models have been evaluated including the approximate deconvolution model (ADM) and related approaches, classical and high-pass filtered (HPF) eddy-viscosity models, and dynamic models.