# A priori non-dimensional meshing criterion of mean flow field discretization for RANS and LES

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Reynolds Average Navier-Stokes (RANS) and Large-Eddy Simulation (LES) are widely used strategies to simulate flows. A necessary condition for their use is to have an adequate mesh, a mesh which guarantee the accuracy of the numerical simulation without too many mesh elements to limit the computational time. Mesh adaptation procedure can help tackle this issue by adapting a mesh depending on flow configurations. It reduces the time spent by users on mesh generation software and can allow user independent solutions.

Whereas all the turbulent fields are modeled in RANS approach, LES proposes to explicitly solve the large turbulent scales, and to model only the turbulence dynamic at small scales, leading to specific mesh constraint for LES[1] to respect the Pope's criterion[2]. However, RANS and LES approaches share the same requirement for a mesh-independent description of the mean fields. For mean flow field discretisation, it can be proposed to limit the interpolation error of the mean velocity field $\langle\vec{u}\rangle$ evaluated as $U_e = c\Delta^2(\vec{x})\|\nabla^2\langle\vec{u}\rangle\|$, where $c$ is a constant depending on the dimension of the problem, $\nabla^2$ is the Laplacian operator (the trace of the Hessian operator), $\|\cdot\|$ is the $L2$ norm, $\Delta$ is the cell size. While this type of criterion have been widely used[1,3], it requires a target value[4] which is case dependent and prevents its utilisation in large and complex geometries.

We proposed a new non-dimensional criterion for mean flow field discretisation[5]: $Re_\Delta = U_e/U_\nu$ where $U_\nu = \nu_{tot}/\Delta$ is the typical velocity characterizing both molecular and turbulent diffusive effects ($\nu_{tot} = \nu + \nu_T$ with $\nu_T$ the turbulent viscosity characterizing the turbulent diffusion). By analogy with the Kolmogorov scale based Reynolds number, at $Re_\Delta \sim 1$, it is expected that diffusive effects acting on the mean field prevents the development of the mean field at scale under $\Delta$. This allows to define an a-priori target value for a correct mean flow field discretisation.

We applied this criterion on various canonical cases and on a complex case successfully for RANS and LES simulations[5]. Convergence is observed for $Re_\Delta \lesssim 1$ with a good precision against references. For example, RANS simulation with a Spalart-Allamaras model is performed with $Re_\Delta = 1$ on a periodic hill flow configuration in Figure 1. It shows good agreement with the simulation performed in the reference[6] with a user defined mesh.

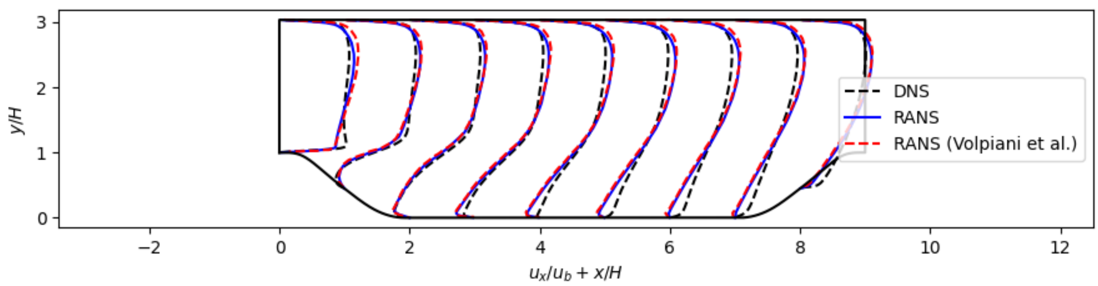


Figure 1: Axial velocity of the periodic hill flow configuration. Solution with $Re_\Delta = 1$ is in blue. Solution[6] with a user defined mesh is in red

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