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# UTILISING HIGH-ORDER DIRECT NUMERICAL SIMULATION FOR TRANSIENT AERONAUTICS PROBLEMS

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The use of computational tools for the simulation of flows in complex geometries is now well-established in the aeronautics industry. However as engineering design progresses there is a need for more accurate simulations of transient flows which are not well-suited to the current generation of numerical models which are widely used within the aeronautics community. One alternative line of research, used more frequently in the academic community, is to instead perform a direct numerical simulation (DNS) of the underlying equations, which given sufficient resolution will capture all the necessary features of the flow to obtain fully accurate statistics.

Figure 1 demonstrates the level of detail that can be obtained from DNS by considering the flow over a periodic hill at $Re = 2{,}800$ driven through the use of a volumetric flux. In this simulation, we use a high-order discretisation of the domain, with two-dimensional spectral elements used to represent the cross-section of the bump and a one-dimensional Fourier pseudospectral expansion in the periodic spanwise direction. The use of these high-order methods allows us to obtain highly accurate results at a comparatively low computational cost.

The main disadvantage of this approach is that most industrial problems have large enough Reynolds numbers that the resolution requirements for a fully resolved simulation are computationally unfeasible; for example the periodic hill of figure 1 uses 28 million degrees of freedom. The purpose of this talk however is to describe how high-order DNS techniques can be applied to aeronautics problems both by reducing resolution in appropriate regions of the domain, either by increasing the mesh size or reducing the polynomial order, and through the use of stabilisation techniques which help preserve the accuracy of obtained statistics.

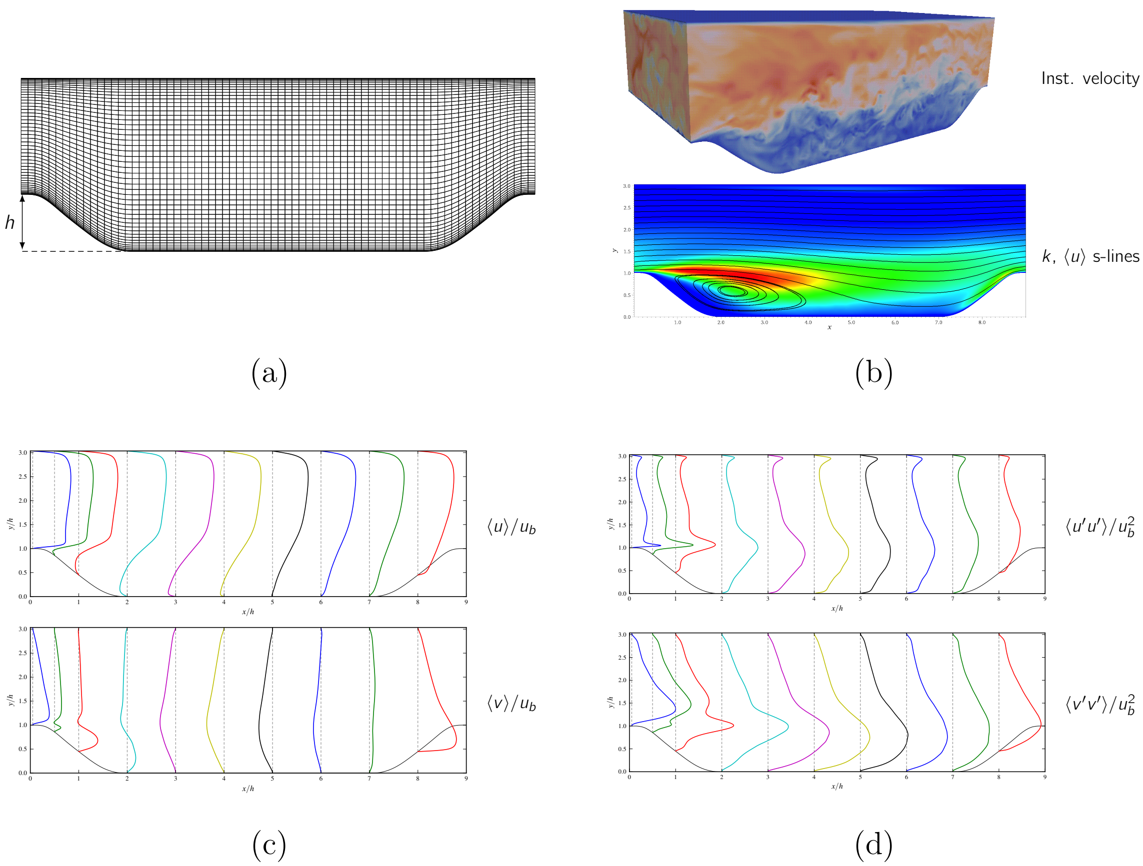


Figure 1: DNS of turbulent flow at $Re = 2{,}800$ in a periodic hill: (a) two-dimensional spectral element mesh with 3626 quadrilateral elements; (b) flow features; (c) velocity profiles; (d) Reynolds stresses profiles.