Fluids and Space Engineering Seminar

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Parameter Extension Simulation of Turbulent Flows

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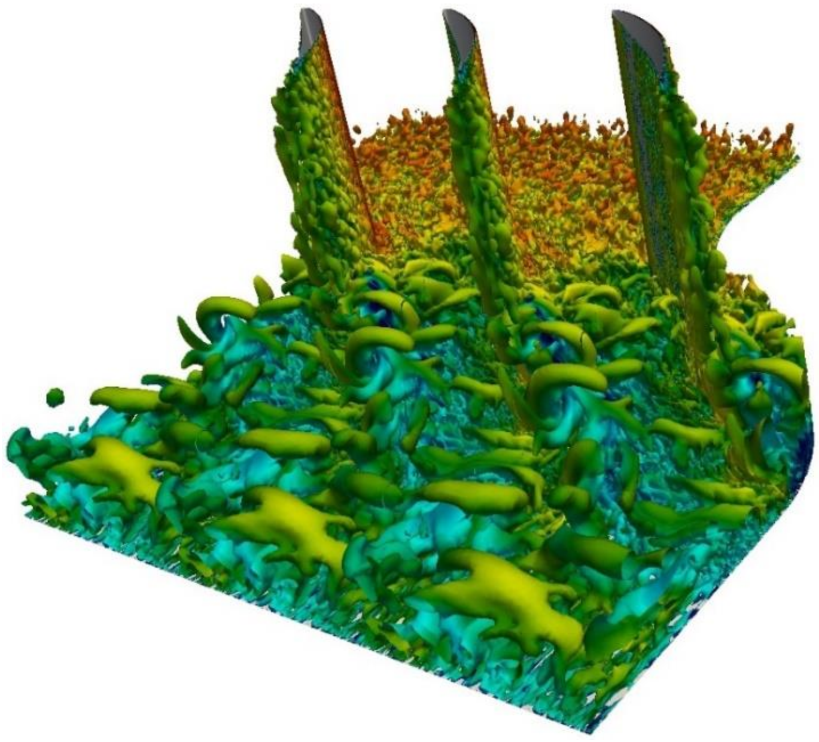

The use of parameter extension simulation (PES) as a mathematical method for simulating turbulent flows is proposed in this study. It is defined as the calculation of a turbulent flow with the help of a reference solution. A typical PES calculation includes three steps, as follows. Set up an asymptotic relationship between the exact solution of the Navier–Stokes equations and the reference solution for the initial parameter values, calculate the reference solution and the necessary asymptotic coefficients, and extend the reference solution to the parameter values to produce the exact solution. The method of controlled eddy simulation (CES) has been developed to calculate the reference solution and the asymptotic coefficients. The CES method is a special case of large eddy simulation (LES), in which a weighting coefficient and an artificial force distribution are used to damp part of the turbulent motions. The distribution of artificial force is modeled with the help of eddy viscosity. The reference-weighting coefficient can be determined empirically or in a convergence study. To demonstrate potential uses, the proposed PES method is used to simulate four types of turbulent flows. The flows are decaying homogeneous and isotropic turbulence, smooth-wall channel flows, rough-wall channel flows, and compressor-blade cascade flows. The numerical results show that the PES solution is more accurate than a Reynolds-average Navier–Stokes simulation solution. Unlike a traditional LES method, which uses the Smagorinsky, k-equation-transport, or WALE subgrid model, the PES requires a lower mesh resolution. These characteristics make it a potential method for simulating the engineering of turbulent flows with complex geometry and high Reynolds number.