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Implicit Large Eddy Simulation using Second and Higher-Order Methods on Unstructured Meshes

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This paper presents an assessment of high-order, finite-volume WENO methods (up to 5th-order accurate) in conjunction with 3D hybrid unstructured meses and the compressible Navier-Stokes equations for implicit large Eddy simulation of turbulent flows.

Three variants of numerical methods are employed: (i) a centrally-based reconstruction; (ii) a multi-dimensional total variation diminishing (TVD) type; (iii) a non-linear WENO scheme. The methods are used in conjunction with the HLLC Riemann solver. Additionally, the accuracy of the methods is assessed for incompressible flows with and without low-Mach corrections. Legendre type polynomials are used for the high order interpolations and a QR algorithm for the solution of the resulting over-determined least squares system of equations. The schemes carry out the reconstruction in conservative or characteristic variables [1, 2].

The solution is advanced in time by a 3rd-order TVD Runge-Kutta method. The implementation of the above takes place in a parallel unstructured 3D Euler/Navier-Stokes CFD code (*Azure*), capable of handling any type of meshes.

The test problems include the transitional turbulent flow of the SD7003 aerofoil in an ILES context, a double-vortex pairing flow problema (Fig. 1), the density current atmospheric flow of Straka (Fig. 2), and the swirling flow of a combustion chamber (Fig. 1). The accuracy, robustness and computational times for all the schemes will be presented in the full paper.

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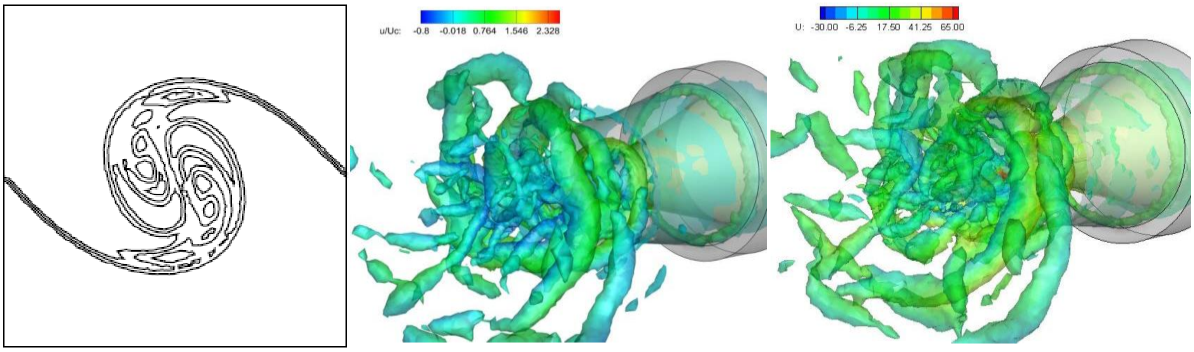

Fig. 1: Contours of passive scalars for the double vortex test problem (left), instantaneous isosurfaces of Q criterion for the swirling flow of a combustor using a 2nd-Order MUSCL Scheme (middle) and a 3rd-Order WENO scheme (right) .

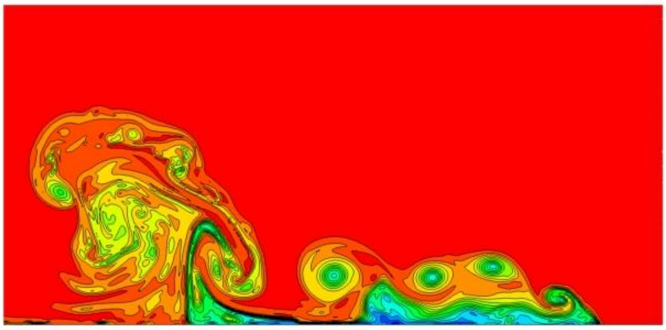

Fig. 2: Contours of potential temperature perturbation for the atmospheric density current flow problem.