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Multi-dimensional upwinding-based implicit LES for the vorticity transport equations[1] DANIEL FOTI, KARTHIK DURAISAMY, University of Michigan — Complex turbulent flows such as rotorcraft and wind turbine wakes are characterized by the presence of strong coherent structures that can be compactly described by vorticity variables. The vorticity-velocity formulation of the incompressible Navier-Stokes equations is employed to increase numerical efficiency. Compared to the traditional velocity-pressure formulation, high order numerical methods and sub-grid scale models for the vorticity transport equation (VTE) have not been fully investigated. Consistent treatment of the convection and stretching terms also needs to be addressed. Our belief is that, by carefully designing sharp gradient-capturing numerical schemes, coherent structures can be more efficiently captured using the vorticity-velocity formulation. In this work, a multidimensional upwind approach for the VTE is developed using the generalized Riemann problem-based scheme devised by Parish et al. (Computers & Fluids, 2016). The algorithm obtains high resolution by augmenting the upwind fluxes with transverse and normal direction corrections. The approach is investigated with several canonical vortex-dominated flows including isolated and interacting vortices and turbulent flows. The capability of the technique to represent sub-grid scale effects is also assessed.

[1]Navy contract titled Turbulence Modelling Across Disparate Length Scales for Naval Computational Fluid Dynamics Applications, through Continuum Dynamics, Inc.

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