TURBULENT BOUNDARY LAYERS IN AIRBLAST PRECURSORS

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Explosions always contain turbulent mixing regions such as boundary layers, shear layers, wall jets and turbulent combustion. Proposed here is a direct numerical simulation method for predicting such flows - where the three-dimensional (3-D) conservation laws are integrated via a high-order Godunov method, and adaptive mesh refinement is used to capture the turbulent mixing processes on the computational grid. Then azimuthal-averaging is applied to the 3-D solution in order to extract the instantaneous mean and fluctuating components of the turbulent field. As an illustration, this methodology is applied to the numerical simulation of the turbulent wall jet and dusty boundary layer flow induced by a point explosion over a soil surface. Principal results include the evolution of the turbulent velocity field near the surface. During the wall-jet phase, the mean profiles resemble previous two-dimensional calculations, while the velocity fluctuation profiles and Reynolds stress profiles are qualitatively similar to measurements of self-preserving wall jets. During the boundary-layer phase, mean velocity profiles evolved with time: initially they agreed with measurements of a dusty boundary layer behind a shock; at intermediate times they resembled the dusty boundary layer profiles measured in a wind tunnel, while at late times, they approached a 1/7 power-law profile. Velocity-fluctuation profiles were qualitatively similar to those measured for a turbulent boundary layer on a flat plate. This methodology can be used to predict the evolution of other turbulent explosion fields that lack a sufficient data base - such as dust clouds, hazardous plumes, afterburning in HE explosions, and turbulent combustion waves in enclosures.