Split-Step Simulations of Sonic Boom Propagation through Turbulence

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Recent flight tests performed during the Sonic Booms in Atmospheric Turbulence (SonicBAT) campaign have shown that sonic boom waveforms at ground level exhibit significant variability caused by interactions with turbulence in the atmospheric boundary layer. We examine the effect of turbulence on two waveforms, a typical sonic boom N-wave and the sonic boom produced by the X-59. We perform split-step simulations of a one-way equation for the acoustic pressure. Turbulence in the domain is generated with a Fourier synthesis approach that uses a von Kármán spectrum to model the turbulent kinetic energy. The turbulence root-mean-square (rms) velocity is varied from 0.2 m/s to 3.0 m/s, which is representative of atmospheric turbulence rms levels recorded at NASA Armstrong Flight Research Center during the SonicBAT program. A length scale is formulated, based on the integral length scale and the index of refraction of the turbulent field, to non-dimensionalize the results. The probability density functions of the first caustic location collapse along the non-dimensional propagation distance for all rms velocities considered. Results for the first and second statistical moments indicate the potential to parameterize the sonic boom overpressure distributions by the rms velocity and integral length scale. Future work is discussed regarding simulations through inhomogeneous atmospheric boundary layer turbulence.

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