

Sonic boom propagation model based on a single-ray Jacobian

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Abstract

A sonic boom is a nonlinear event whose propagation can be modeled involving two stages. The first stage consists of ray path calculations using linear approximations, while the second stage deals with a nonlinear transport of the acoustic energy along these paths. This presentation discusses a second-order finite difference numerical approach used to predict the ray paths in range-dependent atmospheres and compares it to existing finite difference schemes. The approach is validated using exact solutions obtained for stratified atmospheres. In the second stage, the geometrical spreading effect needed in determining sonic boom waveforms from a Burgers' equation is obtained using a method that only needs a single ray rather than four rays required by most existing sonic boom propagation codes. The single-ray method calculates the Jacobian, associated with the coordinate transformation from a suitable ray coordinate system to the Cartesian coordinate system, directly from the ray tracing equations. While the four-ray method approximates the geometrical spreading using a finite difference scheme involving the four rays, the single-ray method does not rely on this approximation and instead depends purely on the acoustical kinematic properties of the atmosphere. Comparisons of results using these two methods are discussed.