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Explosion energy scaling laws for infrasound propagation analysed using nonlinear ray theory

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Using ray theory, long range propagation of infrasound through the atmosphere is modeled in the framework of the Comprehensive Nuclear-Test-Ban Treaty. In atmospheric propagation, the high frequency hypothesis is based on the assumption that space and time scales of atmospheric properties (temperature, wind, density) are much larger than acoustic wave scales. A 3D nonlinear ray tracing code is developed to compute the temporal pressure signature at receivers. These signatures are obtained by solving a generalized Burgers' equation along each ray taking into account nonlinear effects, shear and bulk viscosity absorption and molecular vibrational relaxation mechanisms. Specific developments are performed to pass through caustics. The propagation of infrasound emitted by a motionless point source in a realistic atmosphere is analysed. To quantify the validity limits of our approach, we investigate effects of the wind, atmospheric absorption, nonlinearities, refraction and scattering by small atmospheric scales on observed phase kinds, their travel time and their waveform. Nonlinear mechanisms are important to model the evolution of infrasonic waveform signatures especially to find the N-wave and U-wave shapes of, respectively, thermospheric and stratospheric paths. The relative importance of nonlinear effects are compared for several source energies. Sound exposure level, peak sound exposure level and characteristic frequency for ground amplitudes are analysed in order to develop scaling laws. Comparisons are made with measurements and results available in the literature.