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Finite difference time domain synthesis of infrasound propagation through an absorbing atmosphere

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Equations applicable to finite difference time domain (FDTD) computation of infrasound propagation through an absorbing atmosphere are derived and examined in this paper. It is shown that over altitudes up to 160 km, and at frequencies relevant to global infrasound propagation, i.e. 0.02-5 Hz, the acoustic absorption in dB/m varies approximately as the square of the propagation frequency plus a small constant term. A second order differential equation is presented for an atmosphere modeled as a compressible Newtonian fluid with low shear viscosity, acted on by a small external damping force. It is shown that the solution to this equation represents pressure fluctuations with the observed form for infrasound propagation, i.e. sound is attenuated as $(\beta + \gamma f^2)$. Increased dispersion is predicted at altitudes over 100 km. The equation is separated into two partial differential equations that are first order in time for FDTD implementation. A numerical analysis of errors inherent to this FDTD method shows that the attenuation term imposes additional stability constraints on the FDTD algorithm. Comparison of FDTD results for models with and without attenuation shows that the predicted transmission losses for the attenuating media agree with those computed from the synthesized waveforms.