FACTORS AFFECTING ATMOSPHERIC SOUND PROPAGATION ABOVE AN IMPEDANCE SURFACE

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Predictions of sound propagation through the atmosphere are important in many areas. These areas include prediction of community and environmental noise from road, rail and air vehicles, and the detection and localization of acoustic sources at long distances. Many factors influence the propagation of sound through the atmosphere. Some of these factors are indicated in Fig. 1.

Heating of the ground by the sun leads to variations in the mean air temperature at different heights. The speed of sound depends on temperature, so the temperature profile will cause rays of acoustic energy to refract upward or downward, depending on the shape of the profile. The mean wind speed also varies with height, causing acoustic rays to bend upwards. These refractive effects lead to enhanced sound pressure levels near the ground in the case of downward refraction and reduced levels (acoustic shadows) for upward refraction.

The driving forces of the sun and wind, particularly when coupled with flow over varying terrain and uneven heating of the ground, generate random fluctuations in both temperature and wind flow, i.e., turbulence. Atmospheric turbulence scatters sound energy. Within the acoustic shadow arising from upward refraction or behind a barrier, the scattered energy can dominate the sound field.

When source and receiver are above the ground and not too far apart, the interference between direct and reflected sound paths can produce substantial cancellation at some frequencies. The resulting spectrum is controlled by the ground impedance. At longer ranges with near grazing incidence, the pressure reflection coefficient approaches $R=-1$: the reflected wave will interfere destructively with the direct wave over a broad range of frequencies, producing a diffractive acoustic shadow. For certain ground impedance regimes, surface waves can arise, spilling additional acoustic energy into shadow regions.

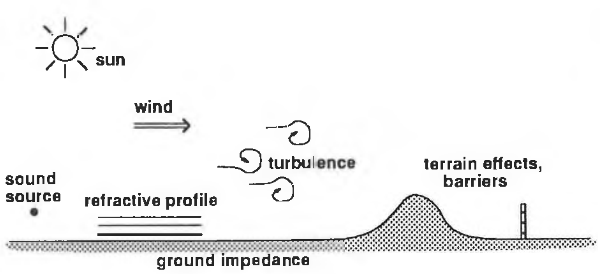

Figure 1. Sketch showing some of the factors that influence the propagation of sound through the atmosphere.

Noise barriers are often used to reduce the level of noise exposure. Procedures for computing insertion losses have been developed to deal with various barrier geometries. Propagation over real 3-dimensional terrain (e.g., hills, buildings), though, is a considerably more challenging problem for prediction.

Atmospheric attenuation reduces sound pressure levels beyond that expected solely because of geometrical spreading. Higher sound frequencies are attenuated much more strongly, so long range propagation is essentially a low frequency phenomenon. Variations in ground impedance, e.g., the transition from roadway to shoulder, are common and will affect propagation.

Different computational procedures can treat various combinations of factors; no procedure handles everything. The Greens function parabolic equation (GF-PE) approach can accommodate a refractive profile, turbulence, and ground impedance. Barrier and terrain effects are excluded, though. Fig. 3 shows a calculation for a 500 Hz tone propagating in an upward refracting sound speed profile. The source is 0.3 m above the ground (flow resistivity 200 c.g.s. rayl/cm) and receivers are on the ground. Calculations made with and without turbulence demonstrate the filling of the acoustic shadow with scattered energy.

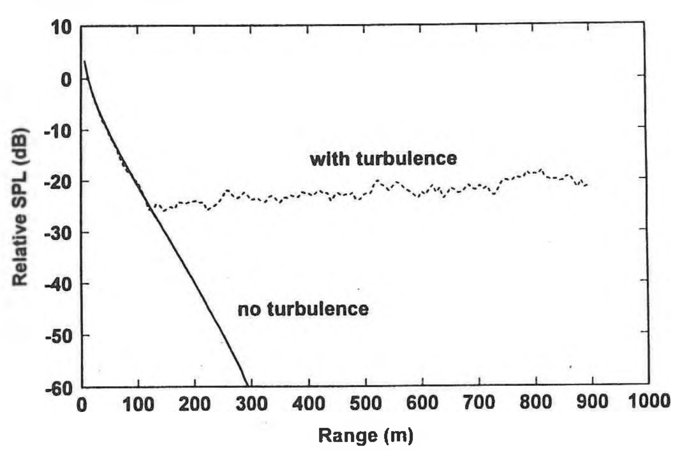

Figure 2. GF-PE prediction for a 500 Hz signal in upward refraction conditions, showing the effects of turbulence..