Evidence for Nonlinear Atmospheric Effects in Infrasound Propagation from Explosions of Different Types and Yields.

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The nonlinear acoustic phenomena in atmosphere are studied both theoretically and experimentally. The fact that the "acoustic pulse" I - the product of the wave profile area S in the coordinates p (pressure) and t (time) by the distance to the source r - is conserved during long-range infrasound propagation in the atmosphere is experimentally supported. The results of the experiments on recording infrasonic waves at long (up to 300 km) distances from different (underground, ground, and air) explosions equivalent to 100 kg - 2000 t of TNT and realized in different geographical regions in different seasons are analyzed. The obtained empirical ratio I_0 » 0.616´$I^{0.988}$ allows one to estimate the initial value of the "acoustic pulse" I_0 in the vicinity of its source from the data on infrasound arrivals recorded within the audibility zone at long distances from explosion. Within the audibility zone, the obtained expression can be used for the stratospheric, mesospheric, and thermospheric infrasound arrivals at any distances from explosions. The empirical ratio E_0 *[kt] =1.38* ´*10* $^{-10}$ *(I [kg /s])* $^{1.482}$ is proposed to determine the energy E (in kt of TNT) of an equivalent explosion from the records of acoustic signals at long distances from sources without regard to the type of ray trajectories. On the basis of the phenomenon of acoustic pulse conservation during long-range infrasound propagation in the atmosphere, the ratio *Df/ f ~ Dp/p* is proposed. This ratio allows one, for a given distance r, to estimate the error *Df* in determining the frequency of the spectral maxima of signal f, which approximately corresponds to the error Δp in determining the acoustic pressure in the infrasonic arrivals from explosions. It was obtained that nonlinear effects will be appreciable up to dissipative effects when initial Mach number M more than critical Mach number $M_{cr} = (l_0 / H)^{1/2} (z_n z_d)^{1/2} / 2ez_0$ (z_n - height when N – wave is formed; z_d – height when acoustic Reynolds number Re equal to Re (z_d) = 1. The maximum heights of acoustic pulse propagation towards the upper atmosphere from explosive sources with different yields are estimated.

New Type of Infrasonic Arrivals in the Geometric Shadow Region at Long Distances from Explosions

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The data on infrasonic signals recorded in the geometric shadow region at a distance of 300 km from surface explosions equivalent to 20–70 t of TNT are analyzed. A new (previously unexplored) type of localized (pulsed) acoustic arrivals from the explosions is revealed. Such signals are recorded in all the seasons and are stable over a few hours of observations. The supposed mechanism of occurrence of the localized arrivals in the geometric shadow region is the partial reflection of acoustic pulses from coherent isolated locally stratified inhomogeneities of the acoustic refractive index in the mesosphere. The mean horizontal propagation speeds for such arrivals suggest reflection altitudes above 60 km. It is assumed that the localization of atmospheric inhomogeneities is associated with the occurrence of the so-called “wind-corner” layers in the mesosphere, within which (according to the data obtained from both rocket and radar observations) a rapid variation is noted in the wind direction with altitude. The vertical gradients of the effective sound speed $\partial c/\partial z$ within such layers and their depth h are estimated for the Epstein symmetric layer model. The resulting estimates are within the range $66 < \partial c/\partial z < 87$ m / s /km at the corresponding changes $1.32 > h > 0.8$ km (with a decrease of h, the necessary values of the vertical gradient of the effective sound speed $\partial c/\partial z$ are increased). The results obtained agree with the data obtained from both the radar and rocket measurements of the vertical gradients of wind velocity and the wind-corner layer depths .