Possible excitation mechanisms of long-period acoustic waves from 0.01to 0.1 Hz

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Recently some groups reported Earth's background free oscillations even on seismically quiet days [e.g. Nawa et al., 1998]. Statistical features of them and annual variations of their amplitudes suggest that atmospheric disturbance is the most probable excitation source. If the atmospheric excitation mechanism is effective, atmospheric acoustic free oscillations must be also excited persistently. In fact there is evidence of acoustic resonance of seismic free oscillations at around 3.7 and 4.4 mHz. The resonant amplitudes of the seismic records suggest the atmospheric excitation of the acoustic free oscillations but there is no direct observation of them.

In an attempt to detect the long-period acoustic waves, we installed a cross array of barometers in a 10 km-wide university forest in central Honshu. The array has 28 micro-barometers employing quartz crystal resonator technology with station spacing of about 500 m. A special care was taken to design a sensor-recording system that runs with a pression of better than 0.1 ppm in clock timing and sampling timing over a year by a single air battery. We analyzed 1-second continuous sampling records in a time period from March 2002 to September 2003.

In order to determine temporal variations of their incident azimuths and amplitudes, we calculate two-dimensional frequency--slowness spectra from 0.04 to 0.08 Hz. All the spectra show acoustic waves traveling from northwest or west with phase velocity of about 400 m/s. They also show clearly an annual variation, with the minimum around 3E-3 Pa in summer and the maximum around 7E-3 in winter.

In order to obtain dispersion curves of the acoustic waves, we measured the time delay between every pair of all the stations with an assumption of a stochastic stationary plane wave for the observed acoustic waves. We determined the slowness vector of a plane wave as the one with which all the measured time delay are most consistent with each other. The plot of the measured slowness as a function of frequency has given for the first time the dispersion curve of atmospheric acoustic wave at frequencies down to 0.01 Hz. The observed dispersion curve shows acoustic waves traveling from the northwest (possibly from the mountaneous region) in a frequency range from 0.01 to 0.1 Hz with a phase velocity of about 400 m/s at 0.1 Hz and about 1500m/s at 0.01 Hz.

The most probable mechanism is the aerodynamic excitation by atmospheric turbulence in mountain regions. Turbulence on a curved boundary (mountain regions) excites a dipole field of acoustic waves, a mechanism more effective than a quadrapole field exited by turbulence on a plane boundary. The observed mountain-associated infrasound waves have several common features (Bedard, 1978): (1) wave periods from 30 to 70 s, (2) duration longer than 3 hours with amplitudes of about 5E-2 Pa at a distance of 400 km, (3) fixed azimuths of arrivals from definite directions, (4) a strong tendency to be observed during winter months, and (5) group velocity of 325 - 425 m/s. These features are consistent with our observations, suggesting that atmospheric disturbance in the mountain regions is the most likely source of the observed acoustic waves.