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Continuously excited infrared sounds

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Recent observations of Earth's free oscillations show that they are continuously excited at nano gal level. The most probable mechanism of such oscillations is that these oscillations are excited by turbulence motions in the atmosphere. To confirm the mechanism, survey of atmospheric disturbances are necessary. If atmospheric turbulence can excite the free oscillations, the same mechanism can also excite continuous atmospheric infrared sounds. Detection of the sound waves can be another test for the mechanism that our atmosphere can really excite global oscillations. So, Fukao et al. recently plan to search continuously excited atmospheric oscillations with an array of high resolution barometers. To evaluate the observational feasibility, here we discuss the excitation of sounds by atmospheric turbulence.

The sound waves considered here are trapped between the Earth's surface and the mesopause. For the infrared sounds the mesopause behaves a lid. The frequency of the waves is about 3.7 mHz which is just inverse of propagation time of nearly vertically traveling sounds in the region, and Q of the waves is low (about 100) since the lid is not perfect. The excitation mechanism of sounds by turbulence is well known as Lighthill mechanism, which shows that efficiency (E) of sound generation is 2*n+1-th power of Mach number. The input energy per unit mass per unit time (I) is evaluated from solar radiation energy absorbed in the lower atmosphere. Thus sound energy per unit mass is equated to I*E multiplied by fraction of solid angle for vertical radiation of sounds, the period of sounds and the squared root of Q. From this equation, the pressure intensity of sound waves are about a thousandth [Pa] for n=2 (quadrupole radiation) and a tenth [Pa] for n=1 (dipole radiation). On the other hand, pressure disturbance of turbulence itself is about 4 [Pa]. To obtain significant signal to noise ratio, stacking of data is necessary. By comparison between signal pressure (sounds) and noise pressure (turbulence), the required number of data ensembles is about one hundred thousands for n=2 or 10 for n=1. This means we require 10 years period for n=2 or one half day for n=1 as the minimum observation period.

The pressure at a thousandth [Pa] for the quadrupole radiation gives 0.2 n gal of acceleration amplitude of the Earth's free oscillation at 3.7 mHz on account of the impedance difference between the solid earth (or ocean) and the atmosphere. It is consistent with the excess amplitude in the coupled free oscillation with sounds observed by Nishida et al. 2000. This also supports the atmospheric excitation mechanism since the same scaling law of the turbulence can continuously excite not only the free oscillations but also the atmospheric sound waves consistently. On the other hand, episodic evolution of clouds by releasing latent heat can excite dipole radiation of sounds, that can be observable in a reasonable period using the array of barometers.