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On seismic background noises

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Recently it has been established that the Earth's free oscillations are continuously excited by phenomena other than earthquakes. The excited modes are almost fundamental spheroidal modes with amplitudes slightly less than 1 ngal and their intensities clearly show annual variations (e.g. Nishida et al. 2000) with some biannual component. In particular the mode, 0S29 located at the branch crossing with the acoustic modes has excess amplitudes having an annual variation of 30%. As the cause of such oscillations, random disturbances in the atmosphere and/or the oceans has been considered. In the previous works, pressure disturbances are treated as random vertical traction forces on the bottom floors of the atmosphere or the oceans. Such disturbances has successfully explained the observed amplitudes of the free oscillations. However the treatments are insufficient conceptually and for detailed features of the observed spectra. In this study, we treat the pressure disturbances volumetrically extending in the bottom atmosphere or the oceans and we use normal mode eigenfunctions of an earth model including the atmosphere in the calculation of the excitation problem.

As the atmospheric disturbances, we used observed power spectral densities (PSDs) of wind speeds recorded by a super sonic wind meter at Kiyosumi station, the Boso peninsula. The PSDs show relatively flat spectra in the mHz band and a power low with steep slope in the higher frequency range. Clearly the process in the bottom atmosphere seem to change around 10 mHz and well known energy cascade of fully developed turbulence are observed above the frequency. Assuming this spectral feature is globally, we calculated free oscillation amplitudes from 0.4 mHz to 1 Hz using eigenfunctions of a combined model of PREM and NRLMSISE-00 (an atmospheric model), which are calculated by a normal mode calculation method developed by the author (Kobayashi 2005). The method can fully treat anelasticity and leaking of energy at the top of the model atmosphere.

In the mHz band, the results show that only the dynamic pressure of atmospheric disturbances can explain the observed amplitudes of 0S29 and the detailed features of the background spectra in the mHz band. This means that the volumetric effect of the atmospheric disturbances is necessary for the details. In 10 mHz band, there is an plateau of PSDs of the background ground motions (e.g. the New Low Noise Model (NLNM) of the Peterson 1993). Such a feature can be reproduced by the given atmospheric disturbances which change the property around 10 mHz. In the tremor band, we can produce a spectral peak which is due to natural responses of oceanic surface modes and the second spectral peak near the double frequency by including the first overtone modes. With the Newtonian attraction effect by air mass passing below mHz, the overall pattern of the calculated spectra is similar to the NLNM of Peterson. From those results, we conclude that atmospheric disturbances play an important role in the background seismic noises.