Coupling of earth's free oscillations with acoustic modes

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Seismology is the best way to probe planetary interior. Kobayashi (1996) proposed an excitation mechanism of oscillations of planets by atmospheric turbulences. This mechanism is important because it light up a way of seismological investigation on the internal structure of less tectonically active planets such as Venus and Mars. On the earth, several researchers including us have reported continuous excitations of free oscillations on seismically quiet days. The amplitudes of such oscillations are about 0.5 nano gal and are somewhat larger in the summer of northern hemisphere. 0S29 near the branch crossing with atmospheric acoustic modes has larger amplitude by about 40% in the summer season than those of the other modes in particular. These observed features of the oscillations is favorable for the proposed mechanism. In order to make it more convincing, we numerically calculated excitation amplitudes of earth's free oscillations by atmospheric turbulences and concluded that these observed features are quantitatively well explained by the mechanism.

The model we used is PREM for the solid and ocean parts and global averages of the atmospheric structure up to 1000 km altitude based on the MSISE90 model. For the atmospheric part, we prepared two models; one is an average of the summer atmosphere and the other is of the winter atmosphere. Then we calculated solid modes and acoustic modes for PREM with the two atmospheric models using newly developed numerical method of normal mode calculations. Frequency of 0P29 (fundamental acoustic mode with angular degree 29) is close to that of 0S29 in the summer and apart from it in the winter. This is due to changes in the thermal structure near the tropopause. In the summer, it behaves more rigid barrier and shorten the path length of the acoustic waves propagating nearly vertically. When 0P29 is close to 0S29, it has larger amplitude in the solid part because it is closer to the resonance of the solid oscillations. So we calculated contribution of 0P29 on ground accelerations assuming random pressure disturbances at the bottom of the atmosphere. The contribution is significant in the summer and can explain the observed excess amplitude of 0S29.

Thus we conclude that the observed continuous excitations of earth's free oscillations are really excited by the atmosphere and the seismological method is promising for exploration of the other planets, Venus and Mars. Especially Venus has dense atmosphere. It means that elastic oscillations of Venus is much coupled with acoustic waves. In the last part of the presentation, we will discuss about a strategy for seismology on Venus.