Two Topics in Background Oscillations: Seasonality and Application to Mars Seismology

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Abstract. Two independent issues related to background oscillations are discussed. The first is the seasonal variations in the Earth's background oscillations, particularly its annual and/or bi-annual periodicity. Both periodicities exist in the data. It is pointed out that noise often show annual variations while background oscillations show predominantly six-months periodicity. The second is the application of this idea to Mars seismology. If the cause of the oscillations is turbulent atmosphere, the same mechanism may be happening in Mars due to its vigorous atmosphere. Theoretical estimates show that expected amplitudes in Mars is about 30-50 percent of those found in the Earth. Considering the difficulties in the terrestrial observation, a single seismic instrument on Mars seems to provide only a marginal chance of observation. Chances of detection of modes will enhance greatly if multiple instruments could be installed and stacking process can be introduced.

1 Periodicity in background oscillations: annual or bi-annual ?

In a recent report, Nishida et al. (2000) presented a case for seasonal variations in background oscillations of the Earth which was dominated by annual cycle, while Tanimoto and Um (1999) showed predominantly bi-annual (6 month) periodicity in data. Recent study by Ekström (2000), reported at Fall 2000 AGU meeting, shows that both periods exist in the data. Our analysis shows that background oscillations by themselves tend to show 6-month cycle while noise, estimated from spectra between fundamental mode peaks, tends to show 12-month cycle.

In this talk, we refer to background oscillation peaks as signal (S) and spectral peaks between fundamental mode peaks as noise (N). Figure 1 shows results at Kunming (KMI), China. This data displays the average amplitudes for 21 modes (0S20-0S40). Monthly averaged amplitudes clearly show two peaks, one in December-January-February and the other in June-July-August. Noise, plotted below, shows a clear annual trend with one peak in December-January-February. Signal, on the other hand, shows two peaks in summer and winter (in both hemispheres). These peaks are also found at virtually all other quiet stations.

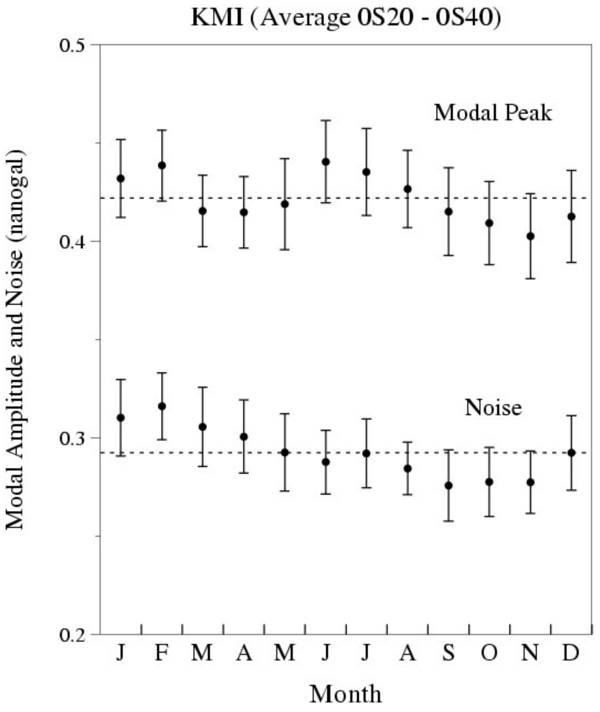

Fig. 1.

Nishida et al (2000) and Tanimoto and Um (1999) agree in claiming to see the seasonal variations in background oscillations. They also agree that they must be excited by the atmosphere. In particular, two resonant modes between atmosphere and the solid Earth, pointed out by Nishida et al (0S29 and 0S37), are a substantial evidence for an atmospheric cause of the excitation rather than an oceanic cause.

Both papers made adhoc claims in interpreting the results; Nishida et al (2000) refers to Earth's Radiation Budget which has an annual cycle (Kandel et al., 1998), while Tanimoto and Um refers to correlation with Oort's surface pressure data (Peixoto and Oort, 1992) which shows bi-annual variation when northern and southern hemisphere are considered. Because we do not understand the periodicities exactly, various scenarios can be created. Clarification of the periodicity may help us make further progress in understanding the detailed excitation process.

2 Application to Mars seismology

Observation indicates strongly that the cause of continuous excitation is in the atmosphere. An interesting application of this idea is whether this method can be used for seismic observation on Mars. Mars has been known to be tectonically quiet (Golombek et al., 1992) and thus installing seismometers and waiting for Marsquakes are clearly not a good approach to learn about its interior structure. Atmospheric excitation is attractive since Mars has a vigorous atmosphere which may be exciting solid body excitation.

Stochastic excitation theory was developed to examine the atmospheric excitation hypothesis (Tanimoto, 1999; Tanimoto and Um, 1999; Fukao et al., 2000). Tanimoto and Um derived a pressure model from barometer data and used it as input for the theoretical prediction. Results showed that observed pressure variation is sufficient to excite amplitudes of terrestrial oscillations as measured in the data set.

Preliminary estimates for the modal amplitudes indicate that approximately 30-50 percent of the level of amplitudes as those excited in the Earth can be expected in Mars (Fig. 2). Observation is therefore not easy but not impossible. Considering the fact that only the stations at quiet sites show good signal, it is a very technicaly challenging task to install broadband seismic instrument under the right conditions on Mars. It seems important to increase a number of instruments (sensors) and add signal enhancing procedure such as stacking in the future data analysis. However, increasing the number of instruments may be difficult with the current limit on (instrumental) weights assigned on Mars missions.

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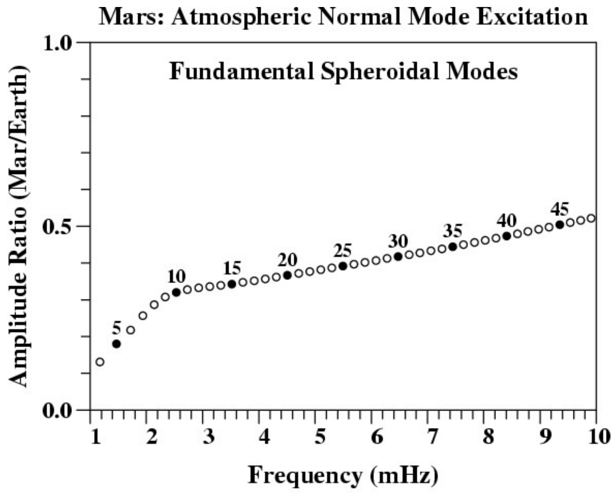

Fig. 2.

3 Reference

Fukao, Y., K. Nishida, N. Suda, K. Nawa, and N. Kobayashi, J. Geophys. Res., in press (2000).

Golombek, M. P., W. B. Banerdt, K. Tanaka, and D. Tralli, Science, 258, 979-981 (1992).

R. Kandel et al., Bull. Am. Meteorol.Soc. 79, 765 (1998)

Nishida, K., N. Kobayashi and Y. Fukao, Science, 287, 2244 (2000)

Peixoto, J. and A. Oort, Physics of Climate, Springer-Verlag, New York (1992).

Tanimoto, T., Geophys. J. Int., 136, 395-402 (1999).

Tanimoto, T. and J. Um, J. Geophys. Res., 104, 28723 (1999)