Long-term variation in amplitude of the Earth's background free oscillations

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The Earth’ s background free oscillations (BFO) are slightly and continuously excited free oscillations of the solid Earth persistent even in seismically quiet periods [Nawa et al. 1998; Suda et al. 1998; Kobayashi and Nishida 1998; Tanimoto et al. 1998]. The observed modes are fundamental modes, suggesting that the excitation sources are atmospheric and oceanic disturbances [e.g. Nishida 2013]. Amplitude of BFO exhibits seasonal variations [Nishida et al. 2002]. Along with such a periodic variation, there may exist transient variations correlated with atmospheric/oceanic phenomena.

The global mean surface temperature (GMST) has increased at nearly 1 degree in the past 120 years. This increase is not monotonically but repeatedly interrupted by decadal hiatuses. The last hiatus was between 2000 and 2010, followed by the recent increase [e.g. Global Warming Projection by JMA]. In this study we analyzed seismometer records to obtain the long-term variation in amplitude of BFO, and compared it with that in GMST.

The target modes are fundamental spheroidal modes ${}_0S_{22}$-${}_0S_{43}$ at frequencies between 3 and 5 mHz because they are most clearly observed in the frequency domain. We use vertical records of STS-1 broadband seismometers at 65 quiet seismic stations downloaded from IRIS DMC. The data periods are from 2003 to 2017. The analysis method is mainly the same as used in Nishida et al. (2000). Continuous records are divided into 3-day records with a step of 1 day. After applying the Hanning taper, each record is converted into power spectral density (PSD) with the correction of system response. To reject noisy data, we discard PSDs whose mean values between 3 and 5 mHz are greater than 10^{-18} m^2/s^3. The remained PSDs are finally stacked over all the stations and over 3 months (91 or 92 days).

The spectrogram has shown clear signals of the fundamental spheroidal modes with the seasonal variation in PSD amplitude. The modes ${}_0S_{29}$ and ${}_0S_{37}$ have prominently larger PSD amplitudes because of the coupling with the acoustic modes of the atmosphere [Nishida et al. 2000]. Besides these well-known characteristics, we have found that the spectrogram indicates larger PSD amplitude after 2010. To compare with the time variation in GMST, we averaged peak PSD amplitudes for the modes ${}_0S_{22}$-${}_0S_{43}$ and plotted the 5-year moving average. The result shows that both the 5-year moving averages correlate well in terms of the increase after hiatus. This is the first observation of the temporal correlation between BFO and GMST. Although the correlation mechanism is unknown at present, the result suggests that the amplitude of BFO may be regarded as an index of the global warming.

