Seasonal and long-term variations in amplitudes of the Earth's background free oscillations and ocean infragravity waves

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The Earth's background free oscillations (BFO) are continuously excited free oscillations of the solid Earth [e.g. Suda et al. 1998]. The observed modes are mainly fundamental modes, suggesting atmospheric and oceanic excitations. The ocean infragravity waves (IGW) are nondispersive propagating waves generated by nonlinear interactions among the wind-waves. [e.g. Longuet-Higgins and Stewart 1962]. The most possible excitation source of BFO is the force exerted on the ocean bottom by the IGW [Nishida 2013] because the dominant periods of those phenomena overlap. We have analyzed time variations in amplitudes of BFO and IGW using several methods of time series analysis. We present the results of the analysis and compare them with the results of the recent meteorological studies.

The time series of global BFO amplitude were created using vertical records of STS-1 broadband seismometers in quiet periods downloaded from IRIS DMC. The data periods are from 2000 to 2017. We divide the frequency domain of 3-5 mHz into the signal and the noise bands [Beroza and Jordan 1990], which correspond to the peak and the trough frequencies of the power spectral density (PSD) of BFO, respectively. By averaging the PSD values in the respective bands, we created the time series of the signal and the noise bands with the sampling interval of one month. We also created the time series of the corrected signal-band by subtracting the noise-band from the signal-band, which represents the true time variations in the BFO excitation. The time series of IGW amplitude with the sampling interval of one month were created using the grid data of WAVEWATCH III [Tolman et al. 1996] downloaded from NOAA NCEI. The data periods are from 2008 to 2017, but the data in 2009 and 2011-2012 are not available. The grid data were averaged in space and time to create time series for the northern-hemisphere, the southern-hemisphere and the global averages. We analyzed these time series using the software package Prophet [Taylor and Letham 2017], which decomposes time series into trend, seasonality and event components using a machine-learning algorithm.

The seasonality of the BFO signal-band is semi-annual with the maxima in July and December, while that of the noise-band is annual with the maximum in December/January. The seasonality of the corrected BFO signal-band is annual with the maximum in July. These indicates the semi-annual variation in the signal-band is the summation of the annual variations in the true BFO excitation and the background noise. All the time series of the IGW amplitude show the clear annual variation. The global and the southern-hemisphere averages have the maximum in July, while the northern-hemisphere has the maximum in December/January. These indicates the global seasonality of IGW is due to the southern-hemisphere component. The correlation between the corrected signal-band of BFO and the southern-hemisphere average of IGW is high (C.C.=0.72), suggesting the excitation of BFO is dominant in the southern hemisphere. Linear trends were obtained from the trend components of the time series. All the linear trends are positive. In particular, the corrected BFO signal-band and the southern-hemisphere average of IGW show a few percent increases. The recent meteorological studies have shown the long-term increase in the global ocean wave power [Reguero et al. 2019; Young and Ribal 2019]. The present result is qualitatively consistent with this positive trend.

Keywords: Earth's background free oscillations, Ocean infragravity waves, Time series analysis

