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Investigations of seismic background noise at long periods

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Several years after the first report by Nawa et al. (1998), the origin of the Earth's background free oscillations, also known as the hum, is still unknown. The aim of our studies is to locate the sources of the globally propagating long-period Rayleigh waves (Nishida et al. 2002) that also make up the hum and, if possible, to identify the acting excitation mechanisms.

Our analyses focus on the broadband stations of the German Regional Seismic Network (GRSN), out of which 8 stations offer the data quality necessary for the investigation of these long-period surface waves. Additionally, some stations in neighbouring countries are included.

We try to locate the sources of the Earth's background oscillations by applying array methods like the frequency-wavenumber analysis on GRSN data. Since the hum is an extremely weak signal that barely exceeds instrument self-noise at even the quietest stations, we have to average over several days or weeks to obtain stable results. Data processing is carried out in several steps:

- splitting the data into 3h segments
- selection of time windows without strong earthquakes by considering total energy and STA/LTA ratio
- f-k analysis between 5 and 8 mHz:

$$E(\vec{k}_o) = \int_{\omega_1}^{\omega_2} \left| \sum_{n=1}^{N} \tilde{X}_n(\omega) e^{-i\omega\, u(\omega) \vec{r}_n \cdot \vec{k}_o} \right|^2 \mathrm{d}\omega$$

- averaging over days/weeks

The energy distribution $E(\vec{k}_o)$ of the long-period Rayleigh wave background as a function of time and back azimuth clearly shows a seasonal variation of back azimuth. The presence of such seasonal variations suggests an atmospheric and/or oceanic excitation of the hum.

In agreement with Rhie & Romanowicz (2004), a triangulation performed by using some stations of the Berkeley Digital Seismic Network (BDSN) as a second array shows that the Earth's background oscillations are excited mainly on the winter hemisphere.

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