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Estimates of Rayleigh-to-Love wave ratio in microseisms by co-located Ring Laser and STS-2

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In older studies of microseisms (seismic noise), it was often assumed that microseisms, especially the secondary microseisms (0.1-0.3 Hz), mainly consist of Rayleigh waves. However, it has become clear that there exists a large amount of Love-wave energy mixed in it (e.g., Nishida et al., 2008). However, its confirmation is not necessarily straightforward and often required an array of seismographs.

In this study, we take advantage of two co-located instruments, a Ring Laser and an STS-2 type seismograph, at Wettzell (WET), Germany (Schreiber et al., 2009). The Ring Laser records rotation (its vertical component) and is thus only sensitive to Love waves. The vertical component of STS-2 seismograph is only sensitive to Rayleigh waves. Therefore, a combination of the two instruments provides a unique opportunity to separate Rayleigh waves and Love waves in microseisms.

The question we address in this paper is the ratio of Rayleigh waves to Love waves in microseisms. For both instruments, we analyze data from 2009 to 2014. Our basic approach is to create stacked vertical acceleration spectra for Rayleigh waves from STS-2 and stacked transverse acceleration spectra for Love waves from Ring Laser. The two spectra at Earth's surface can then be compared directly by their amplitudes.

The first step in our analysis is a selection of time portions (each six-hour long) that are least affected by earthquakes. We do this by examining the GCMT (Global Centroid Moment Tensor) catalogue and also checking the PSDs for various frequency ranges.
The second step is to create stacked (averaged) Fourier spectra from those selected time portions. The key is to use the same time portions for the STS-2 and the Ring Laser data so that the two can be directly compared.

The vertical spectra from STS-2 are converted to acceleration spectra. The Ring Laser rotation spectra are first obtained in the unit of radians/sec (rotation rate). But as the Ring Laser spectra are dominated by fundamental-mode Love waves, the rotation spectra can be converted to transverse (SH) acceleration by multiplying them by the factor 2xCp where Cp is the Love-wave phase velocity. We used a seismic model by Fichtner et al. (2013) at WET to estimate Love-wave phase velocity. This conversion from rotation to transverse acceleration was first extensively used by Igel et al. (2005) for the analysis of lower frequency Love waves and the same relation holds for our spectral data.

The two spectra provide the ratio of surface amplitudes. In the frequency range of secondary microseisms (0.10-0.35 Hz), they are comparable; near the spectral peak (∼0.20 Hz), Rayleigh waves are about 20 percent larger in amplitudes but outside this peak region, Love waves have comparable or slightly larger amplitudes than Rayleigh waves. Therefore, the secondary microseisms at WET consist of similar contributions from Rayleigh waves and Love waves.