Theoretical Low Noise Model for Rotational Ground Motions

[1] LMU Munich, Germany
[2] IPGP, Paris, France
[3] TU Munich, Germany
[4] IES, Taipei, Taiwan

Andreas Brotzer[1] | Heiner Igel[1] | Éléonore Stutzmann[2] | Jean-Paul Montagner[2] | Joachim Wassermann[1] | Felix Bernauer[1] | Ulrich Schreiber[3] | Chin-Jen Lin[4]

1 Why a Low Noise Model?

A low noise model characterizes the lowermost expected noise level for a certain measurement across a frequency range. For vertical translational ground motions on Earth a New Low / High Noise Model (NLNM / NHNM) was defined by Petersen (1993) using data of 75 globally distributed seismic stations. Knowing Earth's seismic background noise floor not only reveals interesting characteristics of the planet, such as the primary and secondary microseisms or hum, but also defines a target limit in terms of instrument self-noise performance. A low noise model for rotational ground motion does not yet exist.

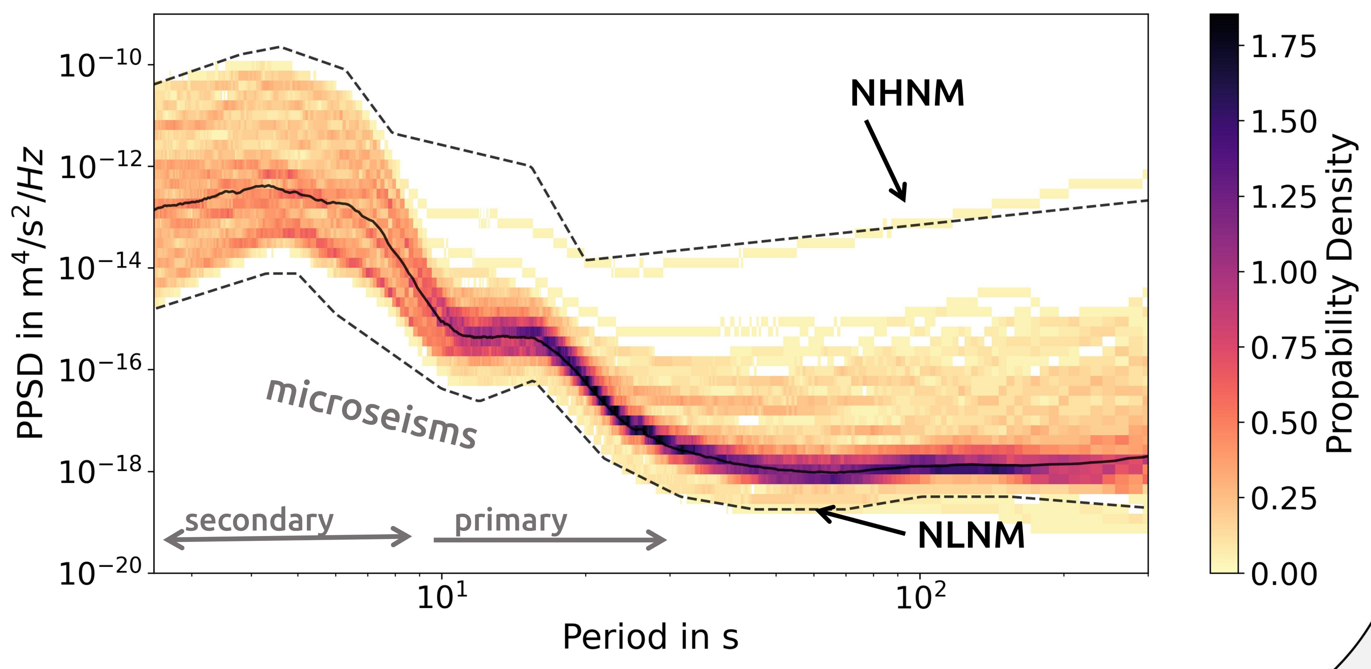

FIG 1: PPSD of selected GEOSCOPE stations (vertical component).

2 Methodology

The transverse acceleration a_T and vertical rotation rate Ω_z are related via the phase velocity c_{ph} (Pancha et al., 2000) mainly accounting for SH-wave types (Love waves):

$$-2c_{ph} = \frac{a_T}{\Omega_z},$$

while for Rayleigh waves (SV-wave type) the transversal rotations and vercial acceleration are relevant:

$$c_{ph} = \frac{a_z}{\Omega_T}.$$

To compute a Rotational Low Noise Model from the the vertical NLNM in dB the conversion is set as:

$$PSD_\Omega = \left(\sqrt{10^{PSD^{dB}_{acc}/10}}/c_{ph}\right)^2 \quad \left[\frac{rad^2}{s^2 Hz}\right]$$

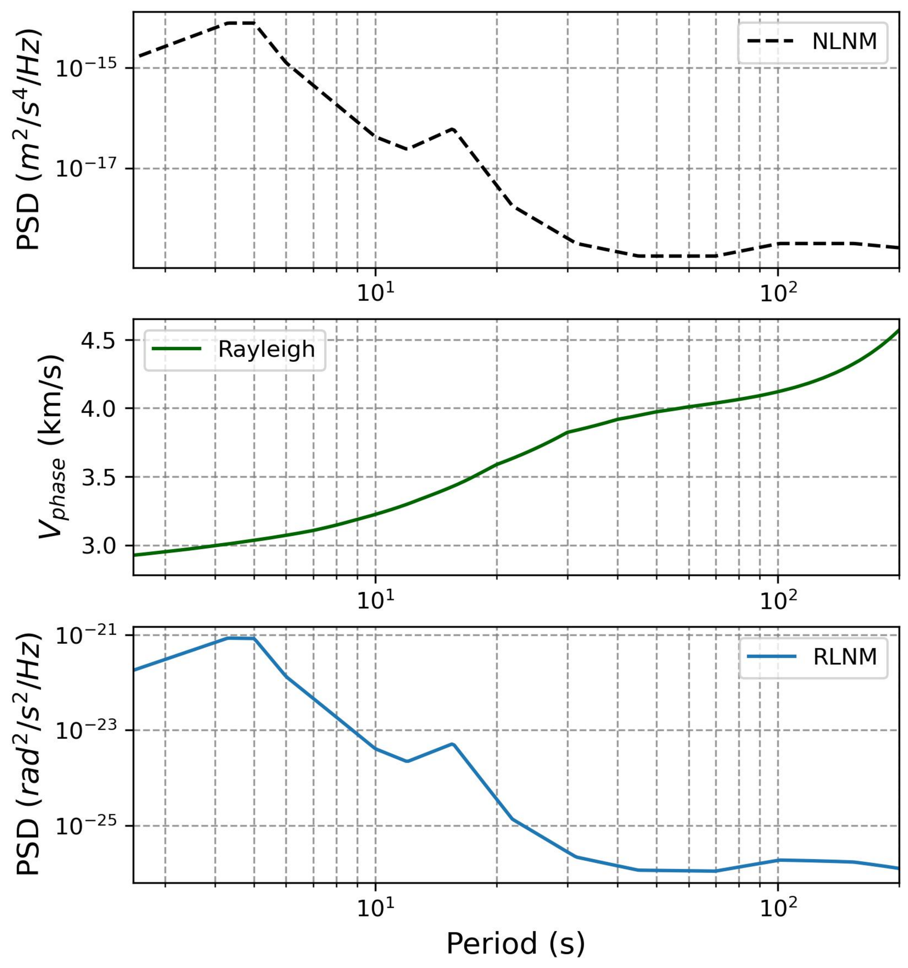

FIG 2: Steps for inferring a theoretical RLNM with a global Rayleigh phase velocity curve.

3 Phase Velociy Model

Extracting phase velocity curves of the global 1x1 degree resolution CRUST1.0 model (Laske et al., 2013) rather equally sampled on continents only enables to compute a median velocity profile for Rayleigh and Love waves, which is used to compute a RLNM.

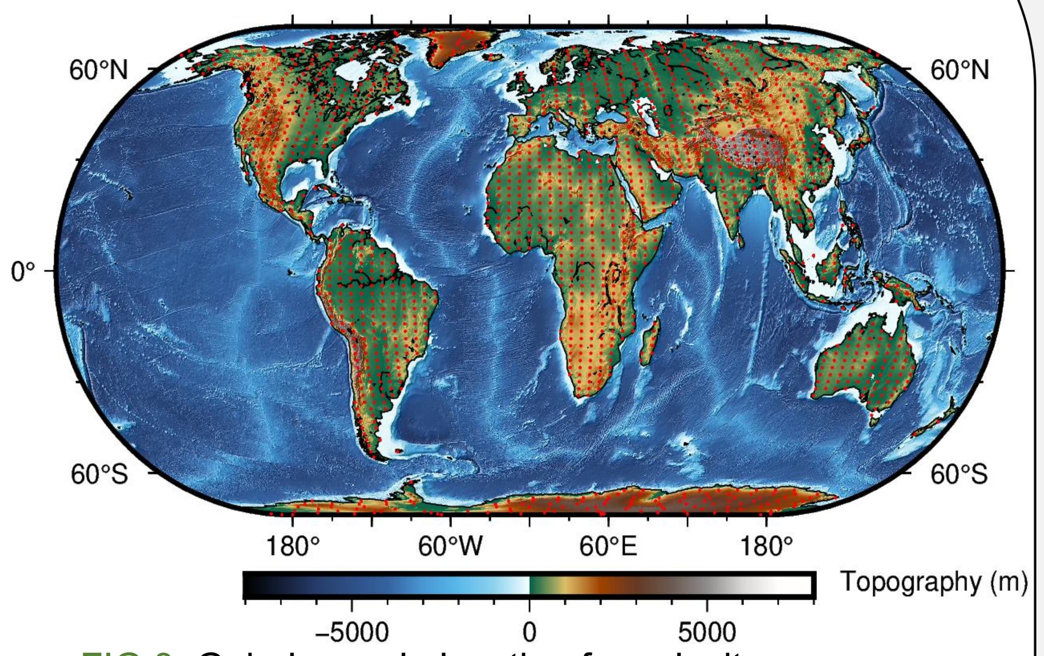

FIG 3: Gobal sample location for velocity curves.

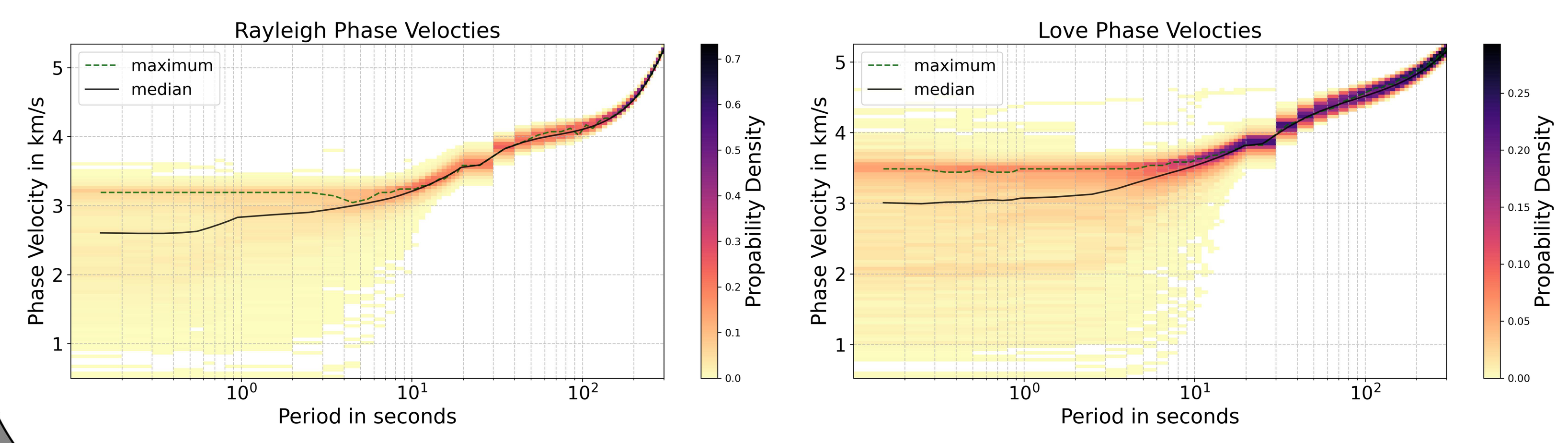

FIG 4: Probability density of phase velocity curves for Rayleigh (left) & Love (right) waves.

4 Observational Data

Available observational data:

- direct ground rotation measurements (3C ROMY, 1C RLAS, ...)
- array derived rotations (PFO Array, ROMY Array, ...)
- translational motions converted to rotations (GeoScope stations)

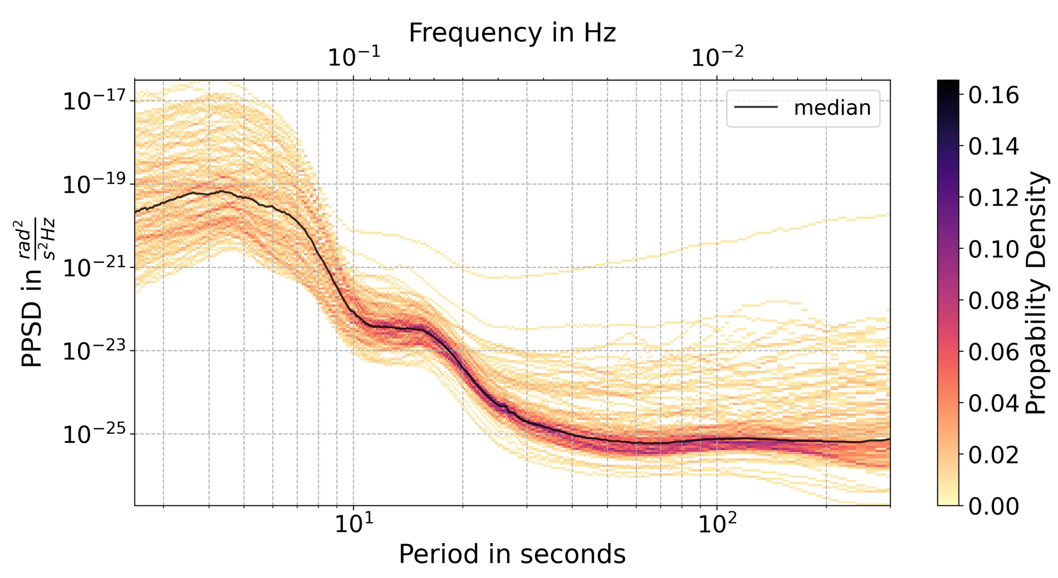

FIG 5: Rotations inferred from GEOSCOPE stations.

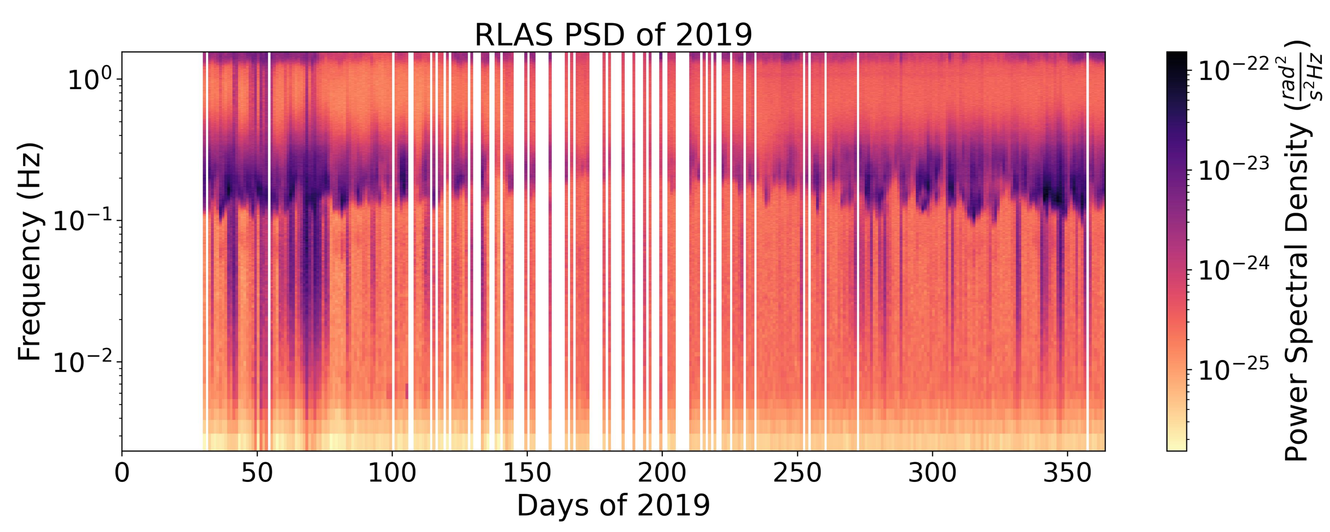

FIG 6: Median of hourly PSDs for each day in 2019 for RLAS ring laser.

6 Discussion

The model is only justified in a frequency band of about 2 - 100 s that contains SV polarized surface waves (Rayleigh). The ROMY-Z and RLAS-Z is sensitive to rotations induced by SH-waves (Love). The ROMY-N and ROMY-E PSDs are infered from less than one day of data, hence less representative. The ROMY 2022 PSD is a selection of several days in March 2022 which also shows the destinct double peak at within the secondary microseism range that is observed for the PFO ADR data as well.

- Should there be a separate low noise model for vertical and transversal rotations ? This would, however, require a horizontal low noise model for translations.
- Why is the RLAS PSD below the RLNM ? Are the assumptions of SV-wave type contributions to infer rotations justified ?
- Is an estimated low now noise model for translation, rotation and strain for extraterrestrial bodies with low data coverage (Moon and Mars) aspirable ?

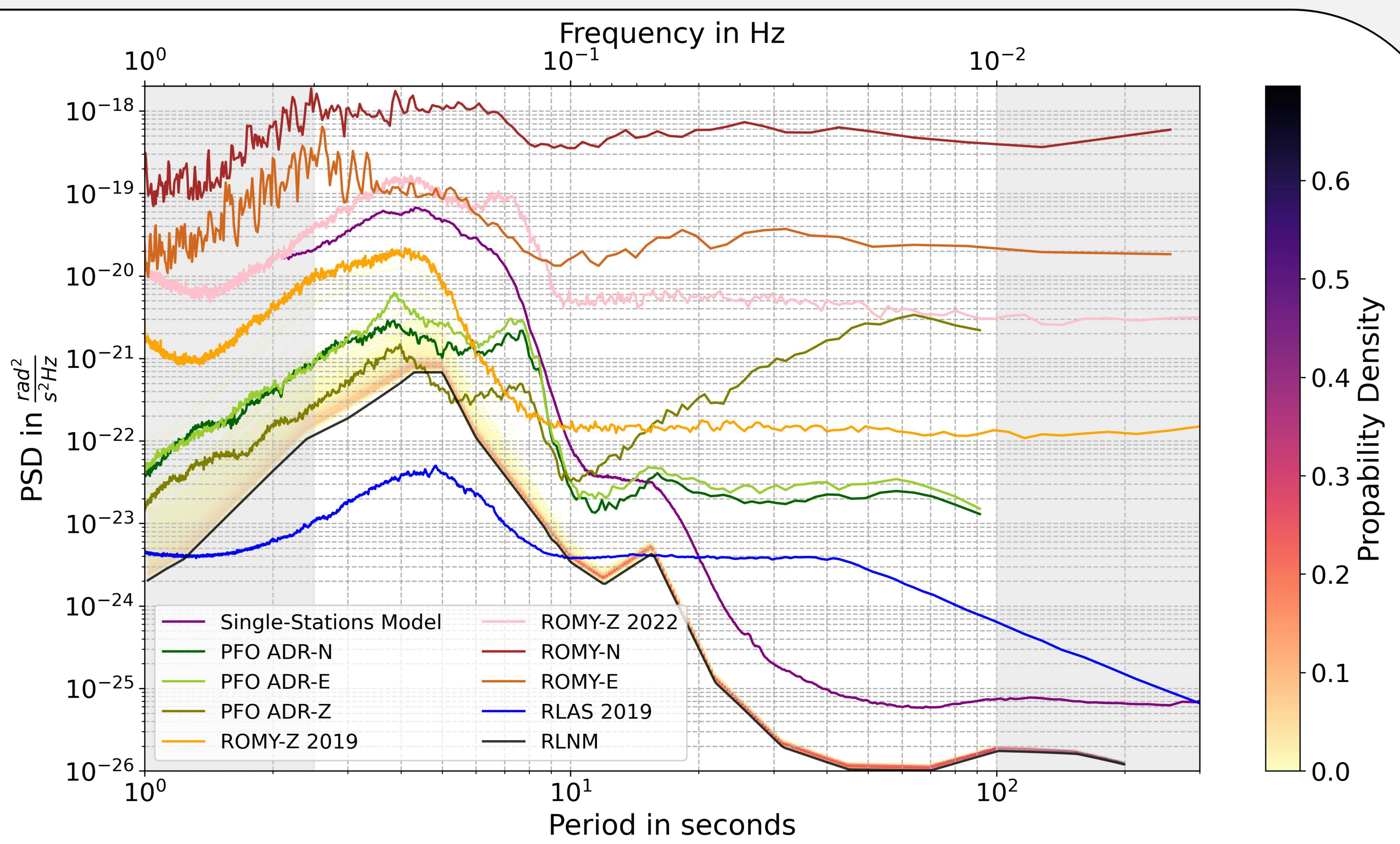

FIG 7: Comparison of RLNM and various observational data for ground rotations.

References:

- Petersen, J. R. (1993), Observations and modeling of seismic background noise, Open-File Report, 93-322, *https://doi.org/10.3133/ofr93322*
- Laske, G., et al. (2013), Update on CRUST1.0 - A 1-degree Global Model of Earth's Crust, Geophys. Res. Abstracts, 15, Abstract EGU2013-2658
- Pancha, A., et al. (2000), Ring laser detection of rotations from teleseismic waves, GRL, *https://doi.org/10.1029/2000GL011734*

Contact

www.rotational-seismology.org

Andreas Brotzer | LMU | brotzer@geophysik.uni-muenchen.de