The origin of Love waves in the ocean generated noise wave field

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Motivation

Ocean generated noise contains considerable amount of Love wave energy for periods smaller than T=20s.

Gualtieri et al. (2013) demonstrated the discrepancy between real and synthetic energy spectra on horizontal displacement components.

Questions arise:
- **How** are microseismic Love waves generated?
- **Where** are Love waves generated?
- **How much** energy do Love waves contribute to the seismic noise wave field?
- **When** are the strongest waves generated?

Possible mechanisms of Love wave generation:
1. Vertical force acting on a sloped bathymetry
2. Rayleigh wave conversion - bathymetry
3. Rayleigh wave conversion - internal scattering

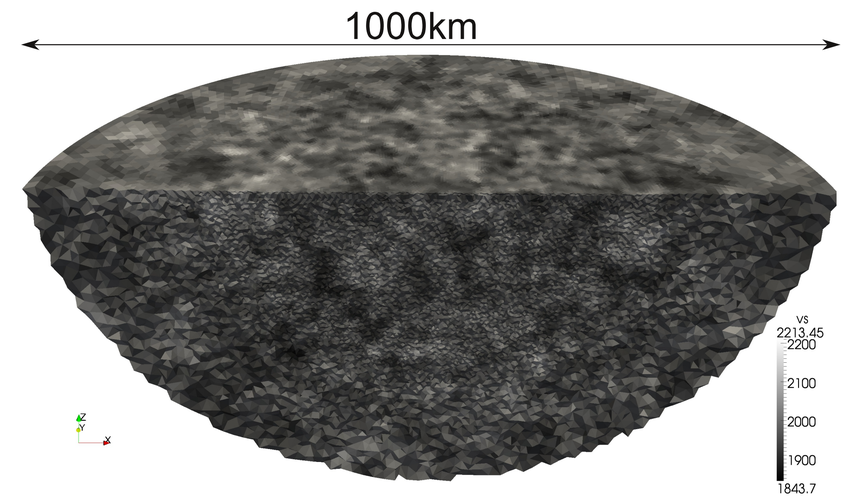
We investigate Love wave generation by scattering.

Random Medium

Heterogeneities in the Earth are characterized as superposition of deterministic and random velocity model.

Random media can be defined by a Fourier transform of a particular correlation function.

Von Karmann type functions are frequently used in geosciences:



$$P(k) = \frac{\sigma^2 (2\sqrt{\pi}a)^E \Gamma(N + \frac{E}{2})}{\Gamma(N)(1 + k^2 a^2)^{(N+\frac{E}{2})}}$$

a - correlation length, s - standard deviation
N - Hurst exponent, E - Euclidean dimension
k - wavenumber

Von Karmann media have fractal (scale-invariant) properties at length scales smaller than the correlation distance. The Correlation length is the upper cut-off of the fractal behaviour.

We applied the following parameters:
a = 10km, s = 5%, N = 0.2, vp = 3000m/s, vs = 2000m/s, rho = 2830kg/m3

Numerical Verification of Scattering Statistics - Equipartitioning

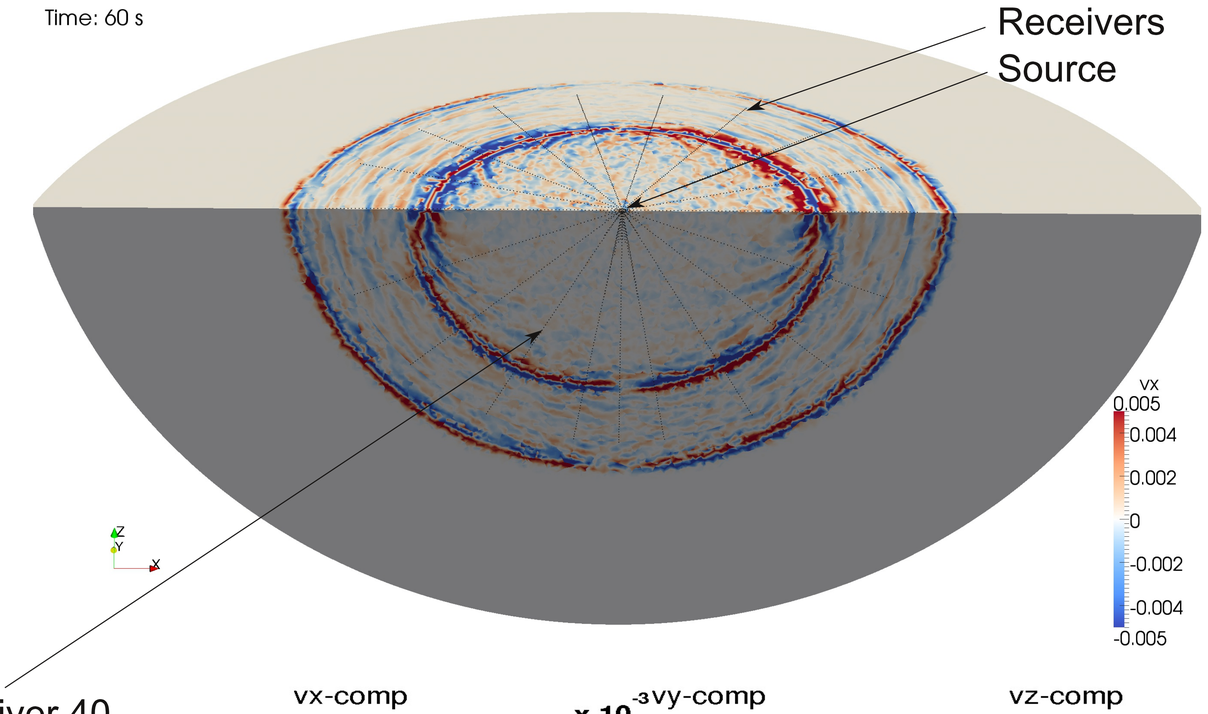
Coda energy follows the equipartitioning of the diffuse wavefield first discussed by Weaver(1982)

Any energy ratio becomes time independent, and independent of magnitude, polarization and distance of the source

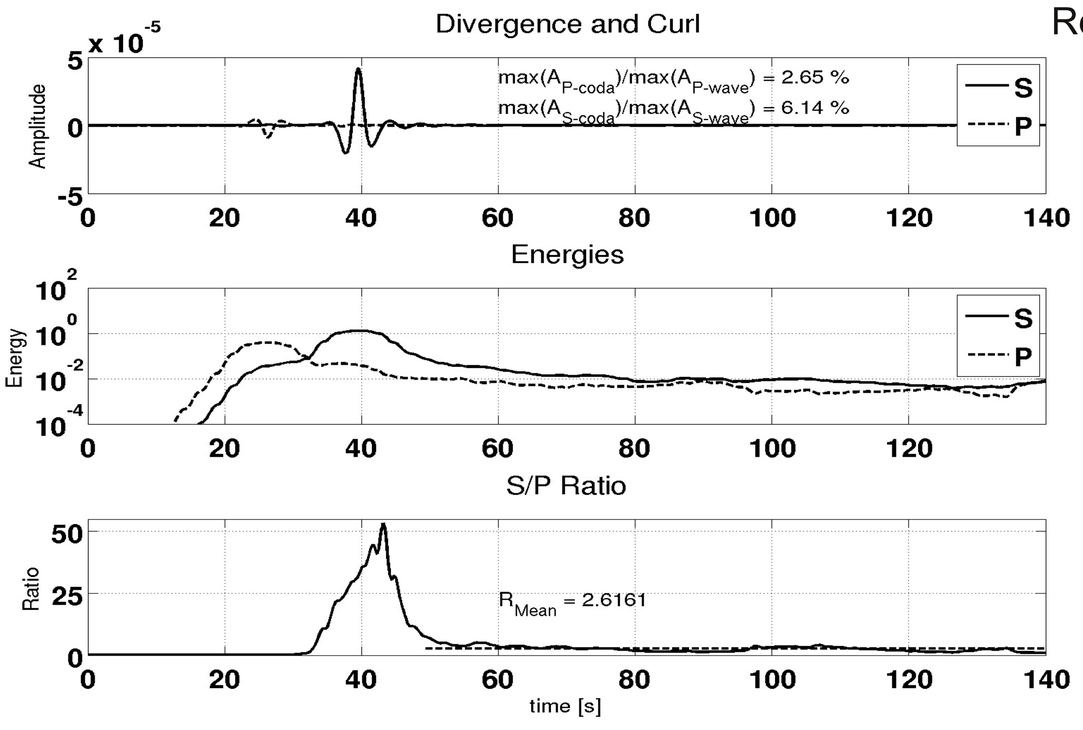
Numerical simulation using the ADER-DG method:
- unstructured tetrahedral grid
- vertical force source, central period of T = 4s
- von Karmann medium

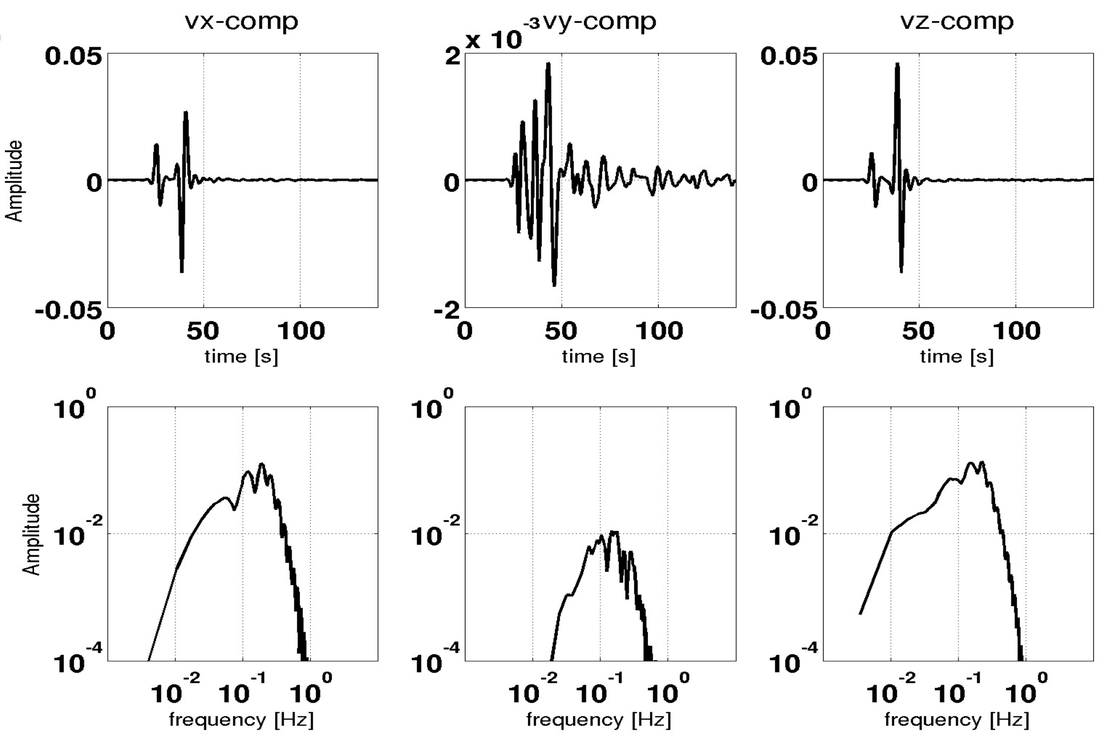
Energy/Ratio calculation by 3D curl and divergence output:
- sliding time window of Tw = 8s
- equipartition ratio Es/Ep calculated from t = [50-140]s

$$E_p = (\lambda + 2\mu)(\mathrm{div}(\mathbf{v}))^2 \quad \text{and} \quad E_s = \mu |\mathrm{rot}(\mathbf{v})|^2$$



Receiver 40





Summary

The generation of Love wave energy in the oceanic noise is not fully understand. Several excitation mechanisms have to be tested. To investigate Rayleigh wave scattering into Love waves, the scattering properties of a von Karmann type medium have to be determined. The simulations show only weak scattering effects. This results in a large discrepancy between the theoretical value (R = 7.2) and the numerically determined value (R=2.6) of the S/P ratio.

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