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Measuring the scattering mean free path of Rayleigh waves on a volcano from spatial phase decoherence

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We analyze the statistics of phase fluctuations of seismic signals obtained from a temporary small aperture array deployed on a volcano in the French Auvergne. We demonstrate that the phase field satisfies Circular Gaussian statistics. We then determine the scattering mean free path of Rayleigh waves from the spatial phase decoherence. This phenomenon, observed for diffuse wavefields, is found to yield a good approximation of the scattering mean free path. Contrary to the amplitude, spatial phase decoherence is free from absorption effects and provides direct access to the scattering mean free path.

Our method may find applications in various areas of seismology where the effects of scattering are prominent and a knowledge of the scattering properties is necessary to describe the propagation. As an example, an unbiased estimate of the scattering mean free path is crucial for the localization of changes in multiply scattering media, where a sensitivity kernel based on diffusion theory is used (Larose et al. 2010; Obermann et al. 2013a,b). Our experimental approach may also provide independent estimates of the scattering mean free path in volcanic areas where particularly strong scattering has been proposed, based on the fitting of energy envelopes using energy transport approaches (Wegler & Lühr 2001; Yamamoto & Sato 2010).

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