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Retrieval of Green's function in a 3D inhomogeneous medium with nonisotropic source distribution using interferometry

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Seismic interferometry is known to retrieve Green's functions in an elastic homogeneous medium with isotropic source distribution (e.g., Wapenaar and Fokkema, 2006), and is applied to estimate velocity structures using long time series of ambient noises (e.g., Shapiro and Campillo, 2004). However, the realistic noise field might be an inelastic inhomogeneous medium with nonisotropic source distribution, and thus the reliability of retrieval of Green's functions using seismic interferometry should be examined.

We study on the reliability of seismic interferometry in a 3D inhomogeneous structure model of Kanto basin with nonisotropic source distribution. The numerical study on seismic interferometry was conducted by using 3D FDM. We cross correlated the surface responses at two sites with multiple surface sources. We used Yamanaka and Yamana (2006) for the 3D inhomogeneous model of Kanto basin. Nonisotropic source distribution was made by using sources located only on the sea area. We investigated the influence for the cross correlation functions by comparing with that in a homogeneous medium or isotropic source distribution.

In a case of homogeneous medium with isotropic source distribution, we see slight difference between the cross correlation function and Green's functions, but the surface wave component was well retrieved and surface wave velocity compares well with the Green's function. The slight difference might have been caused by the approximations in seismic interferometry (e.g., Kimman and Trampert, 2010). The cross correlation function showed symmetry for positive and negative lagtimes. In a case of homogeneous with nonisotropic source distribution, the cross correlation function shows asymmetry whose surface wave cannot be seen in positive lagtimes. However, the cross correlation functions in negative lagtime compares well with that retrieved with isotropic source distribution, and it showed good agreement in terms of group velocity. These indicate the influence of source distribution on seismic interferometry would be large as indicated in numerous studies (e.g., Tsai, 2010).

In a case of a 3D inhomogeneous model of Kanto basin, the cross correlation function showed asymmetry even with isotropic source distribution. That is, an inhomogeneity complicates wave propagations and then make apparent source distribution non-isotropic even with the isotropic case. Specifically, larger amplitudes in negative lagtimes than that in positive lagtimes indicate that eastern sources became large apparently. Considering the Kanto basin model, Kanto mountains located in western part and Pacific Ocean located in eastern part, where have thick sediment layers, the eastern sources would have excited surface wave significantly, which caused apparent nonisotropic source distribution. Due to asymmetry in the cross correlation function, it does not match with the Green's function. Group velocities also show asymmetry, however, they agrees to that of Green's function. In a case of a 3D inhomogeneous model with nonisotropic source distribution, the cross correlation function shows asymmetry and show less agreement with the Green's function. However, the group velocity shows agreement.

As a result, the retrieval of Green's function using seismic interferometry is strongly influenced by source distributions. Moreover, an inhomogeneity affect to source distribution, it would also be the problem. In a realistic case, therefore, to understand how much isotropy is satisfied is important. Because understanding the source isotropy is tough, it is important to examine the influence considering with realistic applications. However, on group velocity estimations as many applications, the reliability showed good in this study, suggesting the high possibility for reliable applications in seismic interferometry.

Keywords: Seismic interferometry, Green's function, inhomogeneous, isotropic source, 3D FDM