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On the accuracy of scattered Rayleigh waves estimated with a correlation method

Dylan Mikesell (1), Kasper van Wijk (2), Thomas Blum (2), Roel Snieder (3), and Haruo Sato (4)

(1) Géoazur, Université de Nice Sophia-Antipolis, Centre National de la Recherche Scientifique (UMR 6526), Observatoire de la Côte d'Azur, Valbonne, France (dmikesell@geoazur.unice.fr), (2) Physical Acoustics Laboratory, Department of Geosciences, Boise State University, Boise, Idaho, USA, (3) Center for Wave Phenomena, Department of Geophysics, Colorado School of Mines, Golden, Colorado, USA, (4) Department of Geophysics, Graduate School of Science, Tohoku University, Aoba-ku, Sendai, Japan

It is now well understood how correlation of the seismic wave fields recorded at two points leads to an estimate of the Green's function between those two points. However, in field applications we rarely, if ever, satisfy all of the theoretical requirements to accurately estimate the complete (direct and scattered) Green's function. Rather, we are often able to construct only the direct wave part. Laboratory measurements allow us to investigate the accuracy of Green's functions constructed from correlation techniques in a controlled environment. Here we use an acoustic approximation to the complete elastodynamic correlation equation to estimate the ultrasonic Rayleigh-wave Green's function for surface waves propagating in an aluminum block with point scatterers. Utilizing source-receiver reciprocity, we sum correlations of the wave fields measured all around two excitation points to estimate the Green's function between these two points. In this way, we investigate the accuracy of the estimated scattered Rayleigh waves. The complete elastodynamic interferometric relationship accounts for the direct wave and the scattered fields; however, we find that under the acoustic approximation the scattered field is not recovered as accurately as the direct field. Finally, looking in the cross-correlation domain, we find that the correlations themselves provide insights into the location of the point scatterers as well as which scatterer is responsible for particular parts of the complicated scattered field. Furthermore, these measurements confirm a constant-time arrival in the correlations, not part of the Green's function, but which has previously been derived as a result of the generalized optical theorem.