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Adjoint-tomography Inversion of the Small-scale Surface Sedimentary Structures: Key Methodological Aspects

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Adjoint tomography has proven an irreplaceable useful tool in exploring Earth's structure in the regional and global scales. It has not been widely applied for improving models of local surface sedimentary structures (LSSS) in numerical predictions of earthquake ground motion (EGM).

Anomalous earthquake motions and corresponding damage in earthquakes are often due to site effects in local surface sedimentary basins. Because majority of world population is located atop surface sedimentary basins, it is important to predict EGM at these sites during future earthquakes.

A major lesson learned from dedicated international tests focused on numerical prediction of EGM in LSSS is that it is hard to reach better agreement between data and synthetics without an improved structural model.

If earthquake records are available for sites atop a LSSS it is natural to consider them for improving the structural model. Computationally efficient adjoint tomography might be a proper tool.

A seismic wavefield in LSSS is relatively very complex due to diffractions, conversions, interference and often also resonant phenomena. In shallow basins, the first arrivals are not suitable for inversion due to almost vertical incidence and thus insufficient vertical resolution. Later wavefield consists mostly of local surface waves often without separated wave groups. Consequently, computed kernels are complicated and not suitable for inversion without pre-processing.

The spatial complexity of a kernel can be dramatic in a typical situation with relatively low number of sources (local earthquakes) and surface receivers. This complexity can be simplified by directionally-dependent smoothing and spatially-dependent normalization that condition reasonable convergence.

A multiscale approach seems necessary given the usual difference between the available and true models. Interestingly, only a successive inversion of μ and λ elastic moduli, and different scale sequences lead to good results.