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Adjoint-tomography for a Local Surface Structure: Methodology and a Blind Test

Filip Kubina (1), Filip Michlik (1), Peter Moczo (1,2), Jozef Kristek (1,2), and Svetlana Stripajova (1)
(1) Comenius University in Bratislava, Slovakia, (2) Slovak Academy of Sciences, Bratislava, Slovakia

We have developed a multiscale full-waveform adjoint-tomography method for local surface sedimentary structures with complicated interference wavefields.

The local surface sedimentary basins and valleys are often responsible for anomalous earthquake ground motions and corresponding damage in earthquakes. In many cases only relatively small number of records of a few local earthquakes is available for a site of interest. Consequently, prediction of earthquake ground motion at the site has to include numerical modeling for a realistic model of the local structure. Though limited, the information about the local structure encoded in the records is important and irreplaceable. It is therefore reasonable to have a method capable of using the limited information in records for improving a model of the local structure.

A local surface structure and its interference wavefield require a specific multiscale approach. In order to verify our inversion method, we performed a blind test. We obtained synthetic seismograms at 8 receivers for 2 local sources, complete description of the sources, positions of the receivers and material parameters of the bedrock. We considered the simplest possible starting model – a homogeneous halfspace made of the bedrock.

Using our inversion method we obtained an inverted model. Given the starting model, synthetic seismograms simulated for the inverted model are surprisingly close to the synthetic seismograms simulated for the true structure in the target frequency range up to 4.5 Hz. We quantify the level of agreement between the true and inverted seismograms using the L2 and time-frequency misfits, and, more importantly for earthquake-engineering applications, also using the goodness-of-fit criteria based on the earthquake-engineering characteristics of earthquake ground motion.

We also verified the inverted model for other source-receiver configurations not used in the inversion.