EGU24-7099, updated on 10 Oct 2024
https://doi.org/10.5194/egusphere-egu24-7099
EGU General Assembly 2024

Three-dimensional shallow velocity structure beneath the urban agglomerations revealed by methane source and dense array

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The three-dimensional (3D) velocity structure beneath urban agglomerations is an important data for urban construction planning and earthquake hazard risk assessment. Combining a short-period dense array with the active source can enable us to conduct high-resolution imaging of shallow structures, with a short observation time. With the increasing limitations on the usage of explosives, we have developed a new type of active source, the methane source, which has been proven to be environmentally friendly, efficient, safe, and economical. It produces seismic waves by rapidly releasing high-pressure air in borehole by igniting oxygen and methane with the reaction products of carbon dioxide and water, and can be applied to various complex terrains to detect small-scale subsurface structures, particularly in cities and fault zones.

To obtain the high-resolution structure beneath the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), we deployed a dense array consisting of 6,172 short-period stations, and carried out 63 active source excitations using new methane green sources in 2020. Using the manually picked 16,885 first-arrival phases from 63-shots methane sources, we present the first high-resolution 3D shallow P-wave velocity structure (above 1.5 km depth) in the central area of the GBA. The obtained results show that (1) the velocity images have a good correspondence with the regional topography and shallow lithology distribution. The depression area presents a low Vp distribution, while the uplift area with high Vp anomalies, which corresponds to clastic sedimentary rocks, granites, and metamorphic rocks, respectively. (2) The velocities have a strong anomaly on both sides of the Guangcong fault, Shougouling fault, Zhujiangkou fault, and Baini-Shawan fault. Among them, the Shougouling fault has the strongest controlling effect, making the velocity images show obvious differences between the north and south side along the fault at different depths. (3) The cross-fault velocity profiles show that regional faults control the distribution and burial depth of sedimentary layers. Our study shows that combination using of new green methane source and dense short-period array is an effective method to detect the shallow velocity structure and fault system under urban agglomerations.