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Application of a new type of six-component seismometer for underground anomaly detection

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A new type of portable six-component seismometer is invented and used in the development of a seismic imaging method for shallow subsurface anomaly detection. This new six-component seismometer contains a mini-MEMS-array for acceleration and rotational velocity measurements. The self-noise for acceleration measurement is about 8 μg/√Hz, and the self-noise for rotational velocity measurement is about 5 μrad/s/√Hz. The frequency band is DC-1000 Hz. Different from the traditional seismic imaging methods that require the deployment of an array of either one-component or three-component seismometers, our imaging method is established based on the data recorded at individual six-component seismometer. Because the rotational field (i.e., the curl field) gives information about the spatial gradient of a seismic wavefield, so the translational field together with the rotational field can be used to derive the frequency-dependent velocity (i.e., dispersion) of the formation right beneath a seismic station. This single station velocity inversion approach delivers localized subsurface velocity information, making it suitable for imaging of small-scale underground anomalies. Especially, the Rayleigh wave dispersion is used in our method as Rayleigh wave is generally the dominant signal in surface seismic data. An underground velocity model can be immediately constructed by consolidating the dispersion curves derived from individual receivers. In our study, we first demonstrate the accuracy of our imaging method through numerical modeling of various scenarios of subsurface anomalies and then conduct an experiment to further verify the performance of our self-invented six-component seismometer and the field applicability of our imaging method.