S31D-0556 - Matrix approach of seismic wave imaging: Overcome phase distortions and multiple scattering

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Moscone South - Poster Hall

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Abstract

Multiple scattering and phase distortions of seismic waves are often seen as a nightmare for conventional migration techniques that generally rely on a ballistic or a single-scattering assumption. In heterogeneous areas such as volcanoes or fault zones, the multiple-scattering contribution limits the imaging-depth to one scattering mean free path, the mean distance between two successive scattering events for body waves. Moreover, large-scale wave speed inhomogeneities induce phase distortions that tend to deteriorate the resolution and contrast of the subsoil image. Inspired by previous works in ultrasound imaging, we propose a reflection matrix approach of passive seismic imaging that allows to overcome those two fundamental issues by making an efficient use of scattered body waves drowned into a noisy seismic coda. Our method is based on the projection of the reflection matrix recorded at the surface to depth by applying focusing operations at emission and reception. Iterative time reversal is then applied in order to: (i) remove the predominant multiple scattering background; (ii) compensate for phase distortions in order to recover an image resolution only limited by diffraction. Although seismic noise is dominated by surface waves, these adaptive focusing operations allow to extract the body wave components and take advantage of them to build a constrasted image of in-depth structures. As proofs-of-concept, the matrix approach is applied to the in-depth imaging of two particularly heterogeneous areas : the Erebus volcano in Antarctica (Blondel et al., J. Geophys. Res.: Solid Earth, 2018 - see figure below) and the San Jacynto Fault zone in California (Ben-Zion et al., Geophys. J. Int., 2015). This matrix approach paves the way towards a greatly improved monitoring of volcanic or tectonic structures in depth. Beyond these specific cases, this matrix method can generally be applied to all scales and areas where wave aberrations and multiple scattering prevent from an in-depth imaging of the Earth's crust.

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