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Virtual Seismology: monitoring the Earth's crust with virtual sources and virtual receivers in the subsurface

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In classical seismic interferometry, the Green's function between two receivers is obtained by cross-correlating the responses recorded by these receivers. In other words, one receiver is turned into a virtual source, and its response is measured by the other. An underlying assumption is that the receivers are illuminated uniformly from all directions. Recent developments, building on the Marchenko method, show that the Green's function can also be retrieved from single-sided reflection data. It appears that virtual sources and/or virtual receivers can be created at any position in the subsurface, without needing physical instruments at the positions of the virtual sources and receivers, without requiring omnidirectional illumination of those positions and without needing a detailed subsurface model: a smooth velocity model suffices. The created virtual sources and receivers are (nearly) omnidirectional and the retrieved Green's functions account for multiple scattering in the inhomogeneous subsurface. This method, which we call "virtual seismology", enables new ways of monitoring the earth's crust. For example, in areas prone to induced seismicity, virtual seismology enables to follow the complex wave field of induced earthquakes all the way from the source to the surface, to characterize the radiation properties of the earthquakes and to forecast the wave field and associated ground motion of possible future induced earthquakes. In the presentation we will demonstrate the principle of virtual seismology with physical model data and field reflection data.