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Coherent body waves in the coda of earthquakes recorded by an underground array

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Local and regional earthquakes recorded in 2007 by the Underseis seismic array, located 1.4 km deep in the Gran Sasso underground Physics Laboratories (LNGS-INFN), have been analyzed. The same earthquakes were recorded also by a temporary seismic array installed at surface in the same area. Coherence, propagation parameters (apparent velocity and azimuth) and polarization properties of the seismic wavefield of more than 50 earthquakes have been estimated at both arrays, using three array techniques in spectral and time domain. The comparison between the results obtained at surface and at depth shows some significant differences. The most striking result is the abundance of well-correlated phases along the coda recorded at depth, compared with the coda recorded at surface. Results of array analysis demonstrate that such coherent signals are body waves. The timing and propagation azimuth of coherent body waves indicate that near receiver scattering gives a contribution greater than near source scattering. The contribution of surface waves at depth is negligible for frequency higher than 2 Hz as expected, while it may be predominant in the coda recorded at surface. At depth the coda of local earthquakes is characterized by a coherence much higher than at surface. This is explained by the much more uniform site response among the deep stations compared with the site effects observed at surface.
The azimuth distribution of the most coherent coda waves does not show any particular characteristics. The seismic noise in the high frequency range (> 5Hz) is considerably different at the two sites, with much smaller amplitude and lower variations with time at depth. The observation of the same earthquakes by two arrays, one at surface and one at depth, gives important insight on the study of the seismic wave propagation.