Global characterization of lateral heterogeneity in the lithosphere revealed from transverse amplitudes of teleseismic P-waves

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We systemically characterize the random heterogeneity of the lithosphere by analyzing short-period seismic amplitudes of transverse component, mainly consisting of scattered waves from lateral heterogeneities. It is in contrast to vertical and radial components which are affected by not only random heterogeneity but also layered structure. We use records of broadband seismic data from 72 stations of the IRIS GSN network deployed around the world. Since deep events are limited in space, we focus on shallow events widely distributed on the globe. We concern events with focal depth less than 35 km and magnitude between 5 and 6, in the period of 1998 to 2002. The source-receiver range is restricted from 30 deg to 60 deg to avoid contaminations from the core reflected phases beyond 60 deg. Within this range, the converted phases from the mantle transition zone do not appear in P-coda waves for at least 60 seconds. Velocity traces are bandpass filtered for 0.5-1, 1-2, and 2-4 Hz ranges where large signal to noise ratios are observed. For each event-station pair, we calculate the ratio of seismic energy in the transverse component to the total seismic energy of the three components for a 20 second window starting from the onset. Taking the square root of the ratio averaged for all events recorded at each station, we obtain the average normalized transverse amplitude. The observed average normalized transverse amplitudes indicate significant regional difference of heterogeneity. All of small amplitudes are found at stations on stable continents where the seismicity is very low, as the total numbers of earthquakes with magnitude greater than 5 occurring within a distance of 300 km from each station for the past 30 years, are less than 25. On the other hand, large amplitudes are generally observed at stations located on active tectonic regions such as along the subduction zones, collision zones and transform faults. The seismicity around these stations is generally high so that large transverse amplitudes reflect strong small scale heterogeneities such as cracks and faults generated by deformation of the crust caused by stress accumulation. We found that 18 stations with large normalized transverse amplitude show very low seismicity as continental stations do and that no earthquake of magnitude greater than 5 is observed around 8 among these stations. Half of these stations without earthquakes of magnitude greater than 5 however are located around hypocenters of small earthquakes of magnitude greater than 3 detected by NEIC/USGS or around Holocene volcanoes, so that large normalized transverse amplitudes are related to heterogeneity caused by recent activities in the lithosphere. However, no seismic and volcanic activities are recognized at several stations on the eastern Eurasian, central North American and central South American continents, and at the south pole in Antarctic. The origins of strong lateral heterogeneity existing around these stations are still unknown, but may be related with ancient activities of the lithosphere.