Compressional-Wave Studies on the Frequency Dependence of and Lateral Variations in Mantle Attenuation

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We study the frequency dependence of and lateral variations in P-wave attenuation in the mantle by analyzing the spectra from >18,000 P and >14,000 PP arrivals. We select seismograms from the IRIS FARM database from large, shallow earthquakes at epicentral distances of 40°-80° for P waves and 80°-160° for PP waves and compute the spectrum for a 12.8-s-long window around each arrival. Each spectrum is the product of source, receiver, and propagation response functions as well as local source- and receiver-side effects, and we use a stacking procedure to isolate the propagation effects. Using separate absorption bands in the upper and lower mantles, we model the average depth and frequency dependence of mantle Q by combining measurements of the amplitude decay of the propagation log spectra between 0.16 and 0.86 Hz with long-period Qβ values of other workers. We find that the upper mantle is more attenuating than the lower mantle and that this contrast is greater at higher frequencies. At 1 Hz, the top 220 km of the mantle is ~6 times more attenuating than the lower mantle. In addition, our results indicate that the upper corner frequency of the absorption band is higher for the upper mantle than at greater depths; the lower layer is about twice as attenuating at 0.1 Hz than at 1 Hz, whereas upper mantle attenuation is relatively constant across this band. Since lower-mantle attenuation is small, we interpret deviations in spectral decay as lateral variations in upper mantle attenuation. The resulting map of more and less attenuating regions generally correlates with previously-published attenuation models and surface tectonics. Continents are usually less attenuating than the global average, whereas oceanic regions tend to be more attenuating.