Power Spectrum of Random Heterogeneity of the Solid Earth

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Recent observations focusing on scattering of seismic waves revealed the existence of random heterogeneities in the solid earth medium. The radiative transfer theory (RTT) has been often used for the study of the propagation and scattering of wavelet intensities. For the statistical characterization of the power spectral density function (PSDF) of the random fractional fluctuation of velocity inhomogeneities in a 3-D space, we use von Karman type with three parameters: the RMS fractional velocity fluctuation, the characteristic length, and the order of the modified Bessel function of the second kind. This model leads to a power-law decay of PSDF at wavenumbers higher than the corner.

We compile reported statistical parameters of the lithosphere and the mantle based on various types of measurements. Reported exponents of wavenumber are distributed between -3 and -4, where many of them are close to -3. Reported RMS fractional fluctuations are of the order of 0.01 -- 0.1 in the crust and the upper mantle. Reported characteristic lengths distribute very widely. In order to grasp the spectral characteristics, eliminating strong heterogeneity data and the lower mantle data, we have plotted all the reported PSDFs of the crust and the upper mantle against wavenumber for a very wide range.

We find that the envelope of those PSDFs is well approximated by the -3rd power of wavenumber. In theory, we need to re-examine the applicable range of the Born approximation in the RTT when the wavenumber of a wavelet is much higher than the corner. In observation, we will have to measure carefully the PSDF on both sides of the corner. It is interesting to study what kinds of geophysical processes created the observed power-law spectral envelope in different scales and in different portions of the solid earth medium.

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