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Stochastic wave guides: lithosphere and subduction zones

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Although a simple zone of high velocity can have some capacity to duct high frequency waves, a rapid diminution in amplitude occurs because of escape of energy to lower velocity surroundings. However, with suitable heterogeneity within the higher velocity region energy can be carried to significant distances. A stochastic medium with correlation lengths along the zone substantially longer than across, with a variation more than a per cent can act as a efficient waveguide for higher frequency energy.

Such a stochastic waveguide within the subducting slab is able to explain the patterns of anomalously large intensity on the eastern seaboard of Japan from deep earthquakes in the Pacific plate and the nature of the observed seismic waveforms. In the region of high intensity the records show a low-frequency (< 0.5 Hz) onset for both P and S waves followed by large, high-frequency (> 2 Hz) later arrivals with a long coda. The preferred model has elongated scatterers parallel to the plate margin described by a von Karmann function with a down-dip correlation length of about 10 km and much shorter correlation length of about 0.5 km in thickness. The standard deviation of wavespeed fluctuations from the averaged background model is about 2 percent. This new plate model produces the required frequency-selective propagation characteristics through scattering of the high-frequency components.

Three-dimensional simulations of the expected propagation characteristics for deep earthquakes recorded in northern Japan for a realistic plate model display anomalously large intensities and distorted intensity patterns comparable to observed patterns. The simulations employ parallel computation on the Earth Simulator supercomputer with a high-resolution structural model including stochastic heterogeneity in the subducted

plate. The simulations demonstrate clearly the scattering waveguide effects for high-frequency waves.

Such stochastic waveguide effects may be characteristic of the lithosphere, since similar behaviour is seen on paths from Indonesian events through the continental lithosphere to Australian stations, and in records of PNE's in the former USSR.