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Deep mantle seismic heterogeneities in Western Pacific subduction zones

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In recent years array seismology has been used extensively to image the small scale ($\sim$10 km) structure of the Earth. In the mantle, small scale structure likely represents chemical heterogeneity and is essential in our understanding of mantle convection and especially mantle mixing. As subduction is the main source of introducing crustal material into the Earth's mantle, it is of particular interest to track the transport of subducted crust through the mantle to resolve details of composition and deformation of the crust during the subduction process. Improved knowledge of subduction can help provide constraints on the mechanical mixing process of crustal material into the ambient mantle, as well as constraining mantle composition and convection.

This study uses seismic array techniques to map seismic heterogeneities associated with Western Pacific subduction zones, where a variety of slab geometries have been previously observed. We use seismic energy arriving prior to PP, a P-wave underside reflection off the Earth's surface halfway between source and receiver, to probe the mantle for small-scale heterogeneities. PP precursors were analysed at Eielson Array (ILAR), Alaska using the recently developed Toolkit for Out-of-Plane Coherent Arrival Tracking (TOPCAT) algorithm. The approach combines the calculated optimal beampower and an independent semblance (coherency) measure, to improve the signal-to-noise ratio of coherent arrivals. 94 earthquakes with sufficient coherent precursory energy were selected and directivity information of the arrivals (i.e. slowness and backazimuth) was extracted from the data. The scattering locations for 311 out-of-plane precursors were determined by ray-tracing and minimising the slowness, backazimuth and differential travel time misfit. Initial analyses show that deep scattering ($>$1000 km) occurs beneath the Izu-Bonin subduction zone, suggesting that subducted crust does continue into the lower mantle in this location. Other findings suggest that upper mantle scattering in the vicinity of many other subduction zones can be correlated to past subduction in the last 20 Myr, indicating the presence and possible storage of crustal material in the upper mantle, for some subduction regions.