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Scattering – Resolving the fine scale structure of the Earth's mantle

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The internal structure of the Earth shows evidence for heterogeneities on many scale lengths. While the large scale structure (with scale lengths of a few hundred to thousands of kilometers) of the planet's interior is well imaged through seismic tomography we lack detailed information about the fine scale structure of the deep Earth. To resolve Earth's structure on scales around 10 km we have to study the scattered wavefield that dominates the codas of short-period ($\sim$1Hz) teleseismic arrivals. These waves originate when high-frequency surface or body waves interact with fine-scale volumetric heterogeneities or rough boundary layers. The scattered wavefield of phases such as PKP, Pdiff and PcP have been used to this end and image regions of the mantle showing lateral variations in their scattering strength. Due to the apparent small size of the scatterers they have been interpreted as chemical heterogeneities that are most likely related to the subduction process. Therefore, we can use these high resolution studies of the deep Earth to elucidate the mineral-physical and geochemical constitution of the Earth.

Here we use scattering related to the phases PKKP and PKPPKP (P'P') to resolve the fine scale structure of the mantle. These phases are especially well suited to study scattering throughout the mantle since their special raypath configurations allow the observation of the scattered energy as precursors to the main (ray-theoretical) arrival. This allows the separation of scattering contributions from the crust and the deep Earth. We use these phases to resolve the fine scale structure of the Earth's mantle from core to crust.

Our results indicate regions of increased scattering at the CMB that can be correlated to larger scale structures identified in tomographic studies. These are namely the large-low shear velocity province beneath southern Africa and a subduction dominated region beneath southern America. This result indicates several processes active in the mantle producing chemical heterogeneity at the CMB. Above the CMB we identify scattering throughout the mantle which allows constraints on the amount of mixing and recycling of oceanic slabs into the ambient mantle.