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3D imaging of Rayleigh wave mantle attenuation with uncertainty quantification

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We present global 2-D maps of frequency-dependent attenuation based on a huge dataset of ~10 million Rayleigh wave amplitude measurements. We incorporate fundamental mode and up to 4th overtone measurements over a period range of 35-200 s to ensure sensitivity in both the uppermost mantle and in the transition zone. In order to isolate intrinsic anelastic attenuation structure, we account for source, path and receiver effects on the amplitude data. Most prominently, we account for focusing/defocusing effects along the ray-path using complementary phase velocity maps. Following the removal of outliers based on strict data selection criteria, the resulting dataset is inverted using a least-squares approach along with a thorough exploration of model regularisation.

Our maps show a strong correlation between attenuation and surface tectonics up to periods of T~100 s, with low attenuation beneath the continents and high attenuation beneath the oceans. Our maps also show a commonly observed age progression trend in ocean basins, with lower attenuation beneath older oceanic crust. In particular, our maps delineate all major global cratons, including some separation between the Congo and Kalahari cratons in Africa, as well as the reletively small North China craton between T~40-100 s. The East Pacific Rise, western North American and hotspots correlate with high attenuation up to T~100s, but then correspond to low attenuation regions at periods greater than T~180 s. As to be expected, uncertainties are higher in regions of poor data coverage (e.g., southern hemisphere and oceans).

We then, for the first time, jointly invert frequency-dependent Q-curves for 1D profiles of shear-attenuation using the Monte-Carlo based Neighbourhood Algorithm. We discuss the implications of our resulting 3D model in terms of mantle temperature and composition anomalies.