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Resolving regional D” structure

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The Earth’s mantle exhibits complex seismic structures: Low velocity regions of 1000km-scale are found in tomographic inversions. D” reflectors of regionally individual shapes at the scale of hundreds of kilometers are observed in several areas, like the Gulf of Alaska, the Caribbean, Central and Southeast Asia, and the West and Central Pacific. On an even smaller scale, ultra-low-velocity zones (ULVZs) of 10% and 30% velocity decrease for P and S waves, respectively, at the scale of tenths of kilometers are found at the core-mantle boundary, often at the boundaries of the two large low velocity regions beneath the South Atlantic and the Central Pacific.

The individuality of the D” structures, the yet unclear relation of the D” structure to the low velocity regions, the ULVZs and small scatterers near the core-mantle boundary, as well as the uneven global distribution of recorded seismic waves sampling the D” lead to the question how well array seismologic methods actually observe the D” structures, especially the reflector with its relatively low impedance contrast of 1-4%, given its suggested high variability in topography. Therefore we use a 2.5D spectral-element wave propagation code to model lateral heterogeneities in the lowermost mantle of various sizes, shapes, elastic properties, topography and either sharp or gradual transition to the ambient mantle.

Our results show that D” reflectors of a certain shape influence their observability via size and magnitude of the elastic property perturbation within the Fresnel zone of the sampling wave as well as via inclination of the reflector. Increasing inclinations result in a strong decrease in amplitude of the observed D” reflections as well as a weak increase in travel time below the usual picking uncertainty. The reflection point, however, is laterally migrated due to the inclination of the reflector. Thus reflectors of several hundreds kilometers extent have to be constrained by several observed reflection points within the same Fresnel zone to avoid misinterpretation in 3D structure of the D” reflector. However, areas with only a few observed reflection points or no observed reflection points could still be areas of no D” structure, D” structure of low impedance constrast, wide gradients, rough or very steep topography. Thus it remains to be answered whether the D” reflector is a global or local phenomenon, and even more so what causes its regional individuality.