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Complex inner core of the Earth constrained by differential travel times and differential ray parameters

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Various studies over the last decades have revealed complex velocity structures of the Earth's inner core. Recently, using high-quality PKPbc-PKPdf differential travel times recorded by the dense Hi-net array, we reported that compressional velocity field (Vp) in the uppermost inner core (top 350 km of the inner core) is regionally perturbed by about 1% within each quasi-hemisphere. Although we showed the existence of heterogeneity on regional scale, the precise location and size of heterogeneities could not be constrained using exclusively the perturbed differential travel times. To overcome this limitation, here we utilize the PKPbc-PKPdf differential ray parameters in addition to the corresponding differential travel times to study the Vp structure of the uppermost inner core. We find that the differential ray parameters measured by phase-weighted stacking of waveforms recorded by the Hi-net array also display regional variations in both quasi-hemispheres. This observation supports previous results and provides additional constraint on complex Vp structure. We examine a number of 2-D models with different nature of heterogeneities including the inner core boundary topography and a mushy zone to predict the observed regional variation of the differential travel times and differential ray parameters. Our estimates of the heterogeneity spectrum represent invaluable new constraints on inner core structure.