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Imaging the East Asia using waveform tomography with massive datasets

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We present a new shear-wave velocity model of the upper mantle beneath the East Asia, ASIA2021, derived using the Automatic Multimode Inversion technique. We use waveform fits of over 1.3 million seismograms, comprising waveforms of surface waves, S and multiple S waves. In total, data from 9351 stations and 23344 events constrain ASIA2021, which maps in detail the structure of the lithosphere and underlying mantle beneath the region. Our model reveals deep structure beneath the tectonic units that make up East Asia. It shows agreement with previous models at larger scales and, also, sharper and stronger velocity anomalies at smaller regional scales. High-velocity continent roots are mapped in detail beneath the Sichuan Basin, Tarim Basin, Ordos Block, and Siberian Craton, extending to over 200 km depths. The lack of a high-velocity continental root beneath the Eastern North China Craton (ENCC), underlain, instead, by a low-velocity anomaly, is consistent with the destruction of this Archean nucleus. Strong low-velocity anomalies are mapped within the top 100 km beneath Tibet, Pamir, Altay-Sayan area, and back-arc basins. At greater depths, ASIA2021 shows high-velocity anomalies related to the subducted and underthrust lithosphere of India beneath Tibet and the subduction of the Pacific and other plates in the upper mantle. In the mantle transition zone (MTZ), we find high-velocity anomalies probably related to deflected subducted slabs or detached portions of ancient continent cratons. In particular, ASIA2021 reveals separate bodies, probably originating from the Indian Plate lithosphere beneath central Tibet, with one at 100-200 km beneath Songpan-Ganzi Block (SGFB) and the other in the MTZ. A strong low-velocity anomaly extending from the surface to the lower mantle beneath Hainan volcano and South China Sea is consistent with the hypothesis of the Hainan mantle plume. The high-velocity anomaly beneath ENCC in MTZ can be interpreted as a detached Archean continent root. The Pacific Plate subducts beneath the eastern margin of Asia into the MTZ and appears to deflect and extend horizontally as far west as the Songliao Basin. The absence of major gaps in the stagnant slab is consistent with the origin of Changbaishan volcano above being related to the Big Mantle Wedge, proposed previously. The low-velocity anomalies down to ~ 700 km depth beneath the Lake Baikal area suggest a hot upwelling (mantle plume) feeding the widely distributed Cenozoic volcanoes in central and western Mongolia.