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Seismic structure near the inner core boundary in the south polar region

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Good spatial coverage of seismic data points is important for better understanding physical processes occurring in the Earth's core. Although fine seismic structure near the inner core boundary (ICB) has been examined using body waves by many researchers, the core structure of the polar region, especially the south polar region, still has been poorly resolved. Investigating the seismic structure in the polar region has a geophysical importance associated with the tangent cylinder in the outer core. The tangent cylinder acts as a barrier to the convective mixing and can create a reservoir of compositional anomalies. The polar region of the Earth's outer core can then be characterized by low density and high temperature. Investigating the polar regions is also important for increasing constrains on the nature of hemispherical variation in properties of the inner core observed in seismological studies. Based on such seismic models anisotropic growth possibly associated with the outer core convection has been suggested. It however remains under discussion whether lower velocities would reflect either a low growth rate or a fast growth rate. The preferential equatorial solidification in the Earth's core leads to slower inner-core growth in the polar region. Thus the comparison of the structure near the ICB between in the polar region and in the rest can provide a test for solidification scenarios.

Seismic rays from South America to Indonesia pass beneath Antarctica. These rays are invaluable because they sample the region near the ICB beneath the south polar region. We analyzed core phases on vertical-component broadband seismograms of JISNET, OHP and IRIS stations in and near Indonesia for earthquakes in South America from January 1998 to September 2002. We selected waveforms including PKIKP whose turning point or one of its intersections at the ICB is located south of 60 S. The total number of selected waveforms is 118 for the 37 earthquakes. The observed waveforms were band-pass filtered between 1 and 20 s. Synthetic seismograms are computed up to the frequency of 2 Hz using the Direct Solution Method (DSM). The PREM model is used as the reference. We analyzed differential traveltimes and amplitude ratios between core phases (PKIKP, PKiKP, PKPbc, and PKPc-diff). The model we obtained (SPR) is described relative to PREM as follows: a 0.05 km/s lower Vp value at the top of the inner core, a 1.5 times steeper Vp gradient in the upper 300 km of the inner core, a smaller Qp (300) in the upper 300 km of the inner core, and a 0.04 km/s lower Vp at the bottom of the outer core.

Our velocity structure in the lowermost outer core lies in between the two global reference models PREM and AK135. Previous models for the western hemisphere are close to SPR for the base of the outer core. The Vp value of SPR at the base of the outer core is larger than that of AK135 by 0.2%, suggesting that the outer core inside the tangent cylinder is not distinctive from the rest of the outer core. As regards the Vp structure in the upper inner core, SPR has smaller Vp values compared to PREM and AK135, and is close to that of previous models for the western hemisphere, although most of our data sample the eastern hemisphere of the inner core. Our results thus indicate that the inner core does not have a simple hemispherical variation as usually supposed. An eyeball-shaped high-Vp anomaly, such that higher Vp than the global reference models is rather concentrated to smaller region beneath eastern Asia, could be consistent with our results. If the same relationship between slow inner core growth and low inner core Vp applies to near the equatorial region, the western-hemisphere would also have a low growth rate of the inner core.