Earth's core rotates faster than surface

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Scientists at Columbia University's Lamont-Doherty Earth Observatory and the University of Illinois at Urbana-Champaign have ended a nine-year debate over whether the Earth's inner core is undergoing changes that can be detected on a human timescale. Their work, which appears in the August 26 issue of the journal Science, measured differences in the time it took seismic waves generated by nearly identical earthquakes up to 35 years apart to travel through the Earth's inner core.

"Our observations confirm the change of inner core travel times, which was first claimed by Song and Richards in 1996," said Jian Zhang, a doctoral student in seismology at Lamont-Doherty and one of the study's co-lead authors. "This should settle the debate on whether these changes are real or an artifact of the original measurement method, and get us back to the work of understanding the history and dynamics of our planet."

Earth's core consists of a solid inner core about 1,500 miles (2,400 km) in diameter and a fluid outer core about 4,200 miles (7,000 km) across. The inner core plays an important role in the geodynamo that generates Earth's magnetic field.

In 1996, two of the current study's authors, Paul Richards of Lamont-Doherty and Xiaodong Song, then a post-doctoral researcher at Lamont-Doherty and now an associate professor at Illinois, presented evidence based on three decades of seismological records that they said showed the inner core was rotating approximately one degree per year faster than the rest of the planet. Their study received substantial popular acclaim,

but also drew criticism from some of their peers. In particular, a few scientists challenged their conclusions based on the fact that their results were right at the edge of what could be claimed.

To address the criticism, groups led by Richards and Song began looking for so-called waveform doublets--earthquakes that occur in essentially the same location and are detected at the same seismic recording station. If such earthquakes could be found, they reasoned, then measurements of changes in travel time could be made much more precisely.

The breakthrough came when Zhang found a September 2003 earthquake in the South Atlantic near the South Sandwich Islands that was detected in Alaska and provided a near-exact match with one that had occurred in December 1993. Zhang, Richards and their colleagues were able to see that the seismograms were almost identical for waves that had traveled only in the mantle and outer core. The waves that had traveled through the inner core, however, looked slightly different--they had made the trip through the Earth 1/10 of a second faster in 2003 than in 1993. Moreover, the shape of the waves themselves changed perceptibly after 10 years. In all, the scientists analyzed 18 doublets from 30 earthquakes in the South Sandwich Islands that were detected at 58 seismic stations in Alaska between 1961 and 2004.

In general, they found that waves passing through the inner core arrived noticeably earlier the more the earthquakes were separated in time. Interpreting this in terms of the known variability of wave speeds, they concluded that material which permits seismic waves to travel faster through the Earth had moved into the path taken by waves traveling through the inner core. They calculated that this movement is caused by the core rotating approximately 0.3-0.5 degrees faster than the rest of the Earth. In addition, the change in the shape of the seismic waves is apparently caused, as Richards describes it, by inhomogeneity or "lumpiness" of the inner core, which has a varying influence on seismic

waves produced years apart.

"For decades, people thought of the Earth's interior as changing very slowly over millions of years," said Richards, Mellon Professor of the Natural Sciences at Columbia. "This shows that we live on a remarkably dynamic planet. It also underscores the fact that we know more about the moon than about what's beneath our feet. Now we need to understand what is driving these changes."