Geophysical Research Abstracts
Vol. 14, EGU2012-3923, 2012
EGU General Assembly 2012

Observations of Shuffling Rotation of the Earth's Inner Core and its Time Correlation With Geomagnetic Jerks

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We report the first observational evidence that the complex rotational dynamics of the Earth's inner core appear to be in close relationship with the geomagnetic field. We infer from a newly observed collection of earthquake doublets that the Earth's inner core "shuffles", exhibiting both prograde and retrograde rotation in the reference frame of the mantle.

Evidence for a complex pattern in the rotation of the inner core characterized by episodes of both prograde and retrograde motion is presented. A key feature of the new analysis is that the number of parameters in the inversion controlling the rotation rate of the Earth's inner core may itself be treated as an unknown, which is robustly constrained by the data itself in a manner consistent with the inherent noise. According to our results, a short time interval (on the order of one to two years) is needed for the inner core to accelerate to a rotation rate of several degrees per year, and typically a slightly longer time is needed to decelerate down to a negligibly small differential rotation rate. These time scales are in agreement with experimental spin-up times obtained when the magnetic torque alone is used to accelerate the inner core.

A significant result is that all three time-intervals in which the inner core distinctively accelerates with respect to the rest of the planet are in agreement with known occurrences of geomagnetic jerks. However, we do not find a correlation between the other three reported geomagnetic jerks and the changes in rotation rate. Hence, intriguingly, a geomagnetic jerk appears to be a necessary, but not sufficient, condition for a change in the inner core rotation rate. Because there is also a documented correlation between the geomagnetic jerks and the Length of Day time series, this all points to the same source and works in favour of a differential rotation rather than processes at the inner core boundary.

Last but not least, when we integrate the rotation rate over different time intervals, it is possible to explain discrepancies between the body wave and normal modes results for the rate of the inner core rotation found by previous authors. We show that the integrated shift in angular alignment and average rotation rates (previously determined to be constant) in normal mode studies are much smaller that those for the body waves.