A possible relationship between core surface flow and geomagnetic jerks

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The geomagnetic jerk is known as one of rapid temporal variations in the Earth's magnetic field, characterized by a step function in the second time derivative. There are many examples, in particular the Y-component in Europe. However, its origin and cause have been still on debate.

Among many geomagnetic jerks of which occurrence was identified so far, the 1969, 1978 and 1991 geomagnetic jerks are confirmed to be global phenomena, whereas the 1985 and 2003 geomagnetic jerks might occur locally. It should be noted that these global geomagnetic jerks did not occur simultaneously over the whole world. Alexandrescu et al. (1996) and Nagao et al. (2002), for example, found that the 1969 and 1978 geomagnetic jerks occurred in the southern hemisphere a few years after occurrence of those in the northern hemisphere. In the meantime, De Michelis et al. (1998) showed that the 1991 geomagnetic jerks occurred in North and South America a few years before its occurrence in other regions, although Nagao et al. (2002) pointed out that the 1991 geomagnetic jerk occurred in the southern hemisphere a few years after its occurrence in Europe, as in the cases of the 1969 and 1978 geomagnetic jerks. These systematic time lags in the occurrence epochs of the 1969, 1978 and 1991 geomagnetic jerks can be caused by the electromagnetic filtering effect due to the electrical conductivity of the mantle. Such a filtering effect might explain the time lag in occurrence epoch of a geomagnetic jerk, but the cause is by no means explained. Thus, the cause has been supposed to be many phenomena; movement of magnetic pole, length of day, torsional oscillation in the core, Chandler wobble, free core nutation, and so on.

It is plausible to consider that the core surface flow has relation to the geomagnetic jerk, because the interaction between the geomagnetic field and core flow gives rise to the geomagnetic secular variation. In fact, Hulot et al. (1993) found that a geomagnetic jerk occurs when the rate of temporal variations in the non-zonal part of the core surface flow shows a sudden change. Waddington et al. (1995) examined instantaneous variations in core surface flows and the occurrence of geomagnetic jerks. Le Huy et al. (2000) mentioned that there are similarities in the geometry of large-scale acceleration flows corresponding to the geomagnetic jerks of 1969, 1979 and 1992. Bloxham et al. (2002) showed that geomagnetic jerks can be explained by the combination of a steady flow and a simple time-varying, axisymmetric, equatorially symmetric, toroidal zonal flow consistent with torsional oscillations in the Earth's core. However, physical origin of thee geomagnetic jerk has not been understood as mentioned above. Here, we show a possible relationship between core surface flows estimated from a geomagnetic field model and global geomagnetic jerks.