Dipole Tilt Effect of Geomagnetic Activity from Low- to High-latitudes

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Geomagnetic activity is dominantly impacted by the orientation of the Interplanetary Magnetic Field (IMF). However, when trying to address why the variations of geomagnetic activity are “semi-annual”, and are greater at equinoxes than at solstices, only IMF control of geomagnetic activity is not enough. This is because these variations are strongly dependent on the Earth’s dipole tilt; the dipole tilt is smaller at the equinoxes than at the solstices. Primitive studies assumed that magnetic reconnection occurs only at the subsolar point of dayside magnetopause. In their studies, the dipole tilt effect was not considered, but only the magnetic field direction between the IMF and the magnetosphere at the subsolar point was discussed in their studies. After them, geomagnetic variations where both dipole tilt effect and IMF direction are taken into account have been investigated. Based on a large database of IMF and AL/AU, we examined the relationship between the IMF clock angle and AL/AU at various dipole tilts. For both positive and negative dipole tilts, geomagnetic activity decrease as the clock angle moves away from 180˚. The AL/AU indices also tend to become smaller for larger dipole tilts. This dipole tilt dependence enhances the semi-annual variation of high-latitude geomagnetic activity.
It also remains unclear how degree energy input rate from solar wind to ring current (dD_{st}^{*}/dt) depends on dipole tilt under various interplanetary magnetic field (IMF) orientation and whether or not ring current development also follows this dipole tilt dependence. We tried to statistically investigate the dependence of dipole tilt and IMF clock angles on low- and middle-latitude geomagnetic activity (D_{st}^{*}), which is a proxy of ring current development, and solar wind energy input rate to ring current (dD_{st}^{*}/dt) over one solar cycle (1978 - 1988). D_{st}^{*} was calculated with the solar wind dynamic pressure and original D_{st} index, and the dipole tilt angle was defined as function of the day of year and universal time. The (dD_{st}^{*}/dt) values were obtained based on the solar wind electric field under the southward IMF conditions. Under positive and negative dipole tilts, the (dD_{st}^{*}/dt) values under low dipole tilt are negatively larger than those in case of high dipole tilt. Further peaks at 180˚ of the IMF clock angle are seen in most of the dipole tilt cases. However, the D_{st}^{*} index shows neither a peak at 180˚ of the IMF clock angle nor particular dipole tilt dependence in case of negative dipole tilt angles. This result suggests that low- and middle latitude geomagnetic activity (ring current development) does not necessarily show dipole tilt dependence and a one-to-one correlation with solar wind energy input rate to ring current (dD_{st}^{*}/dt).

Keywords: Geomagnetic activity (Dst*), Solar wind energy input rate to ring current (dDst*/dt), Semiannual variation , Dipole tilt effect, Interplanetary magnetic field and clock angel, Magnetic reconnection

