Seasonal and solar wind control of the reconnection line location at the Earth's dayside magnetopause

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Geomagnetic disturbances in the geospace such as aurora and geomagnetic storm are driven by solar wind energy transported into the Earth's magnetosphere. Magnetic reconnection at the dayside magnetopause is the most important process by which solar wind energy enters the magnetosphere. This is a phenomenon in which the interplanetary magnetic field (IMF) in the solar wind and the Earth's magnetic field re-connect. Under southward and/or predominantly dawn-dusk IMF conditions, magnetic reconnection takes place along an extended reconnection line at low latitudes, called the X-line. Geomagnetic flux connected to the IMF is transported to, and is stored in, the nightside magnetosphere. The amount of solar wind energy that flows into the magnetosphere is controlled by the efficiency of reconnection occurring at the dayside magnetopause. The efficiency of reconnection may depend on the X-line location. When the X-line location shifts from the subsolar point, where the sun is at the zenith, the boundary conditions around the X-line can change. Therefore, the amount of solar wind energy flowing into the Earth's magnetosphere can change because of the changed efficiency of the reconnection. In recent years, some models and observations showed that finite dipole tilt or IMF B_X controls the X-line location by moving it northward or southward from the subsolar point. Although the X-line location is an important parameter in solar wind energy transport, its dependence on dipole tilt and IMF Bx is not yet made clear based on statistical observational studies. We statistically estimated the X-line location by investigating the occurrence pattern of reconnection jets observed at the dayside magnetopause. Used here are plasma and magnetic field data taken in the dayside magnetopause region within the magnetic local time range of 10 to 14 hours from 10 years of observations by the THEMIS spacecraft.

Among full magnetopause crossing events, flows with a speed tangential to the magnetopause exceeding 150 km/s, which is of the order of the Alfvén speed in the magnetosheath, are chosen as candidates of the reconnection jets. The Walén relation is used to test whether the flow was generated by reconnection, and a total of 715 jets were identified. We estimated the X-line location by the direction and position of the identified jets. The present analysis assume that the northward jets are observed on the northern side of the X-line and the southward jets are observed on the southern side. The average X-line location was estimated by determining a linear discriminant function that minimizes the occurrence probability of the southward jets on the northern side of the estimated X-line or the northward jets on the southern side. It was found that the X-line location shifts about 6 Earth radii from the subsolar point toward the winter hemisphere under the largest dipole tilt. This is also the first study that reveals that the X-line location shifts about 2.5 Earth radii from the subsolar point when the IMF B_X component is large. The results demonstrate that the effect of dipole tilt on the X-line position is larger than that of the IMF B_X component. To summarize, the dipole tilt dependence of the X-line location suggests that efficiency of energy transport into the magnetosphere by dayside magnetic reconnection during southward IMF may decrease when the dipole tilt is large. This suggests that the well-known geomagnetic activity decrease under larger dipole tilts may be partially due to the X line position displaced from the subsolar point for large dipole tilt.

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