Origins of the semiannual variation of geomagnetic activity

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The semiannual variation in geomagnetic activity has been known for a long time (Sabine, 1856). Over the years three principal mechanisms have been proposed to explain the seasonal variation: (1) the axial hypothesis (Cortie, 1912), (2) the equinoctial hypothesis (McIntosh, 1959) and the Russell and McPheron effect (Russell and McPheron, 1973). Recent studies showed that all of the mechanisms contribute to the semiannual variation in which the one related to the equinoctial hypothesis is dominant (Cliver et al., 2000; 2001; Svalgaard et al., 2002). However, the mechanism in the back of the equinoctial hypothesis is not yet clarified (Cliver et al., 2004).

We here report results of an investigation concerning effects of the interplanetary magnetic field (IMF) and the solar wind velocity on the variations in the geomagnetic activity. We used the ACE data and the am-index during the period from 1997 through 2007. Following are the summary of the study: (a) Solar wind velocity affects the variations in the geomagnetic activity more than the southward componentof the IMF (Bs). (b) The larger the solar wind velocity, the higher the geomagnetic activity for the same value of the product of the Bs and the square of the solar wind. (c) Accordingly, when the solar wind velocity is large in summer and winter, the reverse semiannual variation is observed, even if the mean Bs value in spring and fall is larger than that in summer and winter due to the Russell and McPherron effect. (d) The effect of the solar wind velocity on the geomagnetic activity is also recognized in the case of northward IMF, but it is not so large as the case of the southward IMF. (e) The seasonal variation for the northward IMF cases is smaller than that for the southward IMF cases. (f) Year to year variation in the geomagnetic activity is estimated to be caused mainly by the variation in the solar wind velocity. (g) Effects of other components of the IMF on the geomagnetic activity are rather small.

The above results indicate that the seasonal variation caused by the equinoctial effects can not be separated clearly from that produced by the solar wind. Therefore, it is not easy to evaluate the percentage which the mechanism in the equinoctial hypothesis occupies in the seasonal variation. It seems particularly meaningless to estimate the percentage using the mean monthly values of the geomagnetic activity during the long period. Our analysis suggests that the efficiency of the dayside magnetic reconnection in the case of southward IMF depends on the solar wind velocity perpendicular to the geomagnetic dipole axis. We consider this gives a hint to understand the mechanism in the equinoctial hypothesis.