Critical Solar Parameters for Prediction of Geomagnetic Storm

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A geomagnetic storm is a disturbance of Earth's magnetic fields caused by solar wind plasma and interplanetary magnetic field (IMF). Even a moderate storm can lead to satellite loss, such as the falling down of 40 SpaceX Starlink satellites on 2022 February 4. It is believed that coronal mass ejections (CMEs) and coronal holes (CHs) are major sources for geomagnetic storms. Therefore, determining the critical solar parameters is very important for storm predictions by combining solar remote observations, solar wind in-situ measurements, and geomagnetic indices. In this study, the north-south component of IMF (Bz), dawn-dusk convection electric field (Ey), and dynamic pressure (P) are proposed to be the critical solar wind parameters. The geomagnetic indices of disturbance storm time (Dst) and SYM-H are used to define the storm magnitude. Those events during 2010-2019 together with the corresponding solar wind parameters from OMNI database are adopted to derive an equation of state in power-law form. We also identify the potential CMEs and CHs based on the observations from SOHO, STEREO, and SDO spacecraft. Our results show that in comparison with CHs, CMEs tend to accompany with stronger solar wind conditions and thus cause larger magnitude of geomagnetic storms. Besides, our equation of state indicates that Bz and Ey rather than P affect the storm magnitude more significantly. We further apply the derived equation of state to predict the storm events after 2019 and find that our predictions perform relatively well for the moderate storms compared to intense cases.