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Solar Wind Energy Input during Prolonged, Intense Northward Interplanetary Magnetic Fields: A New Coupling Function

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Sudden energy release (ER) events in the midnight sector at auroral zone latitudes during intense (B $>$ 10 nT), long-duration (T $>$ 3 hr), northward (B_z $>$ 0 nT = N) IMF magnetic clouds (MCs) during solar cycle 23 (SC23) have been examined in detail. The MCs with northward-then-southward (NS) IMFs were analyzed separately from MCs with southward-then-northward (SN) configurations. It is found that there is a lack of substorms during the N field intervals of NS clouds. In sharp contrast, ER events do occur during the N field portions of SN MCs. From the above two results it is reasonable to conclude that the latter ER events represent residual energy remaining from the preceding S portions of the SN MCs. We derive a new solar wind-magnetosphere coupling function during northward IMFs: $E_{NIMF} = \alpha \quad N^{-1/12}V^{7/3}B^{1/2} + \beta\, V|Dst_{min}|$. The first term on the right-hand side of the equation represents the energy input via "viscous interaction", and the second term indicates the residual energy stored in the magnetotail. It is empirically found that the magnetosphere/magnetotail can store energy for a maximum of $\sim$ 4 hrs before it has dissipated away. This concept is defining one for ER/substorm energy storage. Our scenario indicates that the rate of solar wind energy injection into the magnetosphere/magnetotail determines the form of energy release into the magnetosphere/ionosphere. This may be more important than the dissipation mechanism itself (in understanding the form of the release). The concept of short-term energy storage is applied for the solar case. It is argued that it may be necessary to identify the rate of energy input into solar magnetic loop systems to be able to predict the occurrence of solar flares.