Radiation belt electrons during intense storms driven by coronal mass ejections and corotating interaction regions

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Modern life depends on satellite observations and communications. Thus, large enhancements of the radiation belt electron flux can sometimes cause a serious problem, because these energetic particles can cause deep dielectric charging of satellites, which in turn can lead to spacecraft anomalies and/or complete failure. A major problem exists to predict the flux enhancement particularly during geomagnetic storms when the whole magnetospheric environment drastically changes. In this paper, we show that coherent changes of the solar wind parameters depending on the large-scale solar wind structures can be used as a flexible tool to predict the flux enhancement of radiation belt electrons during geomagnetic storms 1-3 days in advance. We report the averaged variations of the solar wind parameters and radiation belt electrons during isolated geomagnetic storms driven by coronal mass ejections (CMEs) and corotating interaction regions (CIRs), using a superposed epoch analysis centered on interplanetary shocks and stream interfaces, respectively, whose arrival times can be used as a precursor for the flux enhancement. A total of 49 CME- and 6 CIR-associated storms with Dst $<$ -100 nT are identified during solar cycle 23 from January 1996 to December 2004. In CME-associated storms, the average flux recovers to the pre-storm level about two days after a shock arrival. The occurrence probability of the $>$2 MeV electron flux alert with $>$103 pfu at geosynchronous orbit is 14, 22, 41, and 43% in the 4 days after the shock. In CIR-associated storms, the average flux recovers to the pre-storm level about one day after a stream interface arrival. The probability of an electron flux alert is $>$80% one day after the stream interface arrival, and remains at that level for at least the next four days.