



## **Evidence for IMF-triggered substorms is inconclusive.**

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The Earth's magnetosphere is intermittently disrupted by system-wide, energy release events called substorms that are analogous to earthquakes. Like earthquakes, understanding the necessary and sufficient conditions for substorm onset is challenging and controversial. In this paper we re-examine the two main pieces of evidence supporting the hypothesis that substorm onsets in the Earth's magnetosphere are externally triggered by a northward turning of the Interplanetary Magnetic Field (IMF): First, statistical analyses of the relative timings of candidate external triggers and substorm onsets reveal that they coincide significantly more frequently than expected by random chance. Second, superposed epoch analyses show that, on average, the IMF turns northward immediately after a substorm onset. In both cases we show that these results can be well reproduced using a Minimal Substorm Model in which substorm onsets are determined without the requirement of a northward IMF turning trigger. We discuss the explanation underlying these results and conclude that there is no conclusive evidence in favour of the hypothesis that substorm onsets are triggered by a rapid northward turning of the IMF.