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Statistics of Substorm Onset in the SuperMag Lower Index (SML)

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The SuperMag Project has developed a version of the standard AL index that utilizes many more stations than the standard does to monitor the strength of the westward electrojet underneath the expanding auroral bulge. This SML index has been download and processed by a pattern recognition algorithm that detects the start and ending times of the expansion. From 1980 to the current time there are more than 100,000 expansion onsets averaging about five per day. The duration and strength of the decrease in SML are easily calculated parameters that characterize the substorm. These parameters exhibit breaks in their probability distributions that separate the events into six classes: including small, big, narrow, wide, small/narrow, and big/wide. Ensembles of events have been created relative to the expansion onset. Averages of these reveal such properties as concurrence rate and strength as functions of solar cycle, season, storm time, and time relative to passage of a corotating interaction region. It is essential to separate the small/narrow events from the big/wide events as they have very different occurrence statistics. Although duration and strength have broad distributions, ensemble averages of substorms binned by strength of SML decrease have identical shapes in the averages of standardized data indicating the average temporal behavior is independent of strength. A persistent feature in the ensemble averages is a pea in coupling strength, or a minimum in Bz at expansion onset. This has previously been interpreted as triggering by a northward turning of the IMF. This idea has been dismissed as an artifact or chance association, primarily because no one could explain how the onset might happen physically. This feature is present in all our averages, but more accurate onset times enable us to examine the rate of change of coupling relative to onset. We find a substantial fraction of all substorm onsets is preceded by a negative spike in Bz starting 15 minutes before onset that corresponds to a sudden increase in coupling strength followed by the northward turning. This spike could cause a sudden thinning of the current sheet and possible onset of reconnection.