A semi-empirical model for magnetic storm dynamics

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The near-Earth electromagnetic environment represents a far-from-equilibrium system. The magnetosphere exhibits nonstationary and nonlinear dynamics, especially during magnetic storms. For a broad class of complex phenomena, the dynamics can be interpreted in terms of a superposition of stochastic and deterministic components, occurring at different time scales. The main feature of a magnetic storm is the depression of the horizontal magnetic field component at low latitudes due to the enhancement of the ring current activity. In this work we use the SYM-H geomagnetic index, which is meant for monitoring the global variation of the horizontal component of the Earth's magnetic field along the equator. The aim of this work is to model the SYM-H dynamics via stochastic differential equations whose parameters are properly retained from data. As a first step we investigate the Markovian character of SYM-H, which accurately satisfies this requirement with 1-min time resolution. This allows us to model the SYM-H dynamics via Kramers–Moyal analysis. We give evidence that a purely diffusive process is not representative of the observed dynamics and then a model based on jump-diffusion processes must be taken into account in order to reproduce correctly the dynamical features of the SYM-H index. In light of recent findings on auroral electrojet dynamics, high-latitude magnetospheric activity also shows a jump-diffusion character on small time scales. A discussion of the future perspective of a comprehensive model of both auroral activity and ring current dynamics based on the multivariate Kramers-Moyal analysis is addressed.

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