Analysis of the 3-7 October 2000 and 15-24 April 2002 Geomagnetic Storms with an Optimized Nonlinear Dynamical Model

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A computationally optimized low dimensional nonlinear dynamical model of the magnetosphere-ionosphere system called WINDMI is used to analyze two large geomagnetic storm events, 3-7 October 2000 and 15-24 April 2002. These two important storms share common features such as the passage of magnetic clouds, shock events from coronal mass ejections, triggered substorms, and intervals of sawtooth oscillations. Sawtooth oscillations resemble periodic substorms but occur in association with strong or building ring current populations, and have injection regions that are unusually close to Earth and unusually wide in magnetic local times. The April 2002 event includes one of the best examples of sawtooth events ever observed. On 18 April 2002, sawtooth oscillations were clearly visible when solar wind conditions (IMF Bz, density, pressure) were relatively steady with a slowly varying Dst. In this study WINDMI is used to model the 3-7 October 2000 and 15-24 April 2002 geomagnetic activity. WINDMI results are evaluated focusing on the sawtooth intervals and the overall prediction of the westward auroral electrojet (AL) index and Dst index. The input to the model is the dynamo driving voltage derived from the fluctuating solar wind plasma and the interplanetary magnetic field measured by the ACE satellite. The output of the model is a field aligned current proportional to the AL index and the energy stored in the ring current which is proportional to the Dst index. The model parameters are optimized using a genetic algorithm (GA) to obtain solutions that simultaneously have least mean square fit to the AL and Dst indices and also exhibit substorms of period 2-4 hours. The GA optimization results show that the model is able to predict the Dst index reliably and captures the timing and periodicity of the sawtooth signatures in the AL index reasonably well for both storm events.