MHD simulation of solar wind-magnetosphere coupling during extreme events

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For space weather models of the magnetosphere to be effective they must be able to predict magnetospheric conditions during extreme storms when space weather hazards are likely to be a their greatest. We have been conducting a series of studies using the Lyon-Fedder-Mobarry (LFM) MHD simulation. In this paper we will present various aspects of our findings. A particular focus of our work is understanding how the solar wind electric field generates the potential across the polar cap, which in turn drives a great deal of magnetospheric dynamics. During southward IMF, for small values of VBz in the solar wind the potential is linearly dependent on VBz, but for large values of VBz the potential behaves nonlinearly and reaches a saturation value. The LFM simulation reproduces this effect. We will present a physical model for saturation based on the force on the solar wind exerted by field-aligned currents, whose distribution changes during saturated periods. We will also present observations to support our basic conclusion that the flow of field-aligned current into the magnetosheath along open field lines is the agent that produces the saturation effect. We will discuss these findings in the broader context of simulations of major magnetic storms for space weather prediction.