Multi-Fluid Block-Adaptive-T Solar Wind Roe-type Upwind Scheme: Magnetospheric Composition and Dynamics During Geomagnetic Storms, Initial Results

A. Glocer, G. Toth, Y. Ma, T. Gombosi, J. C. Zhang, L. M. Kistler

Abstract: The magnetosphere contains a significant amount of ionospheric O^{+}, particularly during geomagnetically active times. The presence of ionospheric plasma in the magnetosphere has a notable impact on magnetospheric composition and processes. We present a new multi-fluid MHD version of the BATS-R-US model of the magnetosphere to track the fate and consequences of ionospheric outflow. The multi-fluid MHD equations are presented as are the novel techniques for overcoming the formidable challenges associated with solving them. Our new model is then applied to the May 4, 1998 and March 31,
2001
geomagnetic storms. The results are juxtaposed with traditional single- fluid MHD and multi-species MHD simulations from a previous study, thereby allowing us to assess the benefits of using a more complex model with additional physics. We find that our multi-fluid MHD model (with outflow) gives comparable results to the multi-species MHD model (with outflow), including a more strongly negative Dst, reduced CPCP, and a drastically improved magnetic field at geosynchronous orbit, as compared to single-fluid MHD with no outflow. Significant differences in composition and magnetic field are found between the multi-species and multi-fluid approach further away from the Earth. We further demonstrate the ability to explore pressure and bulk velocity differences between H^{+} and O^{+}, which is not possible when utilizing the other techniques considered.