END-TO-END SPACE WEATHER SIMULATIONS

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The Space Weather Modeling Framework (SWMF) aims at providing a flexible framework for physics based space weather simulations. The SWMF combines numerical models of the Solar Corona, which includes the Eruptive Event Generator, the Inner Heliosphere, Solar Energetic Particles, Global Magnetosphere, Inner Magnetosphere, Radiation Belt, Ionosphere Electrodynamics and Upper Atmosphere into a parallel, high performance model. All the components can be replaced with alternatives, and one has the option to use only a subset of the components. The SWMF enables us to do simulations that were not possible with the individual components. We highlight some numerical simulations obtained with the SWMF.

During the Halloween storms the Sun exhibited some of the most violent outbursts in recent history. Some of the huge coronal mass ejections associated with the Halloween storms hit the magnetosphere and generated very large magnetic storms. In order to test the robustness and accuracy of the SWMF several coupled simulations were carried out.

One simulation was driven by solar wind conditions observed upstream of the Earth by the ACE and Geotail spacecraft. This simulation tested the coupled global magnetosphere, inner magnetosphere, ionospheric electrodynamics and upper atmosphere models. The simulation results were compared with observation in the dayside magnetosphere, cusp region, geosynchronous region, and the distant magnetotail by Cluster, Polar, GOES-10, GOES-12 and Wind. In addition we compared the simulated Dst with the observed values and the simulated cross polar cap potential to those obtained by the AMIE technique. The agreement with all these observations is quite good, demonstrating that the SWMF can accurately handle extreme magnetospheric storms.

A second simulation was driven by a realistic coronal mass ejection injected into an ambient solar wind generated with the use of synoptic solar magnetograms. We simulated two consecutive CMEs, because the first CME created the appropriate solar wind conditions for the second, and larger, eruption. This simulation was carried from the Sun to the upper atmosphere using seven SWMF components. The results were compared with both observations and to the results of the coupled magnetosphere simulation. The full simulation was also be able to handle extreme conditions generated by the two CMEs. Although the Sun-to-Earth simulation does not agree as well with the observations as the solar wind driven simulation, we were able to reproduce the hydrodynamic properties (density, velocity, pressure) and the magnitude of the magnetic perturbations in the vicinity of the Earth. The Dst index and the cross polar cap potentials also agree reasonably well with the observed values.