Space Weather Prediction and a Plan for the Future

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Abstract

The space segment is an integral part of many systems that support terrestrial infrastructure. Space weather monitoring provides details of the environmental extremes against which space craft operate. Monitoring also gives a basis from which models and predictive techniques can be developed. Space weather services, generated by these models, are becoming more sophisticated and more prevalent as technical systems become sensitive to space weather and need adequate protection.

Space weather effects include vehicle damage, deterioration of solar cells, semiconductor damage, and electric charging of the spacecraft. Magnetospheric fields can induce currents in the ionosphere and, at ground level, in terrestrial power systems and long pipe lines that may cause costly damage. Radio systems such as HF communications and radar are influenced by ionospheric conditions.

Space weather services depend heavily on space-based and ground-based monitors. Effective services need to be accurate with minimal false alarms. Recent spacecraft measurements of the solar interior and surface have given an unprecedented chance of understanding the development of solar activity. Near-Earth satellite data have provided models of the radiation environment of near-space in general terms. By using in-situ data the basic model can be updated hourly to provide a specific picture of high-energy electron flux at satellite orbits. Disturbances to the magnetosphere can be predicted coarsely using MHD models. Shock wave effects at the magnetopause can be coarsely predicted. However, the specific geomagnetic effects at ground level depend on the calculation of magnetic and electric fields at ground level and their coupling into power lines or pipelines, a task not yet satisfactorily completed. The predictability of ionospheric models remains largely on a synoptic basis although new work on physical models is showing promise.

At present, the warning of a potential threat from space weather is based on observations of CMEs and verified by in-situ data from spacecraft but the specific severity of the effect, and an increase in warning time, requires further development of models of the sun, solar wind and magnetosphere.

Further development of Sun-to-Earth models and space weather services can be accelerated by the coordination and promotion of scientific groups with the appropriate expertise. A national plan for space weather monitoring, the encouragement of research priorities and public outreach has been prepared.