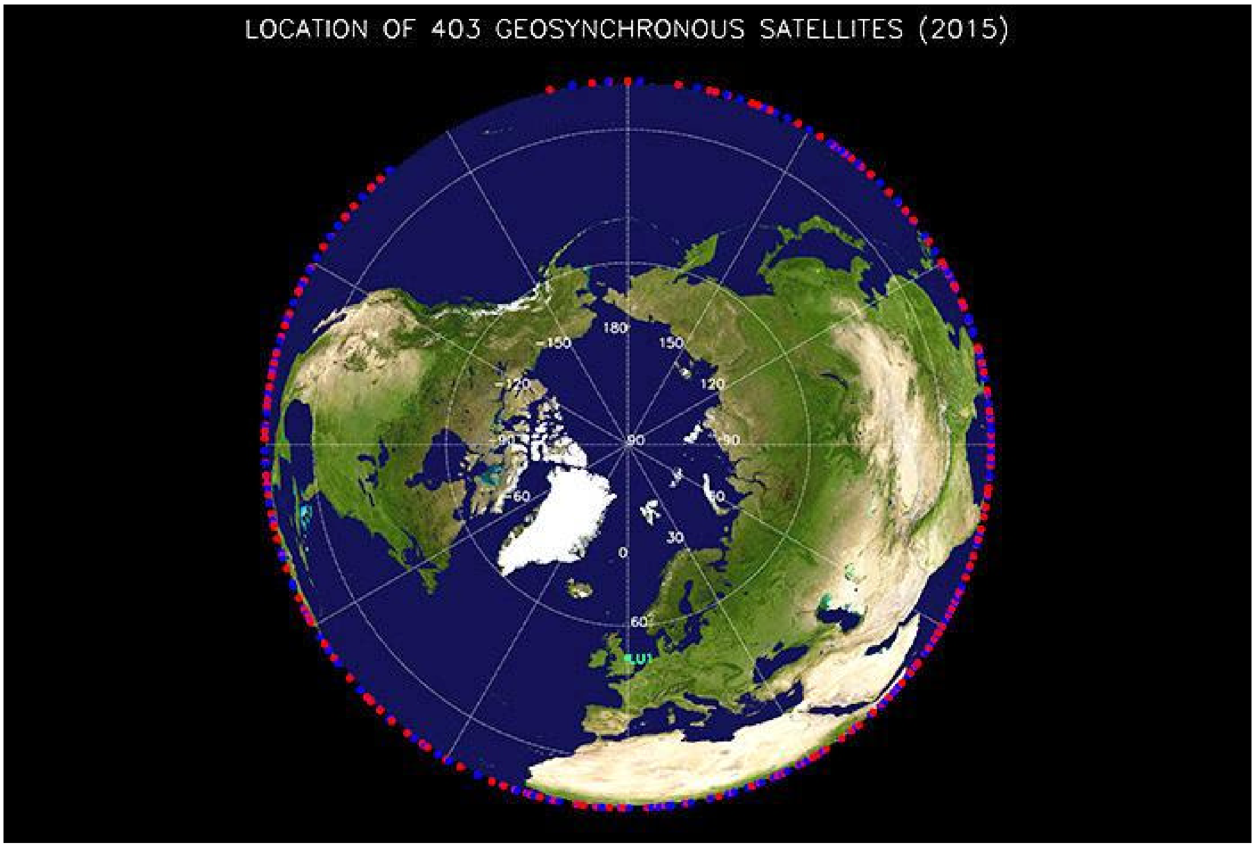
Model predicts space weather and protects satellite hardware

October 11, 2015



Researchers used 82 satellite-years of observations from the Magnetospheric Plasma Analyzer instruments aboard Los Alamos National Laboratory satellites at geosynchronous orbit to create a comprehensive model of how plasma behaves in this region of Earth's magnetosphere — the most heavily populated orbit for spacecraft traffic. The journal *Space Weather* published the work, and the American Geophysical Union newsmagazine *Eos* highlighted it as a Research Spotlight. Knowledge and prediction of the environment at geosynchronous orbit is crucial for spacecraft designers and operators because changes in the plasma environment, caused by the Sun and its solar wind, can interfere with satellite functioning and even lead to satellite failure.

Significance of the research

Geosynchronous orbit — roughly 36,000 kilometers above Earth's surface — is one of the most popular locations for military, scientific, and communications satellites.

The 24-hour orbital period at geosynchronous orbit ensures that satellites maintain a fixed location in Earth’s sky. This area marks the approximate boundary between Earth’s inner and outer magnetosphere, where electromagnetic forces from the two regions control electrically charged particles (electrons and ions) known as plasma. Current models of this environment focus on predicting how fluxes of energetic ions and electrons, which can cause a buildup of charge on spacecraft materials, will affect satellite systems. The new research provides a more comprehensive picture by examining how factors such as solar wind and geomagnetic activity can influence these fluxes in plasma.The researchers created a model that can predict the plasma flux environment at geosynchronous orbit in response to rapid changes in geomagnetic and solar activity. The model predicts the fluxes that can cause a buildup of charge on spacecraft materials over a range of energies and time. The new model provides scientific and operational users with prediction of fluxes over a wider range of conditions than is generally the case with current models. As the model matures, the researchers plan to extend the analysis to predict hazardous fluxes as a function of solar wind speed and magnetic field orientation. These are critical factors that control plasma fluxes at geosynchronous orbit. The model will be useful for satellite operators because more than 400 satellites currently reside in geosynchronous orbit.

Research achievements

The team analyzed the largest existing dataset of electron and ion fluxes. The Magnetospheric Plasma Analyzer instruments on board Los Alamos National Laboratory satellites collected the data over 17 years and one and a half solar cycles. The researchers combined the data sets from seven satellites (a total of 82 satellite-years of data) with observations on solar and geomagnetic activity. They developed a comprehensive model of the flux of electrons and ions at geosynchronous orbit as a function of local time, energy, geomagnetic activity, and solar activity for energies between approximately 1 eV and approximately 40 keV. This energy range encompasses the plasmasphere, the electron plasma sheet, the ion plasma sheet and the substorm-injected suprathermal tails of both the electron and ion plasma sheets. Satellites on station at geosynchronous orbit encounter each of these populations regularly.The team validated the model by comparing its predictions with spacecraft data that another set of satellites collected during a five-day period of both calm and active space weather. As the model matures, the researchers plan to extend the analysis to predict hazardous fluxes as a function of solar wind speed and magnetic field orientation. These are critical factors that control plasma fluxes at geosynchronous orbit. The team has made a beta version of the model freely available.

The research team

The researchers include M. H. Denton of LANL's Space Science Institute, M. F. Thomsen, V. K. Jordanova, M. G. Henderson and J. E. Borovsky of LANL's Space Science and Applications group; J. S. Denton of Sellafield Ltd. (now of Nuclear and Radiochemistry, C-NR); D. Pitchford of SES Engineering; and D. P. Hartley of Lancaster University.The Los Alamos Laboratory Directed Research and Development (LDRD) program funded the research through the SHIELDS project, which aims to understand, model, and predict Space Hazards Induced near Earth by Large, Dynamic

Storms (SHIELDS). This work supports the Lab's Global Security mission area for space situational awareness and the Science of Signatures science pillar.