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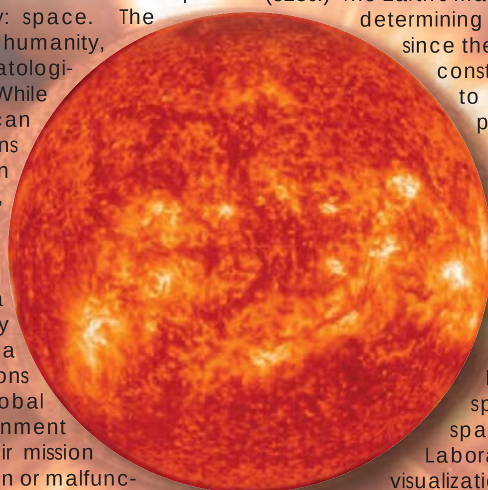
Space, Society and a Tool for Spacecraft Design

With all the talk of global warming and its obvious deleterious effects on human society, it is easy to overlook another aspect of the global environment which has important implications for human society: space. The impacts of the space environment on humanity, while less direct than terrestrial climatological trends, are still very important. While extreme space weather events can interrupt terrestrial power transmissions and increase radiation exposure on trans-polar commercial airline flights, Earth orbiting spacecraft are most at risk. These satellites provide essential communication services, including telephone, television and data sharing, geo-location (GPS), military security, as well as geo-sensing via weather satellites and scientific missions providing crucial data about global warming itself. The space environment directly impacts spacecraft and their mission tasks through component degradation or malfunction due to radiation exposure and interrupted satellite to ground communication links due to space weather "storms". Very extreme events, though rare, can result in the complete loss of a satellite. Replacement costs for satellites range from hundreds of millions for research satellites to billions of dollars for terrestrial weather monitors.



For this reason, the near-Earth space environment, which is predominantly a plasma environment, i.e. an environment whose physics is dominated by charged particles interacting with magnetic fields, has been studied intensively for many years. Through these studies, standard empirical climatological models of the space environment have been developed, including e.g., the IGRF magnetic main-field model and the NASA AE8/AP8 electron and proton radiation belt models. Radiation belt models are particularly important in designing robust spacecraft because impacts by highly energetic charged particles in the radiation belts cause both long-term spacecraft degradation (ionizing dose effect) and single-event-upsets (SEUs.) The Earth's magnetic field also plays a crucial role in determining where the radiation belts are located since the charged radiation belt particles are constrained to spiral along field lines due to the magnetic Lorenz force. Nuclear physics, on the other hand, comes into play in understanding the interactions of the energetic particles with the spacecraft components and materials, and this knowledge has been codified in tools such as the SHIELDOSE2 software.

Until recently, however, few professional software tools have been available for analyzing the space environment and its effects on spacecraft. The Air Force Research Laboratory's AF-GeoSpace model and visualization suite collects many space environment models together in a common application and provides a common 3D visualization environment for them. While excellent for research purposes, AF-GeoSpace lacks some attributes desirable in a commercial product. AER's Space Environment and Effects Tool for STK (STK-SEET) leverages its long support of the AF-GeoSpace model development effort by fully integrating some of the most relevant AF-GeoSpace models (including the AE8/AP8 and CRRESELE/PRO radiation belt models) into AGI's industry standard Satellite Toolkit analysis package. Stop by our booth or poster for more information.

For more information about the research mentioned in this article, contact: **Rick Quinn, Manager Space Plasma & Interactions Group, at +1.781.761.2288 or rquinn@aer.com.**

Remote Sensing for Weather, Climate and Society

For 30+ years AER has been at the forefront of state-of-the-art algorithm development for modeling, simulating and forecasting the Earth's atmosphere state. These include the design and development of numerous algorithms deployed as part of National and International operational and research satellite programs. These algorithms convert fundamental sensor/instrument measurements into geophysical parameters such as vertical temperature/water vapor profiles, estimates of cloud amount, type and phase, and land/ocean parameters such as sea surface winds, net heat flux, and forest fire intensity/extent. With the advent of new instruments/sensors, which provide higher spatial and spectral resolution with lower noise, the desired accuracy and precision requirements placed upon these algorithms are now more stringent than ever.

AER is actively leveraging this expertise and proven algorithm technologies as co-investigators for two NASA decadal survey missions, and as a member of the science team for a Japanese satellite, the Greenhouse gases Observation SATellite (GOSAT). Collectively, these observations will improve our ability to specify the Earth's atmospheric composition and thereby aid in the development of a more comprehensive, coherent and consistent picture of the environment. This will provide scientists and policymakers with data necessary to understand and evaluate the magnitude and impact of global change.

One NASA mission, the Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission, is being developed to monitor climate change by making highly accurate radiometric measurements of the atmo-

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sphere. Climate change signals are relatively small compared to weather signals. To detect them, the data must be carefully calibrated and analyzed. Because CLARREO will make highly accurate measurements of the atmosphere, it will also be indispensible in the inter-calibrating of satellite sensors. AER's fast radiative transfer model technology, directly linked to fundamental line-by-line radiative transfer calculations, provides a fundamental benchmark for assessing the performance and sensitivity of the CLARREO measurements.

Another NASA mission, the Active Sensing of CO_2 Emissions over Nights, Days, and Seasons (ASCENDS) mission, aims to enhance our understanding of the role of carbon dioxide in the global carbon cycle. Measuring CO_2 from space is difficult. ASCENDS accomplishes this by using laser absorption spectroscopy. This allows for identical measurements to be made both during the daytime and at night, providing information about the diurnal cycle of CO_2 sources and sinks. (A carbon sink is a natural or manmade reservoir that removes carbon dioxide from the atmosphere and stores it for an indefinite period.) In support of NASA-Langley and ITT, AER has built an algorithm testbed to develop and refine sensor/algorithm concepts.

While both these NASA missions are still in the concept phase, GOSAT is already returning data to Earth. The use of GOSAT data enhances ongoing validation activities at AER by extending algorithm validations of trace gas remote sensing into the short-wave infrared region of the spectrum and provides the ability to directly compare the data with other measurement technologies, including laser technologies operating in this spectral region. It also allows us to validate source-sink-transport models for atmospheric carbon.

A key element in the remote sensing of weather and climate is the ability to characterize cloud cover. AER-developed cloud analysis algorithms form the basis of the Cloud Depiction and Forecast System (CDFS-II) deployed by the Air Force Weather Agency. AER has continued development of these capabilities, providing a means of determining cloud microphysical properties from multi-spectral satellite data. This data can be used as input to radiative transfer modeling of the atmosphere.

AER remains committed to the design, development and deployment of algorithms and methodologies for the characterization and analysis of ground- and satellite-based data relevant to weather and climate.

For more information about the research mentioned in this article, contact: **Dr. Hilary (Ned) Snell, Vice President, Remote Sensing Division, at +1.781.761.2288 or hsnell@aer.com.**

AER Presenters at the 90th Annual AMS Meeting

Monday, 18 January 2010

George D. Modica, S. Lowe, T. Nehrkorn, J. Wensell, J. Baldwin, G. McMullin, and R. Hoffman - 4:00PM - 5:30PM, 2.1. Typical Day Meteorological Data in Support of ATD Modeling.

James M. Griffin, H. E. Snell, and T. Connor - 2:30PM - 4:00PM, 210. Upgraded Auroral Model for Inferring and Forecasting Globally the Precipitating Electron Dosing To Drive Space Weather-Based Models.

Richard A. Quinn, P. P. Whelan, and N. A. Bonito - 2:30PM - 4:00PM, 211. Space Environment and Effects Tool for STK (STK-SEET) technical primer.

James M. Griffin, H. E. Snell and T. Connor - 2:30PM - 4:00PM, 210 - Poster Session. Upgraded Auroral Model for Inferring and Forecasting Globally the Precipitating Electron Dosing To Drive Space Weather-Based Models.

Richard A. Quinn, P. P. Whelan and N. A. Bonito, 211. 2:30PM - 4:00PM, 210 - Poster Session. Space Environment and Effects Tool for STK (STK-SEET) technical primer.

Tuesday, 19 January 2010

Ross N. Hoffman, P. Dailey, **S. Hopsch,** J. Cox, **R. M. Ponte, and K. J. Quinn - 8:30AM - 9:45AM, 3.3.** Quantification of increased storm surge risk to property as sea level rises.

John J. Holdzkom, T. Nehrkorn, J. F. Galantowicz, S. Lowe, M. Horn, **G. D. Modica, and S. M. Leidner - 11:00AM - 12:00PM**, **5A.1.** WRF-based hurricane simulation in the Environmental Data Cube Support System.

S. Mark Leidner, J. Ardizzone, J.C. Jusem, E. Brin, **R. Hoffman,** and R. Atlas **- 3:30PM - 5:15PM, 6B.8.** Ocean-surface wind impacts on hurricane forecasting, regional and global.

Wednesday, 20 January 2010

George D. Modica, R. d'Entremont, E. Mlawer, and G. Gustafson - 4:30PM - 5:30PM, J12.3. Short-Term Solar Radiation Forecasts in Support of Smart Grid Technology.

Thursday, 21 January 2010

John F. Galantowicz, J. J. Holdzkom, T. Nehrkorn, R. P. d'Entremont, and S. Lowe - 8:30AM - 9:45AM, B218. Satellite imagery and virtual globe cloud layer simulation from NWP model fields.

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