AE9/AP9/SPM: Radiation Belt and Space Plasma Specification Models

AER supports the Air Force Research Laboratory in developing, releasing and supporting the AE9/AP9/SPM radiation environment suite of models. From the model Factsheet, “AE9/AP9/SPM is a new set of models for the fluxes of radiation belt and plasma particles in near-Earth space for use in space system design, mission planning, and other applications of climatological specification. Denoted AE9, AP9, and SPM for energetic Electrons, energetic Protons, and Standard Plasma Model, respectively, the models are derived from 37 data sets measured by satellite on-board sensors. These data sets have been processed to create maps of the particle fluxes along with estimates of uncertainties from both imperfect measurements and space weather variability. These estimates can be obtained as statistical confidence intervals, e.g. the median and 95th percentile, for fluxes and derived quantities, supporting design trades.” More information can be found at https://www.vdl.afrl.af.mil/programs/ae9ap9/factsheet.php and https://www.vdl.afrl.af.mil/programs/ae9ap9/index.php.

AER Provides Near-real-time Dst Index Based on DMSP Data

Government agencies, satellite and other space asset operators and designers, and power grid operators use the Disturbance Storm Time (Dst) index to analyze the strength and duration of geomagnetic storms. Dst is a measure of the decrease in the horizontal component of the Earth’s magnetic field near the magnetic equator due to increases in the magnetospheric ring current (see the FAQ). Values less than −50 nanotesla (nT) indicate high geomagnetic activity. The original Dst index is provided by the World Data Center for Geomagnetism, Kyoto, Japan. The index is produced at an hourly cadence using temporal and spatial averaging from four low-latitude ground observation stations. The Kyoto Dst is frequently updated within a few hours of its initial value, and it occasionally goes off-line for periods of hours or days.

It is desirable to have U.S.-based real-time alternatives to the Kyoto Dst, particularly during gaps in its availability, which is our motivation for the space-based AER Dst. A similar Dst proxy is provided by the U.S. Geological Survey’s Geomagnetism Program in the form of a one-minute resolution ground-based alternative to the Kyoto Dst. The University of Oulu, Finland produces another real-time alternative, the Dcx index, which improves upon Dst by correcting for individual station latitude and removing seasonal quiet-time variations.

More technical details about AER’s Dst product can be found at http://swe.aer.com/dst-faq and plots and data may be found at http://swe.aer.com/dst.

Solar Energetic Particle Statistical Forecasting

Solar energetic particle (SEP) events have impacts on both manned and unmanned space-flight and, in extreme cases, may be of concern for polar airline routes. These impacts include increased radiation exposure for humans and increased risk of single event upset (SEU) in electronic equipment. Fast coronal mass ejection (CME) shocks drive the largest SEP events which are likely seeded by preceding solar flares. Over the last several years, AER has participated in a significant amount of work analyzing SEP data, evaluating operational SEP forecast models and developing statistical SEP forecast models. For instance, Kahler and Ling developed a dynamic SEP event probability forecast [Kahler, S. W., and A. Ling (2015), Dynamic SEP event probability forecasts, Space Weather, 13, doi:10.1002/2015SW001222] that accounts for the variable delay time between solar X-ray flares and SEP event onset at Earth, as illustrated below.

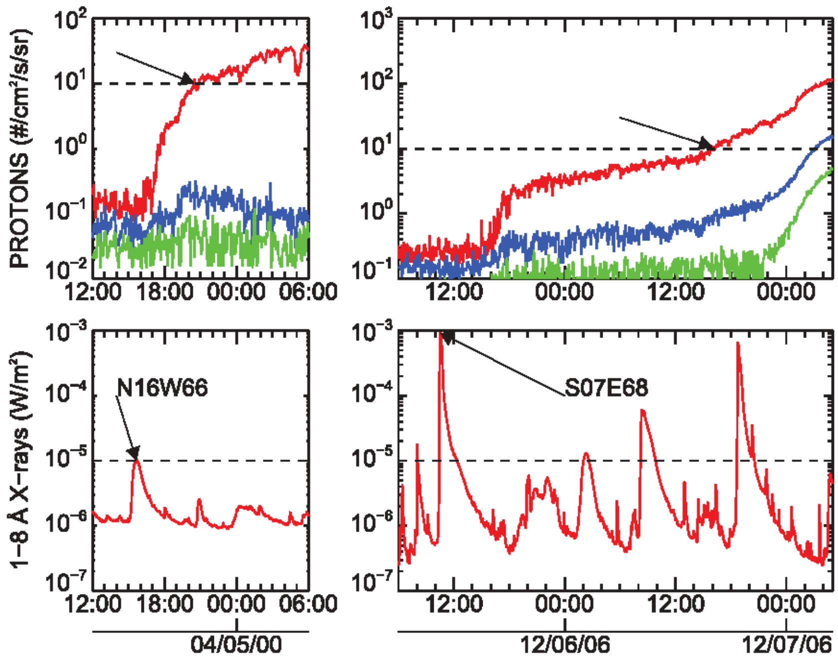

Figure 1. (top) Two SEP events from the primary data set showing the GOES E > 10 MeV (red), E > 50 MeV (blue), and E > 100 MeV (green) proton intensities. The E > 10 MeV thresholds of 10 pfu are indicated by the arrows. (bottom) The associated GOES 1–8 Å solar X-ray flares with peak times indicated by arrows. Time scale is HH:MM in UT. (left) The SEP event of 4 April 2000 associated with an M1 flare at W66◦ has a rapid increase to the 10 pfu level 5.2 h after the flare peak. (right) The SEP event of 5 December 2006 has a 29.3 h delay to 10 pfu following the peak of the X9 flare at E68◦. [from Kahler and Ling, 2015, citation above.]

Further AER research on SEPs is available in the following references:

1. Kahler, S.W., and A.G. Ling, Relating Solar Energetic Particle Event Fluences to Peak Intensities, Sol Phys. 293:30, doi:10.1007/s11207-018-1249-x (2018).

2. Kahler, S.W., White, S.M, and A.G. Ling, Forecasting E>50-MeV proton events with the proton prediction system (PPS), J. Space Weather Space Clim., 7, A13, (2017).

3. Kahler, S.W., and A.G. Ling, Characterizing Solar Energetic Particle Event Profiles with Two-Parameter Fits, Solar Phys 292:59, doi:10.1007/s11207-017-1085-4 (2017).

4. S.W. Kahler, and A. Ling, Dynamic SEP event probability forecasts, Space Weather, 13, doi: 10.1002/2015SW001222, (2015).

5. S.W. Kahler, A. Ling, S.M. White, Forecasting SEP events with same active region prior flares, Space Weather, 13, doi:10.1002/2014SW001099, (2015).