AE9/AP9/SPM Radiation Environment Model

Known Issues and Limitations

Version 1.20.004

The AE9/AP9/SPM model was developed by the Air Force Research Laboratory in partnership with MIT Lincoln Laboratory, Aerospace Corporation, Atmospheric and Environmental Research, Incorporated, Los Alamos National Laboratory and Boston College Institute for Scientific Research.

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The AE9/AP9/SPM model and related information can be obtained from AFRL's Virtual Distributed Laboratory (VDL) website: https://www.vdl.afrl.af.mil/programs/ae9ap9

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V1.05.001 release: 06 September 2013

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In a future release of AE9/AP9/SPM, the model will be renamed to be
"International Radiation Environment Near Earth" (IRENE).

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Listed below are the known issues and limitations of the AE9/AP9/SPM model. Some of these are due to sparse or no satellite sensor data available in specific energy, spatial, and/or temporal regimes, hence our request for new data sets to help fill existing gaps and/or augment the data sets currently incorporated into the model. Other limitations are due to the dependencies upon external models, which have their own limitations.
The AE9/AP9/SPM model continues to be improved and enhanced. The development team is attempting to reduce or eliminate these limitations and minimizing the effect of the various issues when possible.

- The input ephemeris file *must* contain position information at a *fixed* timestep; the fluence and dose values are calculated based on this assumption. This will be addressed in the next version.

- The model currently contains no solar cycle dependence, in particular with regard to LEO region proton variations. This will be addressed in a future version.

- Uncertainties in the LEO region protons for energies <20 MeV are large, due to variability in the satellite sensor data, and sparse data coverage.

- There are significant uncertainties in particle flux gradients for altitudes in the LEO region (i.e. <800km), affecting both AE9 and AP9 models.

- The error bars for the inner zone electrons are poorly constrained at all energies. The Van Allen Probes sensors have detected no electrons with energies >700 keV; past measurements of such are ambiguous. It is unknown if this current environment state is temporary or the nominal condition.

- SPM error bars are lower than actual uncertainties, particularly for O+ and electrons; The O+ and He+ models are based on a single data set (Polar CAMMICE/MICS), and thus contain no measure of uncertainty based on disagreements between data sets.

- The SPM model contains no dependence upon Magnetic Local Time (MLT). This will be addressed in a future version.

- *Untrapped* particles, such as solar protons, are *not* included in the AE9/AP9/SPM model flux calculations. This will be addressed in future versions.

- The AE9/AP9/SPM model uses the IGRF magnetic field model for the main geomagnetic field. Due to the limitations of the IGRF model table of coefficients, the magnetic field results are fixed for all dates after 01 Jan 2020. Continuing development of the AE9/AP9/SPM model may include the ability to calculate valid and realistic results beyond that date.

- The neural network databases for Phi and Hmin cover the history of IGRF from 1965 to 2015 (and extrapolated to 2020), with errors of approximately 1% RMS. These neural networks are retrained when the IGRF coefficients are updated at 5 years intervals. The Phi and Hmin results from the new and old neural networks may differ by the 1% training error, even when evaluated at dates for which the IGRF coefficients have not changed. While this error is well within the uncertainty in the full calculation of the Phi and Hmin values using the IRBEM library, it can lead to larger differences, up to 5-15% RMS when used to compute individual fluxes. Therefore, one should not expect to exactly reproduce AE9/AP9/SPM model runs before/after an IGRF update.

- Model runtime is slow for cases with very long durations and/or multiple scenario runs. A future version of the model (v1.35) will provide parallelization capabilities, and this capability will be expanded in subsequent versions.

Contact Information

Please send any questions, comments and/or bug reports to: ae9ap9@vdl.afrl.af.mil

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