Upgraded Auroral Model for Inferring and Forecasting Globally the Precipitating Electron Dosing To Drive Space Weather-Based Models

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Overview

The Hardy-Gussenhoven Auroral Dosing Model (HGADM) provides the electron characteristic energy, energy flux, and number flux as a function of Kp, geomagnetic latitude and local time. We expanded the capabilities of the HGADM by allowing the use of Auroral Boundary Index (ABI) information, based on the DMSP SSJ particle measurements, to provide a means for correct geographic placement and dosage scaling of the auroral oval. By applying techniques to project future values of the ABI, the HGADM may be run in a forecast mode and, when coupled with a suitable space weather-related model, allows for the prediction of expected modeled responses on a global basis and to be used in determine conditions along a given sensor line-of-sight. For this poster we present a working example of how our expanded HGADM can be used for determining the integrated line-of-sight optical radiance as observed by space-based sensors, and present radiometric results computed with this method compared to space-based sensor measurements viewing auroral scenes.

HARDY-GUSSENHOVEN AURORAL DOSING MODEL: GENERAL DESCRIPTION

- Model is based on statistical binning of DMSP SSJ particle data as function of Kp, and geomagnetic latitude and geomagnetic local time.

- Model (1987) provides the following set of outputs for
  - Electron Number Fluxes
  - Electron Energy Fluxes
  - Pedersen Conductivities
  - Hall Conductivities

- From the first two, we can specify the auroral dosing due to electron precipitation as:
  - Em == Electron Characteristic Energy
  - Qm == Electron Total Energy Flux

- The model can be used to construct the global grid of Em and Qm values

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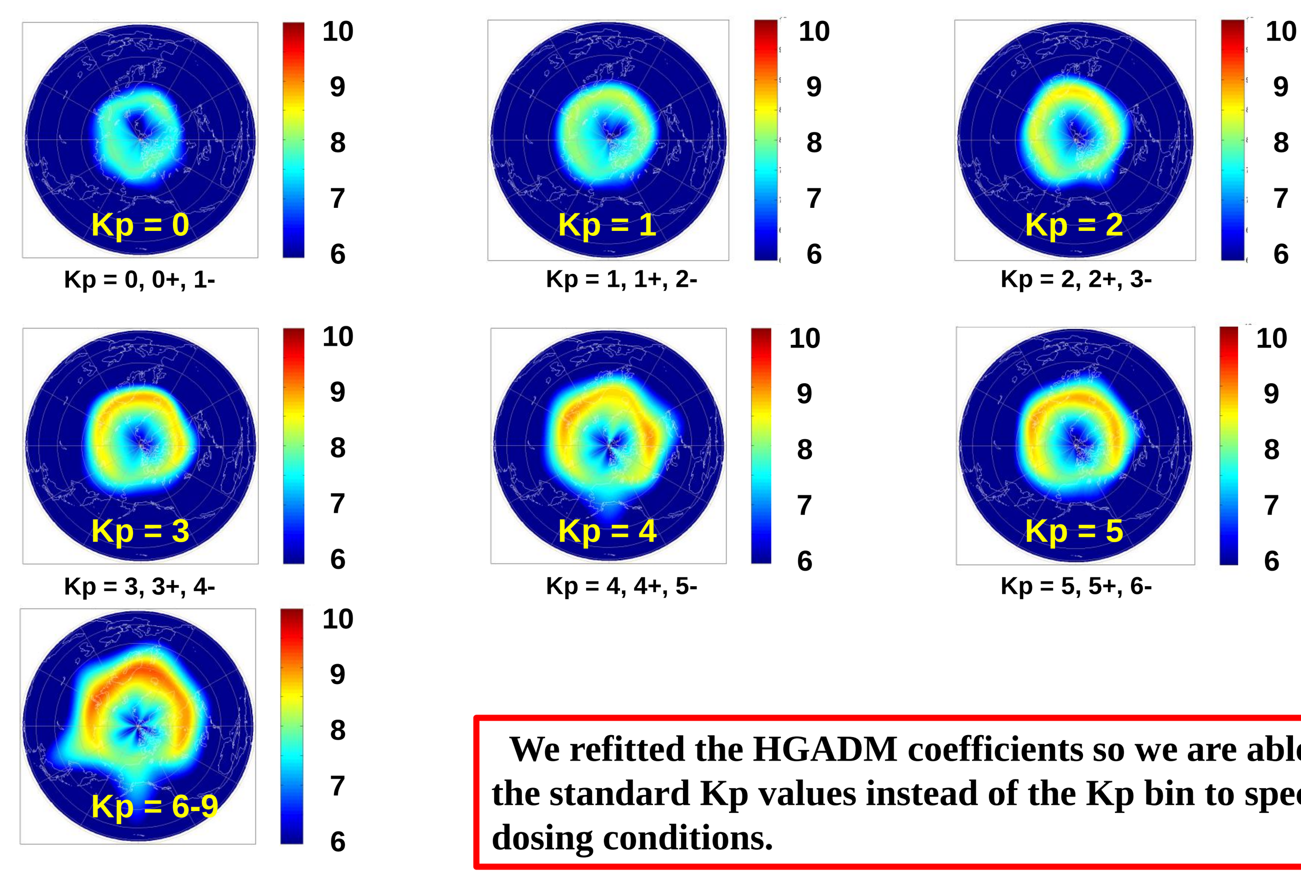
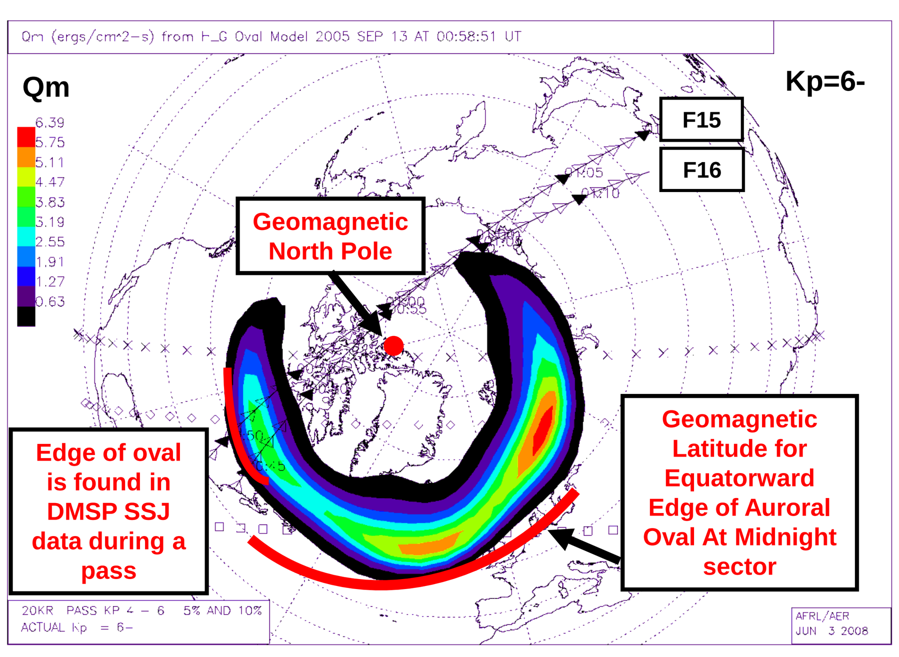
ELECTRON ENERGY FLUXES (ergs/cm²*sec*sr) SHOWN FOR EACH Kp BIN



We refitted the HGADM coefficients so we are able to use any of the standard Kp values instead of the Kp bin to specify the auroral dosing conditions.

HARDY-GUSSENHOVEN AURORAL DOSING MODEL: CONVERSION TO ABI INDEX

Auroral Boundary Index (ABI)



Acknowledgements: The DMSP particle detectors were designed by Dave Hardy of the Air Force Research Laboratory, and the Auroral Boundary/Hemispheric Power Indices are provided with permission from the Space Vehicle Directorate, Air Force Research Laboratory, Hanscom AFB, MA 01731, via the Cedar Database at the National Center for Atmospheric Research which is supported by the National Science Foundation.

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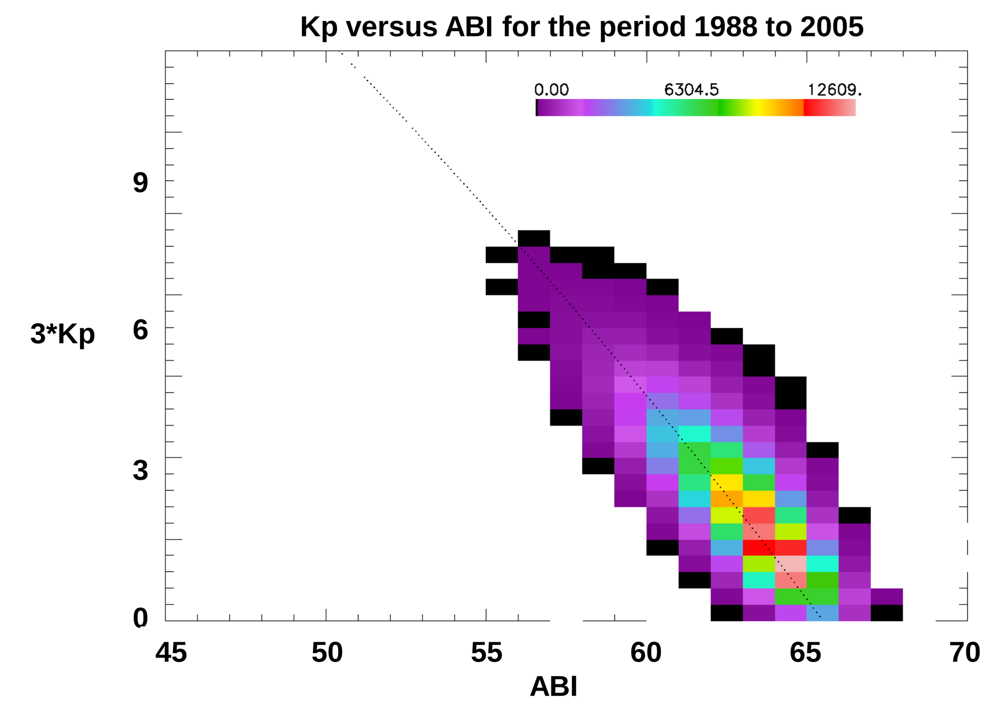
We switch over to the use of ABI index, which is defined as the geomagnetic latitude for equatorward edge of the auroral oval at the midnight sector.

ABI Index is derived from the DMSP SSJ particle data taken during polar passes. ABI can be used to globally locate the auroral oval and provide its size and strength.

The advantage is that ABI can be determined at a higher temporal resolution than Kp, depending on the number of active DMSP satellites and their polar crossing time offsets from each other.

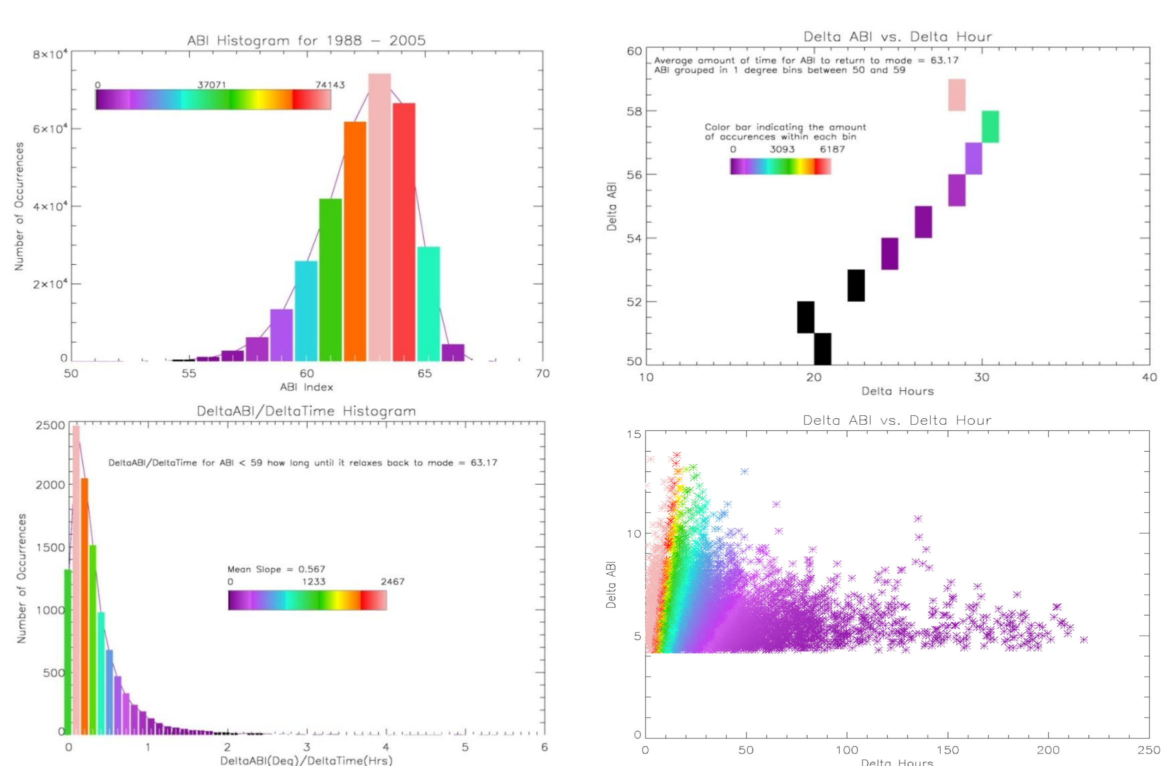
This means that while Kp is a 3-hour quantity, ABI provides greater time resolution. This is useful for performing statistical analysis at the finer temporal variations in the auroral oval size, position, and strength.

Note that there is a linear relationship between ABI and its Kp equivalence as shown.



While the original HGADM (1987) was based on Kp bins, we took advantage of the ABI Index to improve on the scope and variability of the auroral model, and to build a forecast model.

FORECAST AURORA GLOBAL MODEL FROM STATISTICAL ANALYSIS OF ABI VARIATIONS



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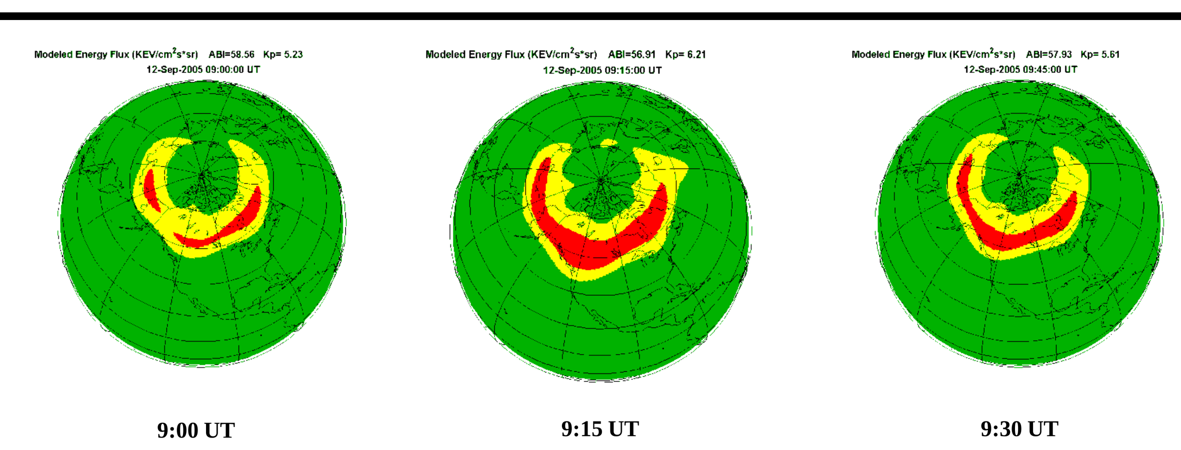
The example on the right shows that the auroral placement and size do change rapidly and quite significantly within 30 minute. A single 3-hr Kp value would not have properly defined the oval placement, thereby causing either an over-rated or understated indication of the auroral dosing for any affected point on the globe.



Through statistical analysis of the Auroral Boundary Index (ABI) indices over the past solar cycle, a first-order rule-based general ABI trend predictor algorithm was developed.

This allows for the past five ABI indices, to provide a one-day forecast projection of where the auroral would likely to be located within the next 24 hours.

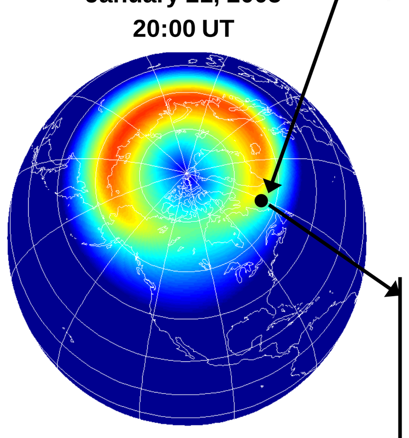
Note that the forecast can be amended with updates of the ABI indices that are provided in real-time.

Using this feature, we should be able to forecast any sudden dynamic variations within the auroral oval during a short period and with frequent updates will robustly correct the forecast oval positions.

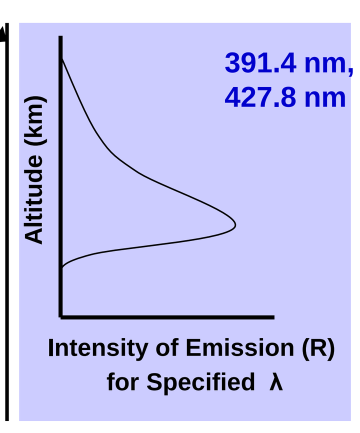
FORECAST AURORA GLOBAL MODEL: APPLICATION TO OPTICAL EMISSION PROFILES

Modeling Emissions Profiles for Computing Integrated Satellite Line-of-Sight Radiances

January 21, 2005
20:00 UT



Em
Qm
Column Integrated 391.4 nm, 427.8 nm



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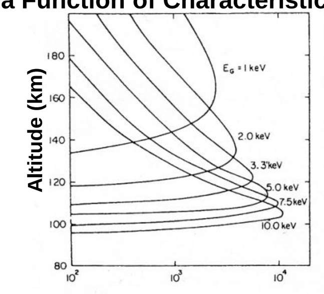
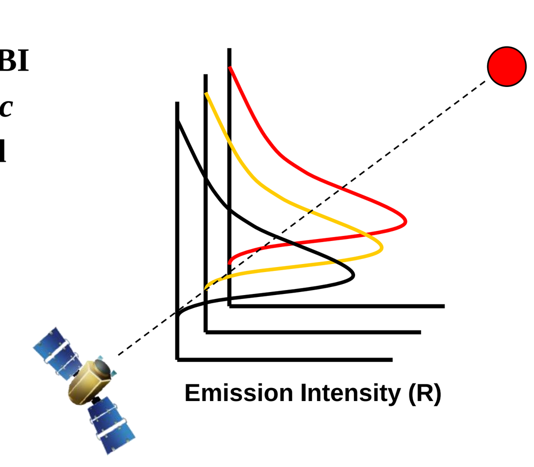
STEP 1: We use HGADM, adjusted by the ABI index, to provide us the electron *characteristic energy (Em)* and *energy flux (Qm)* on a global grid.

Total Ion Production Rates as a Function of Characteristic Energy

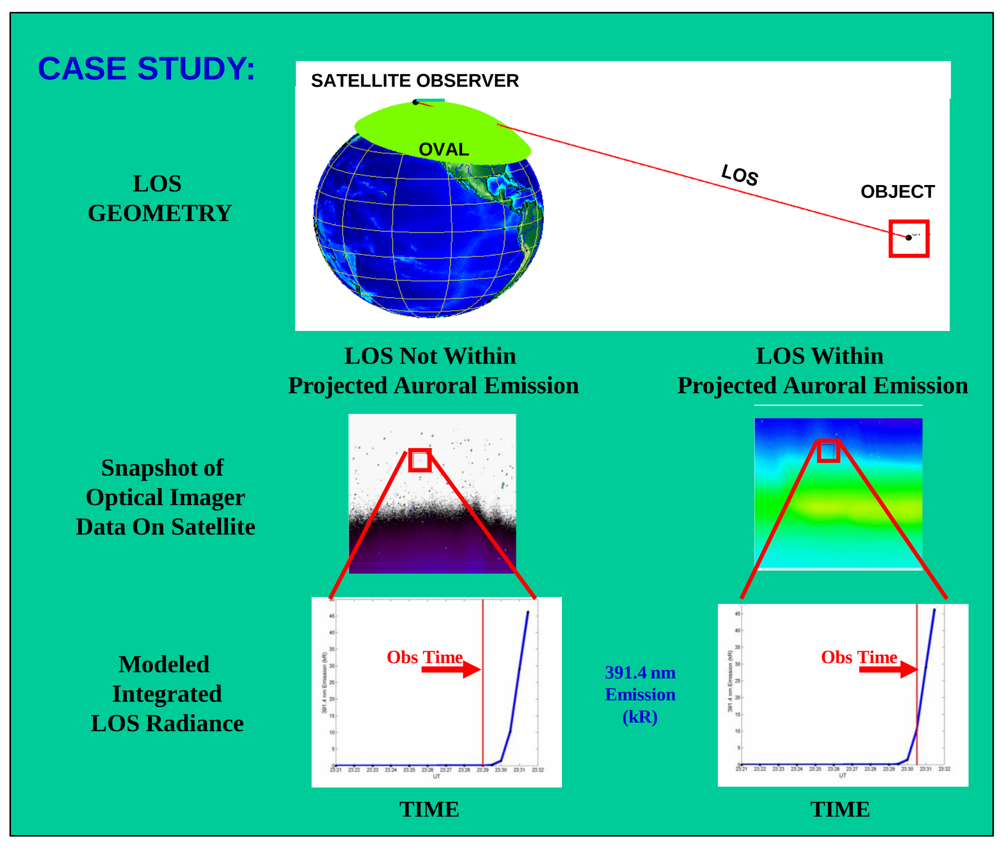


from Strickland et al. [1983]

STEP 2: We then compute the Chapman-like profiles for both the 391.4 and 427.8 nm emissions, using the Em and Qm values, thereby constructing a global grid of emission profiles.



STEP 3: By interpolating the emission profiles along an LOS we can provide a measure of integrated radiance between sensor and the point of interest.



CONCLUSION: Model (bottom) agrees with the measurement (top)

This demonstrates that our enhanced auroral module can be used as input to any space weather model dependent on electron dosing to provide global-based results with forecasting options.

SUMMARY:

We have developed an enhanced auroral forecast module that can provide information about and forecast auroral environmental events. The aurora oval environmental can then be determined and forecasted to provide inputs for models needed to characterize space weather effects within the atmosphere from at high-altitude down to the troposphere. We are currently developing a high-structured version module and will be presented at a later time.

Acknowledgements

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