Systematic Extraction of Auroral Inputs from DMSP SSJ Electron Particle Data for use with Air Force Standard Atmospheric Radiative Transmittance Models

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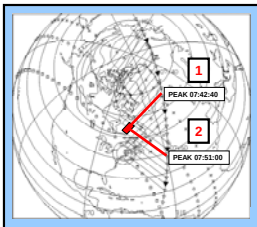
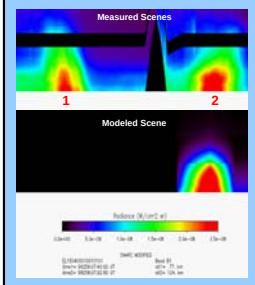
Overview

While the Air Force standard radiative transmittance codes do have the capability to compute radiative enhancement due to auroral dosing as described by model inputs, there still remains the need to readily and consistently quantify those inputs for a wide range of auroral environments. To address that issue, work has been done to use the DMSP SSJ (Precipitating Electron and Ion Spectrometer) electron particle data for characterizing the dosing and extent of the electron precipitation within the auroral regions. This poster starts with the work done to calibrate the SHARC auroral inputs with the measured observations made by MSX SPIRIT III radiometer during a data collect event. The results from a study of the dosing history are then presented to demonstrate the effect of prompt and sustained periods of dosing on radiance due to various key auroral emitters. Finally, this poster presents a demonstration of how the SSJ data can be used to systematically derive a high-resolution spatial and temporal series of the model inputs needed to provide a more variable and reasonable characterization of the IR atmospheric radiance due to presence of active auroral regions.

Calibration of SAMM Auroral Inputs with Measured Scenes

Used Measured Auroral Scenes To Get Dosing and Duration of Electron Precipitation





METHODOLOGY

We used this MSX SPIRIT III Data Collect Event because the satellite observed the same auroral region from two nearly orthogonal viewpoints at two different times.

SUMMARY

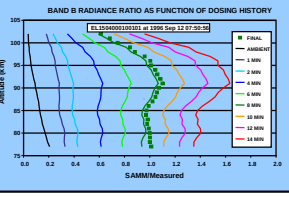
- Use measurements to locate the dosing region and determine its size.
- Time difference between measurements gives minimum dosing duration.
- Adjust model inputs to match measurement taken at the second time to get overall dosing parameters (electron characteristic energy and integrated energy flux).

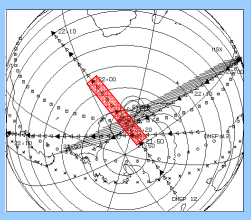
NOTES:

-From triangulation, the dosing region is located within the red boxed area.

The peak of the bandwidth radiances of the observed auroral region occurred at 07:42 UT and at 07:51 UT. Their values are similar.

The modeled scene represents the solution for this scene The plot below shows the ratio of the model to measured radiance profile as the function of the dosing history for the region.





VALIDATION

Assess methodology by matching results from two different data sources.

We use this MSX SPIRIT III Data Collect Event because of the availability of near-simultaneous DMSP SSJ data.

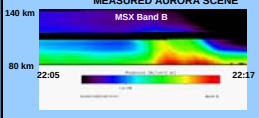
- MSX observed an auroral region from 22:11 to 22:17 UT.

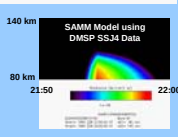
- DMSP F12 SSJ4 sampled the same geographic region from 22:53 to 22:55 UT that was measured by MSX between 22:14 to 22:16 UT.

- We used the SSJ data to infer the auroral inputs for the electron precipitation dosing and did model runs to generate the scene of what a satellite with a MSX-like sensor moving along the DMSP F12 satellite track would have observed within the red shaded box in the top figure.

- Caveat: The dosing history for this case was kept the same as the one used for the previous auroral scene validation to keep the parameter space sufficiently small for the purpose of this study. This assumption of same dosing history needed to be examined in the next step for completion.

MEASURED AURORA SCENE



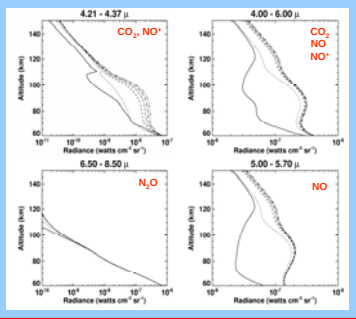


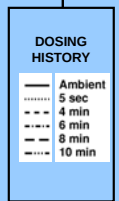
ASSESSMENT

In using these two auroral scenes, we have demonstrated that the calibration of the SAMM Auroral inputs have been achieved and validated.

Dosing History Study With Model Runs

DOSING HISTORY WITH SIGNIFICANT AURORAL EMITTERS





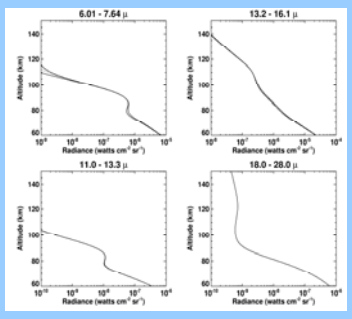
The above plots based on model runs show that for some of these hypothetical bands:

- Most of their enhanced radiances are due to the prompt emissions and subsequent extended dosing will not significantly increased their levels.

OR

- After initial increase of enhanced radiances within a short time period, the longer the dosing persist, greater their level of enhanced radiances will be.

DOSING HISTORY WITH NO SIGNIFICANT AURORAL EMITTERS



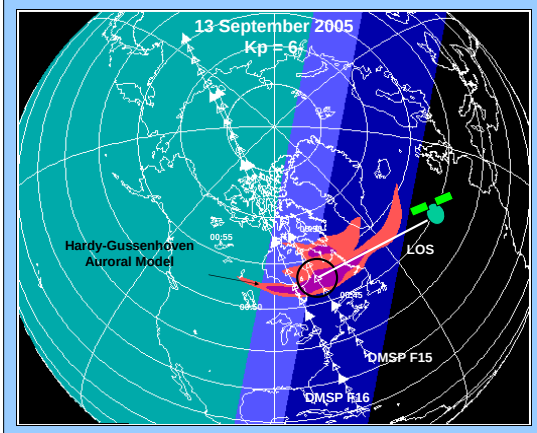
These plots based on model runs show that for some of these hypothetical bands:

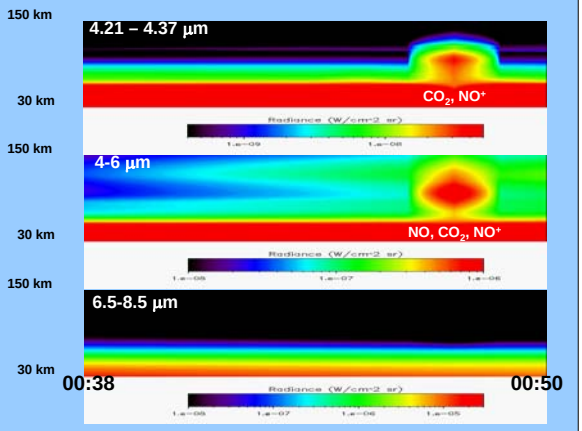
-Where there are no significant auroral emitters, radiances from other emitters will not increase due to the presence of the electron precipitation within the auroral region for any dosing duration.

-Caveat: There is a need to investigate if precipitating electrons with higher energies would affect these hypothetical bands.

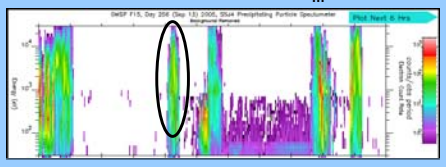
Demonstration of Single-Profile Auroral Scene Generation

Predicting IR Sensor Impacts During Magnetic Storms





DMSP F15 00:46 UT SSJ4 E_m= 7 KeV



S Pole N Pole S Pole

NOTE: One-Minute Average SSJ Data Shown Above

SCENARIO

Given:

- Geomagnetic storm of Kp = 6- on 13 September 2005.
- DMSP F15 and DMSP F16 SSJ data available 00:38 to 00:50 UT

Assume:

- An IR sensor with three different bands onboard a satellite.
- The tangent points of the sensor boresight LOS trace along the subpoints of the DMSP F15 track though the auroral region as represented by the Hardy-Gussenhoven Radiance Probability Auroral Oval model.
- At the time of the peak electron precipitation as seen in the SSJ4 data, use a single pair of characteristic energy and energy flux values to define the auroral inputs.

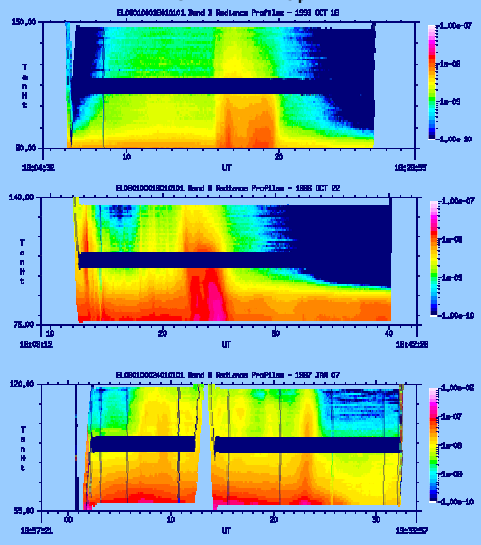
Model Run Results:

-The model radiance profiles (one auroral and several ambient) are plotted as a time-series to generate the scene as it would be observed within the three sensor bands shown above.

Apply Method To Generate Multiple-Profiles Auroral Scene

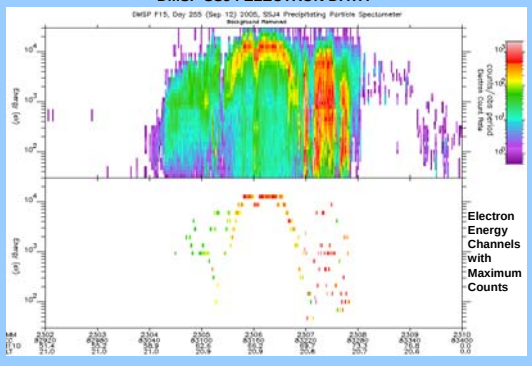
HOW CAN WE GENERATE COMPLEX AURORAL SCENES LIKE THOSE BELOW?

MSX BAND B - 4.3 µm

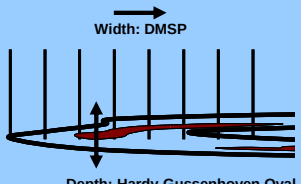


BY USING DMSP SSJ4 DATA AT DESIRED RESOLUTION TO GENERATE AURORAL DOSING INPUTS …

DMSP SSJ4 ELECTRON DATA

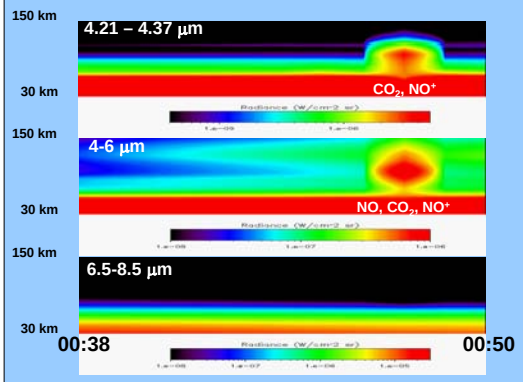


…AND USE HARDY-GUSSENHOVEN AURORAL OVAL MODEL WITH SPATIAL RESOLUTION OF THE DMSP SSJ4 DATA TO DEFINE THE DOSING REGION

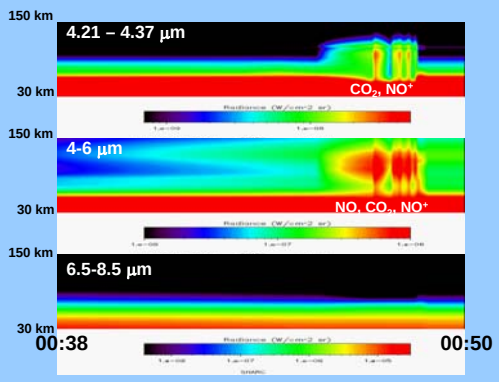


Initial Demonstration of Multiple Profiles Using DMSP SSJ Data at Selected Times Within Auroral Region

Magnetic Storm 13 Sep 2005 – Inferred Impacts on IR within Auroral Region Using DMSP SSJ Data at Low and High Temporal Resolution



Single - Profile Case



5-Second Resolution Case
(Selected Auroral profiles)

Discussion and Conclusion

➢ **DMSP SSJ data can be used to determine electron characteristic energy and electron integrated energy flux to be used as auroral model inputs to AFRL standard radiance transmittance codes. SSJ data can also be used to locate the dosing region but only along the DMSP satellite track.**

➢ **The 2-D extent and magnitude of the dosing region can be delimited by the Hardy-Gussenhoven Auroral Oval Model; the position can be adjusted to match the onset of dosing as perceived within the SSJ data. At this point we can calculate the dosing for arbitrary LOS of a hypothetical sensor within the auroral region. (We have an ongoing effort to configure the RT codes to accept this type of 3-D data).**

➢ **Dosing History can be adjusted for specific radiance bands, but for the most part a fixed duration of the several minutes is sufficient to define the dosing duration for general model runs. If there are additional information available that provide the actual dosing history such as a pair of DMSP SSJ data runs over the same region within a short amount of time then the dosing history can and should be set to a more definitive value.**

➢ **This initial study has demonstrated that there is merit to the methodology and that additional work in this topic is warranted to further refine the technique for application to modeling space-based observations in the IR regime.**

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