

Better modeling through MATLAB: Connecting the auroral oval and the convection reversal boundary using DMSP observations

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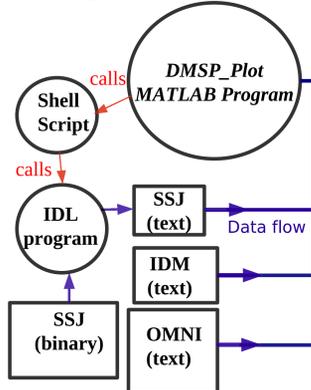
Abstract

Under normal conditions the high latitude ion velocity reverses direction from anti-sunward flow at the polar cap to sunward flow in the vicinity of the auroral oval. This switch marks the transition from open magnetospheric field lines (near the pole) to closed. The location of the convection reversal boundary (characterized by large ion velocities in opposite directions) relative to that of the auroral oval is a key factor in the determination of energy inputs into the ionosphere. To study this relationship, an existing MATLAB interface intended for the interpretation of DMSP 15 data from 2004/2005 was heavily modified to expand the range of dates, satellites, and ground-based data available for the user to visualize. A subset of the routines and auxiliary programs developed for this endeavor were used to create a more targeted tool which calculates the CRB and auroral parameters (peak flux and 1/e fall-off points) for each orbit with a wide range of available times and satellites. Preliminary studies using DMSP 13 show the capability of the tool, but more fine-tuning and analysis are still needed.

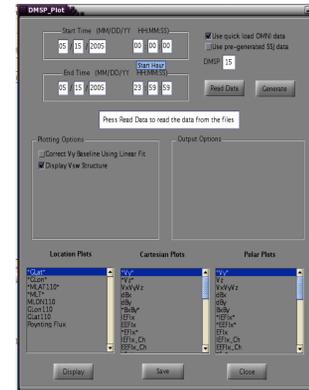
An Improved Tool for DMSP data

DMSP_Plot is a MATLAB program which incorporates many elements from Data_Plotter developed by Adela Anghel at HAO. It expands that program's capabilities to all available data forms. The major step was the integration of the *energy.pro* IDL program to decode SSJ binary data and generate whole-day text files.

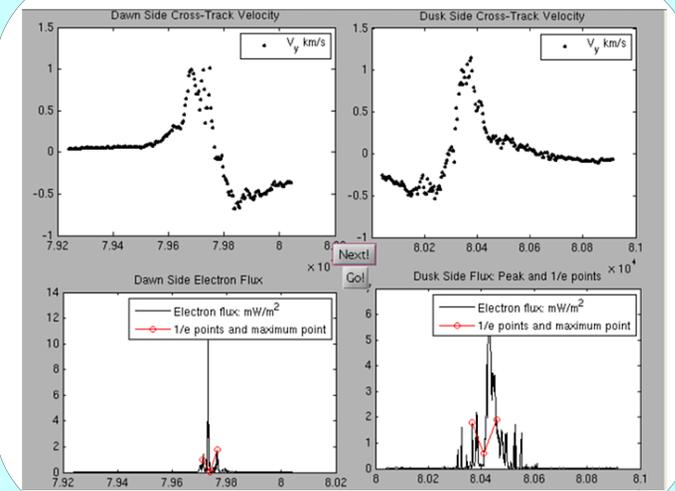
Program Schematic



Screenshot of Plot Setup

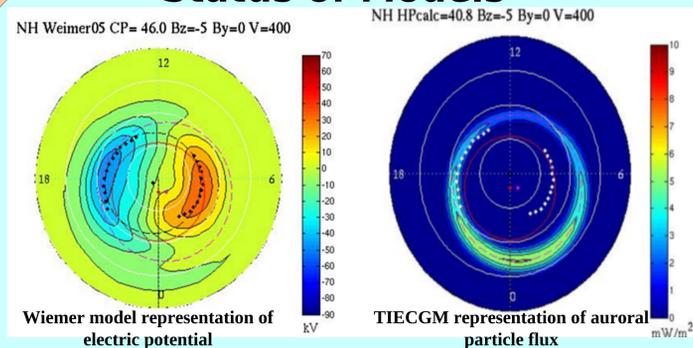


Proof of Concept/Preliminary Results



Pictured above is a screenshot of an auxiliary program which uses the data reading functions developed for DMSP plot to specifically find the CRB and the electron/ion flux maxima and 1/e points. This is the first day of data analyzed with the program, and there are still significant problems (such as the algorithm's failure to find the convection reversal point). However, for the most part, the tool works as intended, and only minor changes need be made before it can be used to begin the statistical study.

Status of Models



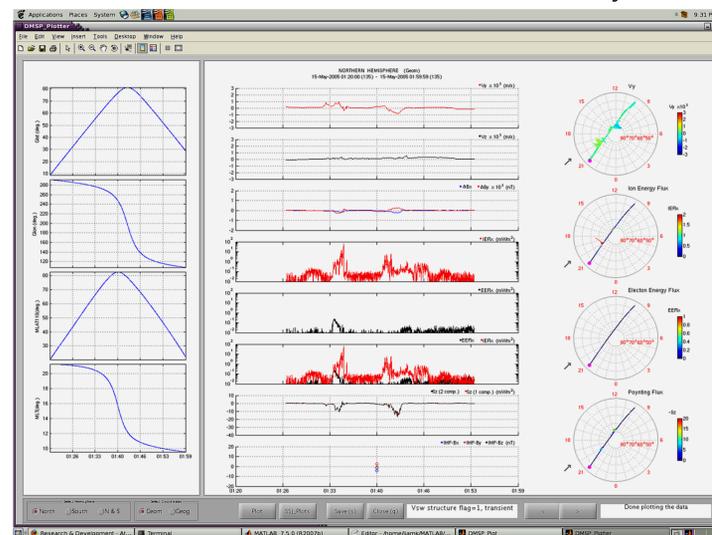
The TIEGCM (Thermosphere Ionosphere Electrodynamics General Circulation Model) relies on its auroral model to ascertain the energy coupled into the upper atmosphere from the solar wind. The primary mechanism for the coupling is Joule heating, by which auroral precipitation helps drive neutral winds by colliding with the neutrals and increasing their internal energy. This is only a part of the total Joule heating, the other major contributor being additional collisions between neutrals and magnetosphere-driven convecting ions in the 'polar cap' region.

Above figures show the model results for convection (Wiemer) and auroral flux (TIEGCM). The equipotential contours in the Wiemer plot indicate the paths of ion convection (analogous to current flow). The black (white) dots in Wiemer (TIEGCM) indicate the **convection reversal boundary**. The black (red) dotted line is a fit of the convection reversal to a circle. In both plots the red dot indicates the center of the **CRB**, and the magenta dot indicates the auroral center. The magenta line indicates the circle fit to the aurora flux max. These model runs used a moderately active solar wind, but with no B_y component.

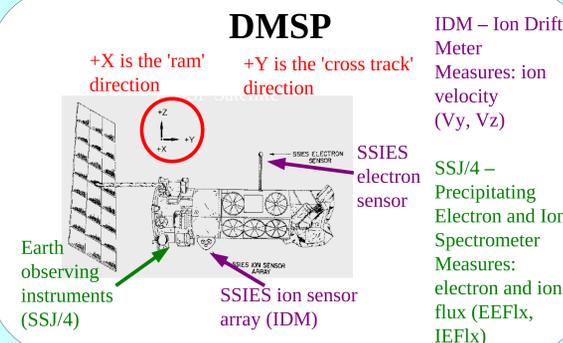
Motivation

The distance between the center of the auroral fit and the center of the convection reversal is fixed in the above models. Though the radius of the CRB varies, the center remains fairly constant over the magnetic pole. It is known that the 'center' and radius of the aurora vary as a function of solar wind parameters. The fact that the models do not take this into account leads to fairly major inconsistencies under certain conditions. This project's aim is to improve the models' ability to calculate the relative positions and radii of the aurora and CRB by introducing a statistical model of the variations in position into TIEGCM, and thereby improve Joule heating estimates.

Screenshot of Plots of Flux and Ion Velocity



Data Sources



Data statistics

Data	Type	Source	Datapoint Frequency	My Frustration
Particle Flux	Binary	DMSP SSJ	1 second	high
Ion Velocity	Text	DMSP IDM	4 seconds	low
Solar Wind (B_{xyz} , v , P , etc.)	Text	OMNI	1 hour	medium
Indices (HP, Kp, eqb, etc)	Text	'OMNI' metafile	1 hour	medium

Conclusions

- Most of the major technical hurdles have been overcome
- The program and functions created for this project should be useful for many other projects inside HAO and possibly at other institution that use DMSP data
- There is still much work to be done before the ultimate goal of improving TIEGCM's aurora model is realizable:

- Find days with desired solar wind conditions
- Acquire data on CRB and flux
- Analyze and correlate to solar wind variables/indices
- Add ability to compare Wiemer and TIEGCM models to DMSP data in *DMSP_Plot*
- Modify the models according to findings

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