Analysis of the Dayside Equatorial Anomaly

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I. EA Analysis Overview

Abstract:

The purpose of this study is to develop a morphology of the dayside Equatorial Anomaly using GUVI data. Signal processing techniques are used to enhance the appearance of the EA from the overlapping day glow, and then compare the EA shape and intensity to other days in the year. The final goals of this project are to determine a model for what drives the dayside EA, compare it to global space weather models, and determine the neutral winds relationship to the EA.

Background:

The Equatorial Anomaly consists of dense regions of plasma on the north and south sides of the equator, at altitudes of approximately 180 km. The driver for this phenomenon is the Equatorial Fountain Effect, which is described by rearranging the Lorentz force equation into $\vec{v} = \frac{\vec{E} \times \vec{B}}{|\vec{B}|} \, m/s$

This shows that that a zonal electrical field crossed with the earth's magnetic field will generate an upward movement on charged particles.

The two most likely causes of these zonal electric fields are terminator charge buildup and E-region Dynamo (caused by neutral winds). The first is a charge differential from the daytime to night-time terminator. The second is caused by neutral winds moving charged particles, which creates an electric field which maps to higher altitudes.

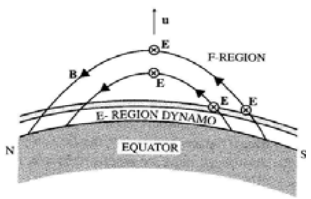


Figure 1: Fountain Effect

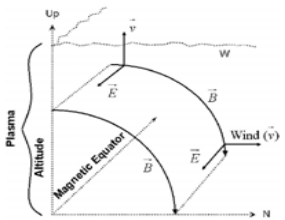


Figure 2: E-field Mapping

GUVI:

In order to look at the E- and F-region dayside plasma densities, we need to use an ultraviolet imager that looks on the earth's limb (this avoids most of the dayglow from the lower atmosphere). The Global Ultraviolet Imager (GUVI), part of the TIMED satellite, gathers the 1356 A wavelengths on its limb scans.

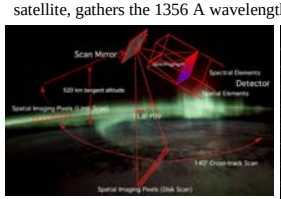


Figure 3: GUVI Instrument

GUVI offers:
- Global sampling
- Easy access to the Net CDF data
- 6 complete global passes/year
- 400 scans/orbit
- 14 longitudinal sectors/day

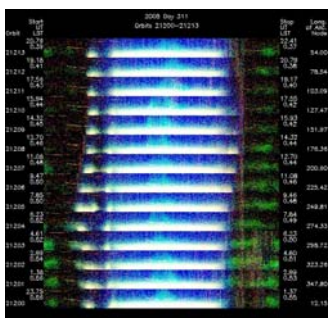
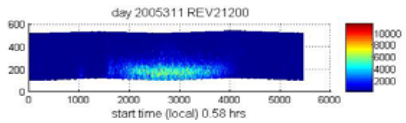


Figure 4: GUVI Limb Scan

II. Data Processing and Analysis

Original Data:

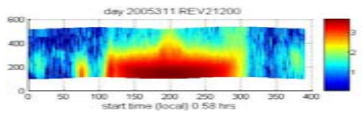
After loading the limb scan for an entire satellite orbit, the along track radiance data is plotted against altitude to display the limb radiance from the initial equator crossing to the final equator crossing. The graph is plotted for 135.6 nm



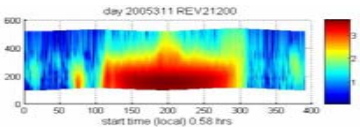
Filtering:

There were a few different filtering methods used to extract the EA shape from the original data. These include across-track mean filtering, Singular Value Decomposition (SVD), and linear surface fitting.

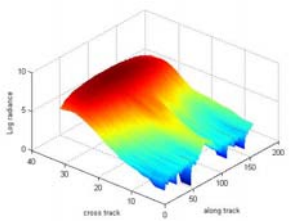
The across-track mean filtering was done on the radiance values averaged for every 14 along track pixels. A sliding window of 6 across-track pixels (vertical columns) was averaged to determine the new image values and data was plotted using logarithmic scale



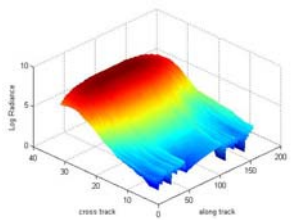
The SVD of the radiance data is determined by the decomposition $M=U\cdot\Sigma\cdot V^T$, where Σ is a diagonal matrix ordered from highest to lowest value and U and V are vectors. In order to smooth the image, the smallest elements of Σ are set to zero and the radiance matrix is reconstructed.



The bright radiance at the lower altitudes of around 150 kms is due to airglow. We use the fact that air glow is of a logarithmic linear pattern to subtract airglow from radiance due to 135.6 emissions. The observed radiance data has a clear lump at an altitude of 350 kms which can be extracted by linear fitting.

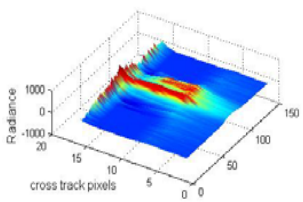


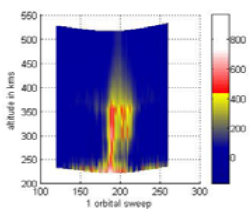
Actual surface



Linear fit to the surface

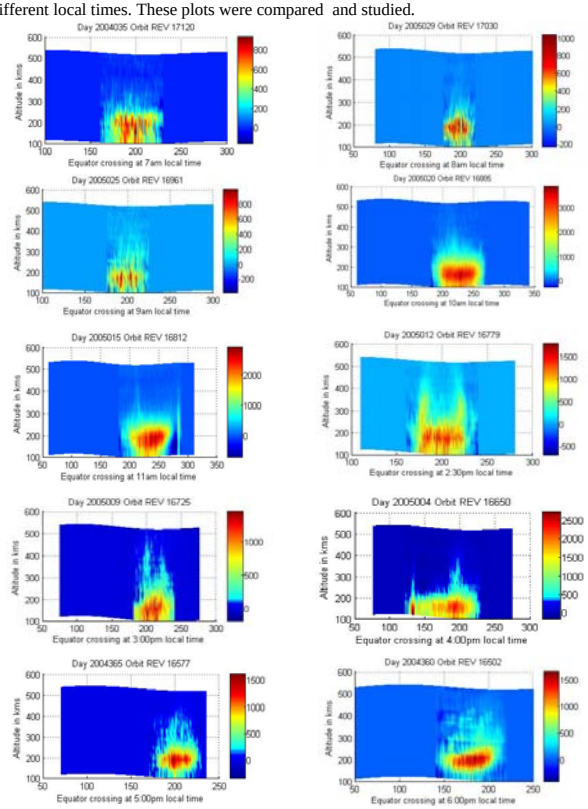
When the linear surface is subtracted, the final surface enhancing the equatorial anomaly is obtained as shown below





III. Results

Limb Files were downloaded for different orbits crossing the equator at different local times. These plots were compared and studied.



IV. Future Work

Some future goals of this study are to:

- Determine crest to trough ratio for the dayside EA
- Examine the EA morphology over the same local time for multiple scans and study the variation, if there is any
- Predict E-fields contributing to the EA
- Study neutral wind relationships to the EA
- Compare neutral wind results to the TIMEGCM global model

References

- Figures 1 & 2 – "Global Characterization of the Equatorial Anomaly with GUVI Data", Sid Henderson
- Figures 2 & 3 - Courtesy of JHUAPL GUVI website