Comparison of GUVI 135.6nm OI radiance observations with outputs from global atmospheric models

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I. Overview

Abstract:

The GUVI instrument on NASA's TIMED spacecraft records radiance data from 135.6nm atomic Oxygen (OI) emissions. This data obtained from GUVI limb scans is used to study the morphology of the Dayside Equatorial Ionosphere as a function of various factors. It can be compared with OI radiance values generated from atmospheric models such as TIMEGCM (Thermosphere Ionosphere Mesosphere Electrodynamics General Circulation Model) and GAIM (Global Assimilation of Ionospheric Measurements) to get insights into how closely these models predict the Dayside Equatorial Ionospheric conditions.

Background:

The primary sources of 135.6 nm Oxygen emissions in the equatorial ionosphere are:

1. The dayglow caused by photo-electron excitation of neutral particles. This 135.6 nm source peaks between 150 and 200 km altitude and rapidly falls off with altitude.

2. The Airglow due to radiative recombination of Oxygen ion with electrons. This 135.6 nm source is proportional to the square of the electron density in the ionosphere.

The GUVI dayside limb-scans observe both sources. At high altitude the primary source of 135.6 nm is the Airglow and is proportional to the ionospheric density. This data is compared with the predicted electron density values from ionospheric models.

At low latitudes the morphology of the ionosphere is dominated by the Equatorial Anomaly. These are dense regions of plasma on the north and south sides of the magnetic equator and are caused by transport of the ionosphere to higher altitudes at the equator by the Equatorial Fountain.

The Equatorial Fountain is an ExB drift,

$$\vec{v} = \frac{\vec{E} \times \vec{B}}{|\vec{B}|} m/s \ ,$$

due to a zonal electrical field and the earth's magnetic field. This zonal electric field is ultimately due to interactions of the neutral winds with the ionospheric plasma. This process is not well understood and there are few observations of it in the daytime ionosphere. The GUVI data presents an opportunity to study the dayside ionosphere, the Equatorial Fountain, and the morphology of the Dayside Equatorial Anomaly.

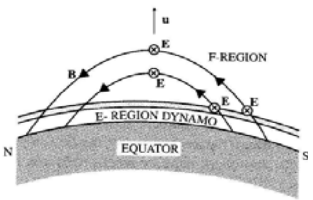


Figure 1: Fountain Effect

GUVI:

GUVI's high altitude limb scans avoid most of the dayglow from the lower atmosphere. Hence we use it to look at the E and F region dayside plasma densities.

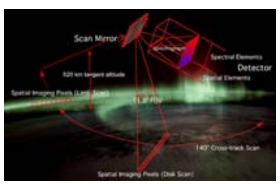


Figure 2: GUVI Instrument

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

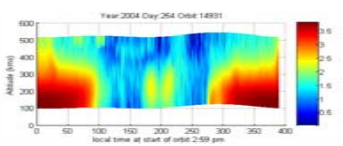
1.Each Limb file has 1 orbit's data

2.It covers 100-500 kms in altitude

3.In the figure given below, the scans at the edges are at the dayside equator and the scan at the center is at the night side equator

4.Dayglow at lower altitudes are seen in the day side

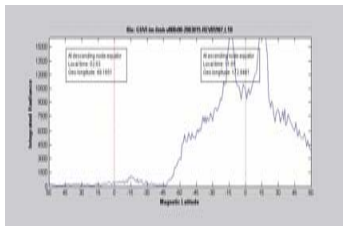
5.Peaks due to the Equatorial Anomaly are observed at the day side equatorial regions at high altitudes



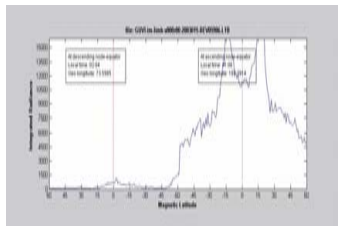
II. Preliminary Analysis

To better characterize the GUVI data, the radiance values were summed in altitude from 300 km upward and plotted as a function of magnetic latitude.

Variability of ionospheric structure at similar local times

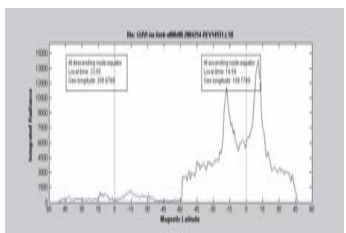


LT 11:05 am, longitude: 172

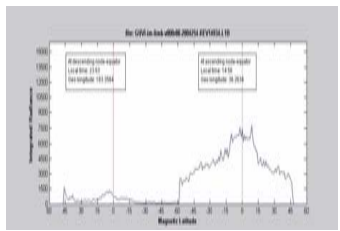


LT 11:05 am, longitude: 197

A movie containing plots like the ones shown here was made for GUVI data from the year 2003-2006. The plots showed a significant variation in the ionospheric structure with longitude, seasons and local times.



LT 3:00 pm, longitude: 109



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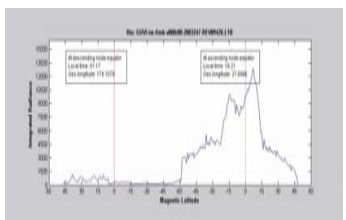
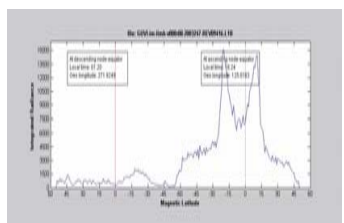


LT 4:30 pm, longitude: 27



LT 4:30 pm, longitude: 125

III. Comparing GUVI Radiance with Models

The electron density values provided by the models have to be reconstructed into a 135.6 nm radiance profile that can be compared with observed GUVI data.

For a selected GUVI orbit, data along every 14 along track pixels is averaged. The GUVI field of view around every pixel's look direction is fragmented into incremental volumes ΔVi at distances s_i from TIMED. For each ΔVi the electron density value is obtained from the model grid using nearest neighbor interpolation. Radiance is given by:

$$L = \frac{\alpha}{\Omega_c} \sum_{i=Numof[\Delta V} \frac{[e_i]^2}{s_i^2} \Delta V_i * 10^{-6} \, Rayleigh$$

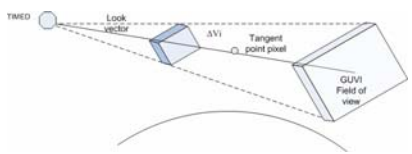


Figure 4: Integrating Radiance along Field of View

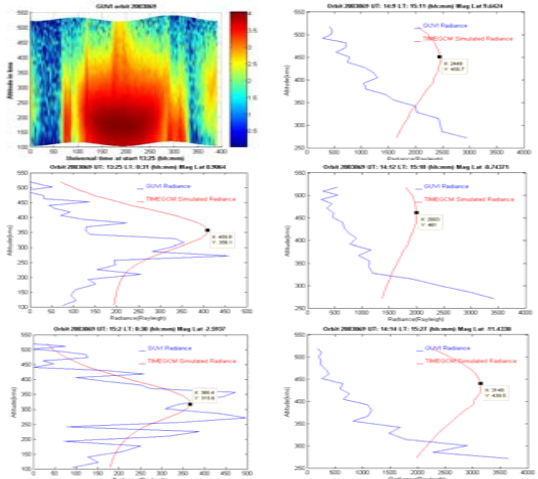
where α is the recombination rate for O^+ ion

Ω_c is the solid angle for GUVI field of view

$[e_i]$ is the electron density associated with ΔVi

TIMEGCM :

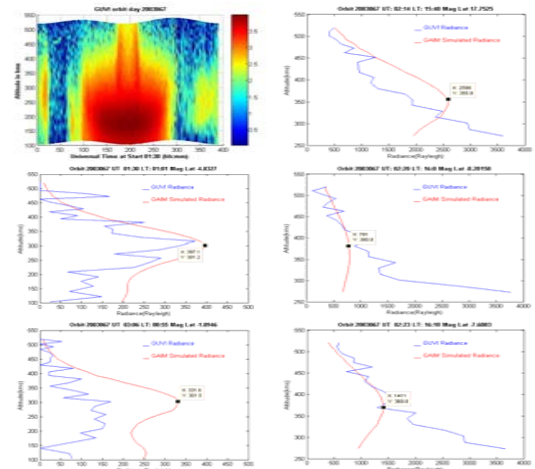
GUVI data and output from TIMEGCM simulation were compared for year 2003 day 69 for the conditions: season- spring equinox, solar flux -143.7 quiet time period.



Altitude profile: Night side **Altitude profile: Day side**

GAIM :

GUVI data and output from GAIM simulation was compared for year 2003 Day 67 for the conditions: season- spring equinox, solar flux -148.3 quiet time period. The mismatch at lower altitudes in the dayside is due to the dayglow observed by GUVI.



Altitude profile: Night side **Altitude profile: Day side**

References

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