Validation of GUVI nighttime Electron Density Retrievals

R. DeMajistre, P. Straus, L. Paxton, D. Morrison

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Overview

- Very brief review of technique
- ISR comparison
  - Profiles
  - Conjugate photoelectrons
- Ionosonde comparison
- IOX radio occultation comparison
GUVI Retrieval Basics

- Based on: \( \text{O}^+ + e \rightarrow \text{O} + h \nu (135.6 \text{ nm}) \)
  - Volume emission rate \( \eta \propto [\text{O}^+][e] \)
- Modified Twomey-Type inversion using non-negativity constraint (see Menke)
- Smoothing constraint based on forward simulations
- Low instrument count rates requires use of multiple scans of GUVI data for a single retrieved profile
Millstone Hill ISR Comparison

- Representative profiles from Oct. 2002
- Good agreement before 3 am local time
- Conjugate photo-electrons the likely source of 135.6nm emission
- Details of ISR validation are being published now
Conjugate Photoelectrons

- Photo-electrons produced on dayside in the opposite hemisphere, transported along field lines
- Effect occurs where southern footpoint has solar zenith angle <95° (dawnside)
- Ratio of 135.6nm to 130.4nm consistent with photoelectron source
- Observations with daylit footpoints are suspect
Ionosonde Validation

- Comparisons made from February 2001 through August 2002 at 21 stations
- Comparison of Ionosonde NMF2 and GUVI estimated NMF2 (from Chapman function fit)

- GUVI data acquired within 200 km and 20 minutes of the station measurements
- Used data where Kp < 4 and Dst > -100
- GUVI inferred NMF2 < 1.e6 and HMF2 < 400 km
Ionosonde Results

- Diamonds show comparison points
- Green diamonds have conjugate footpoint SZA < 100 (not used in averages)
- Solid red shows binned average – broken red the binned standard deviation
IOX validation

- Comparison with electron density peaks from data acquired by IOX (radio occultation)
- Data taken in May and June, 2002
- Coincidences within 15 minutes, and 1000 km (at 300 km tangent altitude)
- $|\text{Magnetic latitudes}| < 50^\circ$
- Roughly 100 coincidences recorded
IOX Results

• GUVI NmF2 is ~23% Low Relative to IOX Retrievals

• Quantitative profile to profile comparison still to be done
Conclusions

- GUVI retrievals yield similar results to ionosonde and ISR and radio occultation measurements
- Unless accounted for conjugate photoelectrons do influence comparisons
- Causes of discrepancies and spread need to be investigated further
- The next step – seasonal maps
Backup Material
Photoelectron Chemistry

- PE density too small for ISR to measure
- $130.4/135.6 \approx 8/3$ (Meier).
- High energy tail of $130.4$ nm emission should have minor effect
- Actual emission depends on local O density

From Meier 91
CPE Analysis

Plot shows average radiance/[O] (from MSIS90) vs. solar zenith angle of southern footpoint.

Radiance clearly depends on footpoint sza, approximately preserving proper ratio.
Millstone ISR data

12 coincidences were taken during Oct. 2002, some near dusk, some near dawn.

10 of the 12 had (southern) footpoint solar zenith angles of less than 95 deg.

Effect not apparent on dusk side – hidden by bright recombination signal?

All dawn side validations are contaminated
More ionosonde

- HMF2 was not systematically compared – it was often not available from the ionosonde
- Ionosonde data acquired from NGDC SPIDR service
GUVI Scan Geometry
Some Limb Profiles

February 1, 2002
Achieving Positive Definite Profiles

- Standard linear constrained retrieval

- Separate model vector into $m_1$ ($m>0$) and $m_2$ ($m<0$) Set $m_2=0$

- Evaluate $\chi^2$ gradient

- Any $m_2$ with negative gradient? Change to $m_1$

- Linear constrained retrieval $m_1$ only ($m_1'$)

- $\delta m = m_1' - m_1$

- $m_1 = a \delta m$, a set so no $m_1<0$, place any $m_1=0$ into $m_2$

- If no $m_2$
Implications of Non-Negativity Constraint

As With Any Constraint, a Bias is Added to the Retrievals

- Tends to add a positive bias (particularly at low signal levels) since high values can’t be offset by negative values
- Tends to concentrate emission within a fixed altitude range since unused pixels set to zero