Comparisons of Auroral Far Ultraviolet and Digisonde Observations

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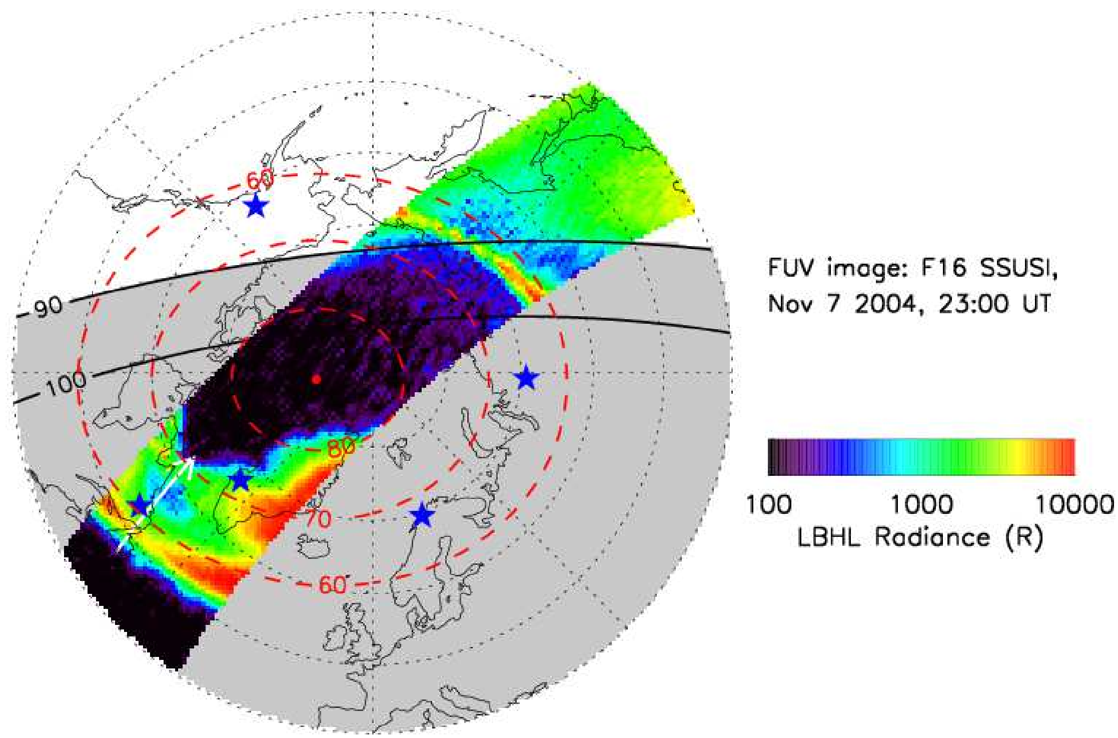
Overview

- NASA grant, H. Knight – PI, Ivan Galkin – Co-I, B. Reinisch – collab., comparing auroral far ultraviolet (FUV) E region derived data products with Digisonde observations to answer a question about auroral FUV remote sensing.
- Problem: fewer usable Digisonde traces than expected.
- Noise contamination of Gakona AK ionograms.
- Relaxing Ea scalability conditions to increase number of usable Digisonde observations.
- Scatter plots showing level of agreement between FUV and Digisonde.
- Ionogram examples illustrating issues.

Idea of Project

- Use established method to derive hmE and NmE from auroral LBHS (140-150 nm) and LBHL (165-180 nm) for NASA TIMED/GUVI and DMSP F16, F17, and F18 SSUSI.
- Compare with Digisonde observations from five high latitude stations to determine whether proton precipitation (indicated by HI Ly α) causes inaccuracy (see Knight et al. [2012]).



(Includes stations at Tromso, Gakona, Norilsk, and Sondrestrom)

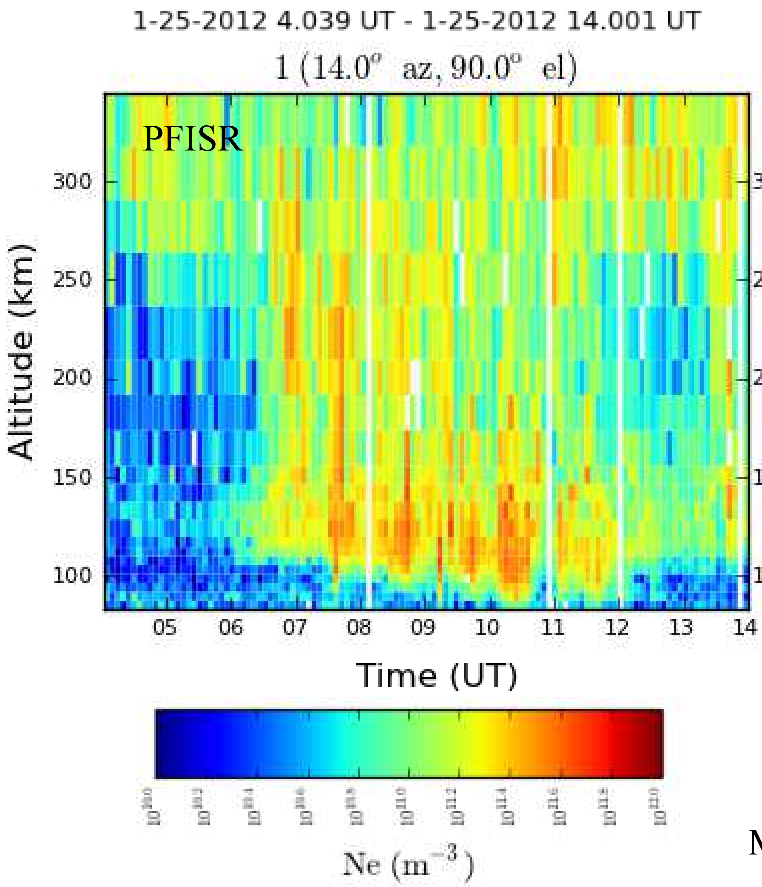
Scarcity of Usable Ea Traces

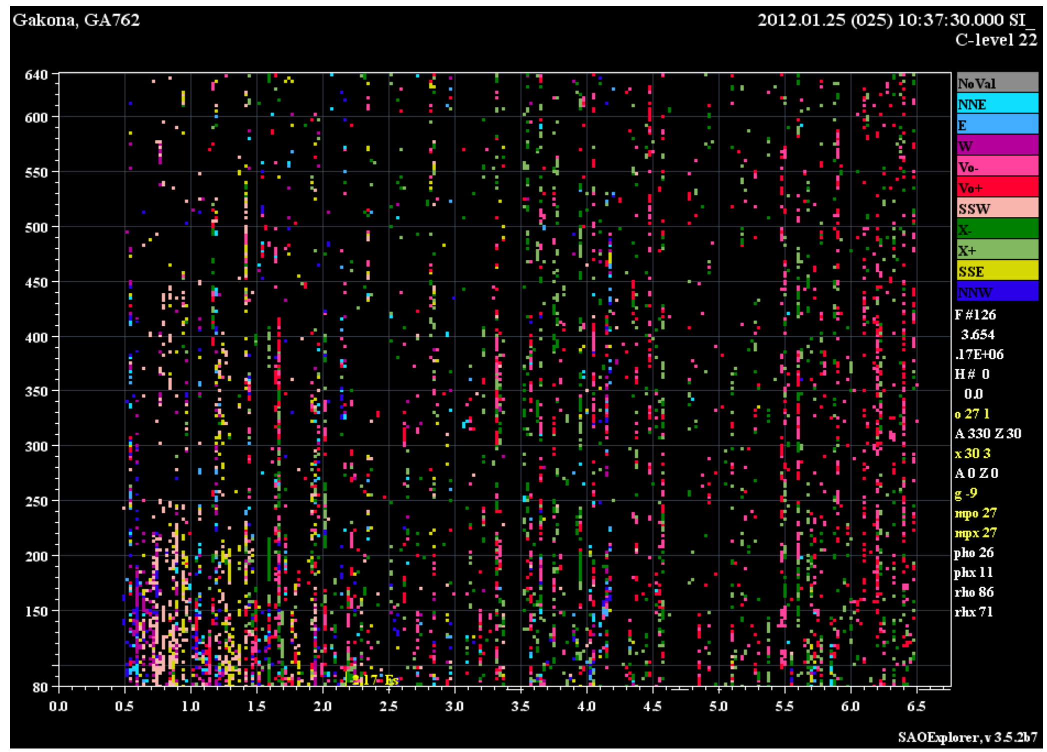
	GUVI 2002-2007		F16 SSUSI 2004-2012		GUVI and F16 Combined	
(a) Coincidences	6022	N/A	3820	N/A	9842	N/A
(b) Good auroral FUV	902	15%	315	8%	1217	12%
(c) Ionosonde data	325	36%	198	63%	523	43%
(d) Scalable	48	14%	61	30%	109	21%

- Imagers are at ~625 km (GUVI) and ~850 km (SSUSI).
- A snapshot of a ~2000 km wide swath crossing the auroral region is obtained once every ~100 min. for each satellite.
- Auroral hmE and NmE can be inferred when there is moderate to intense auroral precipitation.
- The percentage of ionogram observations at the approximate times of the "snapshots" with ≥ moderate coincident auroral FUV for which the manual scalars could obtain auroral E parameters was low.

Noise at Gakona AK

•Gakona ionograms tend to show noise contamination, and a relatively low percentage of Gakona ionograms allowed extraction of auroral parameters.
•Comparisons of Gakona Digisonde with Poker Flat Incoherent Scatter Radar (PFISR) Ne profiles were attempted, but generally no auroral E traces were present during PFISR operation.





Manual Scaling Rules

- •Page from Piggot and Rawer (1972), *U.R.S.I. Handbook of Ionogram Interpretation and Reduction* (with notes added).
- •Determination of Ea presence requires:
    1. F layer with retardation coinciding with E layer cusp.
    2. Blanketing of F layer over E trace.
    3. Selection of inner (lower frequency) trace.

SCALING CONVENTIONS 4-3

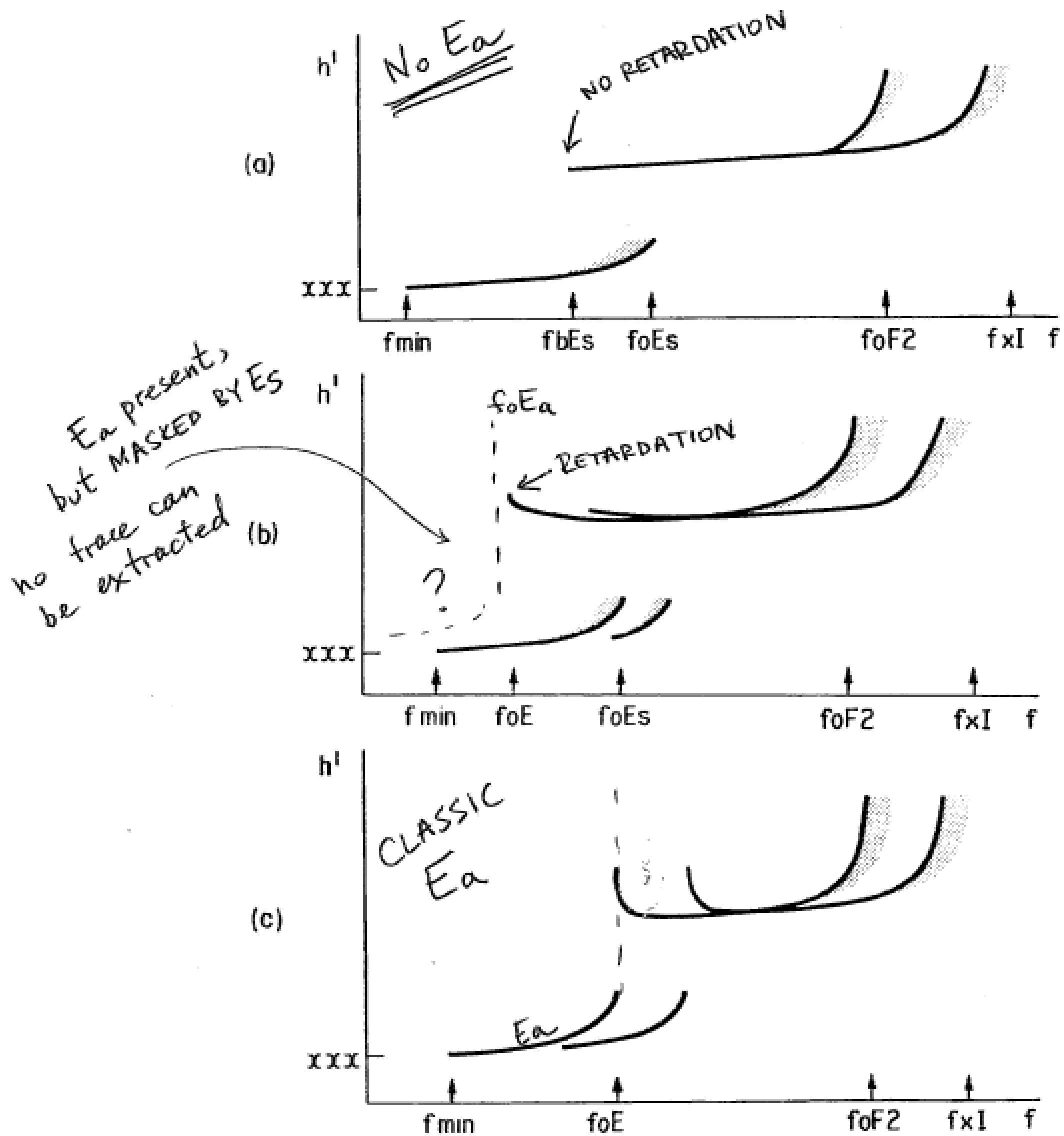


Fig. 4.2 Conventions for Es type r and particle E

(a) (b) show Es type r (c) particle E
In (b) foE for night can be seen by retardation of F trace; (foE)UK but h'E is A
In (c) foEs and fbEs = (foE)-K h'Es = (h'E)-K

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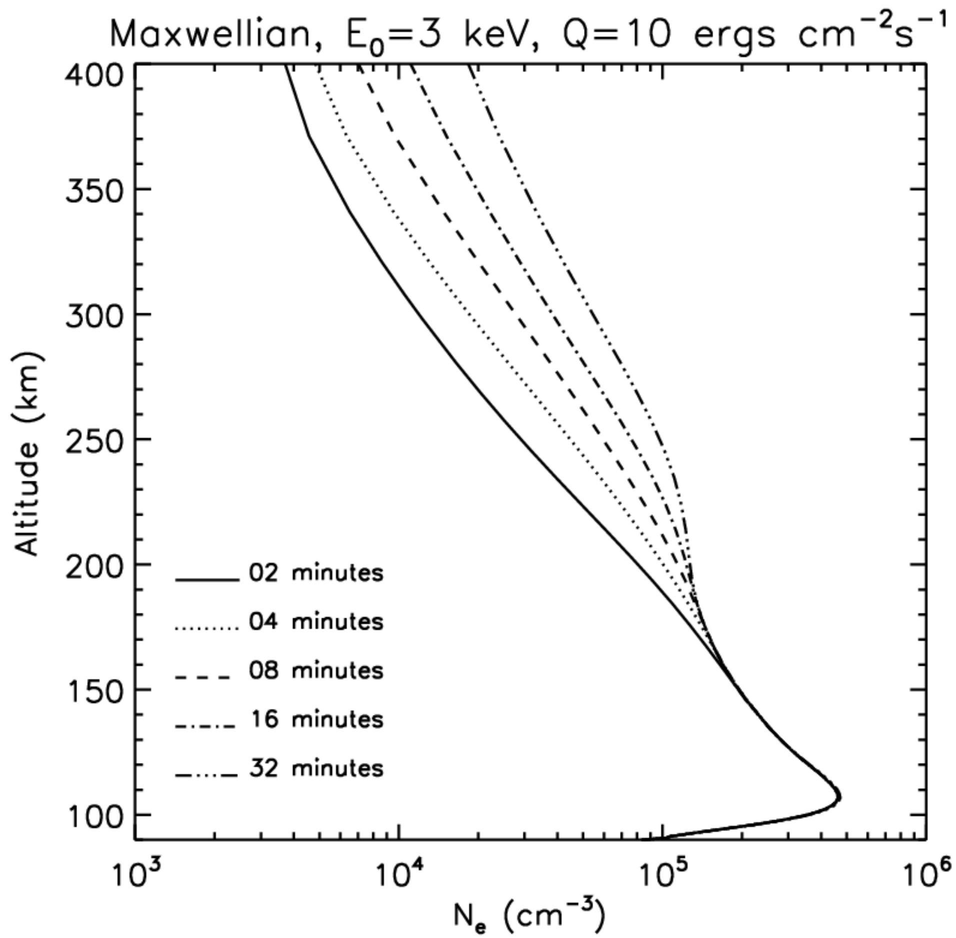
Problem with Requiring F Layer

- The nighttime F layer is usually weak compared to the E layer unless precipitation takes place for an extended time and/or F region plasma drifts in from elsewhere.
- Example to the right shows electron densities generated by CPI's Boltzmann 3-Constituent (B3C, Strickland et al. 1993) auroral transport model. The F layer builds up slowly, while the E layer reaches a steady state quickly.



Summary of Findings

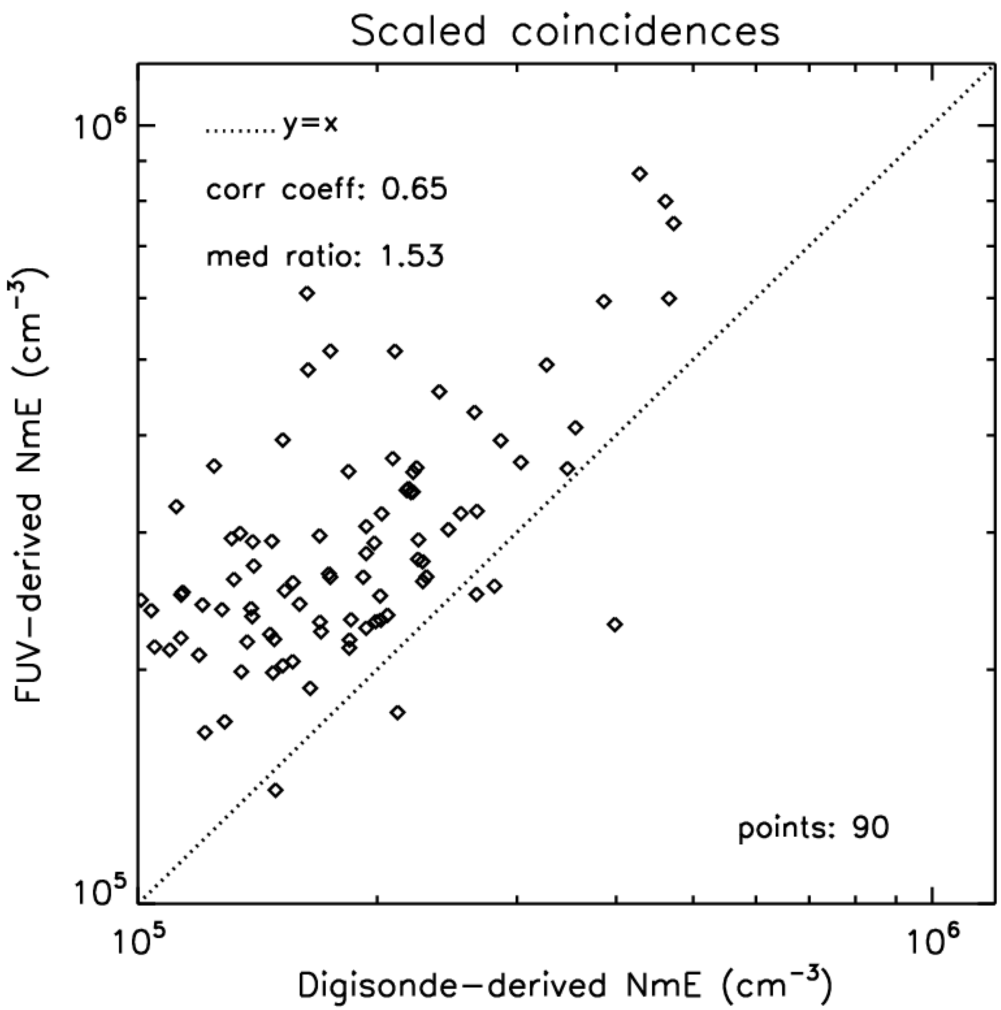
The number of usable Ea traces can be approximately tripled with no decrease in accuracy in NmEa if:

1. The F layer is ignored, i.e.
   a) The presence of an F layer is not required.
   b) If there is an F layer then blanketing and F layer retardation are not required.
2. If there is more than one E layer cusp, the one with the highest frequency is used (makes sense if FUV shows auroral precipitation).
3. Reject E layers with no retardation (slanting upward with increasing frequency), but do not require a well-defined Ea cusp.

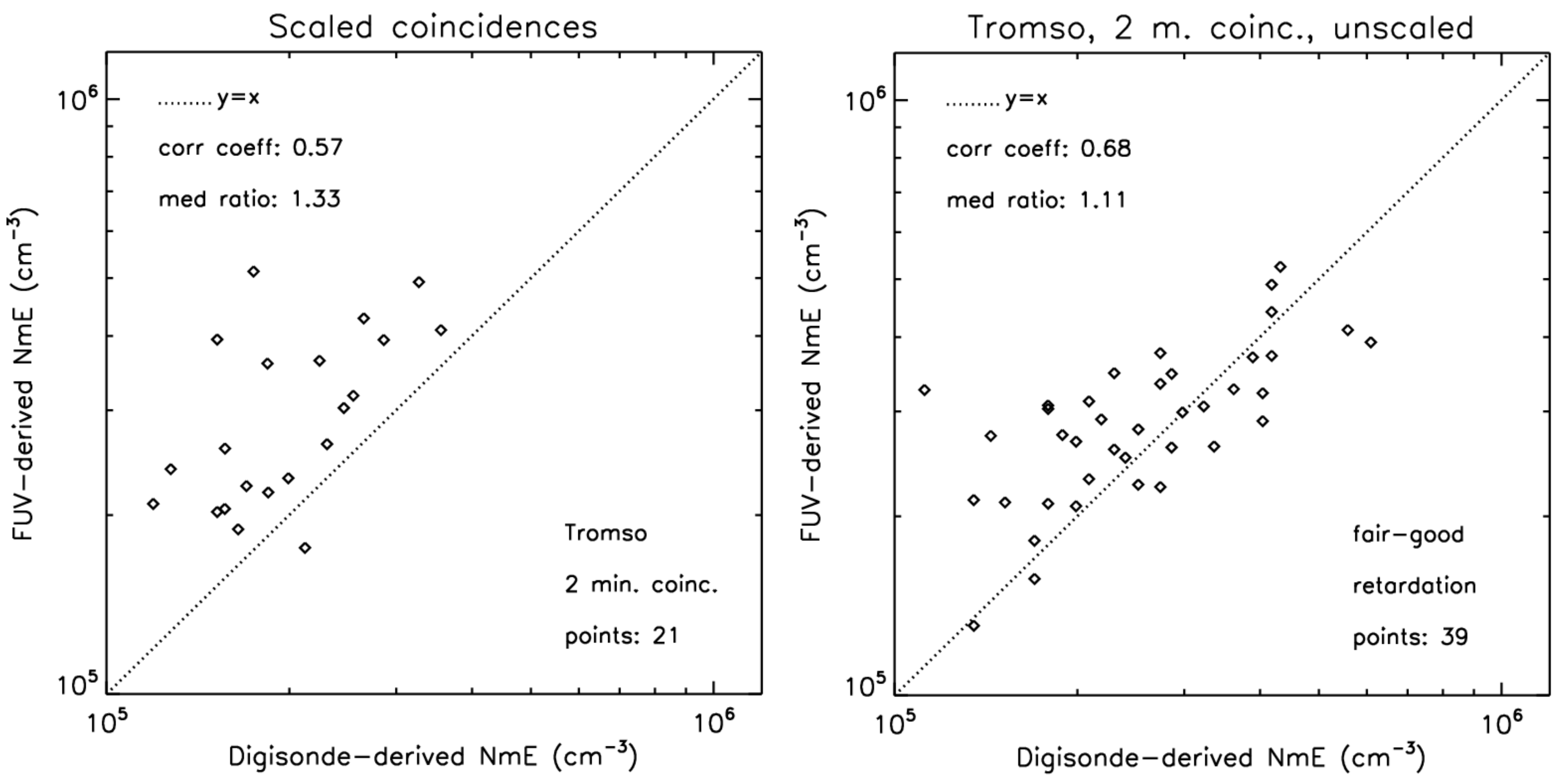
With these changes, there is a strong possibility that auroral NmE extraction can be automated, making manual scaling unnecessary. (Our project primarily requires NmE, not hmE. It may be possible to automate hmE extraction as well, however.)

NmE Comparison for Manually Scaled Traces

- This shows the level of agreement when the U.R.S.I. rules are used.
- Time coincidence is within 7.5 minutes.
- 19 of the scaled E traces with NmE < 10^5 were excluded. (Results from taking the lowest Ea cusp.)

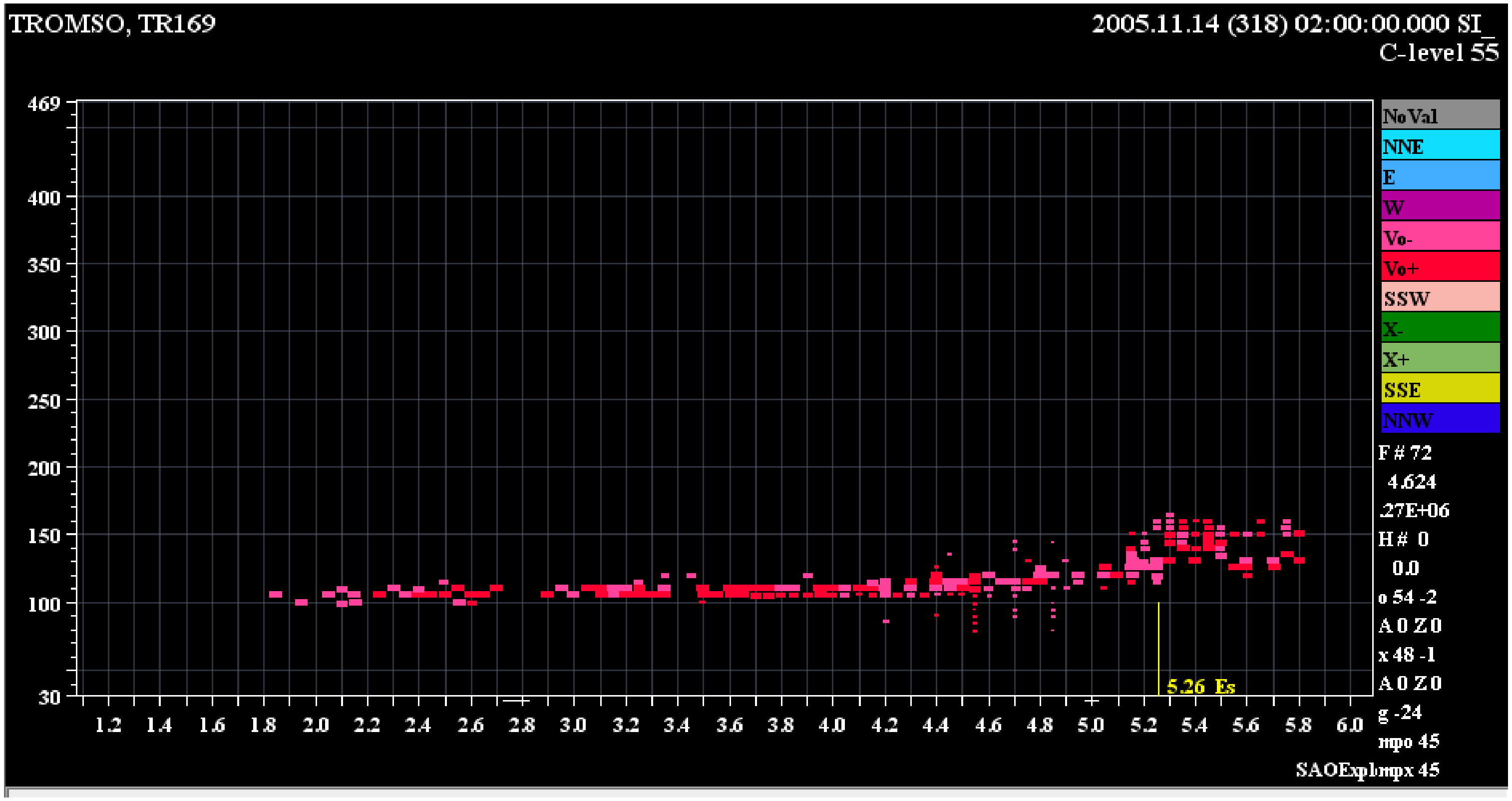


Effect of New Rules



New rules (right) would add 39 coincidences to the 21 available previously (left) in this case (Tromso, < 2 minute coinc.). Indicates that total number will be ~tripled.
(I used the outer edge of the cusp instead of the inner edge for the right panel.)

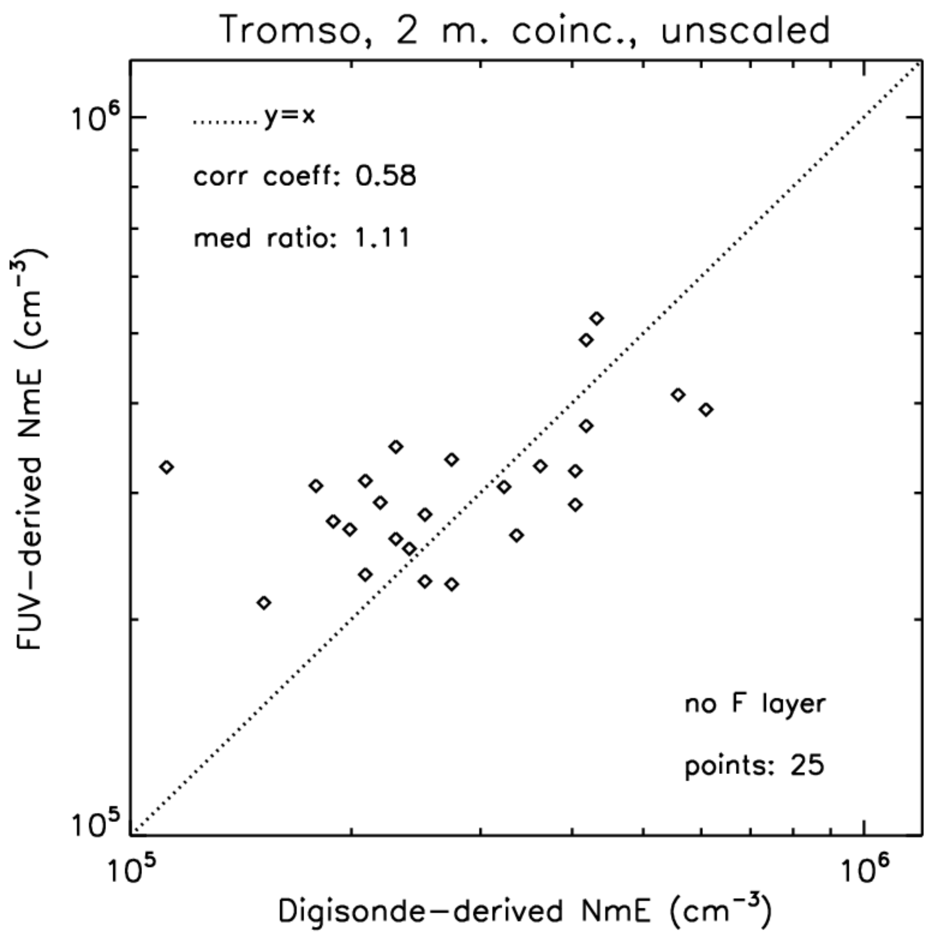
Lack of an F Layer



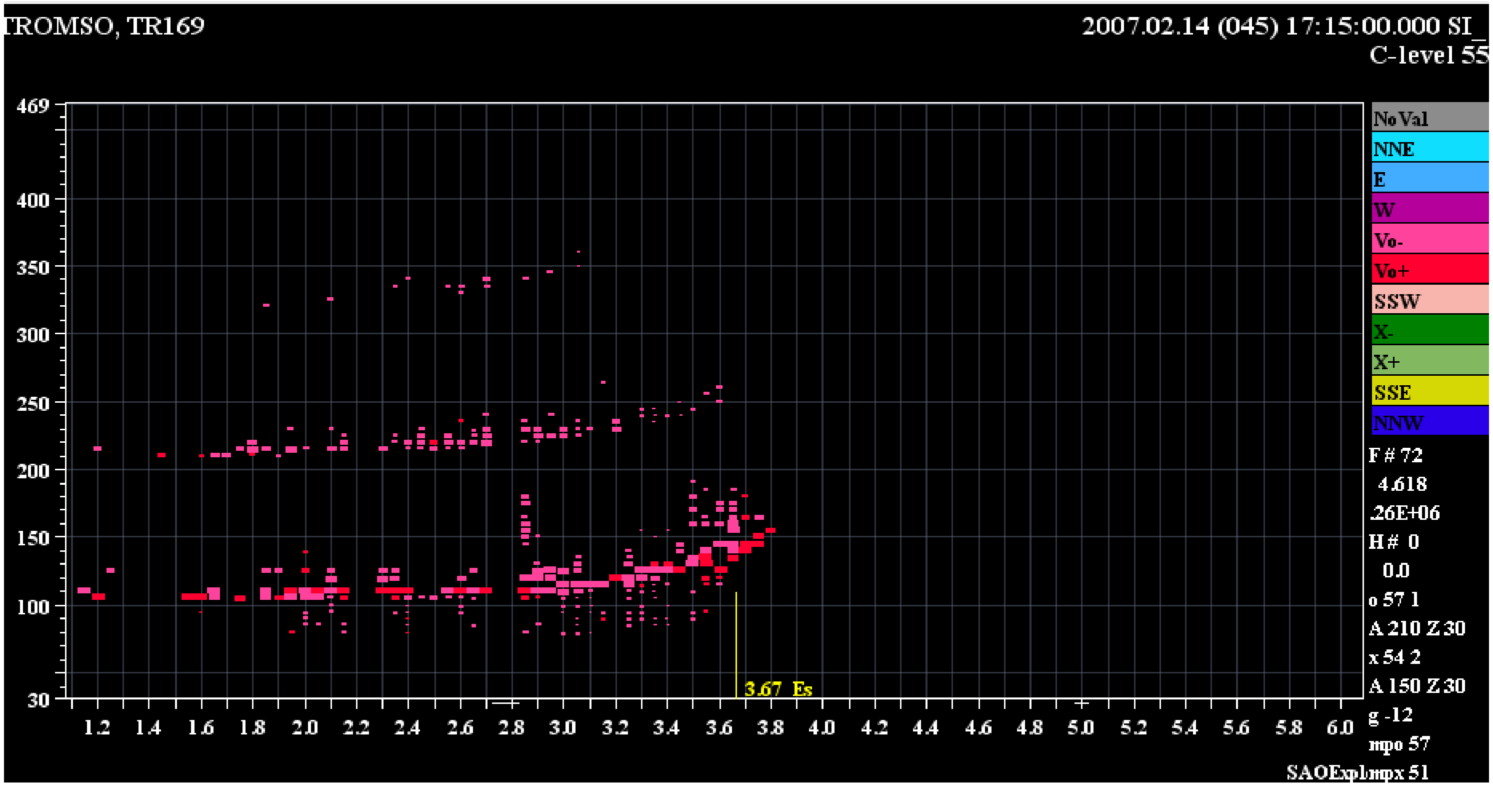
This example was originally interpreted as sporadic because there is no F layer. FUV indicated NmE = 3.7e05 cm^{-3}. The Es frequency would give ionosonde NmE=3.4e05 cm^{-3}.

Lack of an F Layer (cont.)

A comparison of NmE values for E layers with with no accompanying F layer and originally identified as sporadic. (This is only for Tromso with a time difference within 2 minutes.)



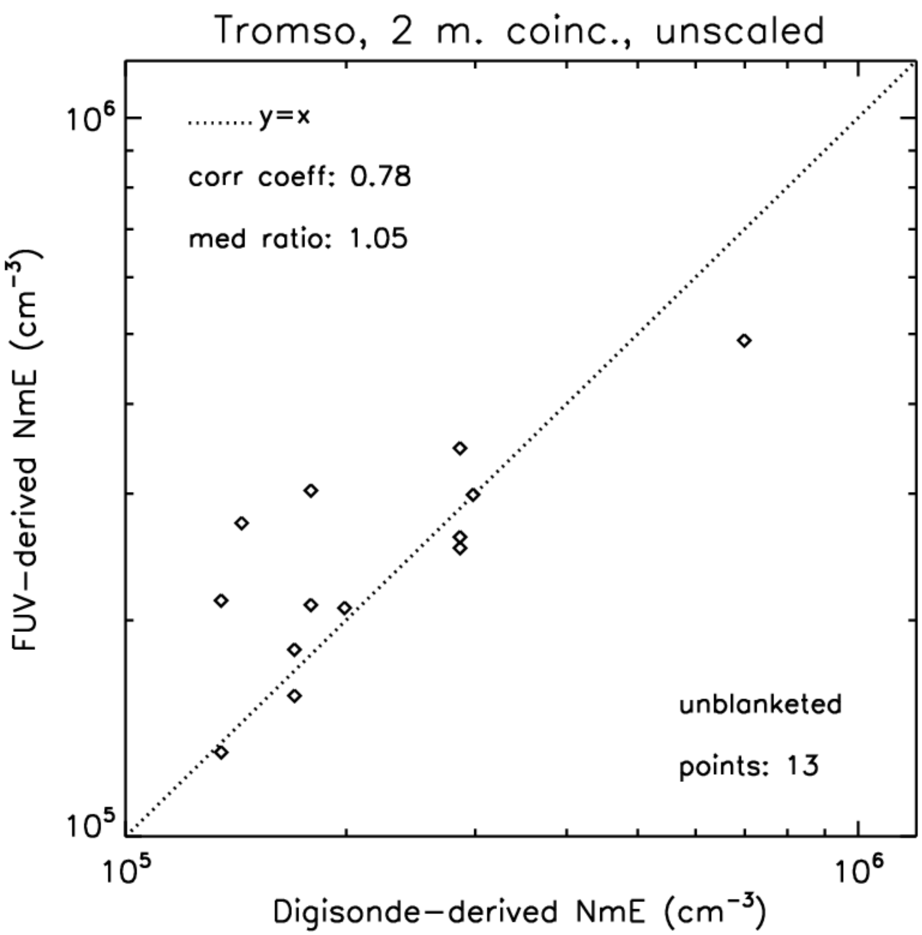
Unblanketed F Layer



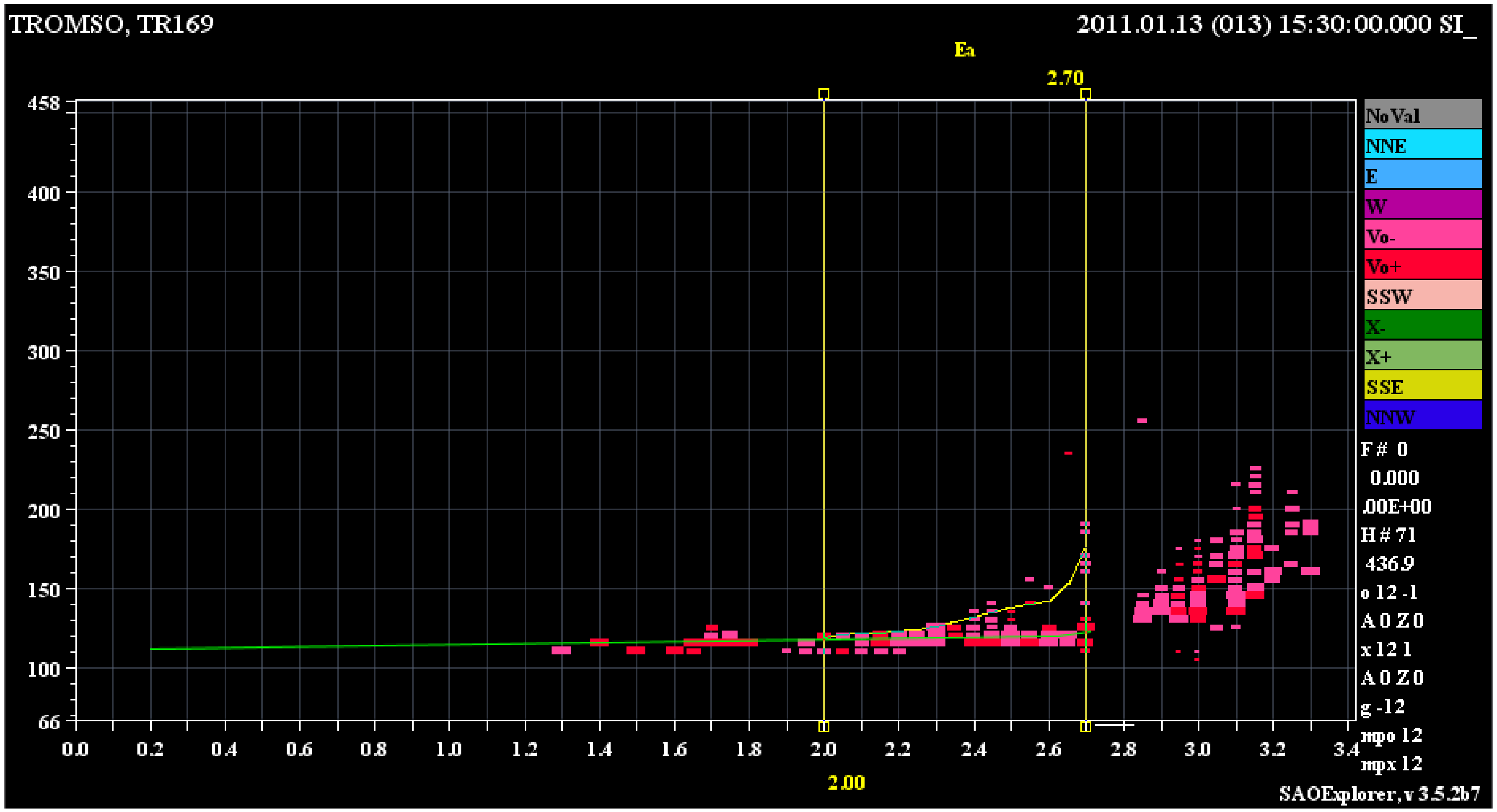
This example was also originally interpreted as sporadic. F layer echoes are not completely blocked by the E layer. FUV indicated NmE = 2.1e05 cm^{-3}. The Es frequency would give ionosonde NmE=1.7e05 cm^{-3}.

Unblanketed F Layer (cont.)

A comparison of NmE values for E layers with with an accompanying unblanketed F layer and originally identified as sporadic. (This is only for Tromso with a time difference within 2 minutes.)



Problem with Innermost Cusp



The inner cusp identified manually gives NmE = $1.24e04 \times 2.7^2 = 9.0e04$ cm^{-3}. FUV-derived NmE was 1.6e05 cm^{-3}. (It is unclear why it was scaled without an F layer.) There are 19 examples like this.