ISIS Data Preservation and Transformation

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GEST
Goddard Earth Sciences and Technology Center

ISIS (International Satellites for Ionospheric Studies) Program

- Polar-orbiting satellites
  - Alouette 1 (1,000 km)
  - Alouette 2 (500 - 3,000 km)
  - ISIS 1 (550 - 3,500 km)
  - ISIS 2 (1,400 km)
- Data over more than two solar cycles
  - Alouette 1 & 2: 1962-1972 & 1965-1975
  - ISIS 1 & 2: 1969-1990 & 1971-1990
- Topside electron density (Ne) profiles obtained from swept-frequency sounders

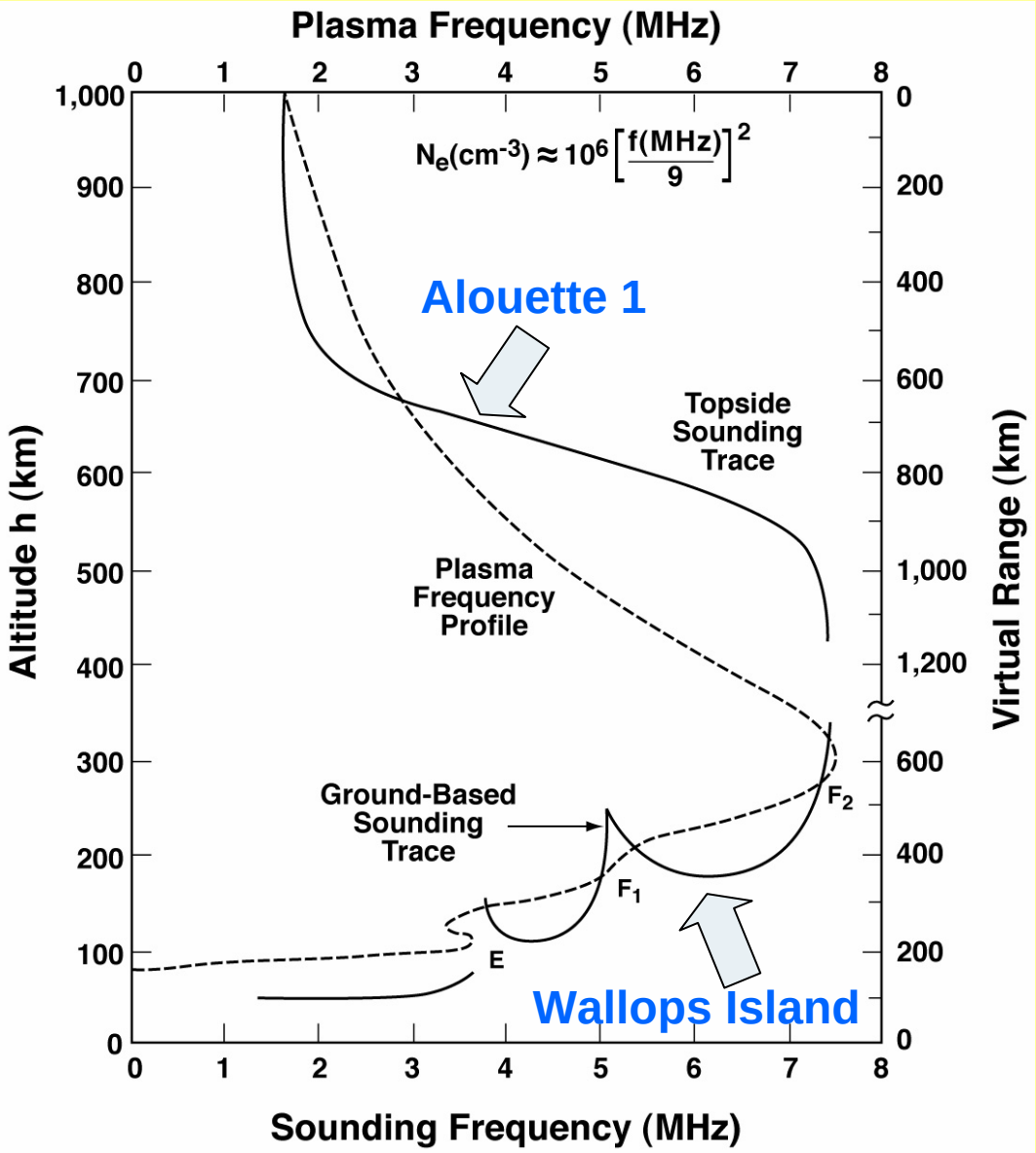
ISIS 1

Topside and Bottomside Plasma Frequency Profiles

Alouette-1 over flight of Wallops Island Ionosonde

1651 UT, 10 June 1968

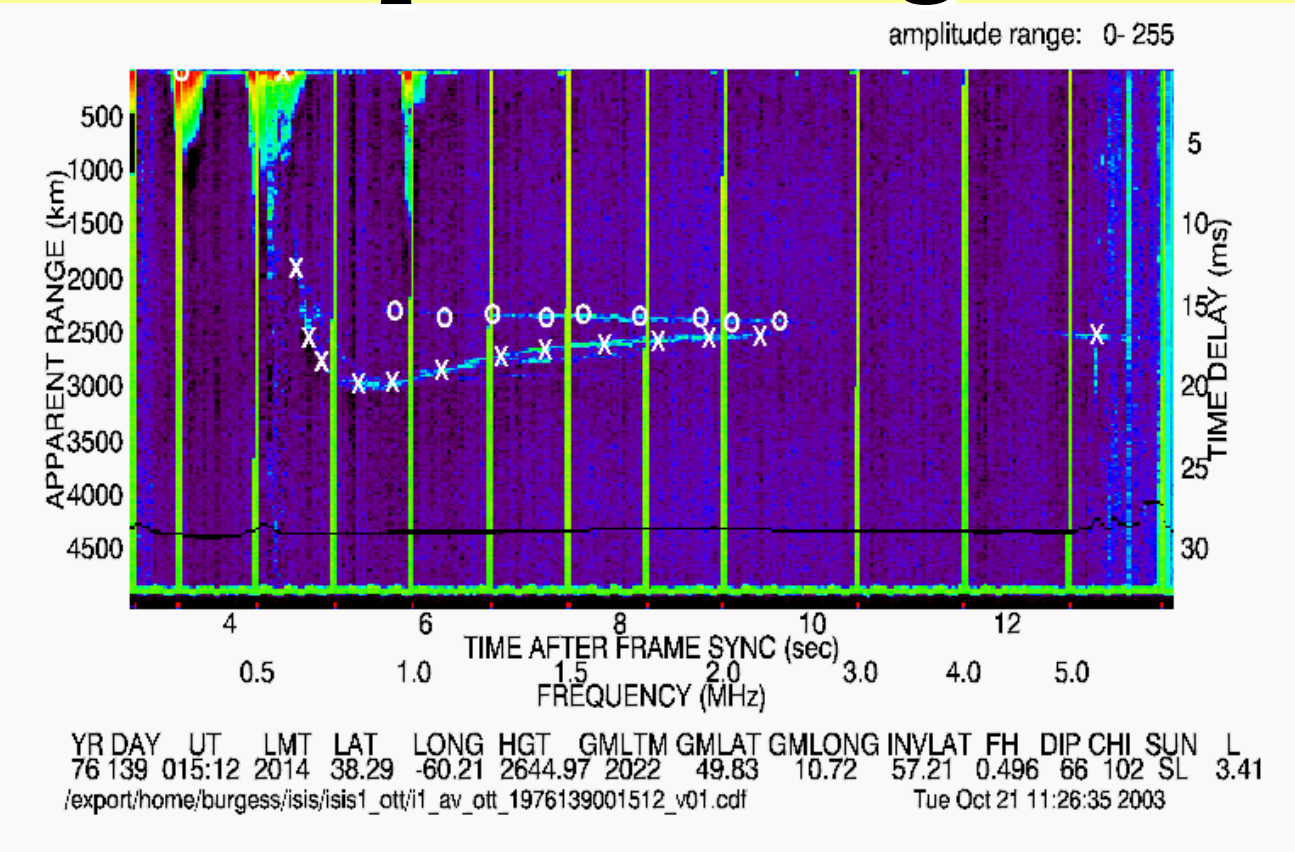
Adapted from *Jackson et al.* [1980]



ISIS Topside-Sounder Data

- Analog systems
- Data recorded on magnetic tapes at 20+ globally-distributed telemetry stations
- Not all analog telemetry tape data were converted into 35-mm film-format records called ionograms due to cost considerations.
- Not all ionograms then were processed into Ne profiles because of the cost of the manual effort involved.
- In recent years an analog-to-digital (A/D) project involving nearly 14,000 selected analog telemetry tapes has been underway at GSFC (AISRP connection!)

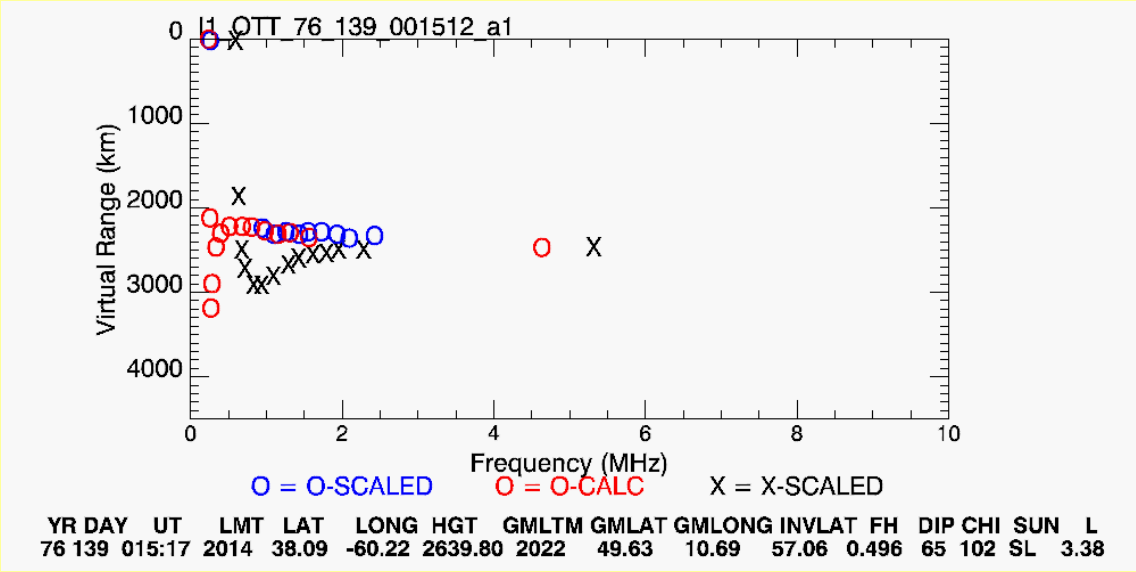
Sample ISIS-1 Digital Topside Ionogram



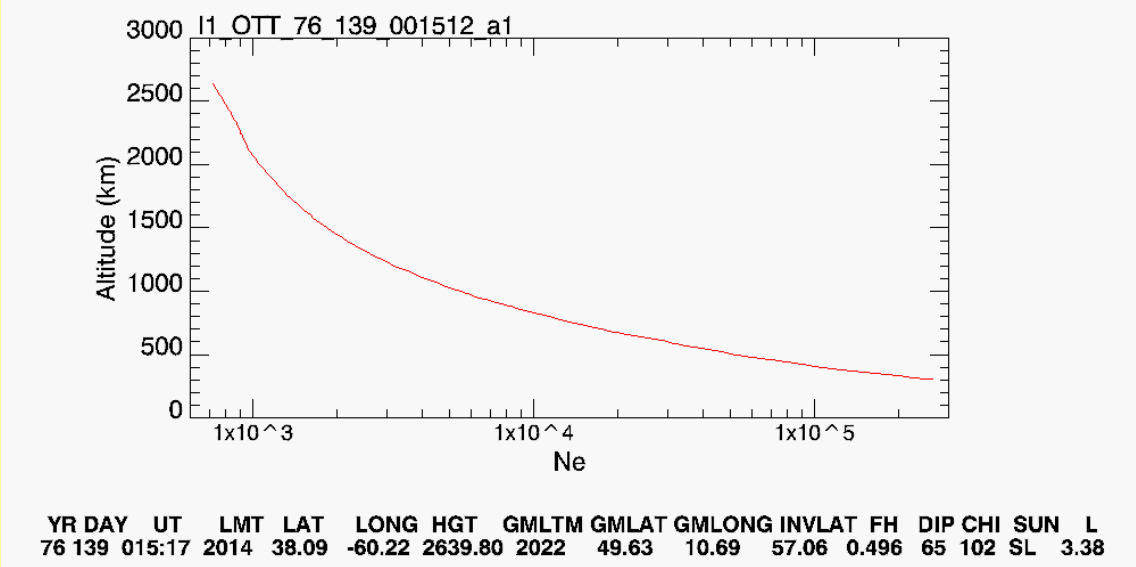
Manual scaling of ordinary and extraordinary mode traces

Trace Inversion to Electron Density (Ne) Profile

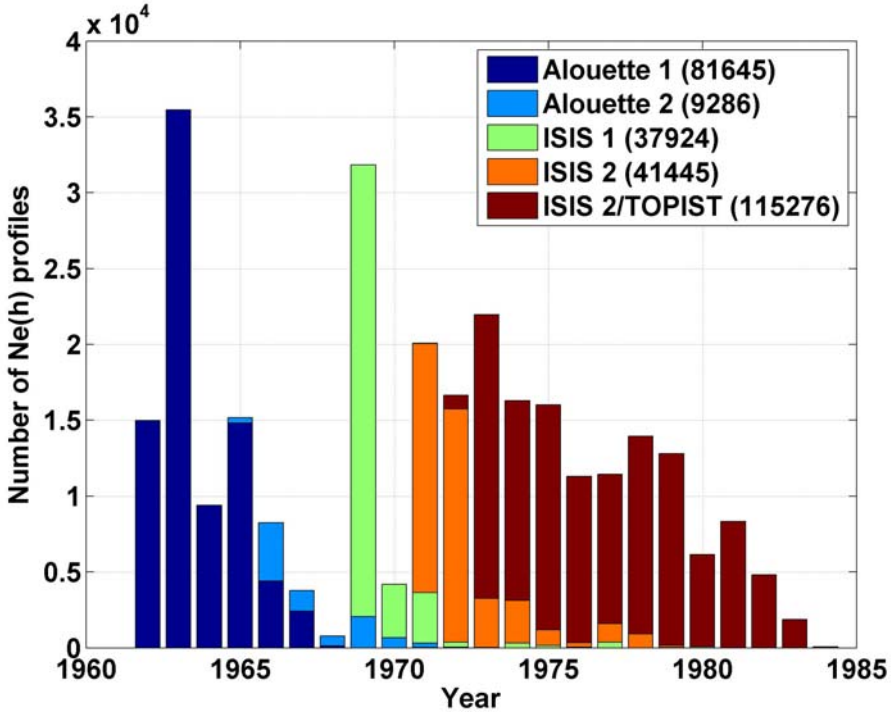
Validation by comparison of scaled and calculated O-mode traces (also scaled X-mode trace).



Ne profile derived from X-mode trace.

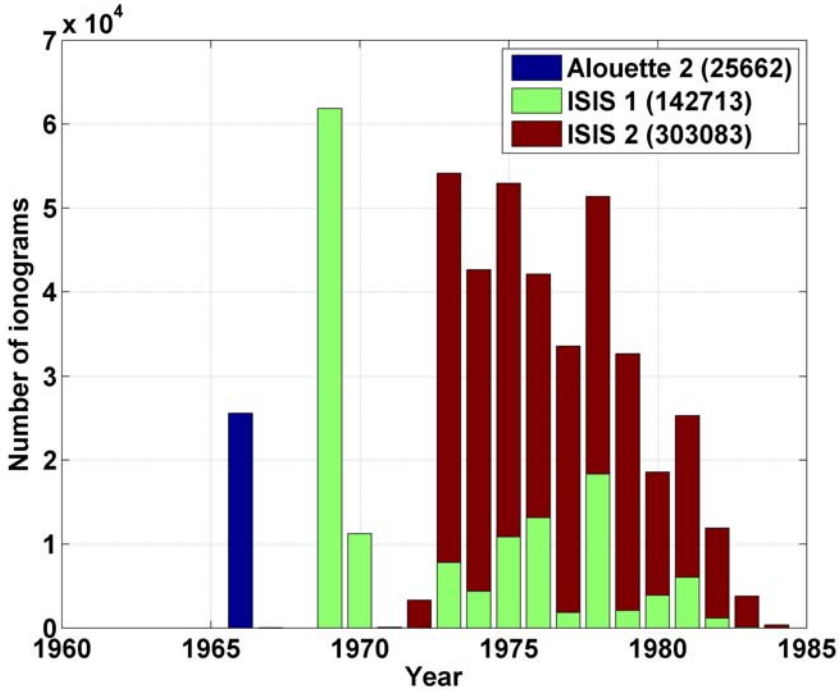


NSSDC ISIS Sounder data sets



Manually and automatically-scaled Ne profiles (TOPIST)

New digital ionograms selected for global coverage.

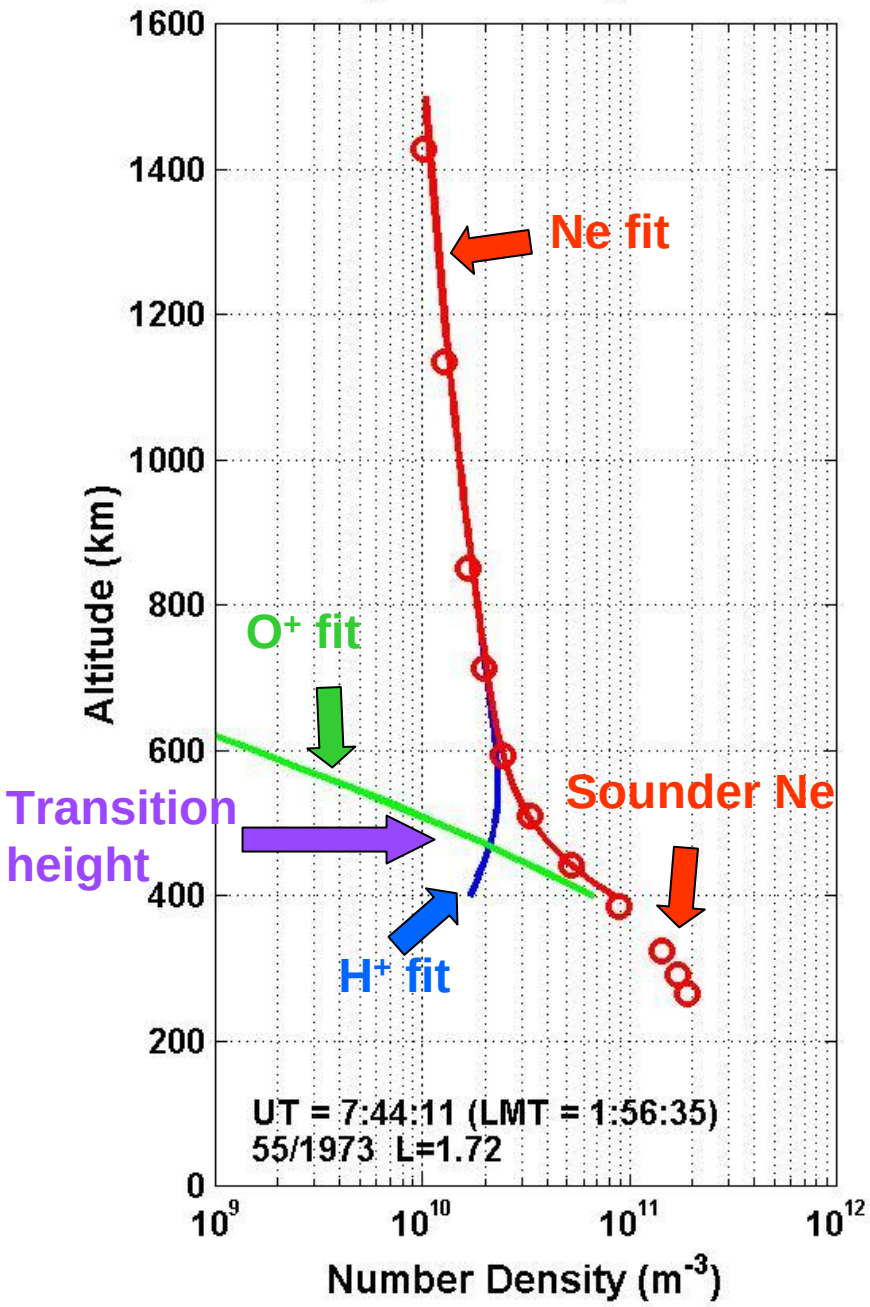


Analysis of Topside Ionospheric Ne Profiles

- **Fitting procedure**
  - Assume diffusive-equilibrium
  - Use Titheridge [2005] field-aligned electron temperature (Te) expression using Te at 400 km and Te gradient at 400 km.
  - Conduct fits to Ne in a least-square sense.
  - Neglect He^+
- **Emphasize mid-latitude regions**
  - Main interest: mid-latitude ionospheric features associated with the plasmapause

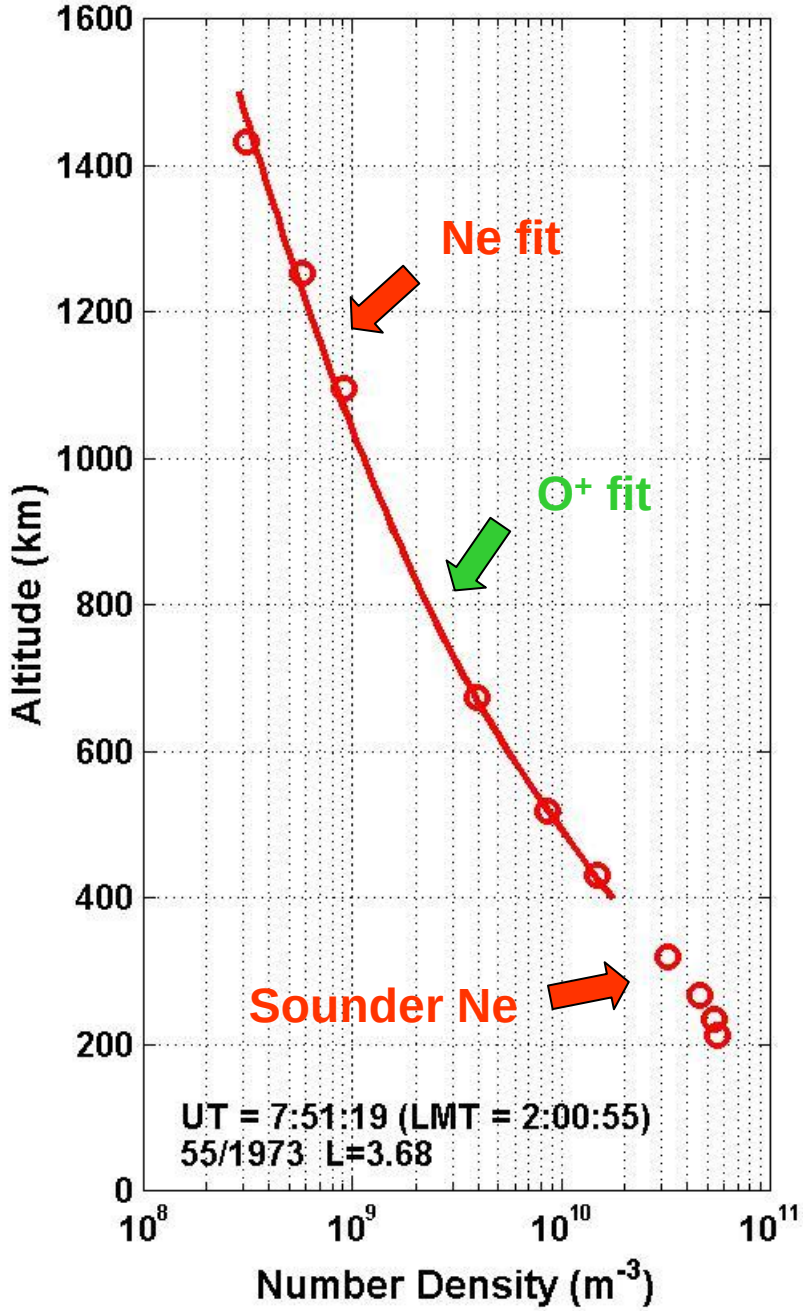
Example of plasmasphere region (mid-latitude) profile

Analysis of ISIS-2 Ne profile with O^+/H^+ transition height (TH) within plasmasphere.

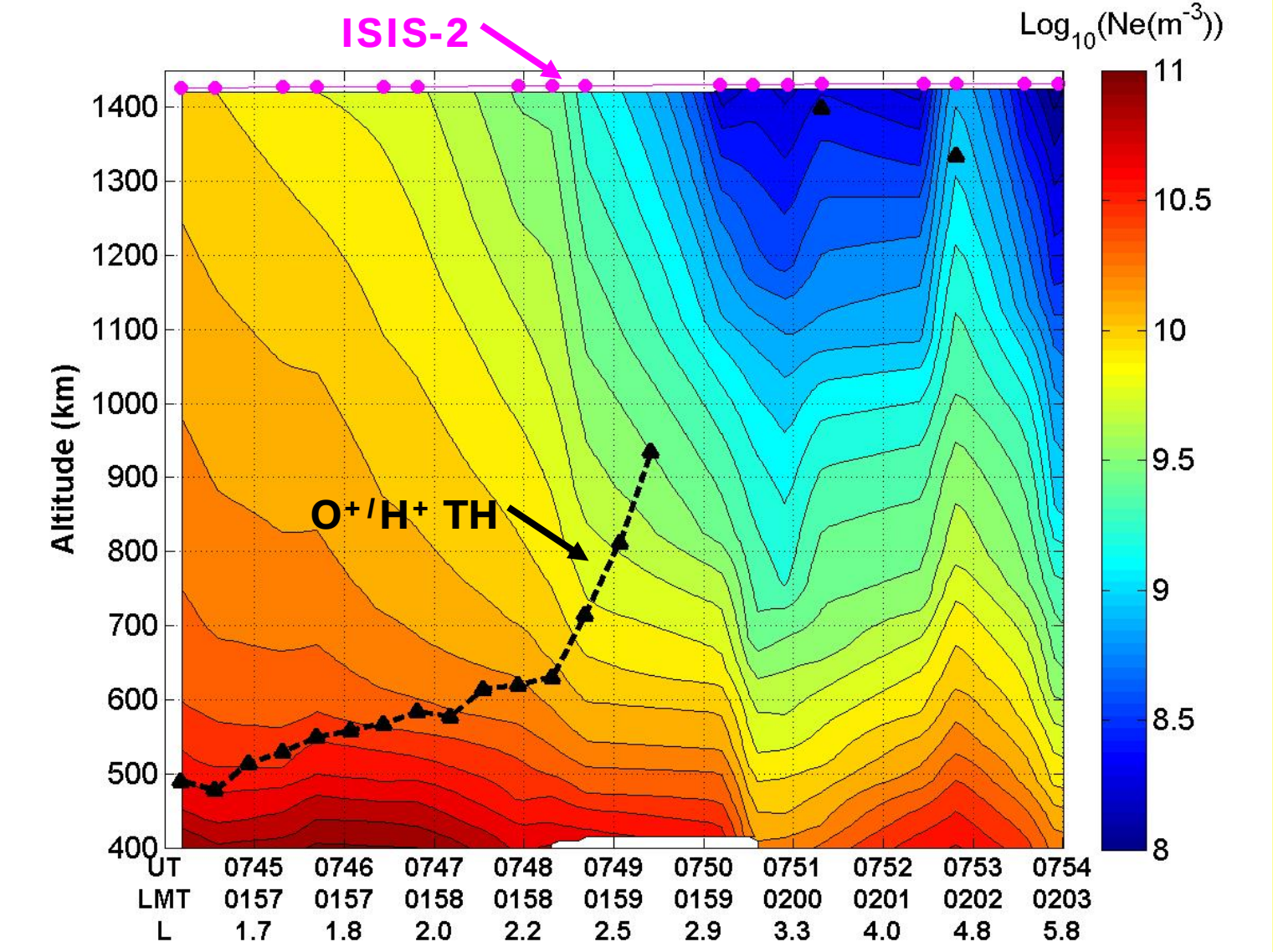


Example of plasmatrough region (high latitude) profile

Analysis of ISIS-2 profile without O^+/H^+ transition height in plasmatrough (i.e., H^+ not significant).

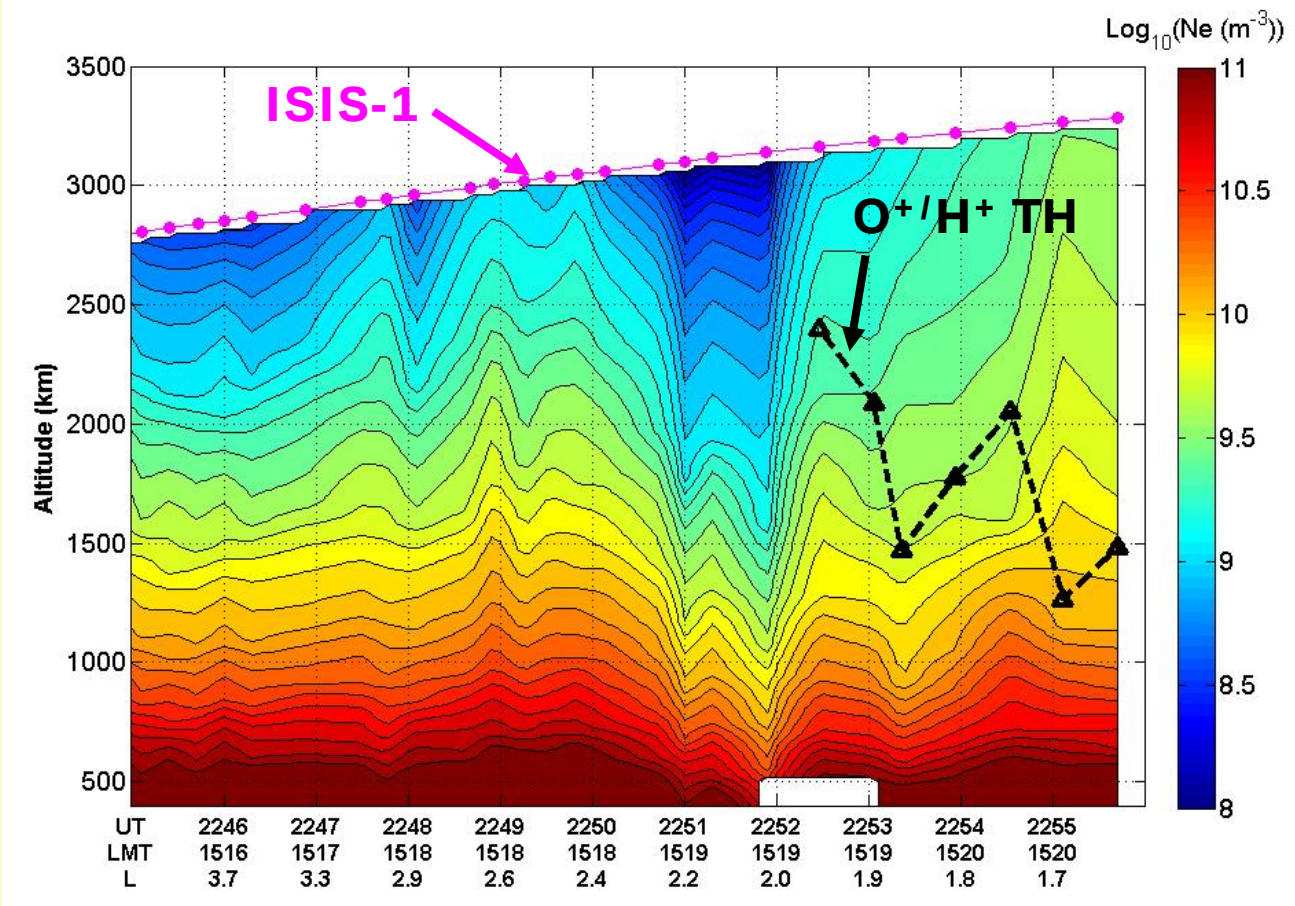


ISIS-2 sounder-derived Ne contour plot for 24 February 1973



Elliptically Orbiting ISIS-1: 5 October 1974

Higher apogee (3500 km) versus circular orbiting ISIS-2 (1400 km) => observe higher O^+/H^+ transition heights.



Summary

- New topside Ne profile-analysis technique determines
  - O^+/H^+ transition height
  - altitude distribution of dominant ions
- Plan: determine short- and long-term changes in Ne profiles using
  - ~ 160,000 hand-scaled Alouette/ISIS Ne profiles
    - ftp://nssdcftp.gsfc.nasa.gov/
  - > 460,000 digital ISIS-1,-2 and Alouette-2 ionograms
    - http://nssdc.gsfc.nasa.gov/space/isis/isis-status.html