Investigation of the latitude and altitude dependence of large mid-latitude ionospheric electron *and* ion density gradients associated with outer-plasmaspheric structures

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Abstract

We present initial results of an investigation to relate steep mid-latitude trough region plasma gradients to plasmapause determinations. The approach is to use early archived data corresponding to time intervals with coincident vertical ionospheric topside electron density profiles $N_e(h)$, and ionospheric and magnetospheric ion-composition data and magnetospheric electric-field data. The emphasis in this presentation is on the analysis of latitudinal cuts of ISIS-2 topside $N_e(h)$ profiles and Explorer-45 magnetospheric electric-field measurements (used to identify plasmapause crossings).

BACKGROUND & OUTLINE

Based on LWS project: **"Characterizing the composition of large mid-latitude topside-ionospheric/plasmaspheric gradients"** (Benson, Bilitza, Grebowsky, and Webb)

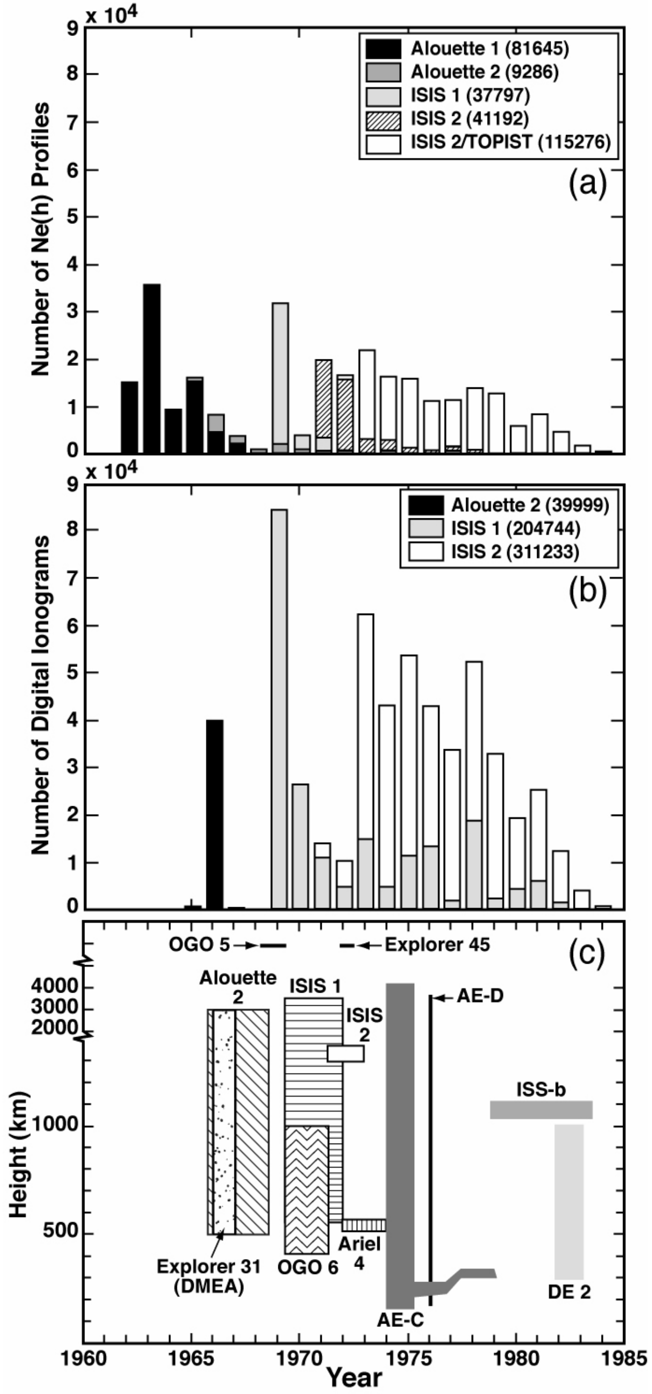
Main goal: characterize latitude and altitude dependence of large mid-latitude ionospheric N_e and N_i gradients associated with outer plasmaspheric structures

Approach: investigate topside ionospheric $N_e(h)$ profiles, and ion composition values deduced from the profiles, coincident with magnetospheric ion composition and **E**-field measurements using early archived data (see Figure 1)

Emphasis: topside ionospheric constant-altitude orbit-plane N_e contours (Figures 2, 5, & 6), O^+/H^+ transition heights (Figures 3 & 8), and relating ionospheric trough structures to plasmapause determinations based on a statistical model (Figure 2) and on satellite observations (Figures 4, 5 & 6), some during disturbed magnetic conditions (Figure 7)

Data used in this investigation: hand-scaled ISIS-2 $N_e(h)$ profiles, available from the National Space Science Data Center (NSSDC), and Explorer-45 plasmapause-crossings determined from **E**-field saturation/non-saturation transitions (converted from hard-copy list to digital form for deposition into the NSSDCftp.gsfc.nasa.gov)

Figure 1. Data sets available from the NSSDC containing (a) manually-scaled N_e(h) profiles from Alouette-1, Alouette-2, ISIS-1, and ISIS-2 35-mm film topside ionograms, automatically-scaled N_e(h) profiles (labeled TOPIST) from ISIS-2 digital topside ionograms, (b) digital Alouette-2, ISIS-1, and ISIS-2 topside ionograms selected for global coverage and to complement the earlier manually-scaled data, and (c) time-altitude coverage of *in-situ* ionospheric ion mass spectrometer and N_e measurements, and time intervals of operations of the much higher altitude OGO-5 and Explorer-45 satellites containing plasmapause-crossing information (note: an OGO-5 data gap from 4/24/68 to 6/12/68 is not shown)



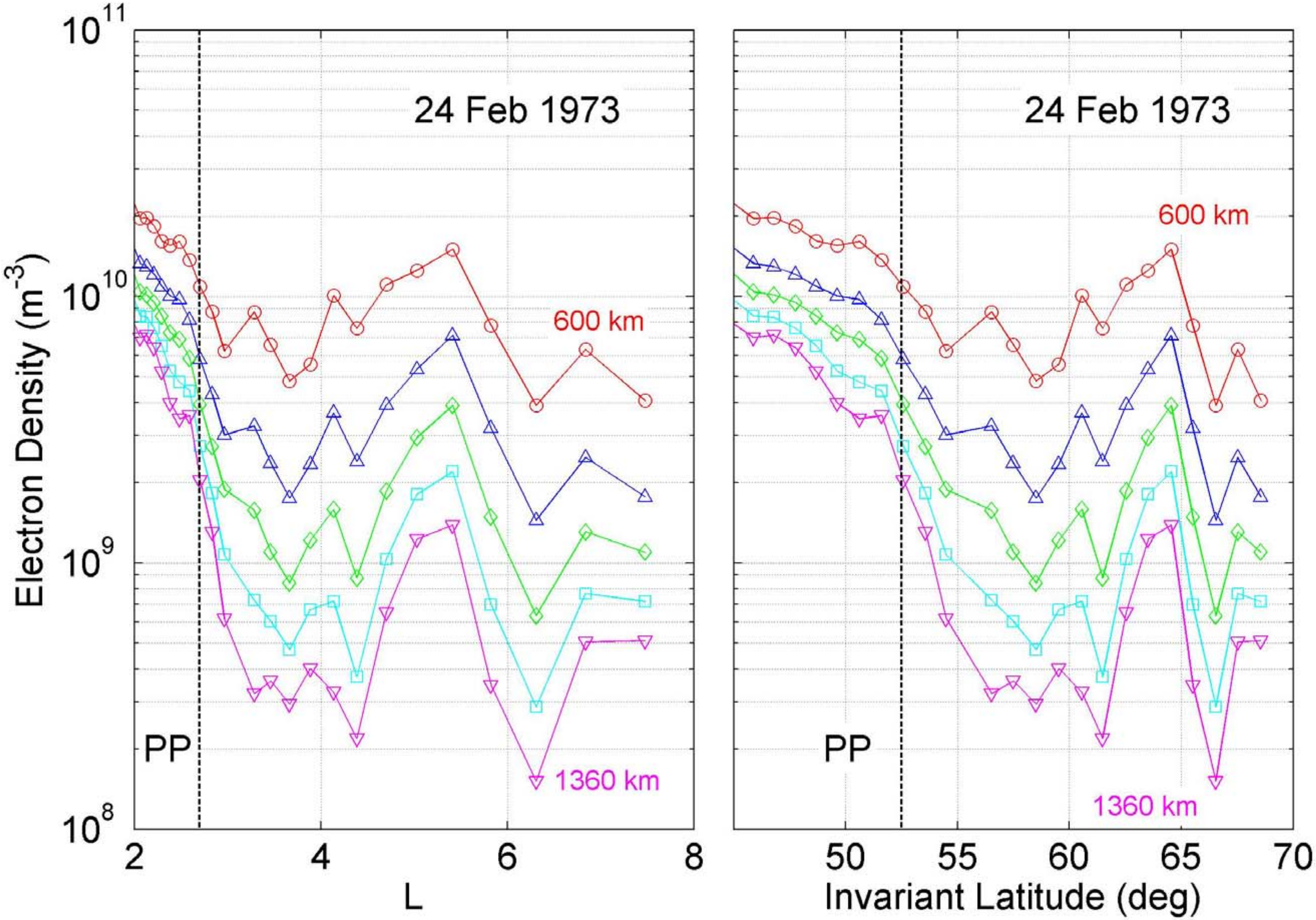


Figure 2. Constant-altitude orbit-plane N_e contours derived from ISIS-2 topside-sounder $N_e(h)$ profiles from 0744:11 - 0754:42 UT on 24 Feb 1973 near 0200 LMT. PP = approximate plasmapause location based on the *Carpenter and Anderson* [*JGR*, *97*, 1097, 1992] statistical model.

Figure 3. O^+/H^+ transition heights (TH), determined from the data of Figure 2 corresponding to (left) a position well within the plasmasphere, and (right) the mid-latitude trough region where TH was near or above the satellite altitude indicating that diffusive equilibrium is based almost solely on O^+ in this case. Solid dots: sounder-derived N_e values; solid and dashed lines: modeled values from a base height of 400 km. (Adapted from *Webb et al.*, *Radio Sci.*, *41* RS6S34, 2006.)

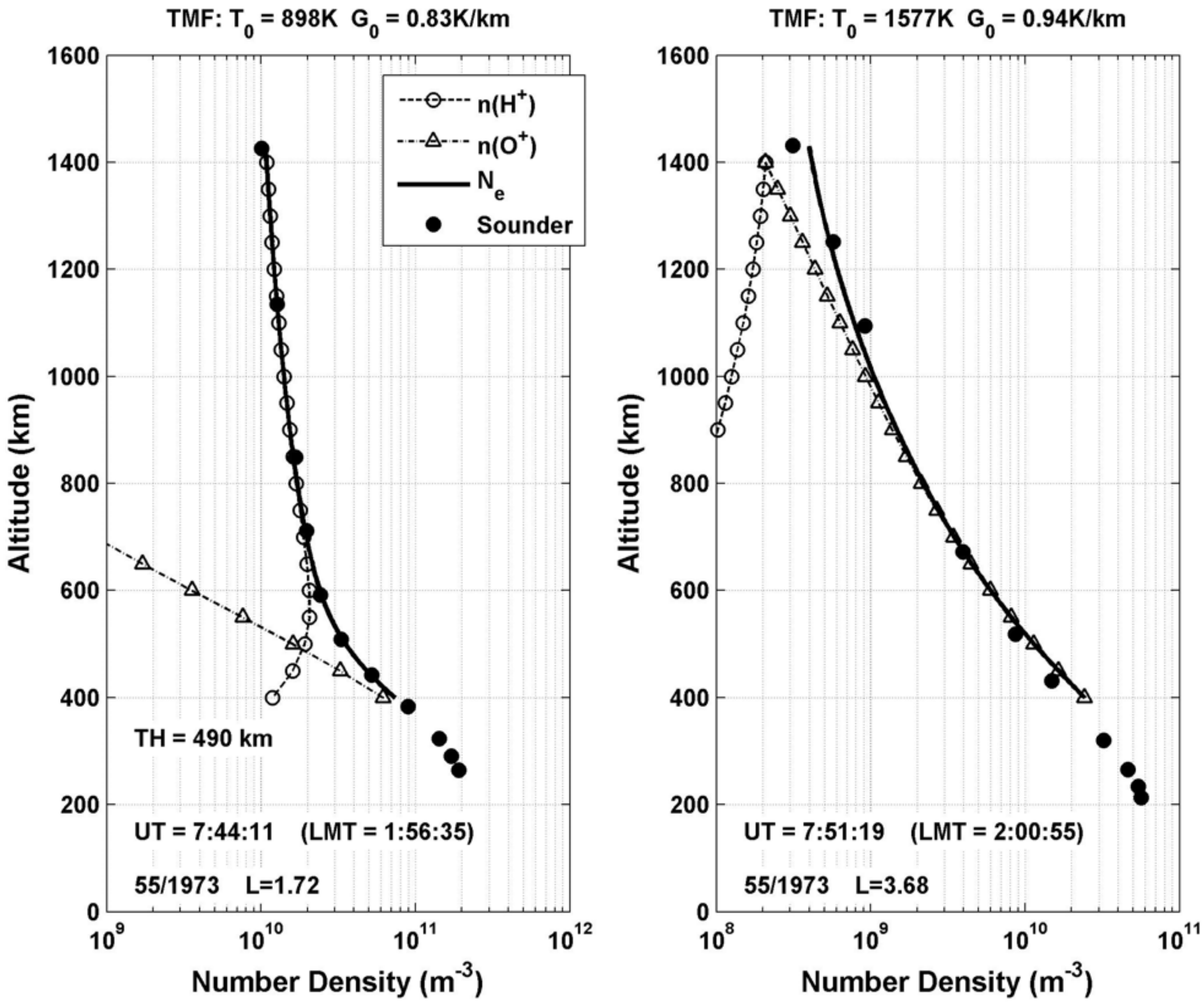
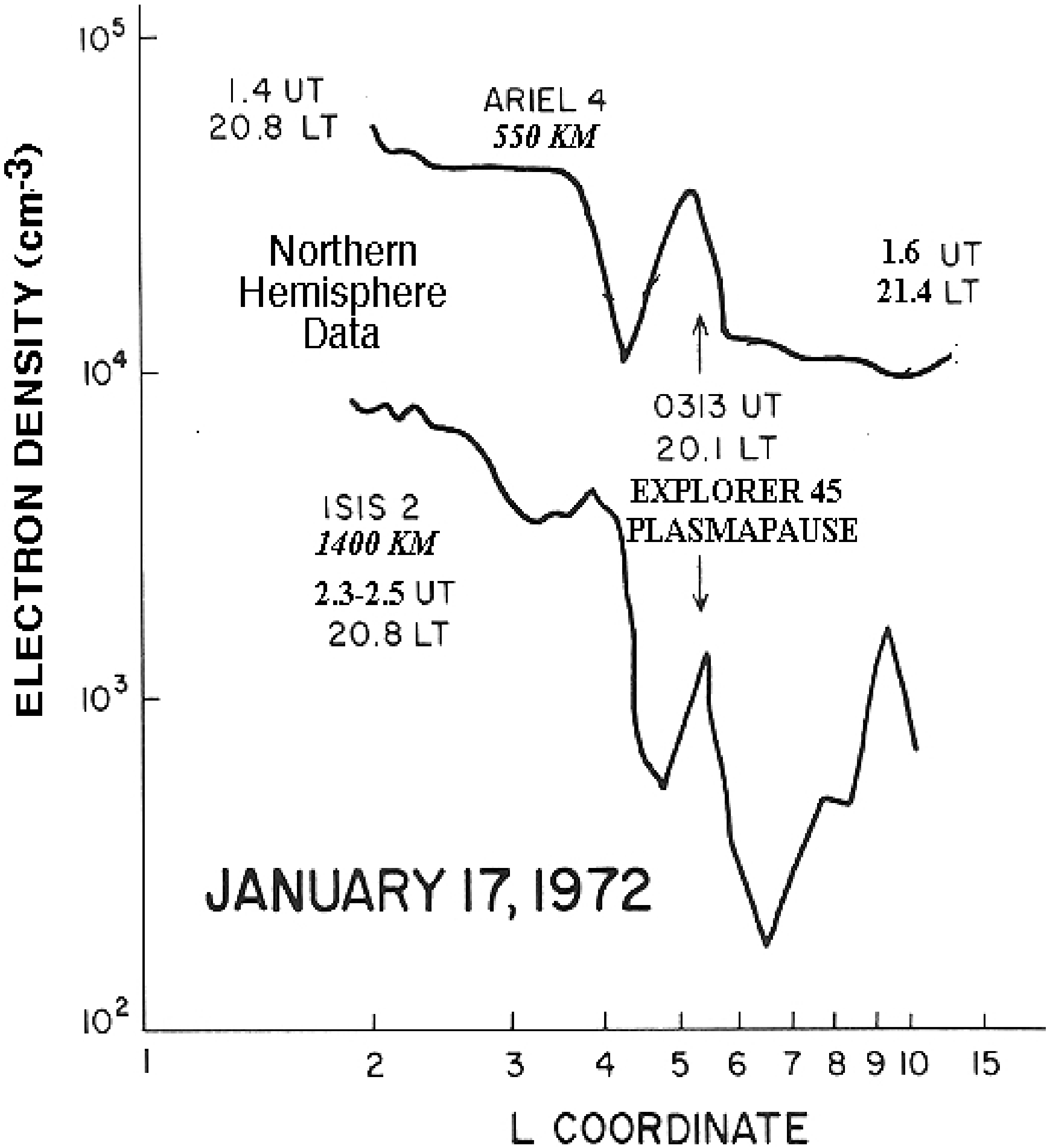


Figure 4. Nearly simultaneous overflights of mid-latitude N_e troughs at two altitudes with an imbedded field-aligned N_e filament in the vicinity of the Explorer-45 determined plasmapause field lines during moderately-disturbed conditions (3-hr Kp = 4). (*In-situ* N_e measurements from the NSSDC).



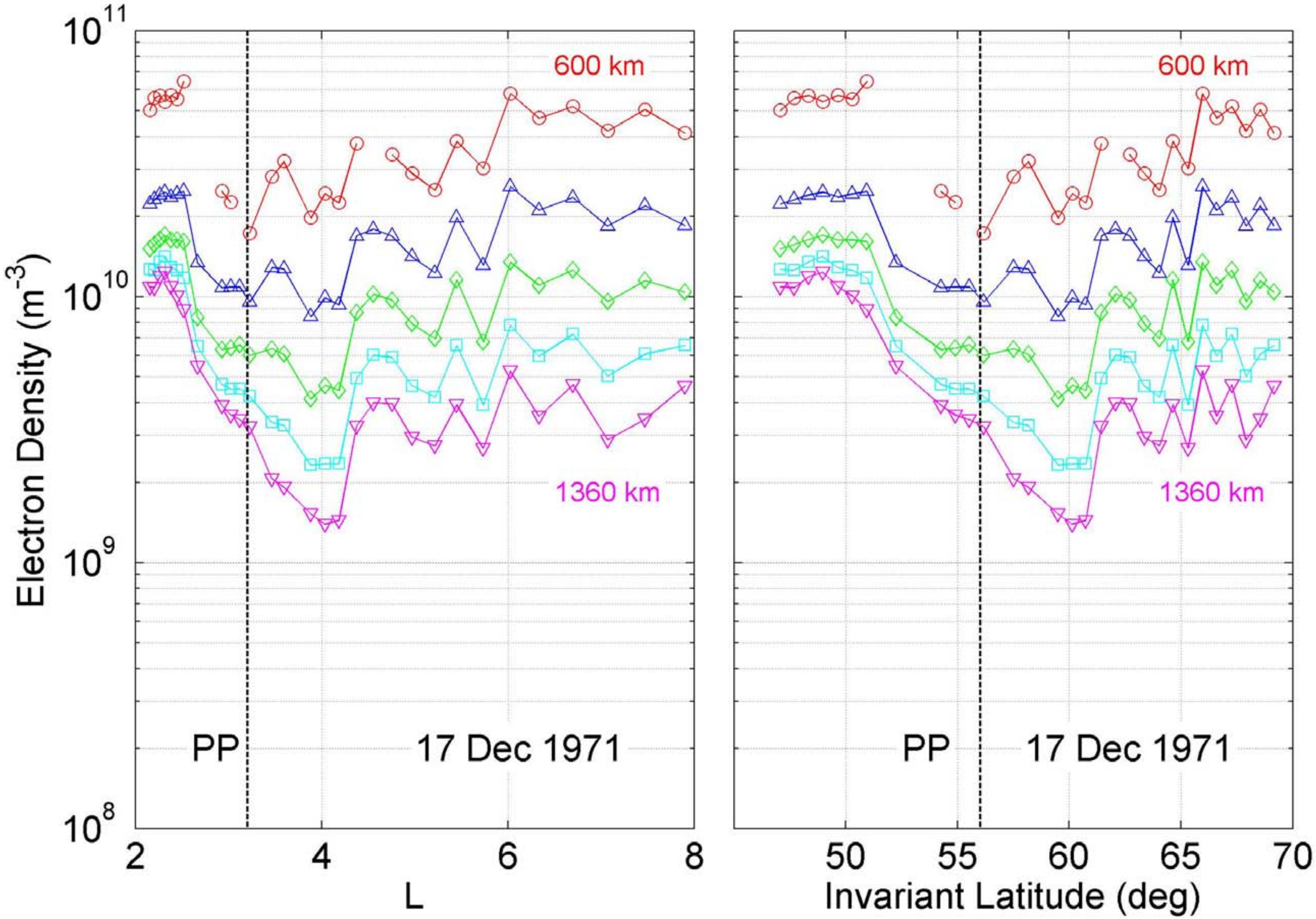


Figure 5. Same as Figure 2 except 0531:31 - 0539:36 UT on 17 Dec 1971 near midnight LMT and PP determined by Explorer 45 (reduced by 0.25 L based on magnetic-field model values for the appropriate Kp, see Figure 7)

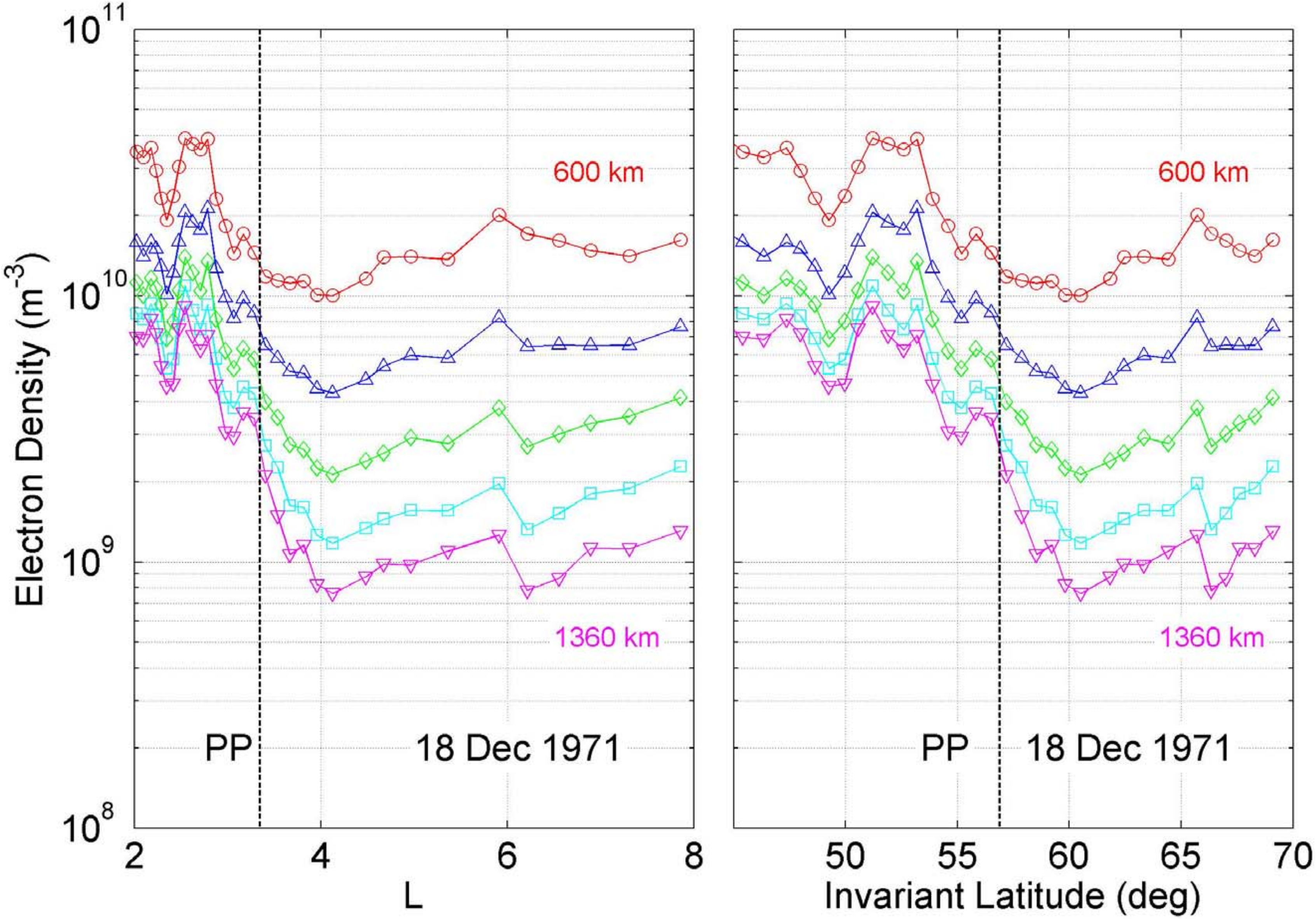


Figure 6. Same as Figure 5 except for 0608:44 - 0623:57 UT on 18 Dec 1971 near midnight LMT.

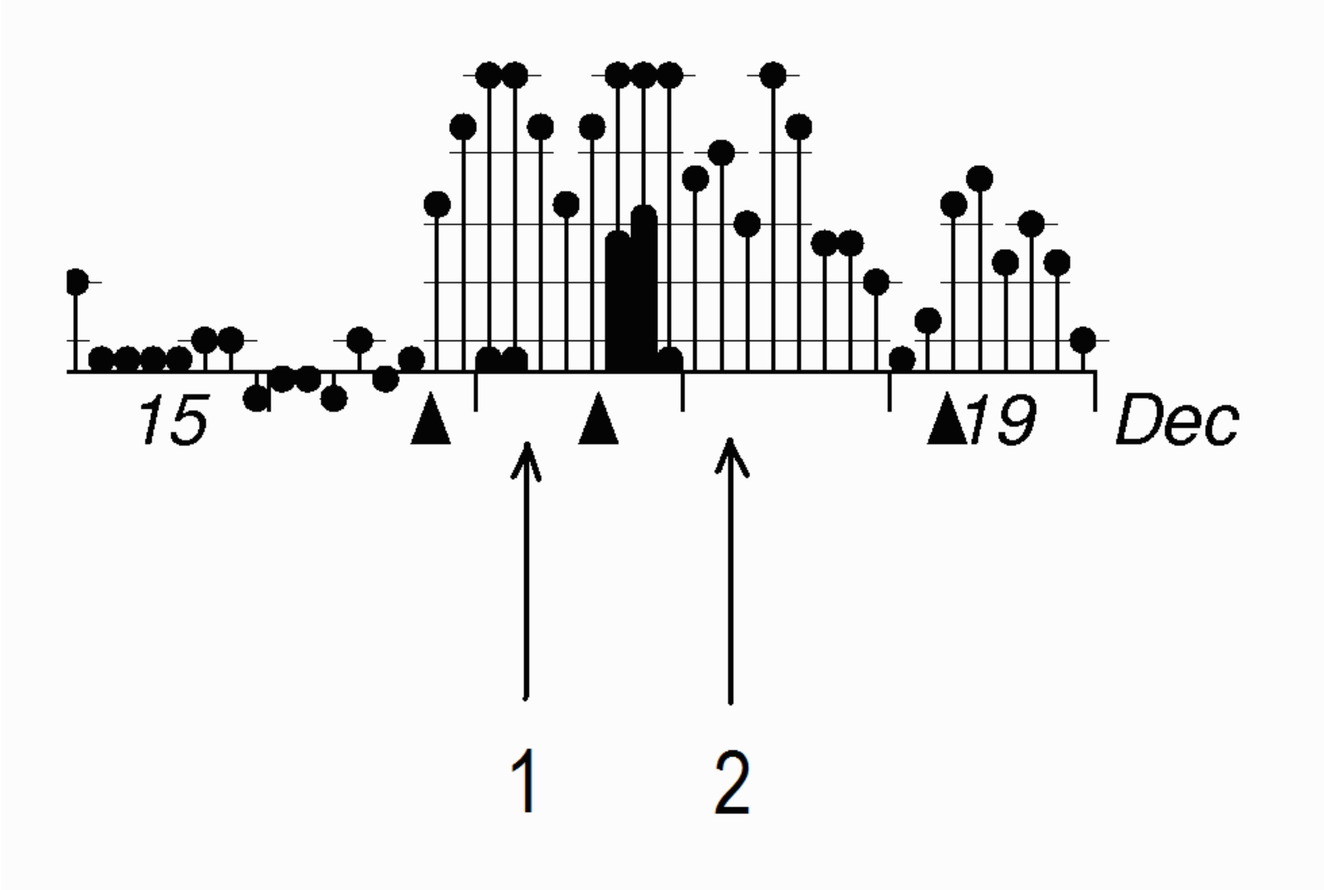
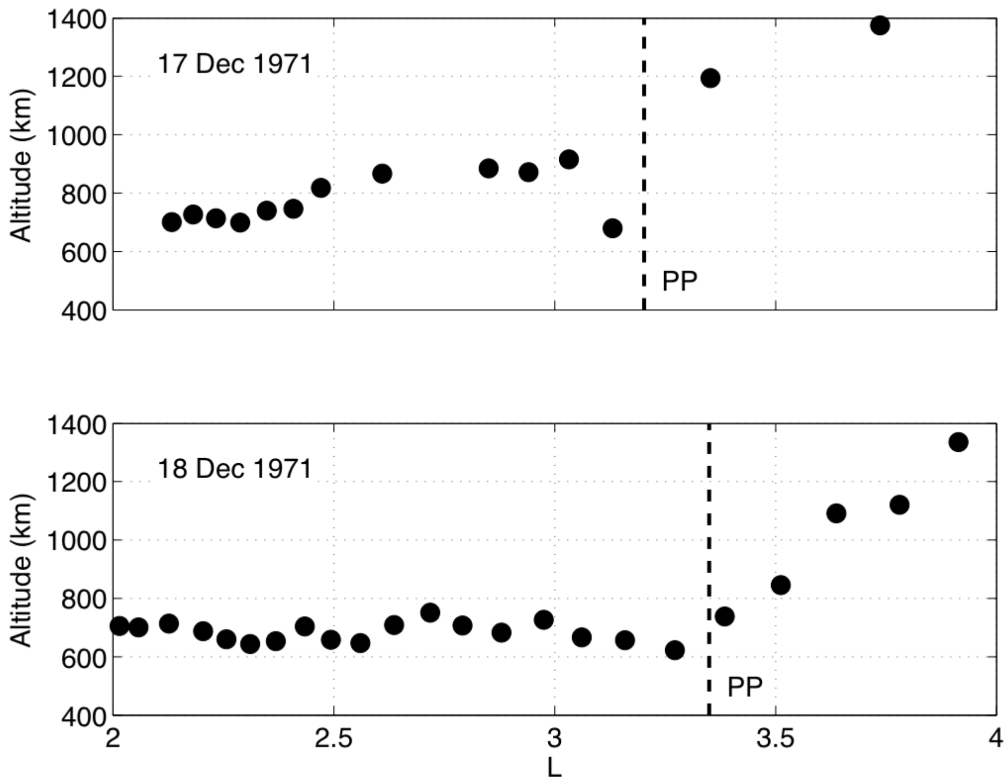


Figure 7. Planetary magnetic 3-hour-range indices (Kp), 15-19 Dec 1971 from ftp://ftp.gwdg.de/pub/geophys/kp-ap/music/musi1971.ps. The solid triangles indicate magnetic-storm sudden commencements. The top line corresponds to Kp = 5. Solid bars indicate Kp > 5; the maximum value on 17 Dec being 7+ which occurs between the PP times of Figures 5 & 6 (arrows labeled 1 & 2, respectively).

Figure 8. O^+/H^+ transition heights along the ISIS-2 orbital tracks corresponding to the ISIS-2 topside-sounder data of Figures 5 (top) and 6 (bottom). These transition heights increase poleward of the Explorer-45 determined plasmapause field lines, designated by PP, due to the escape of H^+.



Discussion and Summary

- In the examples of Figures 5 & 6 the plasmapause field line is on the midlatitude ionospheric N_e trough wall at high altitudes but in the midst of the trough depression at low altitudes
- The midlatitude N_e trough is composed of O^+ near the F peak but with increasing altitude light ions (particularly H^+) become more dominate and reflect a direct coupling to the outer plasmasphere and the plasmapause transition region
- Material submitted to JASTP as *Grebowsky et al*.
- Other pertinent references

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