The Data and Fits for a New Global Core Plasma Model and the Oddities Revealed

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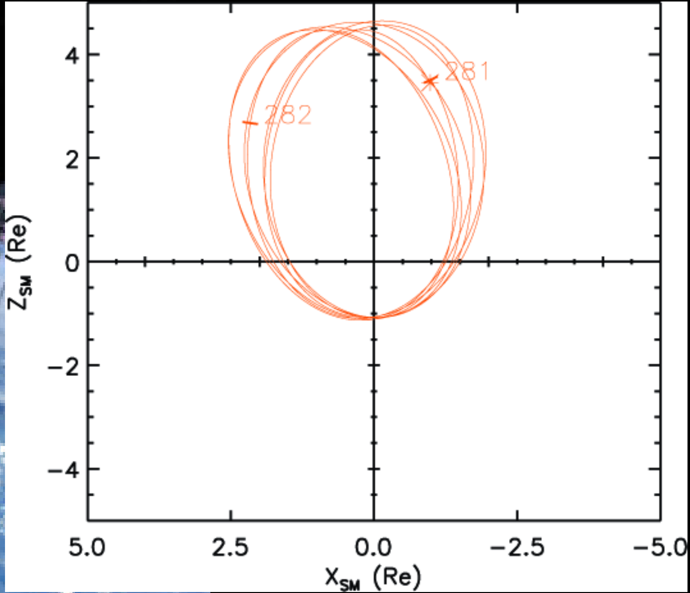
Outline

- Notes about Dynamics Explorer 1 and the Retarding Ion Mass Spectrometer (RIMS)
- The DE 1 RIMS moments database? What is in it? What are the limitations?
- Densities (spatial and long term variations)
- Temperatures (spatial and long term variations)
- Summary
- Editorial

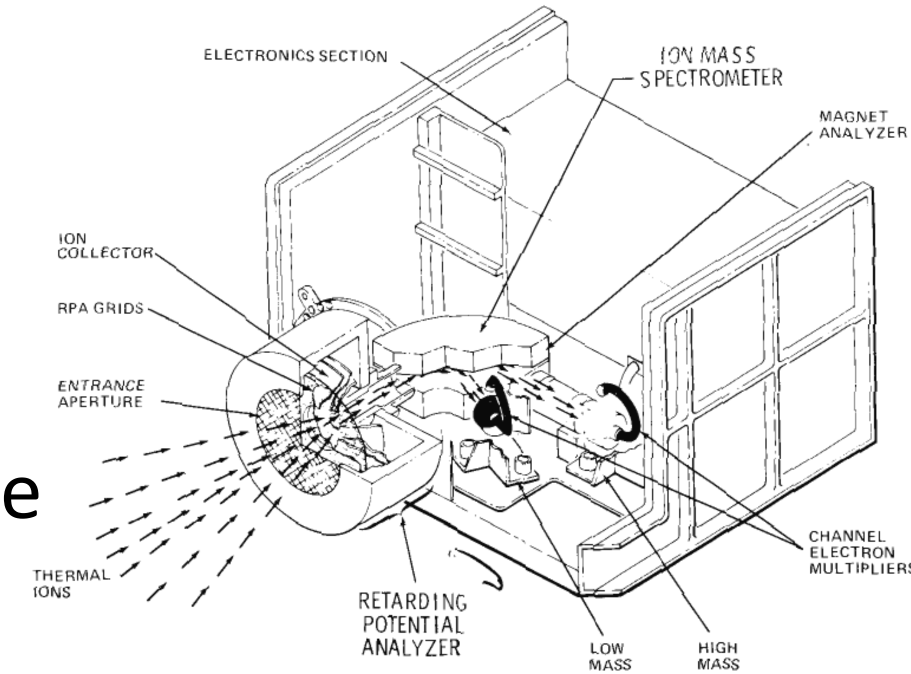
Dynamics Explorer 1

- Launched August 3, 1981
- High inclination,
- Altitude 568km x 23,290km ($4.6R_E$) orbit
- 6.8 hour orbital period



Retarding Ion Mass Spectrometer (RIMS)

- 3-sensor heads
  - two spin-axis w/55º fov
  - radial w/20 º x 110 º fov
- 0-45 eV energy/charge range
- 1-32 μ mass/charge range
- 16 msec time resolution
- Included annular collar for potential control



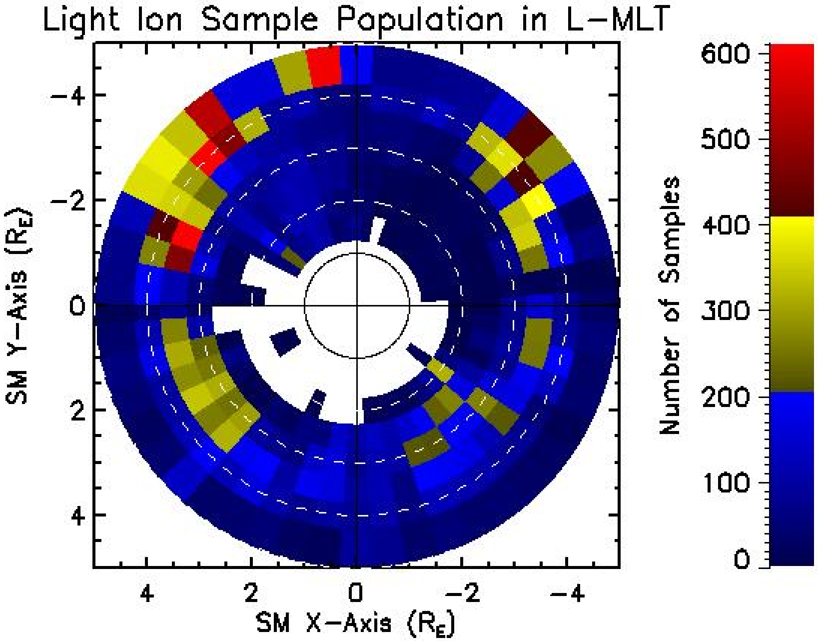
The RIMS Moments Dataset

- https://plasmasphere.nasa.gov
- 1 minute sums, uses all 3 sensors, Maxwellian distribution assumed, ion densities and temperatures; method discussed in Craven et al., JGR, 102/A2, pg.2279, 1997
- Ion order in file is H^+, He^{++}, He^+, O^+, O^{++}
- RIMS_starter_kit includes data, data description, and sample read routines in C and IDL code
- Includes this synoptic study in PDF
- All will be offered to the NASA/SPDF
- Data file description is still incomplete

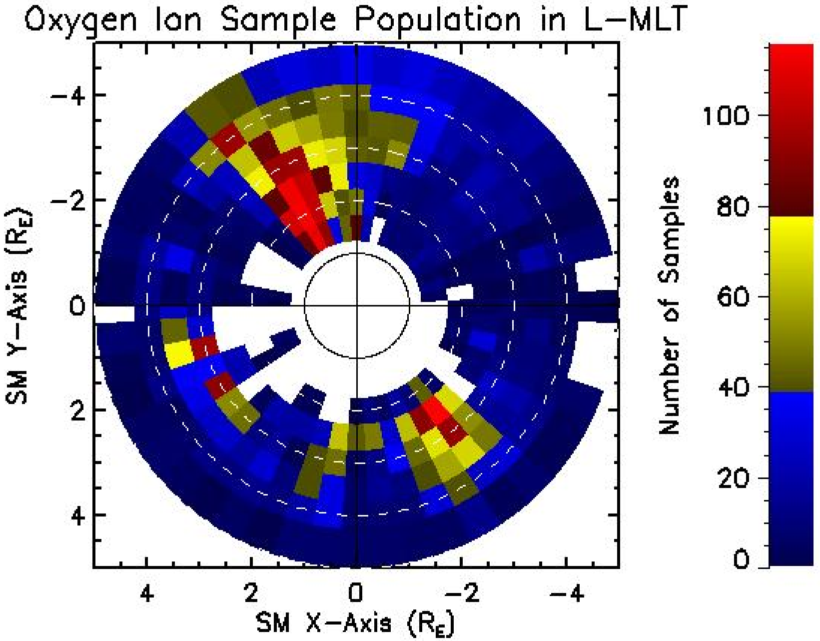
Density and Temperature Data Set

- H^+, He^+, He^{++}, O^+, & O^{++}
- October 8, 1981 thru 1984

36,291 samples

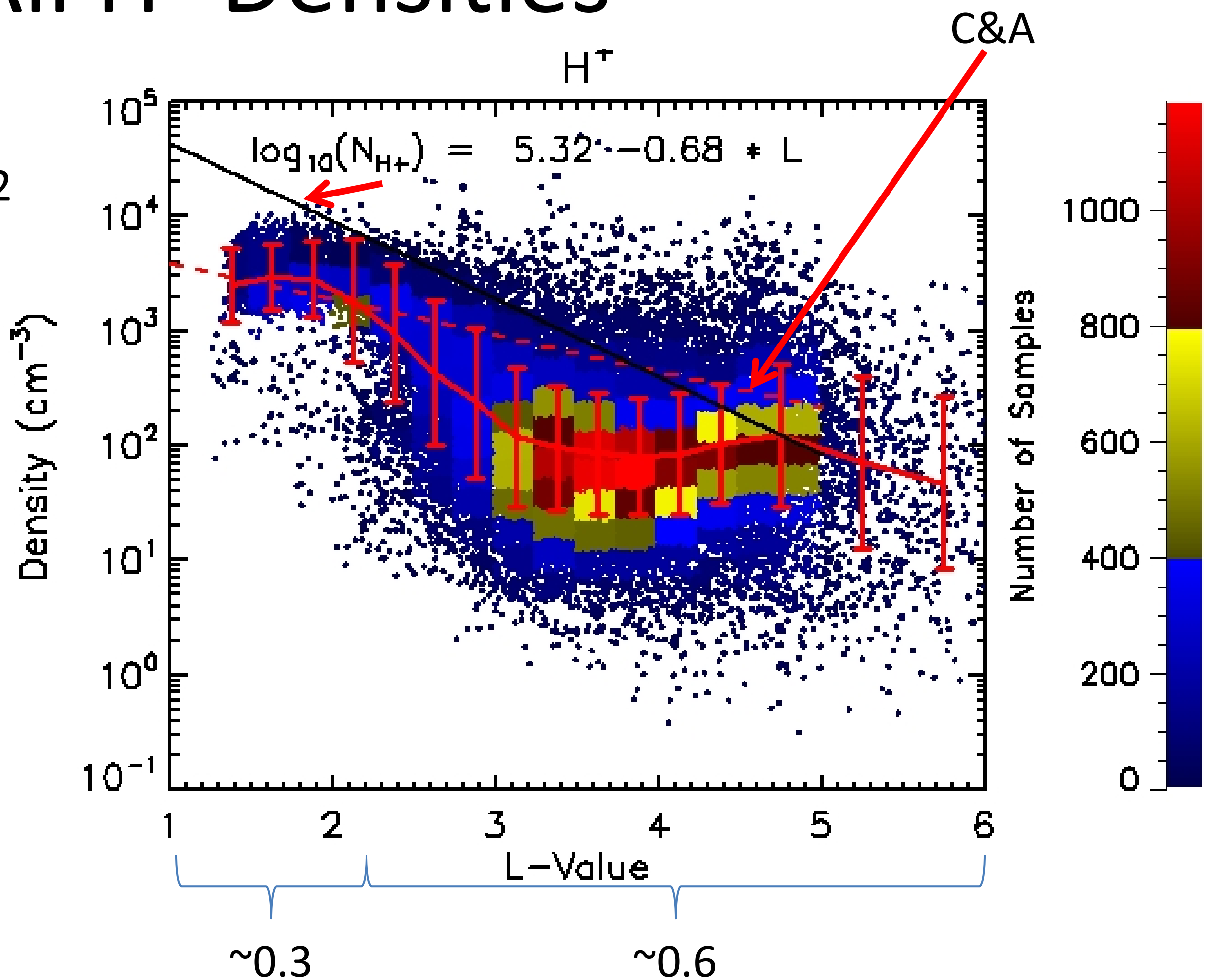


7,601 samples



All H^+ Densities

- The red line shows the Carpenter and Anderson 1992 saturated plasmasphere density profile.
- The black line borders the upper range of densities at middle L-values, for comparison to C&A.
- The lower boundary appears to demonstrate plasmapause variability with activity, that rarely extends inside L=2.2.
- The in situ derived densities often do not provide a smooth, continuous plasmapause boundary.
- Increased densities at higher L-value may arise from storm enhancement or plumes.



σ *of the* $log_{10}(density)$

1.375	1.625	1.875	2.125	2.375	2.625	2.875	3.125	3.375	3.625	3.875	4.125	4.375	4.750	5.250	5.750
3.399	3.469	3.455	3.270	2.980	2.632	2.372	2.075	1.978	1.932	1.908	1.924	2.013	2.090	1.850	1.673
0.320	0.286	0.327	0.536	0.601	0.627	0.656	0.610	0.548	0.524	0.509	0.530	0.516	0.627	0.755	0.746

Fits are for the log10(density)

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close,3
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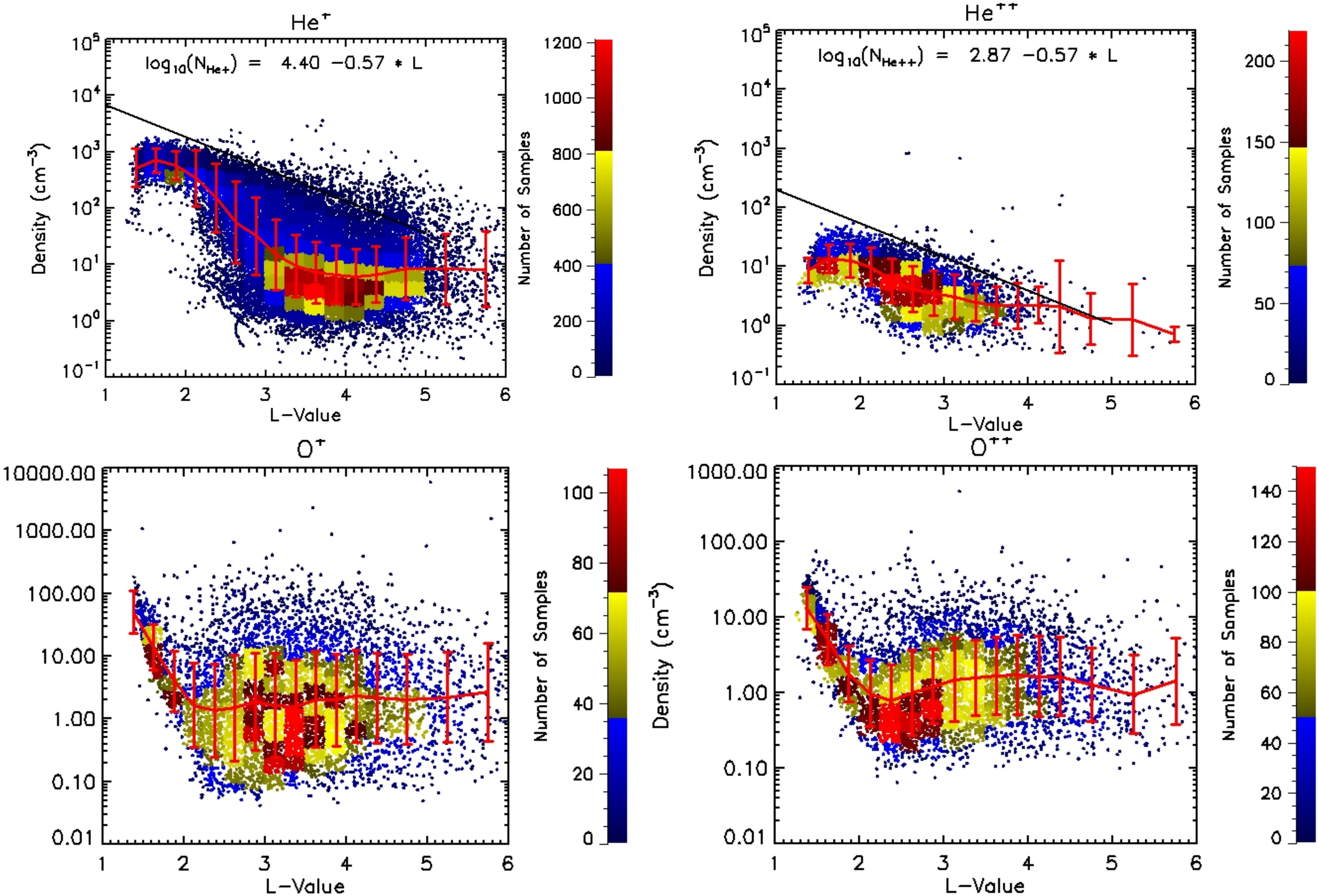
Rims_HpN_vs_L.txt

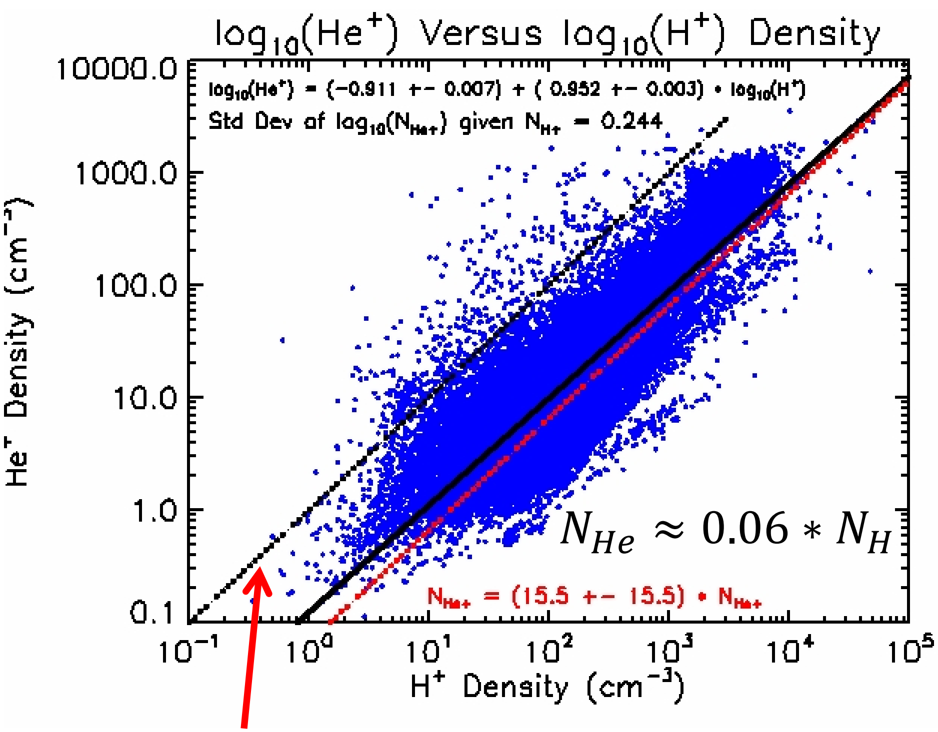
Other Ion Densities

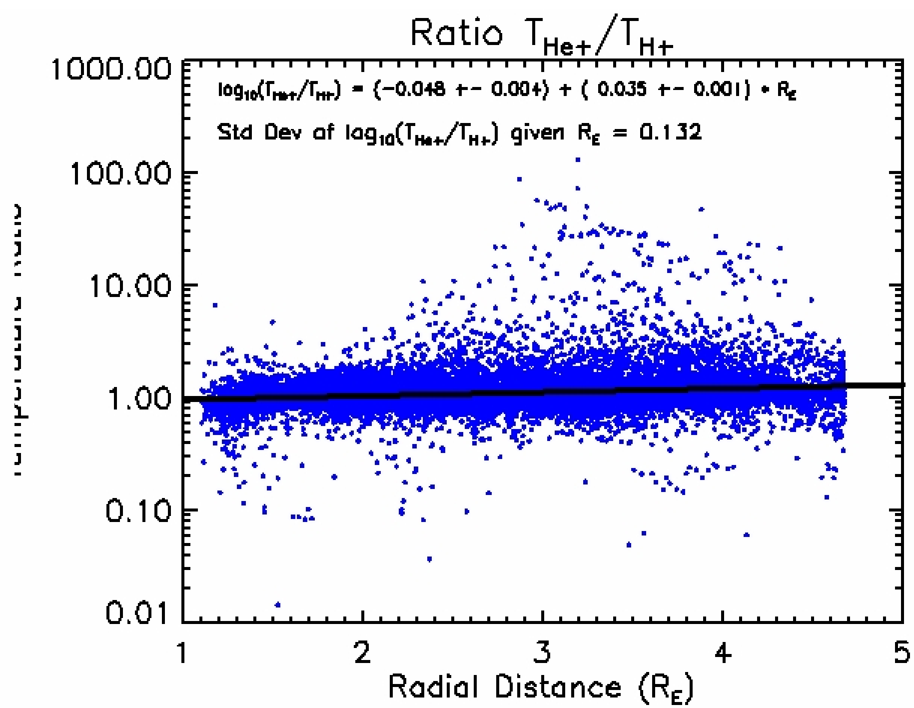
The strong drop in oxygen density above the ionospheric peak is followed by an enhancement in the region dominated by geomagnetic activity; more dramatically than that of the light ions.



He^+ Versus H^+

- Only first order dependencies are expressed here and in the following content.
- The density comparison has the same result as that of Craven et al., JGR, 1997.
- Over all the He^+ densities are an average of about 6% of H^+ densities.
- He^+ and H^+ temperatures are about the same under all conditions.
- Fit parameters are shown with associated σ.
- The separately stated σ is for differences between ratio values and fit.

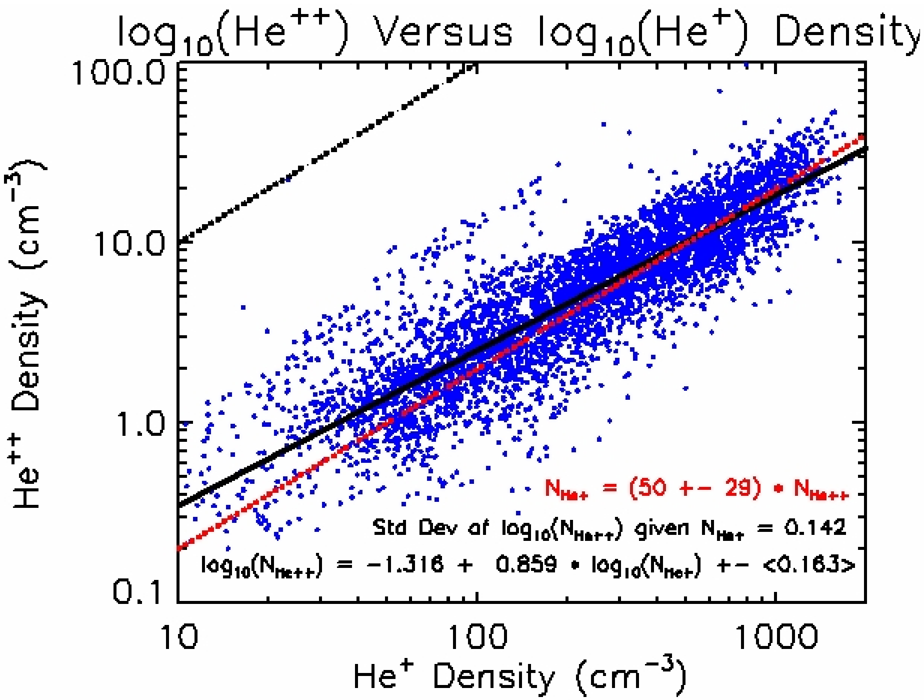


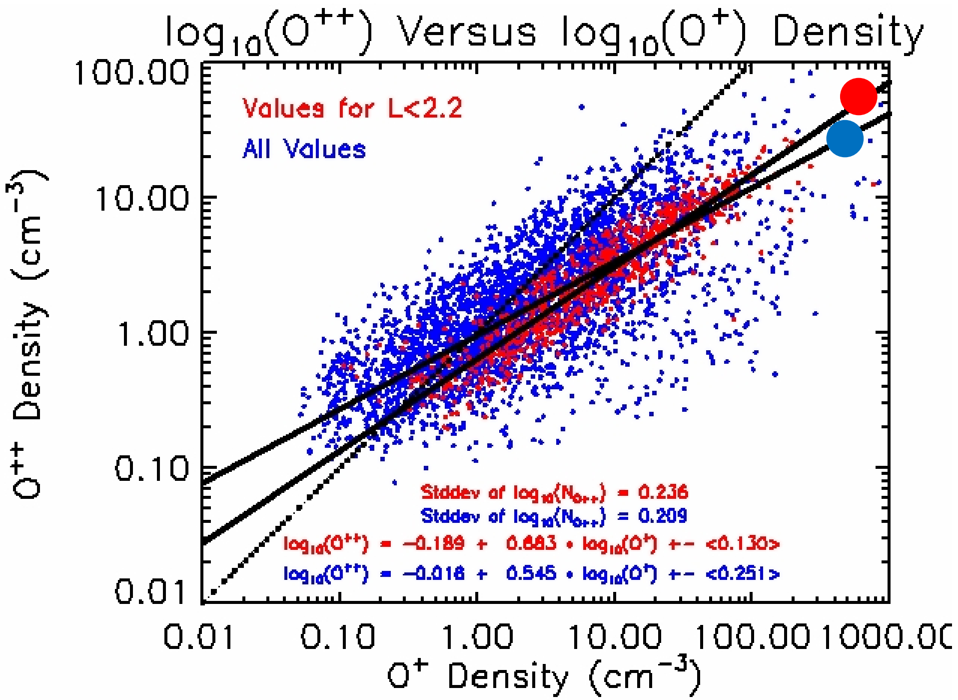


Black dotted line marks equal densities.

Single vs Doubly Ionized Ions

- The density of He^{+} is about 50x that of He^{++} on average, without significant statistical variation away from a constant factor.
- O^{++} densities are found to be statically higher than O^{+} when below 1 cm^{-3} and lower when above that density.
- Nearly all of the O^{++} below L=2.2 is less dense than O^{+}, with increasing divergence at lower altitude (greater density).
- It is at higher L-value and low density that O^{++} has higher density than O^{+}.



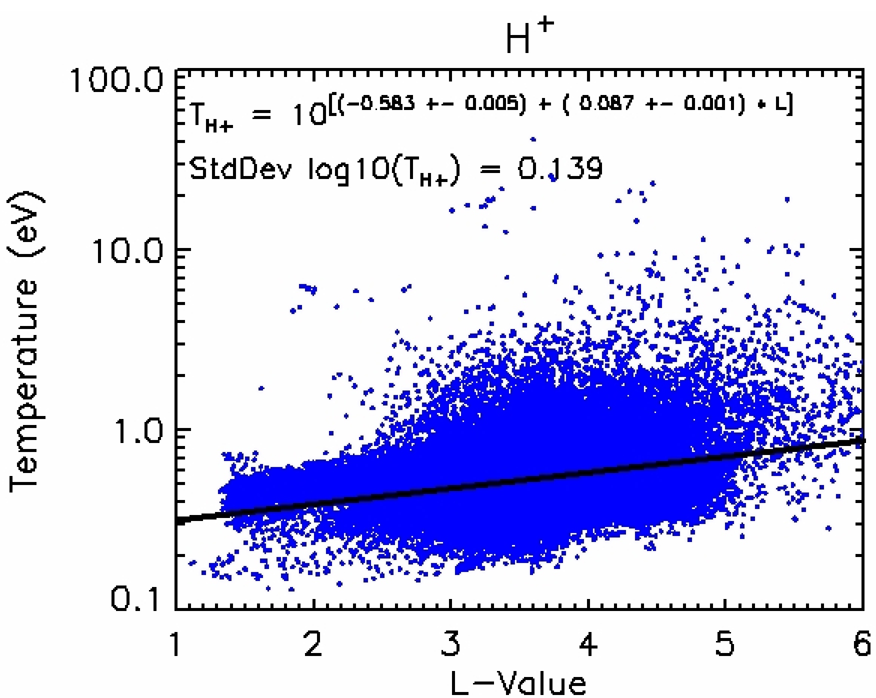


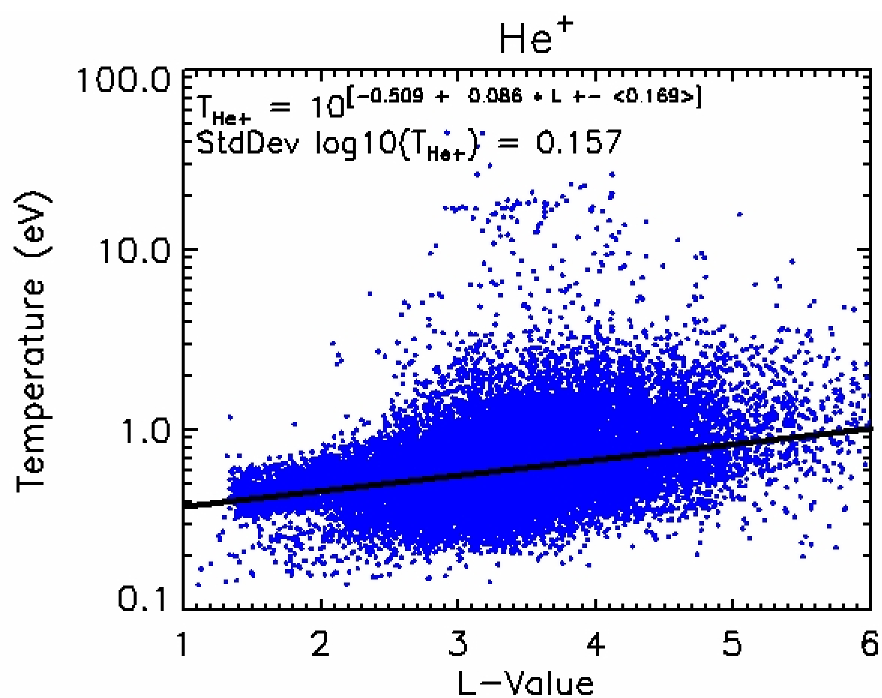
Black dotted lines mark equal densities.

Ion Temperatures: H^+ & He^+

Relative to light ion densities, the temperatures have somewhat less scatter, though still more above L=2.2 where geomagnetic activity has its strongest influence.

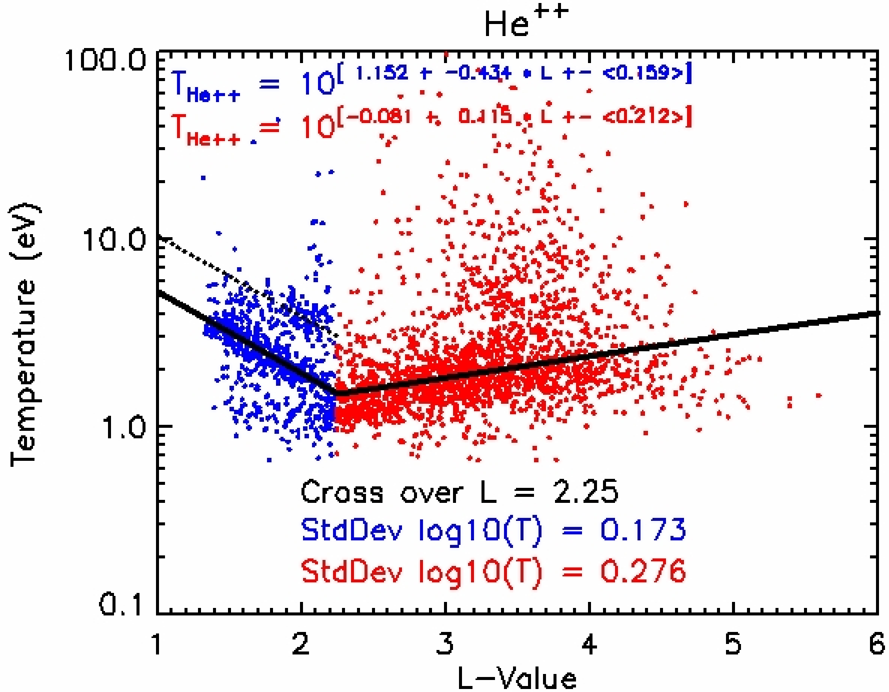
Temperatures rise as densities fall, though not as much.

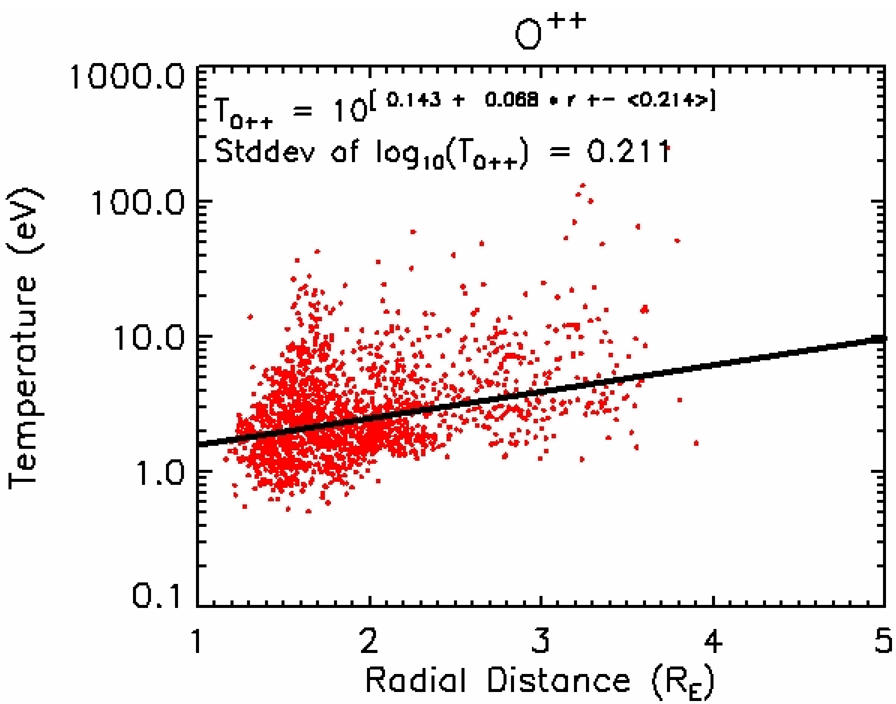


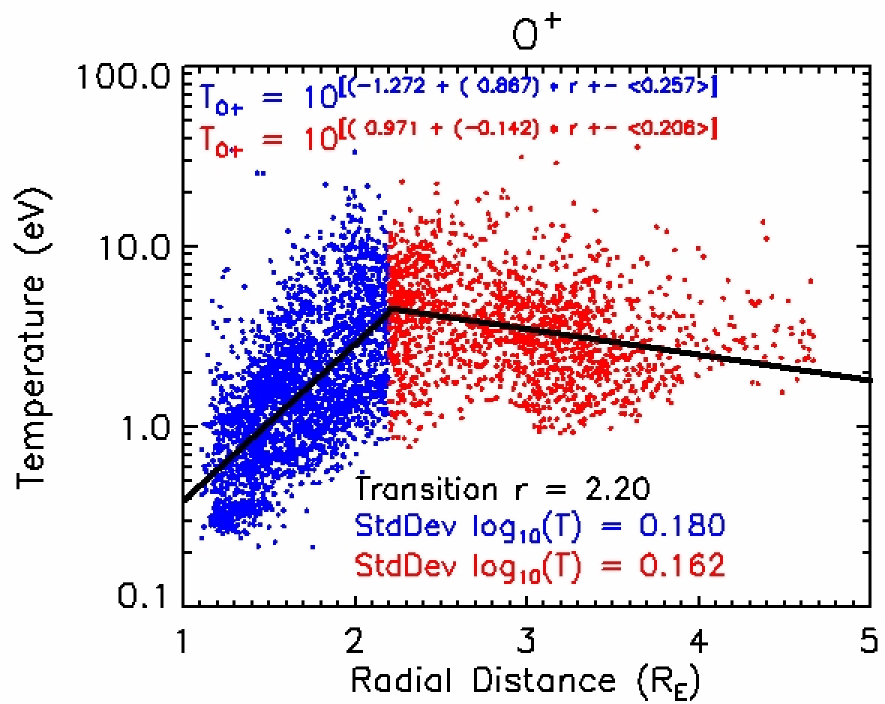


Ion Temperatures: He^{++}, O^{+}, & O^{++}

- The He^{++} temperatures are interestingly odd. Temperatures initially fall with increasing L-value before rising after L=2.25. There is the suggestion that the low and high L-value populations overlap, hence are distinct.
- There is the suggestion of another population at 2x higher temperature and at low L, consistent with D^{+}.
- O^{+} behavior is no less interesting.
- O^{++} behaves more like the light ions.

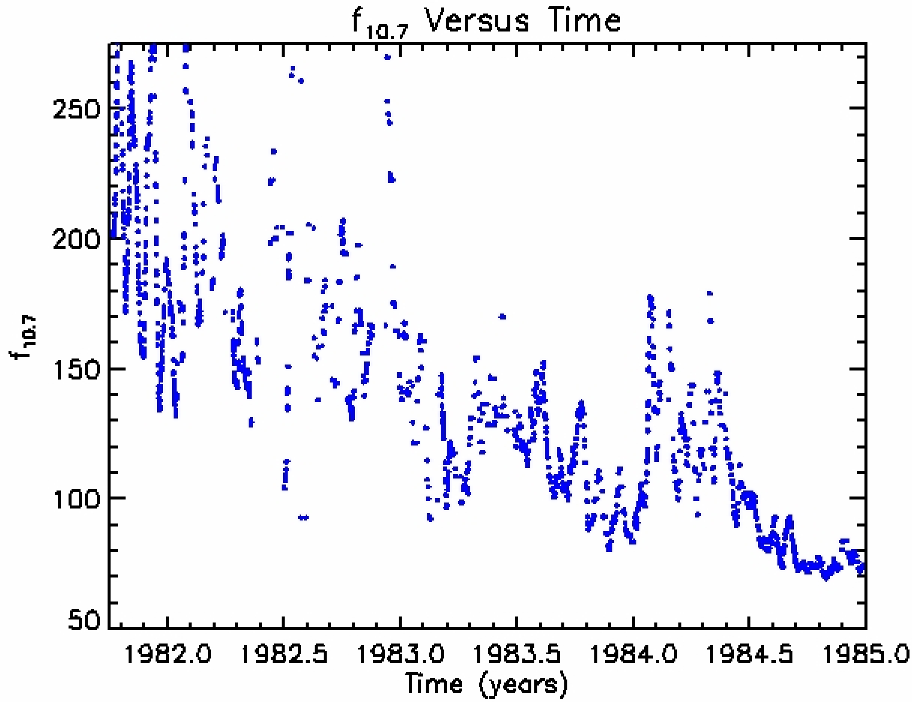


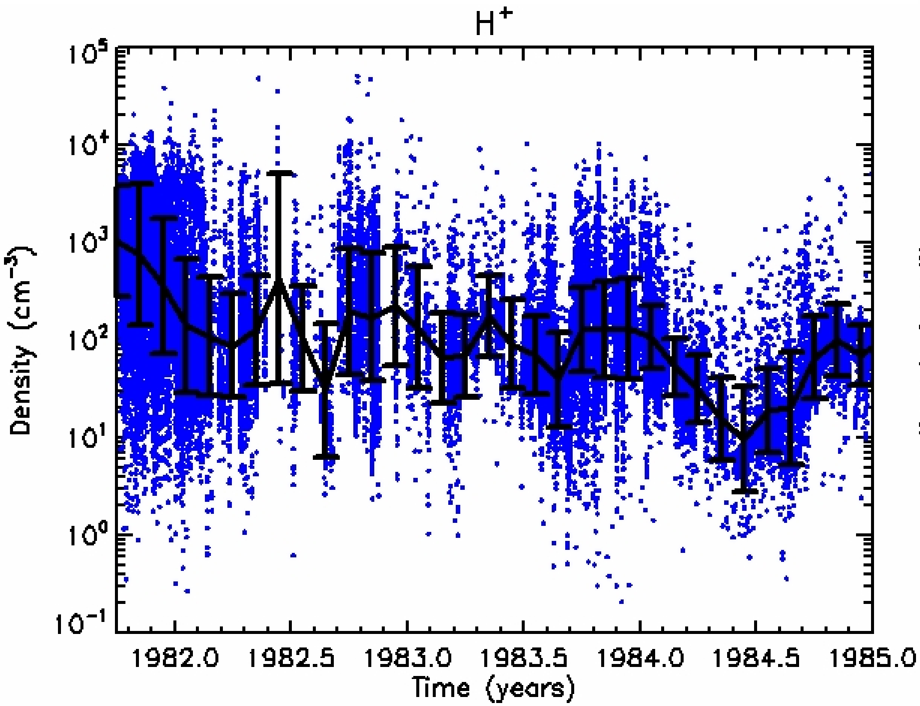


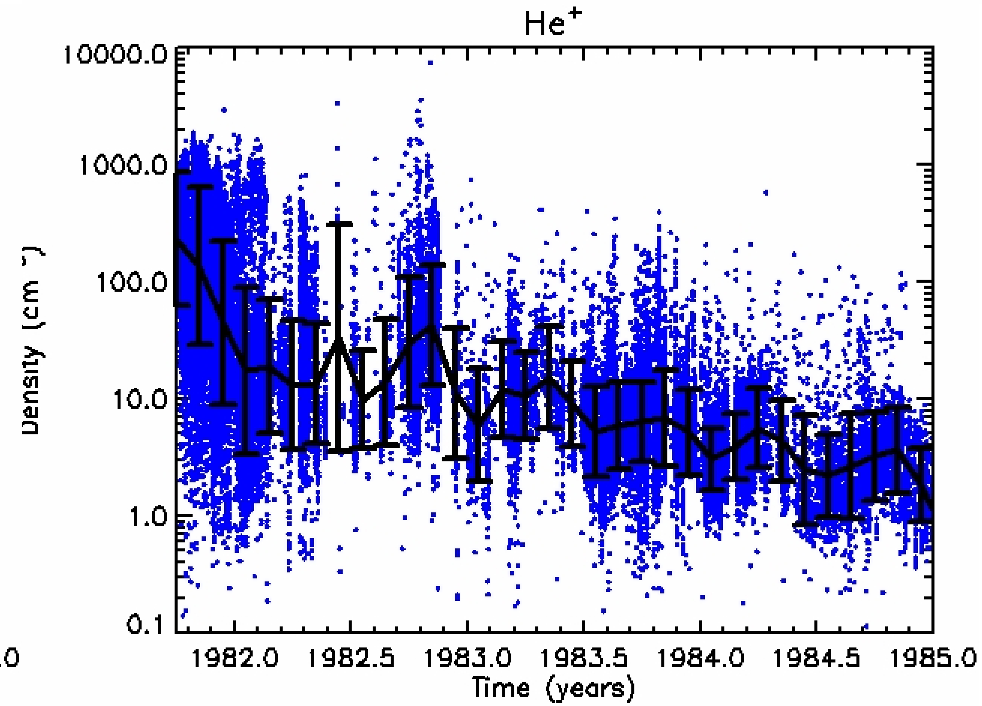


Solar Cycle Variation

- Both a seasonal and solar cycle variation in plasmaspheric density have long been observed. These plots clearly display a strong relationship between $f_{10.7}$ and light ion density as solar minimum is approached.

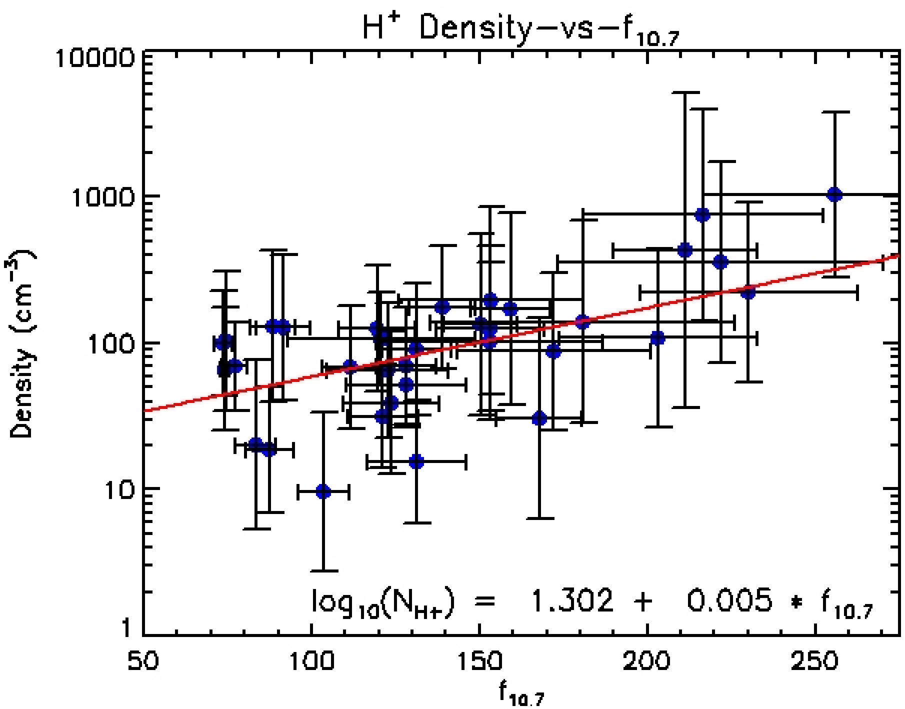


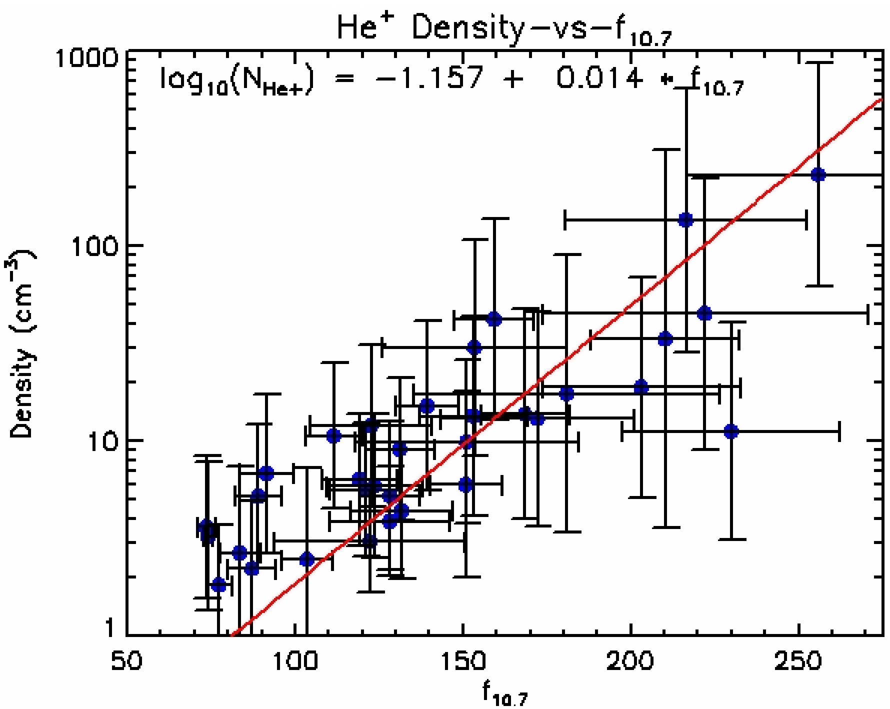




Mean Density vs $f_{10.7}$: H^+ & He^+

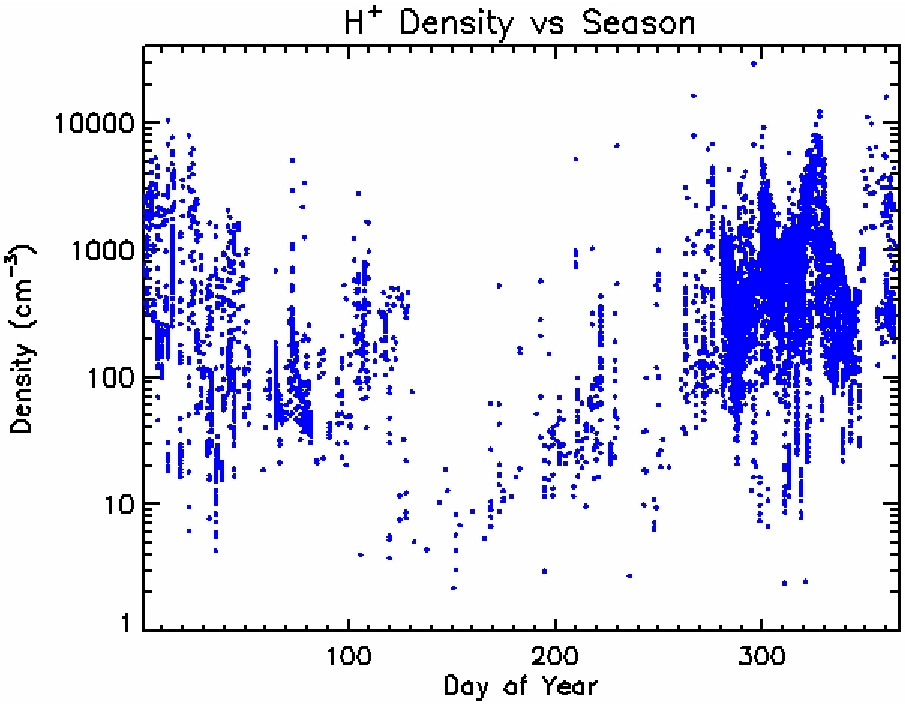
- Only part of one solar cycle is available in these data.
- Like previous studies, such as Carpenter & Anderson 1992, there is a significant increase in density with increasing solar activity.
- Perhaps not previously seen is the stronger response in He^+ relative to H^+.

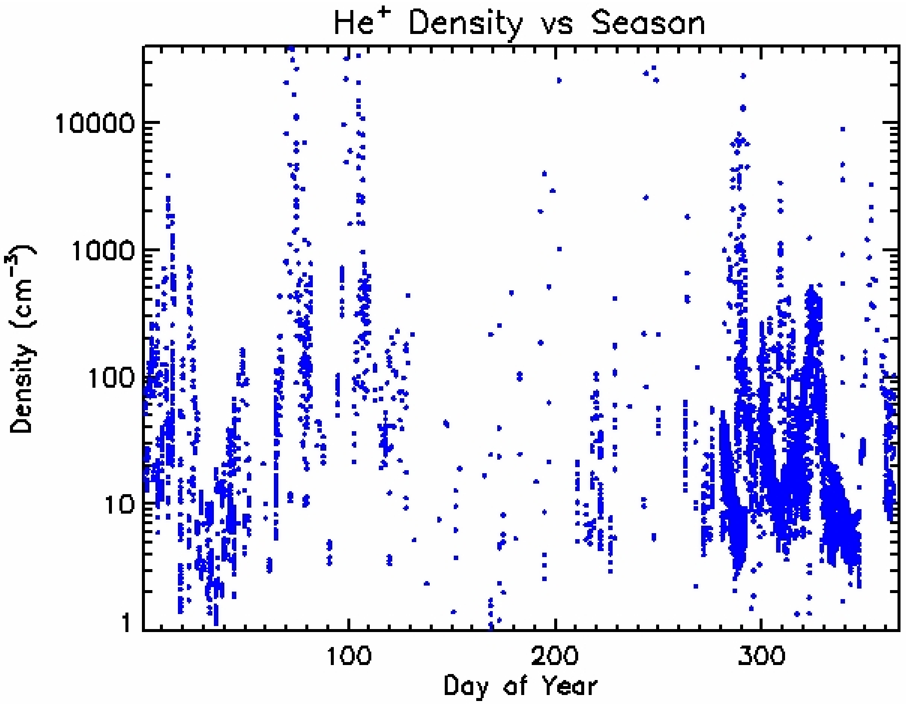




Mean Density vs Season: H^+ & He^+

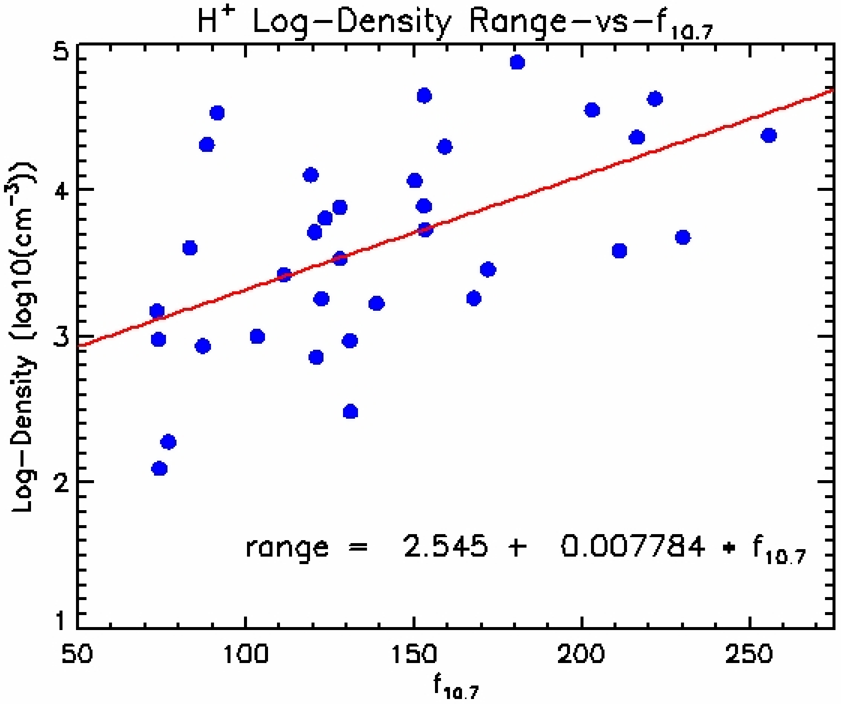
- Density versus the day of the year is plotted here after removing the density versus f10.7 trend shown in the last slide.
- There is the suggestion of annual periodicity, especially in H^+.
- There is also the suggestion of periodicity on the order of 24 days or one solar rotation period. Examination of surface features, such as flares, during these times will resolve this possibility, but that remains to be done.

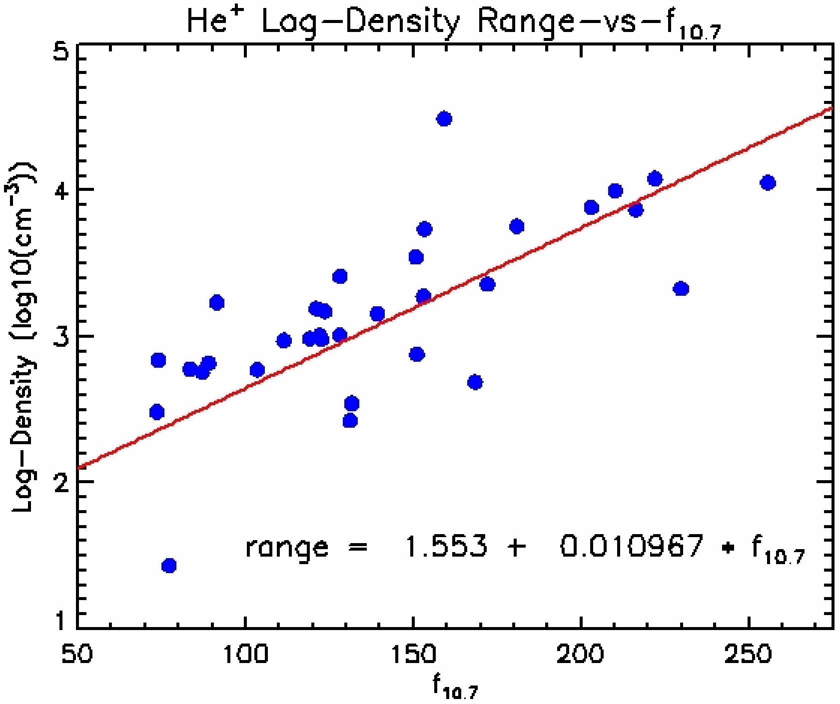




Density Range vs $f_{10.7}$

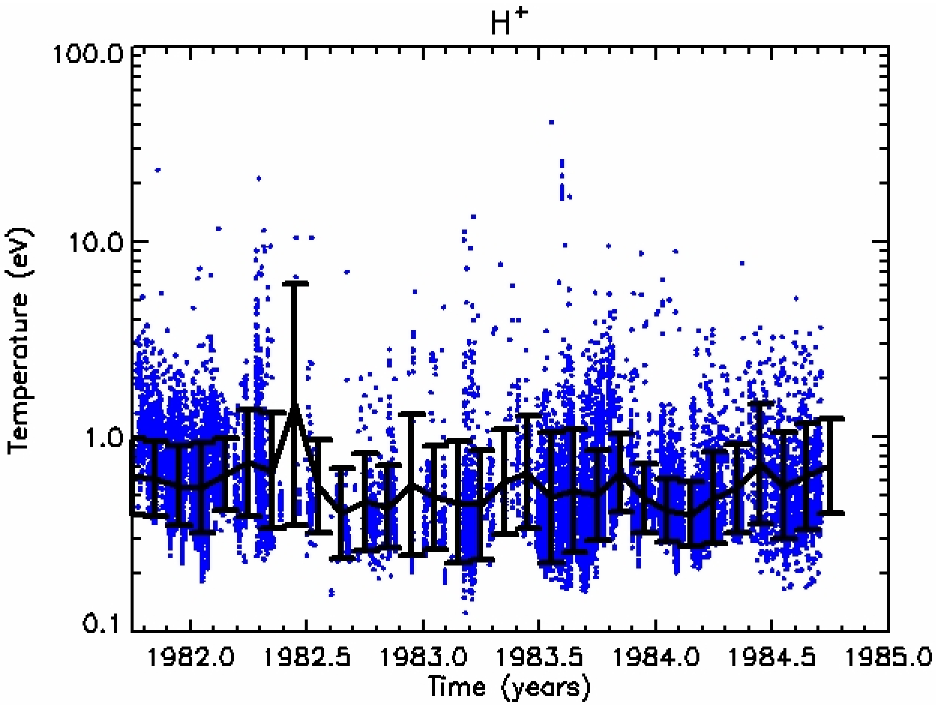
- Not previously noted is that the range of all observed densities also increases with increasing solar activity.
- Again, the response of He^+ appears to be stronger than that of H^+.
- There are not enough O^+ and O^{++} ion values to perform either analysis.

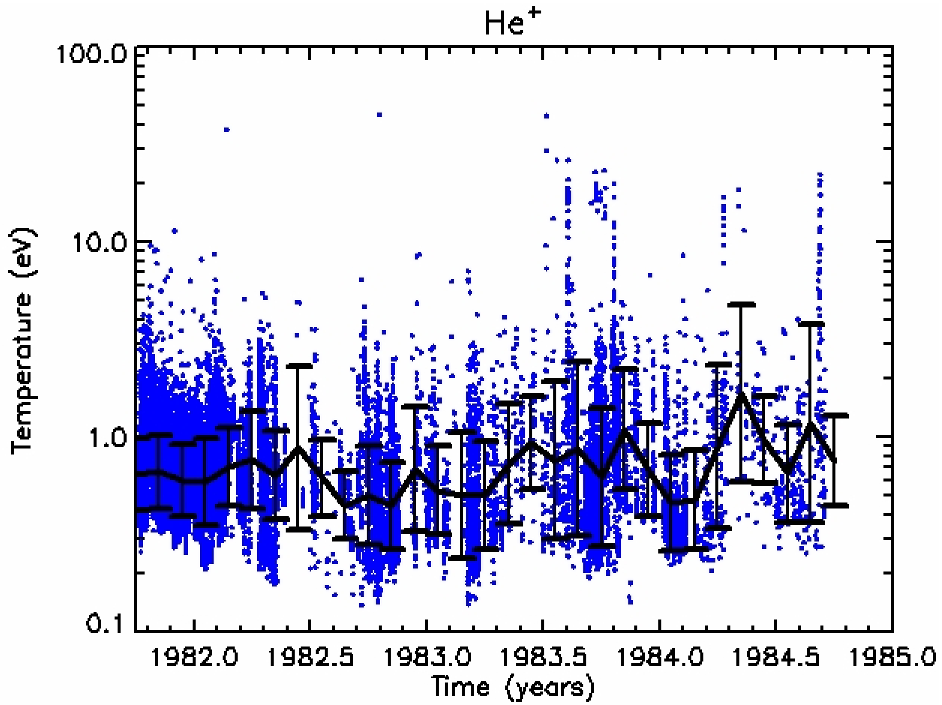




Mean Temperature vs $f_{10.7}$: H^+ & He^+

Temperature does not show the same sensitivity to solar cycle, but may show a weak seasonal response.





Summary

- These conservatively derived densities and temperatures provide unique H^{+}, He^{+}, He^{++}, O^{+}, and O^{++} ion properties.
- On average He^{+} is about 6% of H^{+}density.
- He^{++} is about 50x less than He^{+} in density.
- H^{+} and He^{+} temperatures rise with increasing L-value at a ratio of 1.
- Inside of L=2.25 He^{++} temperatures fall with increasing L-value, then rise beyond that. In addition, D^{+} appears to be present.
- Contrary to the light ions, O^{+} temperature rises sharply with increasing L-value up to L=2.2, then falls gradually beyond that.
- Oddly, O^{++} follows the light ion behavior.
- Overall average H^{+} and He^{+} densities fall with falling $f_{10.7}$ in the declining solar cycle in the mid-1980s.
- In addition the range of light ion densities also diminishes with falling $f_{10.7}$. This is seen for all values without regard for location or conditions.
- Light ion temperature does not show a significant $f_{10.7}$ dependence.

Upon Reflection

- The RIMS moments data set will be provided to the NASA Space Physics Data Facility this year. The data file and an IDL example to read it are available online at http://plasmasphere.nasa.gov.
- DE 1 RIMS densities and temperatures remain a unique resource for the community, but the spatial and temporal sampling is limited.
- These data are without reliable identification of their morphological origin: plasmasphere, plasmapause, trough, auroral zone, polar cap.
- If we are to understand the processes of refilling, wave-particle instabilities, and wave transport, it is critical to obtain full phase-space, Sub-eV to 100 eV energies, mass spectroscopy, and ions and electrons. A more equatorial perspective across all inner magnetospheric L-values in concert with the global context is also needed.