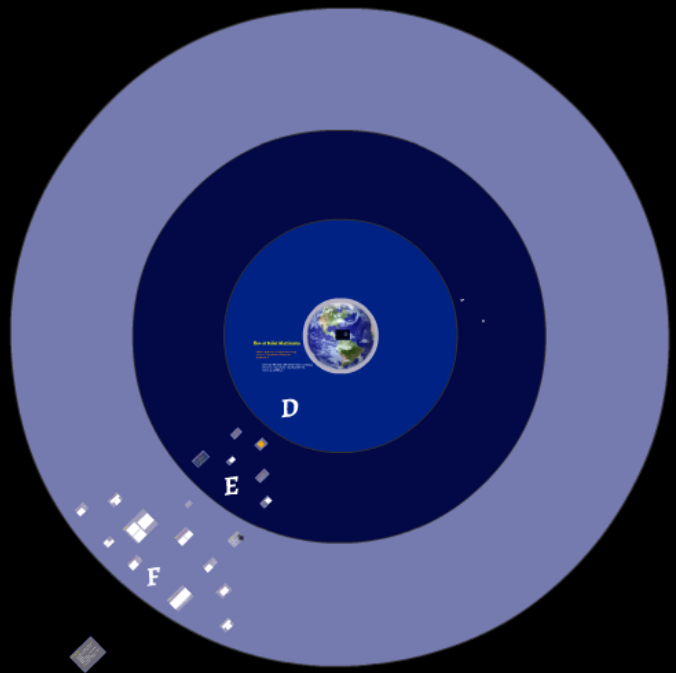
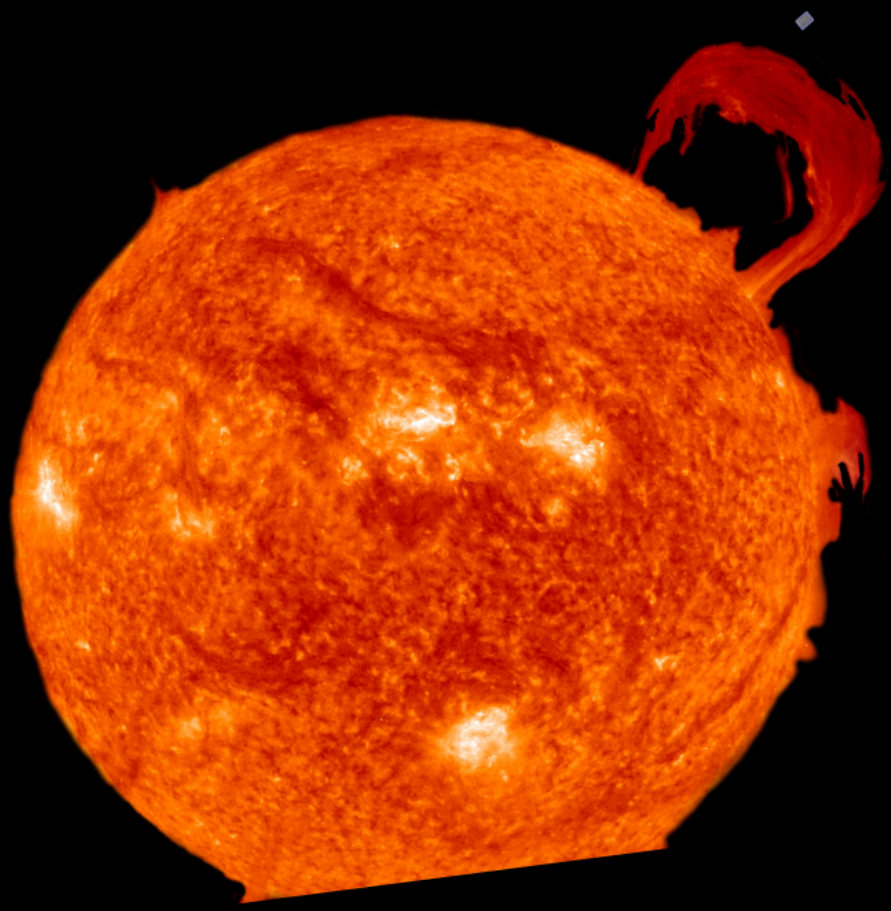
Questions?





He+ at Solar Maximum

Boyi Gao [1], Eframir Franco [2], Ehab Hassan [3], Leda Sox [4], Luis Navarro Dominguez [4], Weiwei Sun [5]

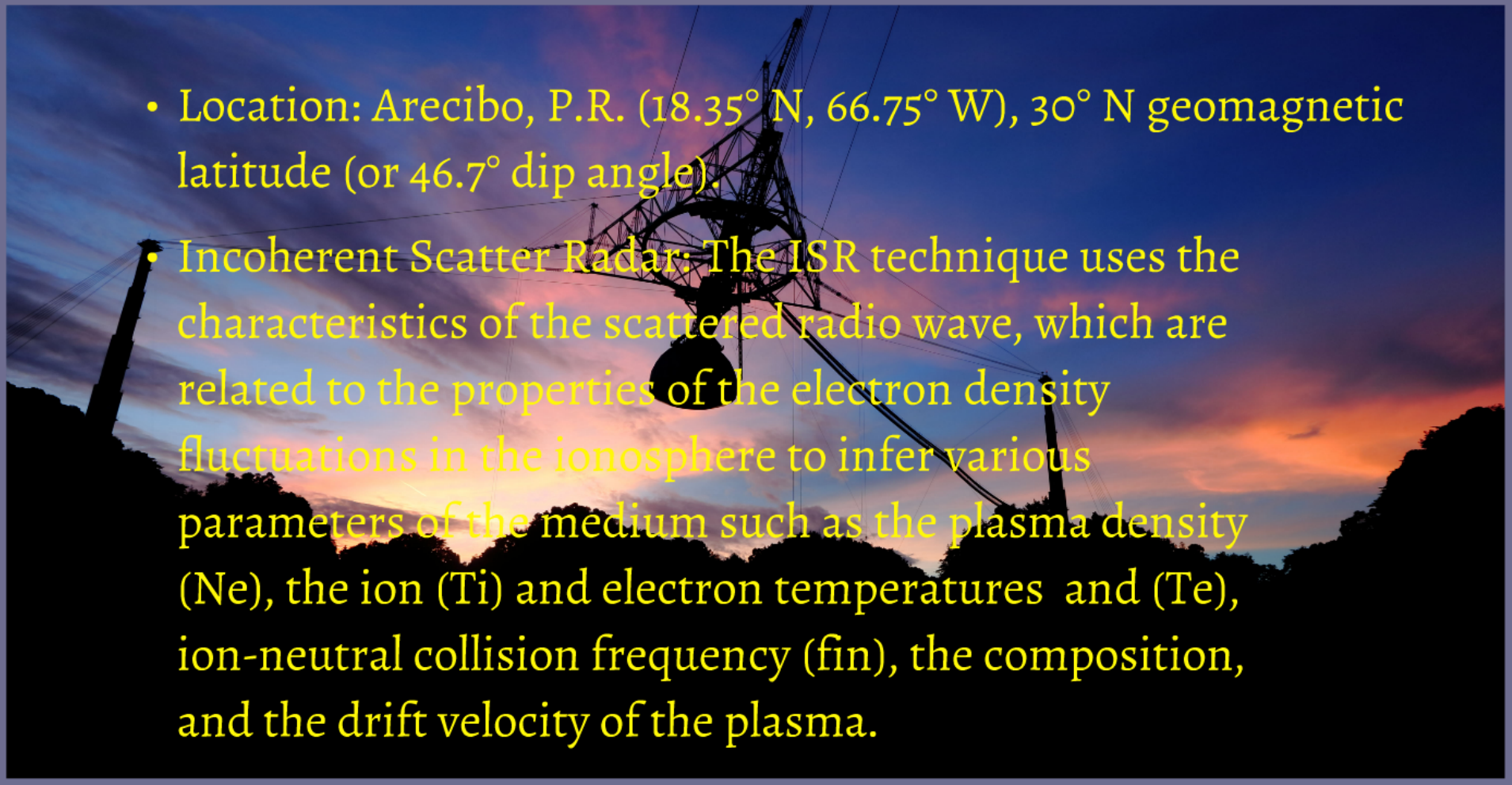
[1] Penn State University; [2]University of Puerto Rico at Humacao; [3]University of Texas, Austin; [4]Utah State University; [5]University of Washington

Puerto Rico

Puerto Rico

Arecibo Observatory, Puerto Rico

Arecibo Observatory



- Location: Arecibo, P.R. (18.35° N, 66.75° W), 30° N geomagnetic latitude (or 46.7° dip angle).
- Incoherent Scatter Radar: The ISR technique uses the characteristics of the scattered radio wave, which are related to the properties of the electron density fluctuations in the ionosphere to infer various parameters of the medium such as the plasma density (Ne), the ion (Ti) and electron temperatures and (Te), ion-neutral collision frequency (fin), the composition, and the drift velocity of the plasma.

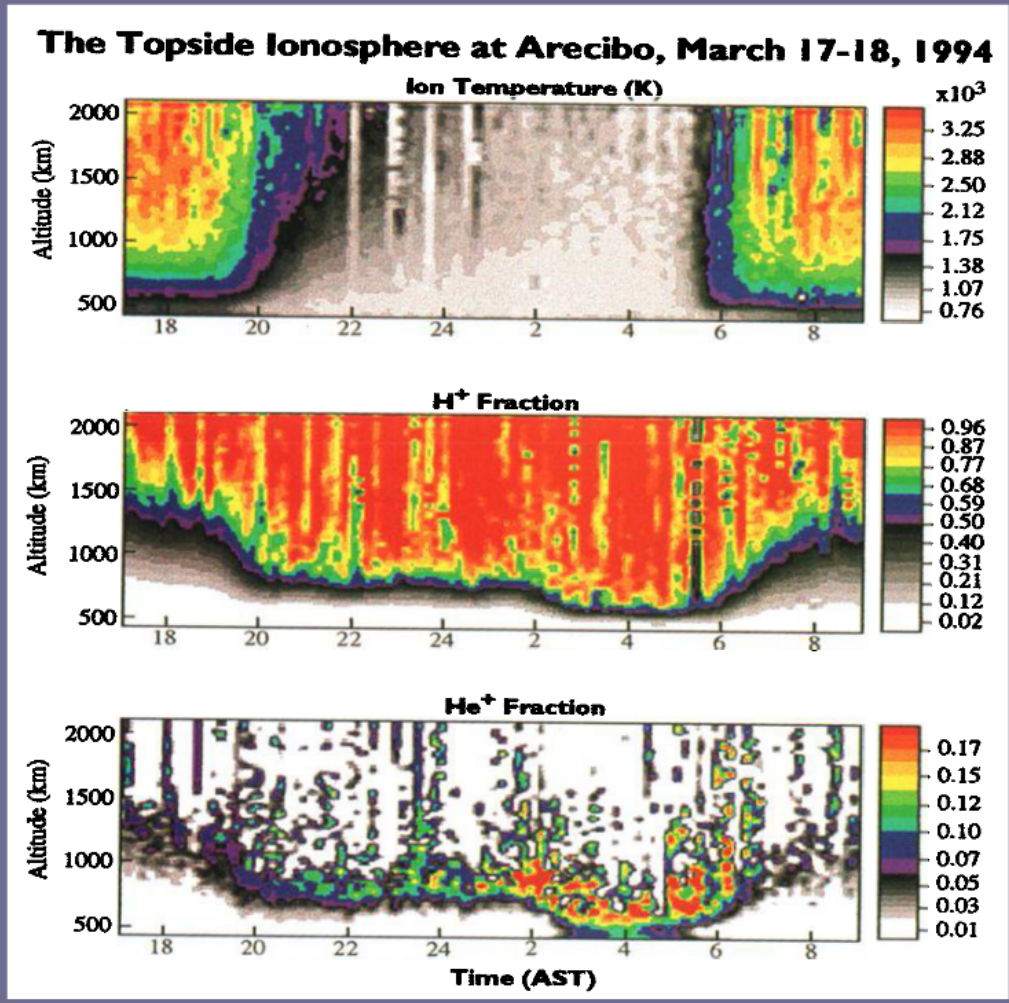
Motivation

The inclusion of He+ in the ISR spectral analysis could:

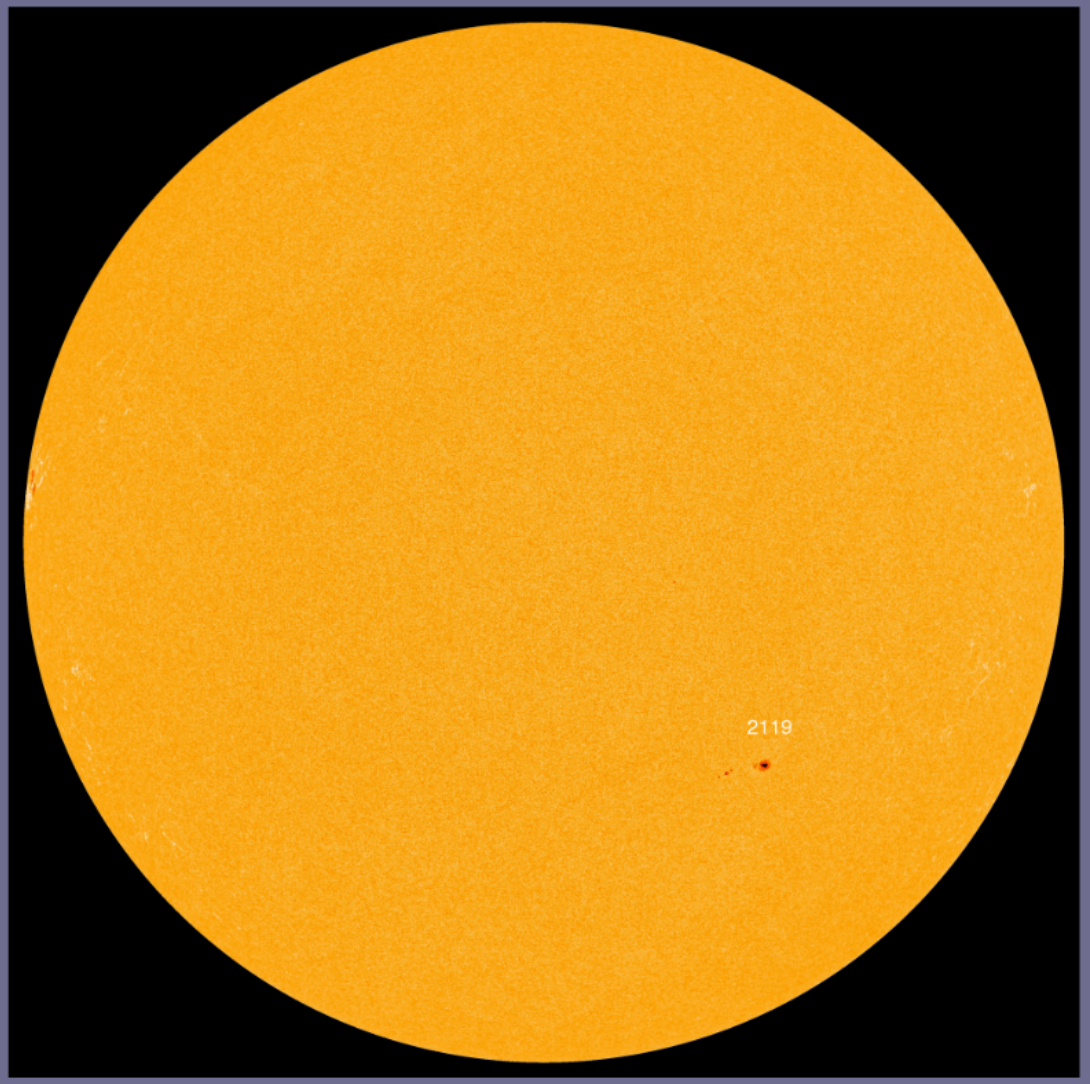
- Specify light ions partitioning in the topside.
- Produce correct topside ion temperature (Ti).
- Accurate measurements of O+ and H+, and their temperatures, will allow us to quantify the local charge exchange mechanism that is the dominant source of hydrogen escape during both, solar minimum and moderate conditions.
- Improve the accuracy of exosphere H density and H escape flux.
- useful to verify current theoretical simulations for upper atmospheric ion-energy balance and charge exchange equilibrium.

Background

- *Gonzalez and Sulzer, GRL, 1994* explored helium fractions for solar minimum conditions March 17-18, 1994
- Helium layer intensified and descended at ~2 AM AST and then began to rise and then disappear at 6 AM AST
- Topside mode at Arecibo was used, alternating with MRACF for calibration purposes



Solar "Maximum" Conditions



22 July 2014, 10.7 cm flux: 90 sfu

Experiment Configuration

- Time: 3 a.m. - 5 a.m. AST,
  July 23, 2014
- Pointing Direction: Zenith
- Peak Power: ~1.3 MW
- Antenna: Linefeed
- Data Acquisition Modes:
  - 60 seconds Topside Mode
  - 10 seconds MRACF Mode

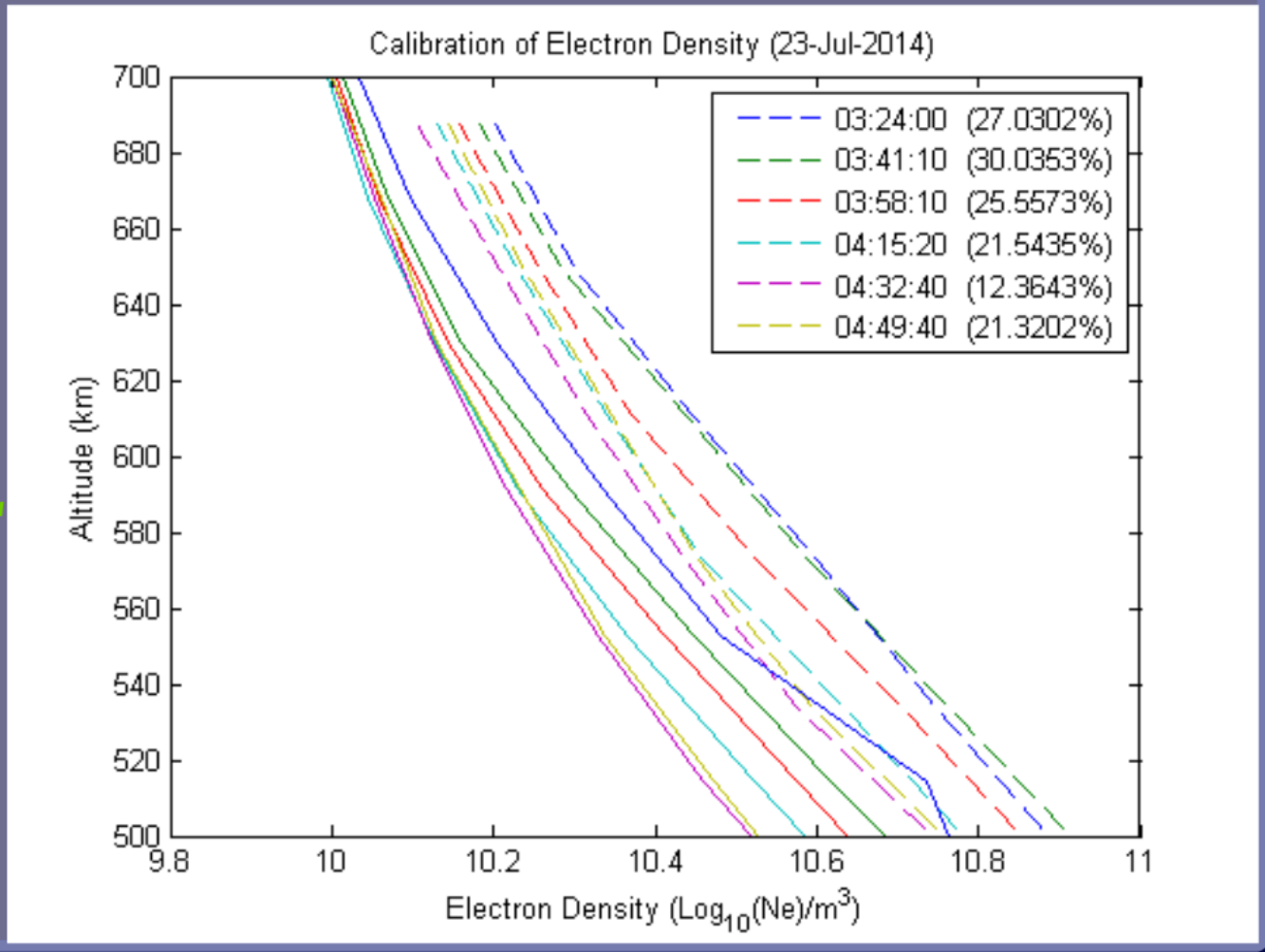
Topside Mode

- Pulse Width: 500 µs
- Code: Uncoded
- IPP: 20 ms
- Sampling Rate: 2 ms
- Integration Time: 20 min

Calibration of Electron Density

Solid Line: **Topside**

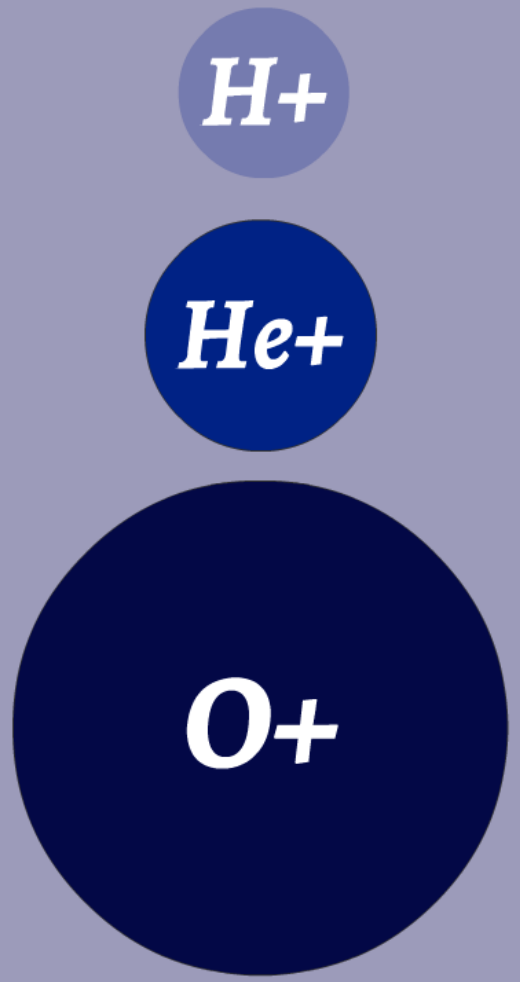
Dashed Line: **MRACF**



Results

Diffusive Equilibrium

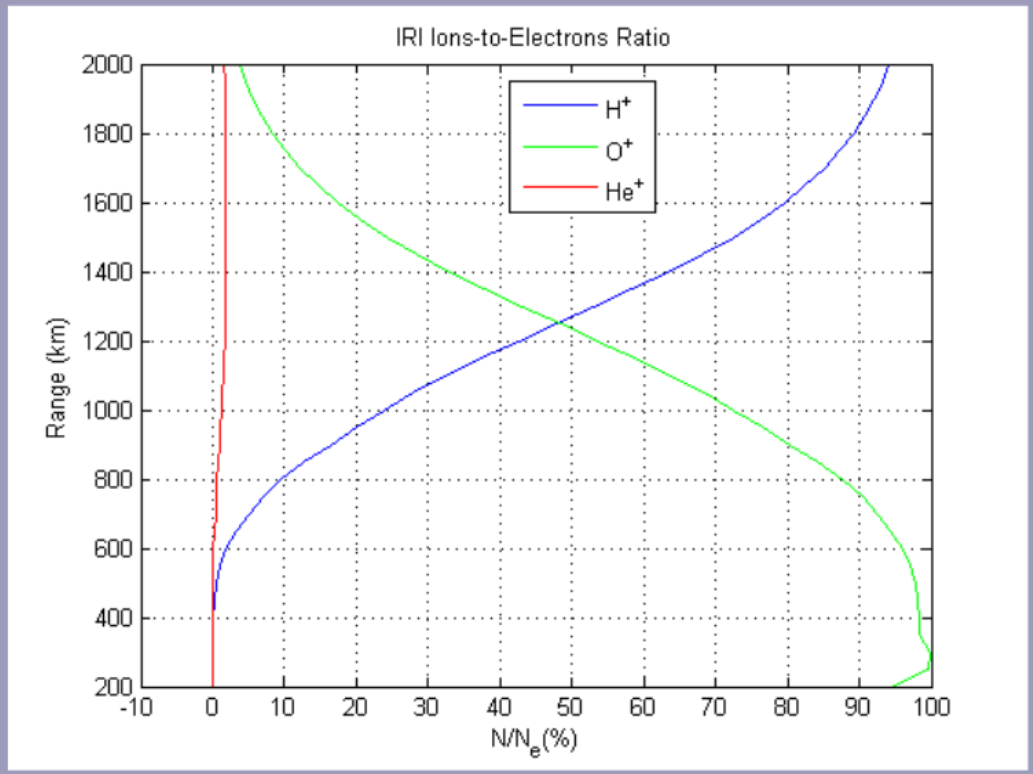
- With decreasing atmospheric density, diffusion processes become more important
- This accounts for the layers of ions on the topside ionosphere
- Ions with higher masses stratify at lower altitudes



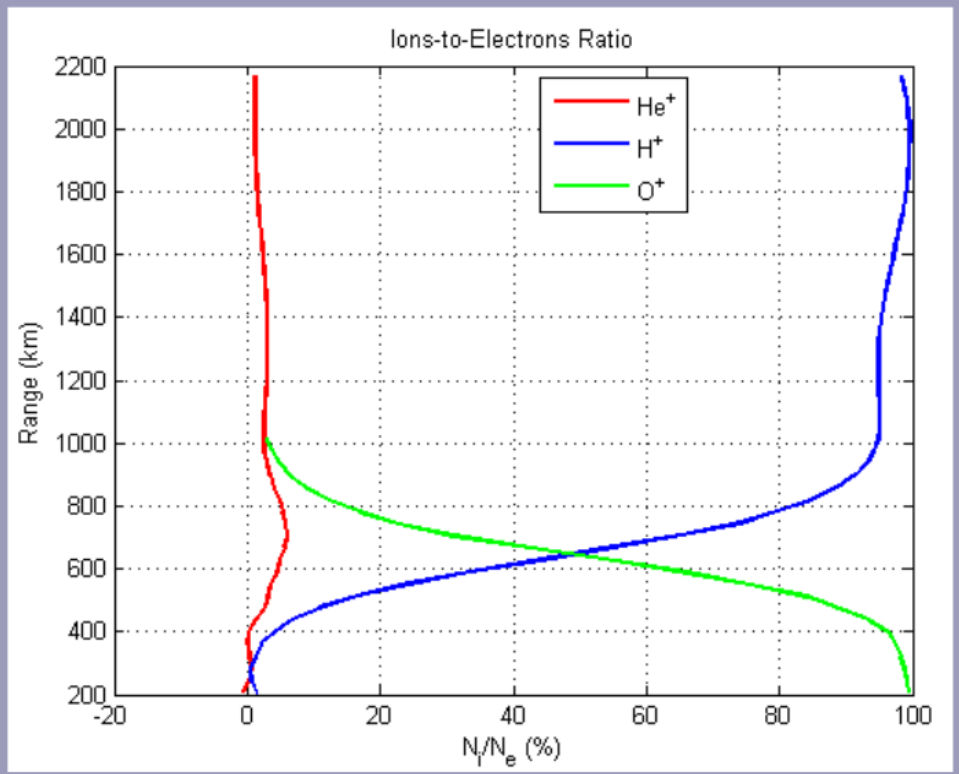
Results

Diffusive Equilibrium with Ion Layers

IRI Model

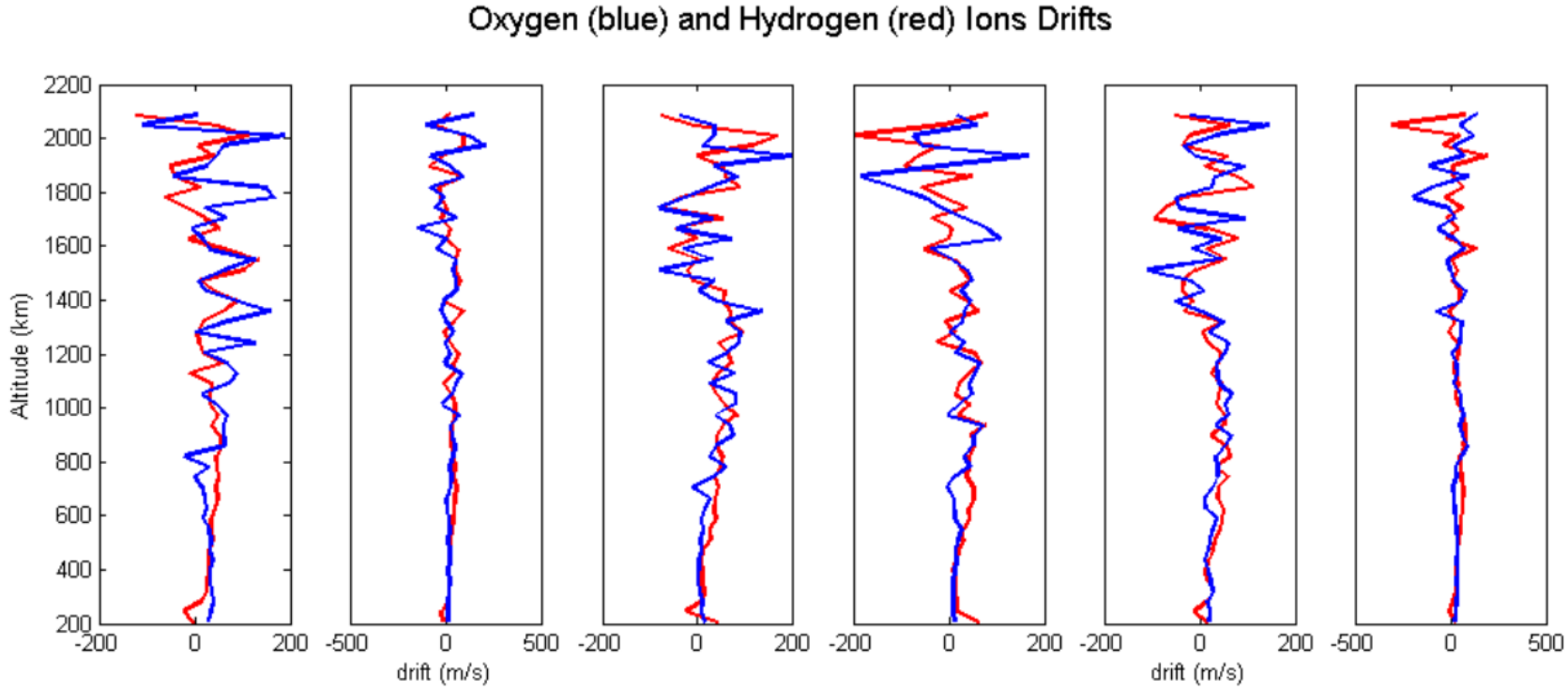


Arecibo Data



Results

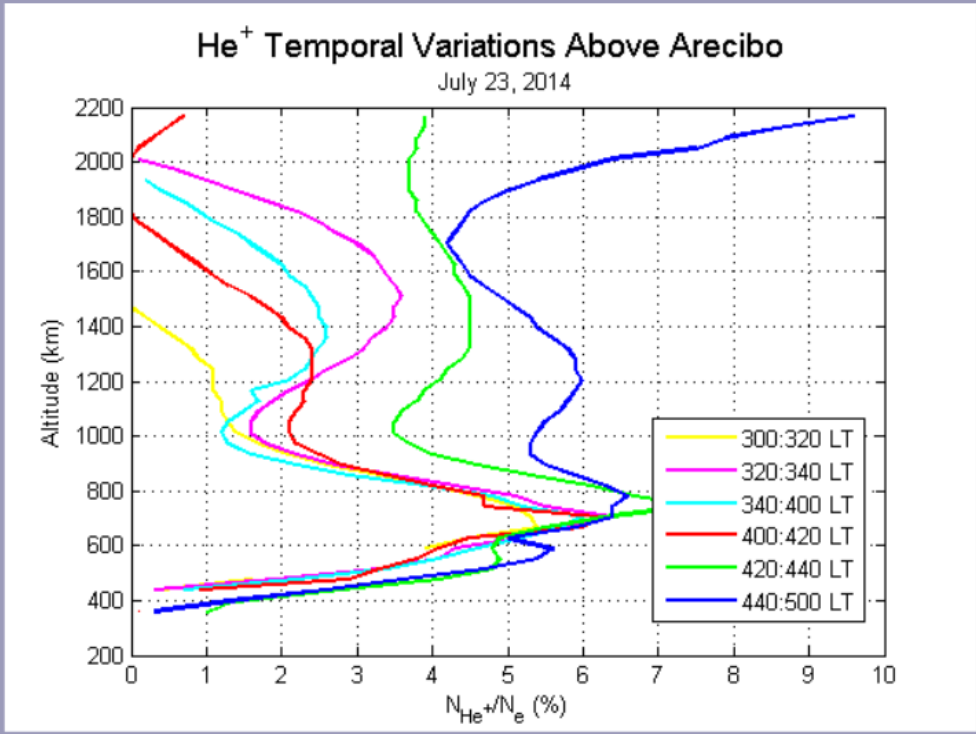
Ion Drifts



O+ and H+ ions drift together

Results

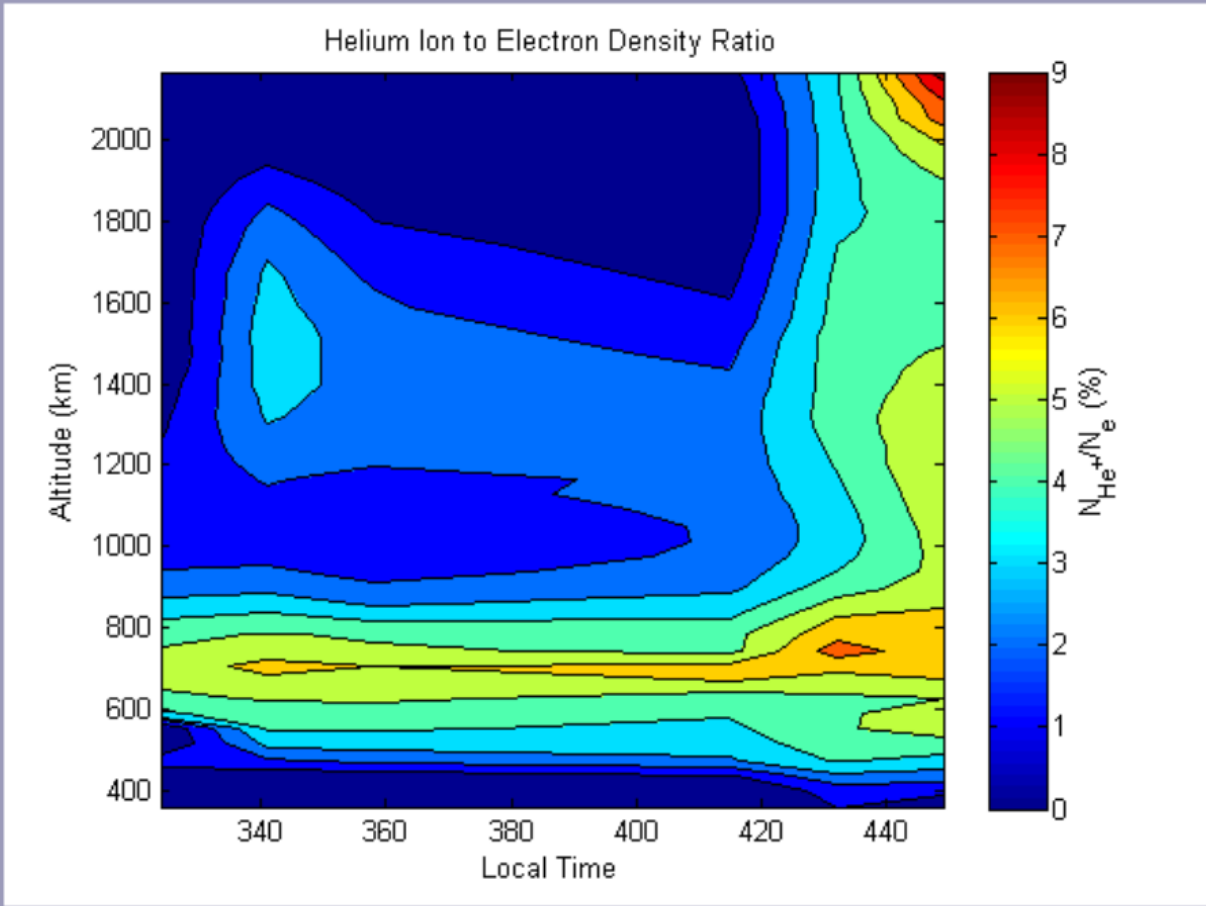
He+ Temporal Variation



- At low altitudes, there is little variation in the density of Helium ions over the observation time slots.
- Above 800 km, there is more variability of the Helium ions density over the observational time slots.
- There is a steep increase of Helium ions density over the last time slot of the observations above 1800 km.

Results

He+ Density Fraction (%)



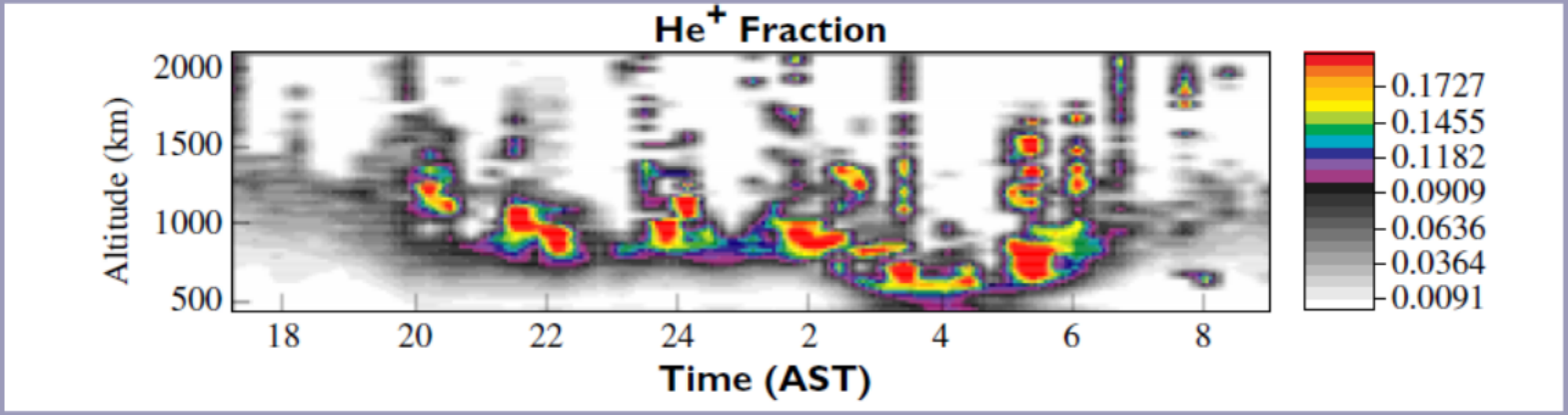
- He ions layer of 6% relative to the ionosphere background is found between 600 - 800 km.
- There is enhancement in the density of Helium ions after 4:30 AM.
- There is another blob of Helium ions between 1300 - 1700 km at 3:40 AM.
- These enhancement does not seem physical and we suspect they come from errors in the measurements or the data fitting technique.

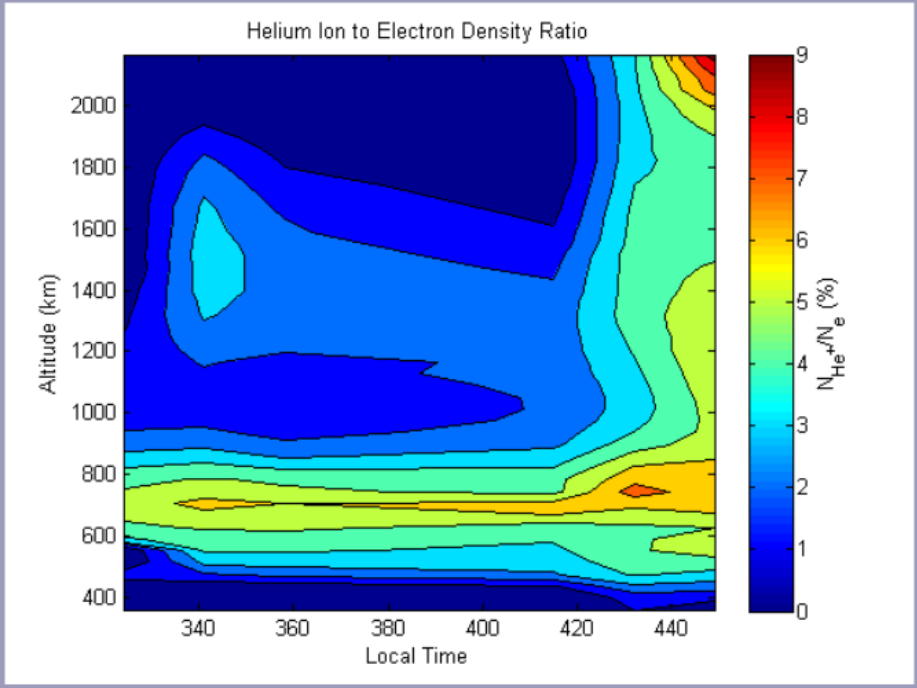
Results

Helium Ions Density

Solar Maximum vs. Solar Minimum

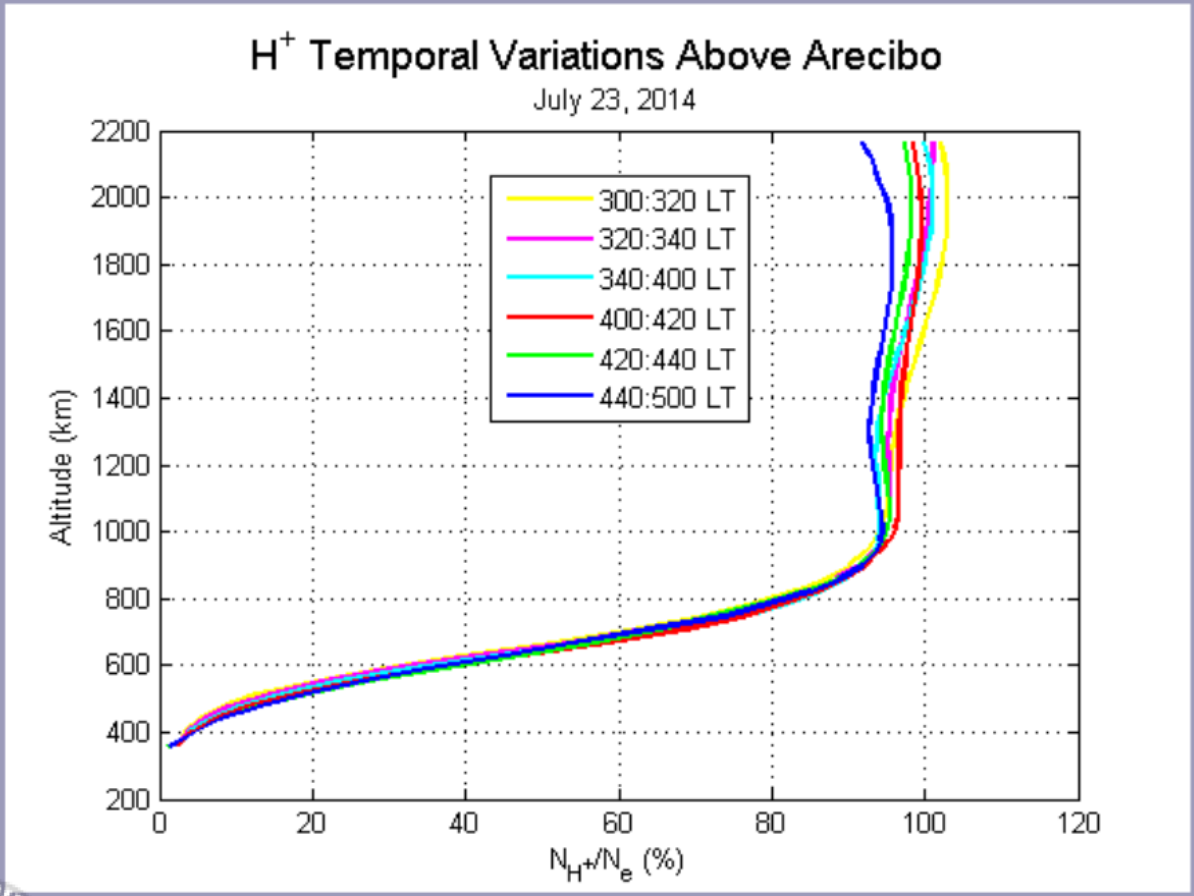
1994 winter data





Results

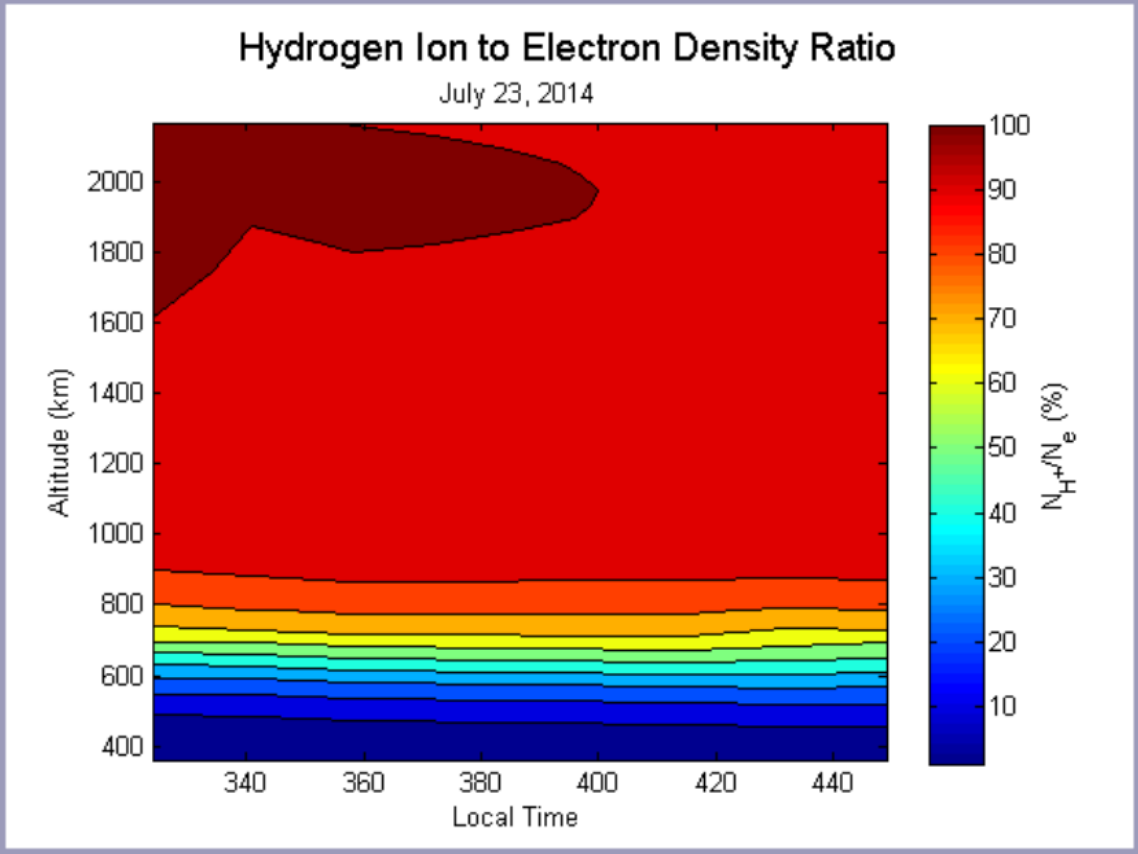
H+ Ion Fraction (%)



- The Hydrogen ions density shows almost no temporal variations up to 1000 km altitude.
- Above 1000 km, there is small temporal variations of the density.

Results

H+ Density Fraction (%)



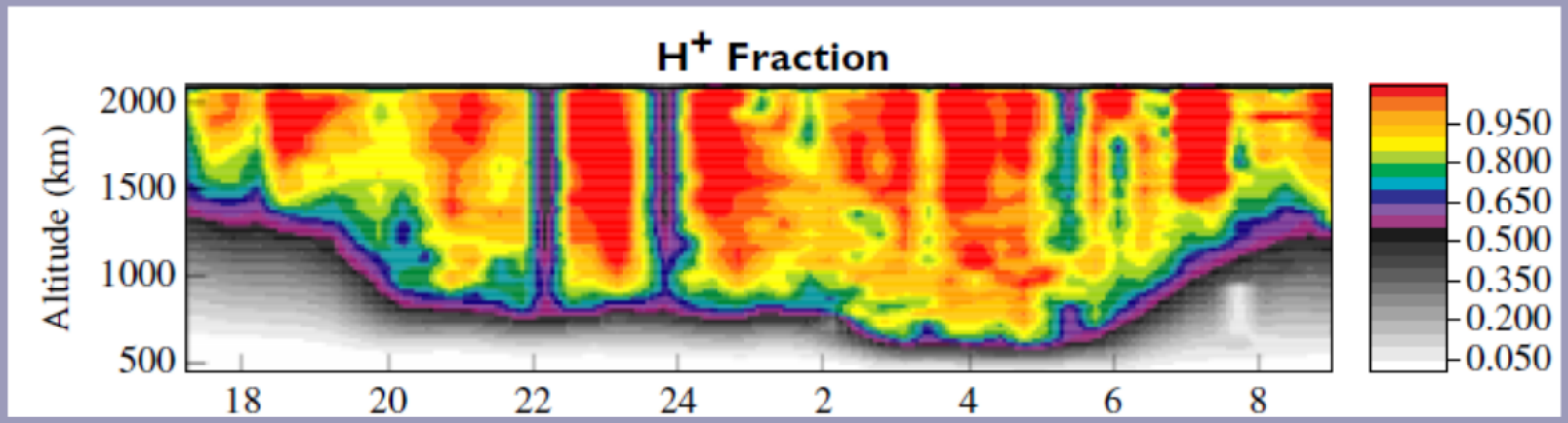
- **The Hydrogen ions dominate the ionosphere compositions above 1600 km in altitude.**

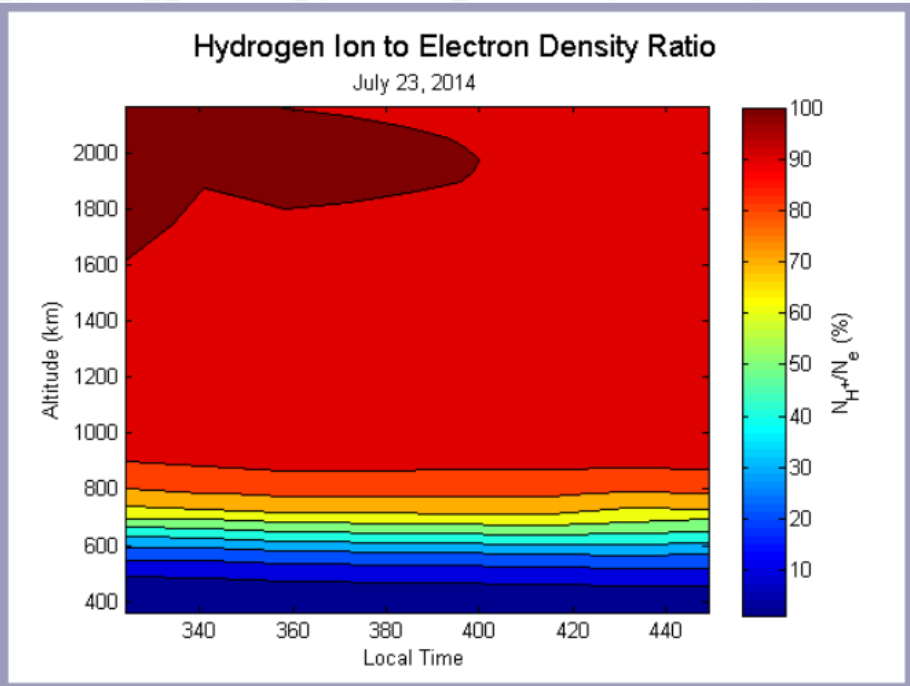
Results

Hydrogen Ions Density

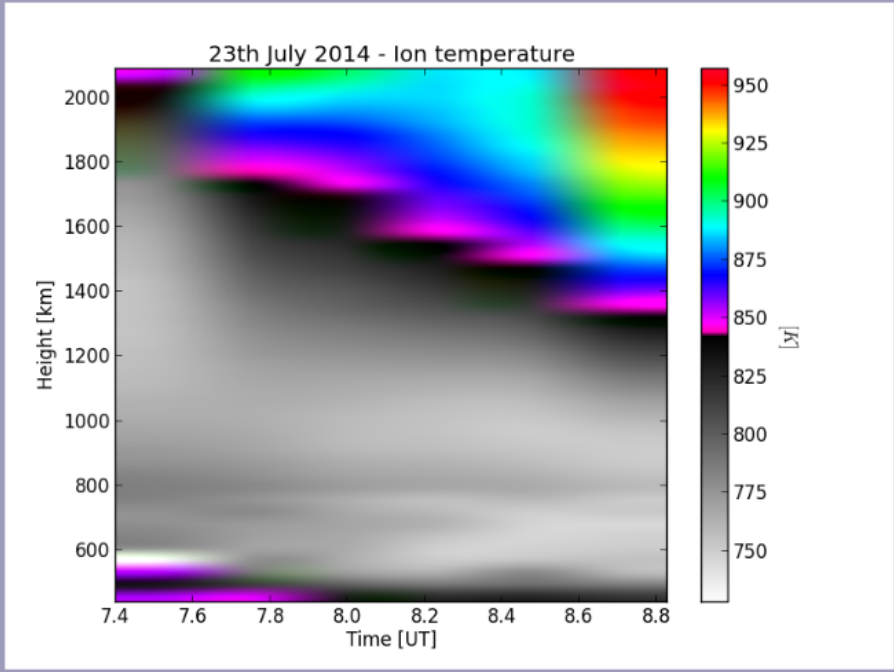
Solar Maximum vs. Solar Minimum

1994 winter data

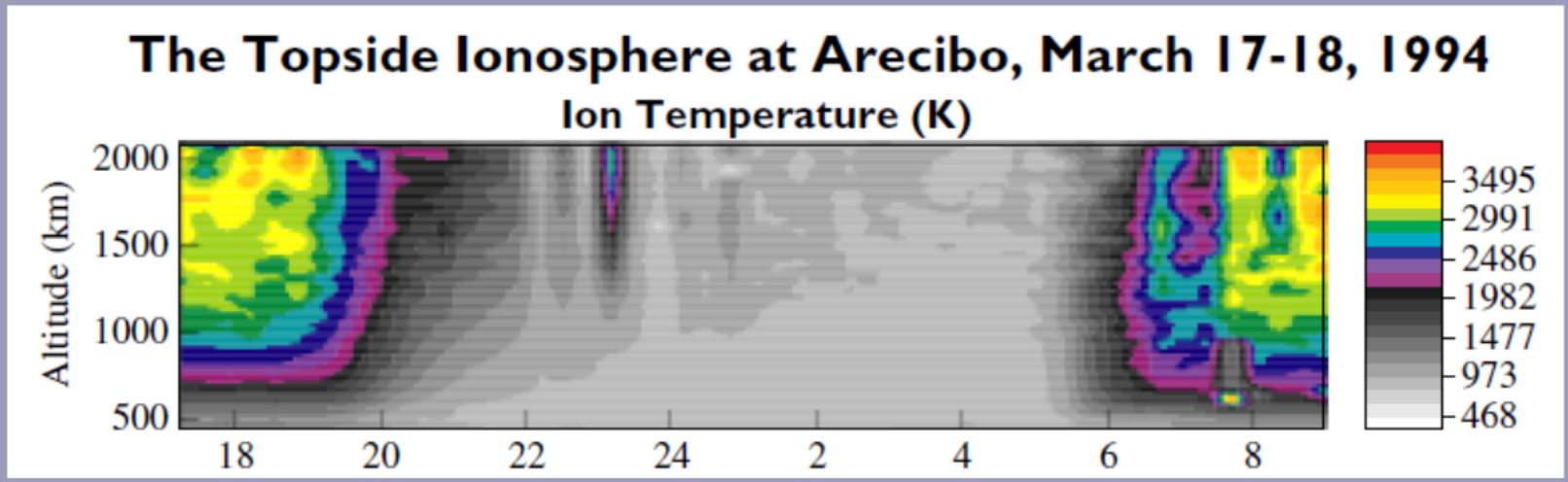




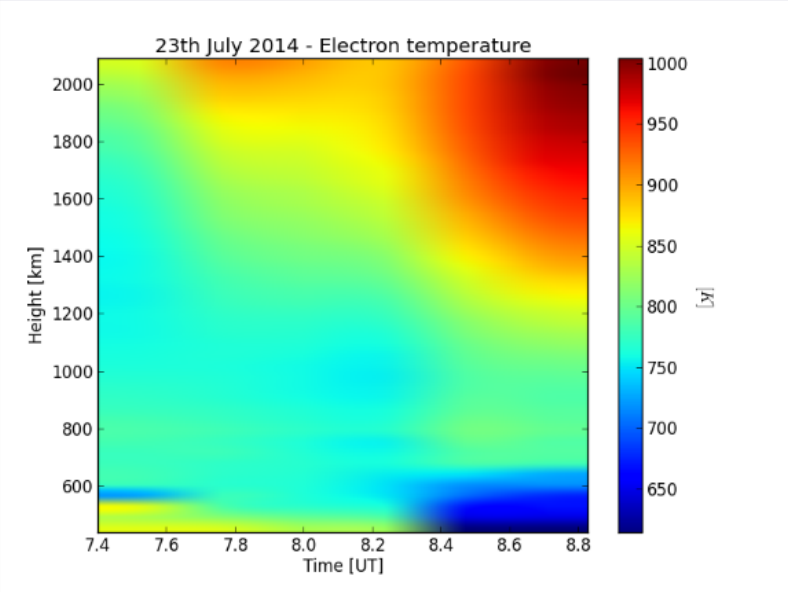
Results

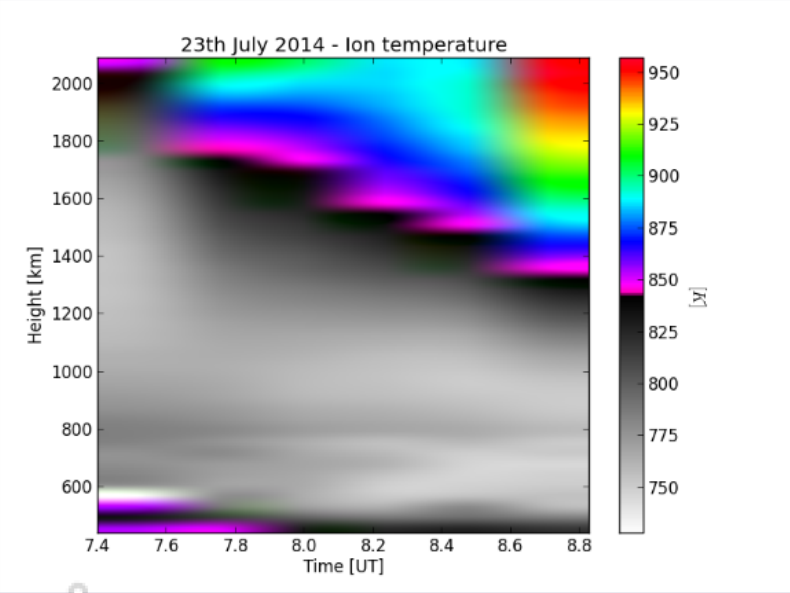


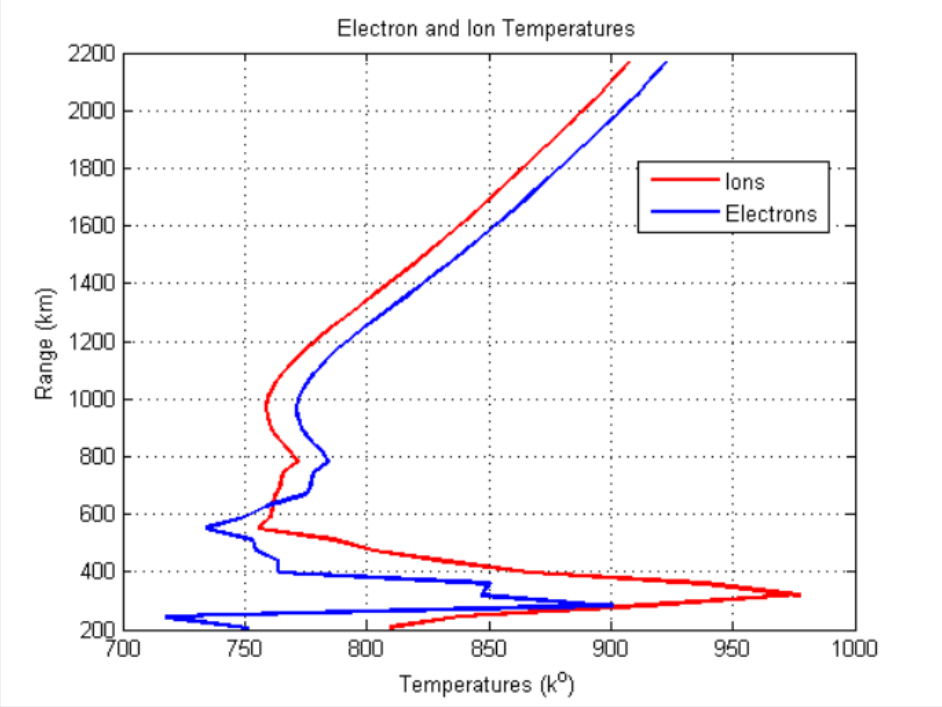
Ion Temperature, Ti



Results







Conclusions:

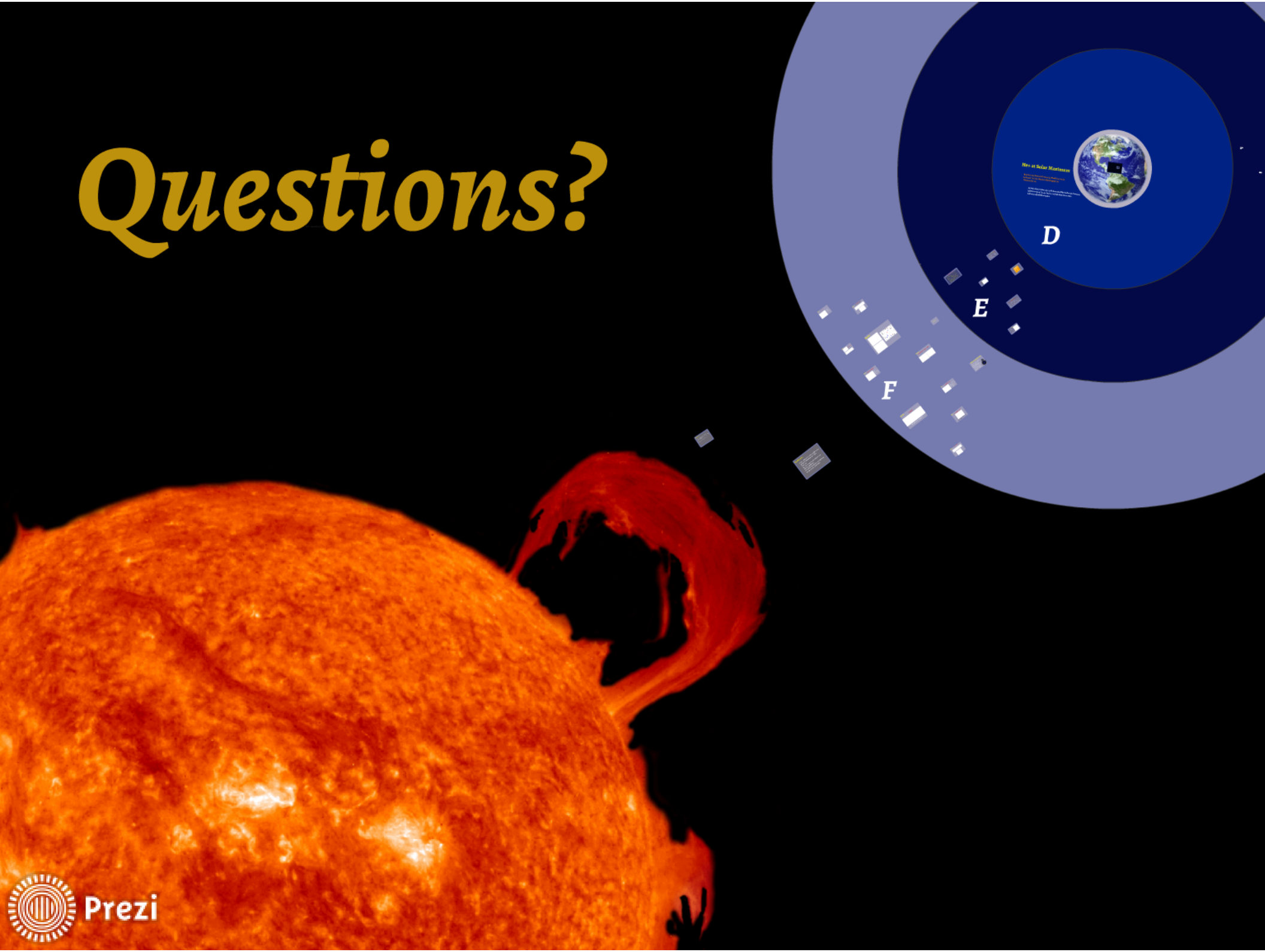
- Solar conditions were more similar to Solar Minimum although we are in Solar Maximum
- The three ion species were shown to be in diffusive equilibrium
- A 6% Helium density layer was detected in the experiment around 700 km

References

[1] Gonzales,S., Sulzer, M. Detection of He+ layering in the topside ionosphere over Arecibo during equinox solar minimum conditions, Geophysical Research Letters, Volume 23, Issue 18, 2509-2512, 1996.http://onlinelibrary.wiley.com/doi/10.1029/96GL02212/references

[2]Bauer, S. J. Diffusive Equilibrium in the Topside Ionosphere, Proceedings of the IEEE, Vol. 57, No. 6, 1114-1118, 1969

Questions?



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