Field-aligned irregularities generated in and around the auroral oval

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Background and Motivation

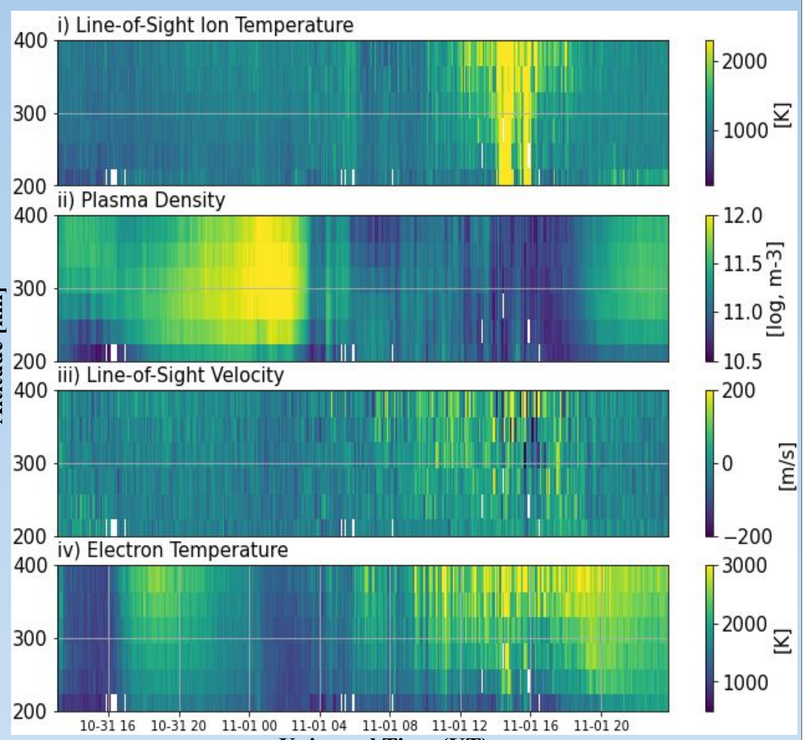
- High-latitude F-region ionospheric plasma density structures are generated by photoionization and precipitation, then modulated by instabilities, and coupling from above (solar and geomagnetic activity) and below (gravity waves, diurnal tides).
- Plasma density in the auroral oval is highly variable, and understated by parameters like NmF2.
- **Here, we present quantified F-region plasma density variability with respect to solar and geomagnetic activity.**

Dataset and Methodology

- This study utilizes field-aligned Poker Flat Incoherent Scatter Radar (PFISR) measurements between 200 and 400 km from years near solar maximum with large amounts of data, namely: 2010, 2011, 2015, 2016.
- 2011 and 2015 have enhanced solar activity, while 2010 and 2016 are quiet years.

Fig. 1: PFISR (Photo Credit: Craig Heinselman)

Fig. 2: Example PFISR field-aligned plasma parameters from 10-31-2011 to 11-1-2011 (Elevation: 77.5°, Azimuth: -154.3°)



- Solar (F10.7) and geomagnetic (Kp & SML) indices are obtained from OMNIweb and SuperMAG.
- Seasonal and Magnetic Local Time (MLT) variations are organized using box plots and linear regression correlations.

References

1. Lei, J., Liu, L., Wan, W., & Zhang, S. R. (2005). Variations of electron density based on long-term incoherent scatter radar and ionosonde measurements over Millstone Hill. *Radio science*, *40*(2), 1-10.
2. Moen, J., Qiu, X. C., Carlson, H. C., Fujii, R., & McCrea, I. W. (2008, August). On the diurnal variability in F2-region plasma density above the EISCAT Svalbard radar. In *Annales geophysicae* (Vol. 26, No. 8, pp. 2427-2433). Copernicus GmbH.

Results

Fig. 3: (top) Median plasma density between 200-400 km for 2011 (left) and 2015 (right). Dashed lines indicate solstices and equinoxes. (bottom) F10.7 for 2011 (left) and 2015 (right).

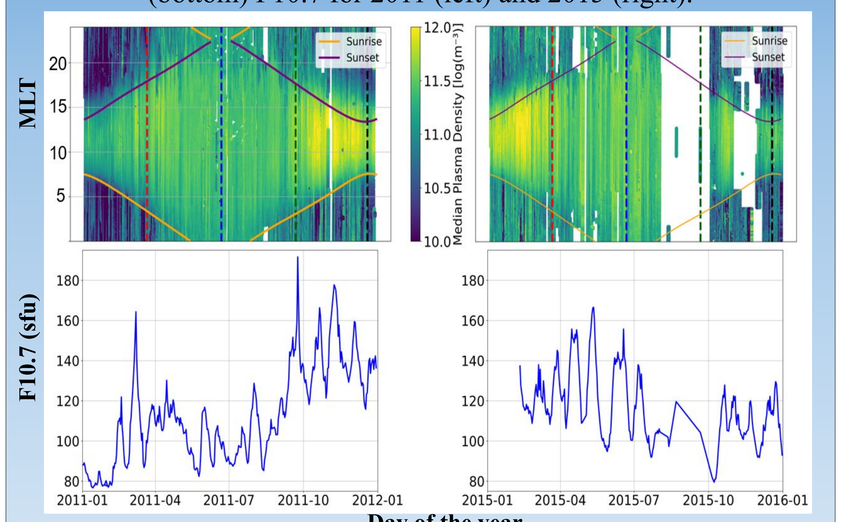
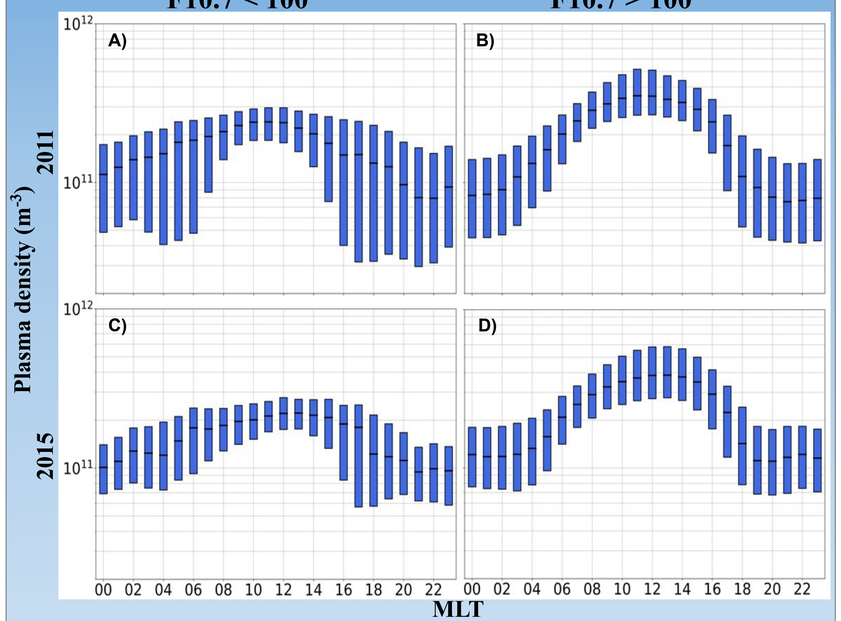
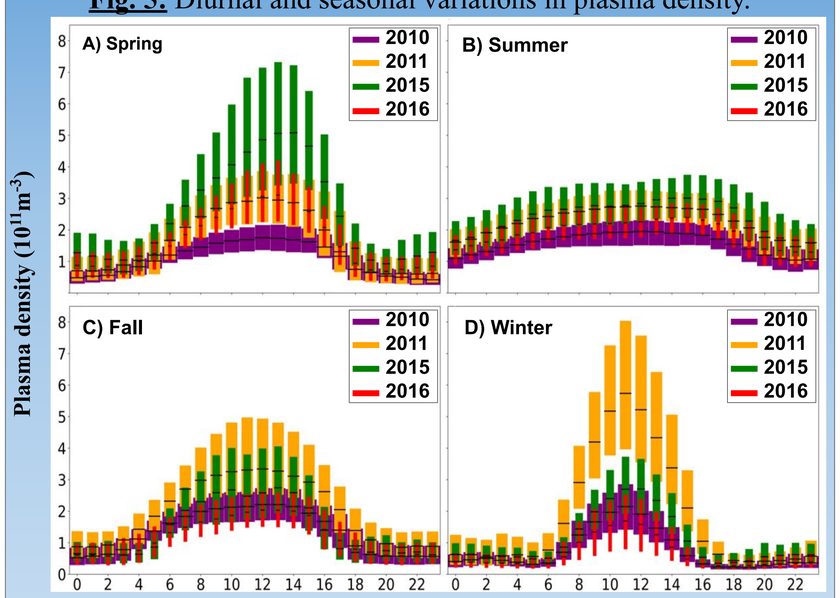


Fig. 4: Box plots for plasma density during low (left) and high (right) solar flux conditions, during 2011 (top) and 2015 (bottom).



- The Interquartile Range (IQR) is smallest around noon.
- The IQR is largest at near dawn and dusk due to a drop in first quartile, particularly during low solar flux conditions.

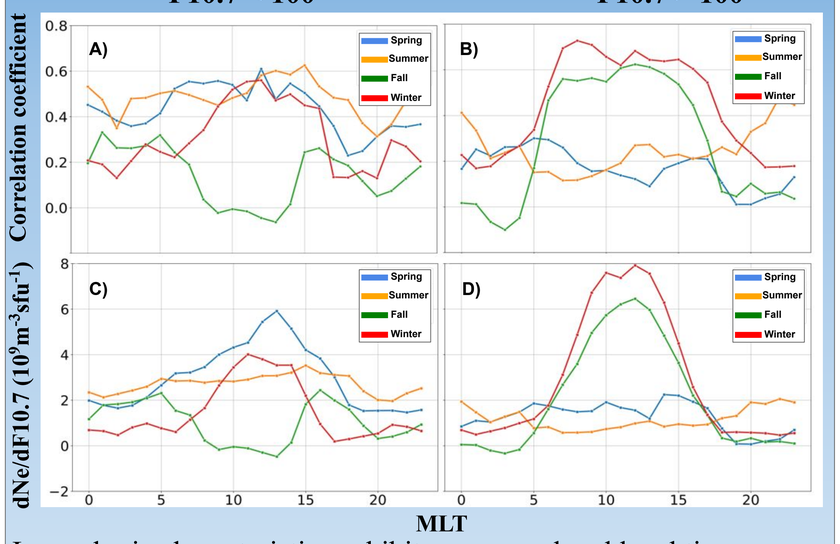
Fig. 5: Diurnal and seasonal variations in plasma density.



- The lowest plasma density variability is during summer.
- The enhanced density on 2011 winter and 2015 spring can be attributed to high solar activity.

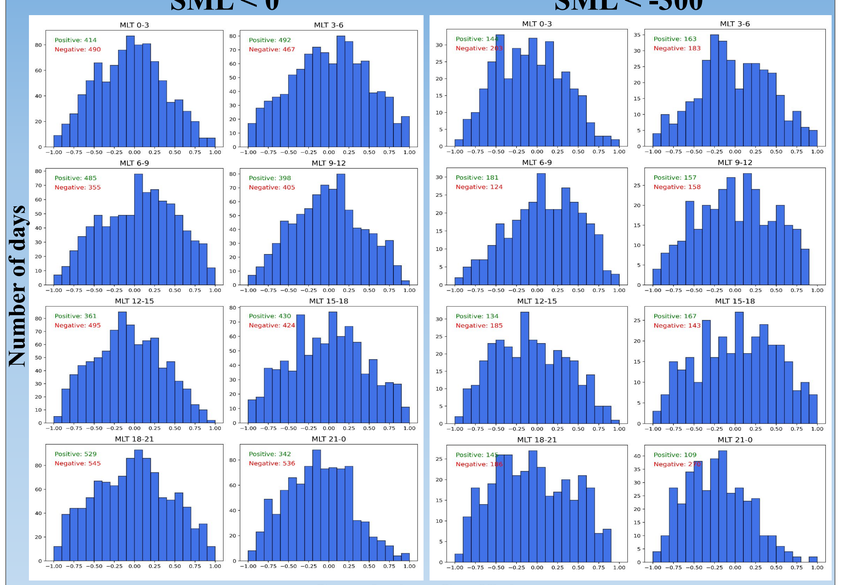
Results (Continued)

Fig. 6: Seasonal correlation of median density (Ne) with F10.7 (top), rate of change of Ne with respect to F10.7 (bottom)



Ionospheric characteristics exhibits a seasonal and local time variation similar to that seen at mid-latitude [1].

Fig. 7: Correlations between Ne and SML for 3 hour intervals of combined years



- Noon and midnight have heightened negative correlations.
- Increase in plasma density with drop in SML suggests possible cross polar transport of solar Extreme Ultraviolet (EUV) ionized plasma during strong geomagnetic activity [2].

Conclusions

- The rate of enhancements of plasma density due to solar flux appears to be in good terms with the correlation coefficient.
- F-region plasma in auroral oval are most affected by geomagnetic activity around noon and midnight.

Future works

- Investigating the correlation between plasma density and F10.7 at active (Kp>3) and quiet (Kp<3) geomagnetic conditions.
- Observing Interplanetary magnetic field (IMF) components to study the inflow and outflow conditions.

Acknowledgements

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