Hemispheric Asymmetry in the Mars Summer Ionosphere

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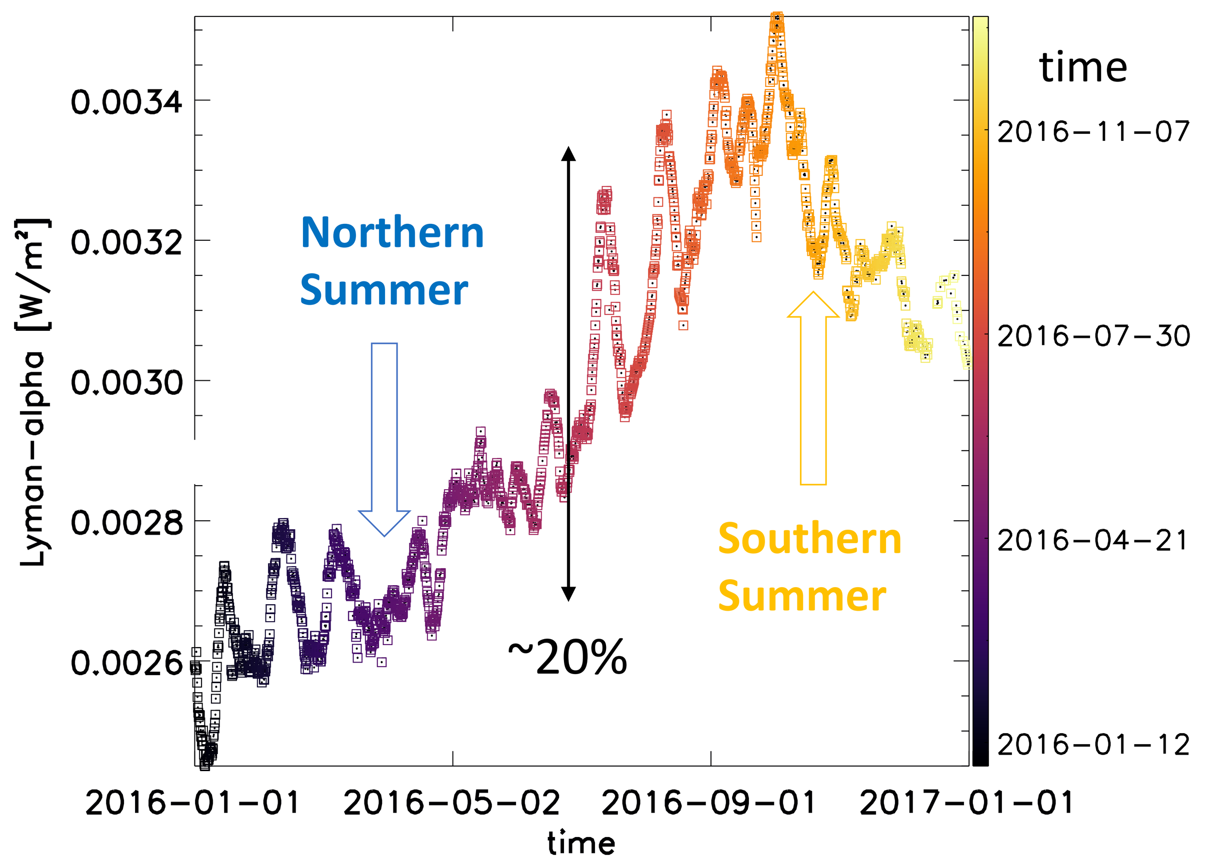
Introduction

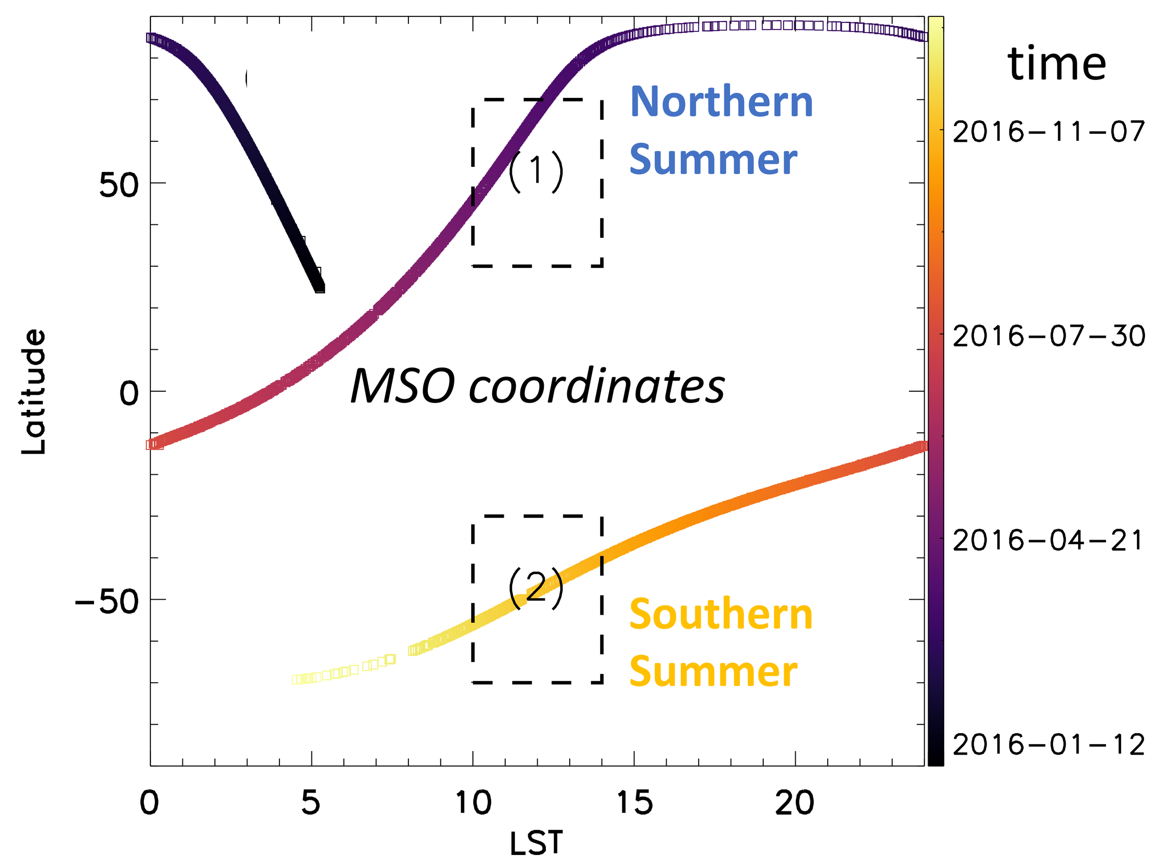
The MAVEN satellite has now made two Martian-years of ionosphere-thermosphere (I-T) observations enabling limited studies of seasonal changes in the upper atmosphere. Previous studies have revealed the morning electron temperature overshoot as well as a close dependence between electron temperatures and neutral densities in the equatorial regions. We examine the I-T in the polar regions. Specifically, we will discuss how and why the northern and southern summer polar ionospheres differ. Differences between the equatorial and polar regions are expected due to (A) differences in neutral circulation and neutral atmosphere scale heights, (B) differences in equatorial and polar gravity due to planet oblateness, and (C) the equilibration of I-T coupling due to constant solar illumination of the summer poles, which suppresses the electron temperature overshoot.

MAVEN data reveals significant differences in the north and south polar regions. Differences between the North and South summer poles could result from several factors. The first is that variations in the Mars-Sun distance result significantly lower EUV forcing at aphelion (northern summer) than at perihelion (southern summer). Second, acceleration of ionospheric particles due to the straightening of draped magnetic field lines as they pass over the poles should be different in north and south. As the draped field lines are dragged from the equatorial ionosphere to the polar region, they interact with crustal magnetic fields, which are located predominately in the south. The result of this is that draped magnetic fields can penetrate to lower altitudes in the northern hemisphere thus changing the altitude at which ions become demagnetized. In this study, we present these results in the form of a statistical analysis of MAVEN measurements comparing the north and south summer polar I-T.

MAVEN Data

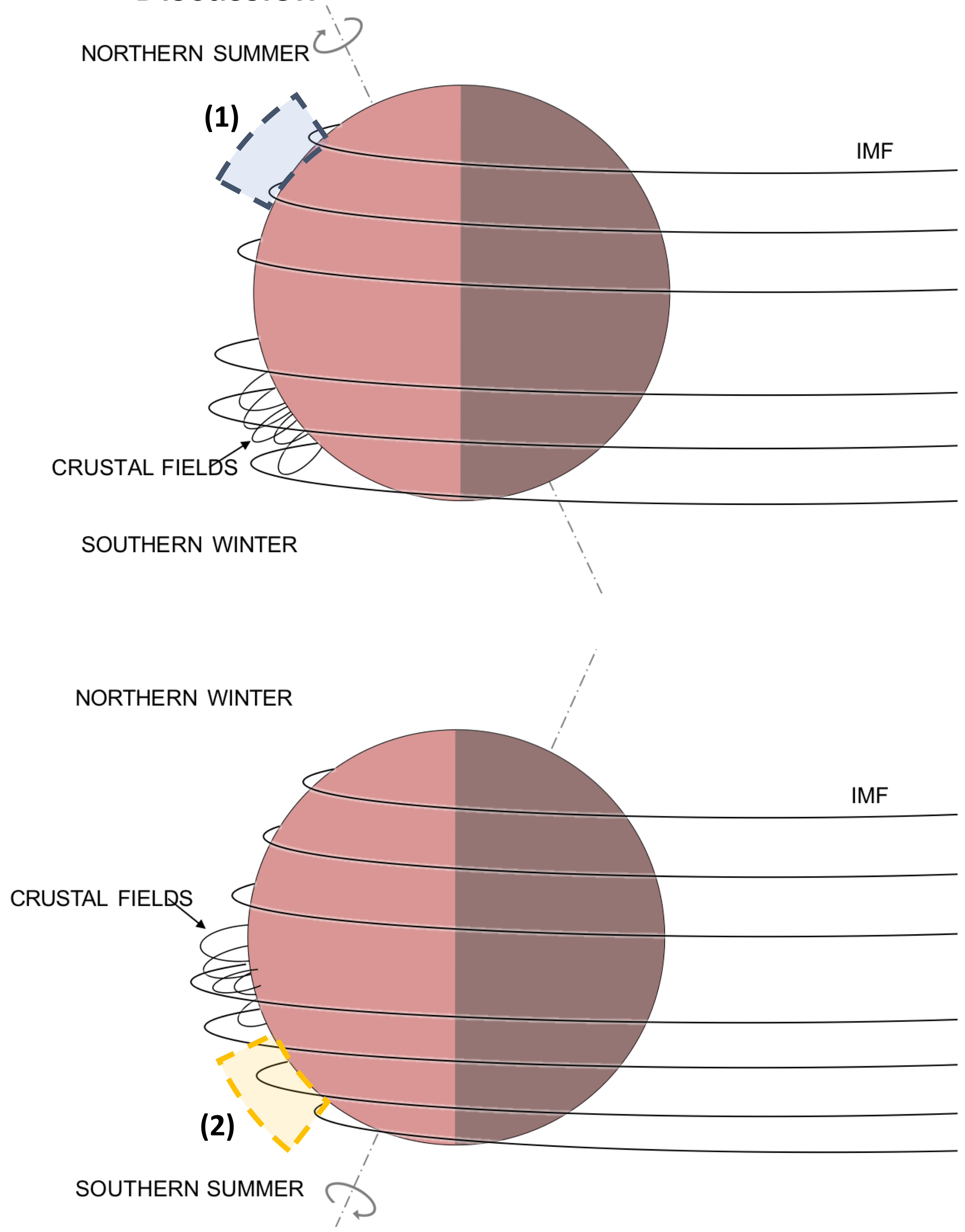
- Neutral Gas and Ion Mass Spectrometer (NGIMS) (descending/ascending) number densities [Mahaffy et al. 2014].
- Extreme Ultra-Violet (EUV) Lyman-α measured by MAVEN EUV Monitor [Eparvier et al. 2015]
- Langmuir Probe & Waves (LPW) N_e[Andersson et al., 2015]



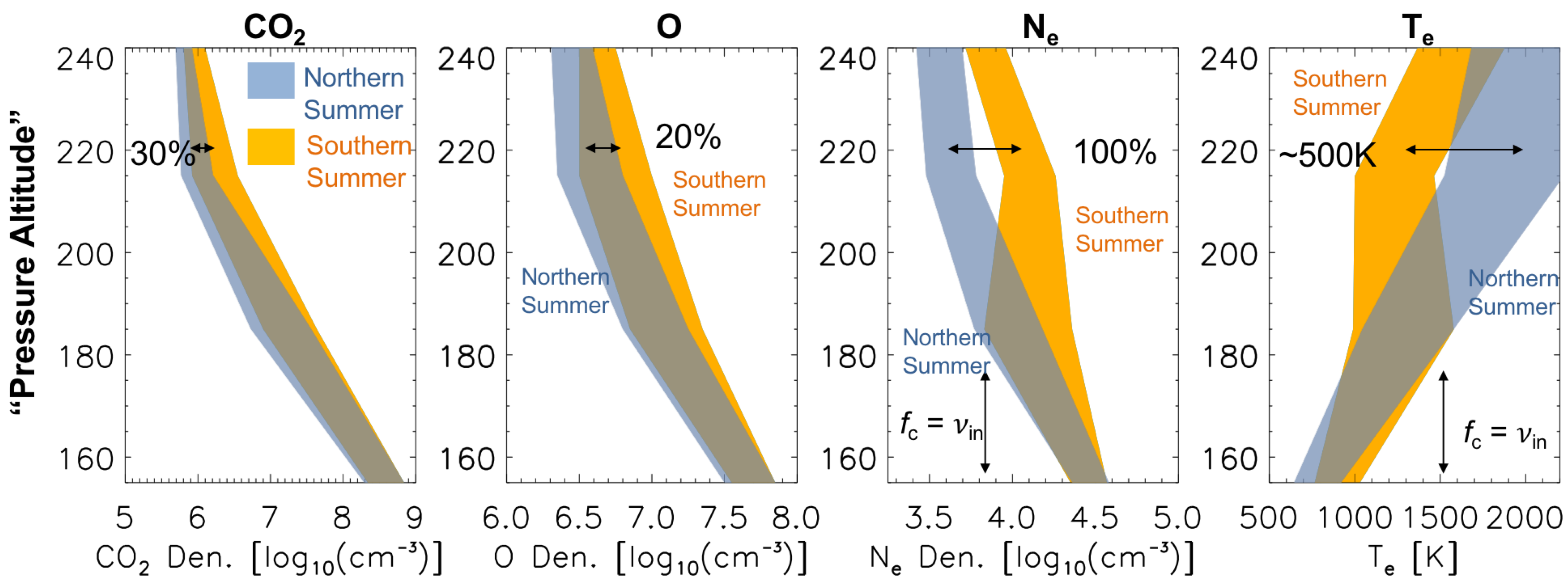


- Seasonal and latitudinal differences are expected in general due to differences in
  - Sun-Mars distance
  - global neutral circulation
  - the equilibration of I-T coupling due to constant solar illumination of the summer poles (length of day)
  - gravity as a function of latitude
- Comparing summer hemispheres allows us to control for amount of time I-T has been exposed to sunlight in each case
- Differences in North and South Summer Polar I-T might result from
  - acceleration of ionospheric particles due to the straightening of draped magnetic field lines as they pass over the poles
  - Draped field lines are dragged from the equatorial ionosphere to the polar region, interacting with crustal magnetic fields
  - Draped magnetic fields can penetrate to lower altitudes in the northern hemisphere
- When comparing northern and southern summer, the neutral pressure must be controlled for to compensate for seasonal differences in the background thermosphere

Discussion



Results



- Neutral profiles are similar
- To be expected; the data is presented as a function of neutral pressure, changes result from increase in temperature and 20% increase in EUV forcing

- Northern and Southern Summer N_e are similar at high pressures (low altitudes)
- Northern summer N_e is lower at lower pressures
- Northern summer T_e is higher

Conclusions

- There is a significant difference in the altitude profiles of plasma between Northern and Southern summer hemispheres when neutral pressures are controlled for
- Data indicates the potential for significant loss process associated with acceleration of ionospheric particles by the draped magnetic fields at altitude where ions are not demagnetized
- This loss process seems to be diminished in the southern hemisphere due to the presence of crustal magnetic fields