Ionospheric Plasma Depletions at Mars as Observed by MAVEN

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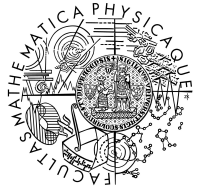
EGU General Assembly 2022, Vienna, Austria
May 23–27, 2022



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Plasma Depletion Events (PDEs)

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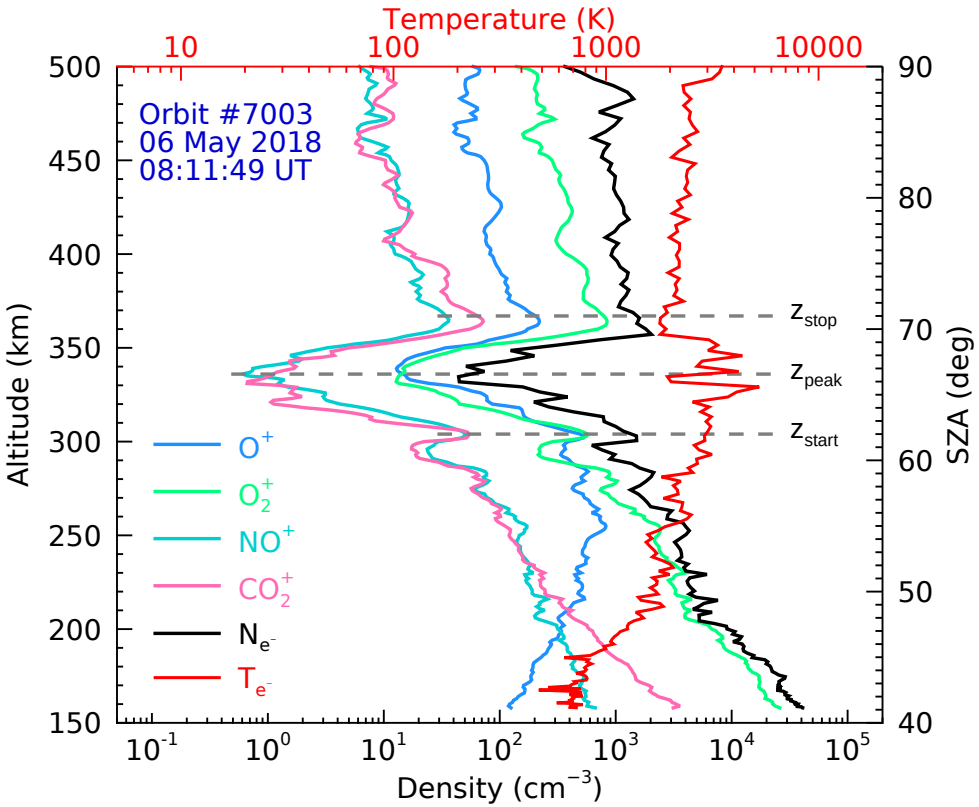
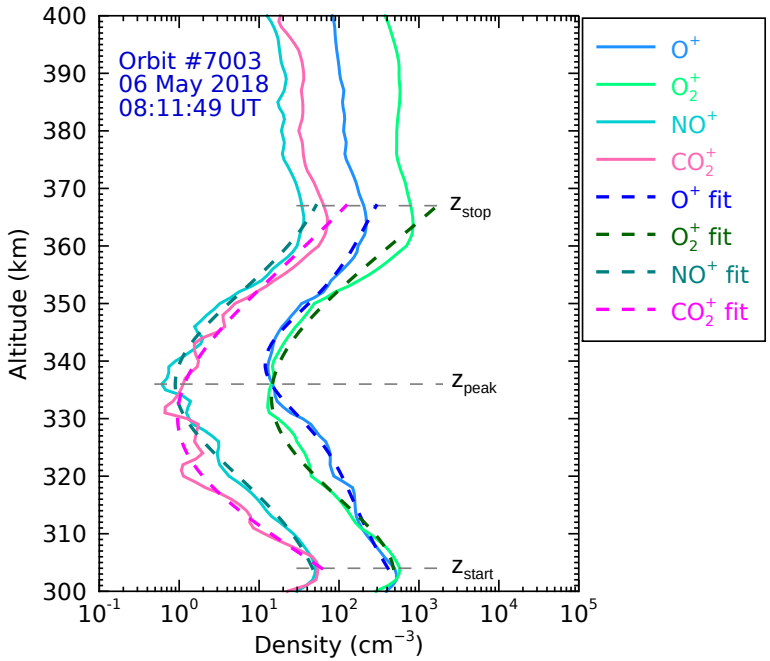


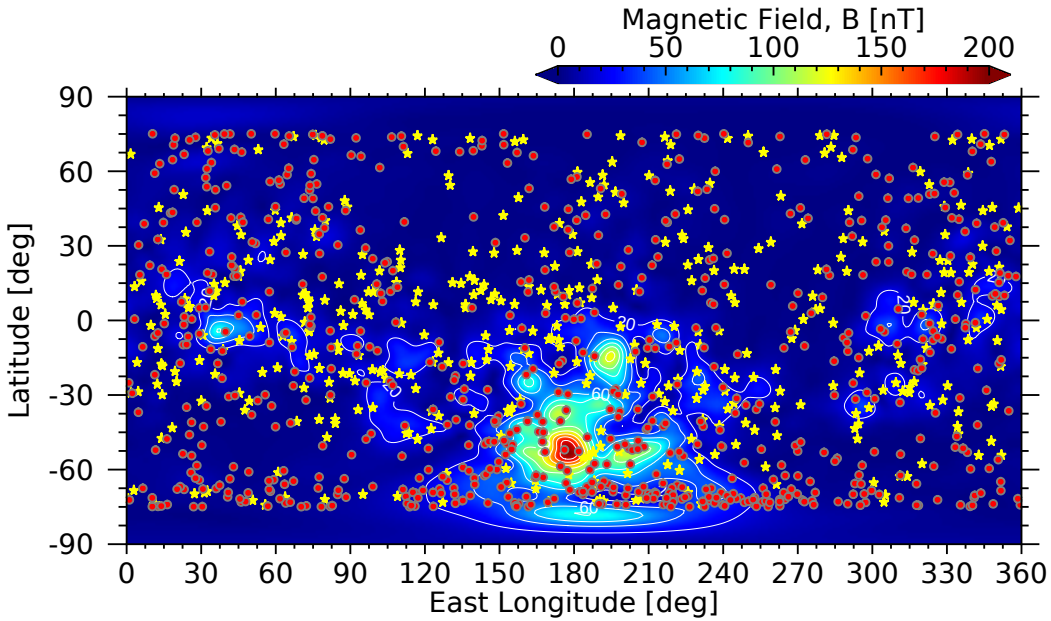


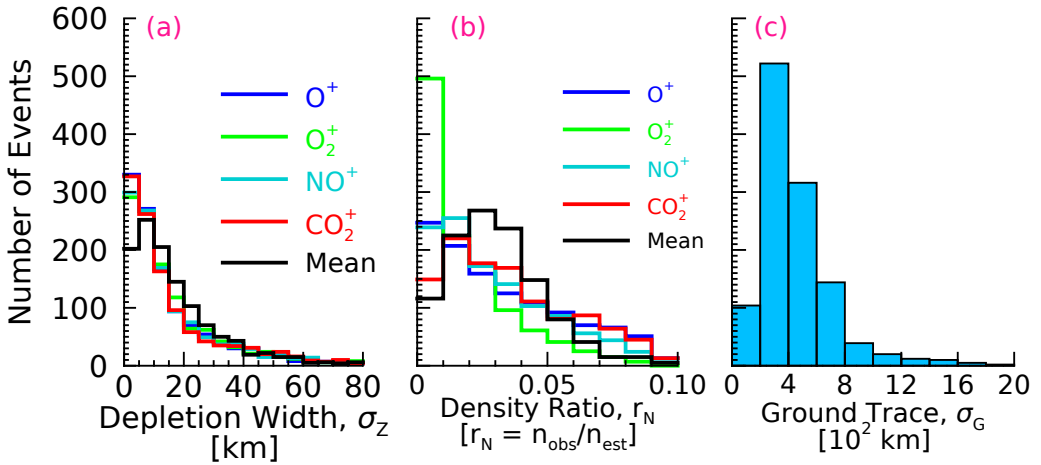
1. NGIMS → O^+, O_2^+, CO_2^+, NO^+
2. LPW → N_{e-} and T_{e-}
3. Depleted Region → z_{start} to z_{stop}
4. Peak Depletion Altitude → z_{peak}
5. Event Identification Criteria

$$\frac{1}{2N}\sum_{i=1}^{N}\left[\frac{n_i(z_{peak})}{n_i(z_{start})}+\frac{n_i(z_{peak})}{n_i(z_{stop})}\right]\leqslant 0.1$$

6. 1060 out of 8618 Orbits → **1177 PDEs**

Location and Sizes





7. Number of Events (Total= **1177** PDEs)

	Day	Night	Total
NH	205	275	480
SH	224	473	697

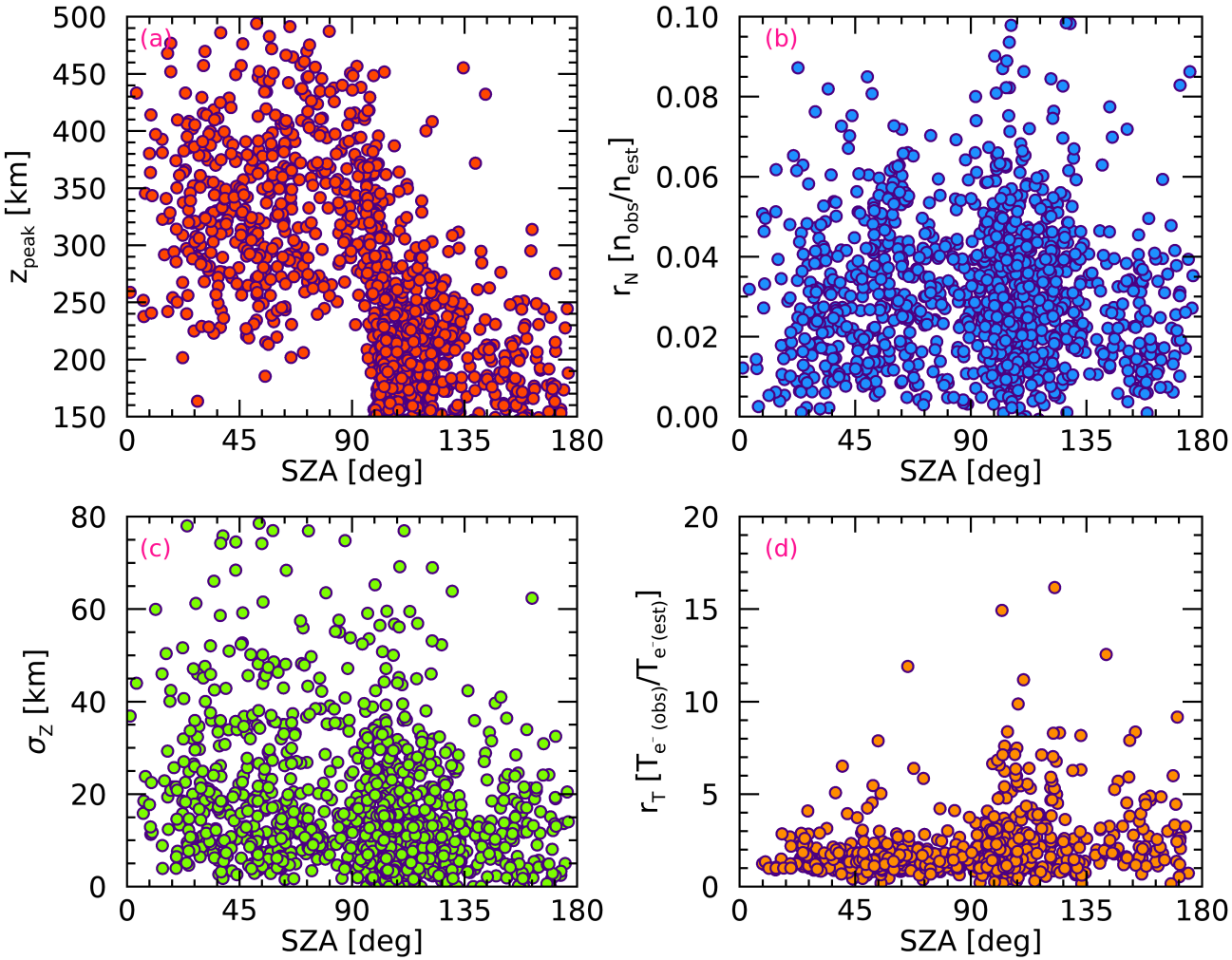
$\left\{ \begin{array}{l} NH \rightarrow Northern\ Hemisphere \\ SH \rightarrow Southern\ Hemisphere \end{array} \right\}$

8. Normalized Occurrence Rates (#events/hour)

	Day	Night
NH	0.31	0.52
SH	0.26	0.91

9. depletion width $<$ 20 km [69% PDEs]
10. most depleted $\rightarrow$ O_2^+ [abundance!]
11. $\sigma_G > \sigma_Z$ [horizontal]

Dependence on Solar Zenith Angle



a. Peak Depletion Altitude
   ↳ $>$ 250 km (Day)
   ↳ $<$ 250 km (Night)

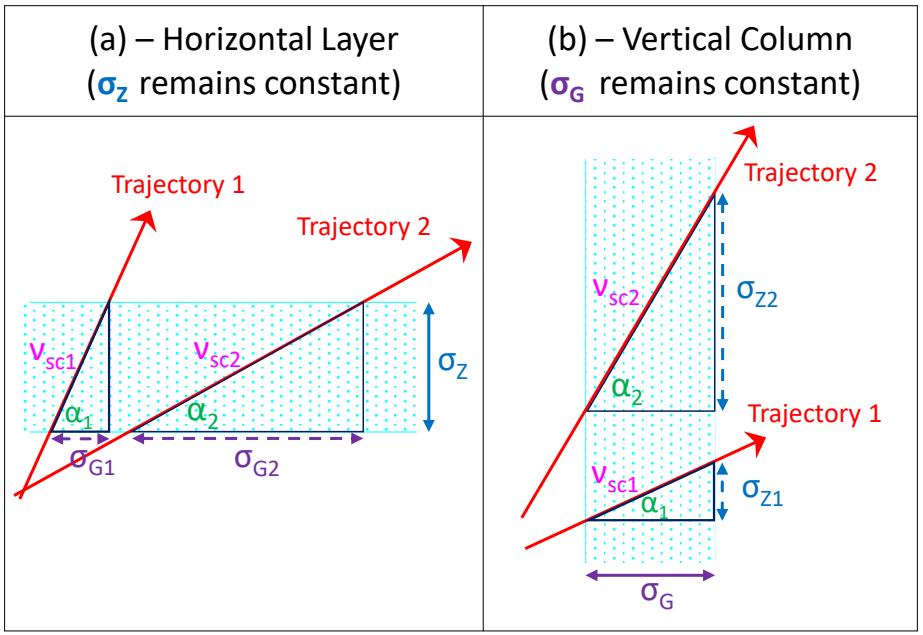
b. Density Ratio
   ↳ independent on SZA

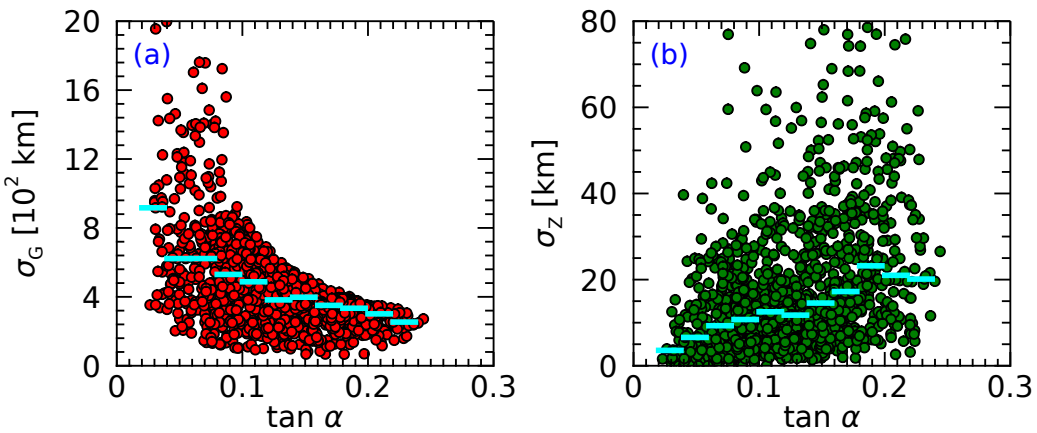
c. Depletion Width
   ↳ independent on SZA

d. Electron Temperature Ratio
   ↳ 66% PDEs remains between 1 and 2 (Day)
   ↳ 46% PDEs are larger than 2 (Night)

12. nighttime → SZA $> 105^\circ$ (Lillis et al., 2009; Dubinin et al., 2016)
13. more PDEs detected near the terminators

Spacecraft Trajectory → Shape of PDEs





14. orbit inclination angle α,

$$\tan\alpha = \frac{\vec{v}_{(radial)}}{\vec{v}_{(horizontal)}}$$

15. for a horizontal layer

$$\sigma_G \propto \frac{1}{\tan\alpha} \quad [\sigma_Z = const.]$$

16. for a vertical column

$$\sigma_Z \propto \tan\alpha \quad [\sigma_G = const.]$$

17. PDEs are limited in both directions but more vertically [more probable for a horizontal layer]

Discussion and Summary

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Previous Studies

18. ionospheric holes in Venusian ionosphere
    ↳ Brace et al. (1980,1982)
19. suprathermal electron depletions in the ionosphere and magnetosphere of Mars
    ↳ Mitchell et al. (2001); Hall et al. (2016); Steckiewicz et al. (2017)
20. ionospheric thermal electron depletions
    ↳ Duru et al. (2011)
21. sudden increase/decrease in thermal electron densities
    ↳ Withers et al. (2012)
22. formation of sporadic E-like layers and rifts in the Martian dynamo region due to neutral wind induced $(\vec{E} \times \vec{B})$ drift
    ↳ Collinson et al. (2020)

Characteristics of PDEs

- >90% reduction in plasma densities
- accompanied by increased T_e–
- structure extends more horizontally
- almost absent in daytime photochemically dominant region (<250 km)
- abundant in the nighttime southern hemisphere → links to crustal magnetism
- often detected near terminators
- multiple PDEs identified on same orbits
- analogous to Earth's plasma bubbles

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Manuscript Under Review in JGR: Planets

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Thank You...♡