Atmospheric loss from Earth's plasma mantle and its dependence on solar wind conditions

Audrey Schillings,

R. Slapak, H. Nilsson, M. Persson, R.Ramstad, Y.Futaana

audrey.schillings@irf.se

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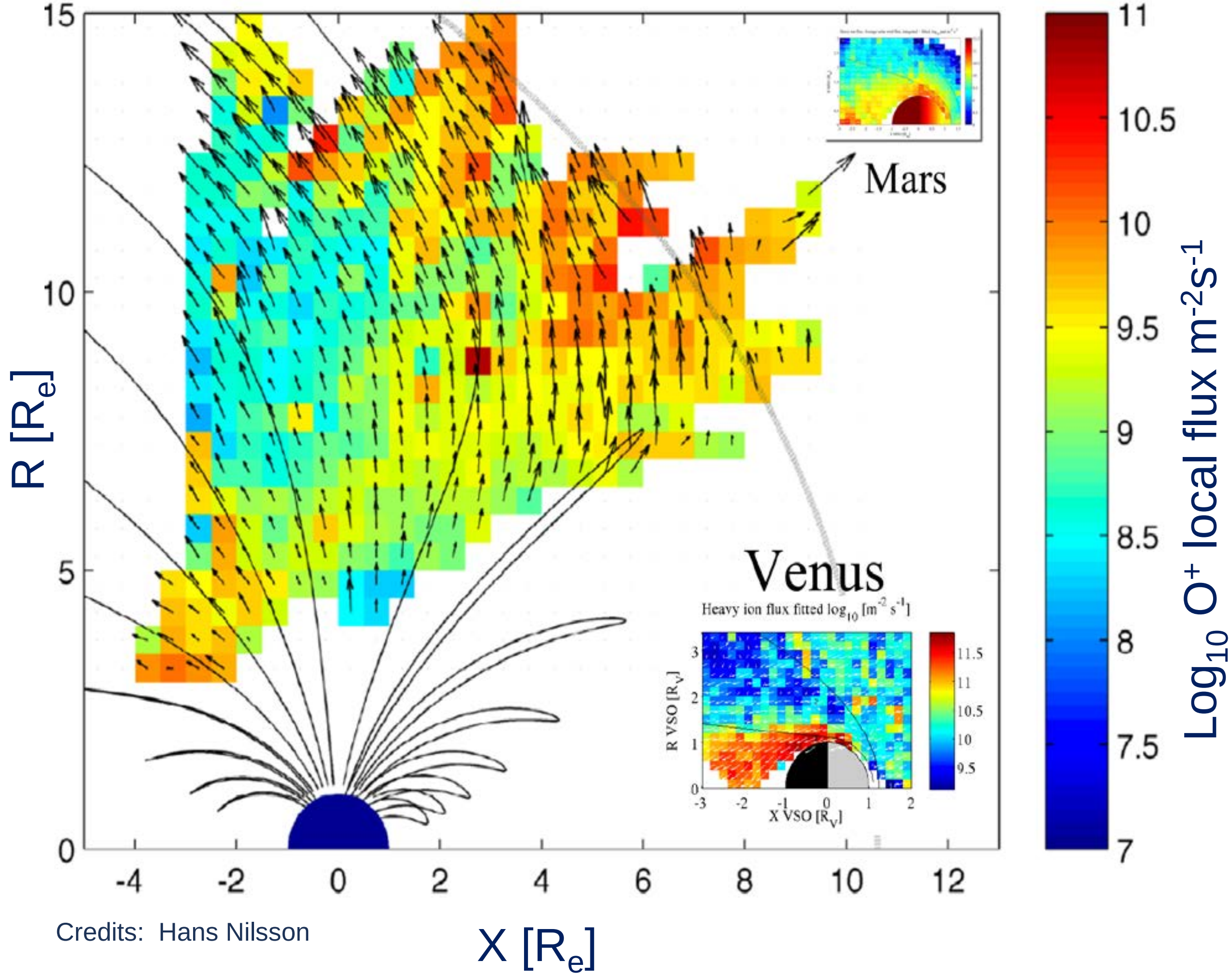
LULEÅ UNIVERSITY OF TECHNOLOGY

1. Introduction: VEM?



Credits: Hans Nilsson

Motivation:
compare ion outflow between **magnetized** and **unmagnetized** planets

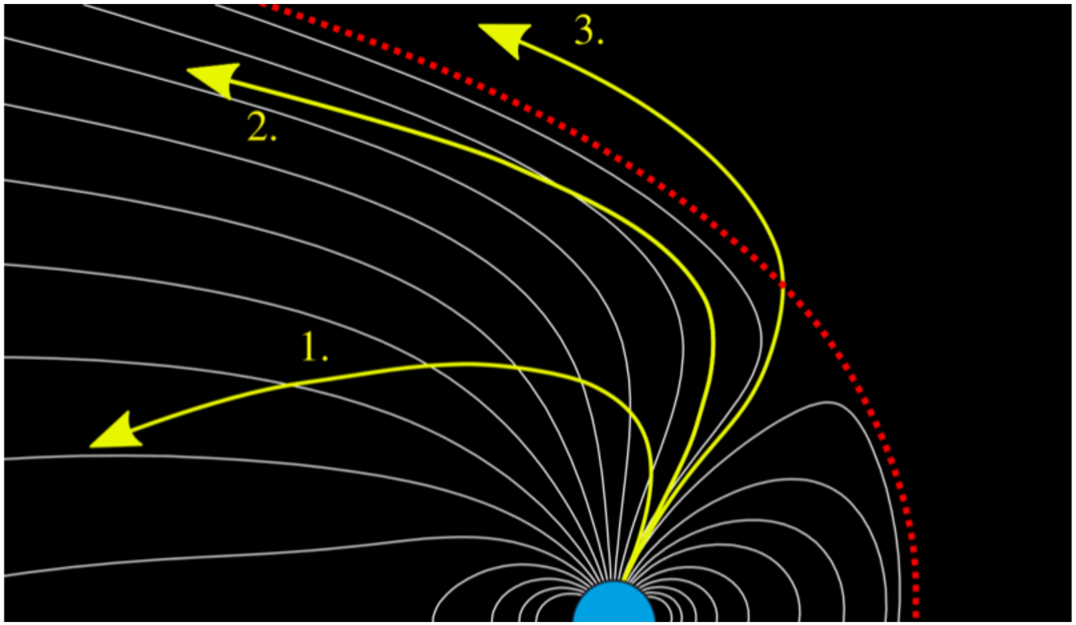
How the O^+ escape rate from the plasma mantle depends on solar wind parameters?

1. Introduction

Upflow = gravitationally bound
Outflow = escaping Earth's gravity
Escape = lost into the solar wind

Ion outflow **main paths**:

1. low-energized ions
   ⟶ **plasma sheet**
2. High-energized ions
   ⟶ **distant tail**
3. High-energized ions
   ⟶ **solar wind**



Credits: Slapak et al. 2017

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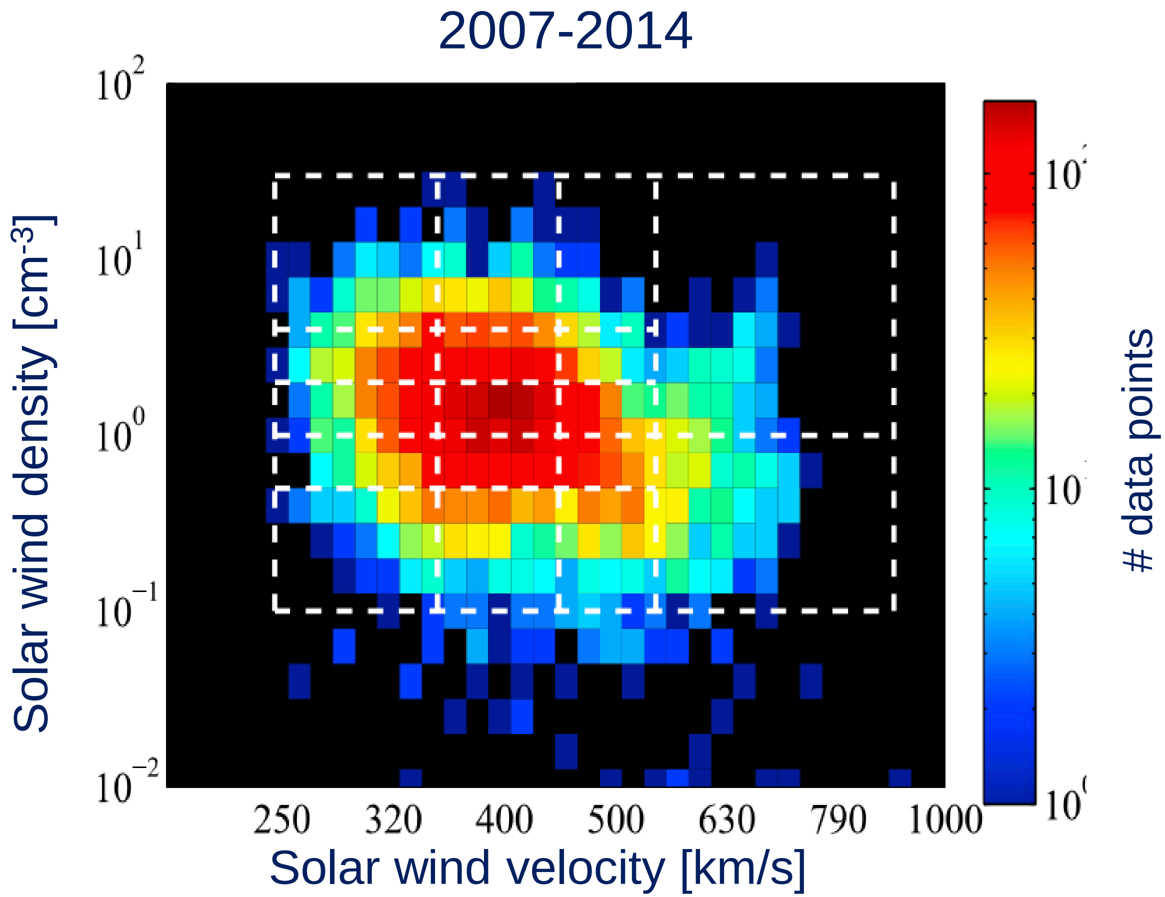
2. Context and method

- Based on Ramstad et al. (2015, 2017a, 2017b)
- At Mars: solar wind density, velocity, dynamic pressure, EUV/photoionization flux
- Similar solar wind parameters for the O^+ escape rate at Earth



Credits: Ramstad et al. (2015)

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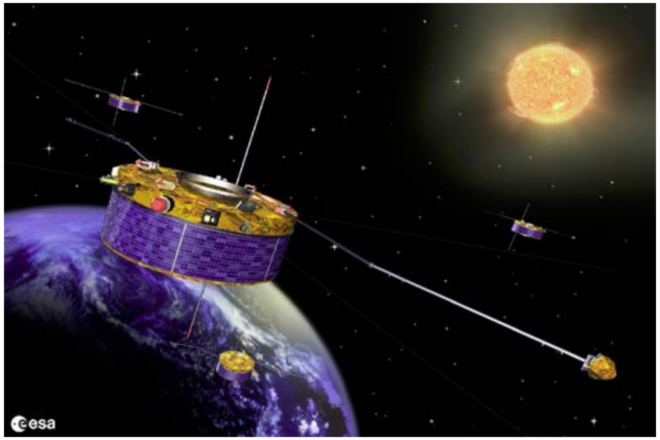
2. Context and method

Cluster – CODIF; OMNI; SEE (TIMED) data

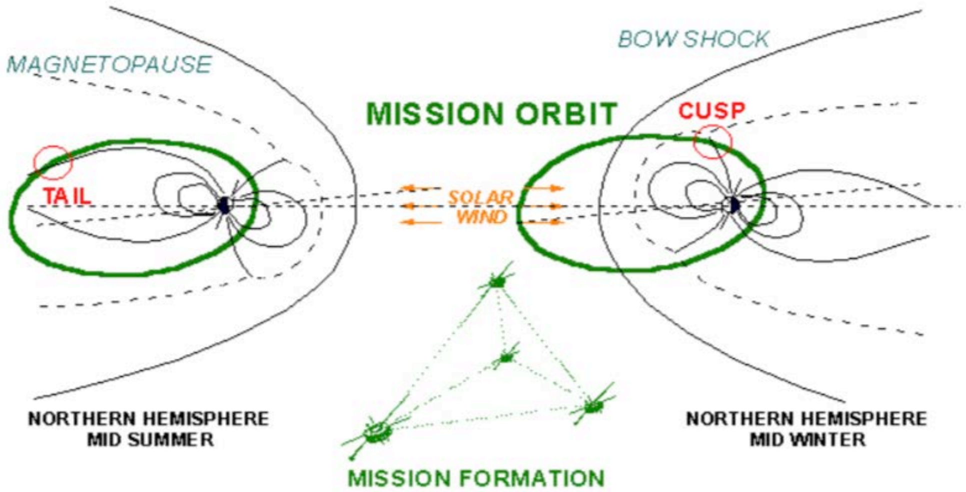
Credits: ESA

Credits: Max-Planck-Institute

- 4 spacecraft, 11 instruments
- Elliptical polar orbit
- TOF section
- Energy range of 15 eV/e – 40 keV/e



Credits: ESA



Credits : Martin Waara

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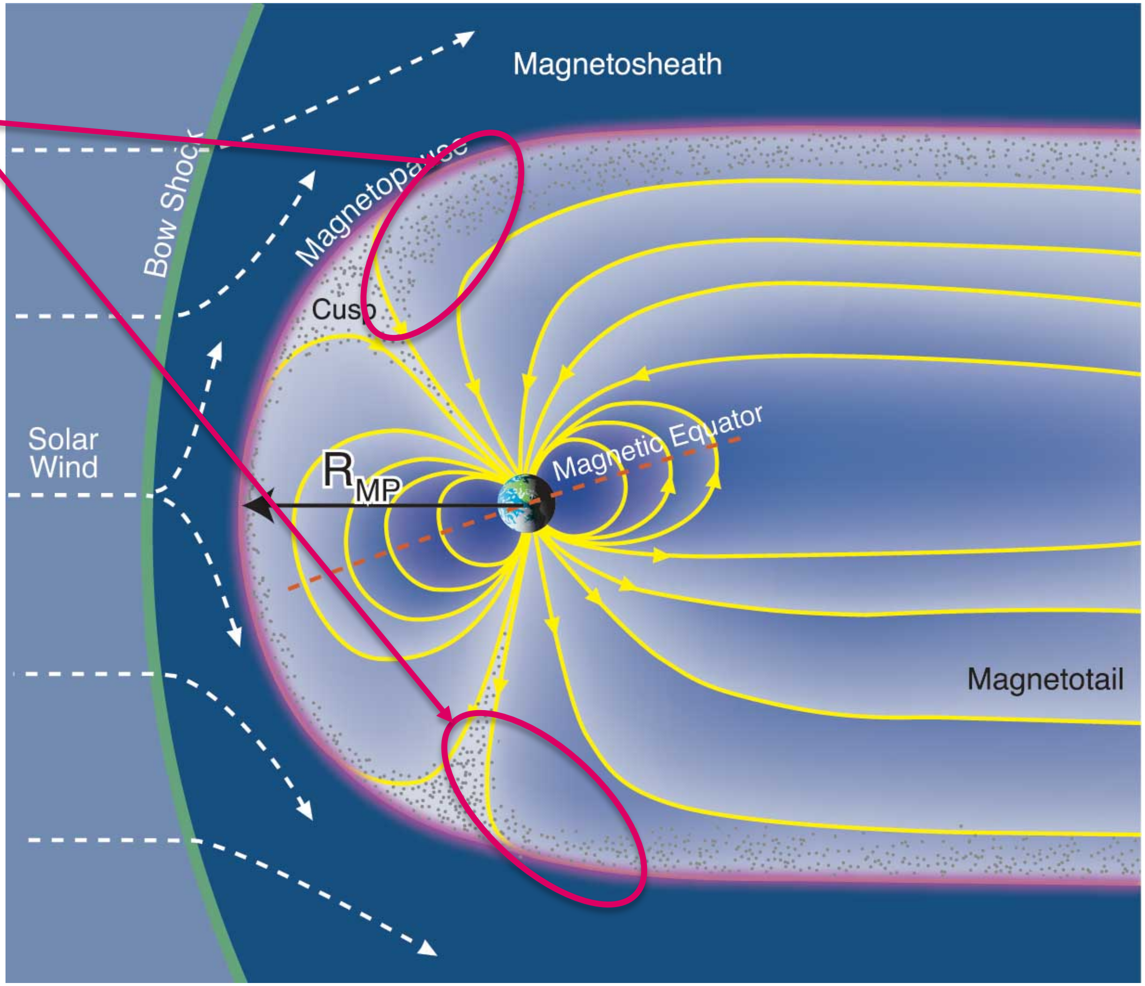
2. Context and method

Plasma mantle (PM) region

- High energetic ions
- higher plasma β (> 0.1)
- T⊥ < 1.75 keV
- Cylindrical coord.
  $R_{min} = 6\ R_e$ and.
  $-5 < X_{GSM} < 8\ R_e$

$$\beta = \frac{nk_B T}{B^2/2\mu_0}$$



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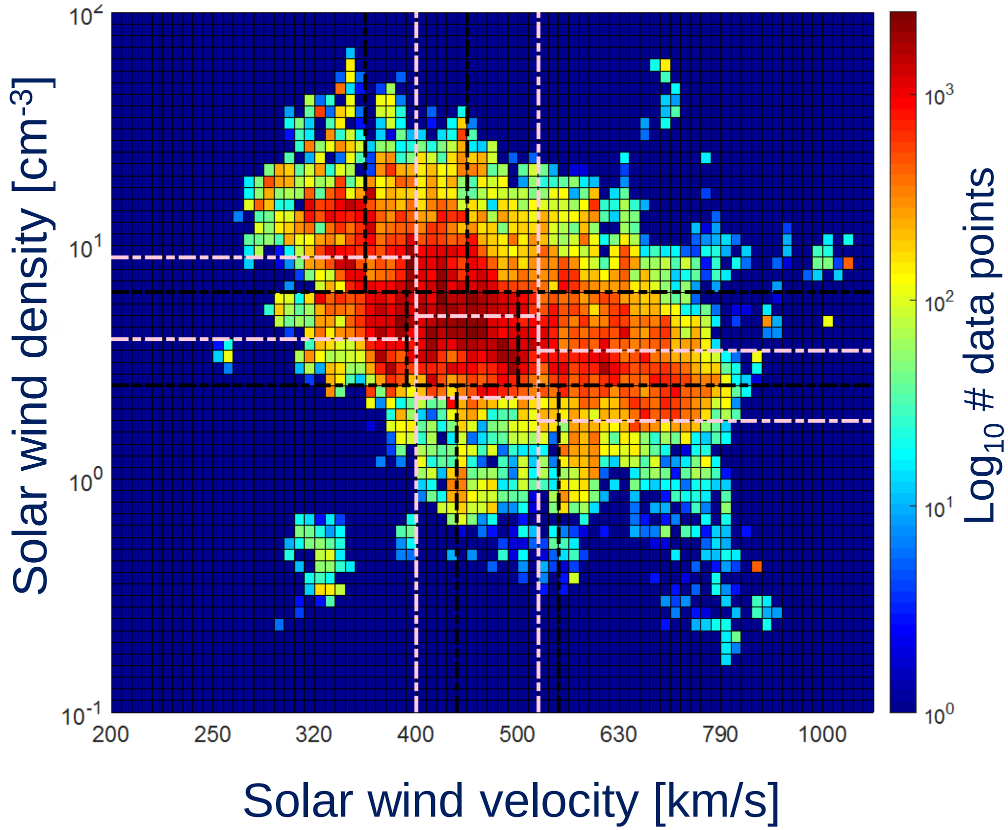
2. Context and method

- Divisions in solar wind **density** and **velocity**
- Division in **9 boxes**: low, medium, high
- Same amount of data points in the boxes for mapping the average O^+ outflow

Cluster O^+ observations in the PM for 2001-2005



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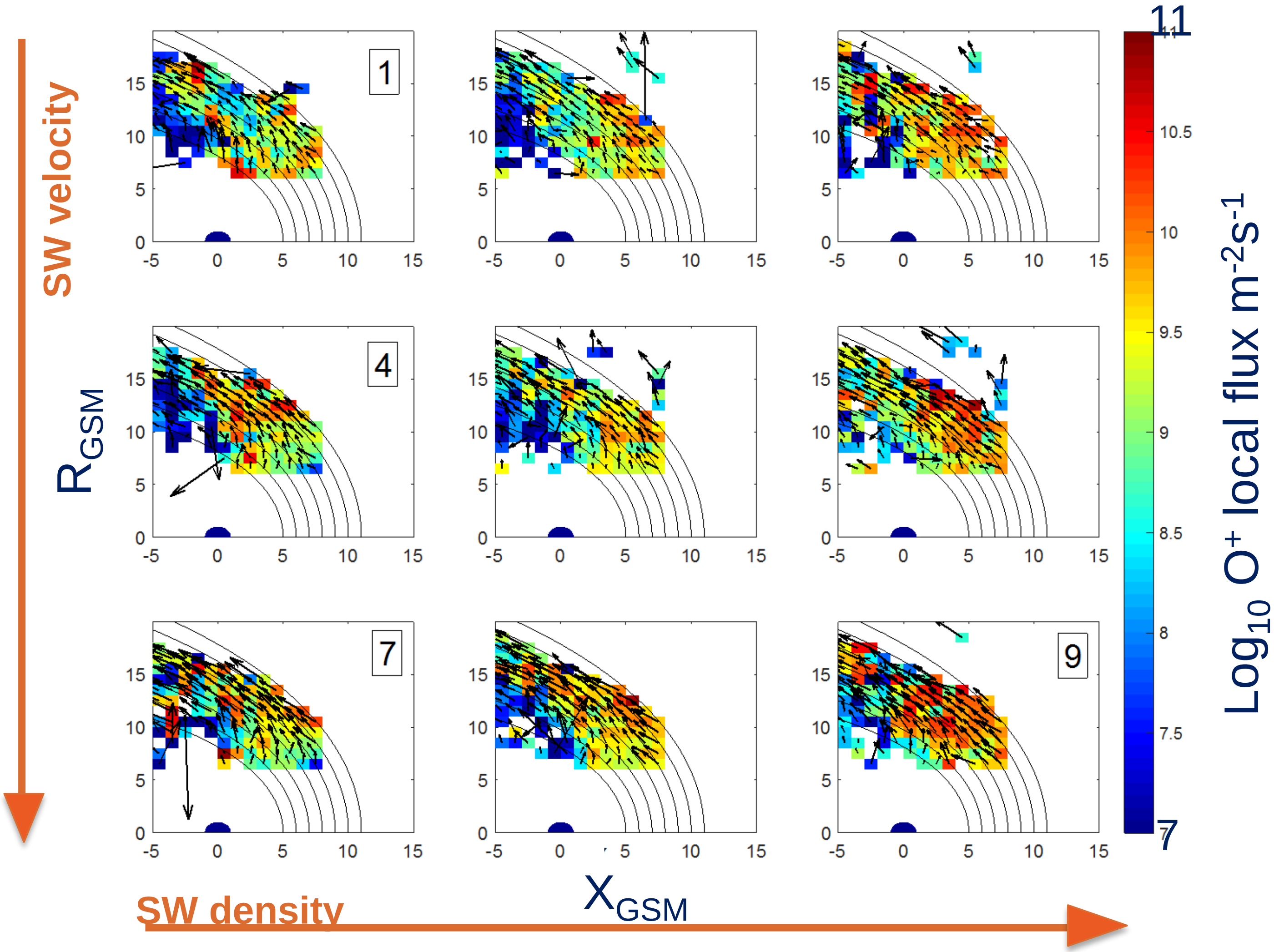
2. Context and method



Higher O^+ flux for higher density

Use of the **dynamic pressure** instead of density and velocity

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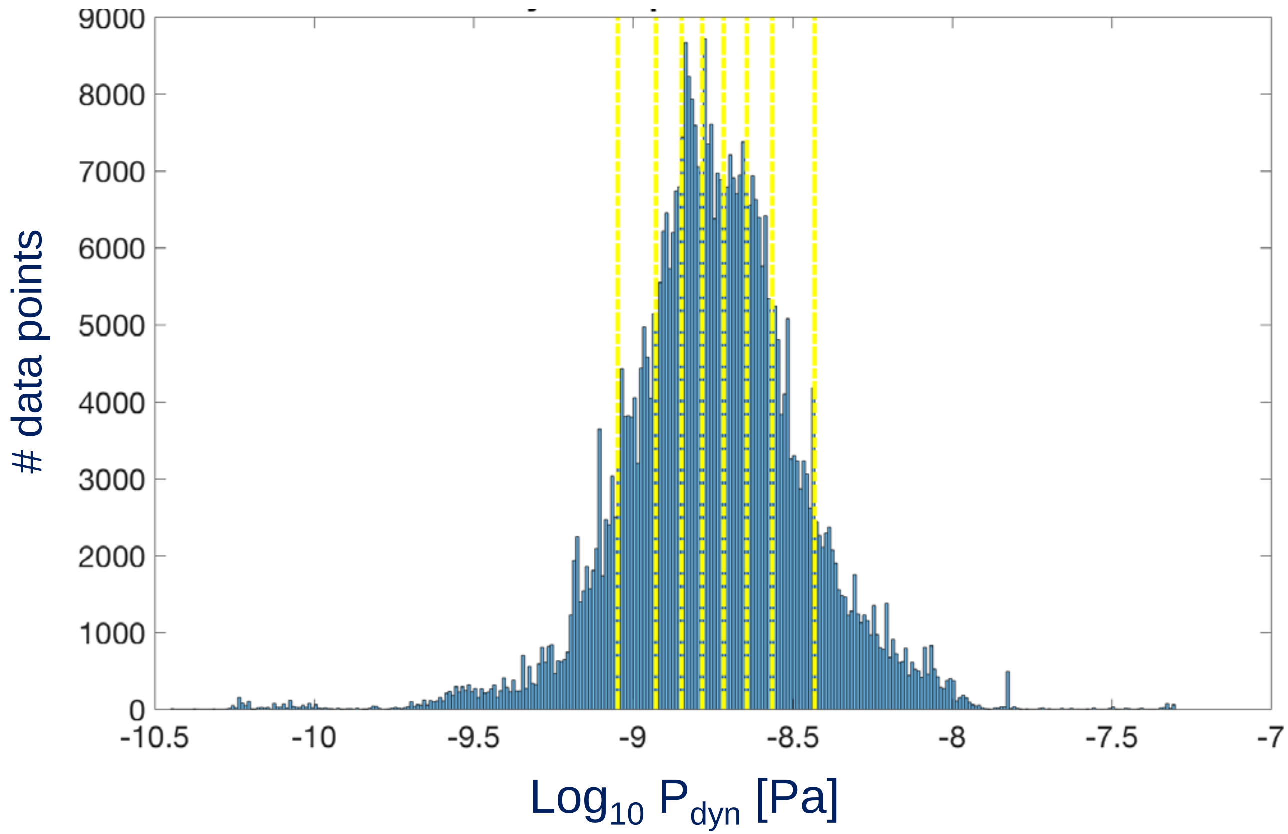
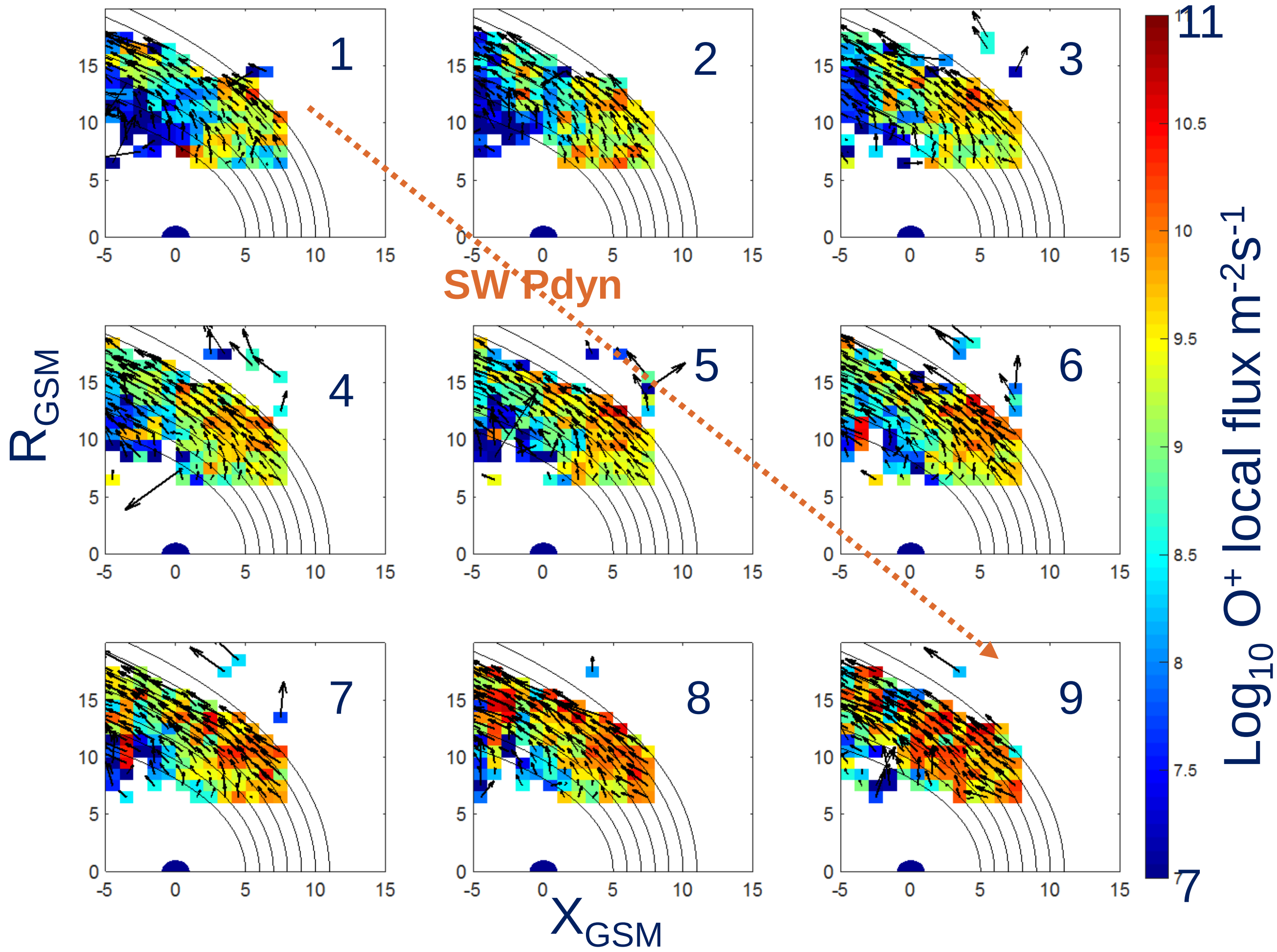
2. Context and method

Cluster O^+ observations in the PM for 2001-2005



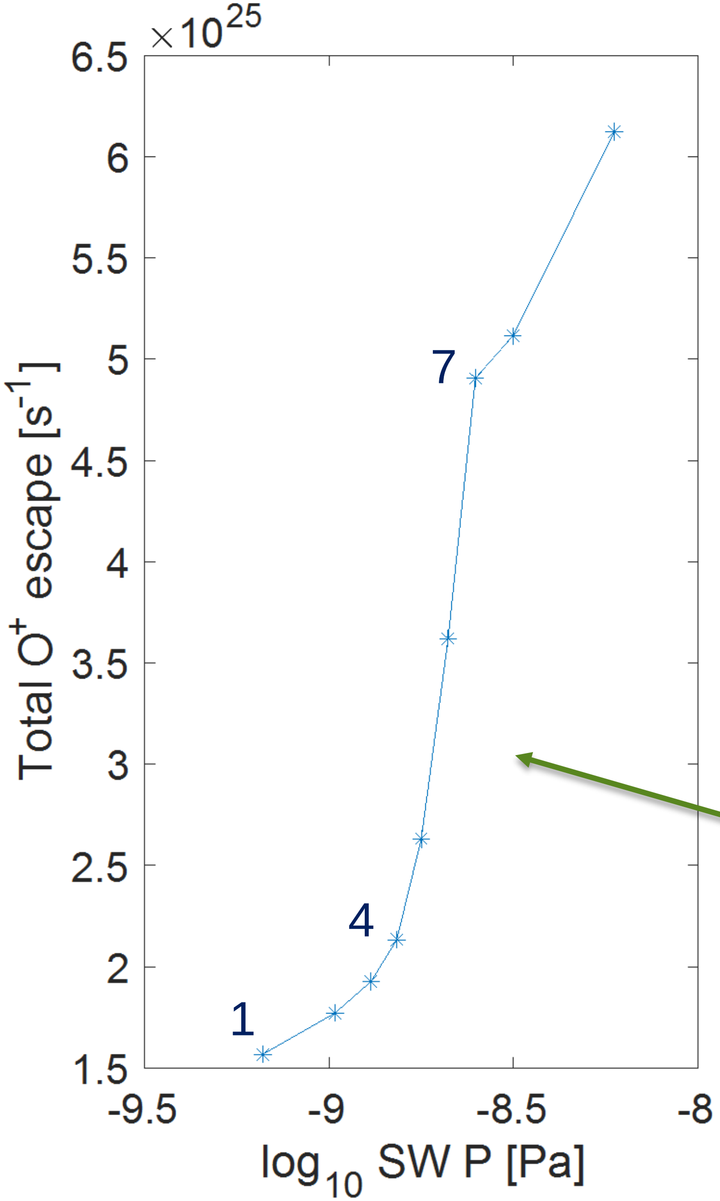
- **Linear divisions** of the dynamic pressure
- Same amount of data points
- Estimation of the **O^+ local flux** for each division

2. Context and method



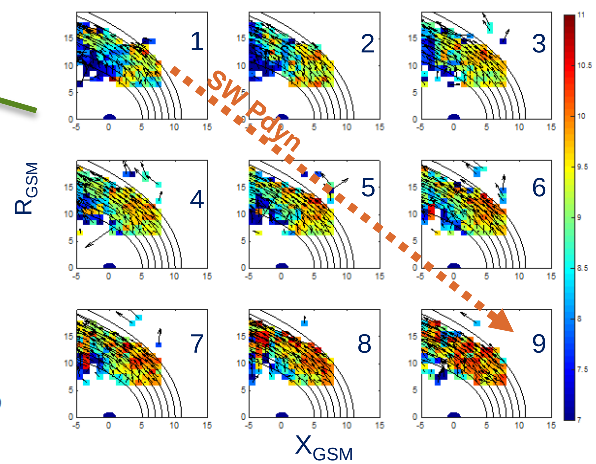
- **O^+ flux** in the plasma mantle
- Solar wind dynamic pressure divided in 9 boxes with the same amount of data points
- From low (1) to high (9) solar wind P_{dyn}
- 5 years of data (2001-2005)

→ **Higher O^+ flux for higher P_{dyn}**



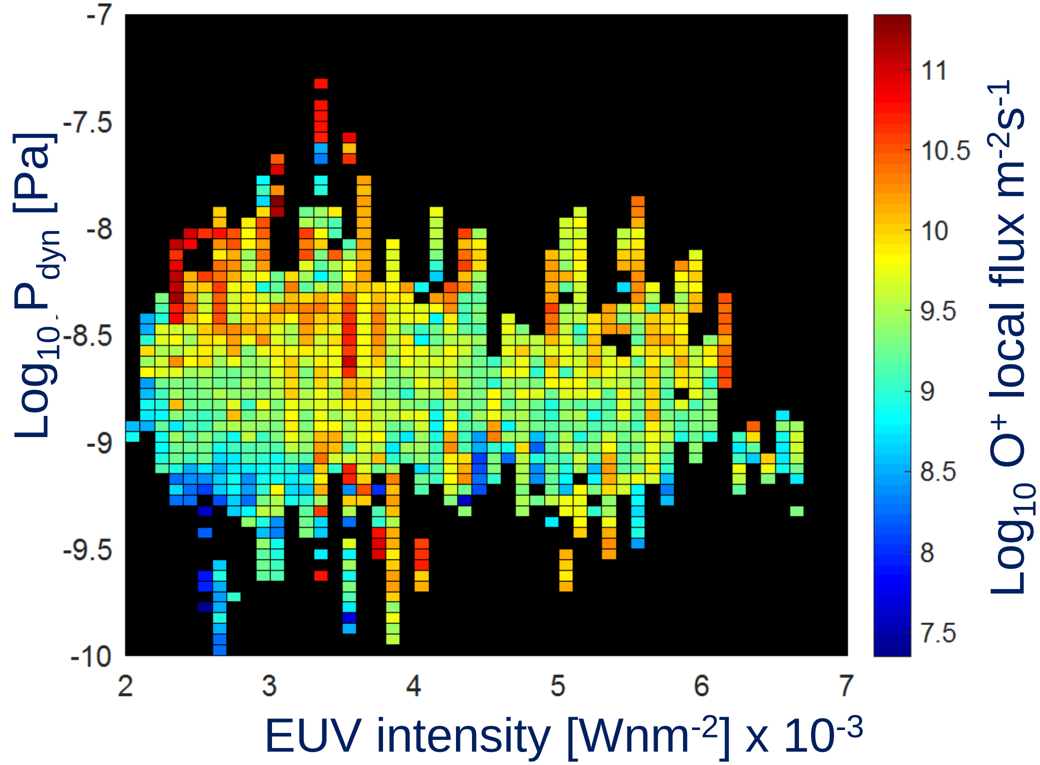
3. Results: Dynamic pressure

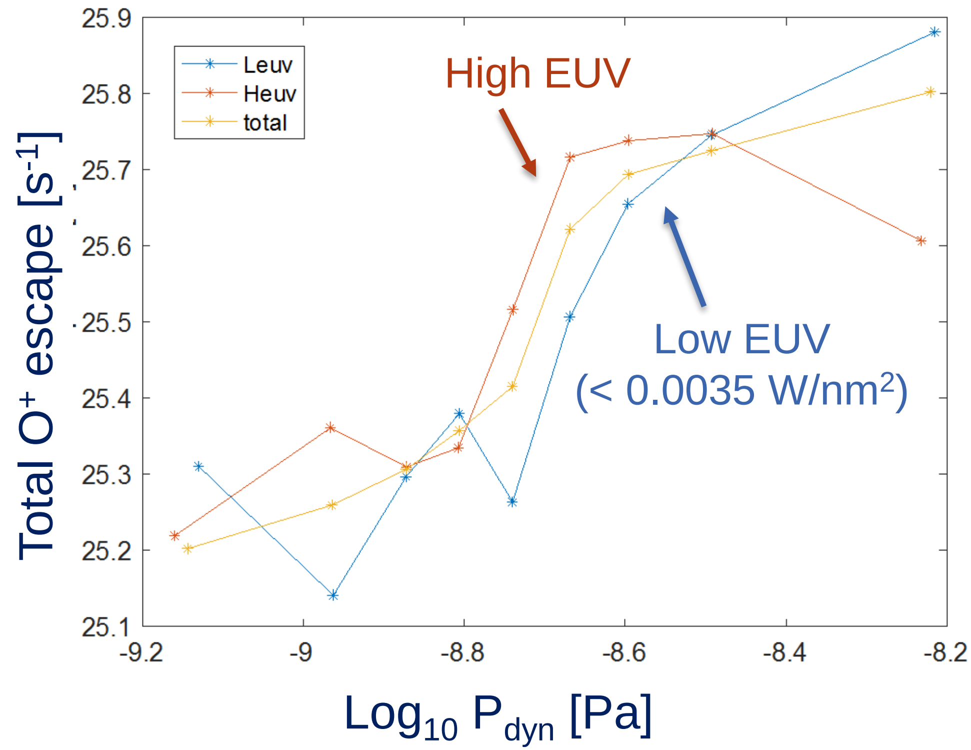
- Total **O^+ escape increases** for higher solar wind dynamic pressure



- Stronger convection in the cusp region **more efficient heating and acceleration of O^+**

3. Results: EUV





- Not strong influence of EUV on the total O^+ escape
- Different effect of what was seen at Mars (Ramstad et al. 2015)

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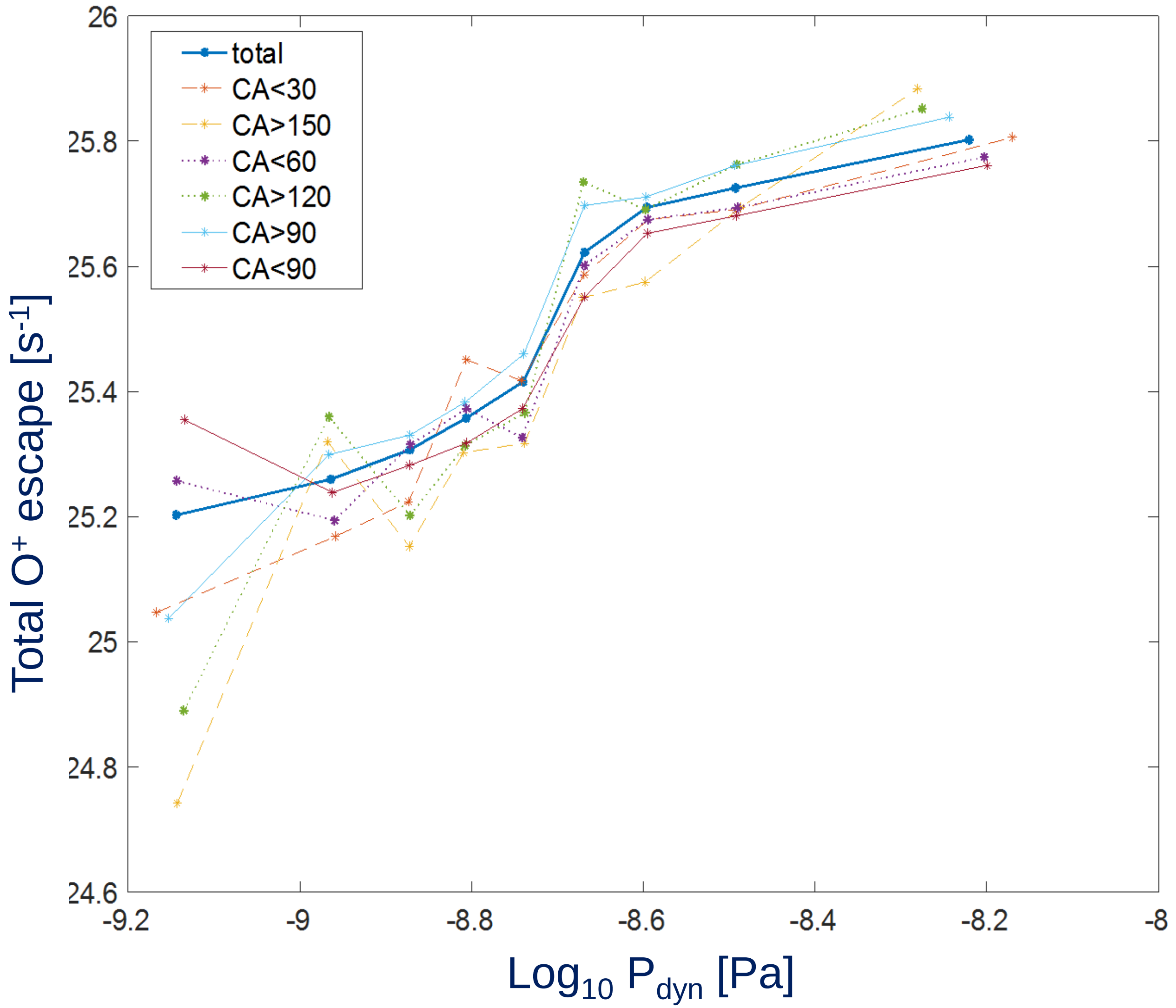
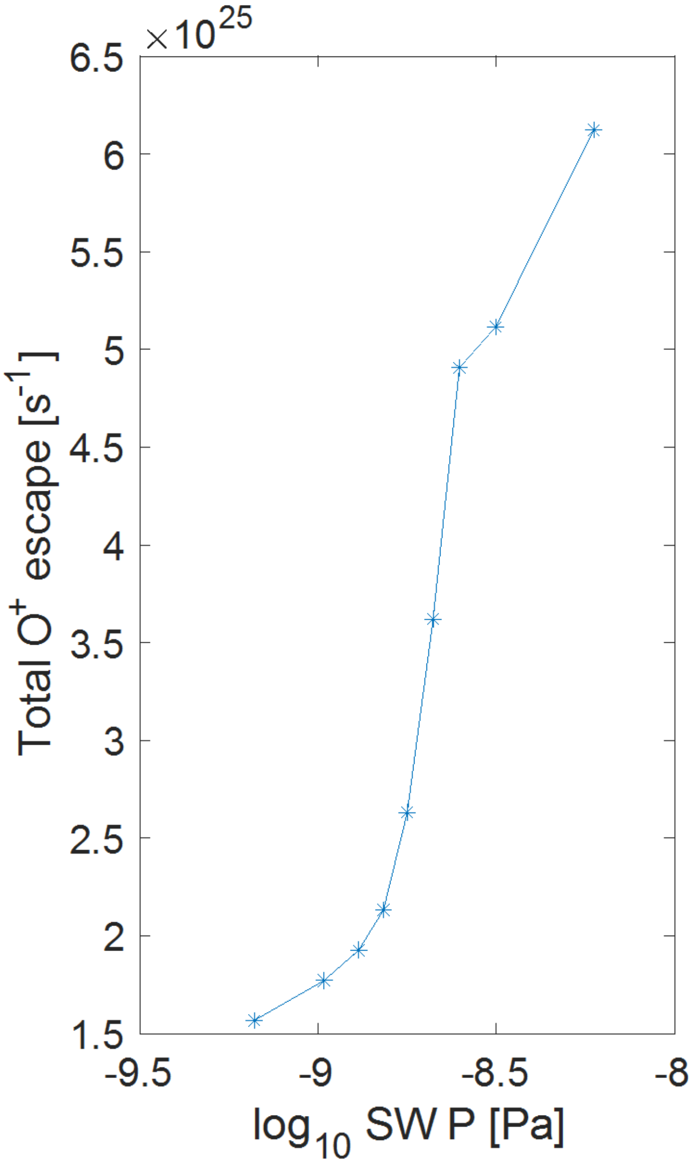
3. Preliminary result

- **Not strong influence** of IMF on the total O^+ escape?
- Northward and southward IMF seem to have the same influence





4. Conclusion

1. The total O^+ escape from the plasma mantle **increases** with higher dynamic pressure
2. No strong correlation between EUV and the total O^+ escape

3. IMF does not seem to influence the O^+ escape

4. Conclusion

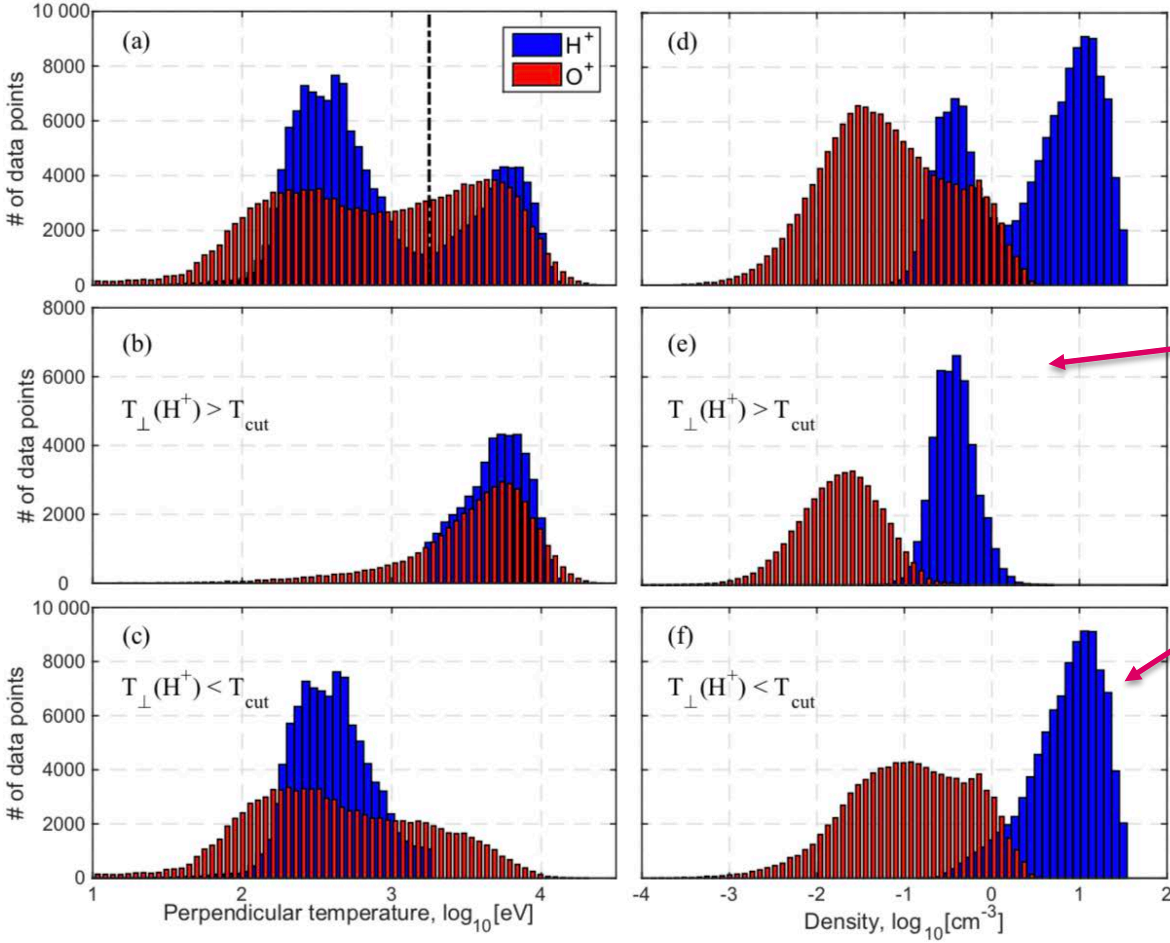
Venus	Earth	Mars
10^{24} s^{-1} Nordström et al. 2012 Solar minimum	10^{25} s^{-1} This study 5 years	10^{24} s^{-1} Ramstad et al. 2015 10 years

Similar escape rate for Earth, Venus, and Mars.

Does the terrestrial intrinsic magnetic field really protect Earth from atmospheric loss?

Additional slides

O^+ and H^+ populations



- Tcut = 1750 eV
- High T ~ low density = plasma sheet (b, e)
- Low T ~ high density = plasma mantle (c, f)

Slapak et al. (2017)

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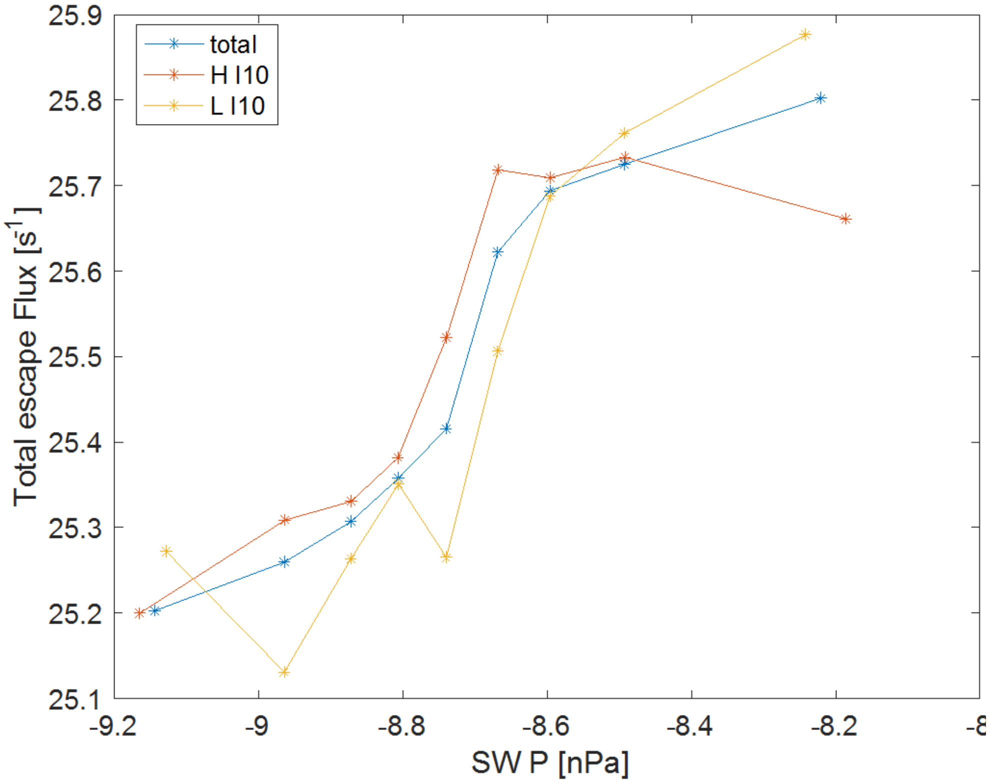
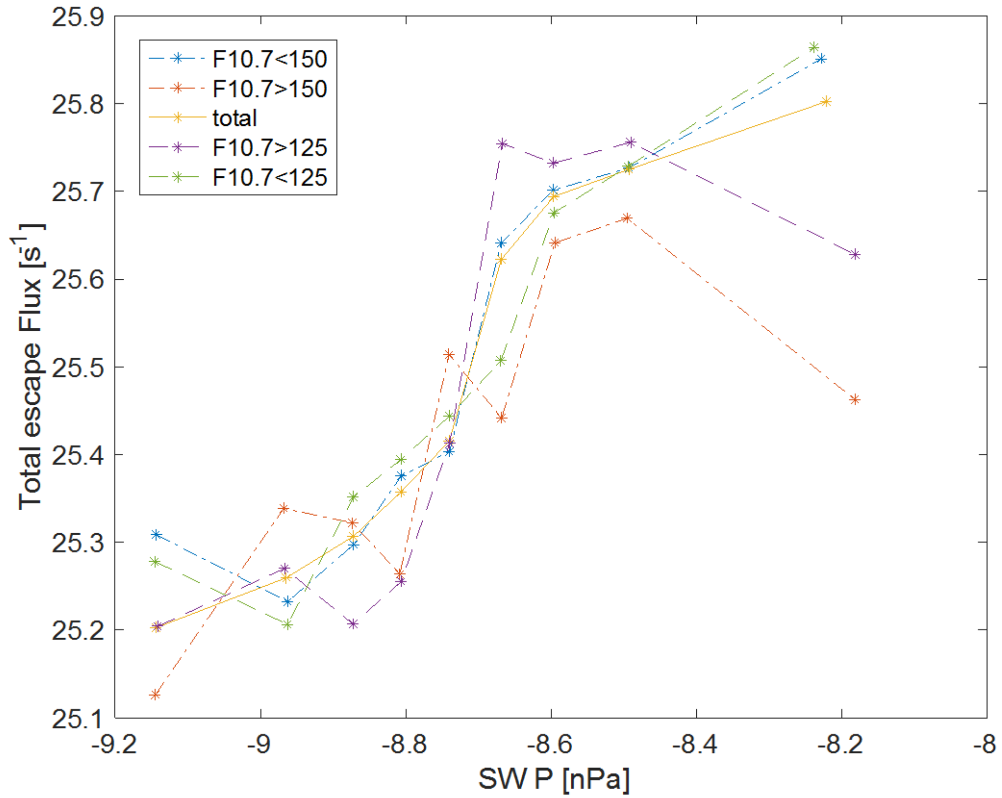
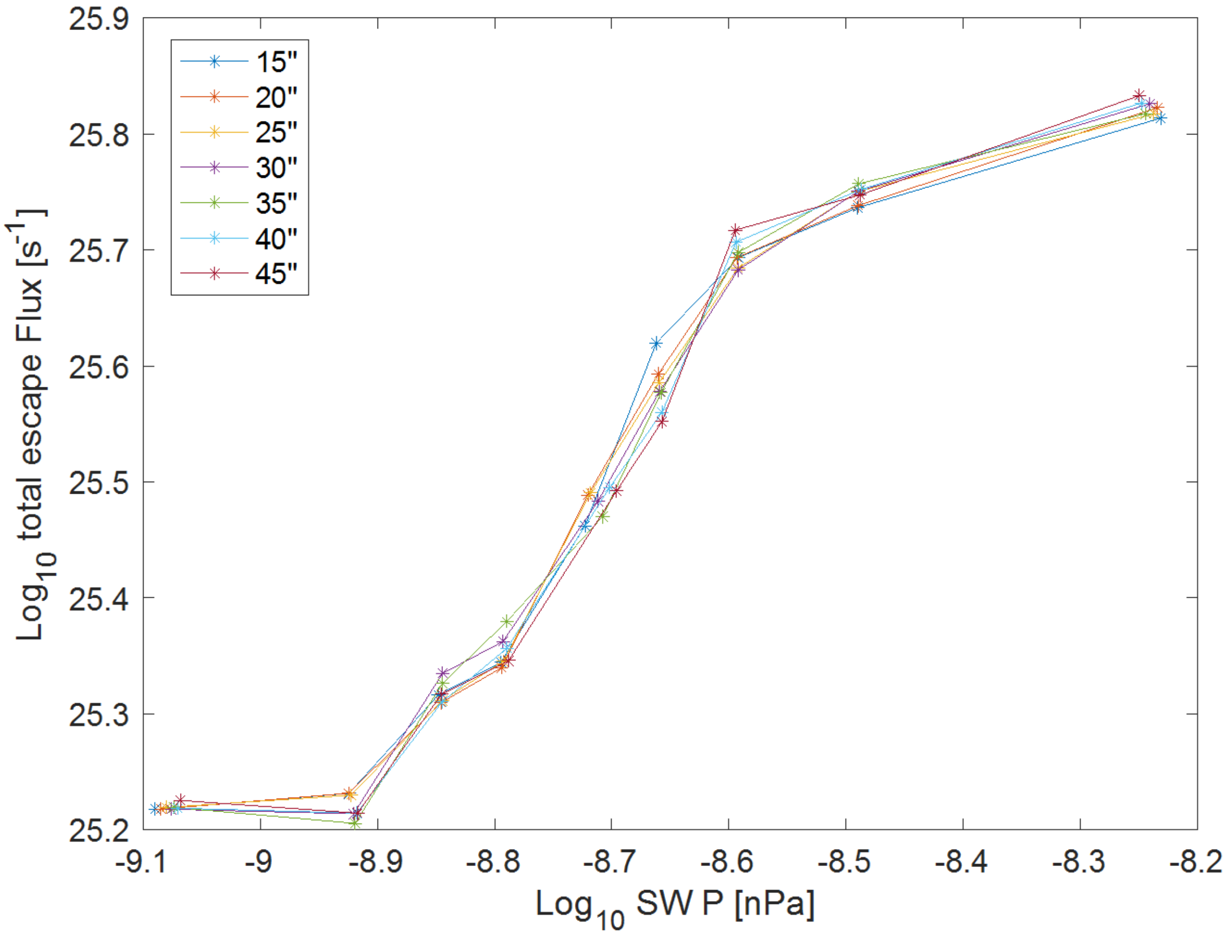
EUV intensity and F10.7





Shifting time for solar wind data



EUV intensity and Flux

Based on Ramstad et al. (2015) calculations taken from the SEE (Solar EUV experiment) instrument onboard NASA TIMED (Woods et al. 1998).

The intensity, wavelength and standard deviation are given. 15 measurements/day; 1 averaged measure for 3 minutes/orbit -> observational average

O^+ dominant in the F layer of the ionosphere -> wavelength 10 < lambda < 90 nm

Calculation of the EUV intensity for those wavelengths and of the photoionization flux

$$I_{tot} = \int I(\lambda) d\lambda \cong \sum_{n=\lambda}^{\lambda_{end}} I(\lambda) \Delta\lambda$$

$$F_\gamma = \frac{I}{E_\gamma} \quad \Rightarrow \quad E_\gamma = \frac{hc}{\lambda}$$

$$F_{tot} = \int F(\lambda) d\lambda \cong \sum_{n=\lambda}^{\lambda_{end}} F(\lambda) \Delta\lambda$$

Interpolation of the intensity and the total flux to Cluster resolution (4s), 2002-2005.

Take the median of the total intensity and below -> Low EUV; above -> high EUV