Solar cycle dependence for the H+/O+ flux ratio in the Venus' magnetotail

Moa Persson*,[1],

Y. Futaana[1], A. Fedorov[2], S. Barabash[1]

*moa@irf.se

[1] Swedish Institute of Space Physics, Kiruna, Sweden

[2]IRAP, CNRS, Toulouse, France

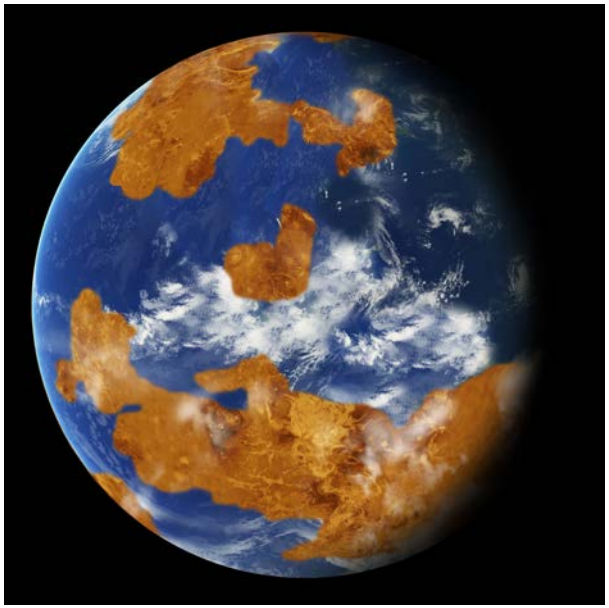
2018-05-17

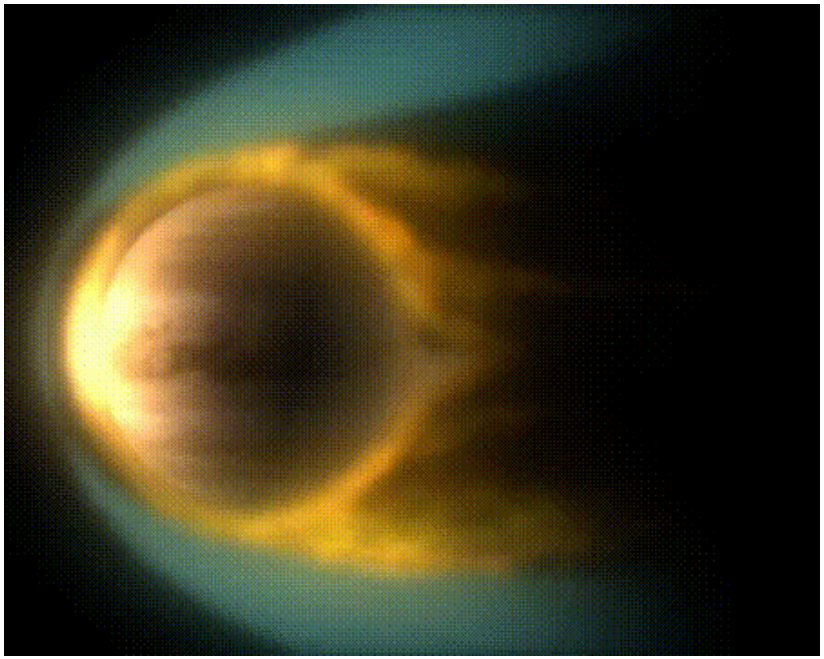
ESLAB, Noordwijk, the Netherlands

VENUS' WATER

Venus once had water in its atmosphere, but today Venus is very arid
[Donahue+97, Way+18]

How was the water lost?





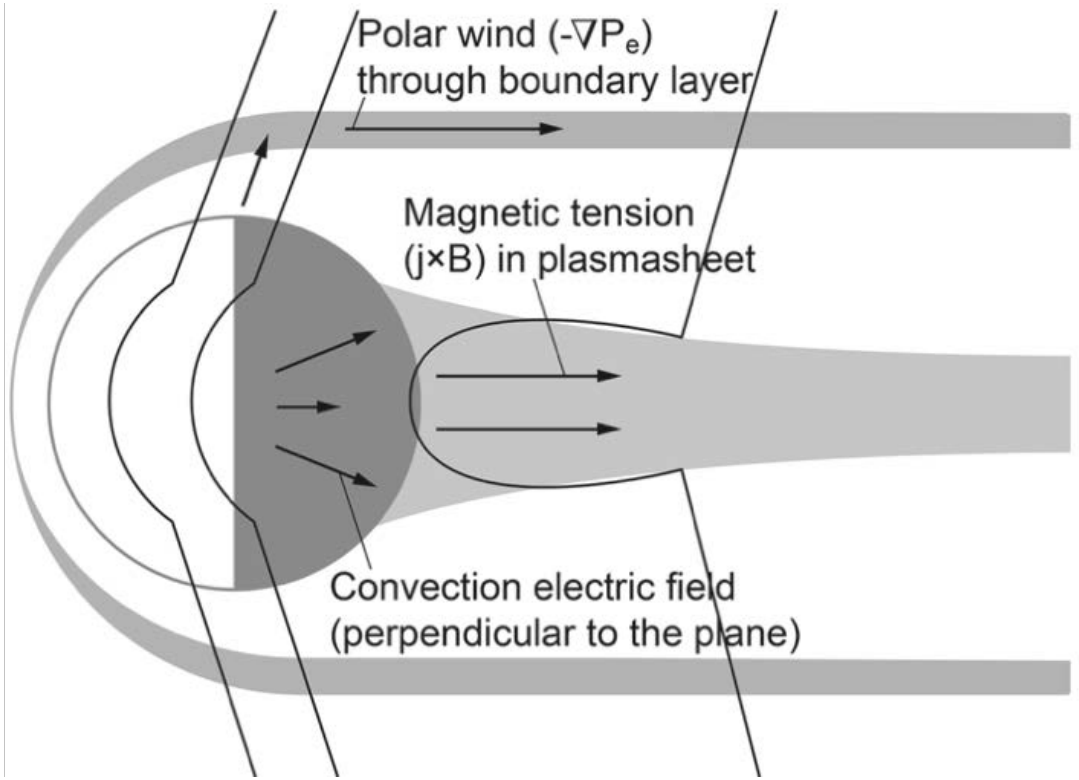
Escape of water through space is one major mechanism

Several thermal and non-thermal processes involved through Venus' history

NON-THERMAL ESCAPE PROCESSES

In this study we focus on:

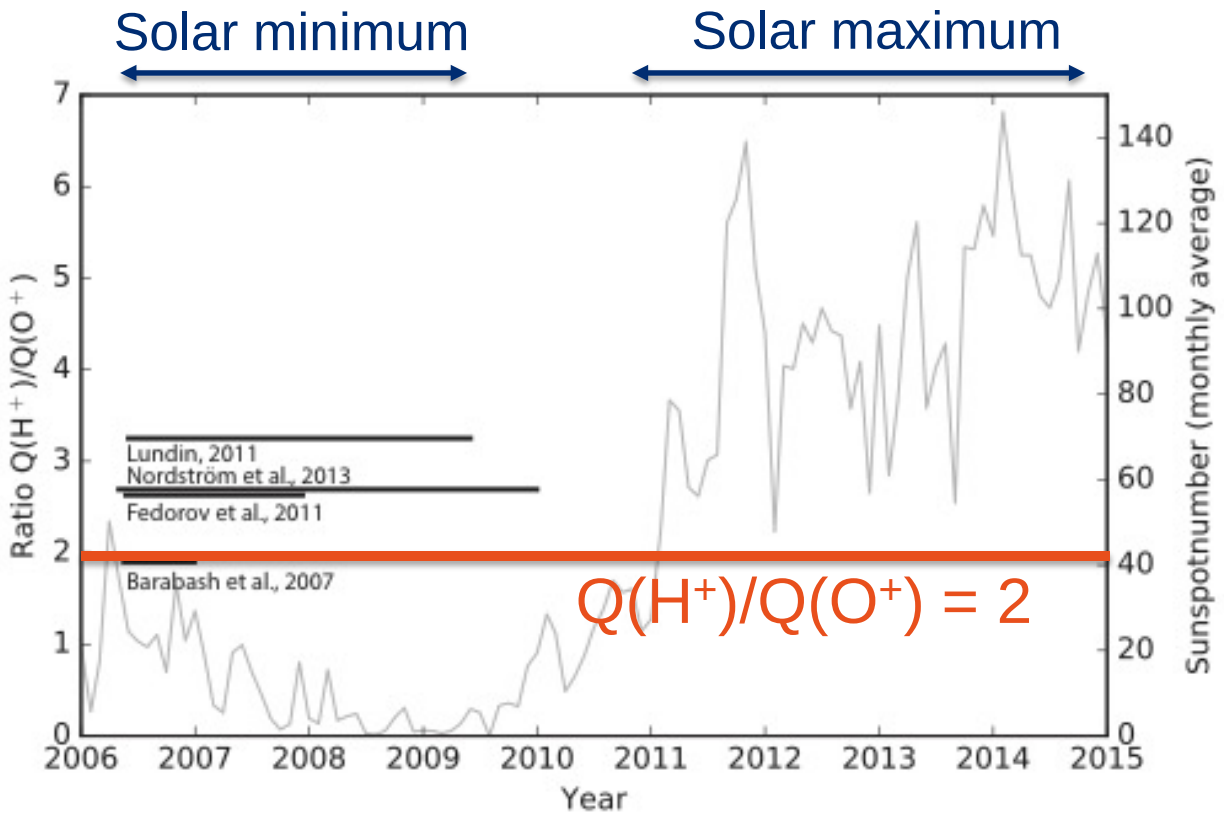
- Non-thermal escape
- H^+ and O^+ ions
- Venus' magnetotail



[Futaana et al., 2017]

PREVIOUS H^+/O^+ ESCAPE RATIO STUDIES

- Previous studies made for solar minimum
  [Barabash+07, Fedorov+11, Lundin+11, Nordström+13]
- They found a ratio close to 2:
  Stoichiometric ratio of water
- We focus on the change from solar minimum to solar maximum
- How much does the solar cycle variations influence the escape rate ratio?

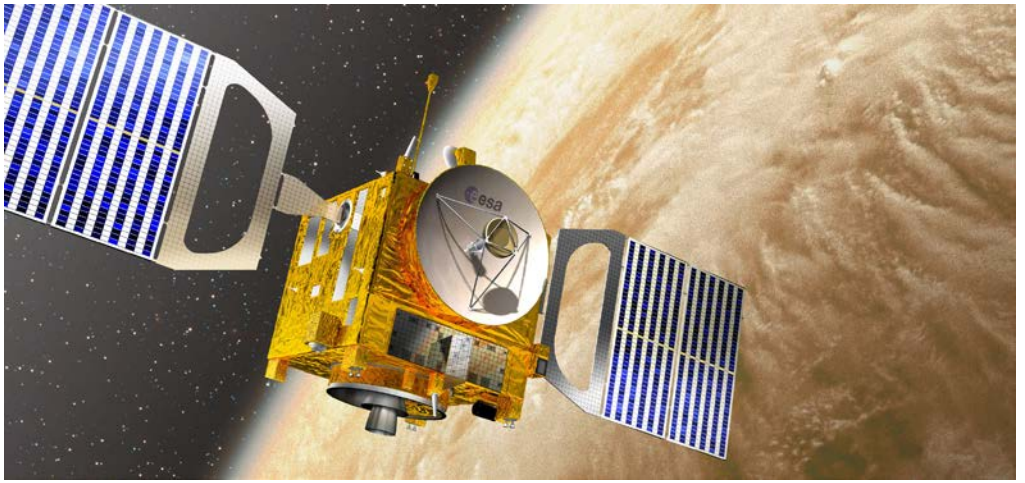


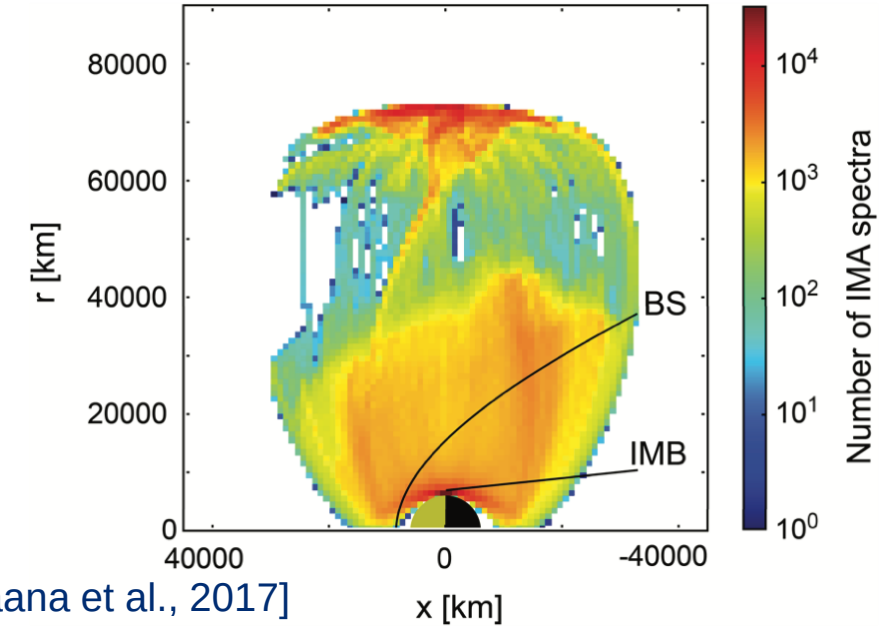
INSTRUMENTATION: VEX/ASPERA-4/IMA

Venus Express

2006-2014

>3000 orbits





[Futaana et al., 2017]

ASPERA-4/IMA

FOV: 90x360º

Energy range: 0.01-36 keV/q

M/q = 1, 2, 4, 8, 16, 32, >40

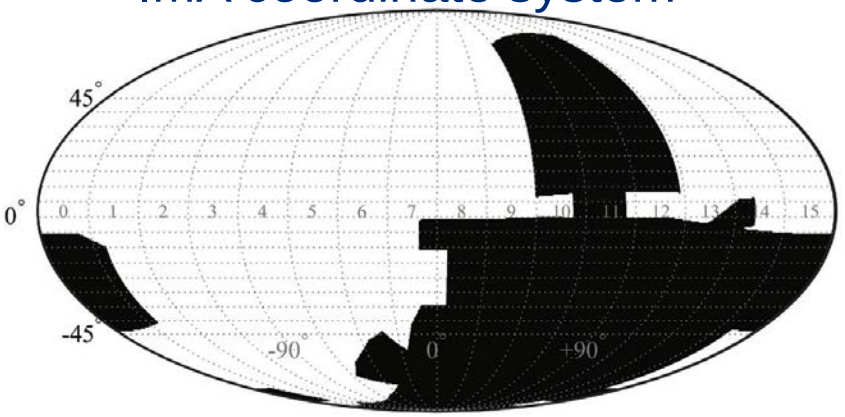
Time resolution: 192 s

ONE IMA MEASUREMENT

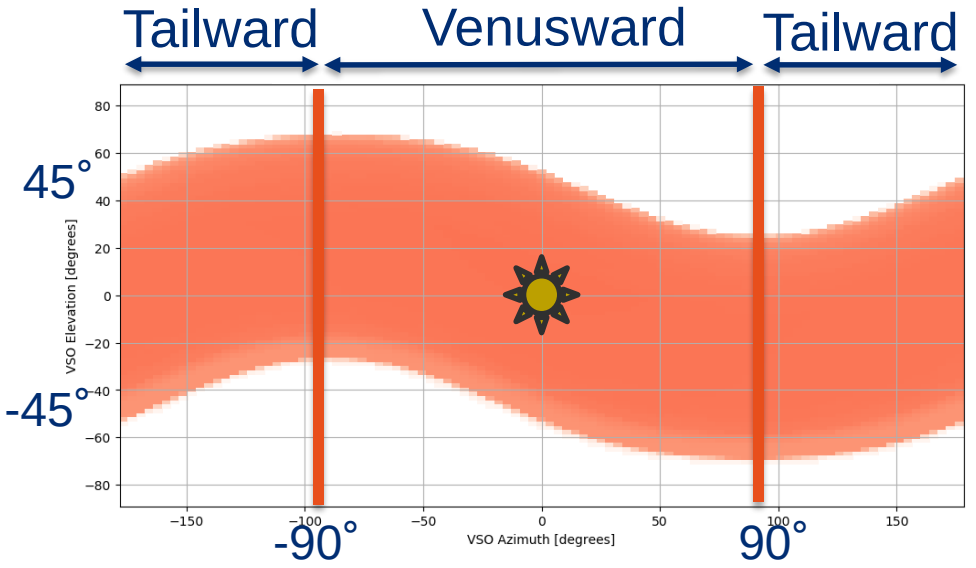
One measurement does not cover the full ion angular distribution

- Large portion of field-of-view covered by the spacecraft body
- One measurement covers 90x360˚
- Need for a method to correct for these limitations

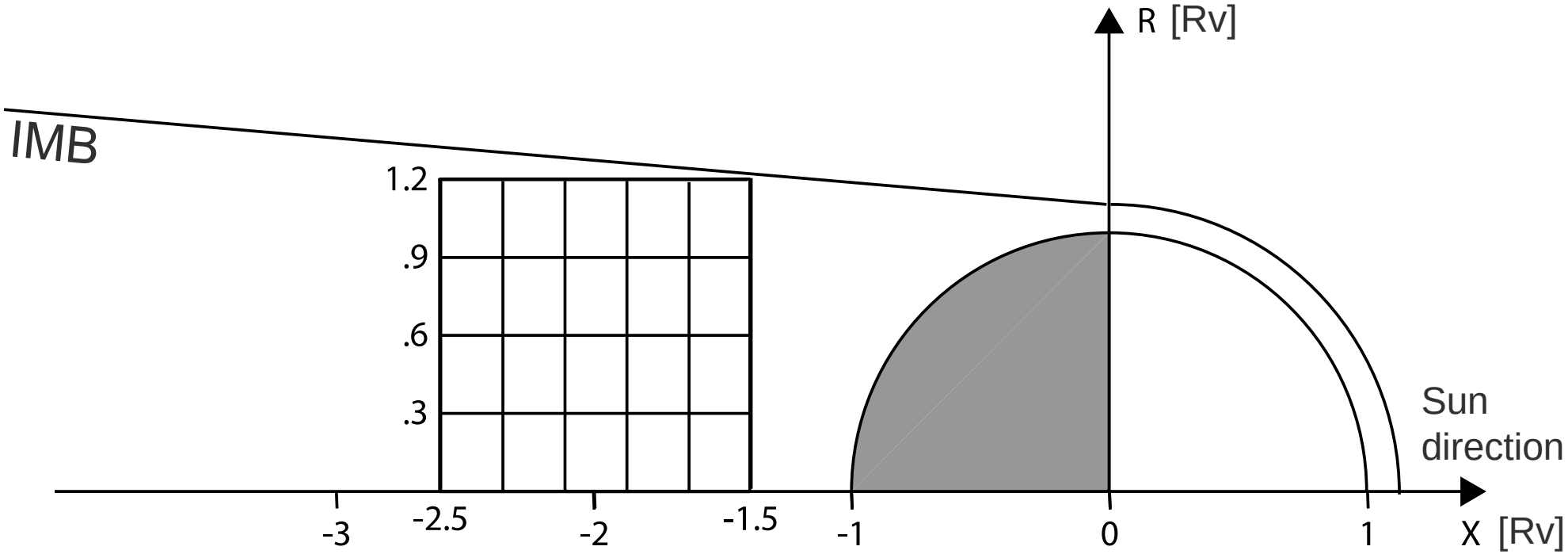
IMA coordinate system



VSO coordinate system

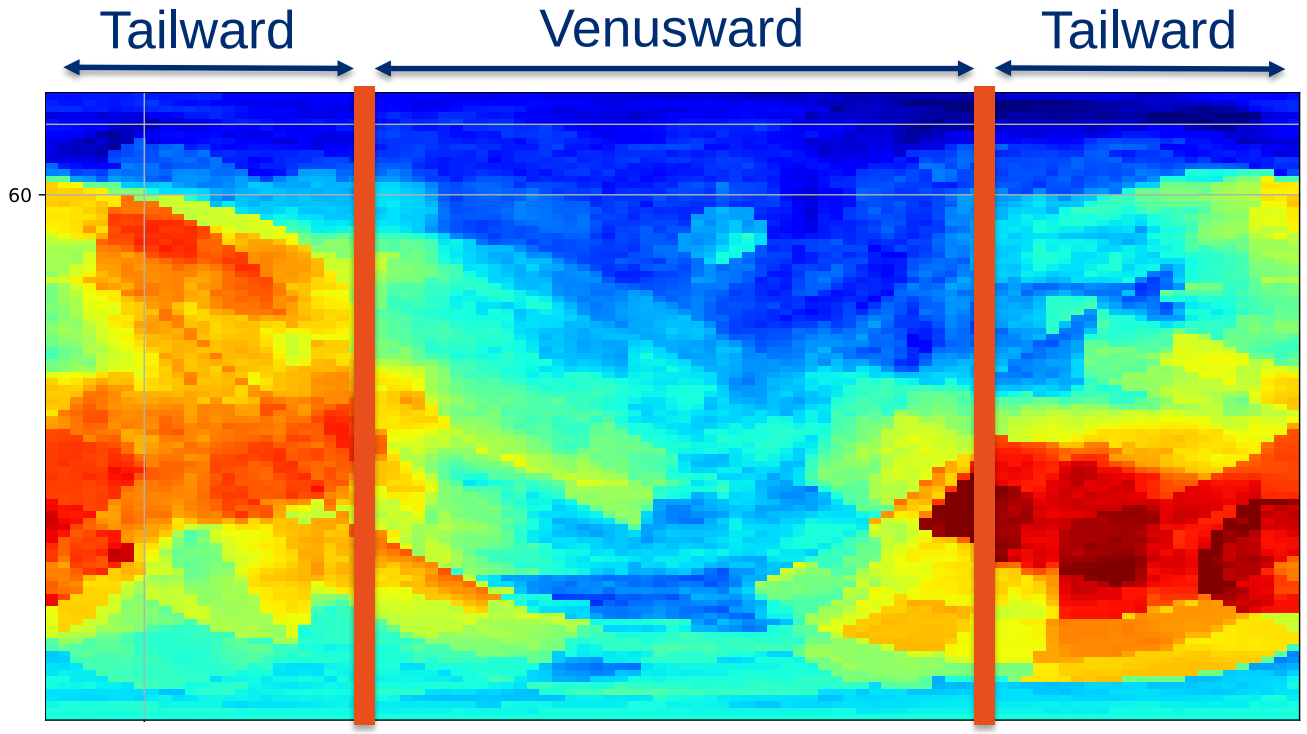


METHOD: SPATIAL GRIDS



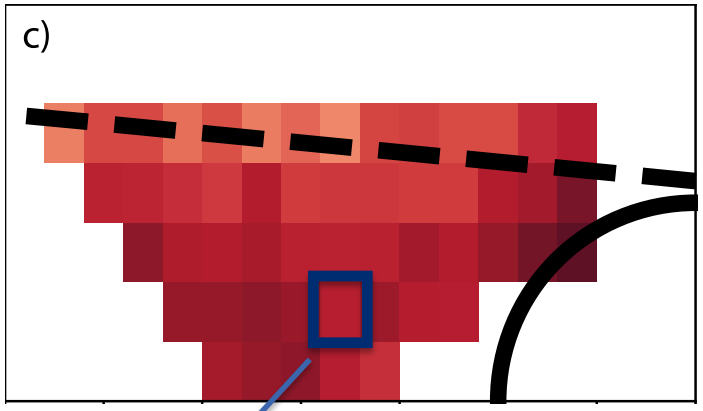
Divide the tail into several spatial bins for measurements

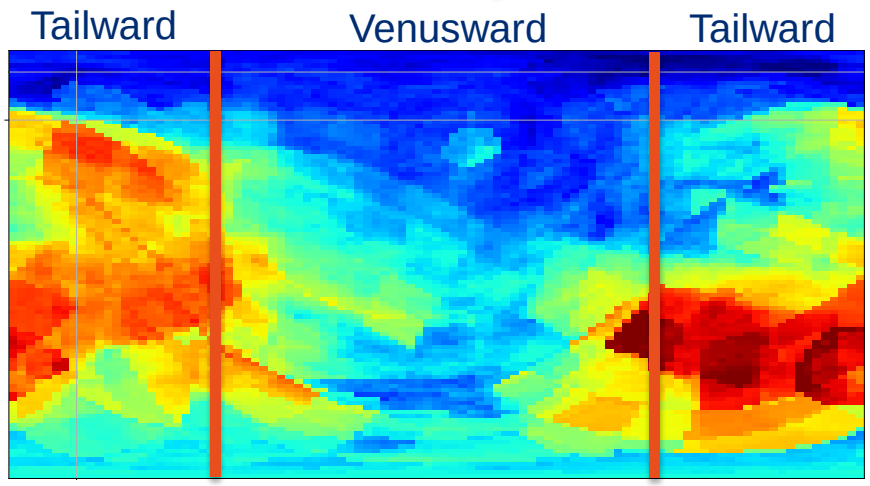
METHOD: AVERAGE VELOCITY DISTRIBUTION



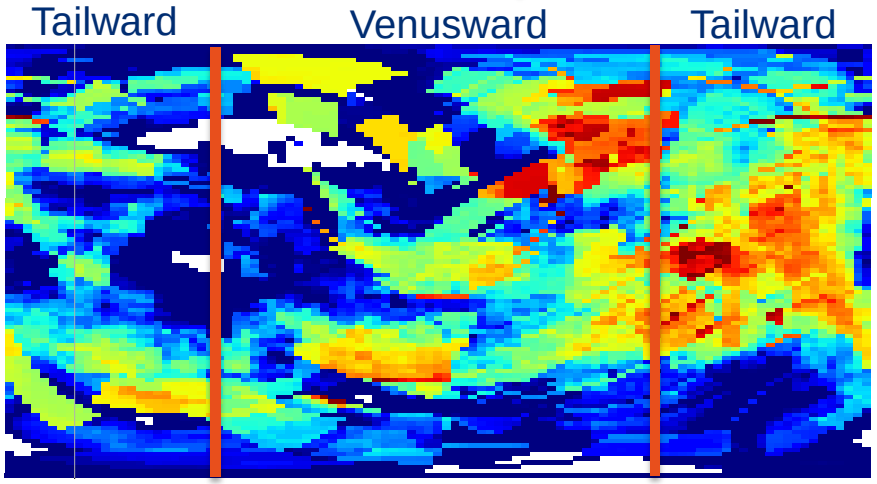
O^+ FLUX MAPS

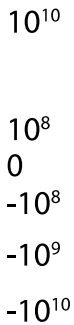
Solar minimum

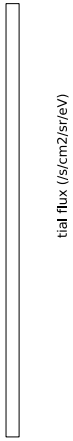




Solar maximum

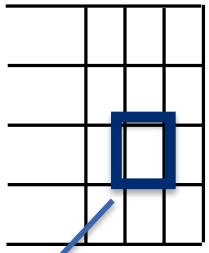


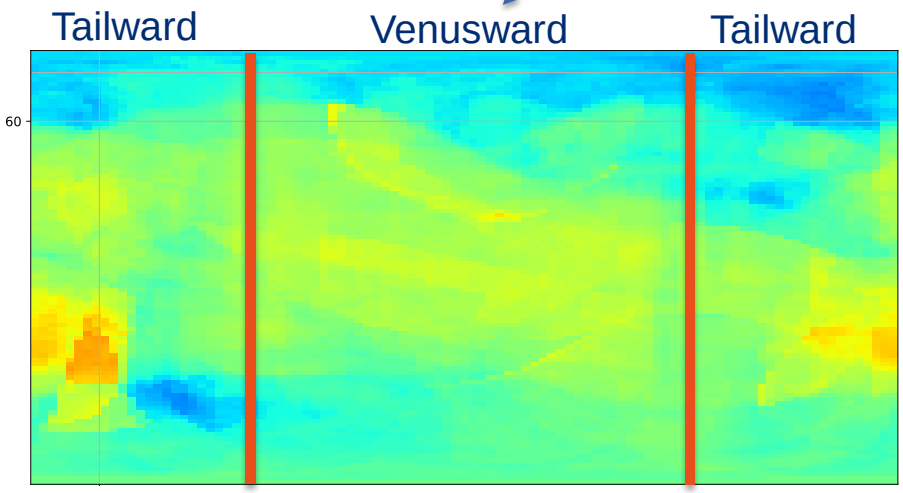




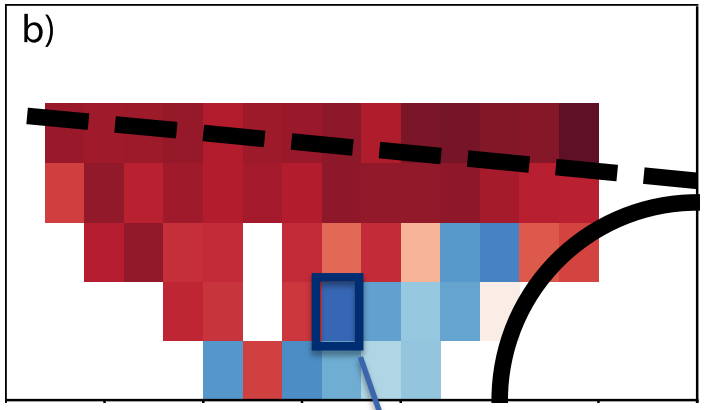
H^+ FLUX MAPS

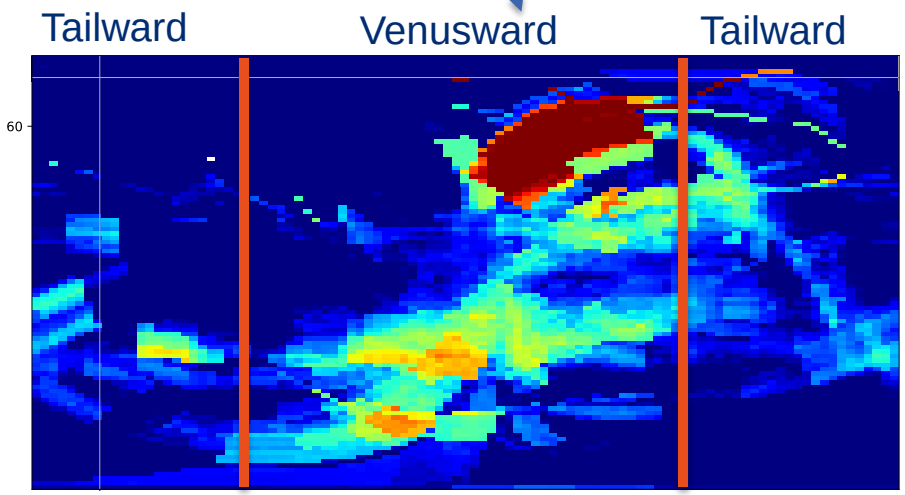
Solar minimum



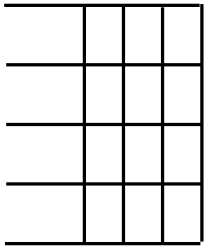


Solar maximum





ESCAPE RATE RESULTS



	Solar minimum 2006-2009	Solar maximum 2010-2014
$Q(H^+)$ [s^{-1}]	$8.9 \pm 4.7 \cdot 10^{24}$	$1.9 \pm 1.6 \cdot 10^{24}$
$Q(O^+)$ [s^{-1}]	$2.6 \pm 1.1 \cdot 10^{24}$	$2.4 \pm 1.1 \cdot 10^{24}$
$Q(H^+)/Q(O^+)$	3.4 ± 2.3	0.8 ± 0.7

DISCUSSION

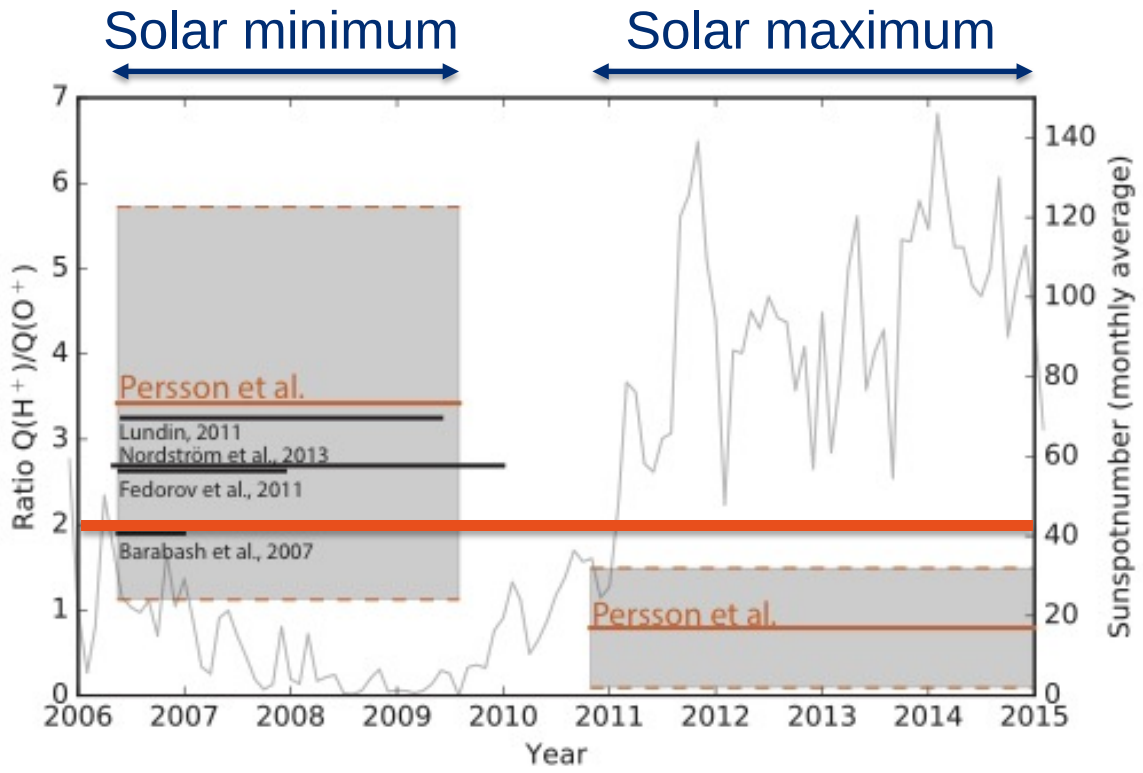
- Lower limit of neutral escape:
  - H: 50% of Q(H^+)
  - O: 25% of Q(O^+)

  [Lammer+06]
- Several studies suggest a higher number for H escape
  [Rodriguez+84, Chassefiere+96]
- Pre-historic solar conditions was closer to solar maximum conditions [Ribas+05]

	Solar min 2006-2009	**Solar max 2010-2014**
Q(H^+ + H) [s^{-1}]	$1.3 \cdot 10^{25}$	$2.9 \cdot 10^{24}$
Q(O^+ + O) [s^{-1}]	$3.3 \cdot 10^{24}$	$3.0 \cdot 10^{24}$
$\frac{\mathbf{Q(H^+ + H)}}{\mathbf{Q(O^+ + O)}}$	3.9	1.0

CONCLUSIONS

- O^+ escape rate average is steady over solar cycle
- H^+ escape rate decreases by a factor ~5 from solar minimum to maximum
- H^+ flow direction during solar maximum affect escape rate
- H^+/O^+ escape rate ratio 3.4 ➔ 0.8
- Non-thermal escape in Venus' magnetotail dependent on the solar cycle variations



moa@irf.se

ADDITIONAL SLIDES

LARGE VARIATIONS

- Long time period
- Large spread in solar wind upstream conditions
- Detailed relation between solar wind and ion escape planned for future study