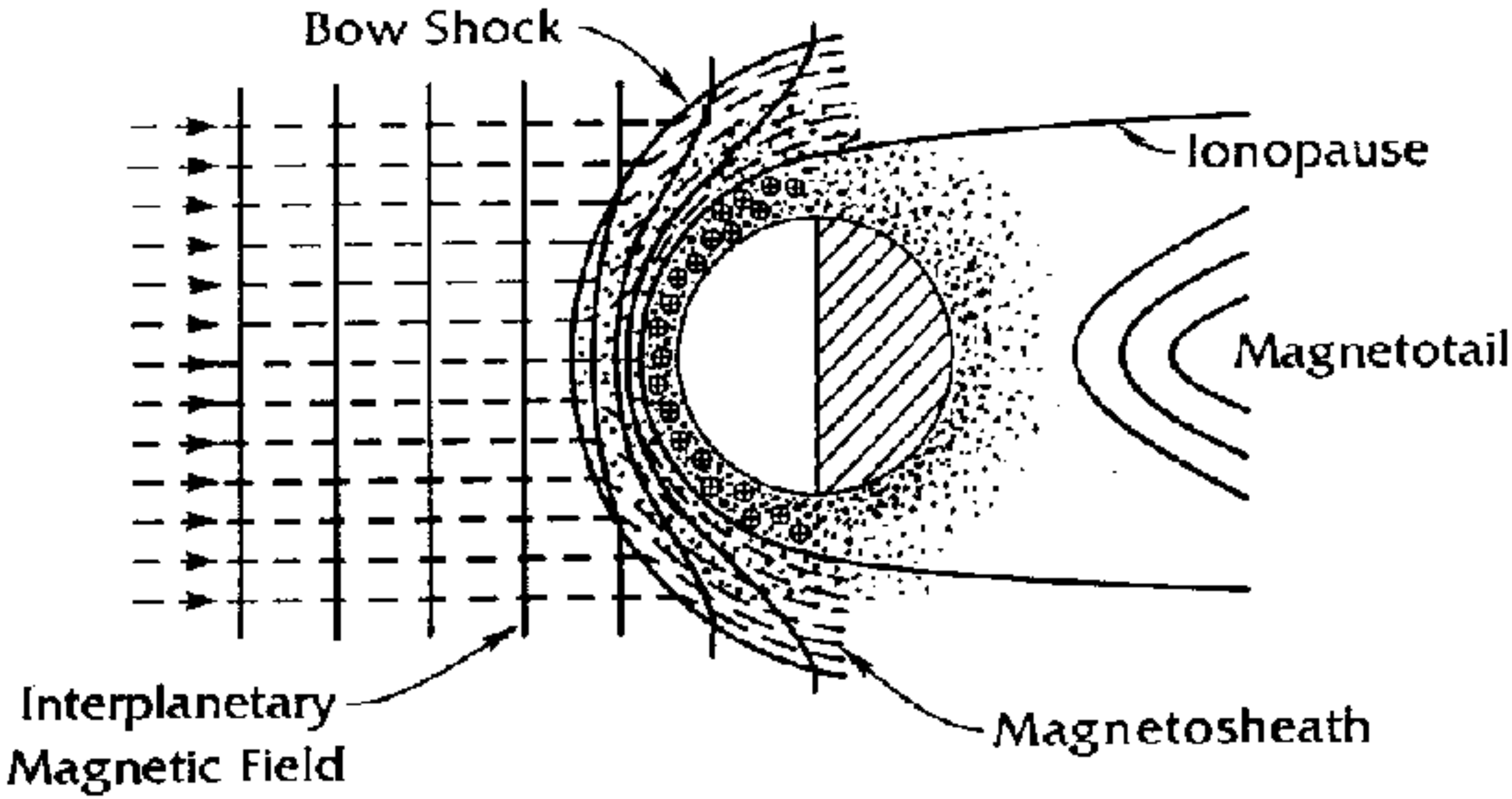
Precipitation and escape at Mars and Venus

Gabriella Stenberg

Swedish Institute of Space Physics

Kiruna

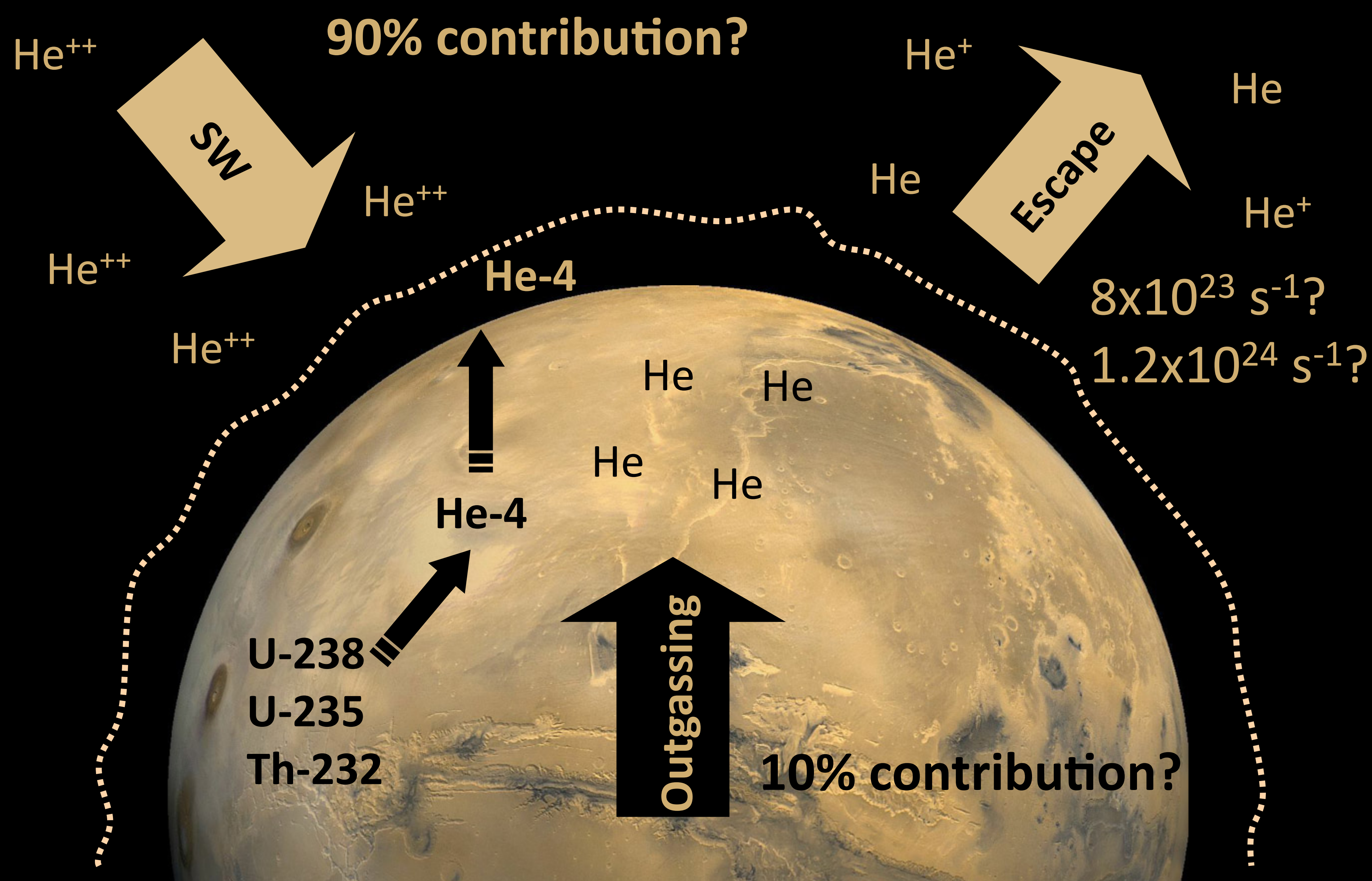
Induced magnetospheres



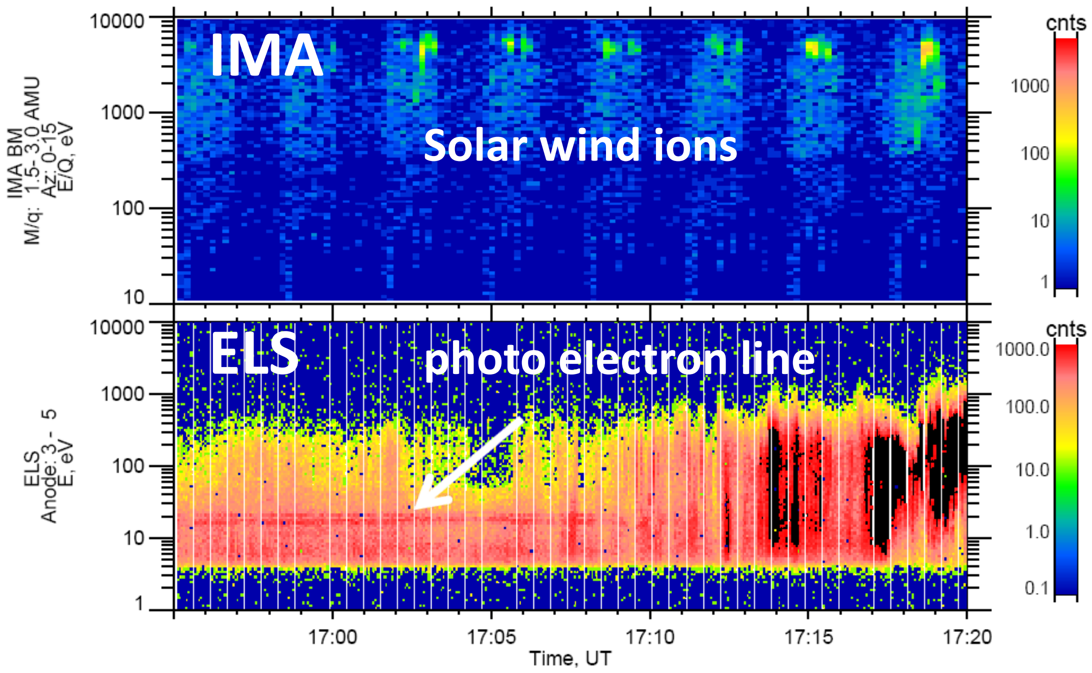
Smaller in size.

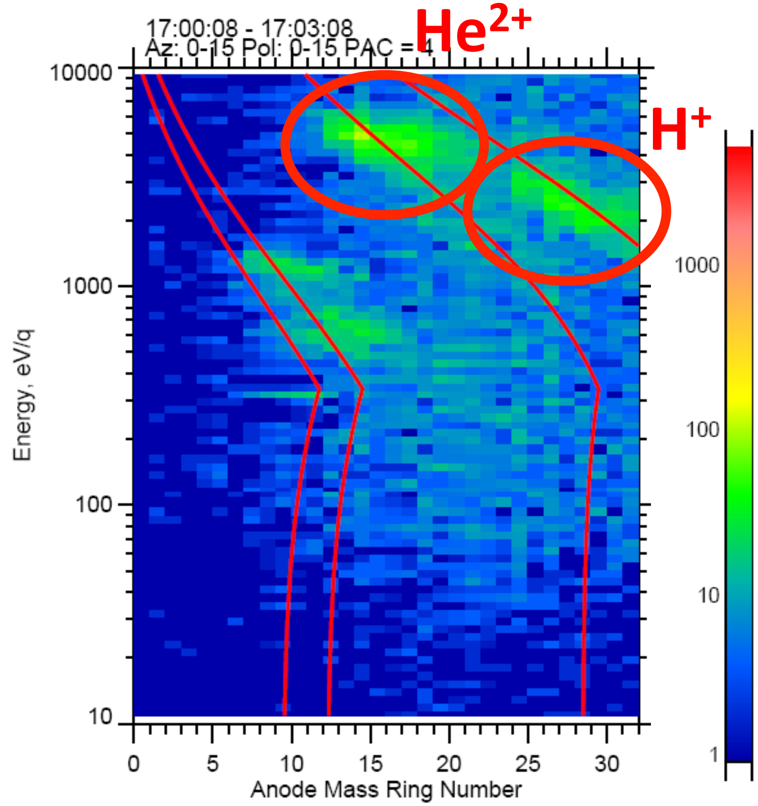
The solar wind directly interacts with the atmosphere.

The Helium balance



Solar wind precipitation at Mars

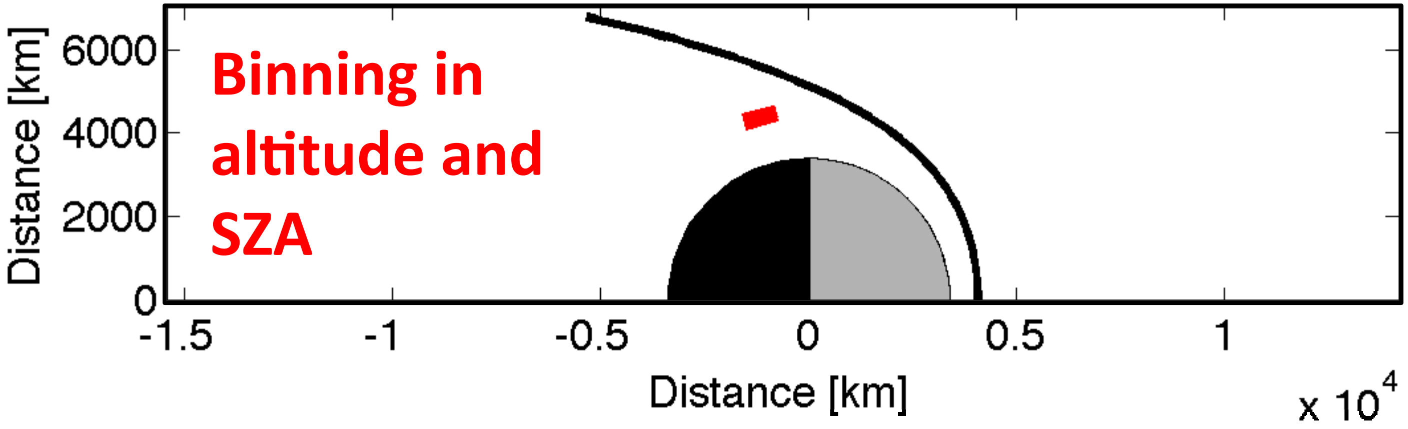




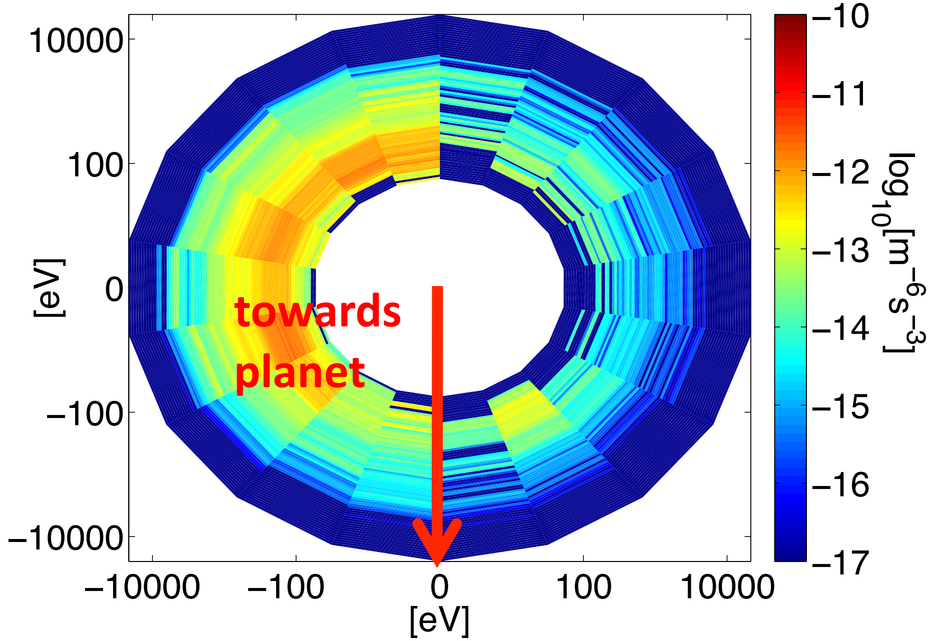
Intermittent precipitation
Narrow in energy and direction
Both up- and down-going fluxes

Lundin et al, 2004
Stenberg et al., 2011
Diéval et al., 2012a & 2012b
Shematovich et al., 2012

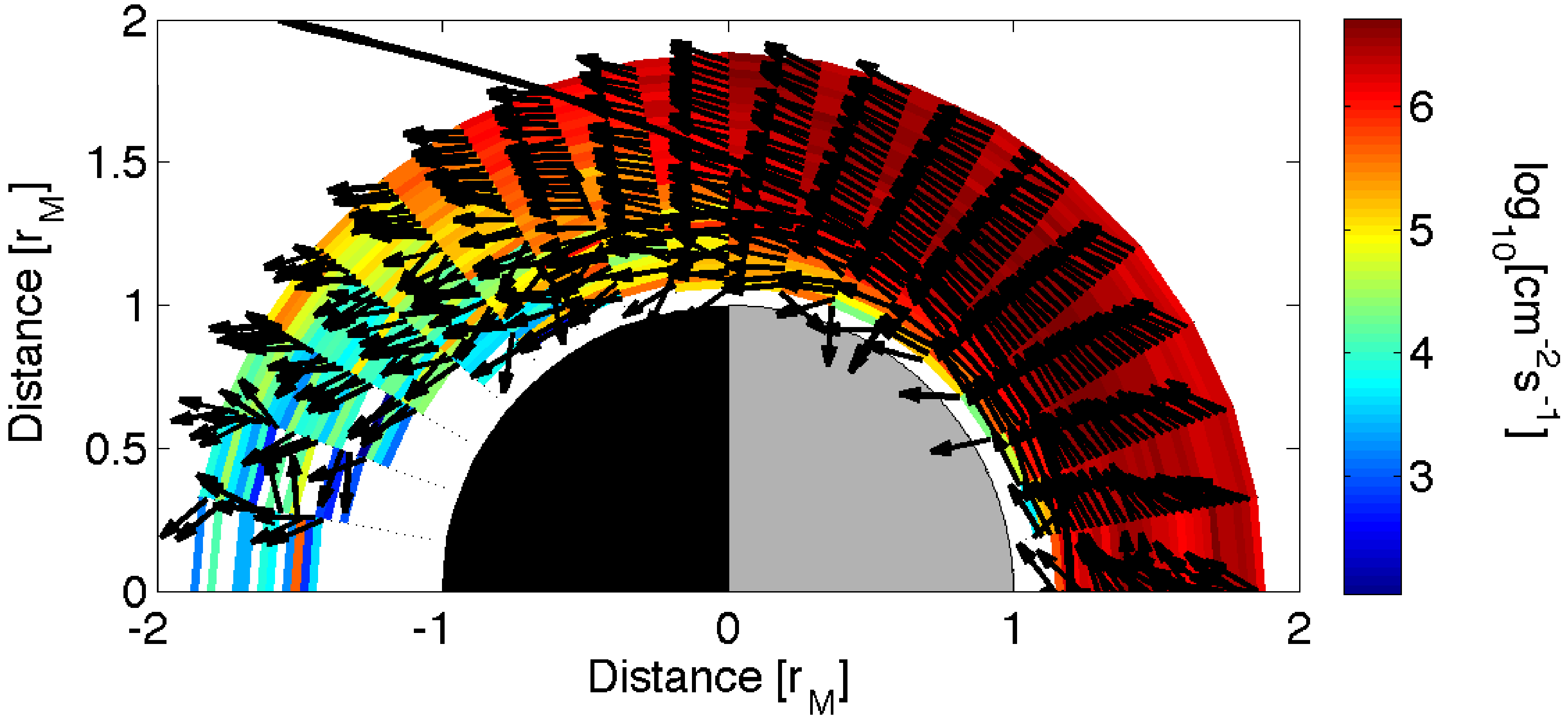
Statistical approach



Average distribution function



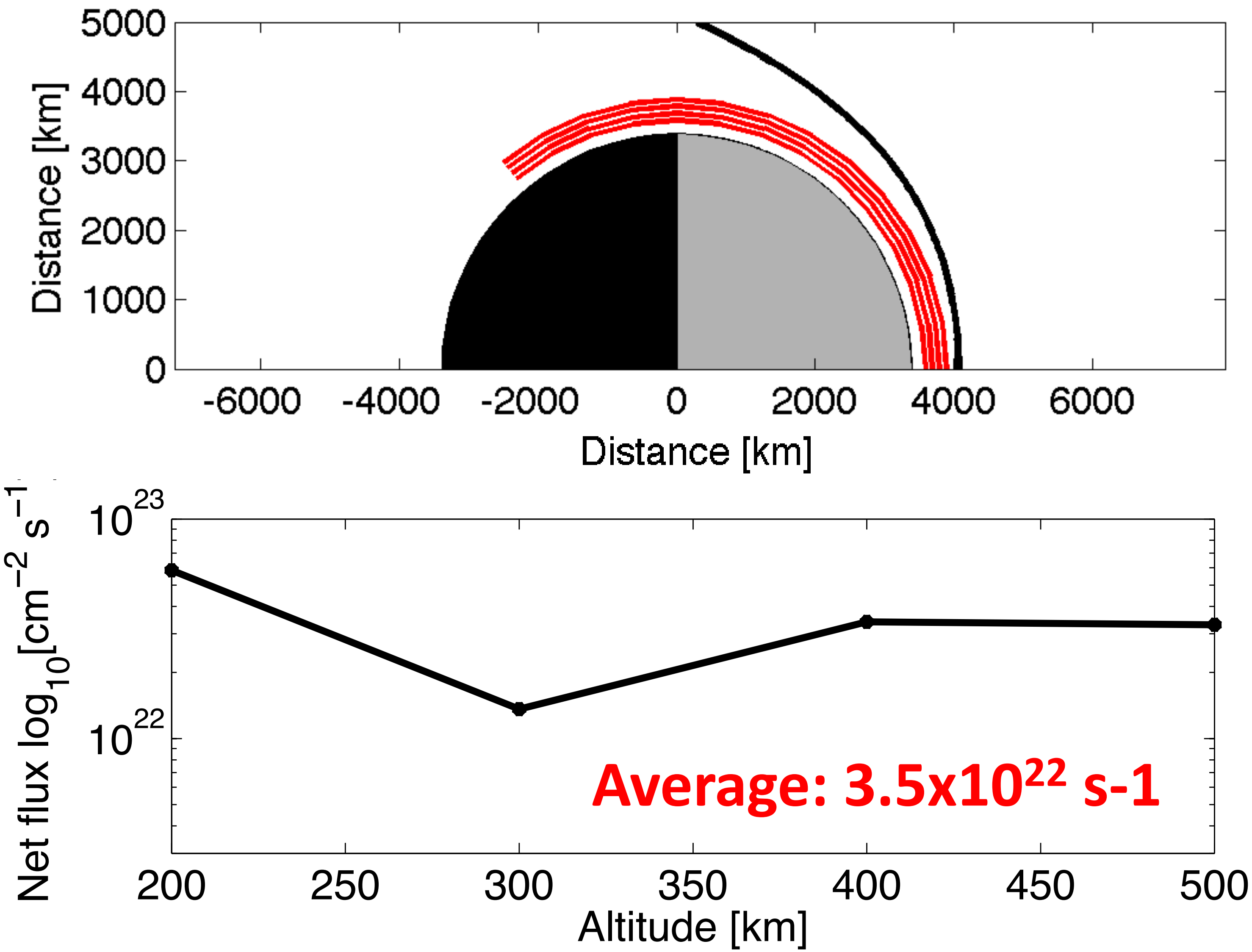
Total He^{2+} flux and flow direction



Colour-coded: Omni-directional flux

Arrows: Net-direction of flow

He^{2+} flux through 4 spherical shells



The Helium balance - Mars

Stenberg et al., 2012 (MEX):
3.5×10^{22} s^{-1}

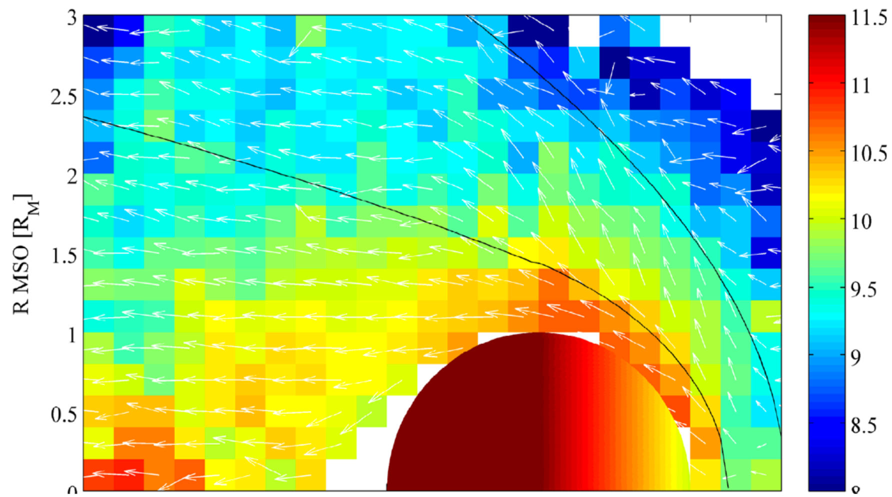
Chanteur et al., 2009 (modelling):
7×10^{23} s^{-1}

Barabash et al., 1995 (Phobos 2):
1.2×10^{24} s^{-1} (He^{+})

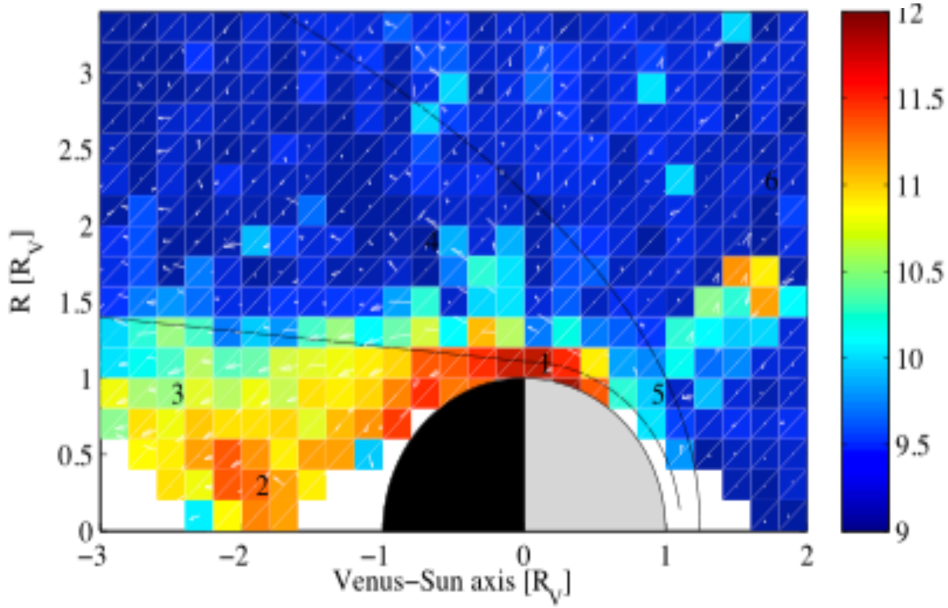
Krasnopolsky and Gladstone, 1996 (modelling):
8×10^{23} s^{-1}

Atmospheric escape

Mars



Venus

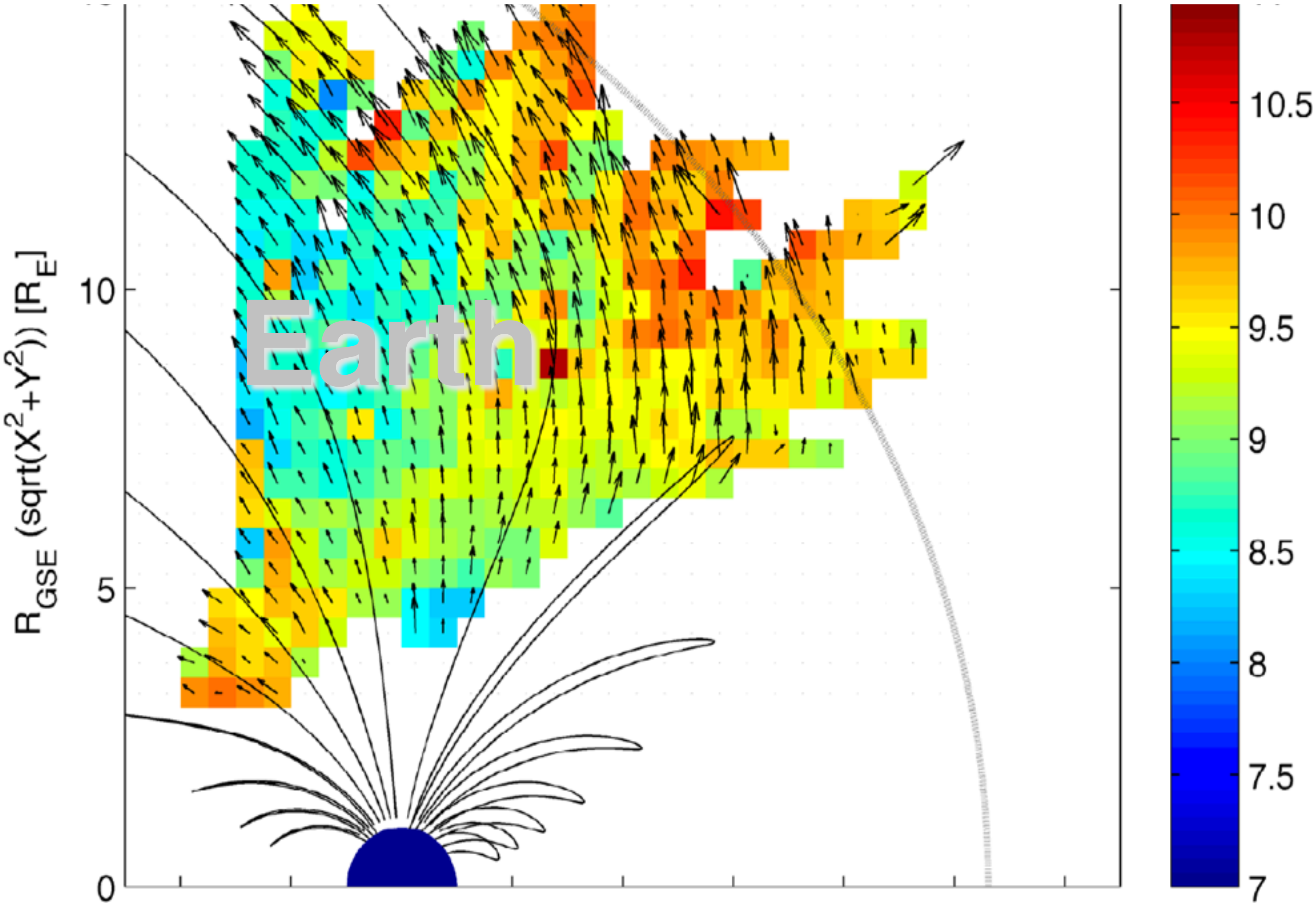


Colour-scale: Flux [m-2 s-1] of heavy ions (log10)

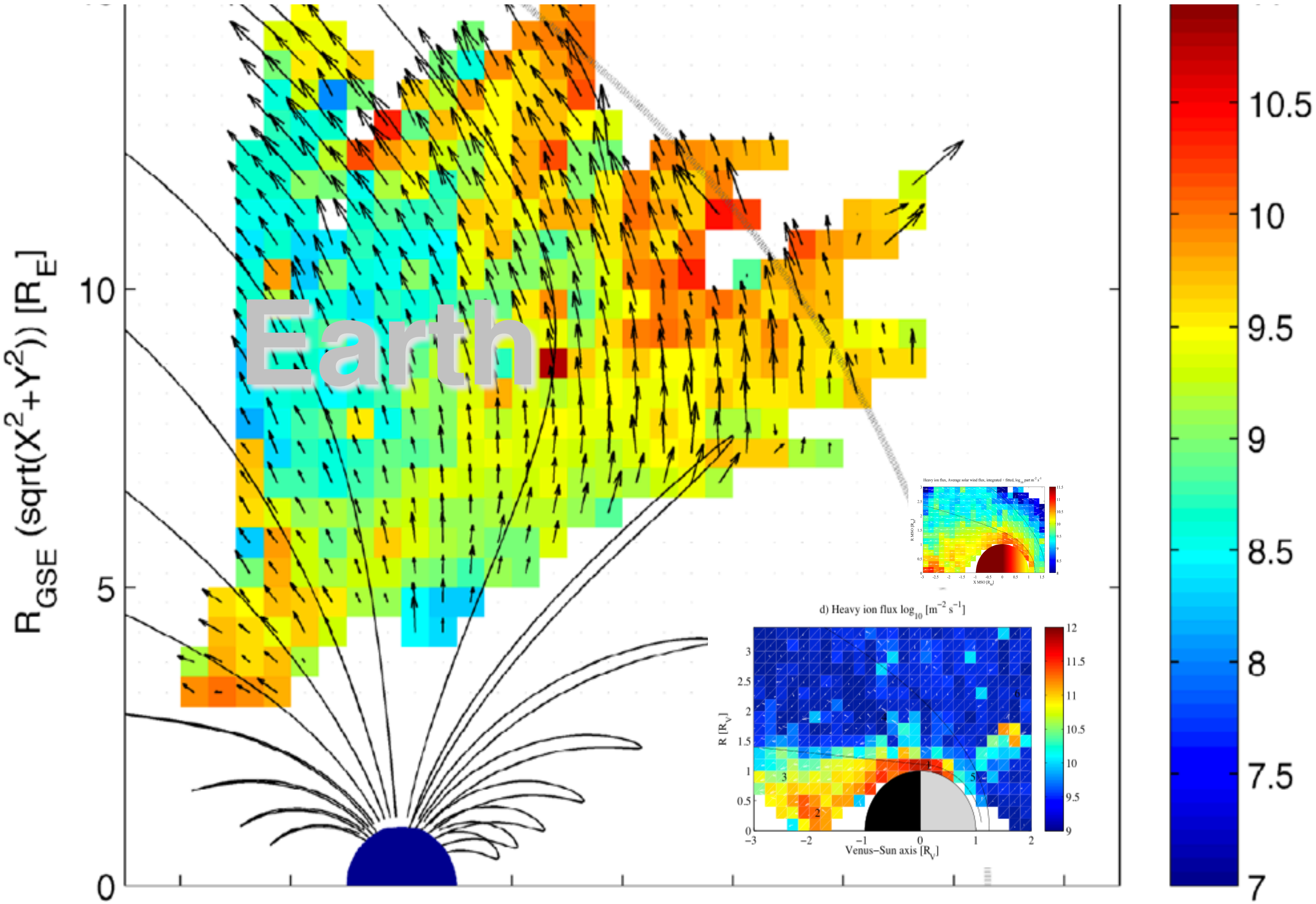
Escape rates

Condition /Planet	Minimum	Maximum
Venus	**2.7×10^{24} /s** (Fedorov et al. 2011)	**6×10^{24}-5×10^{25} /s** (Brace et al. 1987, McComas et al. 1986)
Mars	**3×10^{24} /s** (Nilsson et al. 2011)	**3×10^{25} /s** (Lundin et al. 1989)
Earth	**3×10^{24} /s** (Nilsson et al. 2011)	**3×10^{25} /s** (Lundin et al. 1989)

Size comparison



Size comparison



Conclusions

✓Solar wind He^{2+} precipitate onto the ionospheres both at Mars and Venus.

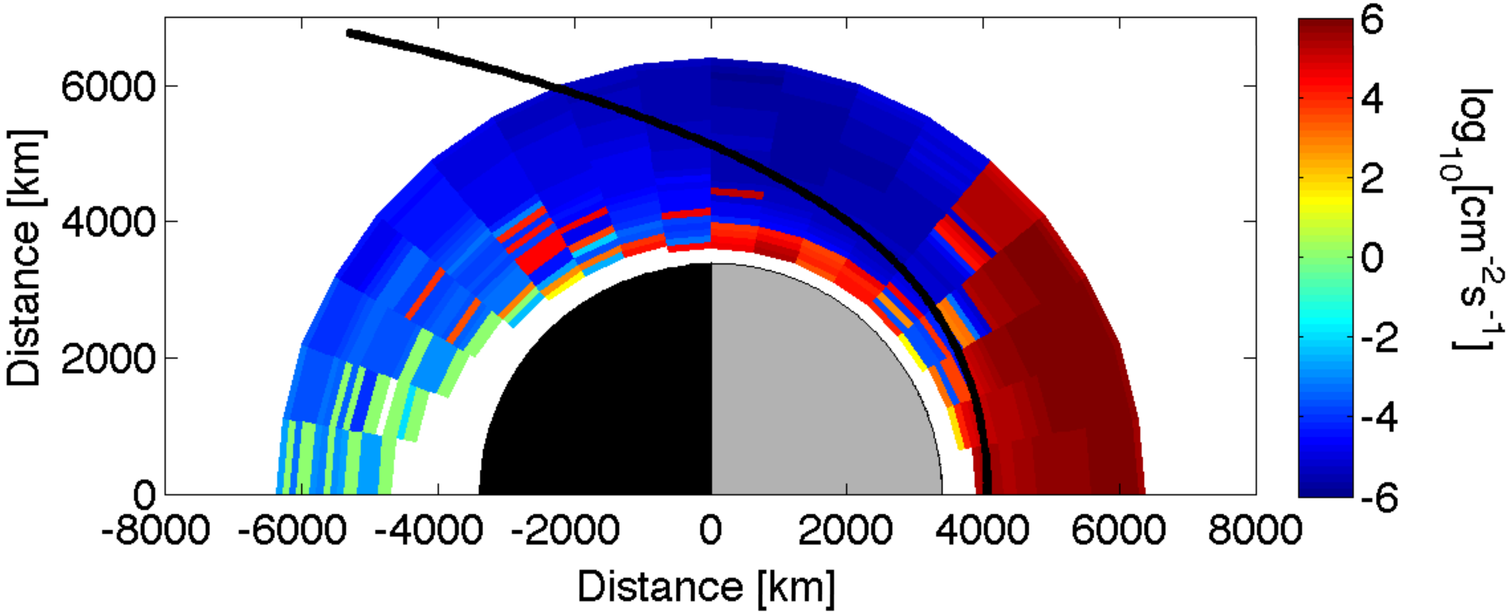
✓The best estimate of the inflow of He^{2+} at Mars is 3.5×10^{22} s^{-1}. This is just a few percent of the solar wind He^{2+} and at Venus the inflow is much smaller: **Our current models are wrong!**

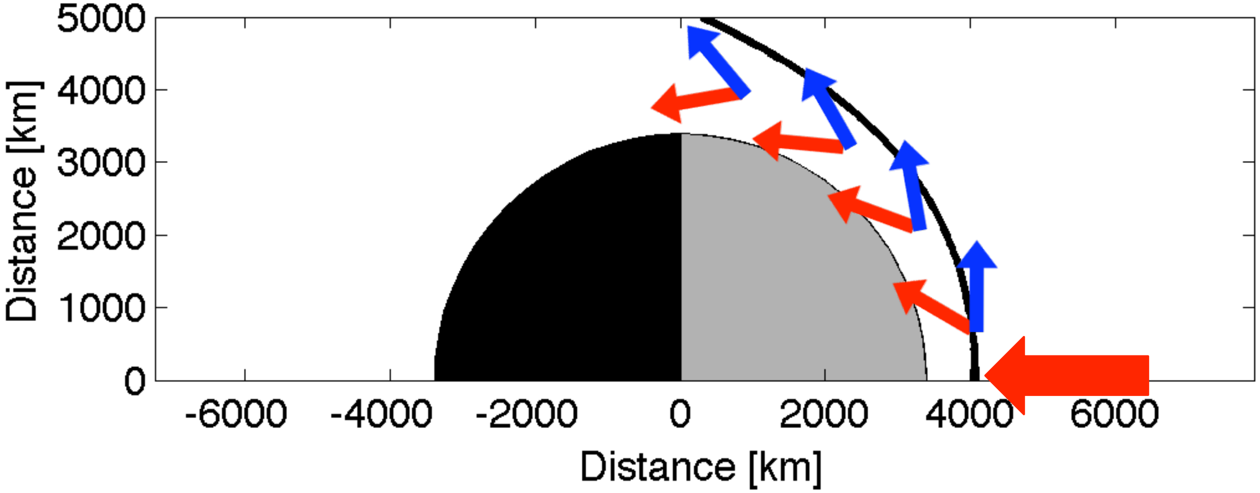
✓The oxygen escape from Venus and Mars is comparable to the escape from Earth. The Earth's magnetosphere cannot protect the atmosphere. **Compare the sizes of the objects!**

He^{2+} flux in radial direction

Upgoing

Downgoing





Solar Wind Precipitation

Planet	SW Proton precipitation	SW Alpha Precipitation
Venus	10^{21}-10^{22}/s	10^{20}-10^{21} /s
Earth	10^{24} /s	10^{23} / s
Mars	10^{21}-10^{22} /s	10^{22} /s

Alpha: Stenberg et al., 2011, Protons: Dieval et al. 2012a,b
Earth: Hardy et al. (1989) (+back of the envelope)

The big context

And what about Venus?