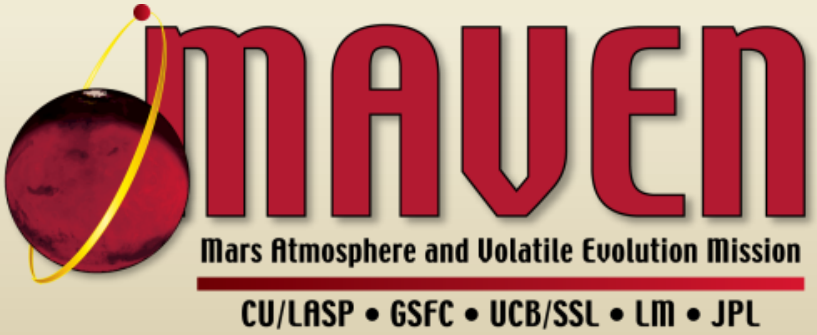
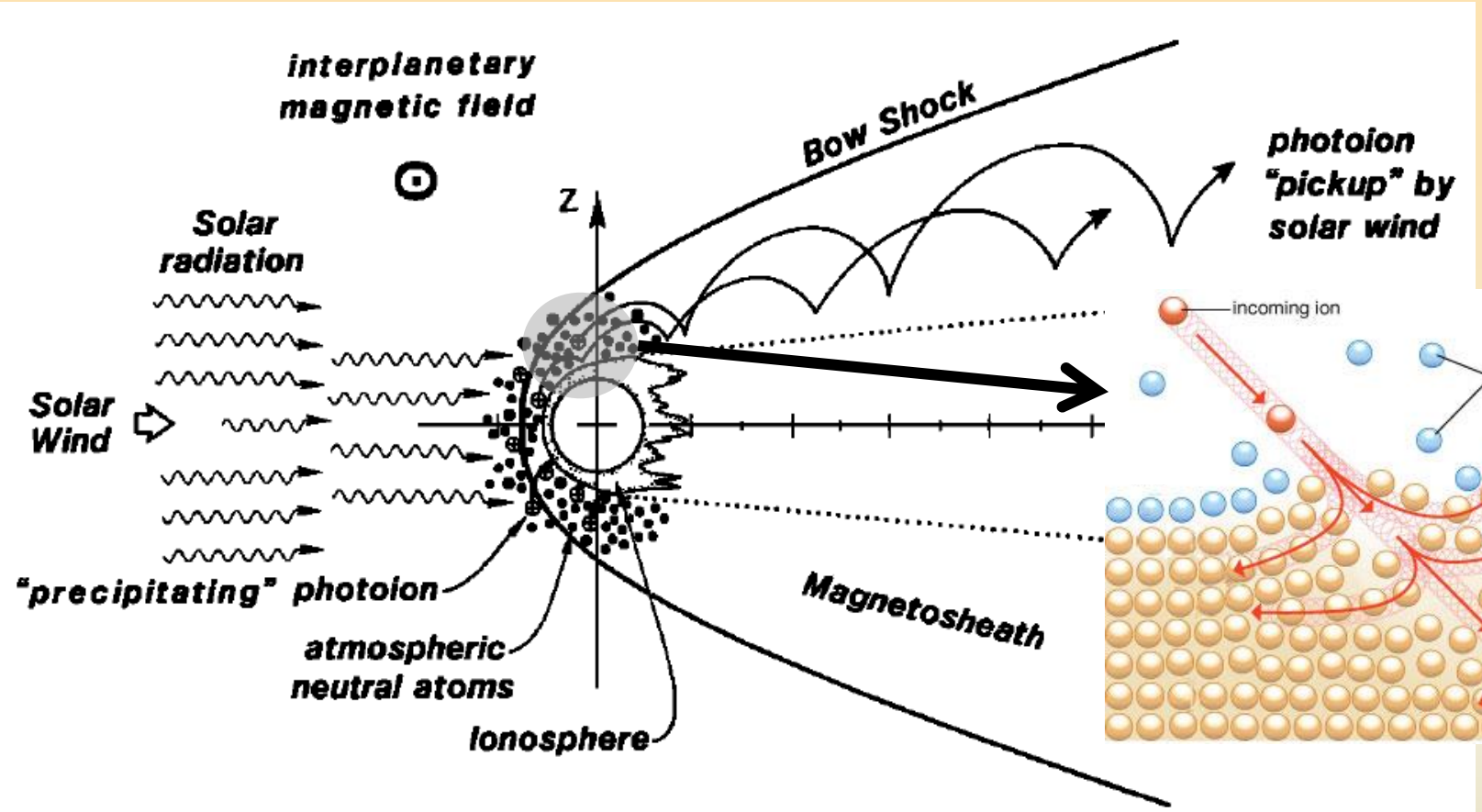
Signatures of sputtering at Mars: a first evidence?

F. Leblanc, *M. Benna, J.Y. Chaufray, A. Martinez, M. K. Elrod, P. Mahaffy, R. Modolo, J.G. Luhmann, R.E. Johnson, and B. Jakosky*



Sputtering



Luhmann & Kozyra (1991)

Solar wind ions and planetary picked up ions can precipitate into the atmosphere and lead to atmospheric escape (O, C, CO_2…)

Average measured precipitating differential flux

MAVEN
Mars Atmosphere and Volatile Evolution Mission
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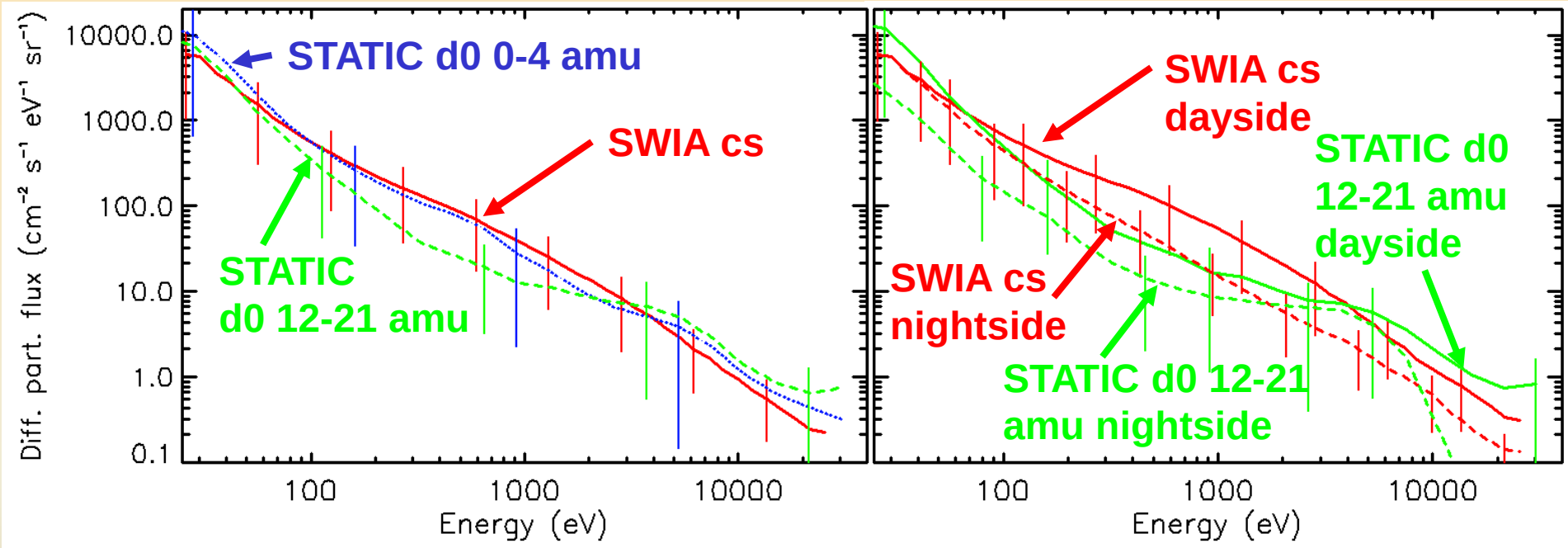
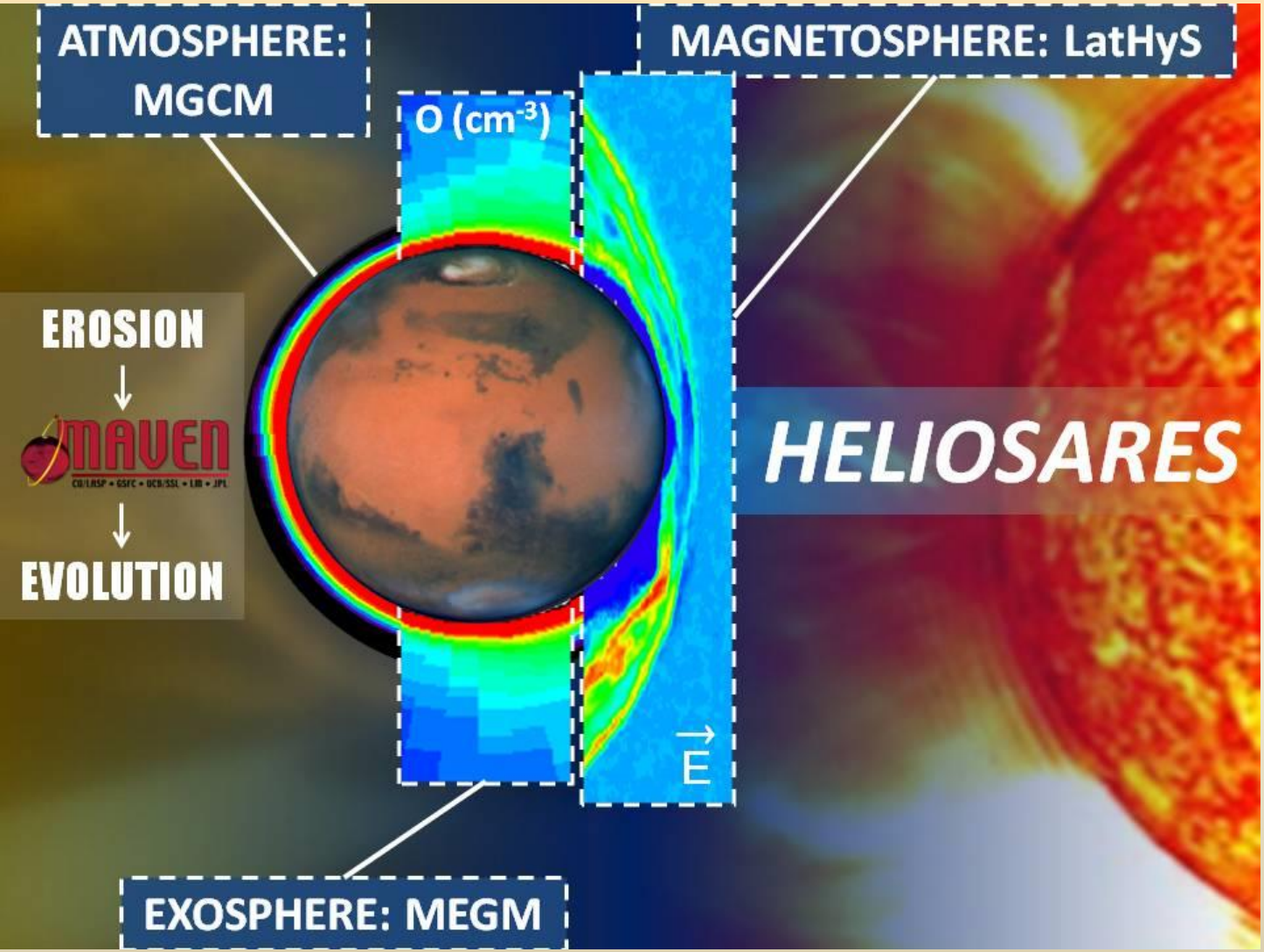
12/2014 - 12/2017



ALL DATA

NIGHTSIDE
DAYSIDE

Use of HELIOSARES to model the effect of MAVEN measured precipitation on Mars' atmosphere



Modelling of both sputtering and dissociative recombination for a given Ls and solar activity

Analysis with HELIOSARES of IUVS O 130.4 nm

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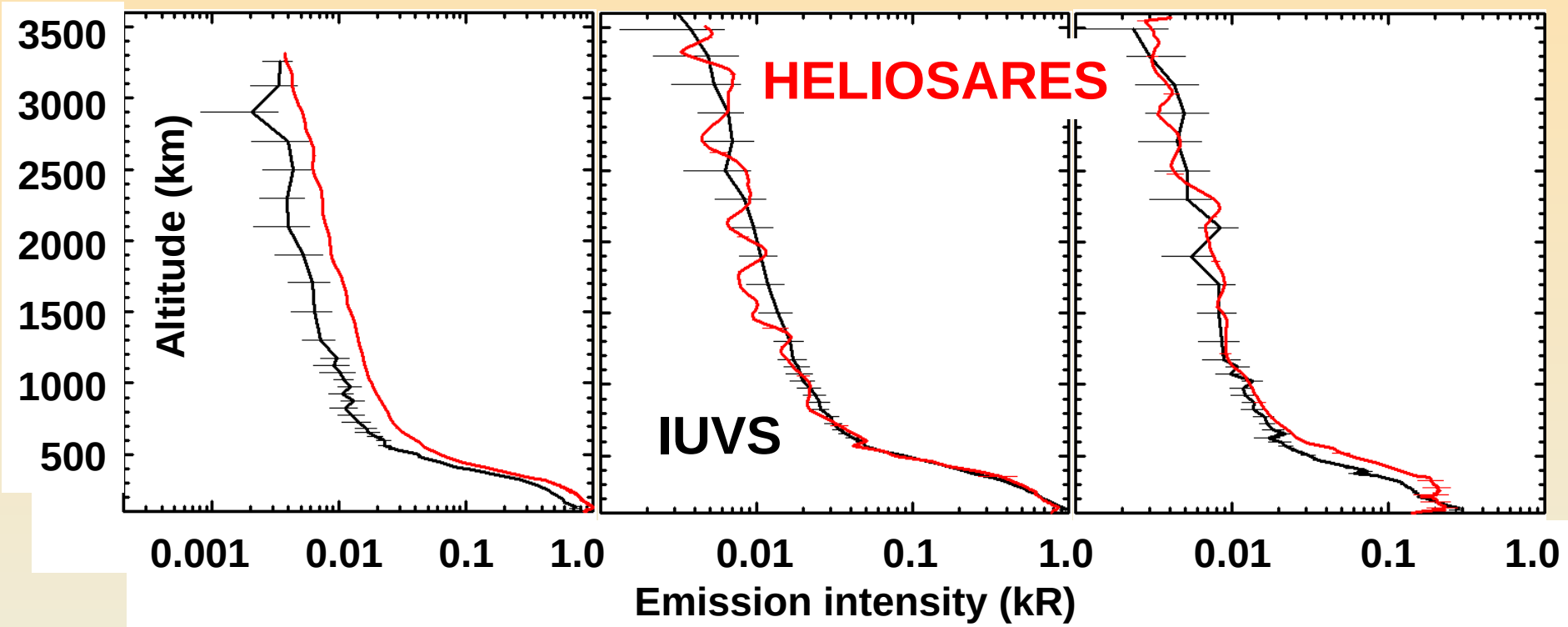
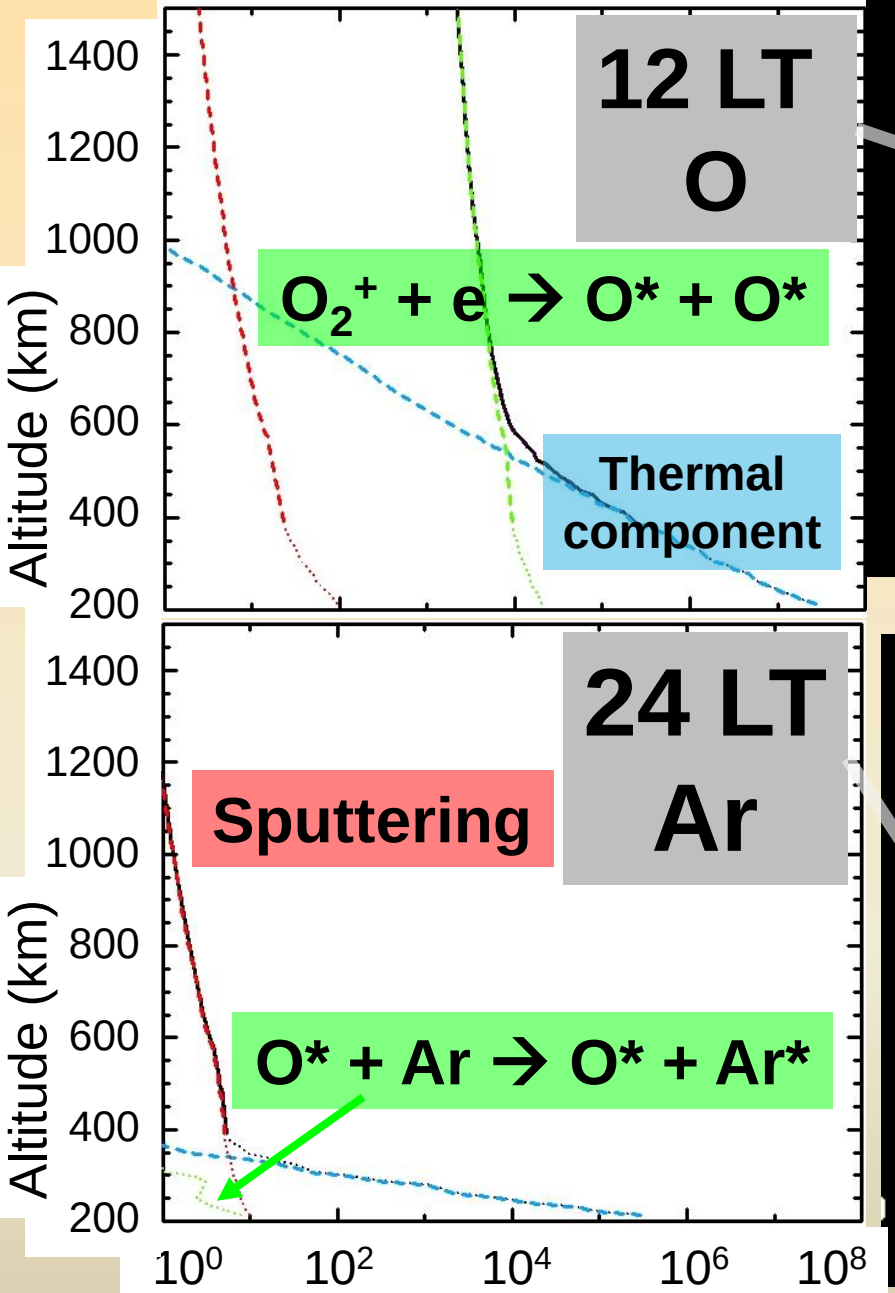


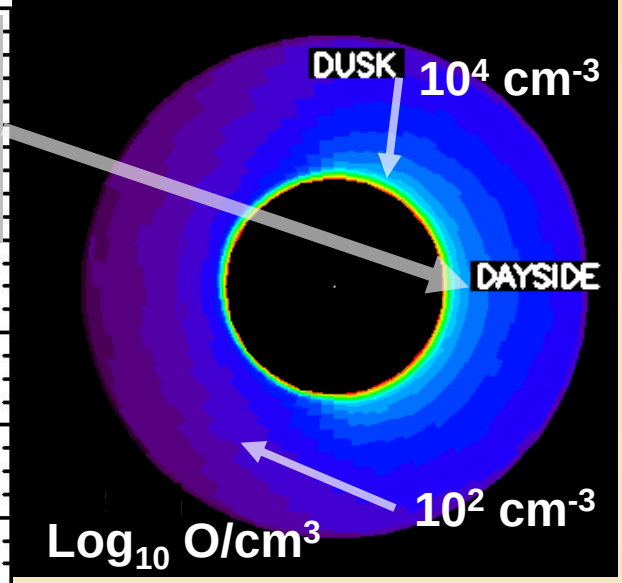
Ls = [187°, 197.6°]
SZA = [15.9°, 21.7°]
07/16/2016-08/04/2016

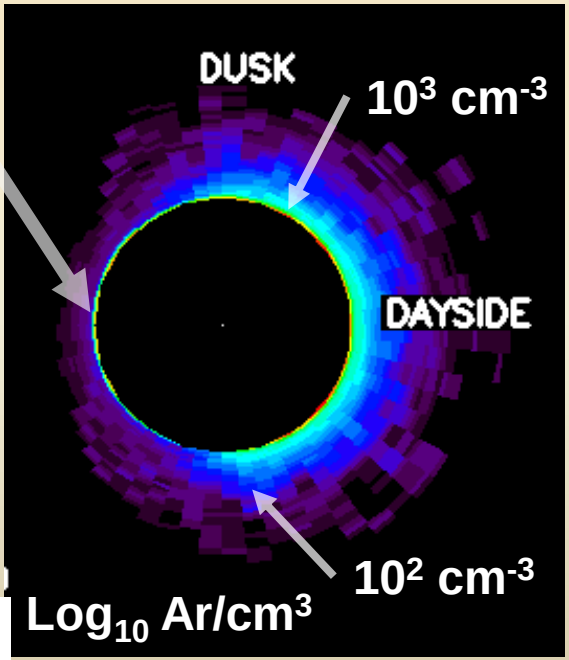
Ls = [251.75°, 263.85°]
SZA = [51.0°, 61.3°]
12/13/2014-01/01/2015

Ls = [288.8°, 298.9°]
SZA = [76°, 85°]
02/09/2015-03/01/2015

Good agreement, validation of collision cross section
Sputtering contribution cannot be identified







HELIOSARES modelling of all components populating the exosphere

The Argon

Ls=180°
Nominal SW

12/01/2014 – 12/31/2017 3923 individual NGIMS profiles (inbound and outbound)

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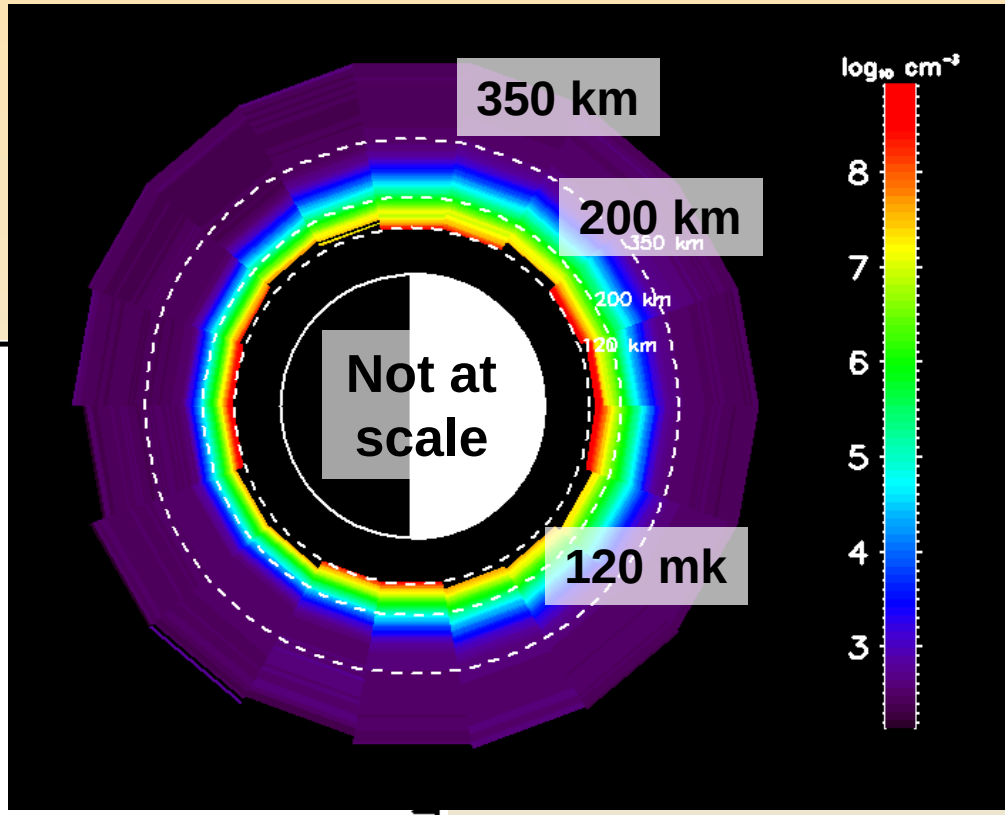
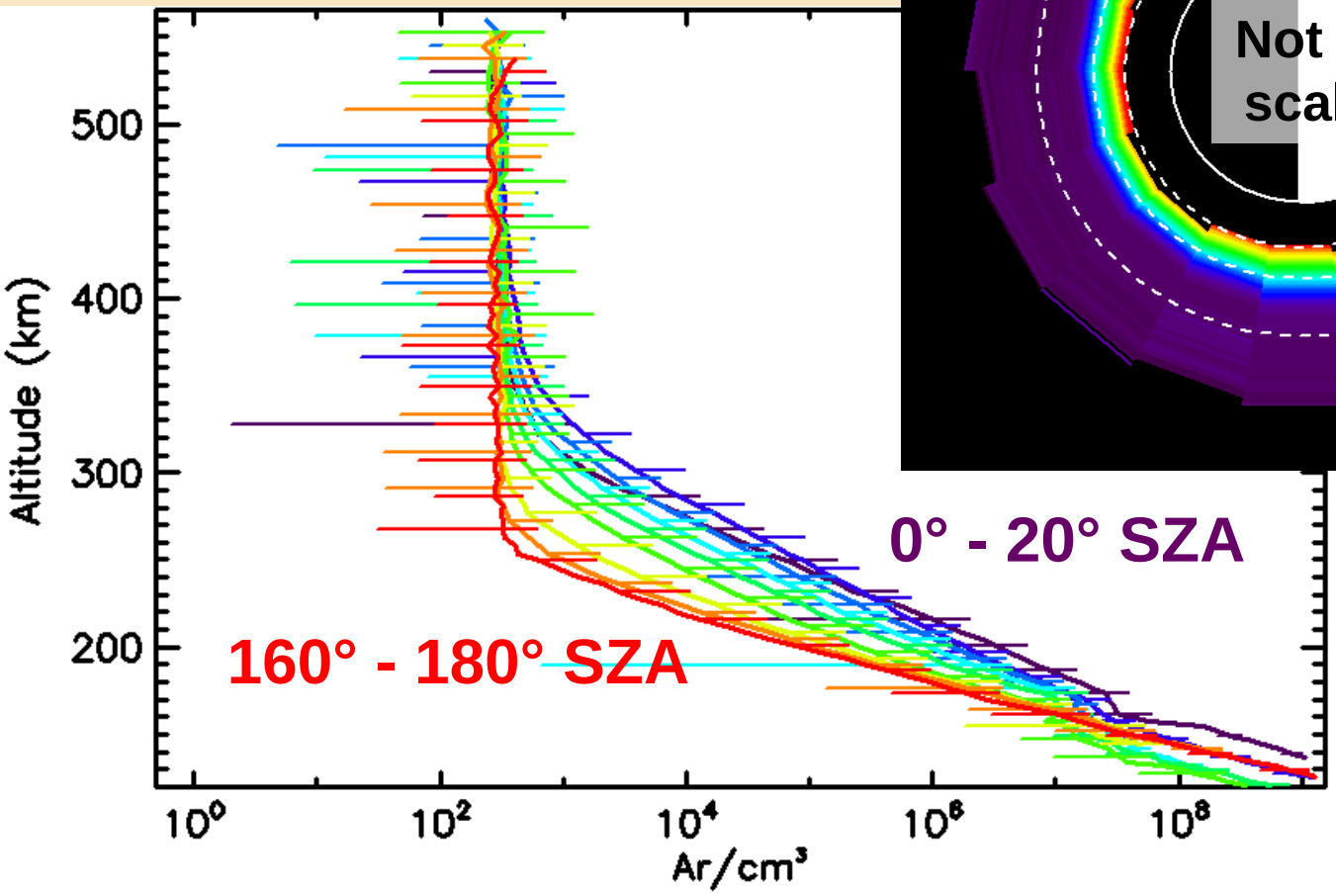
Two slopes Ar density profile





Almost vertical slope above 250 km at SZA > 160° and above 350 km at SZA < 20°

Comparison between HELIOSARES and MAVEN

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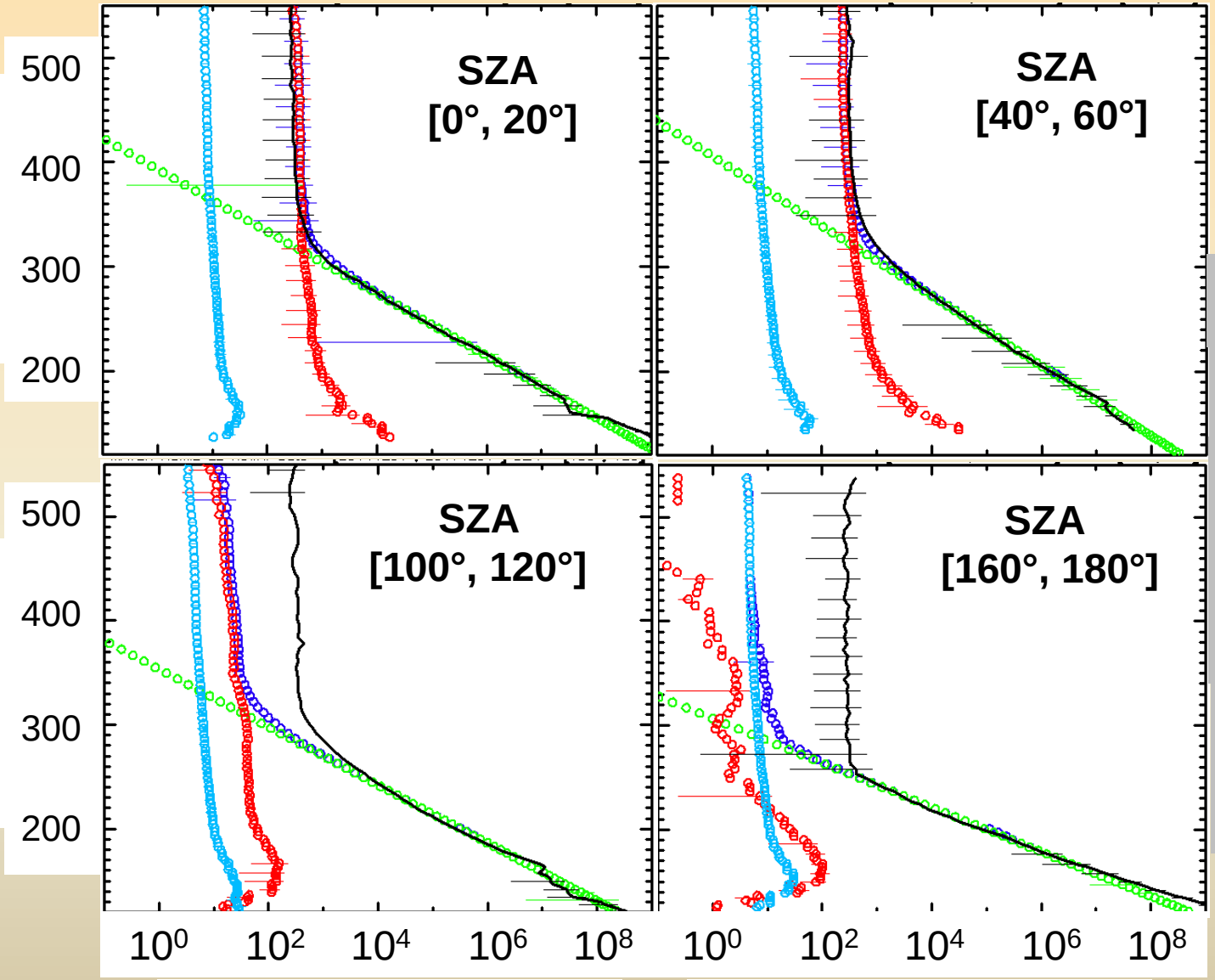

NGIMS

Sum =

Thermal

+

O*+Ar→ O*+Ar*

+

Sputtering

Ar

Comparison between HELIOSARES and MAVEN

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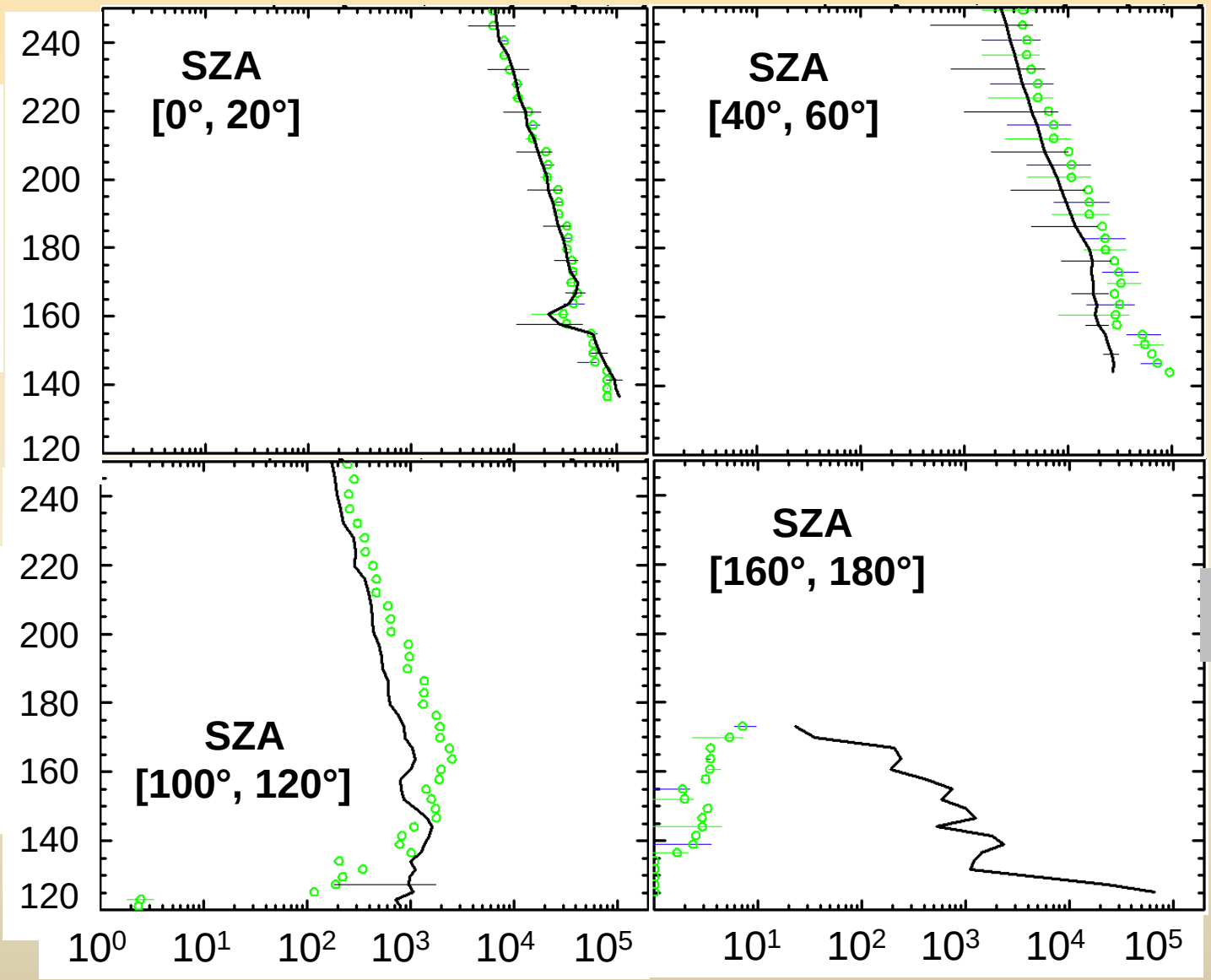


NGIMS

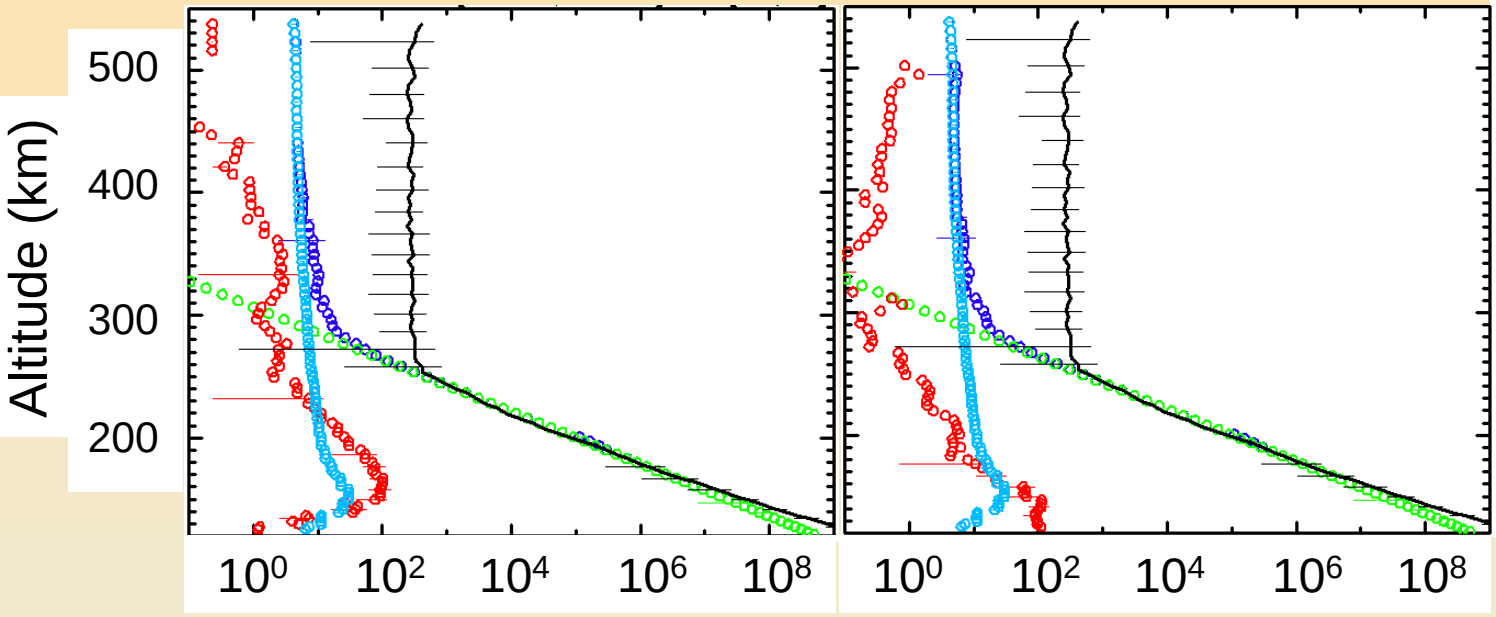
LMD-GCM

O_2^+

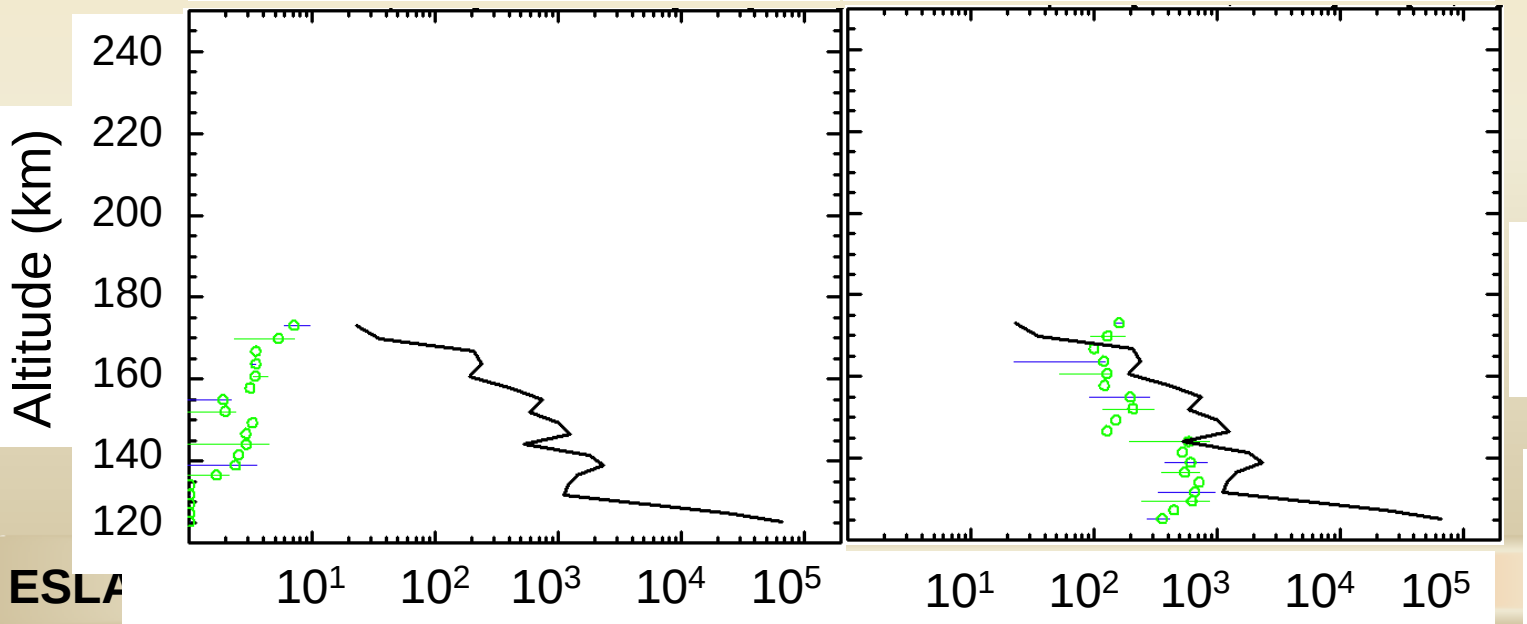
Without ionization by precipitation

With ionization by precipitation

Based on « Empirical Model of Electron Impact Ionization on Mars' Nightside" *by Lillis R.*



Ar density (cm^{-3})

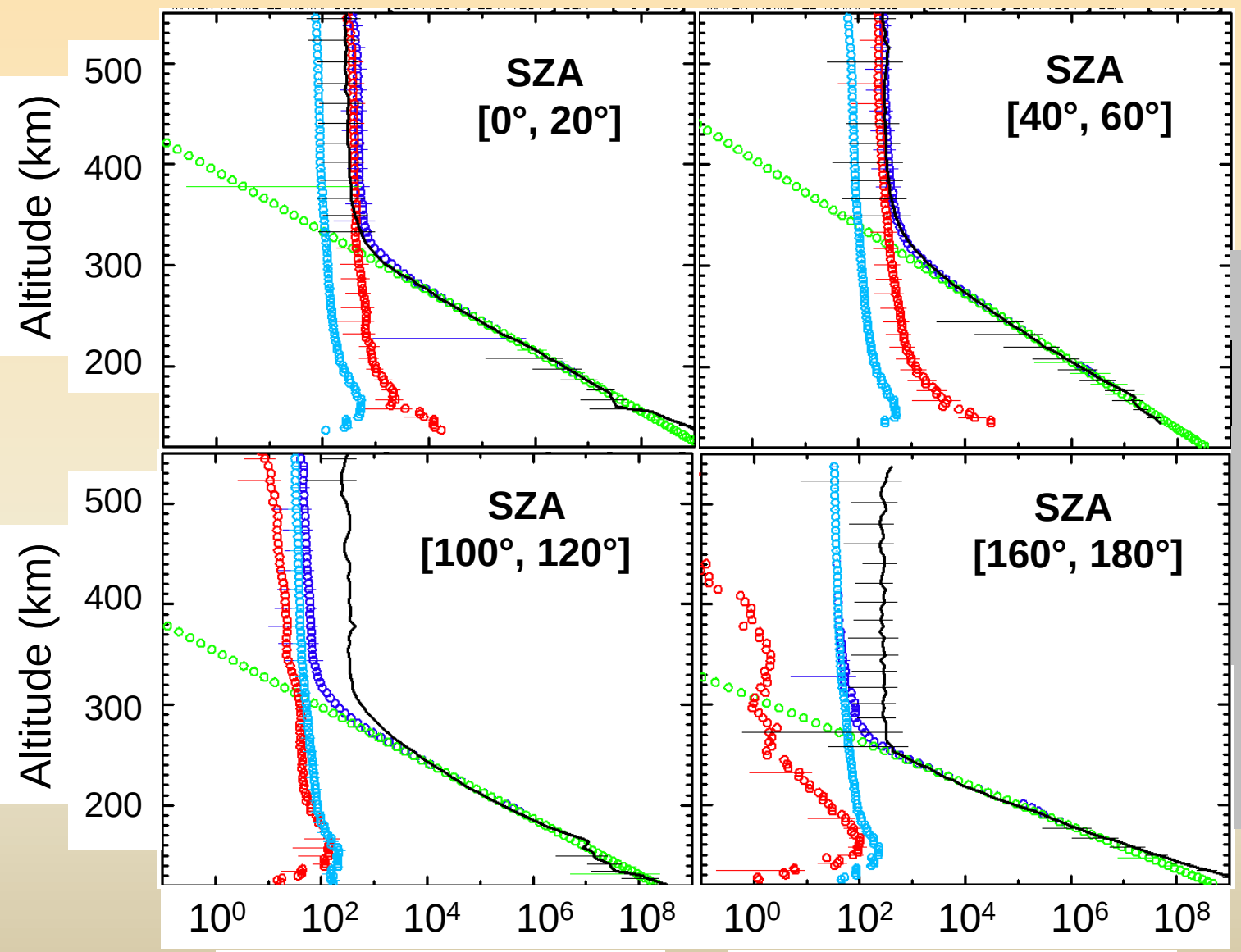


O_2^+ density (cm^{-3})

SZA [160°, 180°]

ESLA

Sputtering: precipitating flux mutiplied by 8



NGIMS

Sum =

Thermal

+

O*+Ar→ O*+Ar*

+

Sputtering

Ar

Conclusions

Clues for indirect observations of atmospheric sputtering

⇒

Sputtering effect might be significantly underestimated:

- **Simulation taking into account only O^+ and not other ions,**
- **Cross section of collision at high energy might be wrong,**
- **Too low signal/noise ratio (background underestimate?)**

What's next?

→MAVEN increased rate of Ar measurements

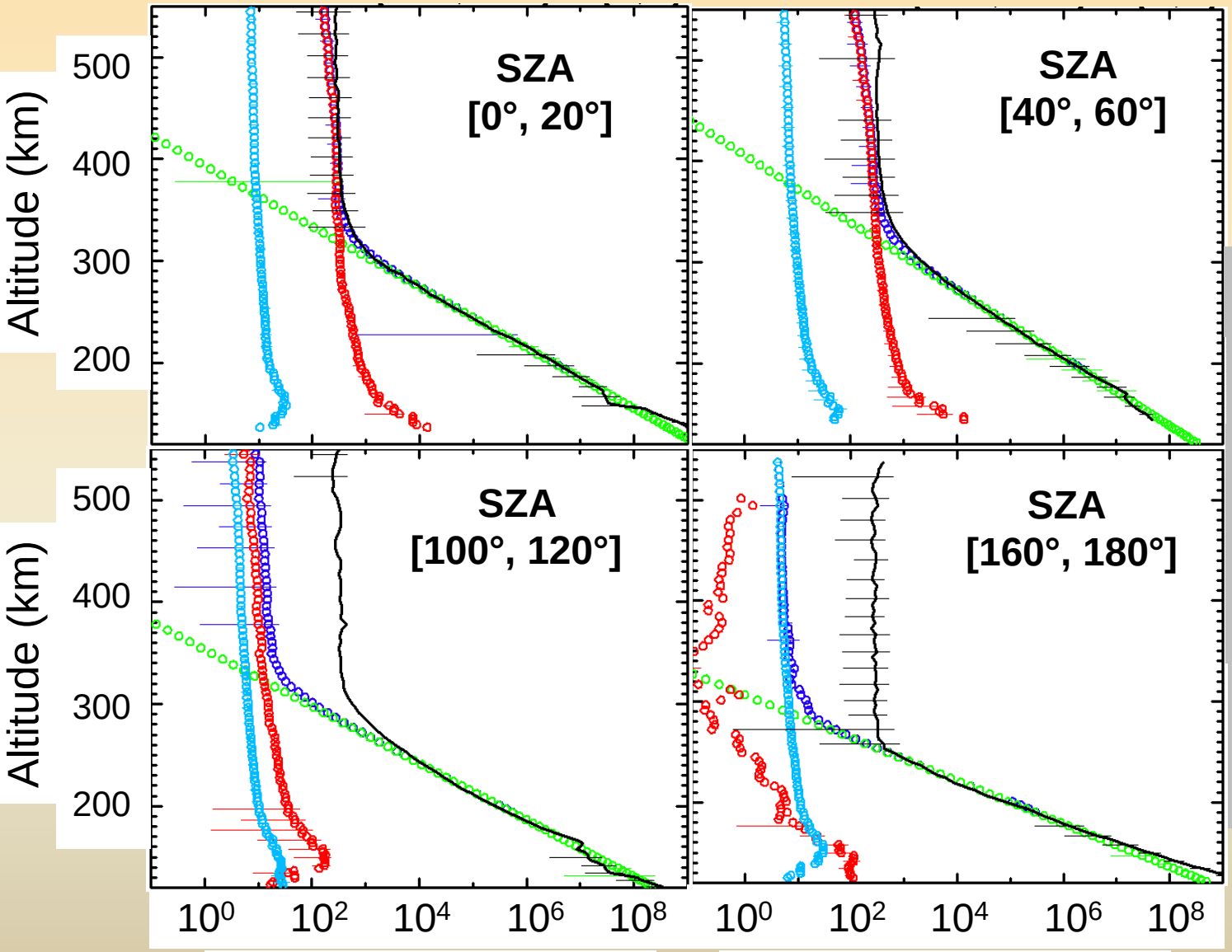
→100 times more measurements above 300 km

→MAVEN Ar measurements at higher altitudes

→Reconstruction of the scale height at various SZA

BACK-UP

Ar night density: with ionization by precipitation



NGIMS

Sum =

Thermal

+

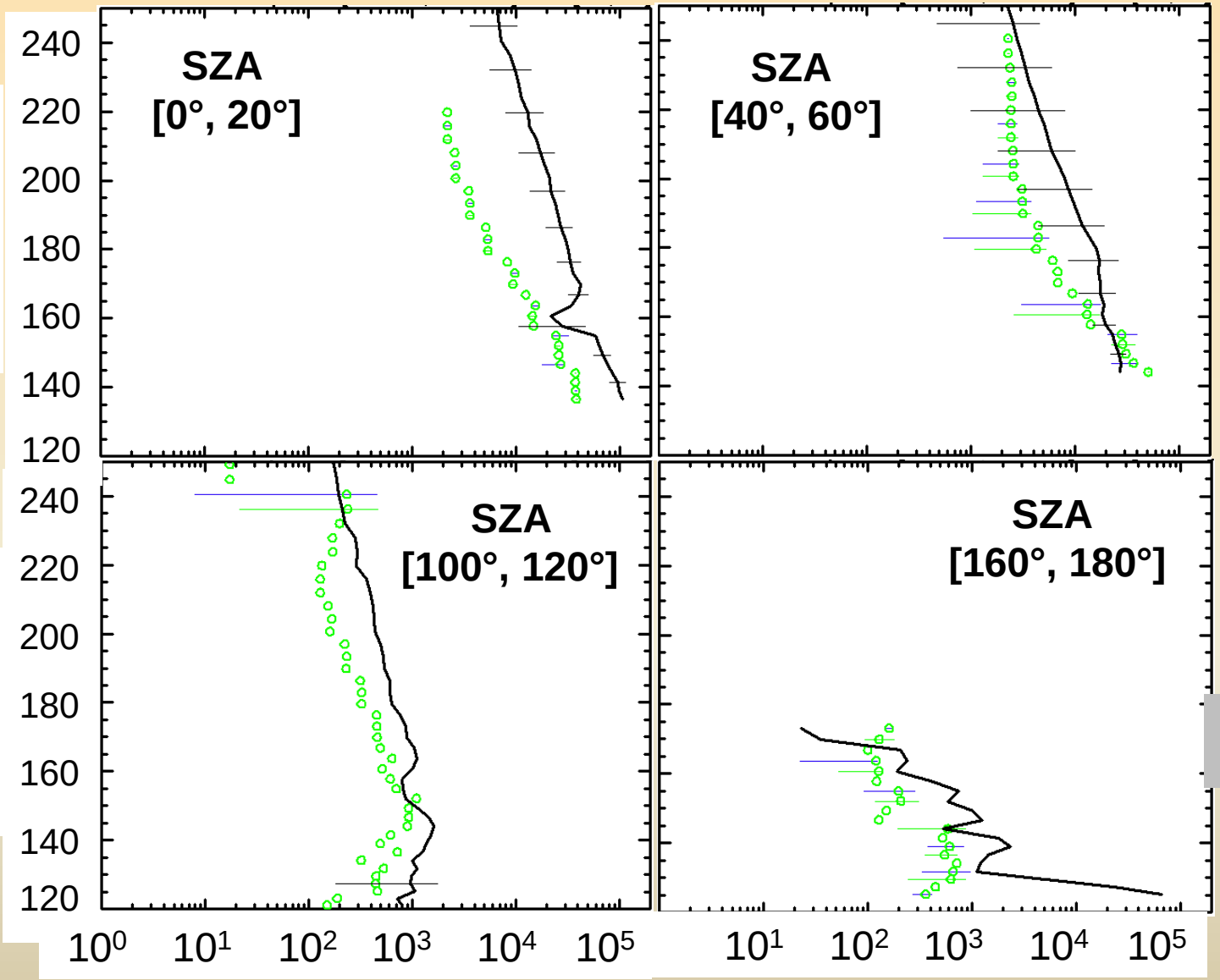
O*+Ar→
O*+Ar*

+

Sputtering

Ar

O_2^+ night density: with ionization by precipitation



NGIMS

LMD-GCM

O_2^+