Metastable oxygen $O(^1S)$ Martian airglow: observations and model

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Why study this particular emission?

- Not particularly bright
- Not extensively observed in the past

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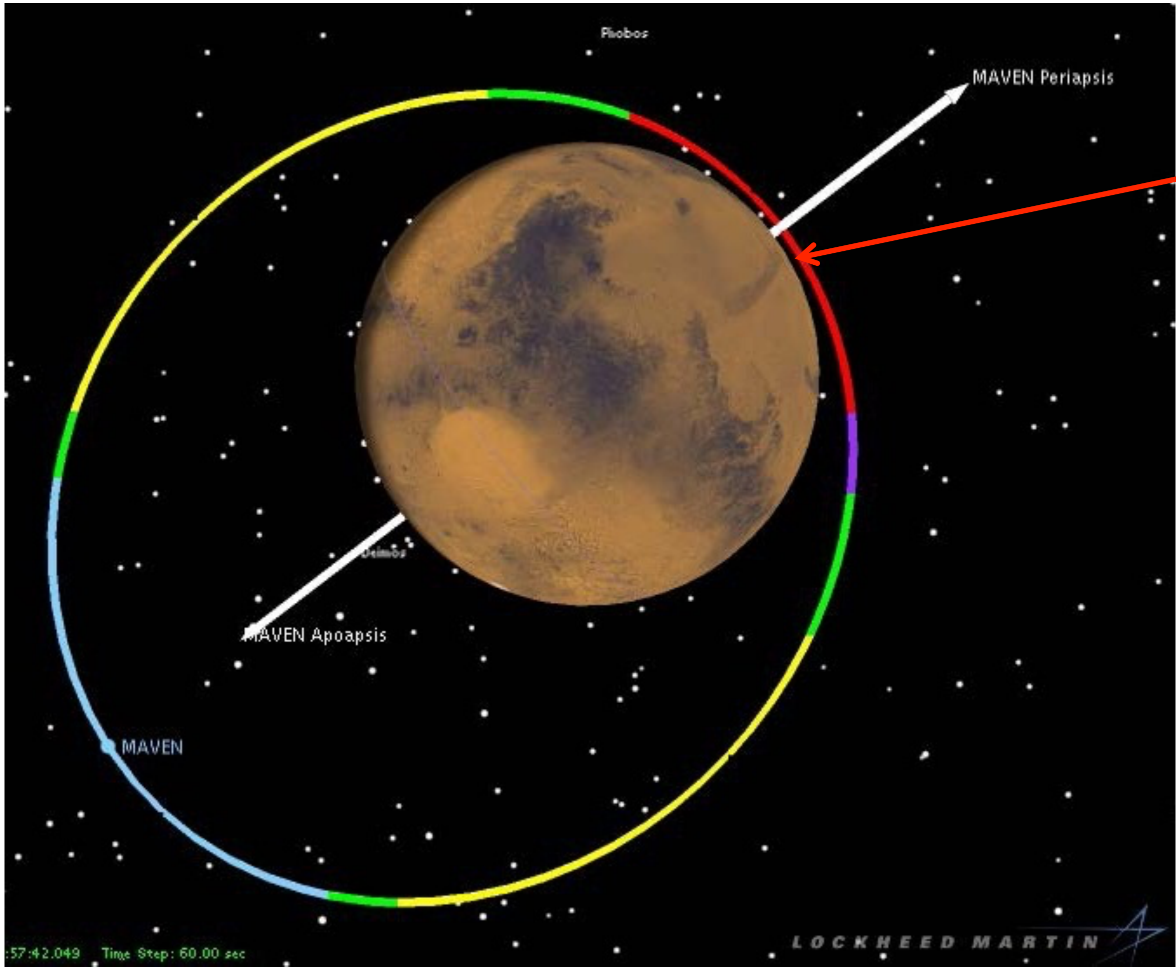
BUT:

- IUVS-MAVEN improved sensitivity provides high S/N ratio
- Its intensity distribution is relatively simple to model and provides direct information on the thermospheric structure
- Very close behavior to a Chapman layer

MAVEN orbit

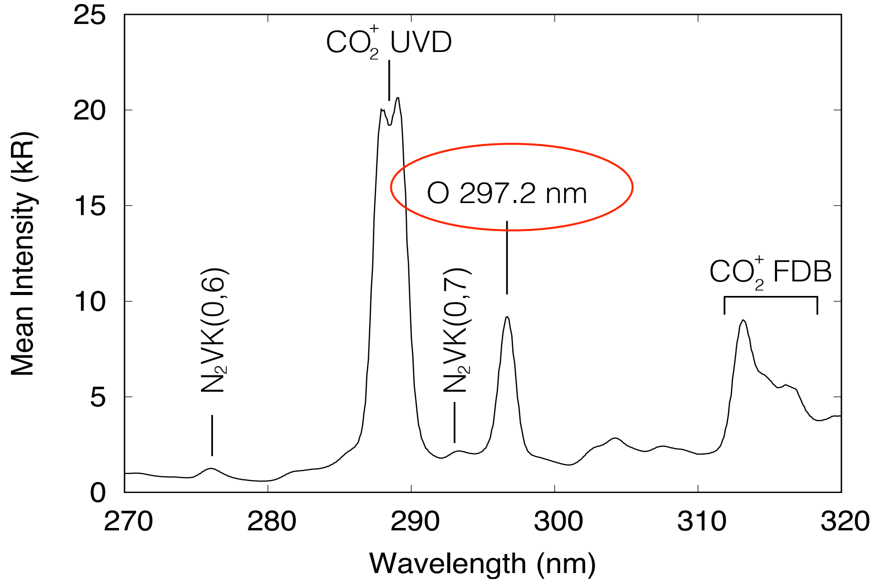


Periapsis phase:
up to 12 successive limb scans

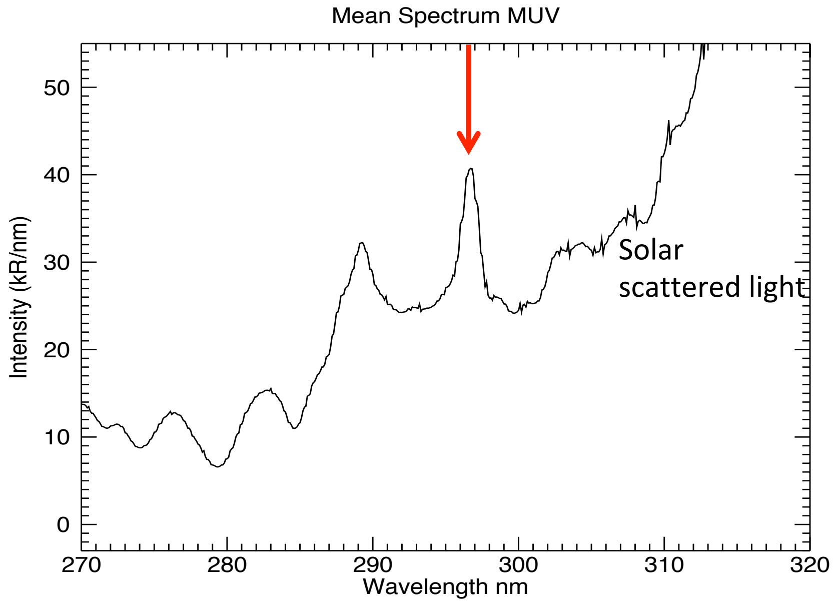
IUVS spectral range:
120 to 320 nm

IUVS Resolution:
1.2 nm

Sum of IUVS limb spectra in the region of the O 297.2 nm emission

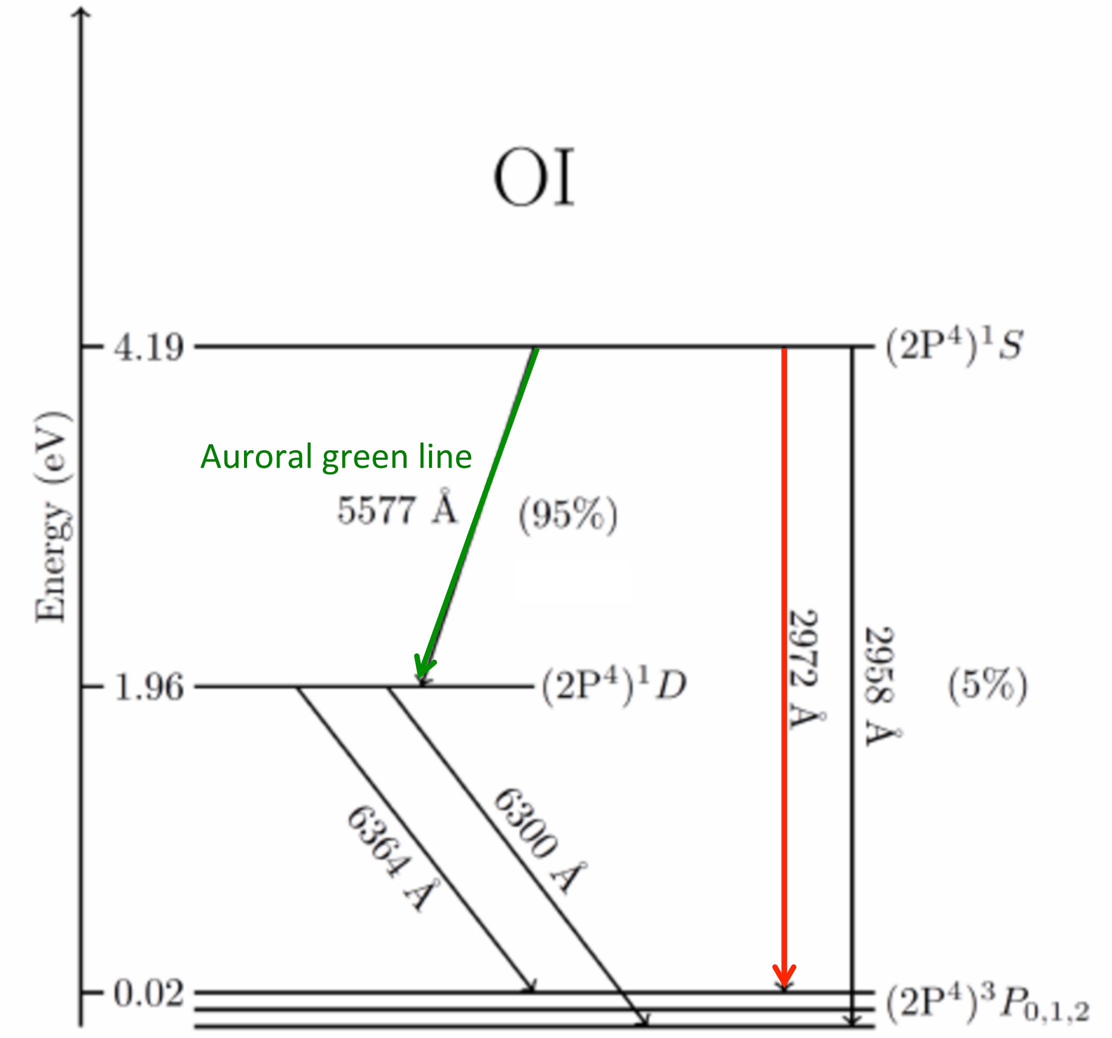


130 km



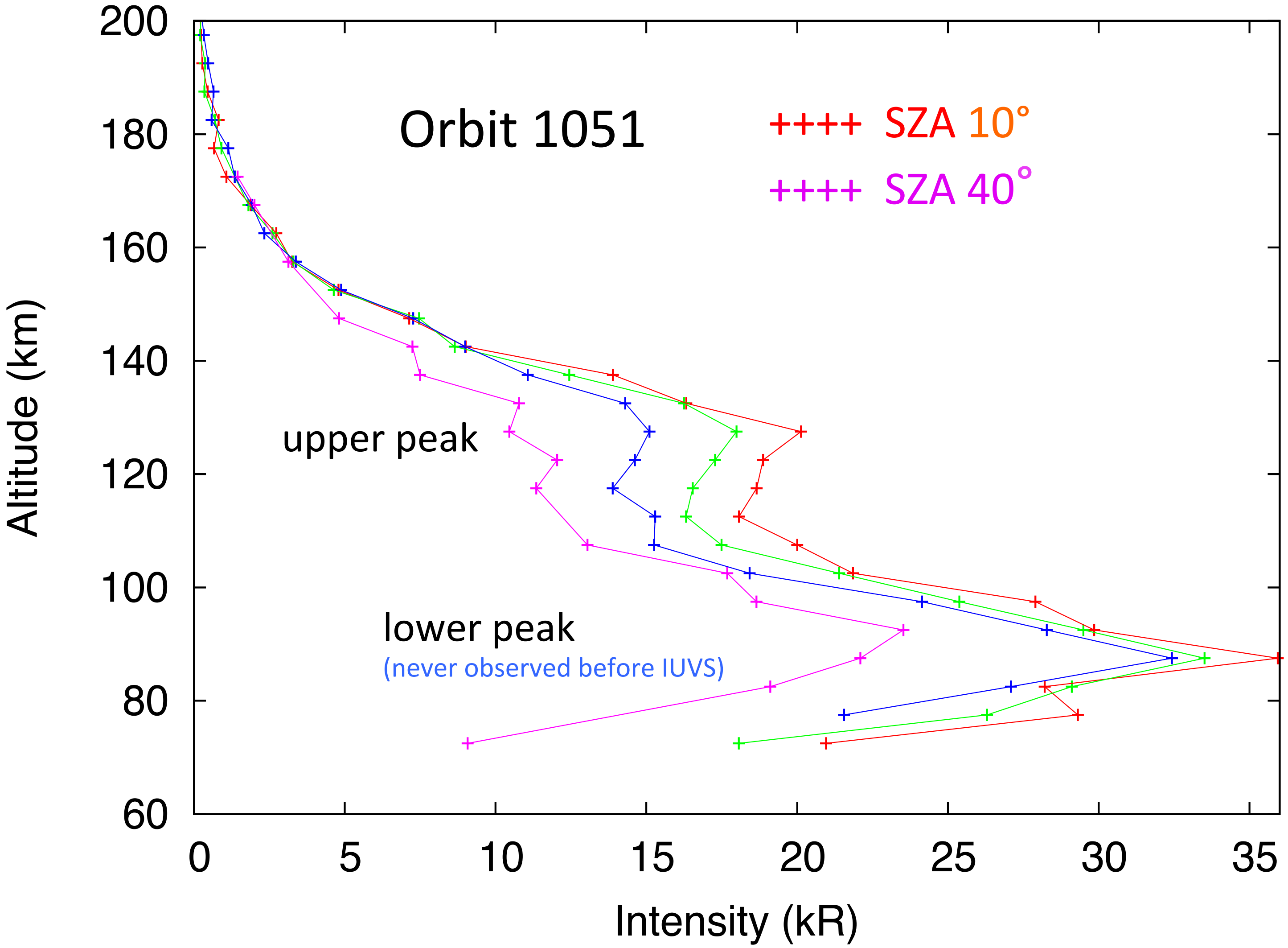
85 km

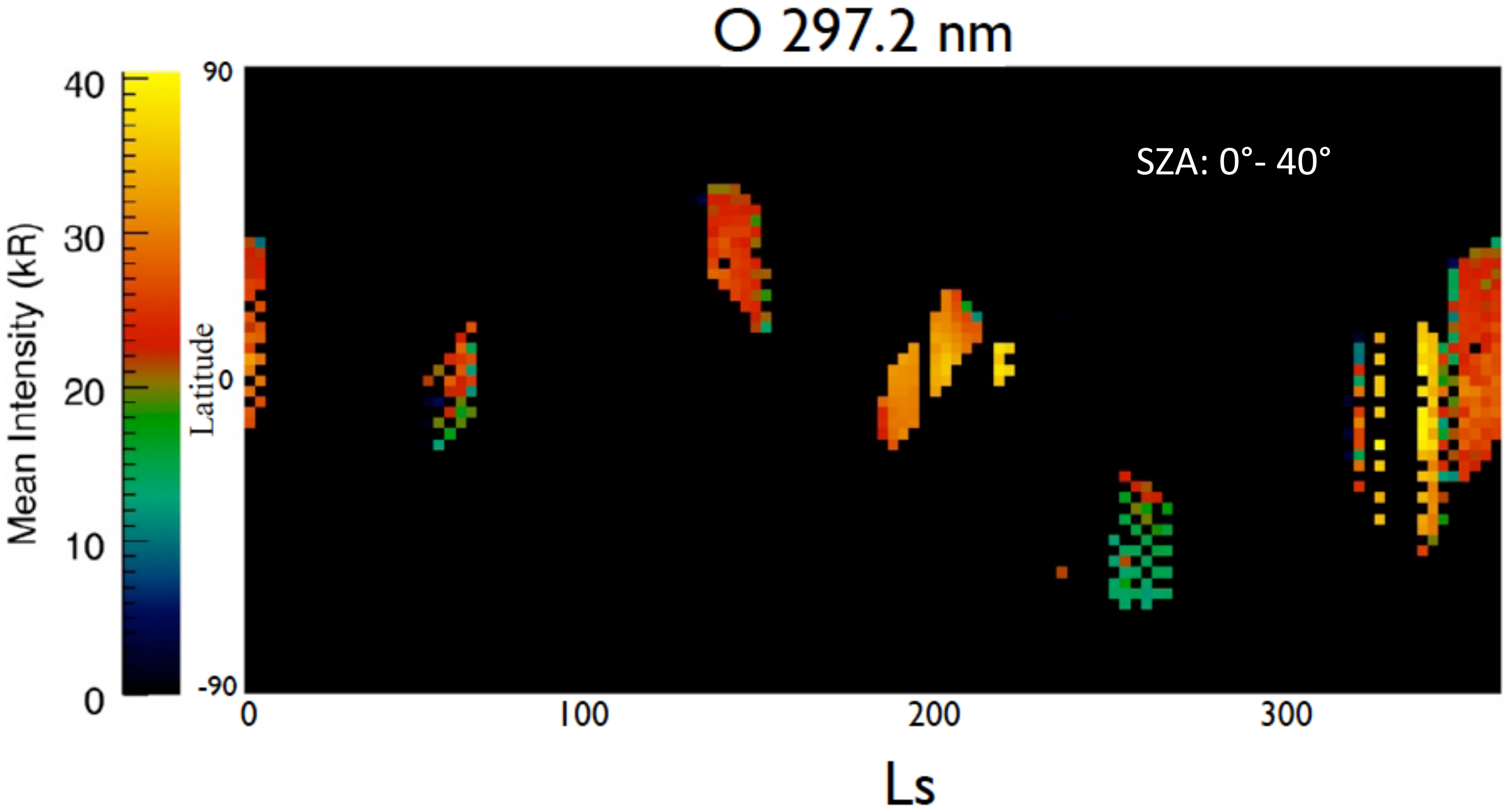
Oxygen energy levels ($2p^4$ configuration)



Both transitions to ^{1}D and ^{3}P levels are forbidden

Limb scans at 297.2 nm along one MAVEN orbit



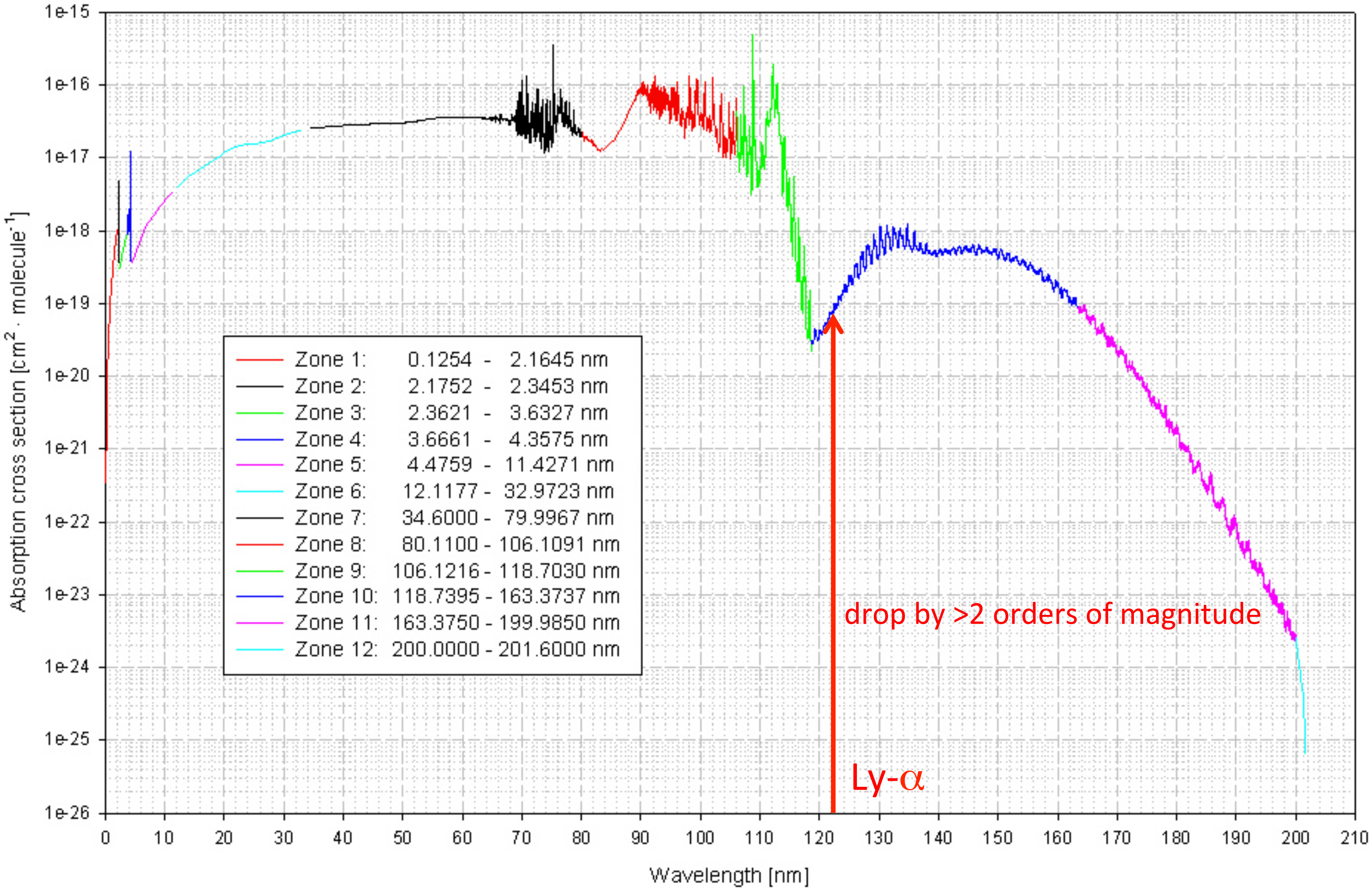

O 297.2 nm
SZA: 0°- 40°
Mean Intensity (kR)
40
30
20
10
0
Latitude
90
0
-90
0
100
200
300
Ls

Sources of $O(^1S)$ atoms

Process	quantity	quantum yield	number
CO_2 + photons → CO + $O(^1S)$	EUV flux	QY_1	(1)
	Ly-α flux	$QY_{Ly\text{-}\alpha}$	
$O_2^+ + e_{th}$ → O + $O(^1S)$	α_1,	QY_2	(2)
$e_{pe} + CO_2$ → CO + $O(^1S)$	σ_1		(3)
$e_{pe} + O(^3P)$ → $O(^1S) + e_{pe}$	σ_2		(4)
e_{pe} + CO → $O(^1S) + C + e_{pe}$	σ_3		(5)
$CO_2^+ + e_{th}$ → CO + $O(^1S)$	α_2	QY_3	(6)

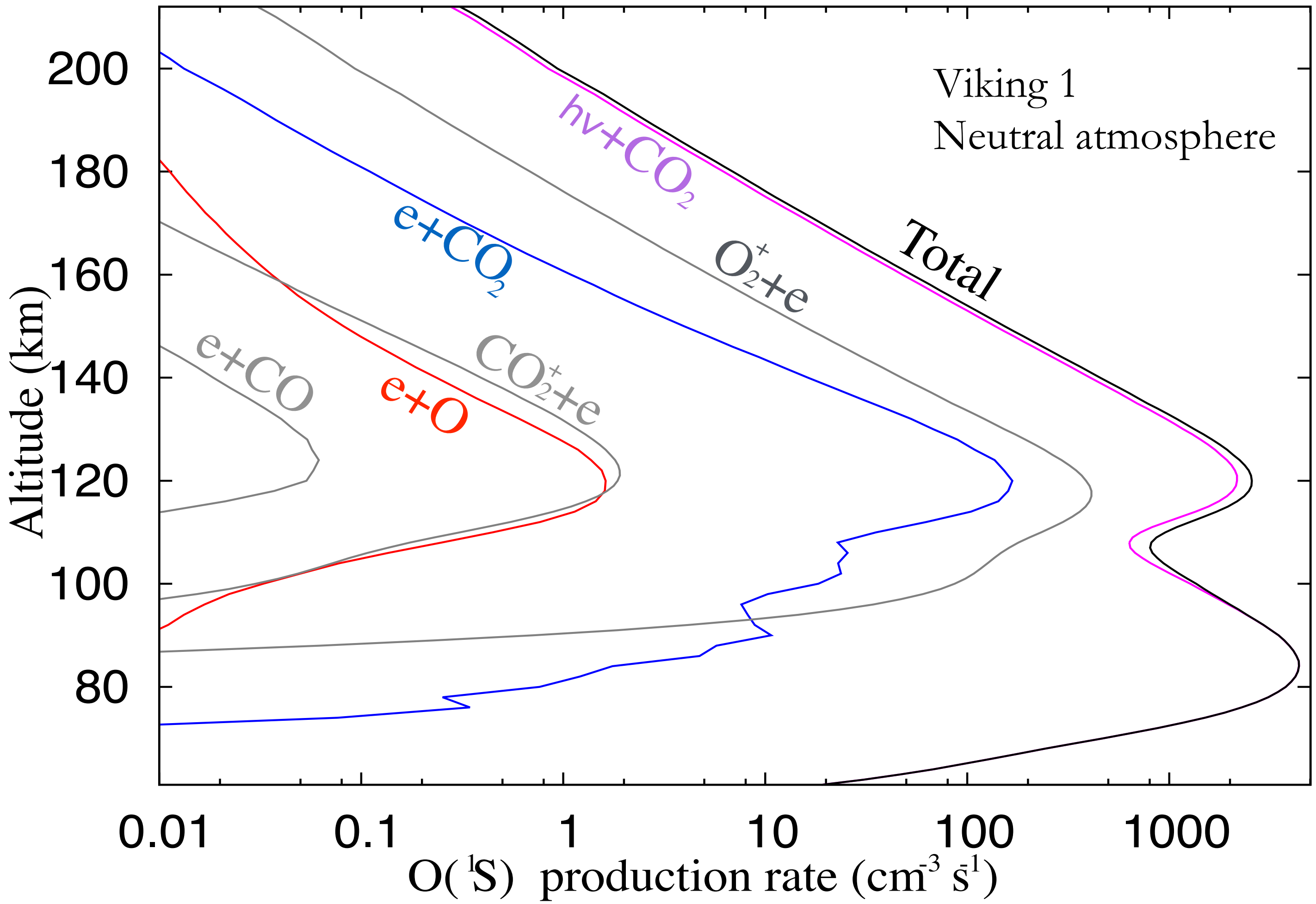
Losses: radiation + collisional quenching by CO_2, O and CO

CO_2 absorption cross section (cm^2)



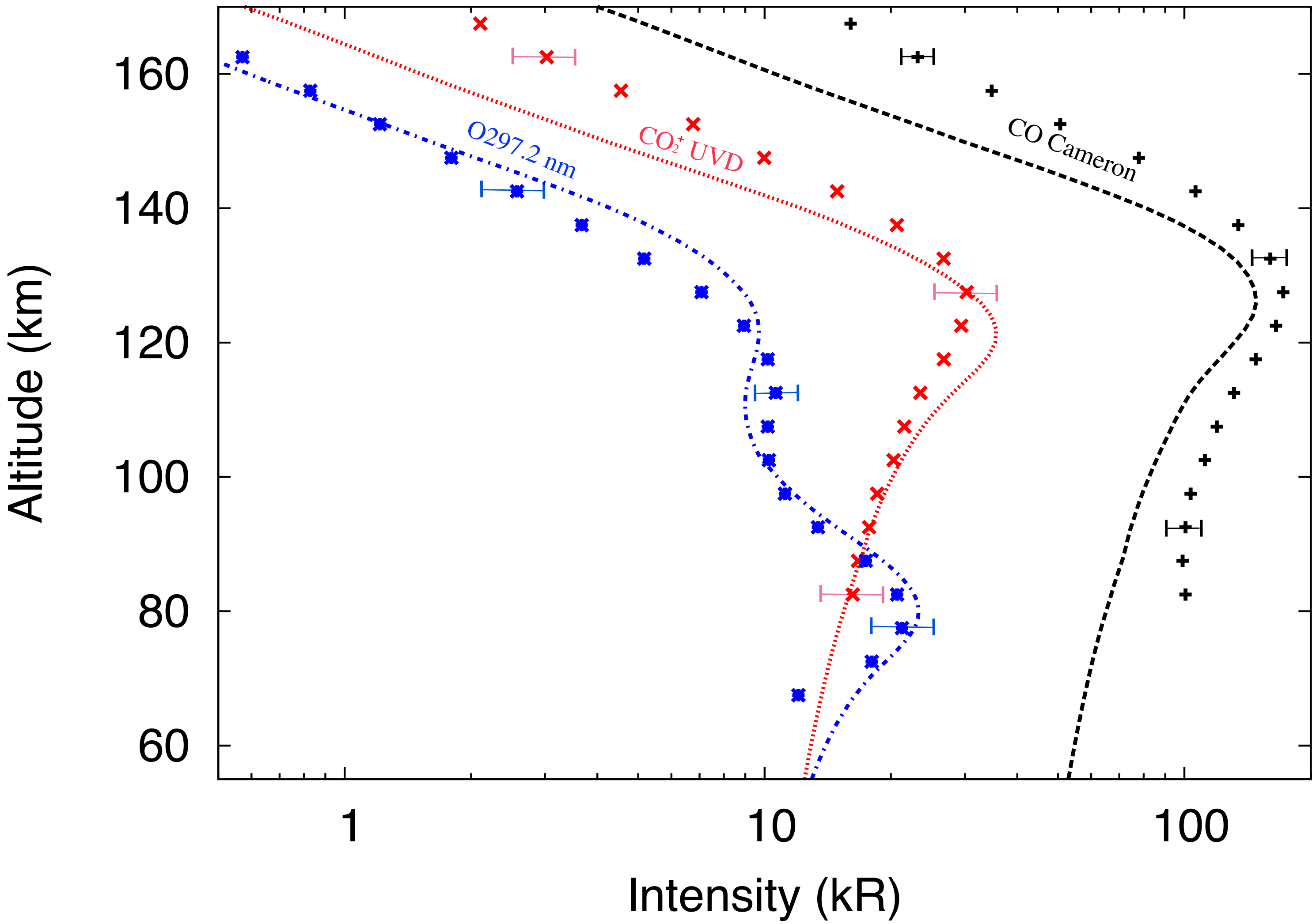
Critically evaluated VUV absorption cross sections of carbon dioxide CO_2 at 300 K,
Huestis and Berkowitz, Advances in Geosciences Vol. 25:
Planetary Science (2010) 229-242 (World Scientific company).

Sources of O(^{1}S) atoms



Calculated from combined photochemistry and photoelectron impact model (Monte Carlo)

Other airglow emissions



CONCLUSIONS

- Limb profiles of OI 297.2 nm dayglow observed with IUVS/MAVEN show seasonal and latitudinal variations of the intensity and altitude of both peaks

- Production of $O(^1S)$ atoms in the Martian upper atmosphere is dominated by photodissociation of CO_2 at all altitudes below 200 km

- The lower peak is produced by penetration of Ly-α solar radiation down to the 80 km region

- The quantum yield for $O(^1S)$ production by CO_2 dissociation by Lyman-α is about 10%

- The 297.2 nm emission changing peak altitude reflects variations of the CO_2 column density and thus the pressure level