Martian UV dayglow: global simulation, MEx measurements and perspectives for ExoMars

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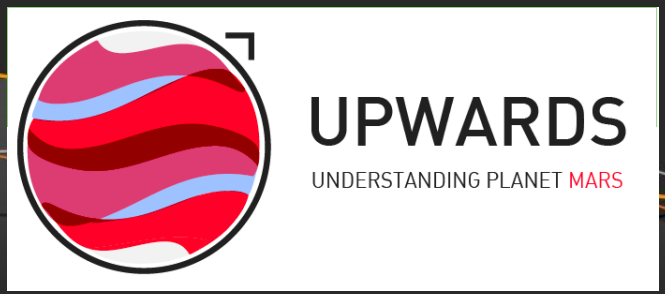
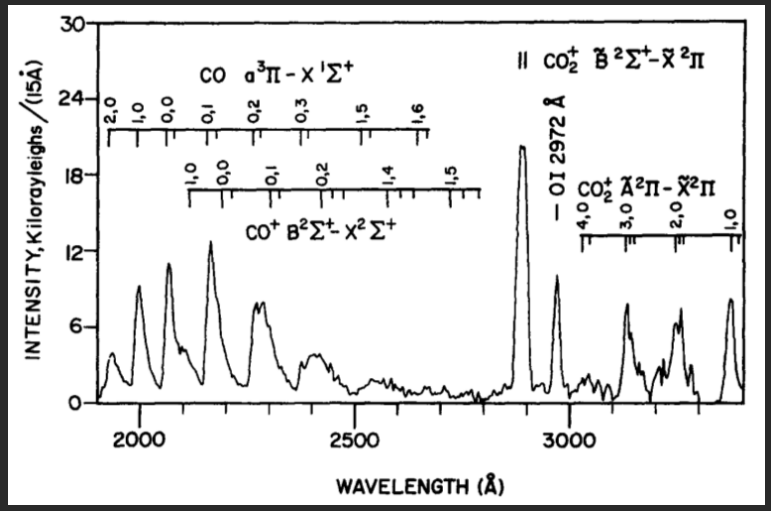
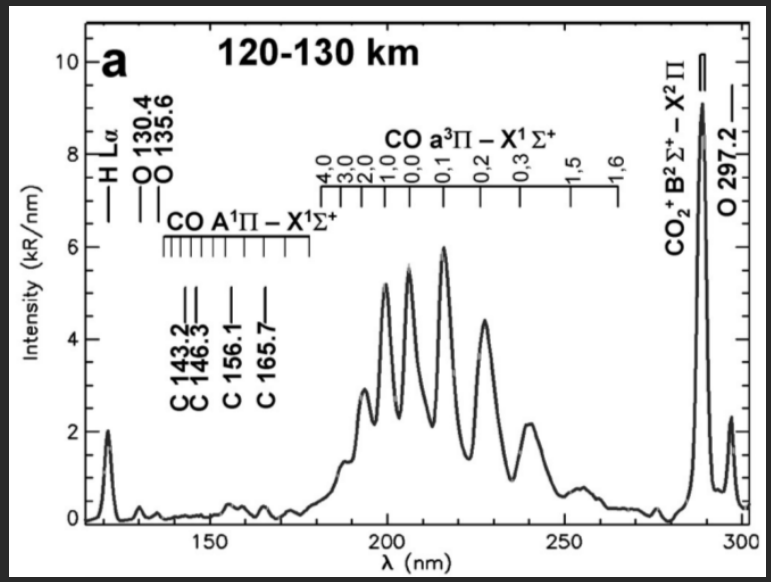


Motivation and goals

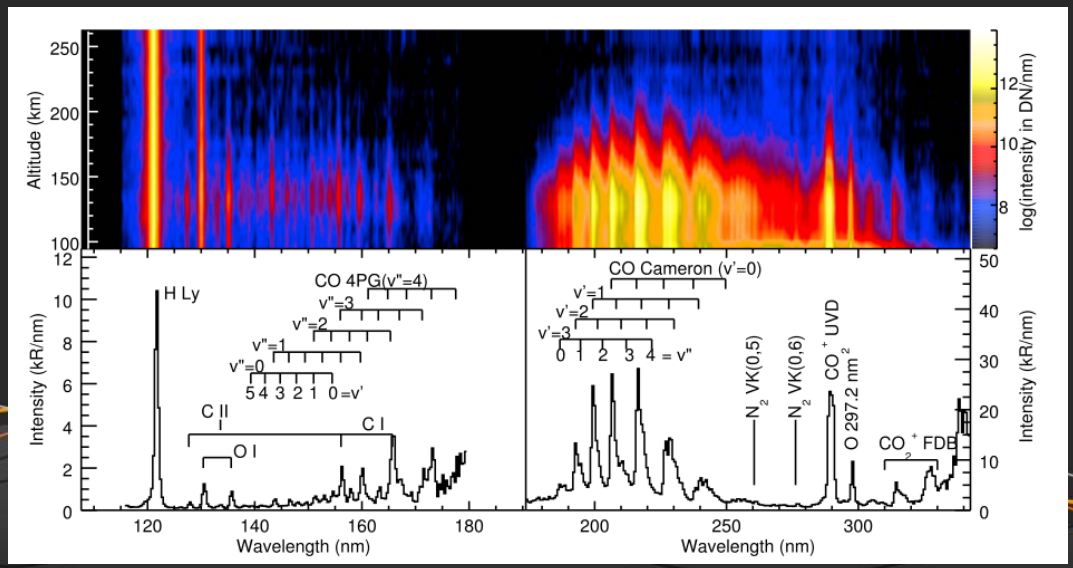
- UV emissions from Mars observed since Mariner missions



Mariner 9 (Stewart+ 1972)



MEx/SPICAM (Leblanc+ 2006)



MAVEN/IUVS (Jain+ 2015)

Physical processes

- Emission from CO_2^+ ($B_2\Sigma^+$) (UVD) and CO($a^3\Pi$) (Cam)

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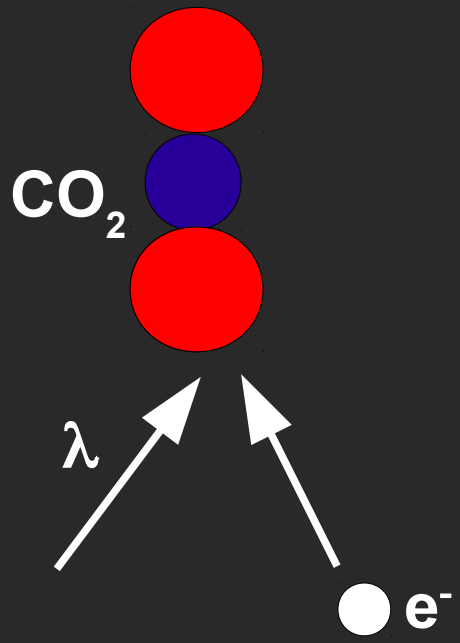

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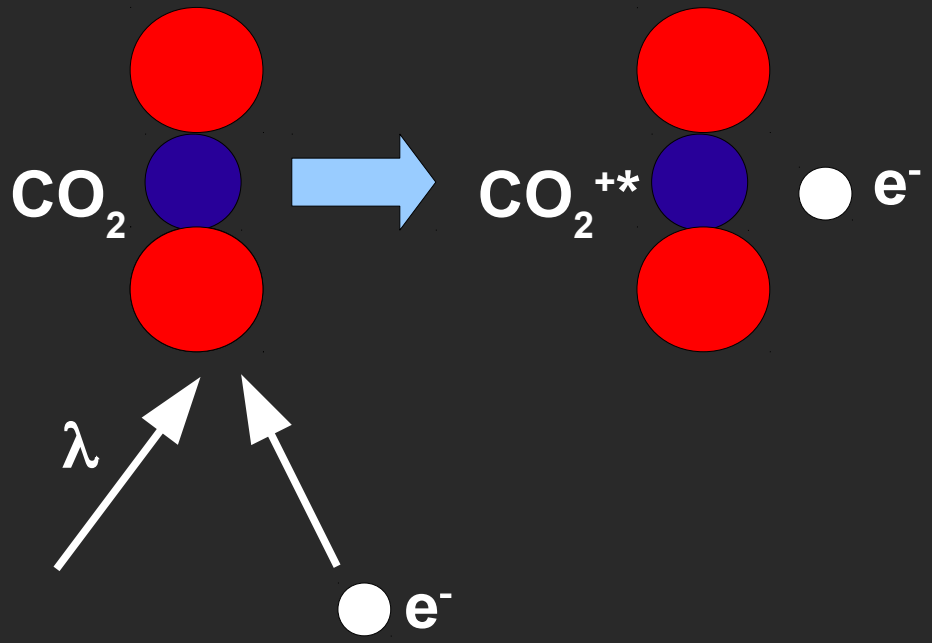

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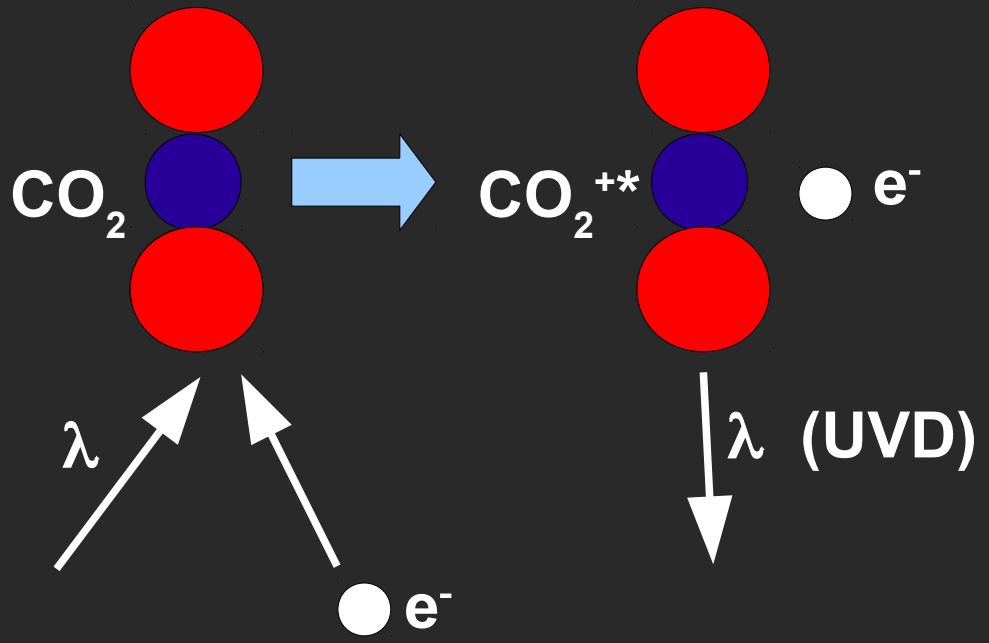

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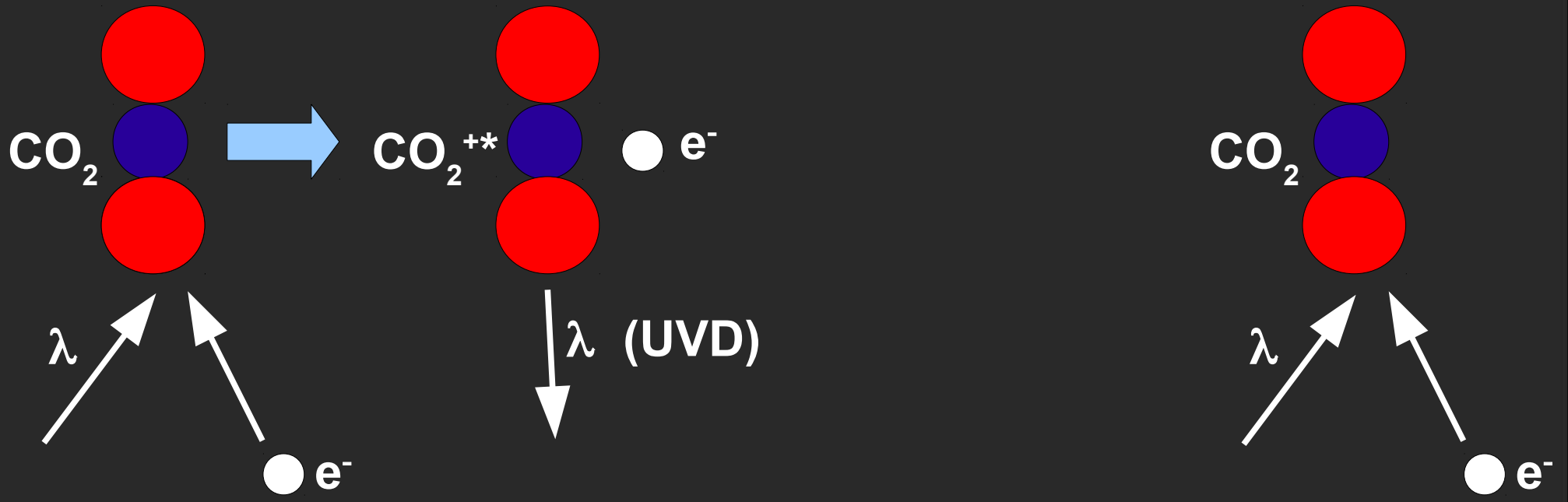

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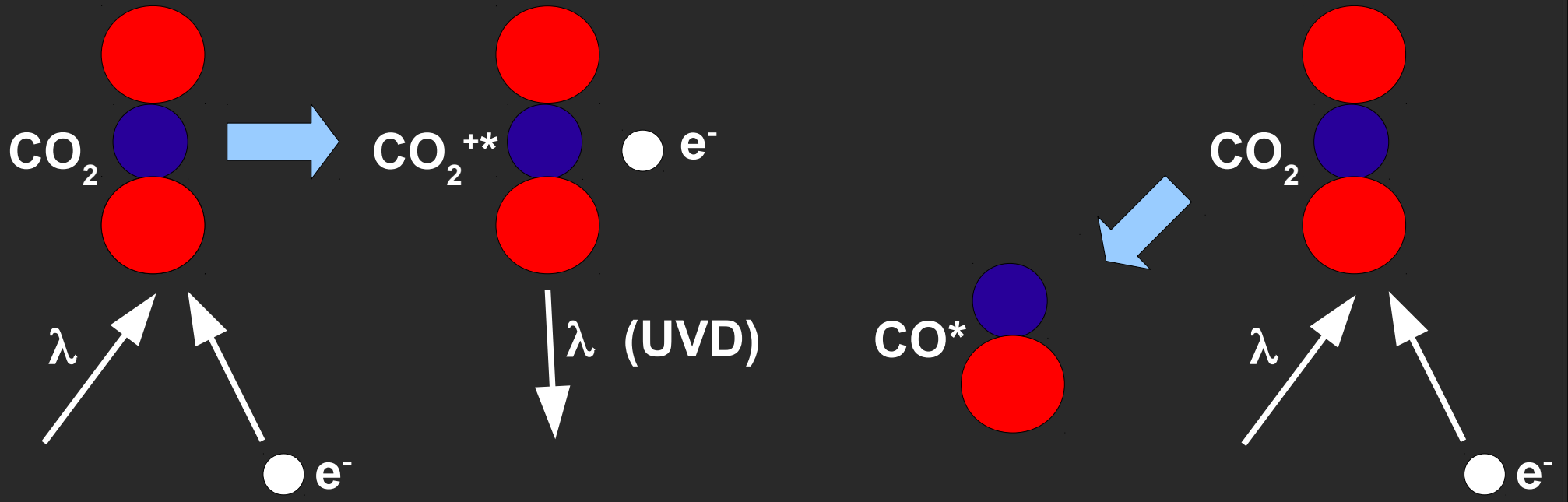

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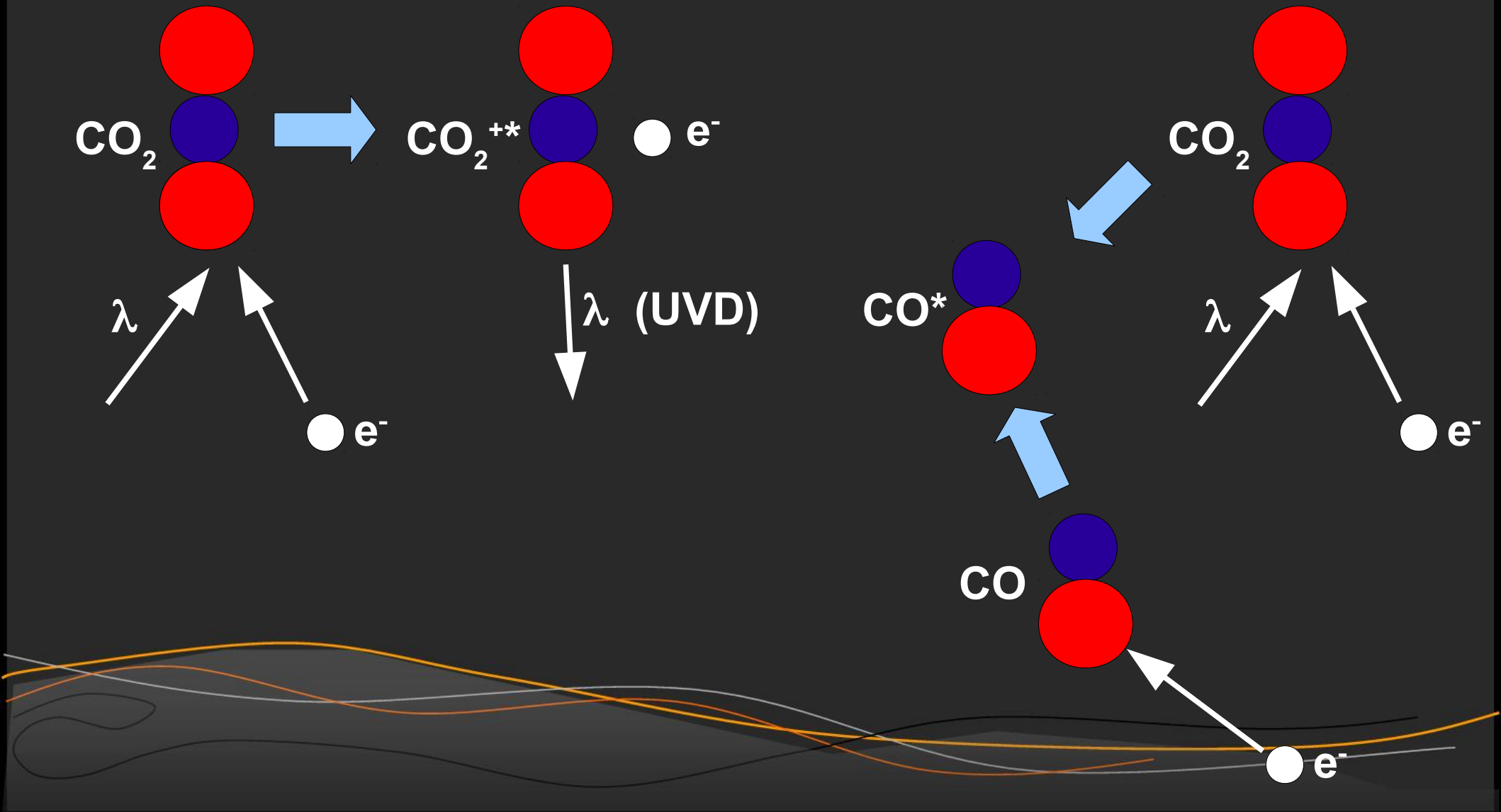

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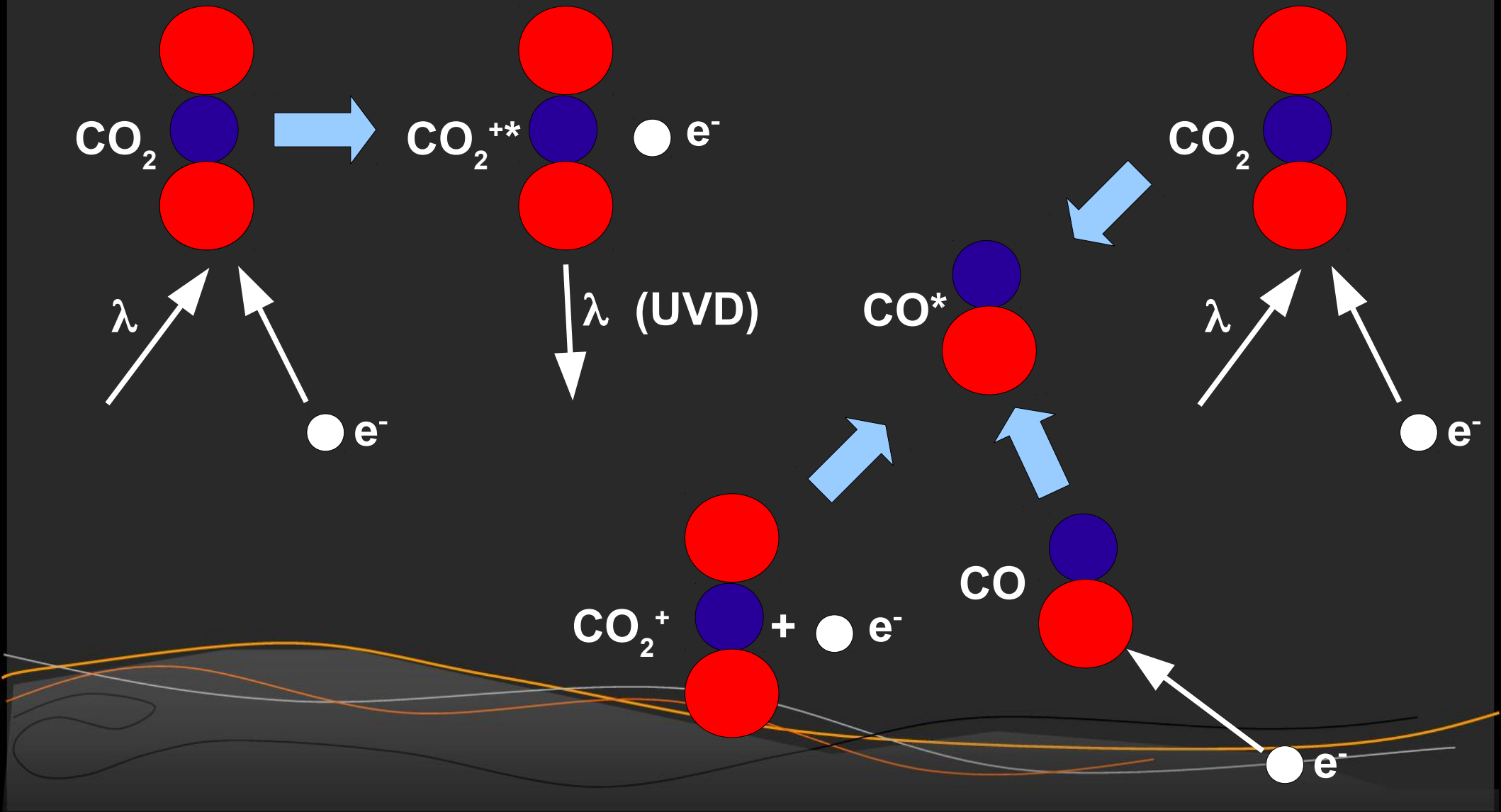

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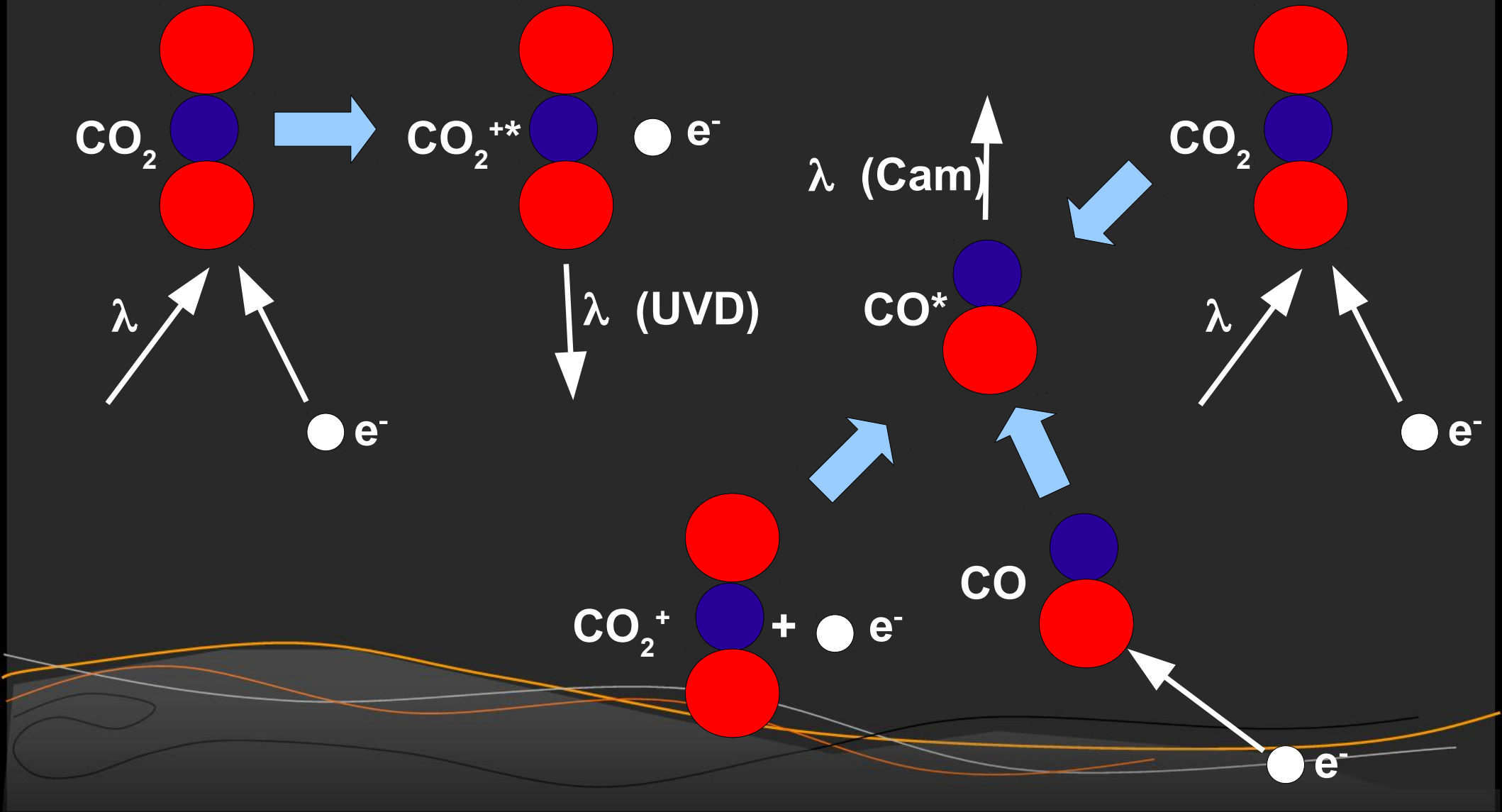
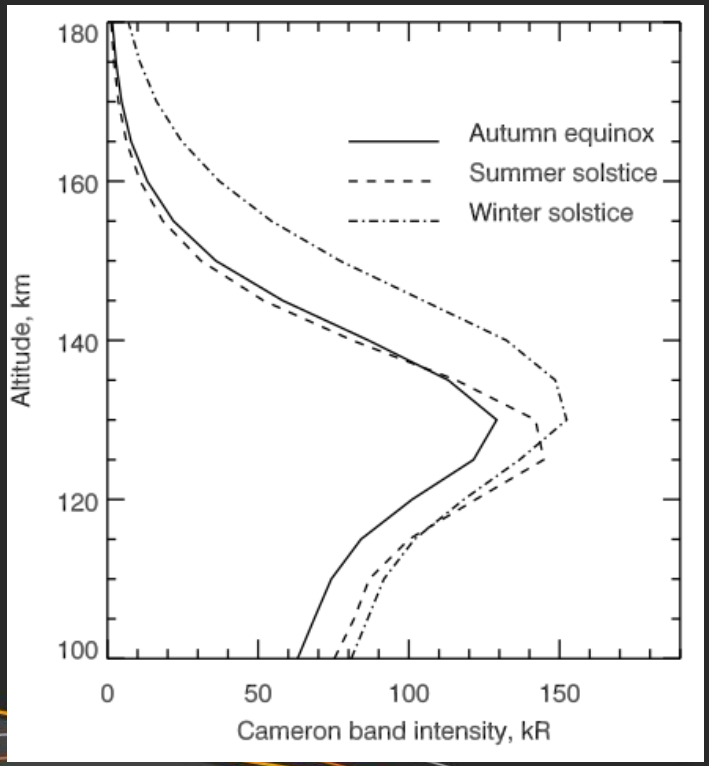


Motivation and goals

- UV emissions from Mars observed since Mariner missions
- Provide information about temperature and CO2 density
- Most models are 1D: no full atmospheric variability



Shematovich+ 2008

Motivation and goals

- UV emissions from Mars observed since Mariner missions
- Provide information about temperature and CO2 density
- Most models are 1D: no full atmospheric variability
- Aim: Global modeling of UV dayglow. Main goals:
    - Effects of atmospheric variability
    - Revisit conclusions from 1D models
    - Provide global maps of emissions

Basic characteristics of the LMD Mars Global Climate Model :

1) LMDZ final Dynamical Core (Grid point Model)

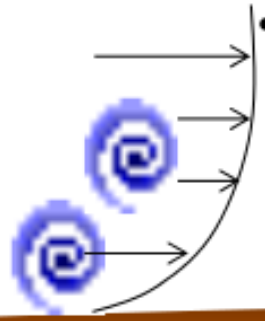
2) Radiative transfer:

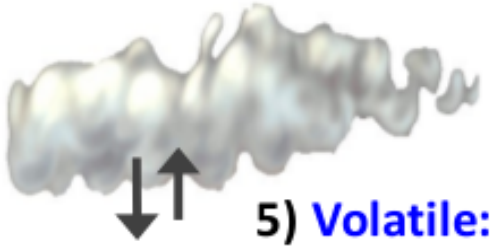
- TIR CO2 wide band model (Hourdin 1991) + NLTE model (Lopez-Valverde 2011)
- NIR CO2 (NLTE)
- EUV absorption
- Aerosols: Toon et al. 1989

6) Dust transport and distribution : see below

3) Subgrid scale dynamics

- **Turbulence:** Mellor and Yamada 2.5 Scheme
- **Convection :**
- **Gravity waves (orographic) + low level drag:** Prametrisation of impact on the main flow





5) Volatile:

- **CO2 cycle: see below**
- **H2 O cycle: see below**

4) Surface and subsurface thermal balance

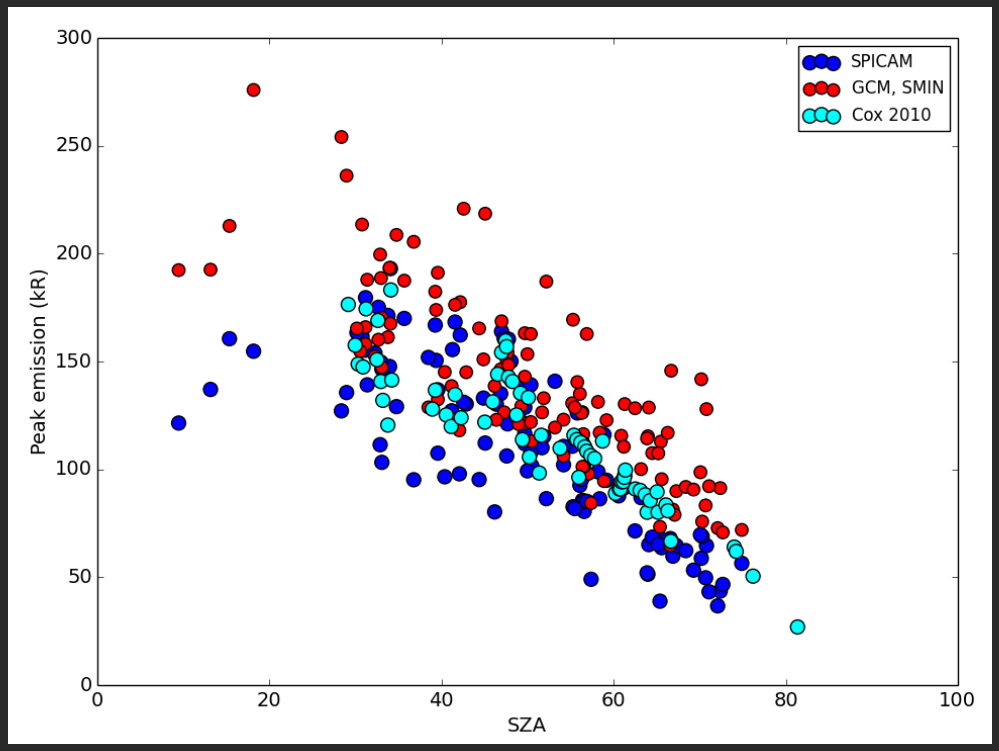
Forget and Lebonnois (2013) In

Physical processes

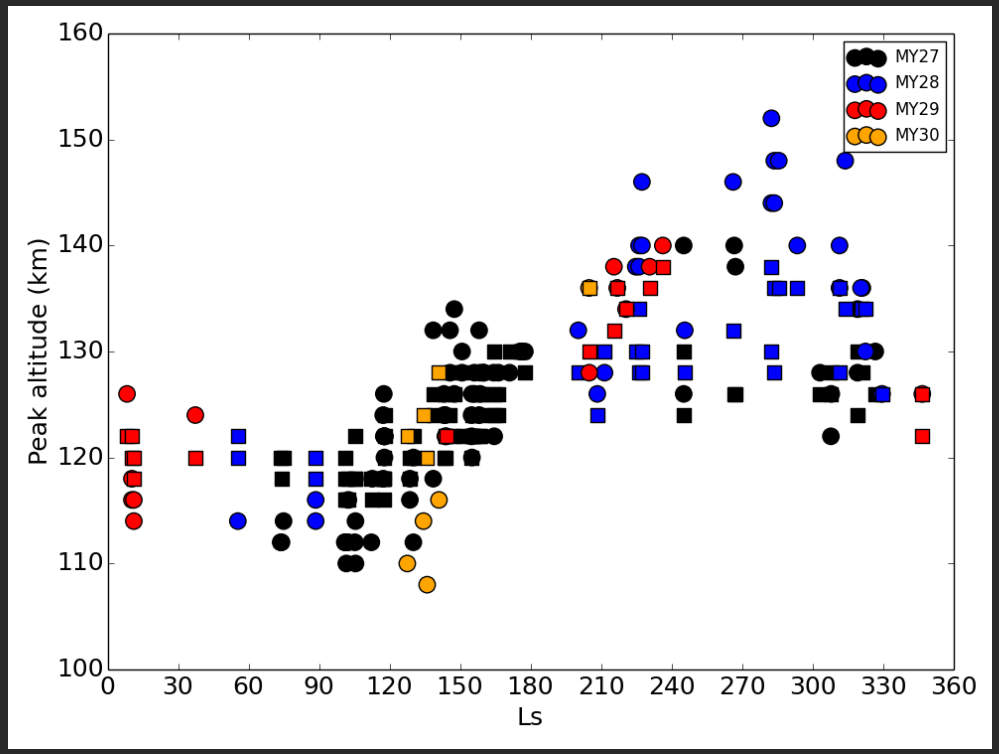
- Emission from CO2+ ($B_2\Sigma^+$) (UVD) and CO($a^3\Pi$) (Cam)
- UVD:
  - $CO_2 + hv \rightarrow CO_2^+ (B_2\Sigma^+) + e^-$
  - $CO_2 + e^- \rightarrow CO_2^+ (B_2\Sigma^+) + e^- + e^-$
- Cameron
  - $CO_2 + hv \rightarrow CO\ (a^3\Pi) + O$
  - $CO_2 + e^- \rightarrow CO\ (a^3\Pi) + O + e^-$
  - $CO + e^- \rightarrow CO\ (a^3\Pi) + e^-$
  - $CO_2^+ + e^- \rightarrow CO\ (a^3\Pi) + O$
- Photoelectrons included using AYS technique (Bhardwaj & Jain, 2009)

Results: Comparison with SPICAM

Peak intensity, Cam



Peak altitude, UVD



- Peak intensity comparison supports previous results suggesting reduction in electron impact cross sections
- Peak altitude variability reproduced. Effect of MY28 dust storm

Results: Comparison with SPICAM

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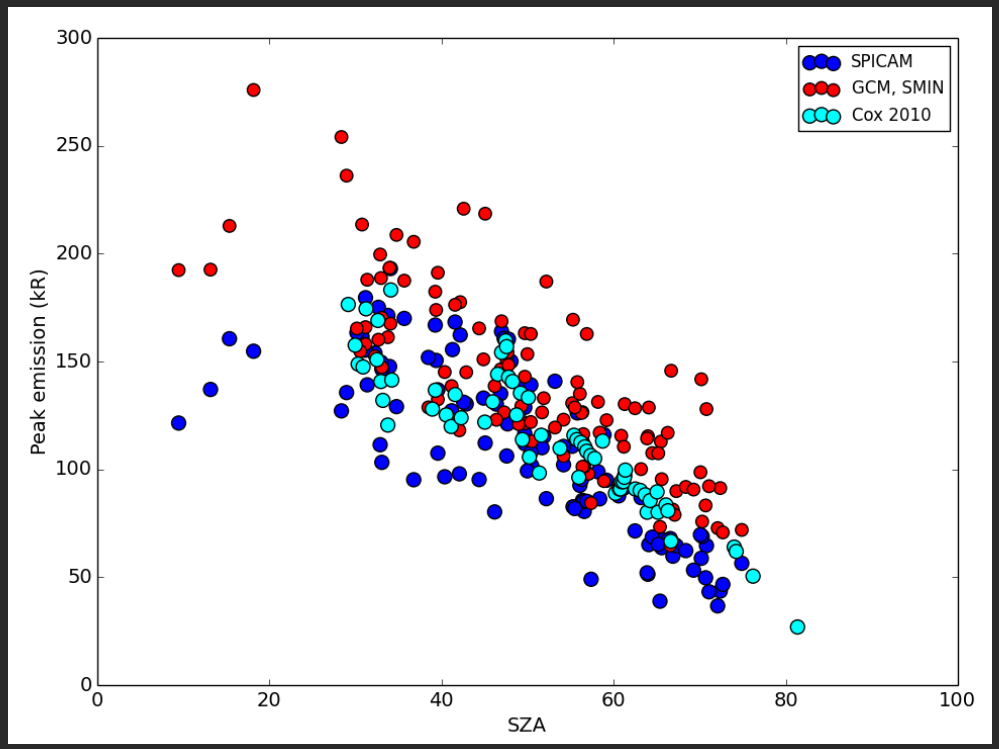

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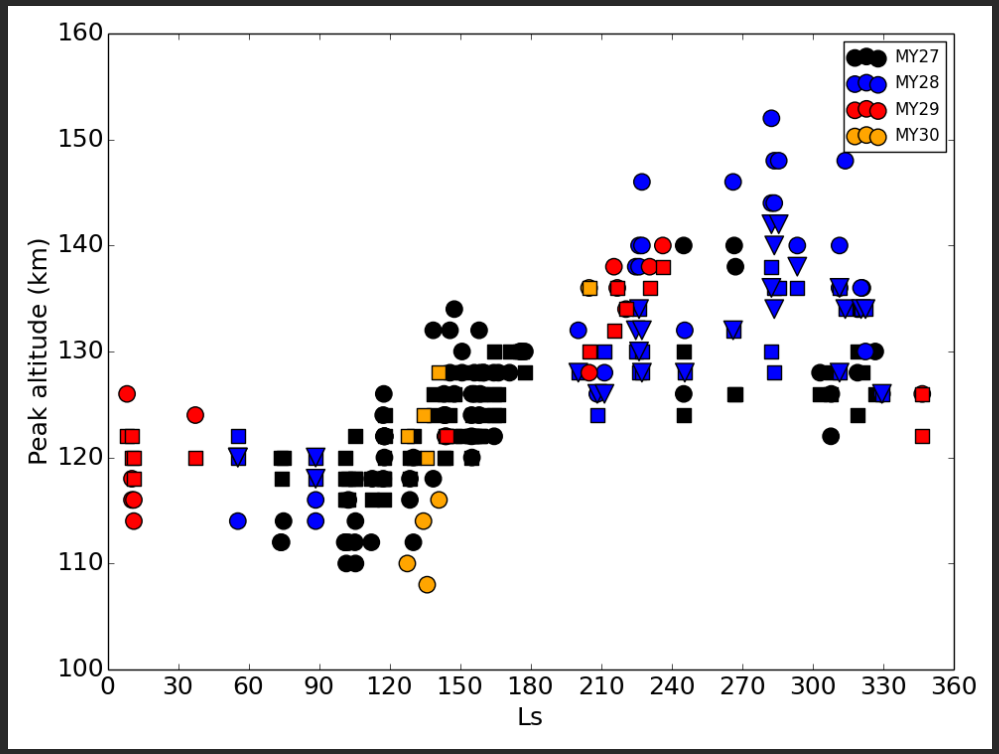

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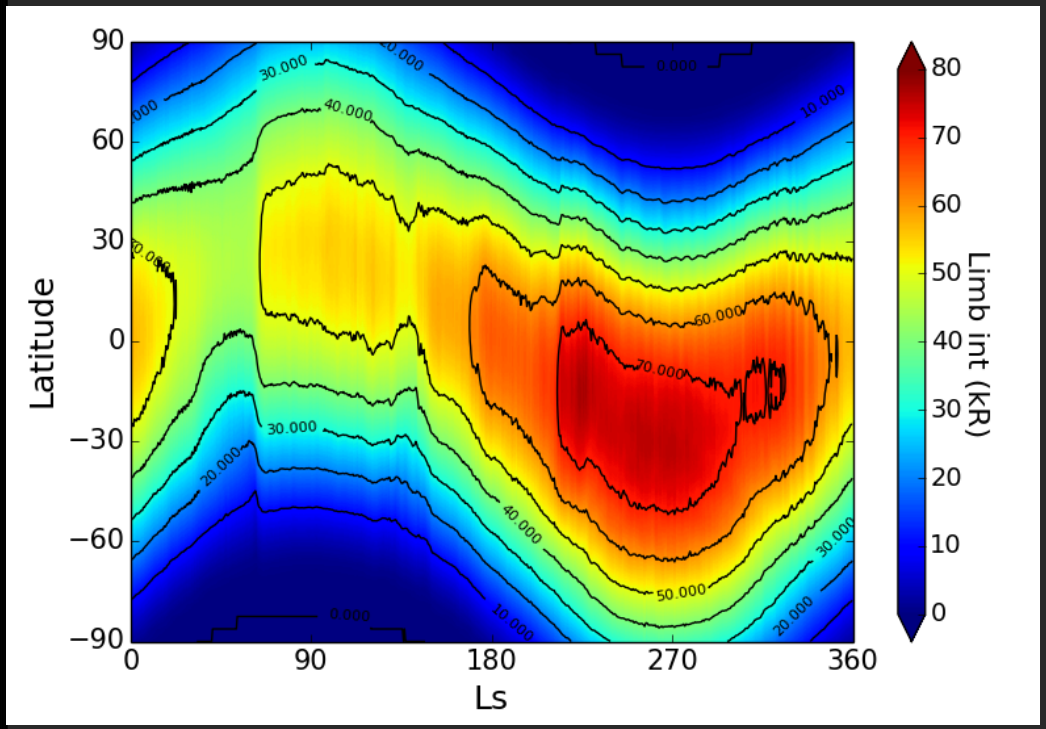
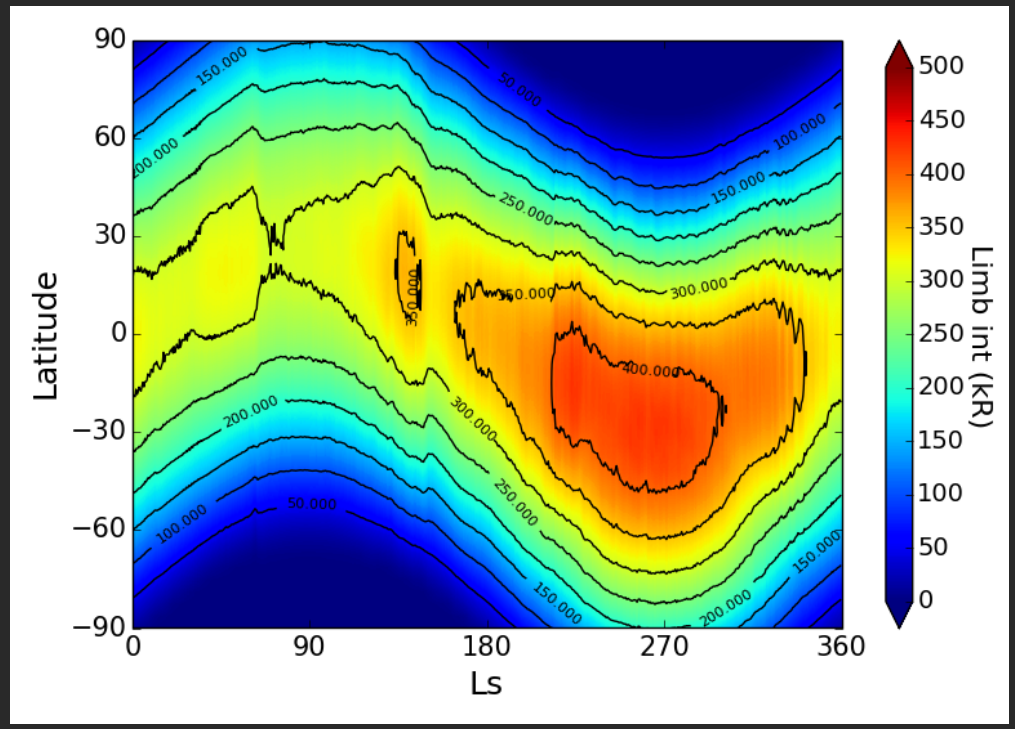
Results: global maps of UV dayglow

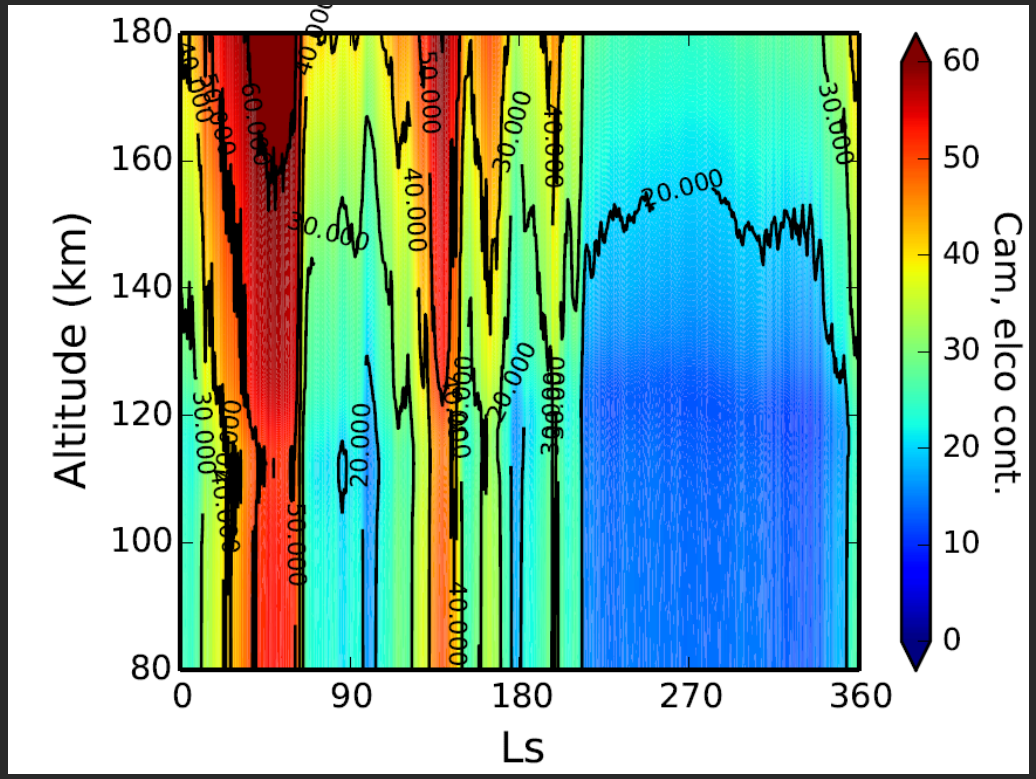


CO2+ UVD, noon,
peak limb intensity

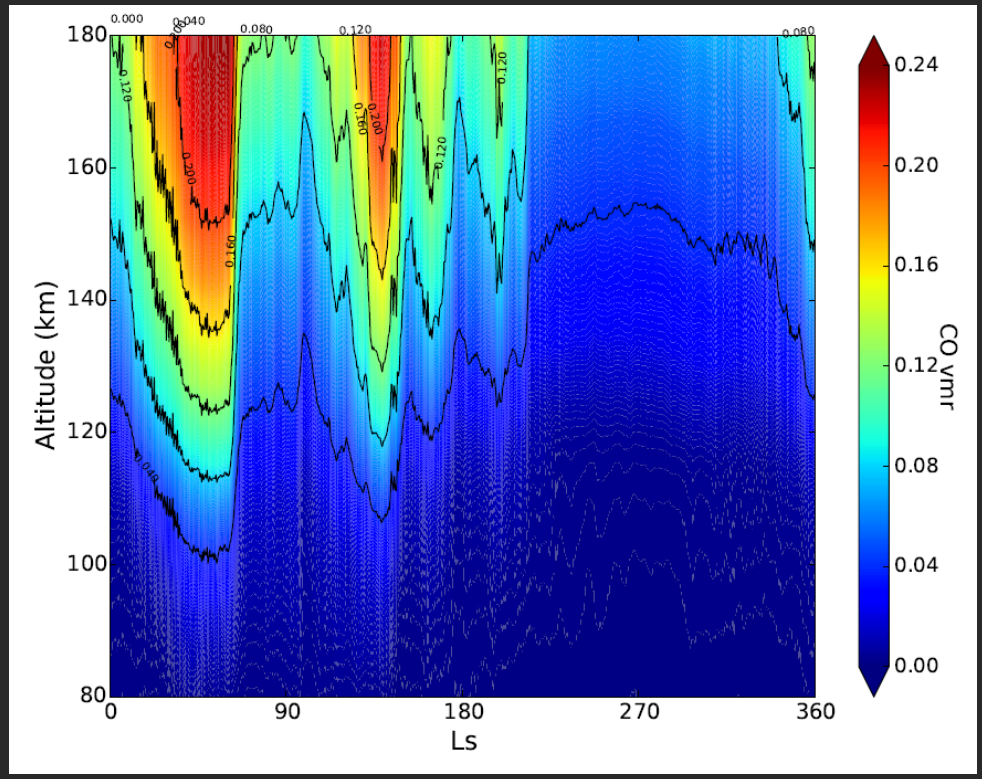


Cameron, noon,
peak limb intensity

Results: effect of CO abundance

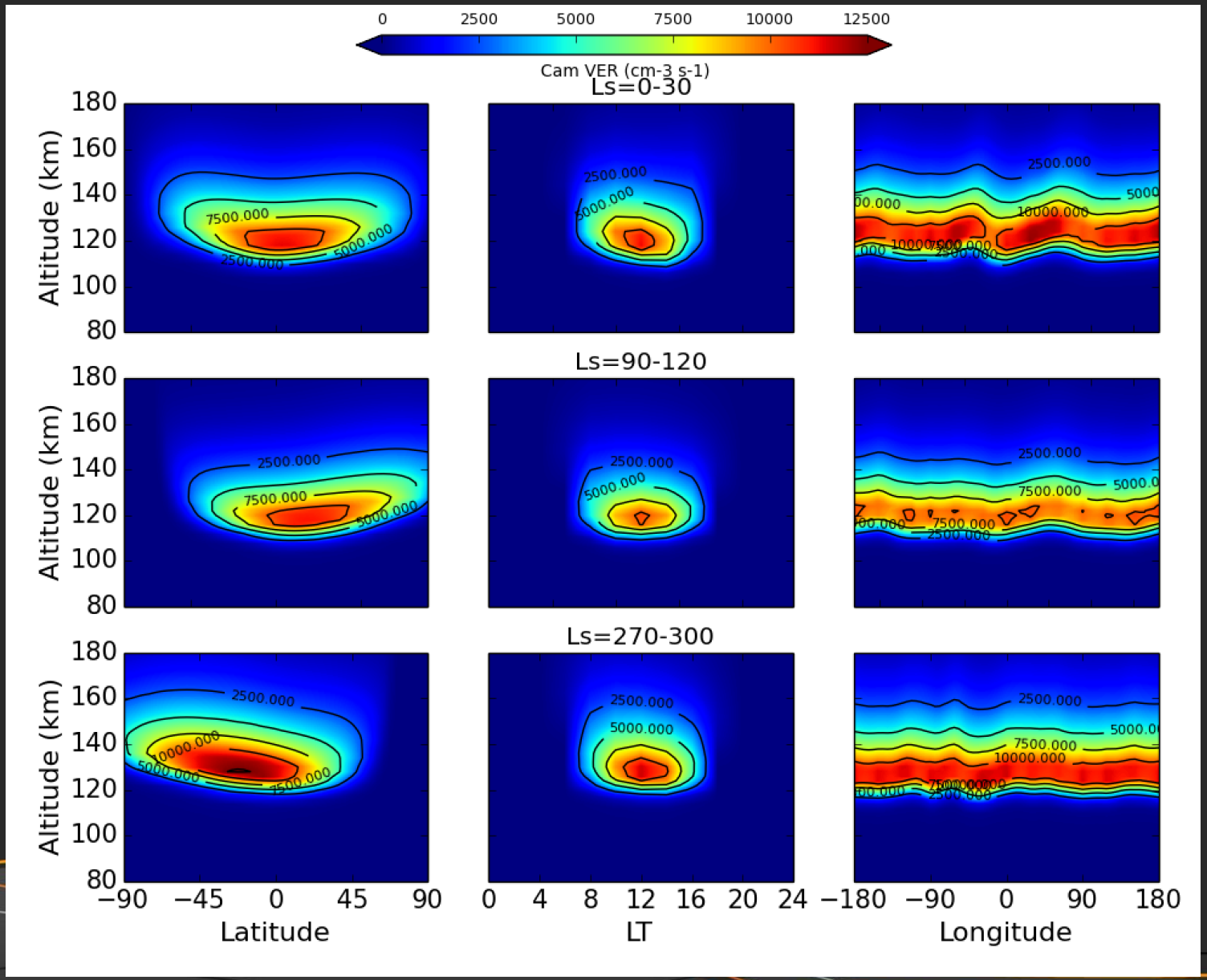


CO + e contribution, noon, equator



CO vmr, noon, equator

Results: variability



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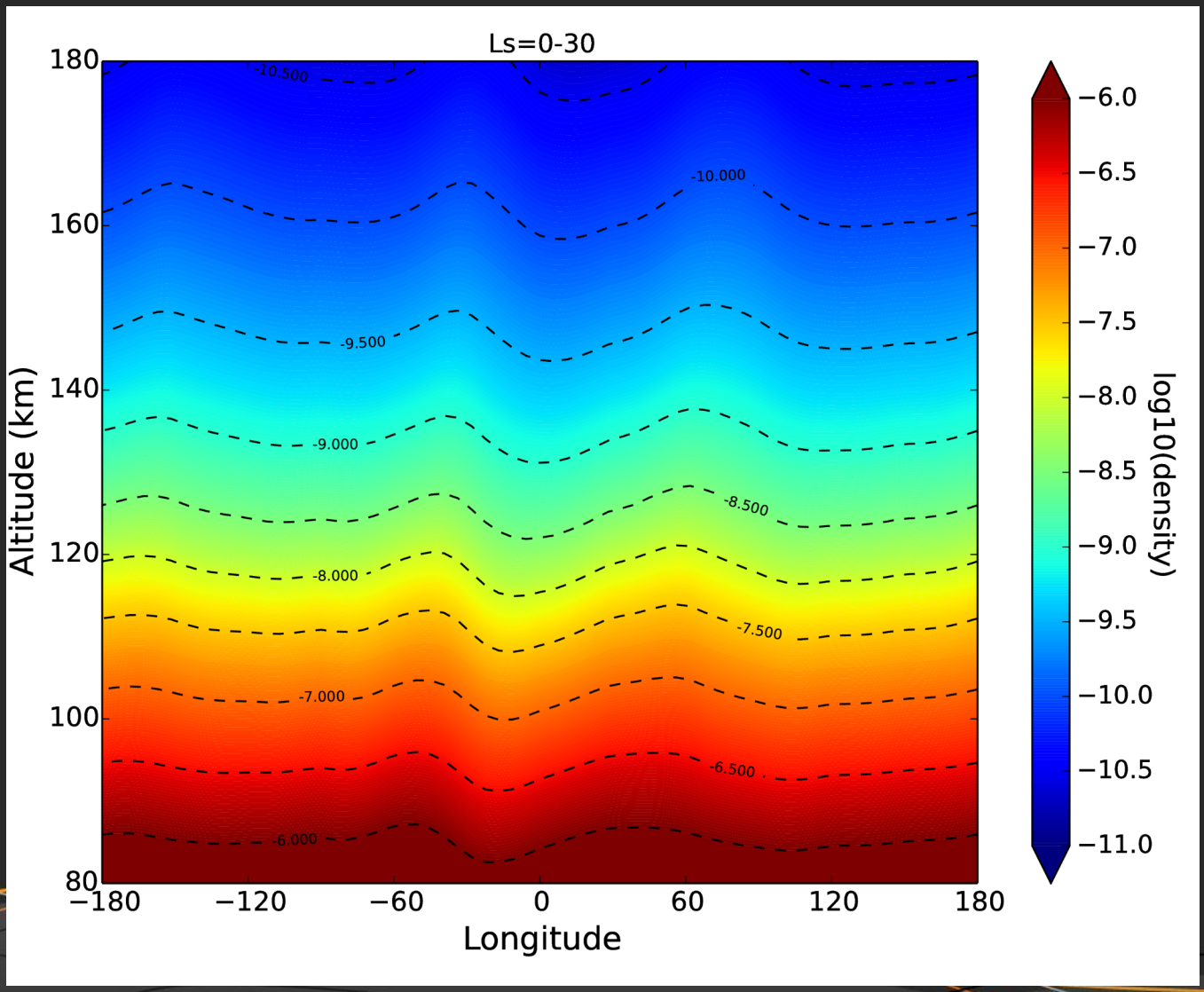
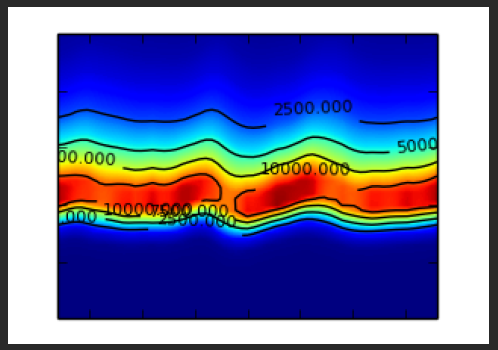




Perspectives for ExoMars TGO

- Both emission systems fall within UVIS spectral range
- Both are quite intense and may be observable with UVIS sensitivity
- Limb observations possible, but not in the initial plan
    - Would add new science topics
- Nadir observations planned, but
    - Need to separate surface contribution
    - No information on altitude variability

Summary and future work

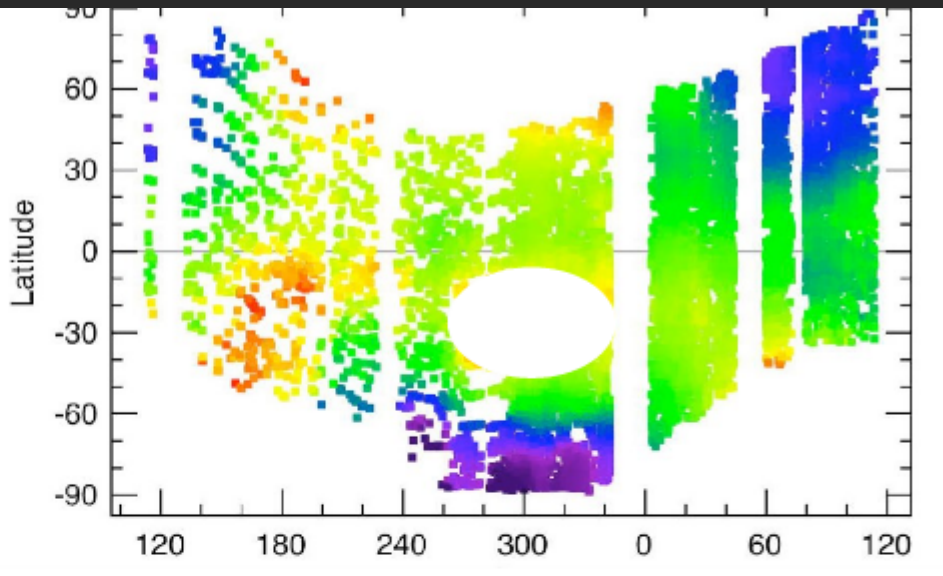
- Dayglow model implemented in LMD-MGCM
- First global maps of UV dayglow produced (and delivered to PSA)
- CO abundance variations induce significant effect on Cameron bands. Implications for temperature analysis from scale heights
- Density variability induces variability in the emission
- Future work:
    - Comparison with 1D models (e.g. Jain & Bhardwaj, Shematovich)
    - Comparison with IUVS measurements
    - Future comparisons with NOMAD/UVIS, if detected?
- Open question: Is the CO abundance variability predicted by the model real? Comparison to NGIMS?

Backup slides

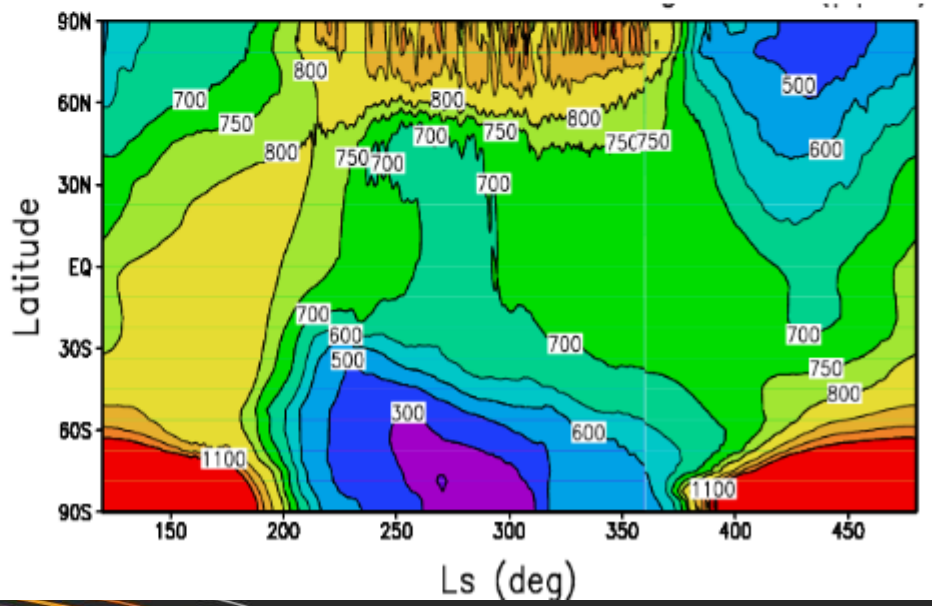
CO measurements

Observation of CO by CRISM (ppm)
(Mike Smith 2008)

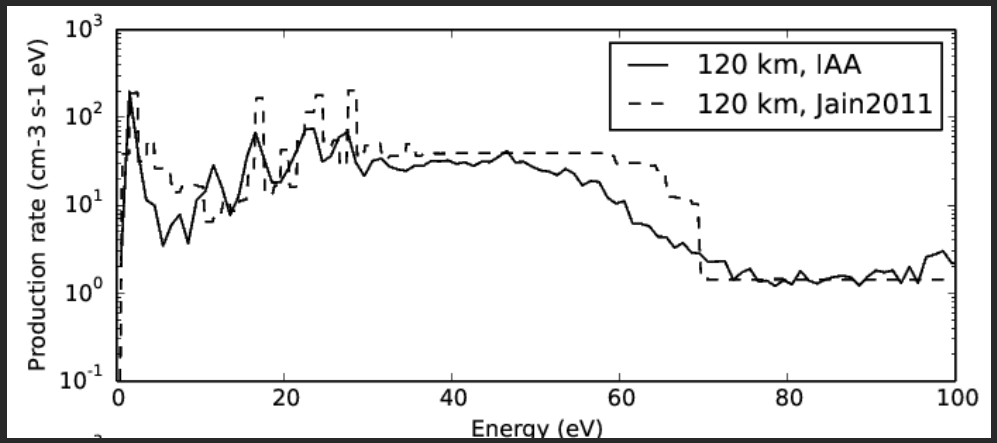
Observations



Model

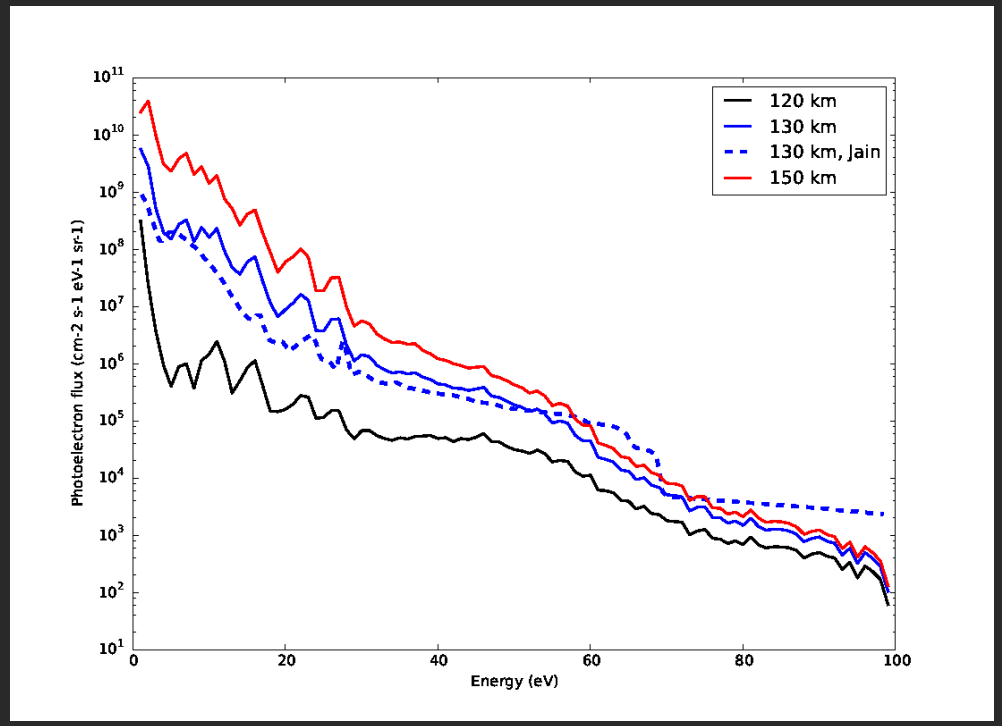


Photoelectron energy

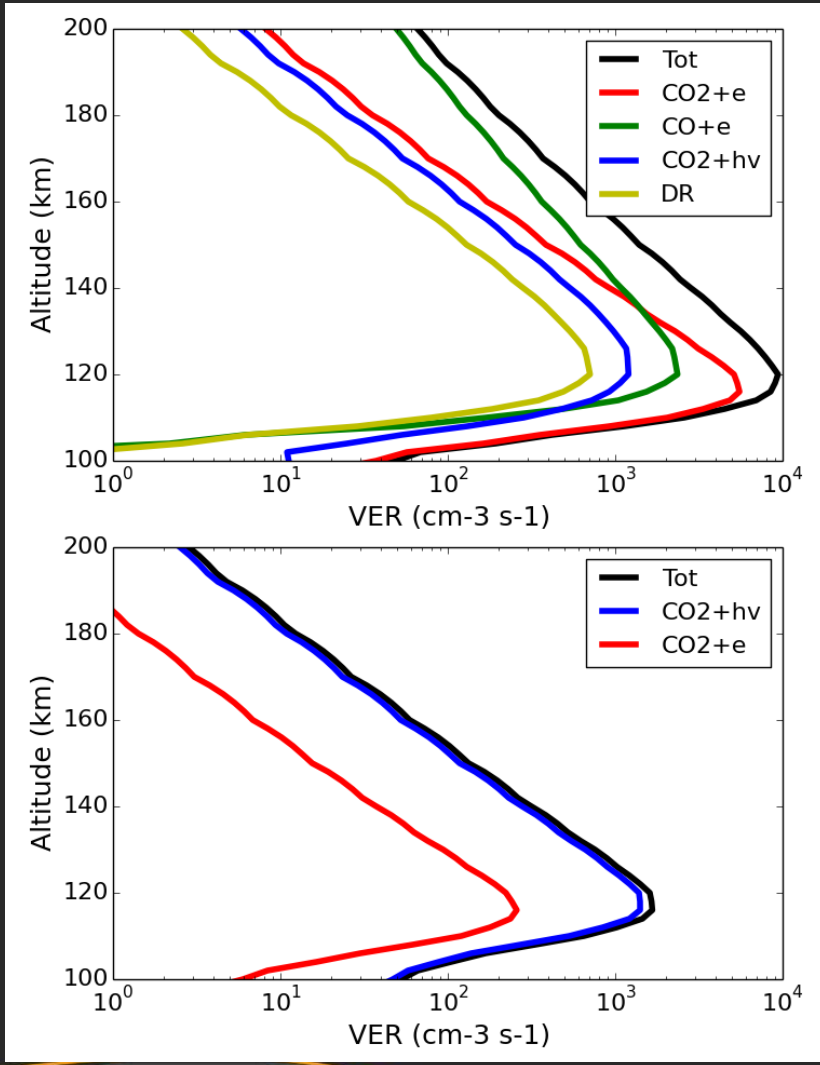


Initial energy

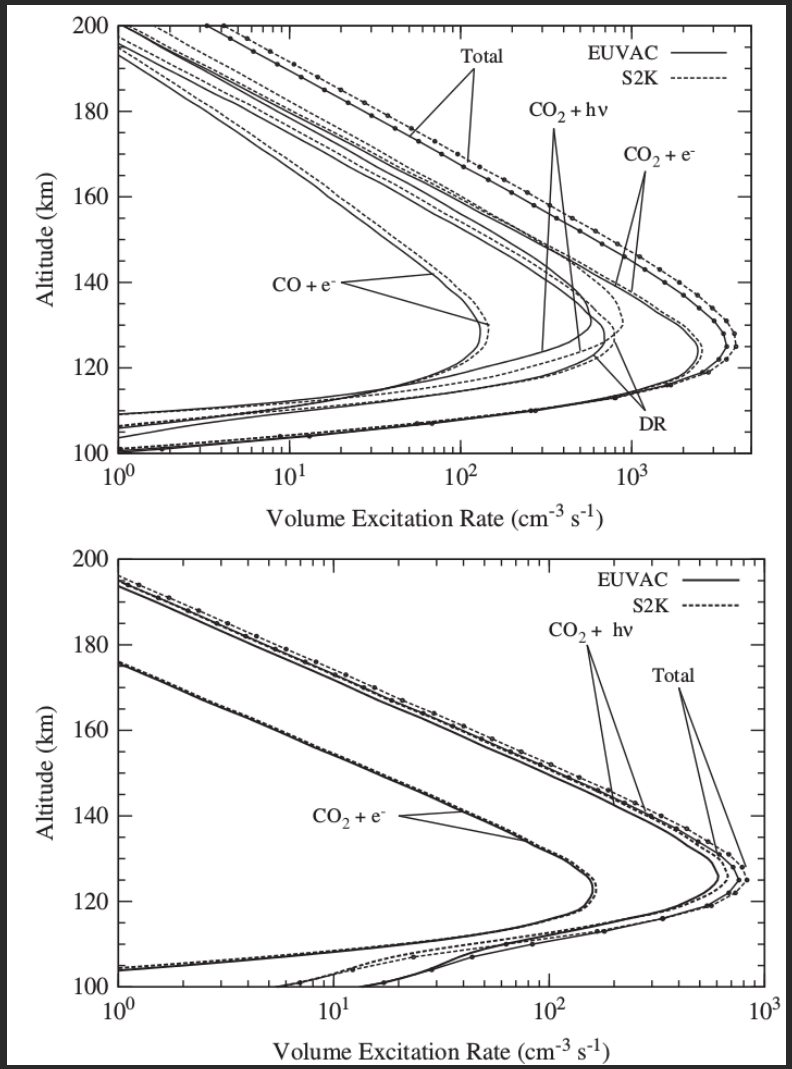
Final energy



An example profile

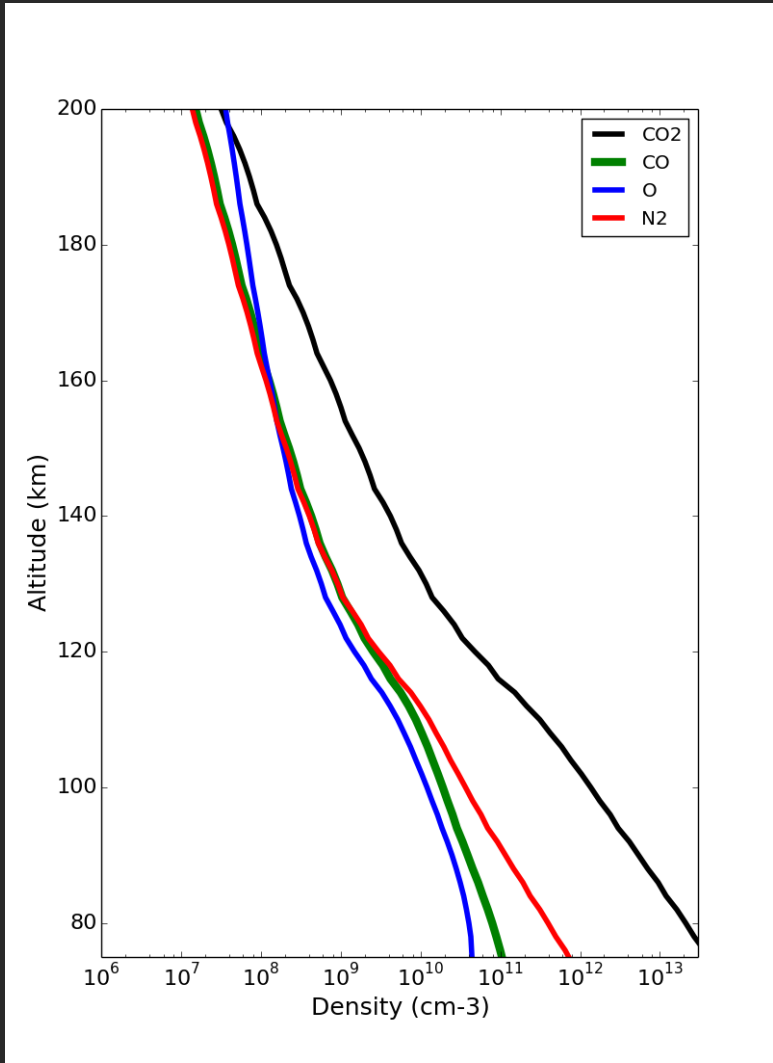


LMD-MGCM
Ls=90-120, SAVE, lat=0,
LT=14 (SZA~35)

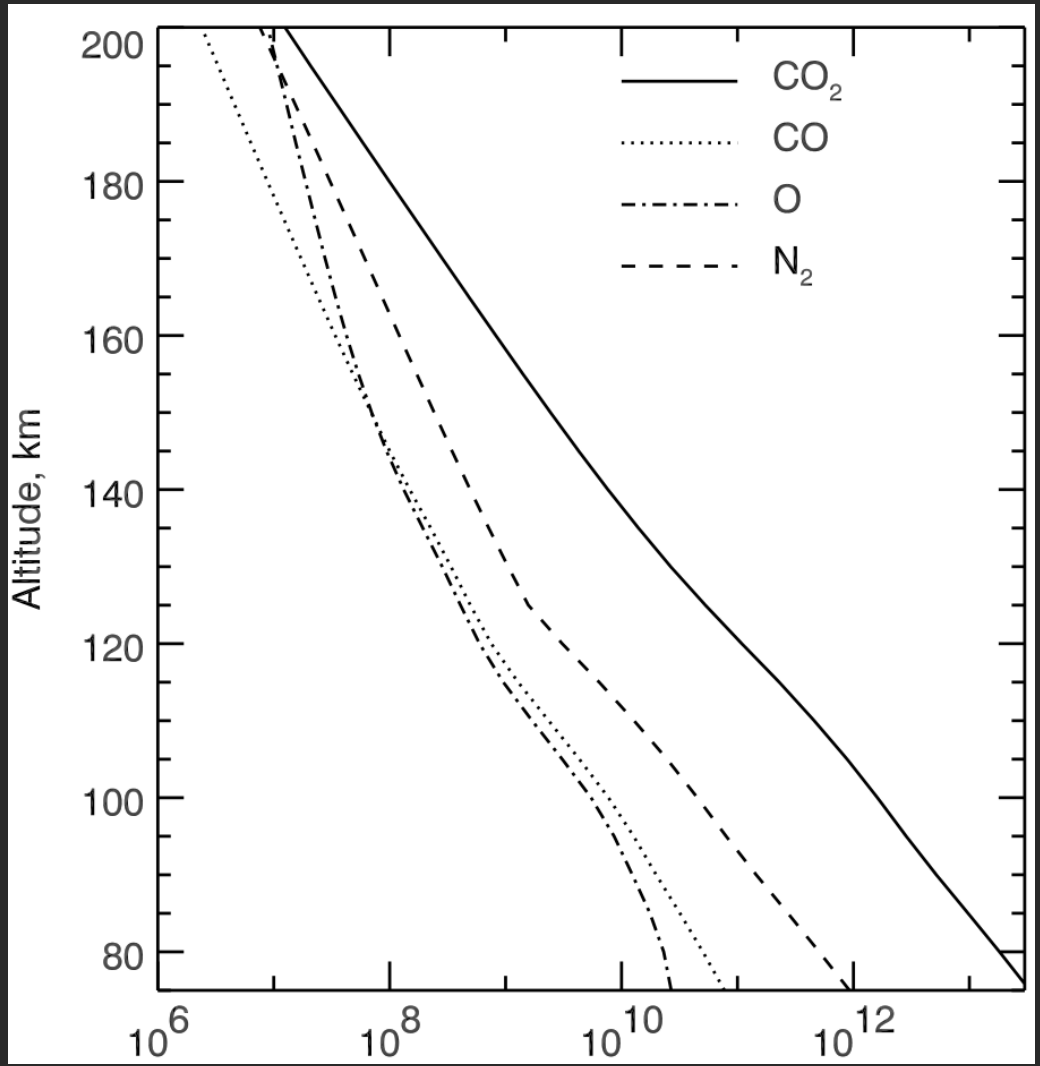


Jain & Bhardwaj 2012
Ls=100-130,
F10.7=87.7, SZA=45

Background atmospheres



GCM
Ls=120-150, SAVE,
lat=0, LT=14 (SZA~35)



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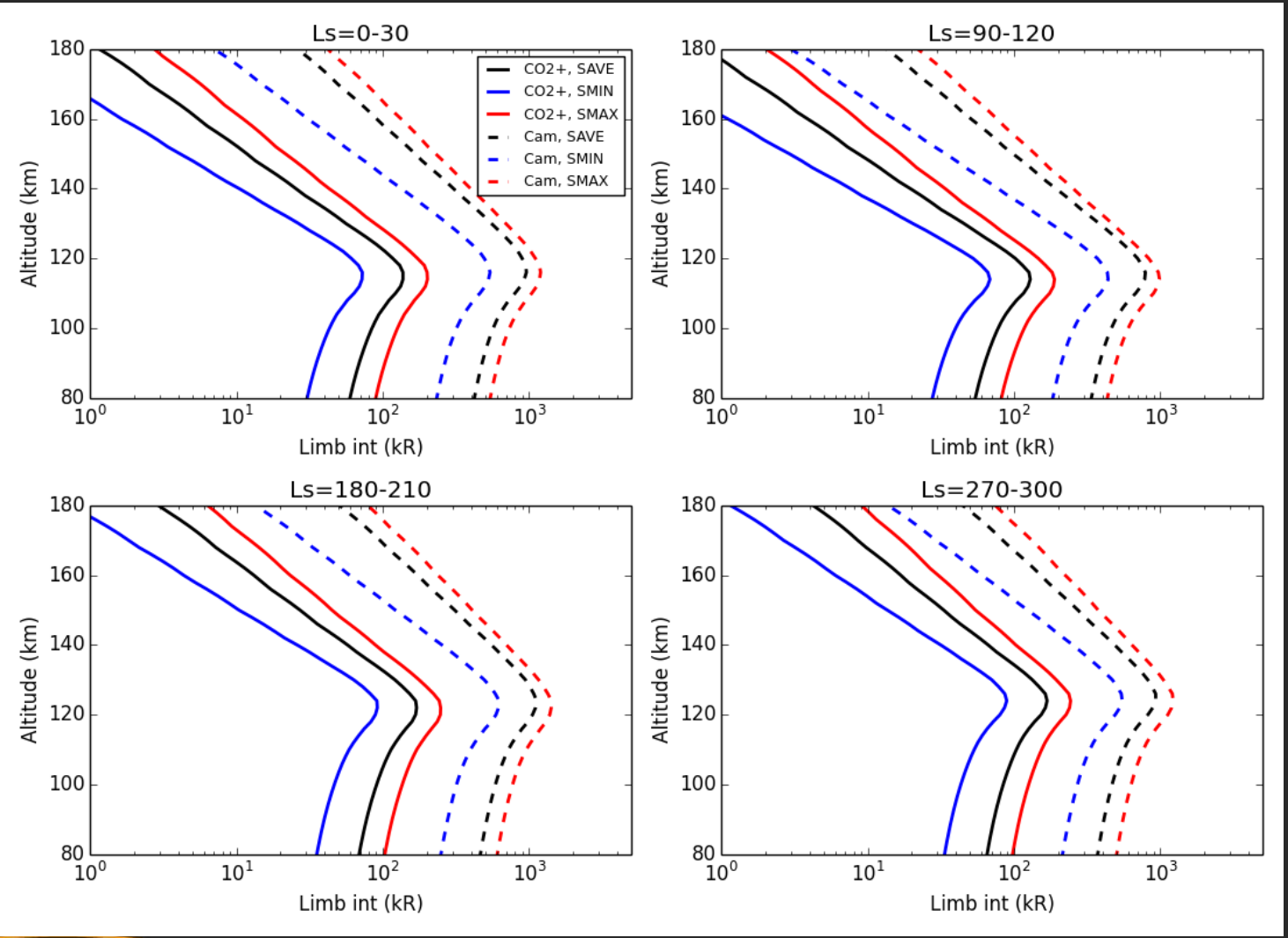
Solar variability



Lat=0, LT=12

SPICAM distribution