Ozone vertical distribution on Mars from SPICAM/MEX UV occultations

A. Määttänen[1], F. Lefèvre[2], F. Montmessin[1], S. Guilbon[1], C. Listowski[1]

[1]LATMOS/IPSL, UVSQ Université Paris-Saclay, Sorbonne Université, CNRS, Guyancourt, France

[2]LATMOS/IPSL, Sorbonne Université, UVSQ, CNRS, Paris, France

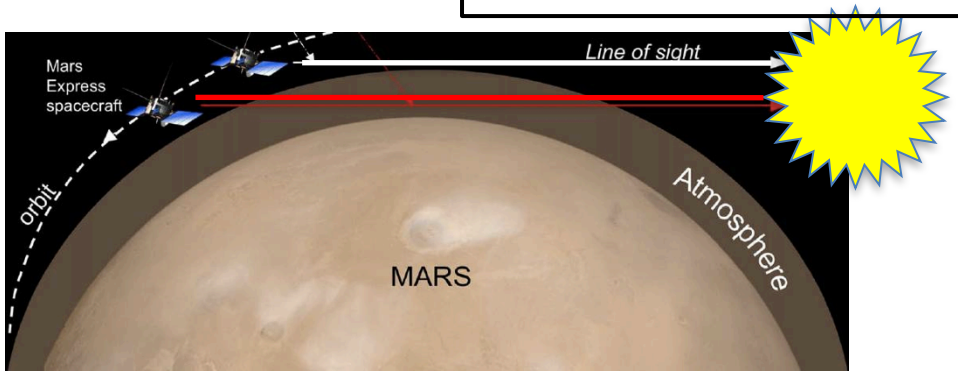
SPICAM UV solar and stellar occultations: O_3

- Previous analyses from stellar occultations: Lebonnois et al. 2006 and Montmessin&Lefèvre 2013
- Ozone vertical distribution climatology (MY 27-30)

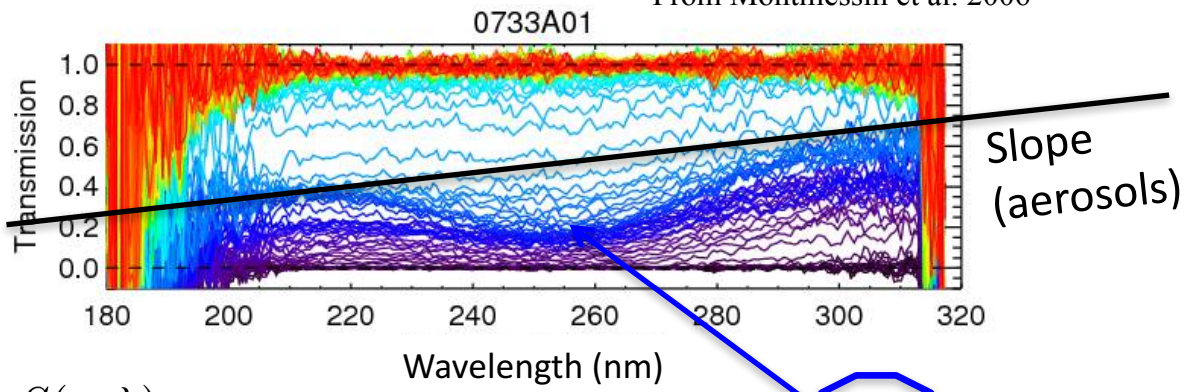
From transmittances through slant profiles to local profiles

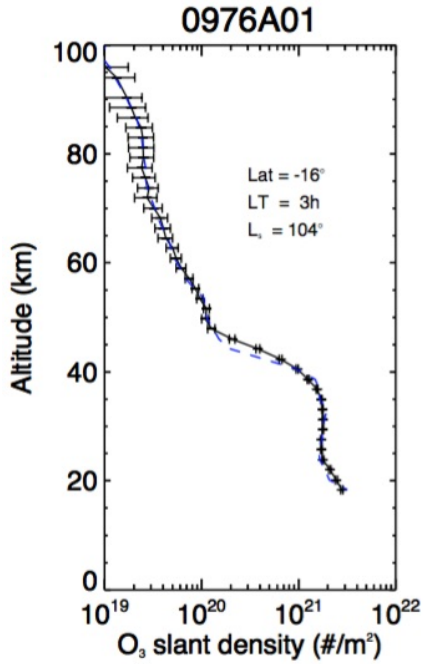
$S_\odot(\lambda, z)$

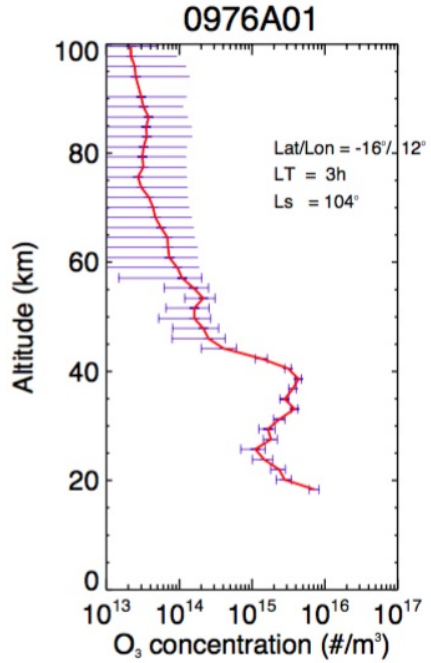
$S(\lambda, z)$



From Montmessin et al. 2006





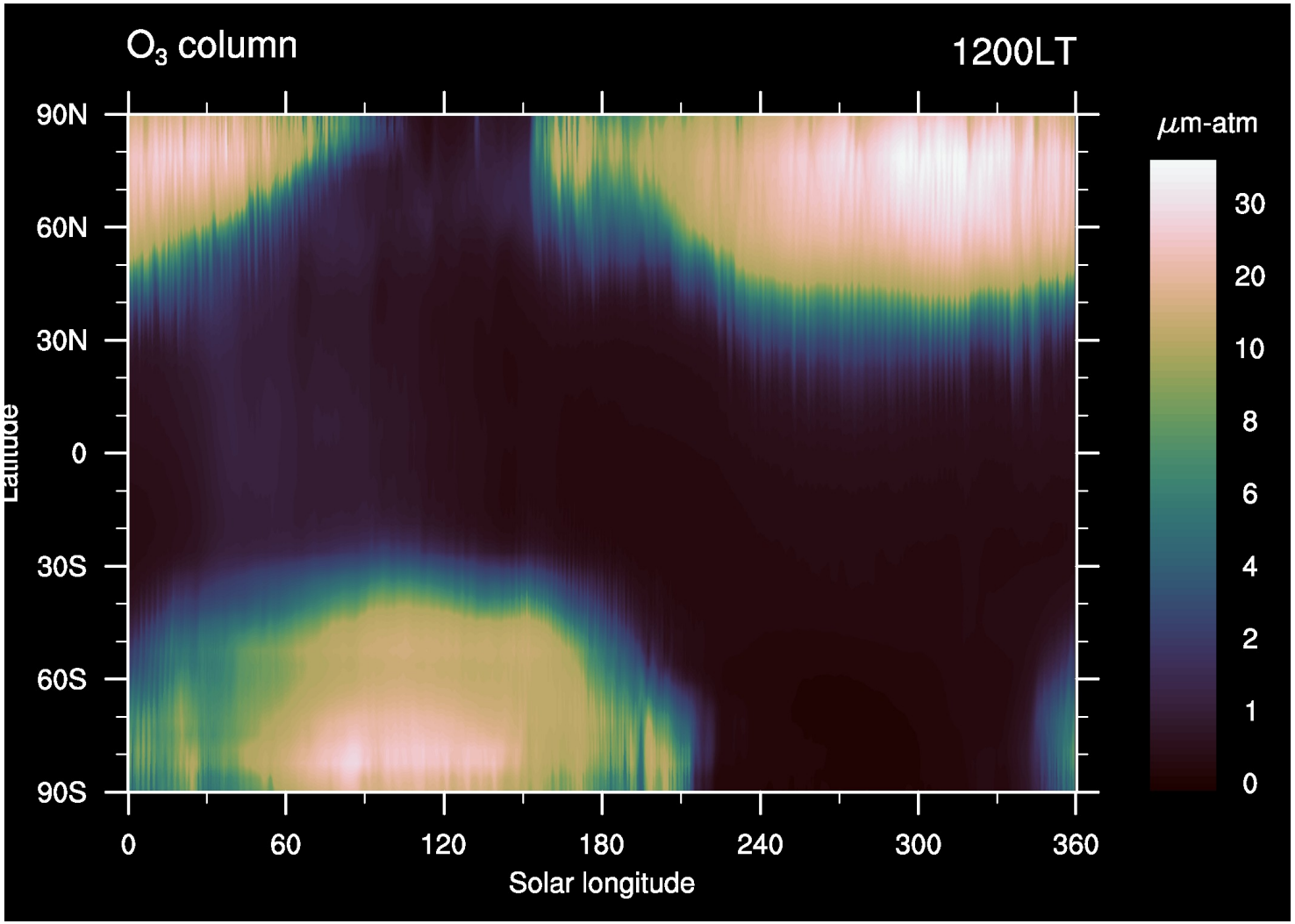


$$T(z,\lambda) = \frac{S(z,\lambda)}{S_\odot(\lambda)} = \exp(-\sigma_{CO_2}(\lambda)N_{CO_2} - \sigma_{O_3}(\lambda)N_{O_3} - \tau_{aer}(\lambda))$$

Spectral behaviour of aerosols

$$(\tau_{aer}(\lambda) = \tau_0(\frac{\lambda_0}{\lambda})^\alpha)$$

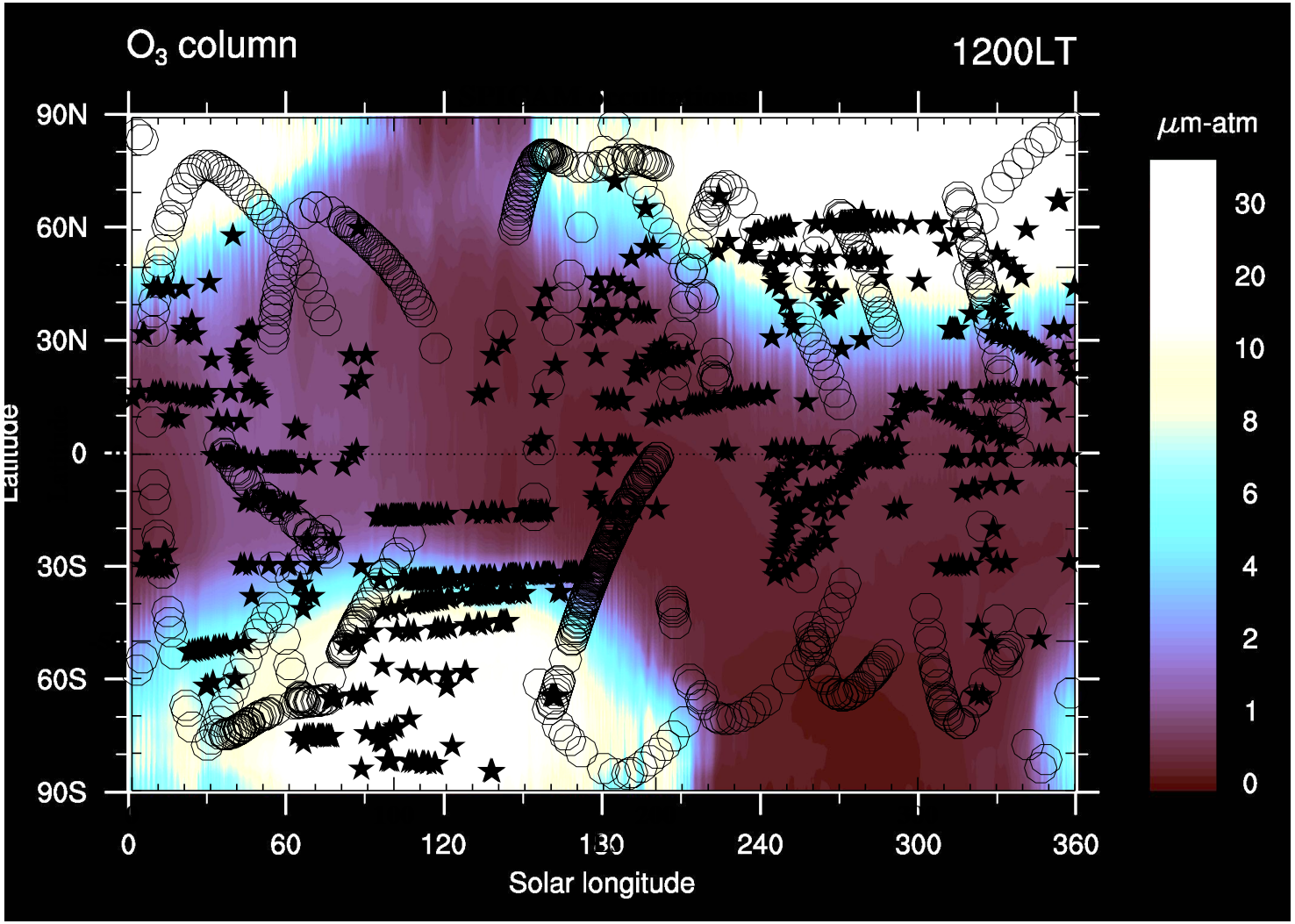
Ozone climatology



- Modelled ozone column climatology
- Ozone concentrations locally controlled by water vapor distribution (anti-correlation)

(LMD Mars GCM, courtesy of Franck Lefèvre)

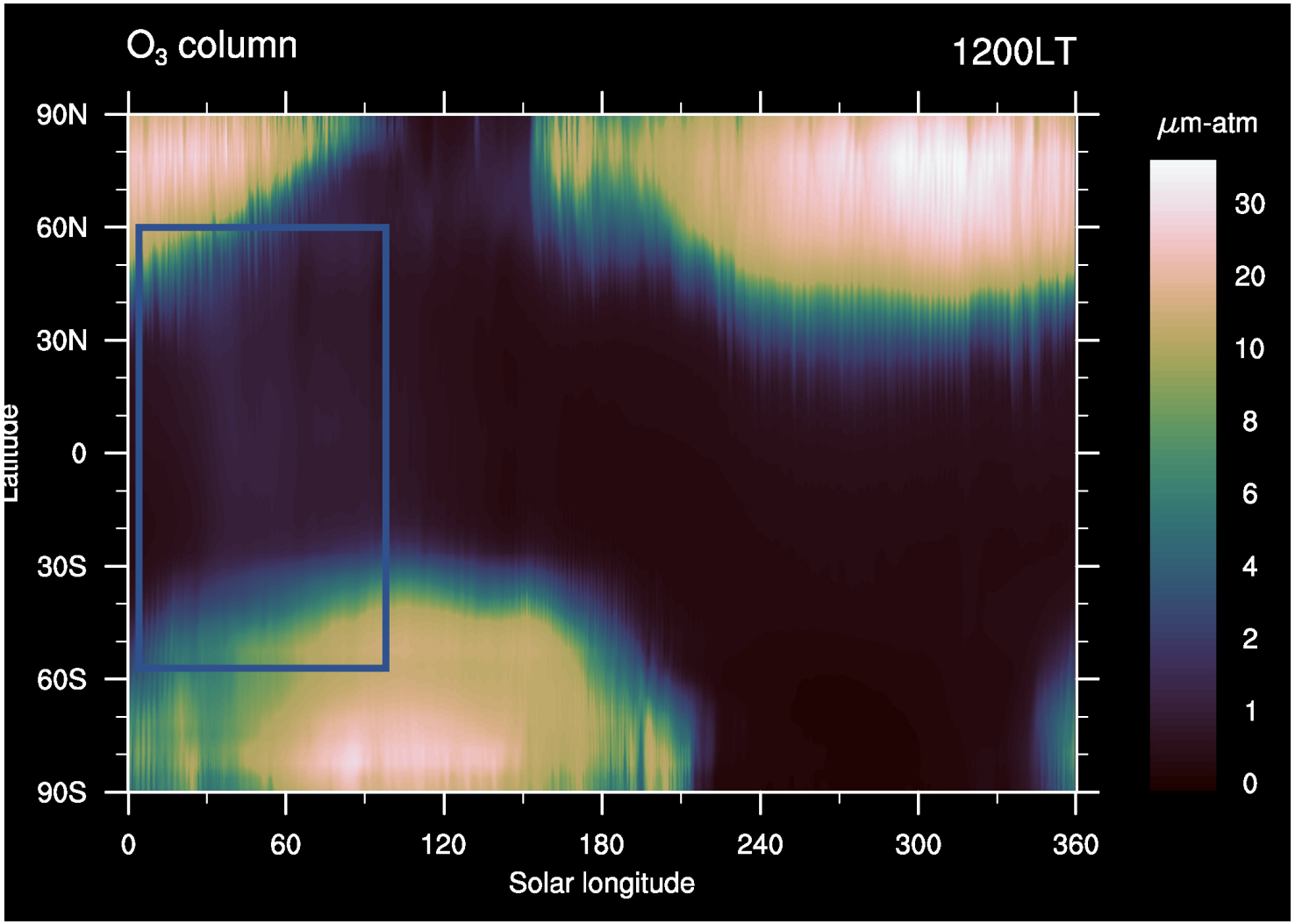
Ozone climatology



- Modelled ozone column climatology + full SPICAM UV occultation coverage

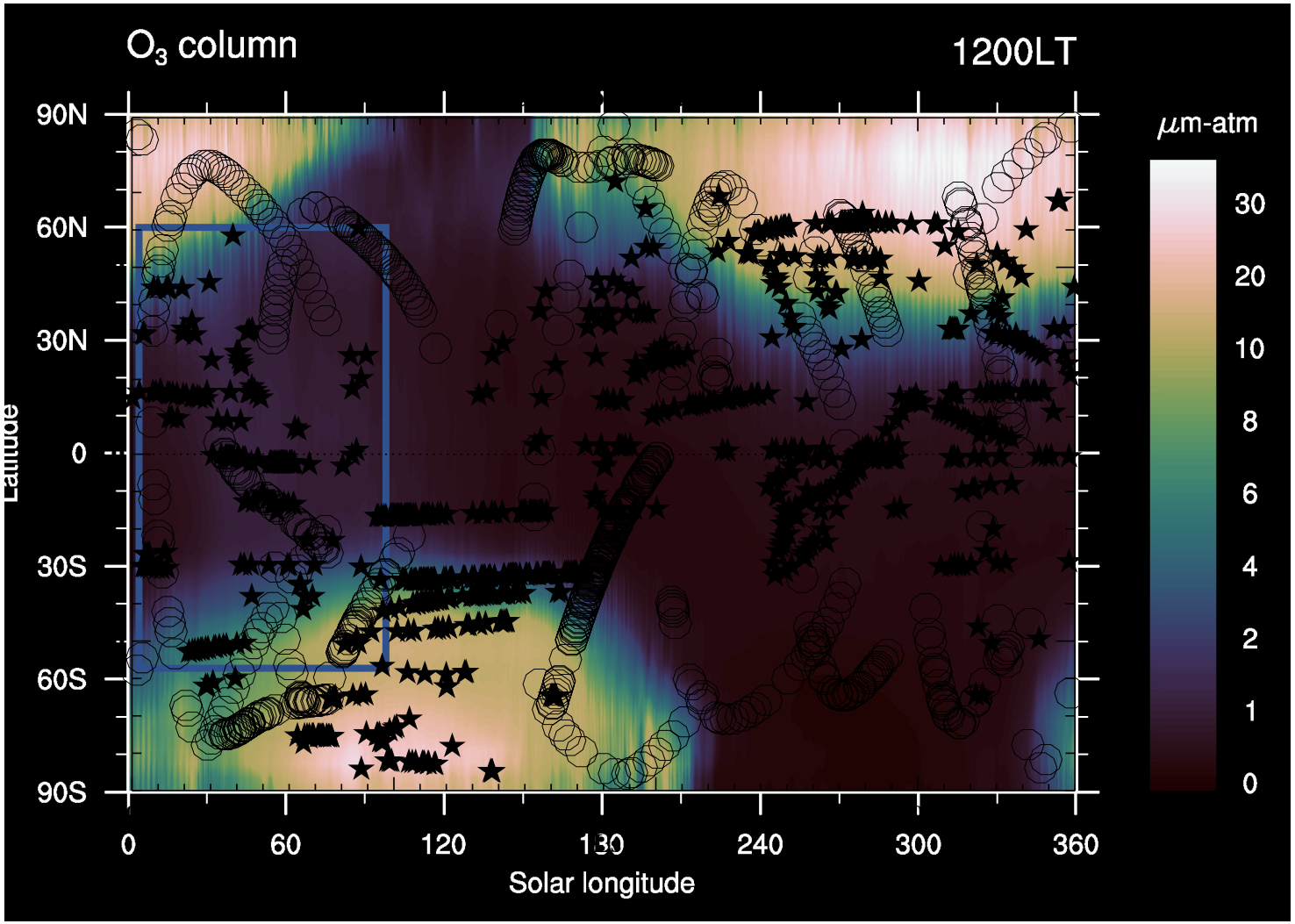
(LMD Mars GCM, courtesy of Franck Lefèvre)

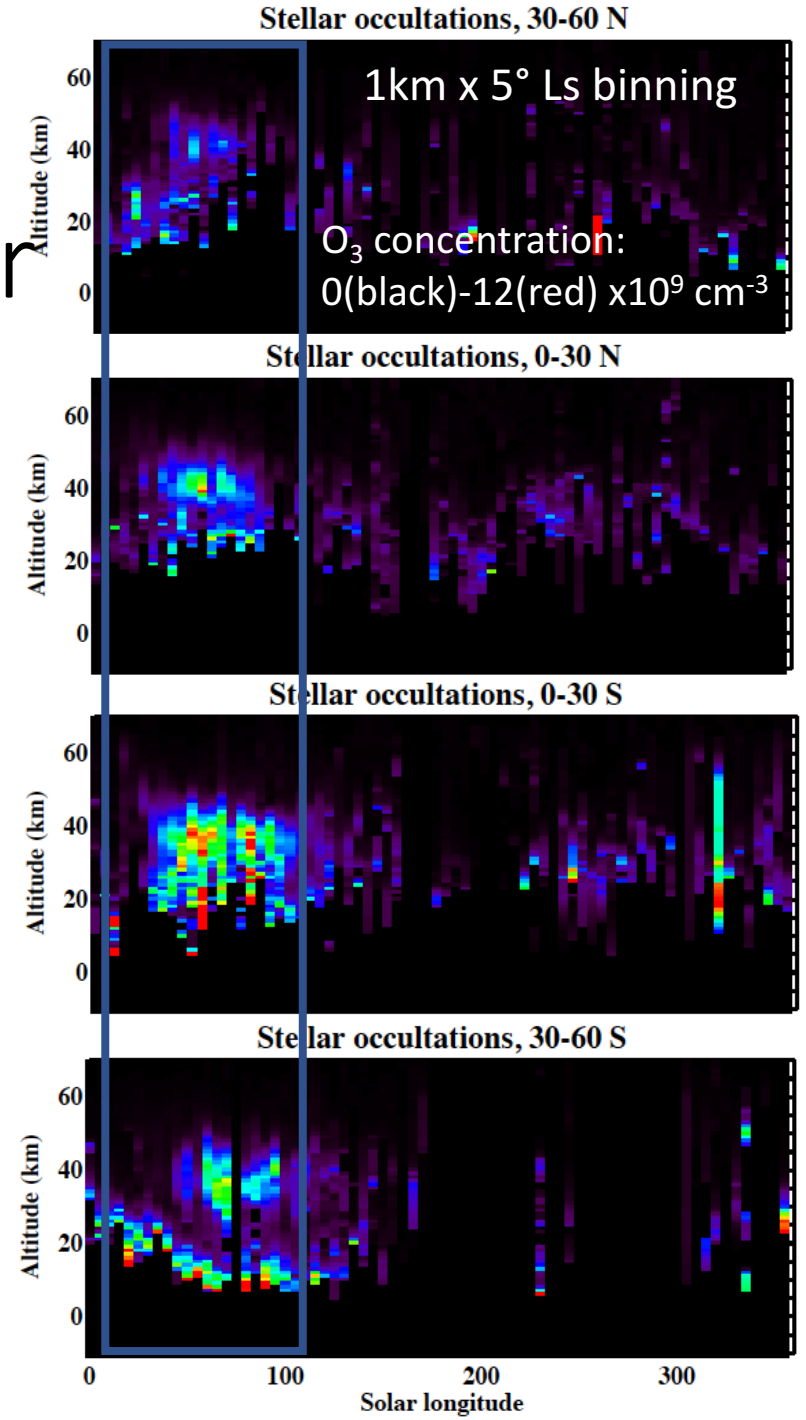
Ozone climatology: tropical & midlatitude ozone layer



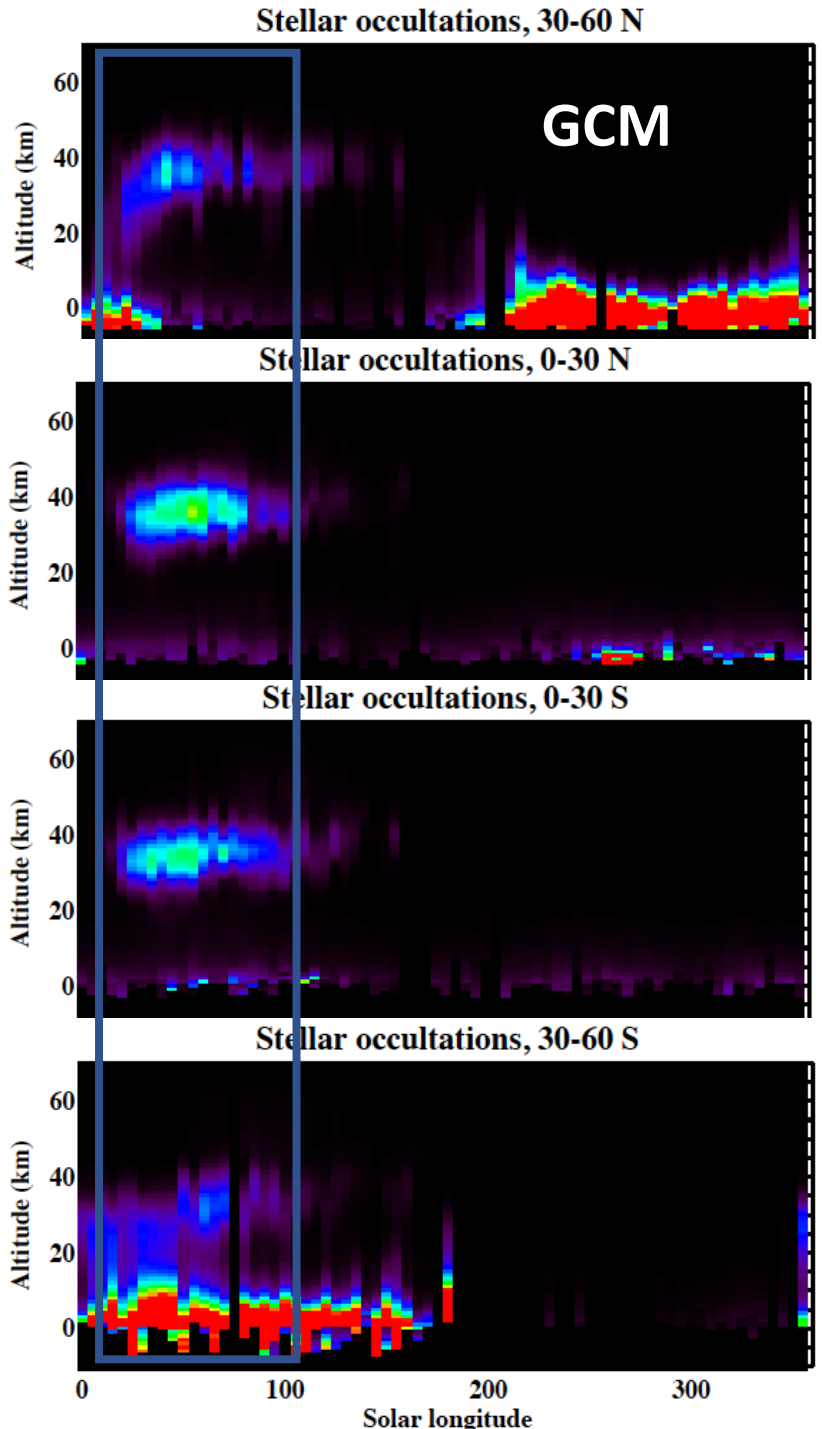
- Low and midlatitudes in spring:
  - Nighttime ozone layer around 30-40 km at aphelion related to low hygropause and confinement of water vapor (OH radicals) at lower altitudes
  - No ozone closer to perihelion season: rise of hygropause level and OH leading to destruction of ozone

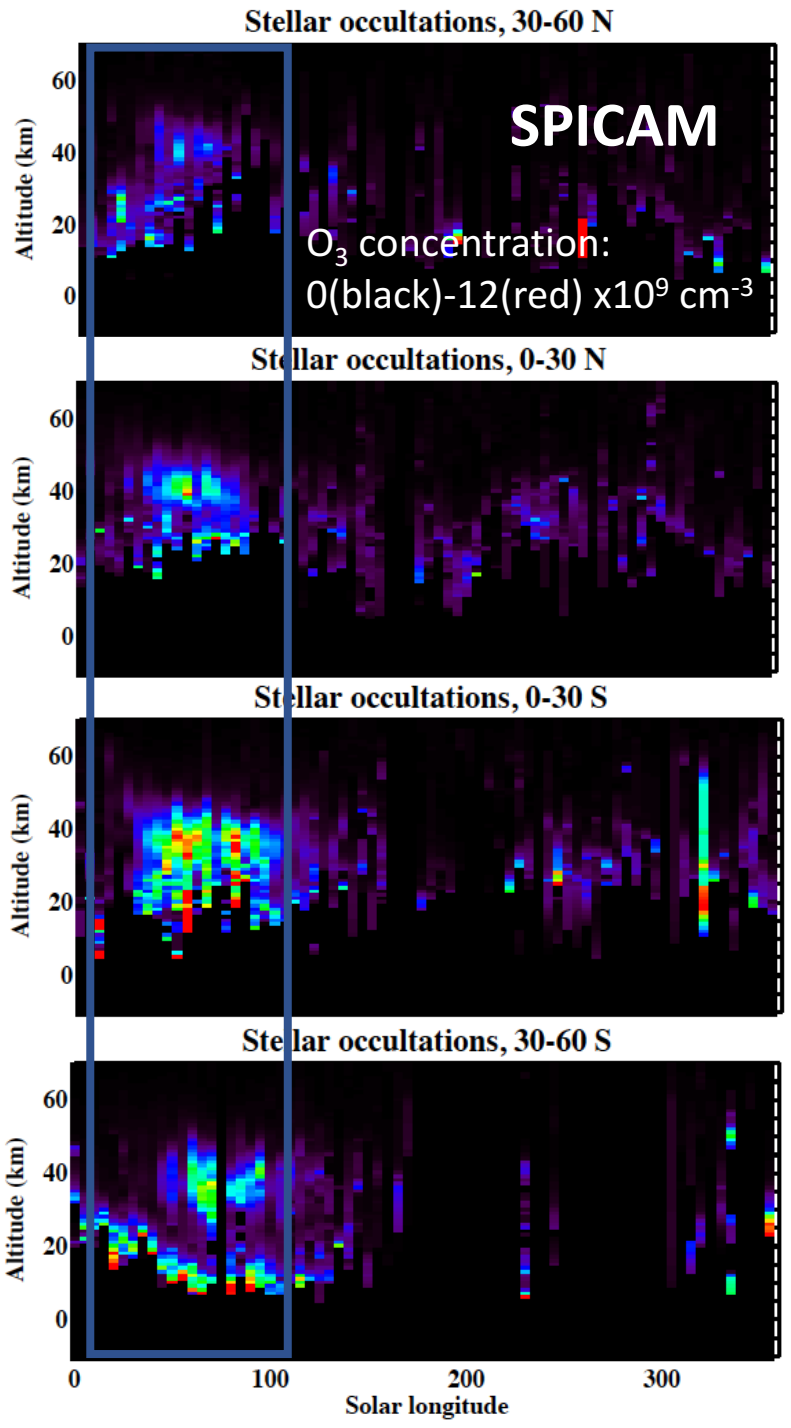
Ozone climatology: tropical & midlatitude ozone layer



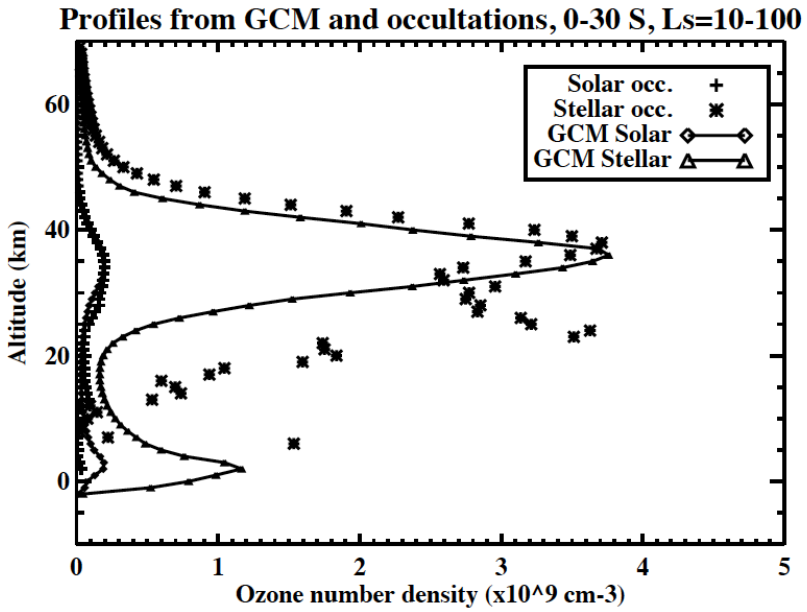


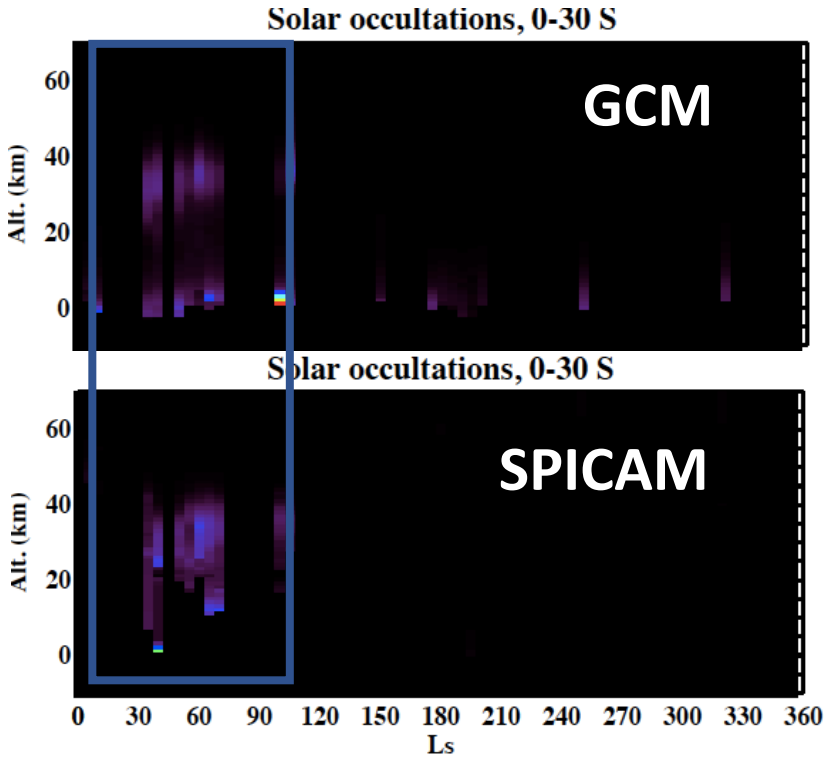
- Low and midlatitudes in spring:
  - Ozone layer around 30-40 km **well predicted by the GCM**
  - Small differences:
    - Structure
    - Max concentrations
    - Duration

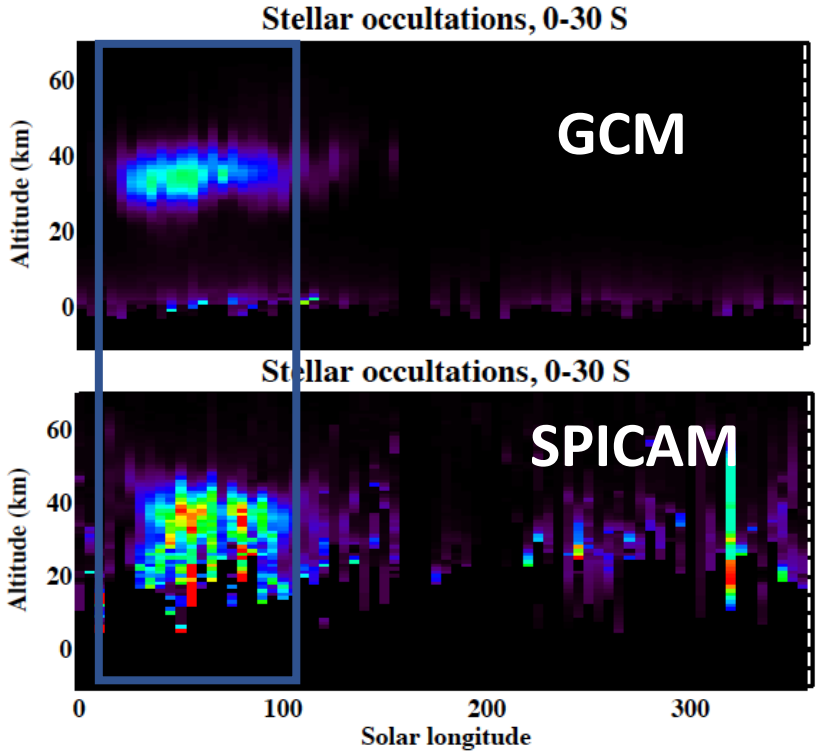




Average profiles & layer diurnal variation (0-30°S)

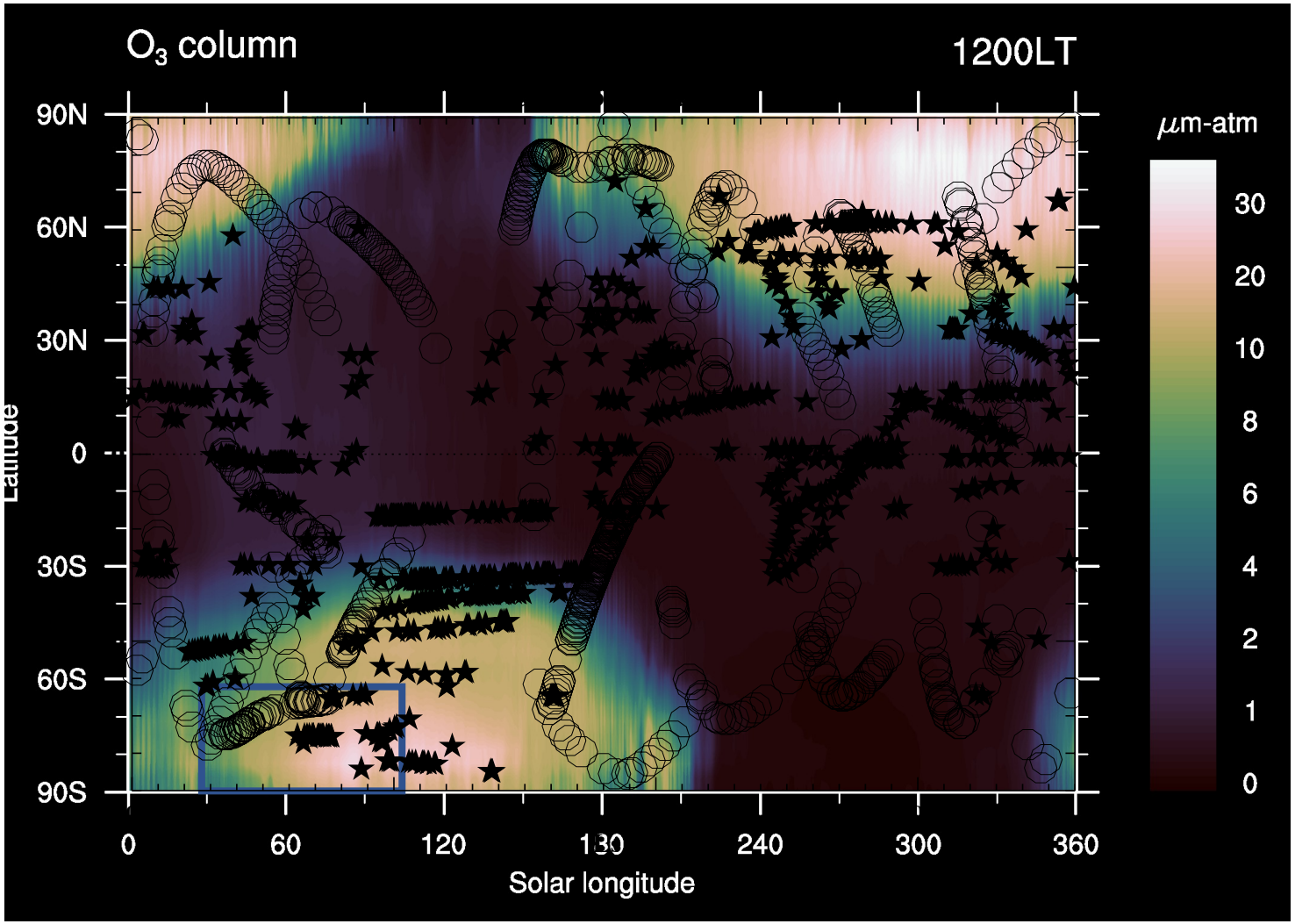




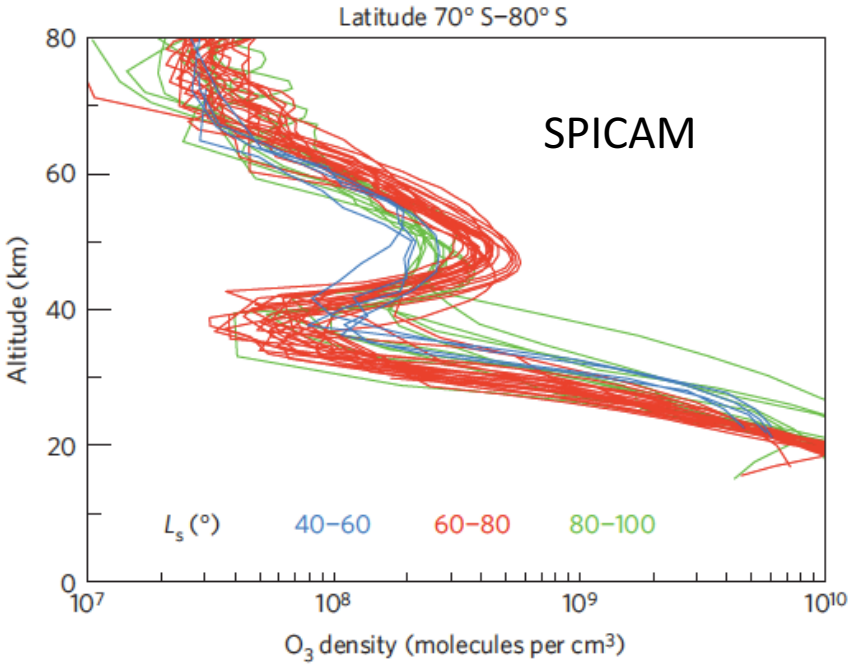


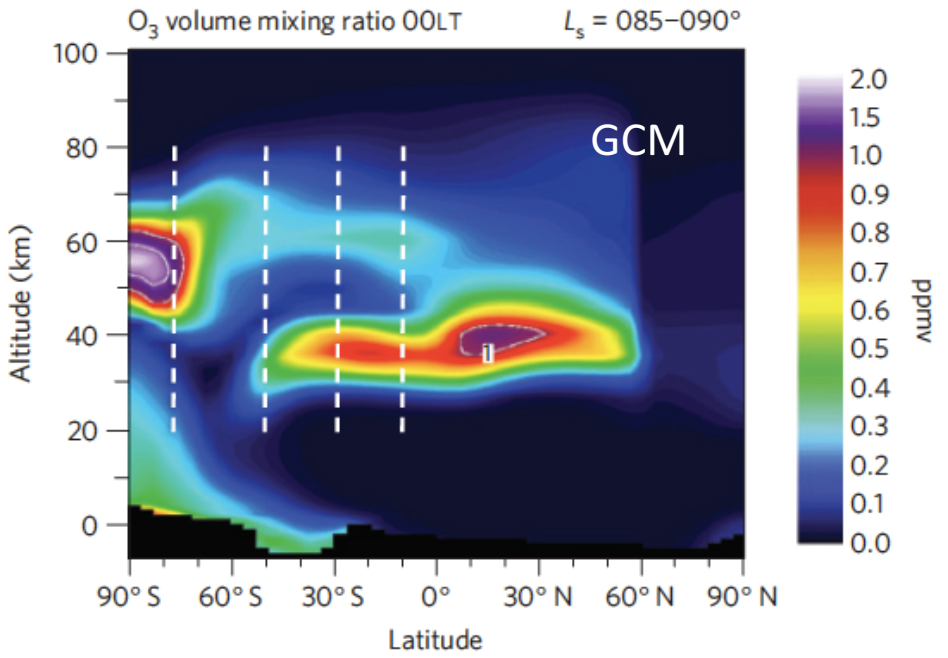
O_3 concentration:
0 (black) -12 (red) x10^9 cm^{-3}

Ozone climatology: southern polar winter vortex



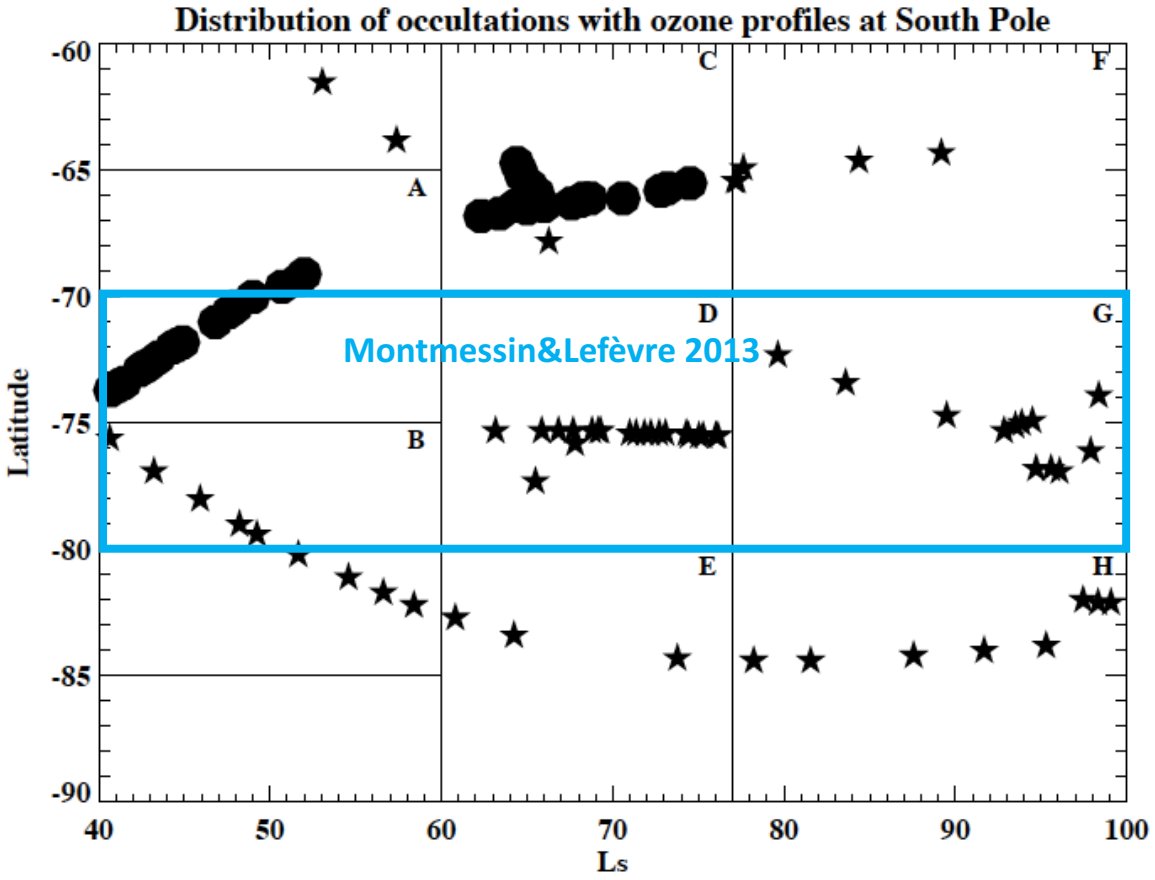
SPICAM O_3: SP Winter



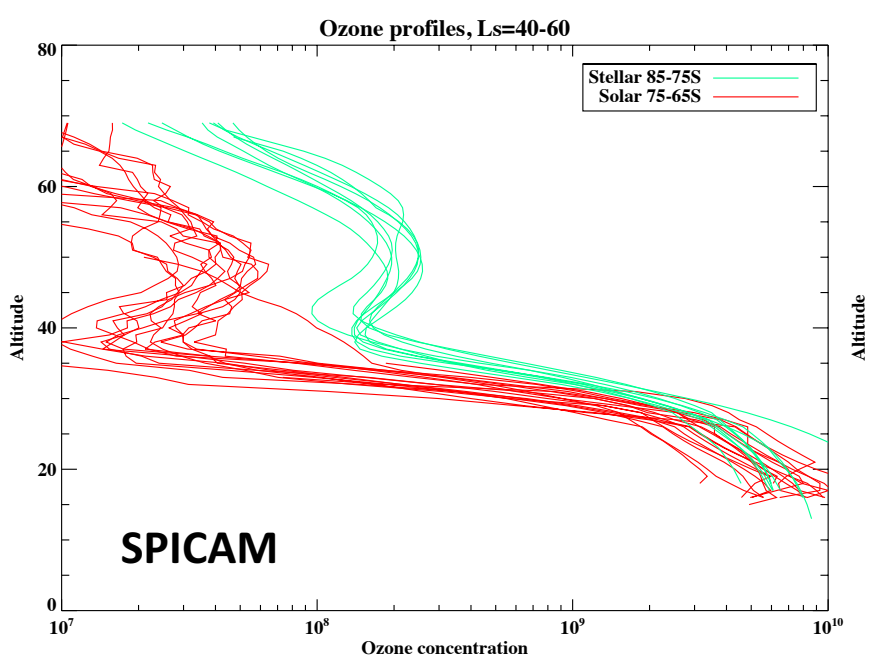


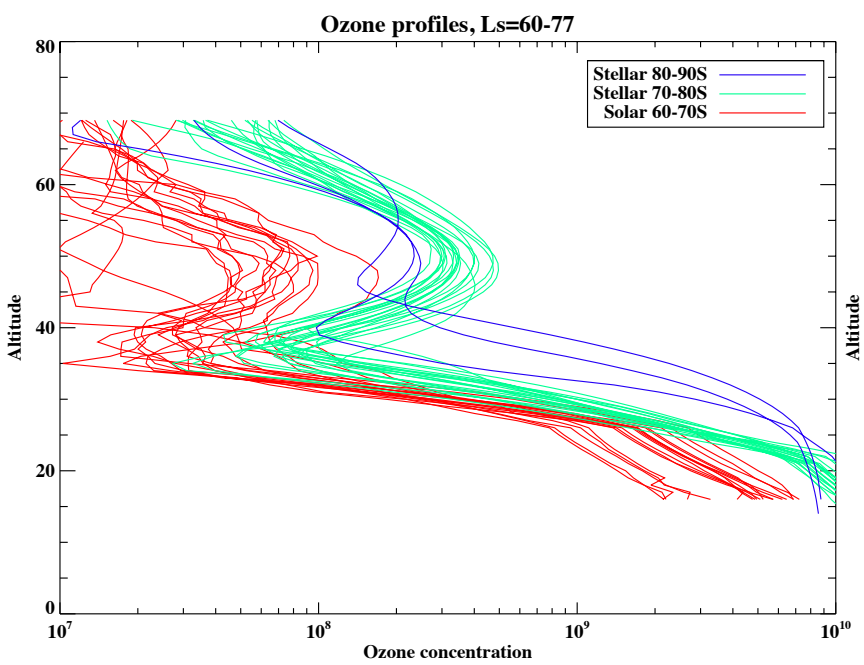
- Montmessin and Lefèvre 2013
- Transport-driven ozone layer within the South polar vortex (no equivalent in the Northern winter), latitudes 70-80°S, Ls=40°-100°
- Result of the large-scale transport of oxygen-rich air from sunlit latitudes to the pole, where the oxygen atoms recombine to form ozone during the polar night

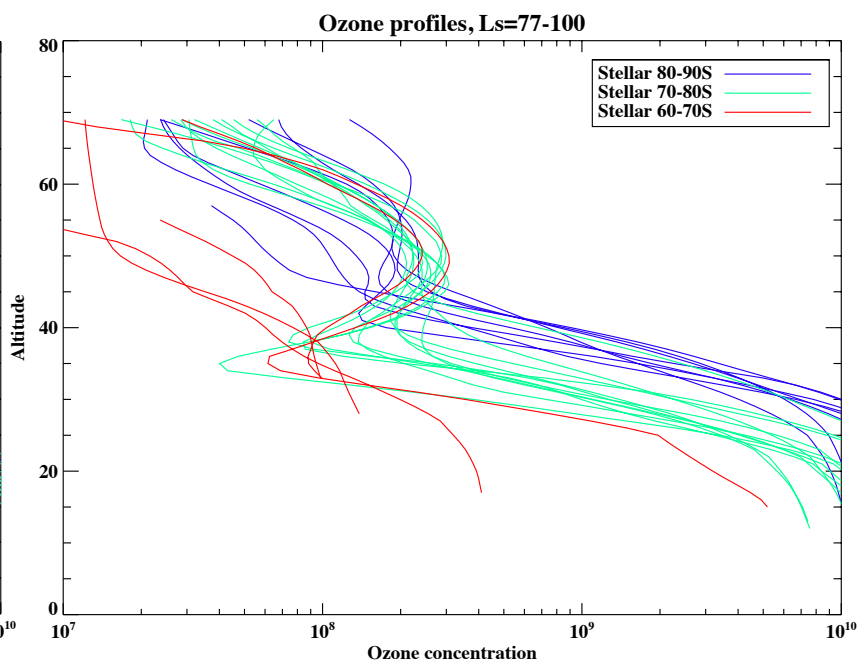
SPICAM O_3: SP Winter



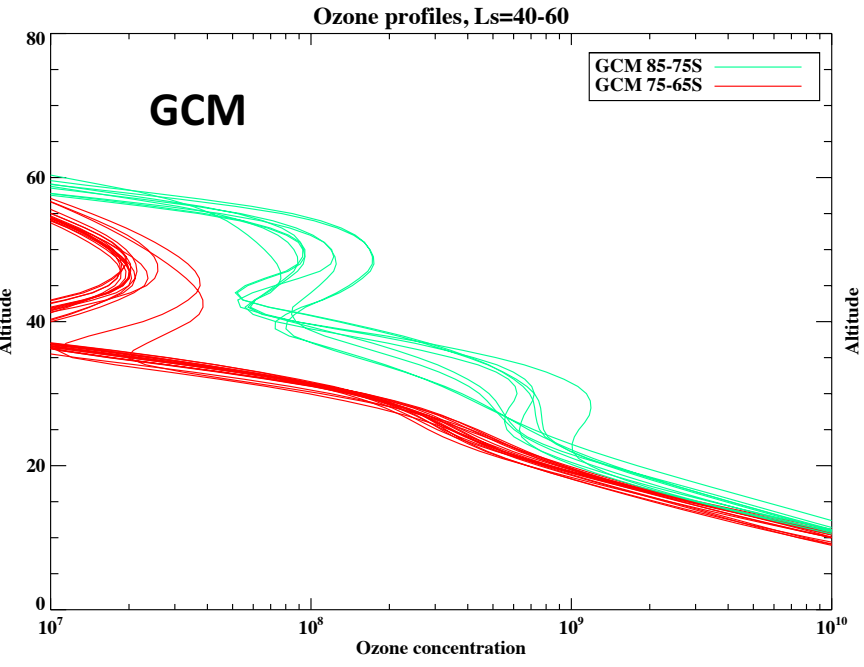
- Latitude-Ls coverage of all occultations
- Circles: solar occultations
- Stars: stellar occultations

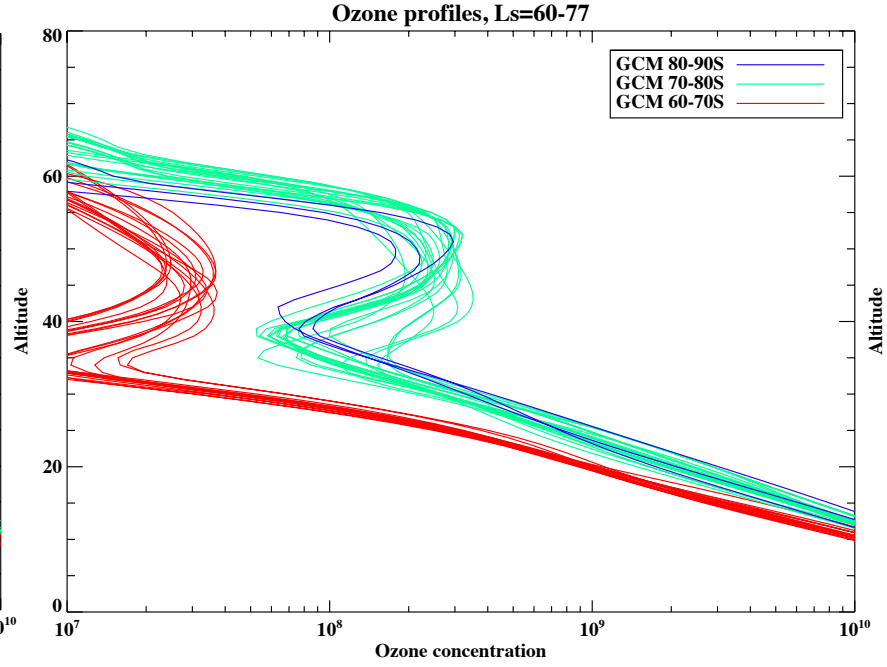


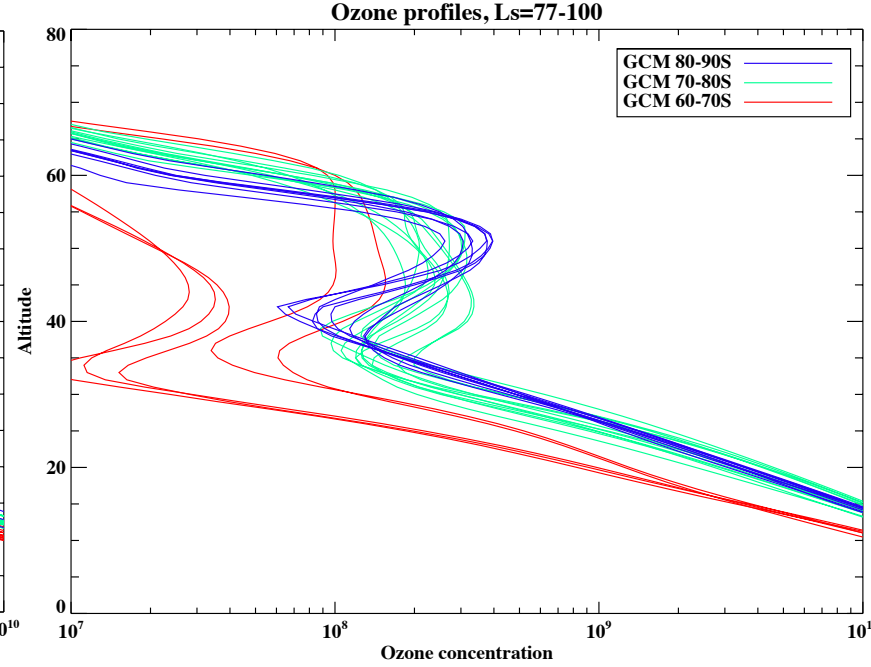




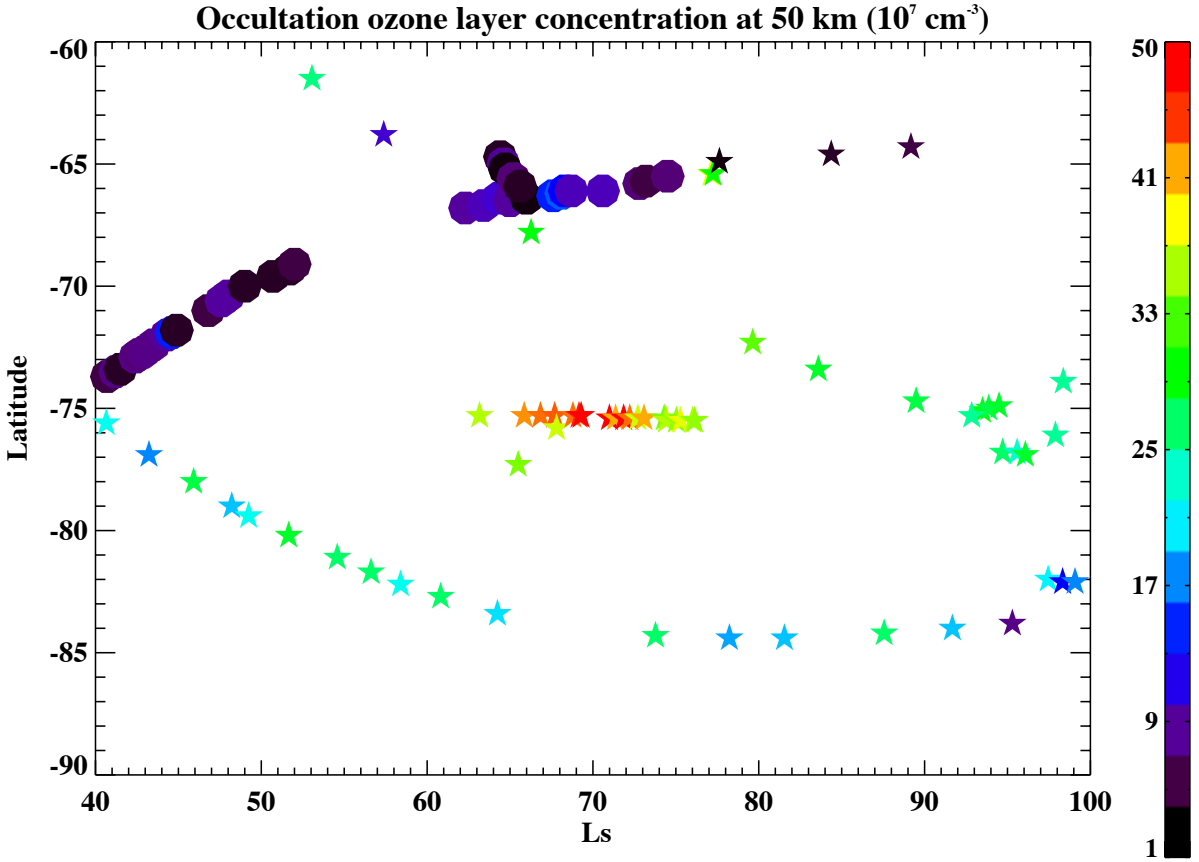
Ls 40-60° 60-77° 77-100°

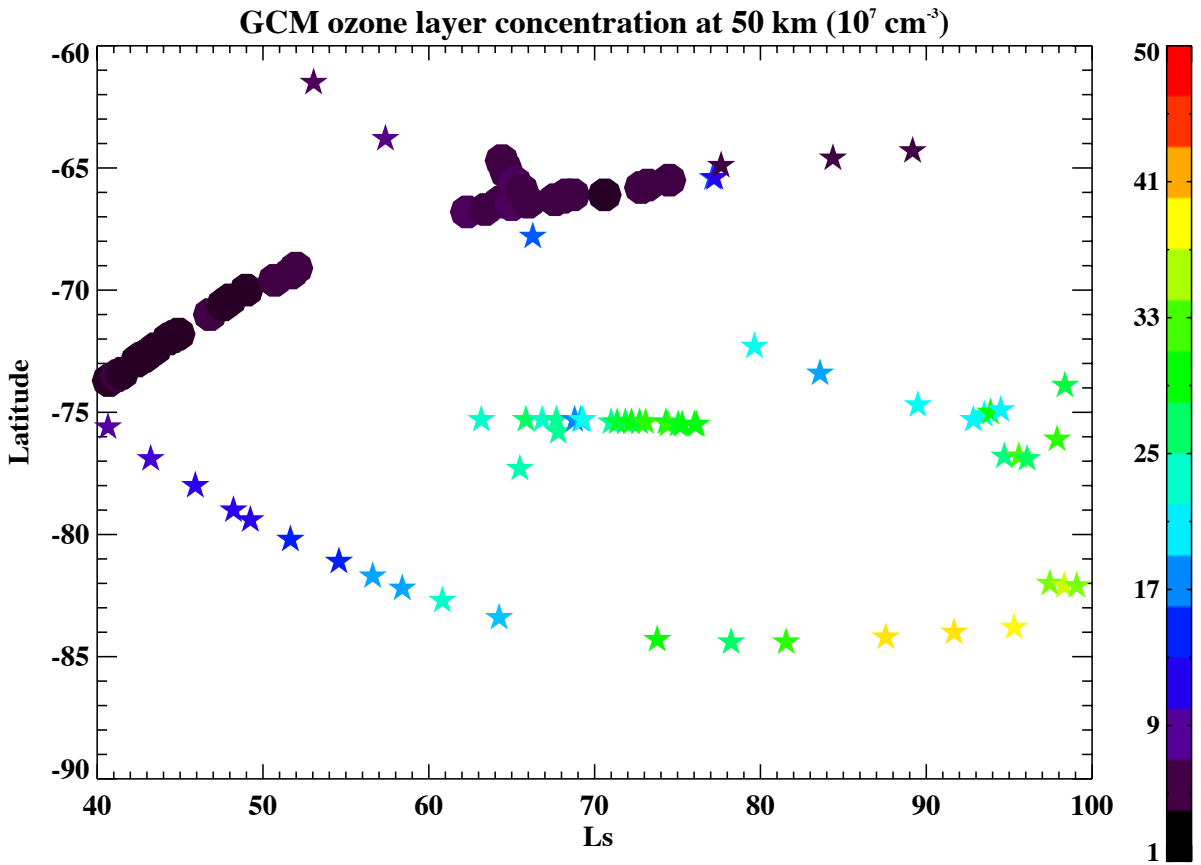




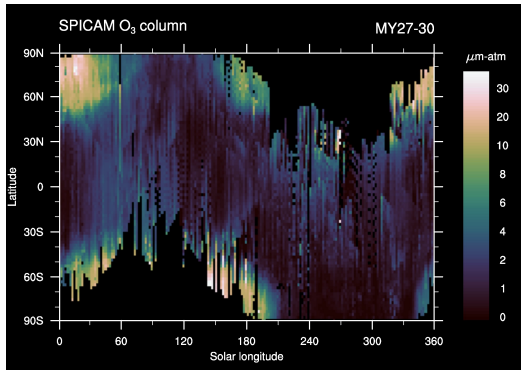


SPICAM O_3: SP Winter



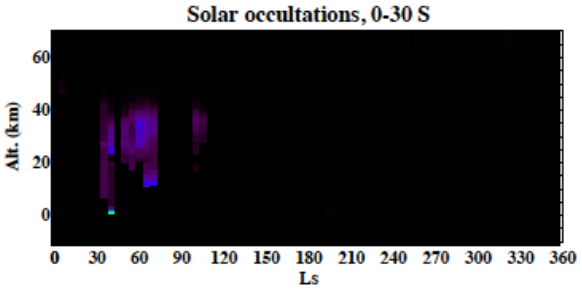


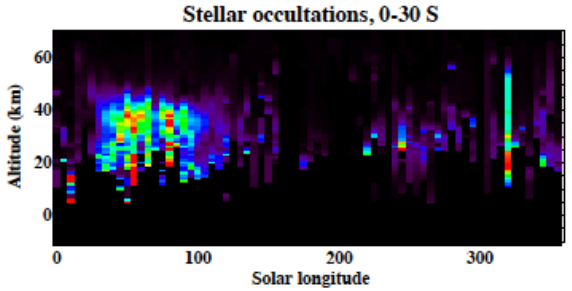
- O_3 concentration @ 50 km (~max in previous profiles): Occultations vs. GCM



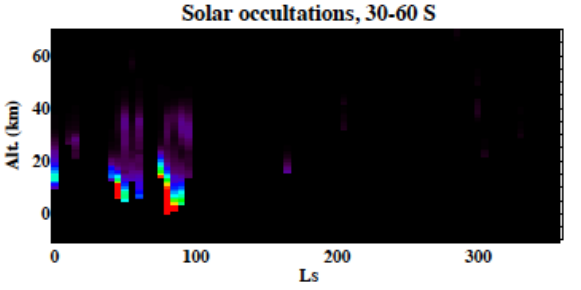
SPICAM O_3

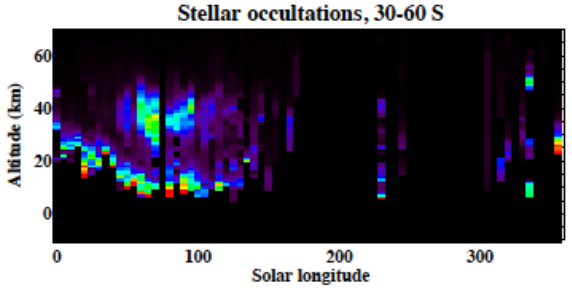
- SPICAM UV solar and stellar occultations combined reveal the O_3 vertical distribution and its variations
  - A 3D picture of O_3 with SPICAM (nadir+occultations)



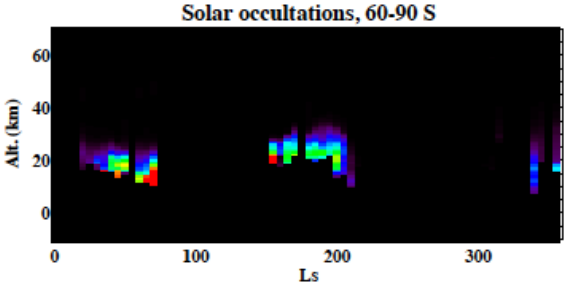


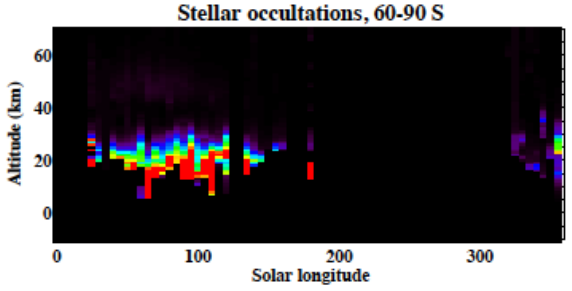
- SPICAM has probed the low and midlatitude O_3 layer and mapped the southern polar night O_3 layer throughout the polar vortex





- Good overall agreement with the GCM results
  - Next step: constrain the GCM with co-located O_3 and H_2O profiles (SPICAM UV and IR)





- Keep in mind the strong horizontal gradients in solar occultations that should be accounted for in vertical inversion (Piccialli et al. talk)