3D modelling of the ACS chemical targets

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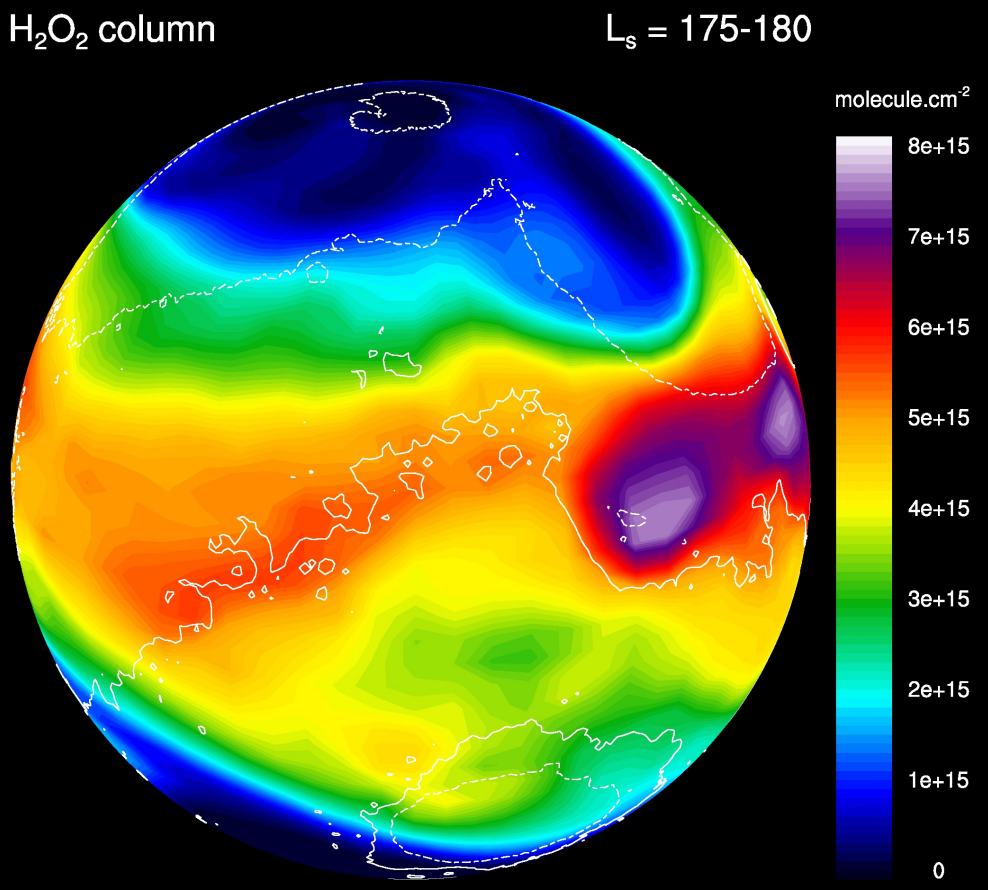
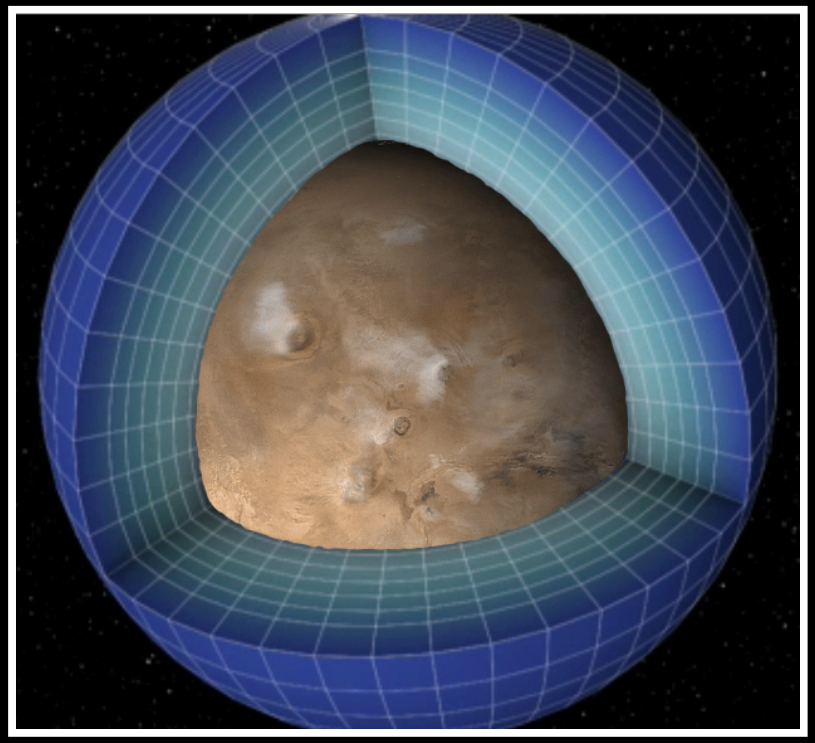


The LMD Mars General Circulation Model

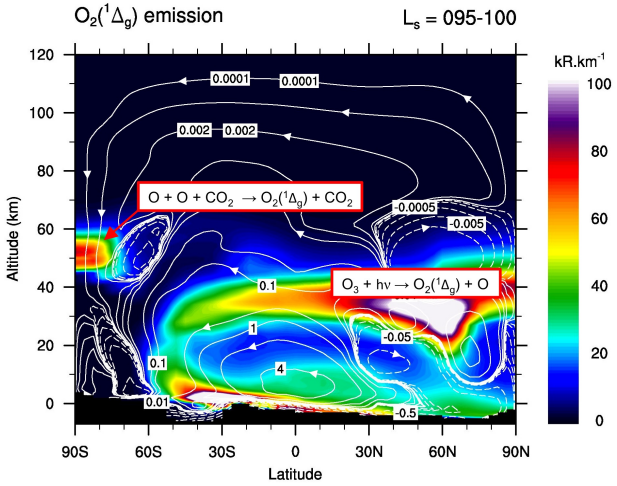
Forget et *al., JGR*, 1999; Angelats i Coll *et al., JGR*, 2004; Montmessin *et al., JGR*, 2004; Lefèvre *at al., JGR*, 2004; González-Galindo *et al., JGR*, 2005

- Developed jointly by Laboratoire de Météorologie Dynamique, LATMOS, University of Oxford, Instituto de Astrofísica de Andalucía
- Dynamical core inherited from the LMD GCM Earth model
- Martian topography, thermal inertia, and albedo
- Radiative transfer in visible and thermal infrared bands
- Sub-grid scale parameterizations
- Comprehensive representation of CO2, water, and dust cycles
- Photochemistry (CO2, CO, HOx, Ox)
  - inherited from the Reprobus Earth chemical model
  - 16 species, 50 reactions
  - interactive coupling with water cycle
- Terrain-following vertical coordinates, 39 levels from the surface up to about 120 km
- Horizontal resolution : 5.6° x 3.8°



Some of the ACS chemical targets

- $O_2(1\Delta g)$ NIR
- CO NIR, MIR
- CH_4 MIR
- CH_2O MIR
- C_2H_6 MIR
- H_2O_2 TIRVIM
- HO_2 MIR



Formation of O2(1Δ)

$$O3 + h\nu \rightarrow O2(1\Delta) + O$$
$$O + O + CO2 \rightarrow O2(1\Delta) + CO2$$

Loss of O2(1Δ)

$$O2(1\Delta) \rightarrow O2(3\Sigma) + h\nu\ (1.27\ \mu m)$$
$$O2(1\Delta) + CO2 \rightarrow O2(3\Sigma) + CO2$$

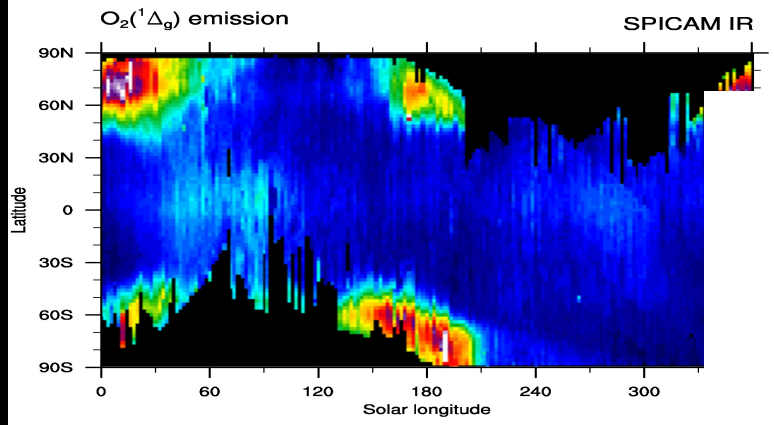
τ = 1.2 hour

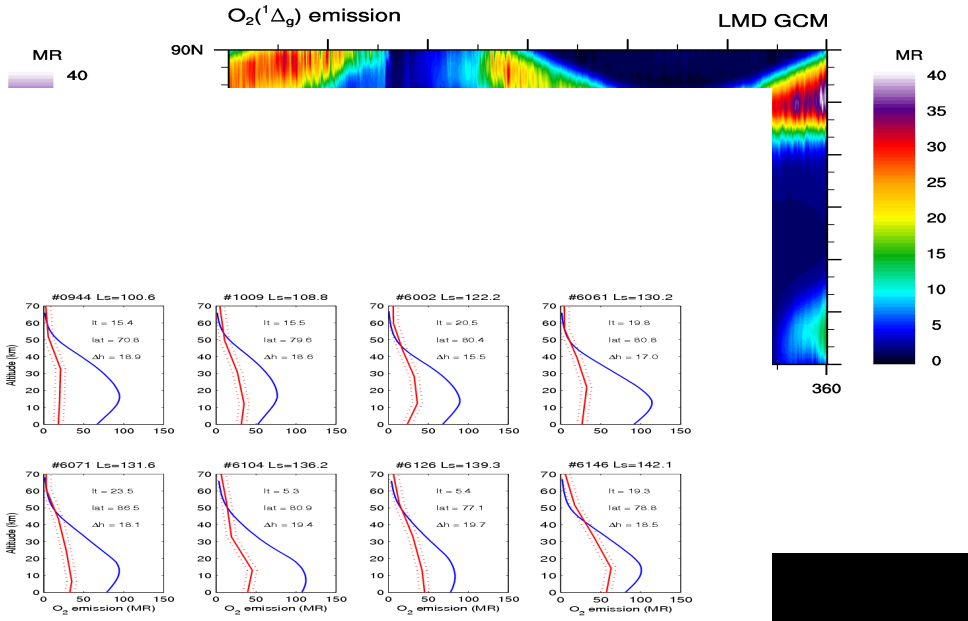
k < 2x10-20 cm3 s-1

During the day: $O_3 + h\nu \rightarrow O_2(1\Delta) + O$

SPICAM

GCM

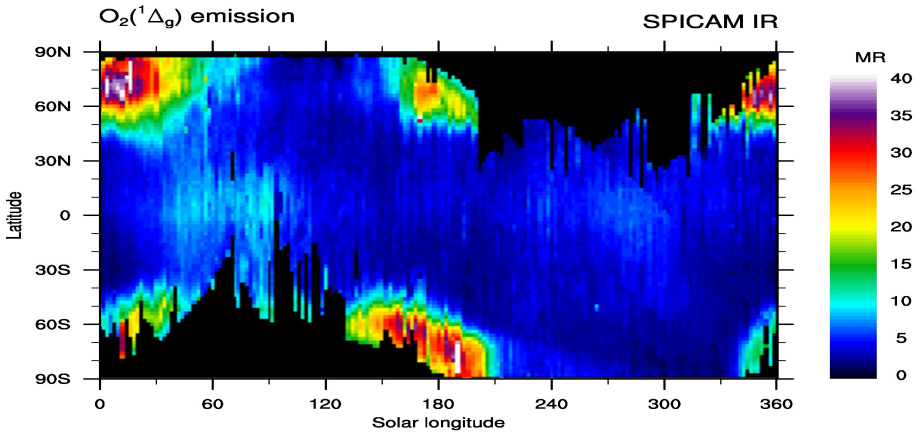


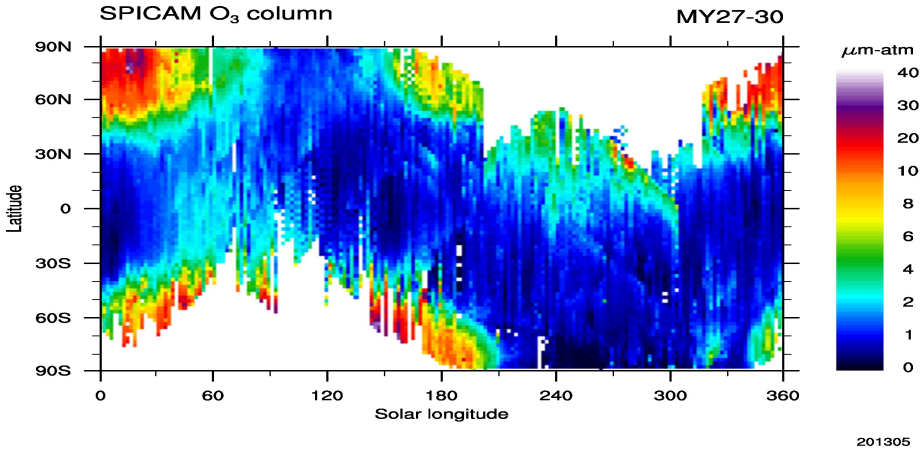


updated from Fedorova et al., 2006

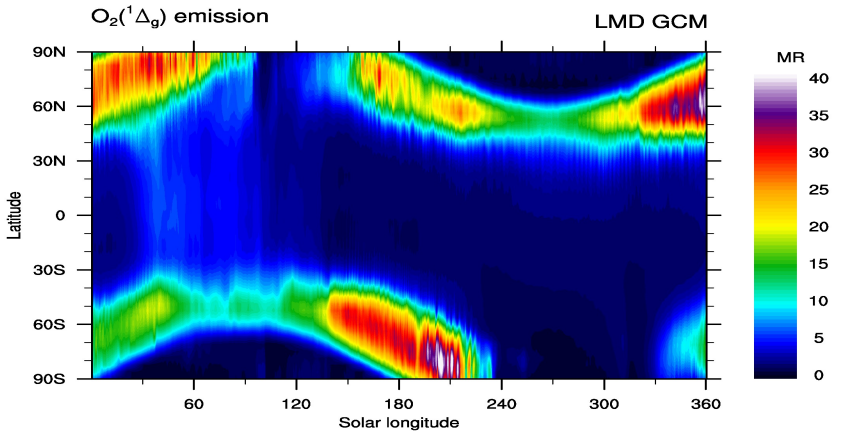
Guslyakova et al., in prep.

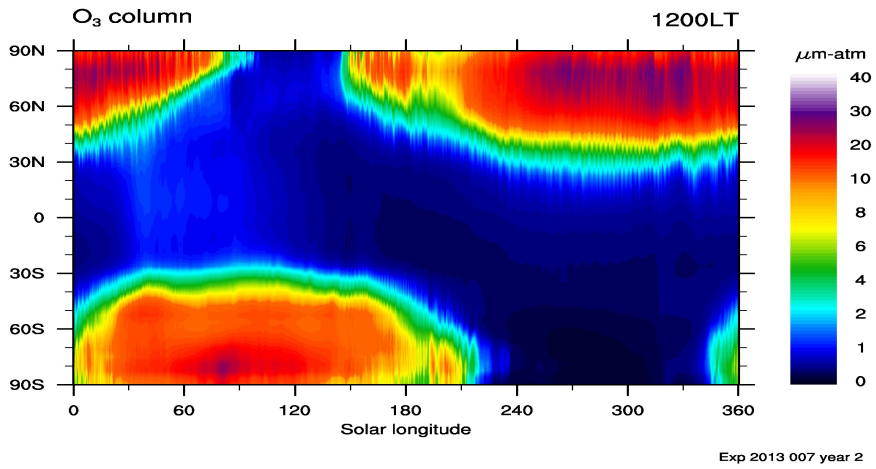
SPICAM


$O_2(^1\Delta_g)$ emission
SPICAM IR
MR
40
35
30
25
20
15
10
5
0
90N
60N
30N
0
30S
60S
90S
Latitude
0
60
120
180
240
300
360
Solar longitude

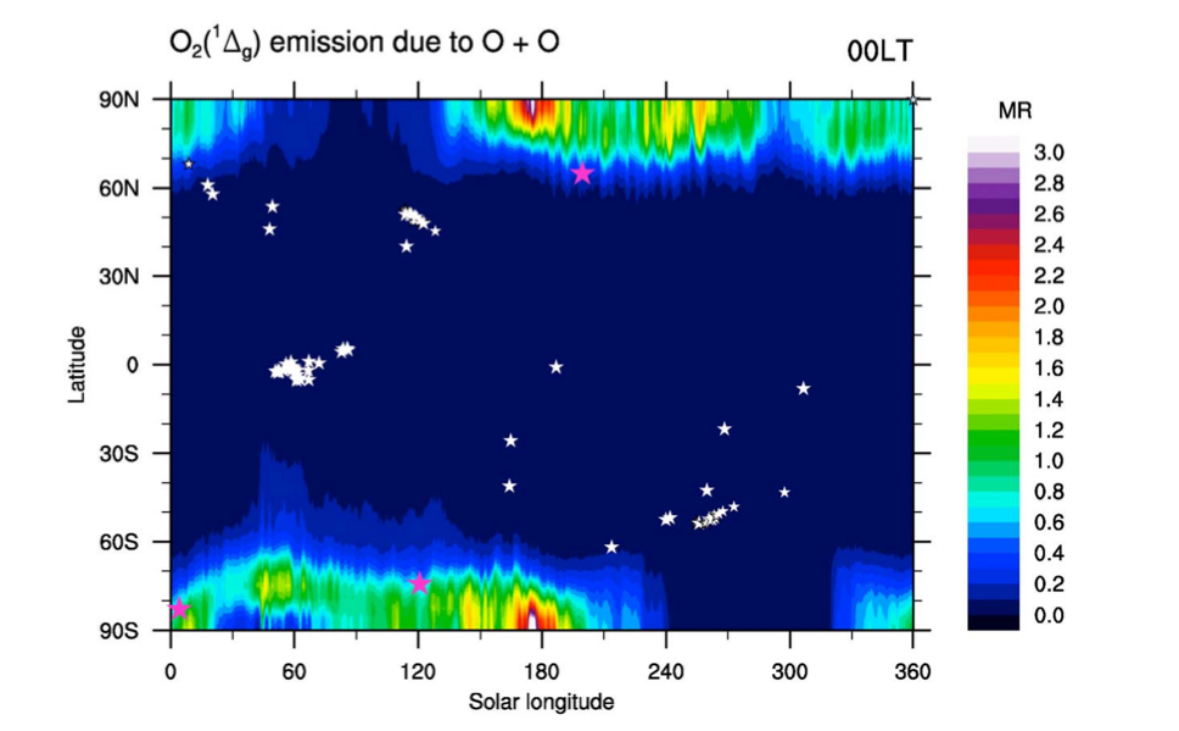

SPICAM O_3 column
MY27-30
μm-atm
40
30
20
10
8
6
4
2
1
0
90N
60N
30N
0
30S
60S
90S
Latitude
0
60
120
180
240
300
360
Solar longitude
201305

GCM

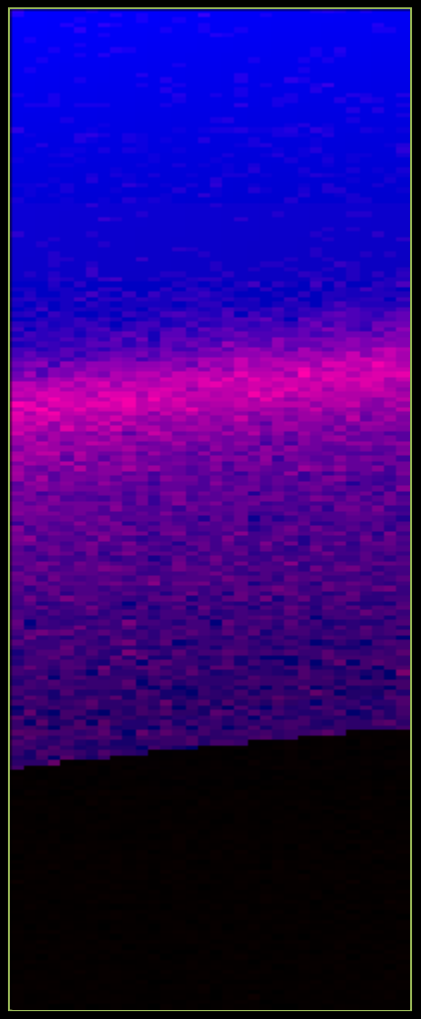

$O_2(^1\Delta_g)$ emission
LMD GCM
MR
40
35
30
25
20
15
10
5
0
90N
60N
30N
0
30S
60S
90S
Latitude
60
120
180
240
300
360
Solar longitude


O_3 column
1200LT
μm-atm
40
30
20
10
8
6
4
2
1
0
90N
60N
30N
0
30S
60S
90S
0
60
120
180
240
300
360
Solar longitude
Exp 2013 007 year 2

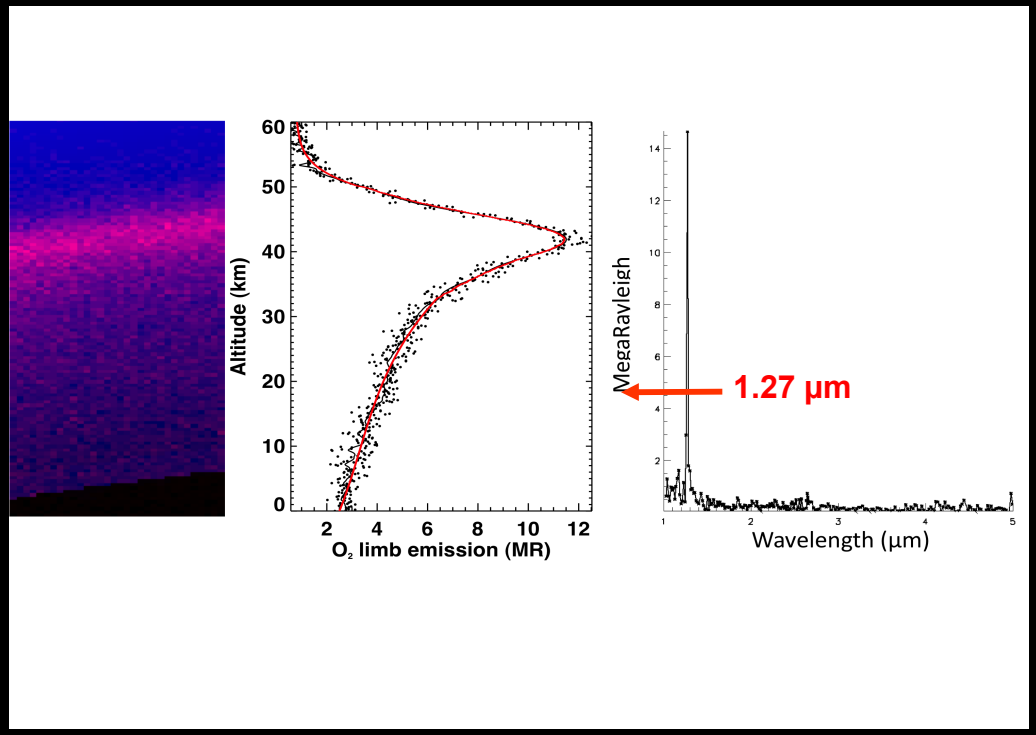
$O + O + CO2 \rightarrow O2(1\Delta) + CO2$



Bertaux et al., 2012



22 November 2004
Ls = 120°
76°S 13°E

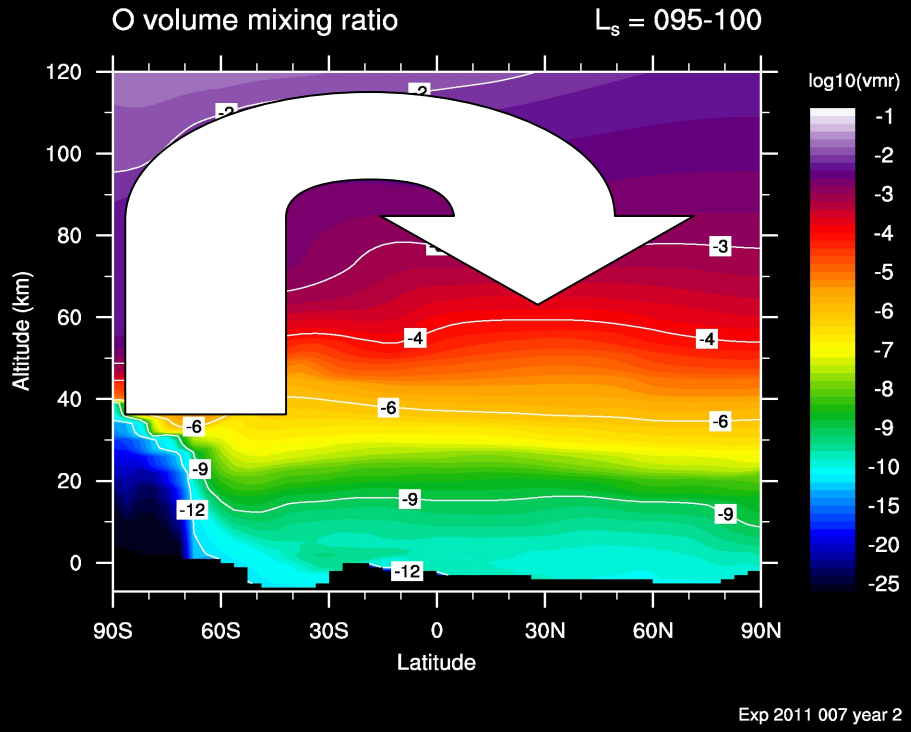


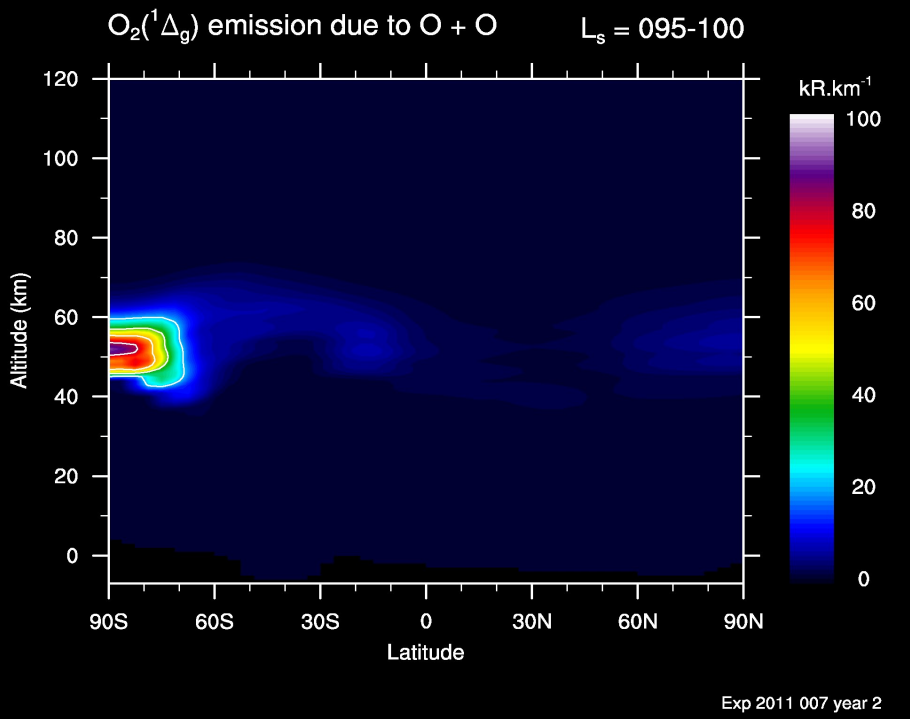
$O2(1\Delta) \rightarrow O2(3\Sigma) + h\nu\ (1.27\ \mu m)$

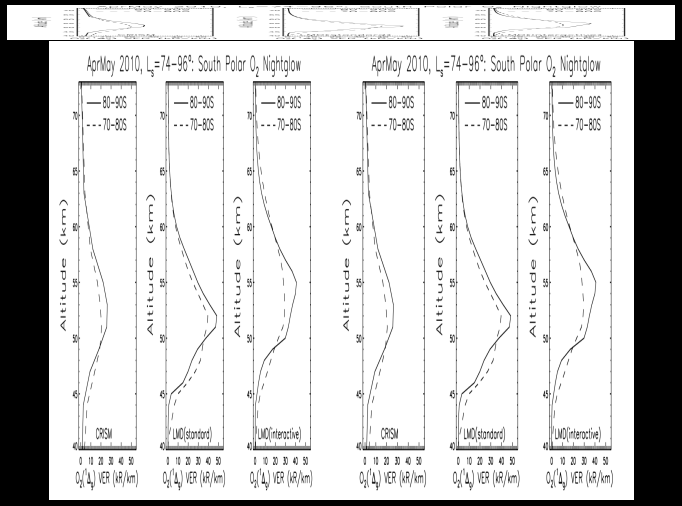
excited
singlet state

ground
triplet state

τ = 1.2 hour

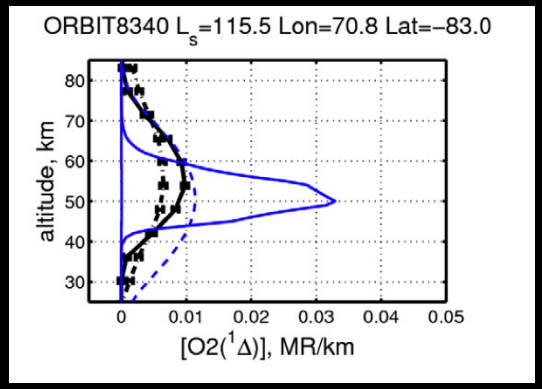






CRISM limb observations

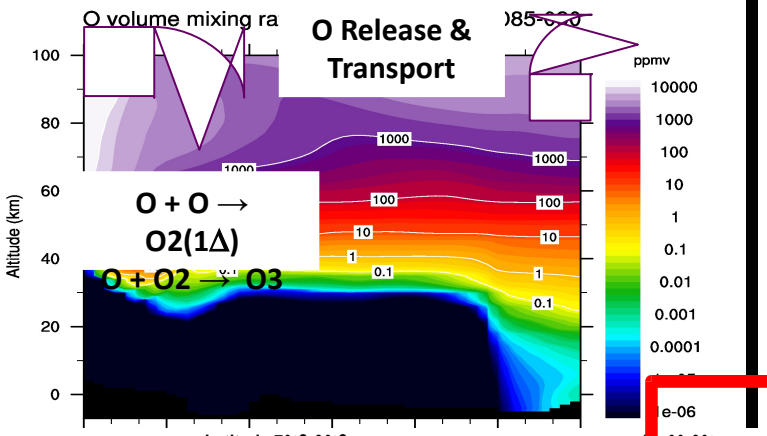
Clancy et al., 2012; 2013

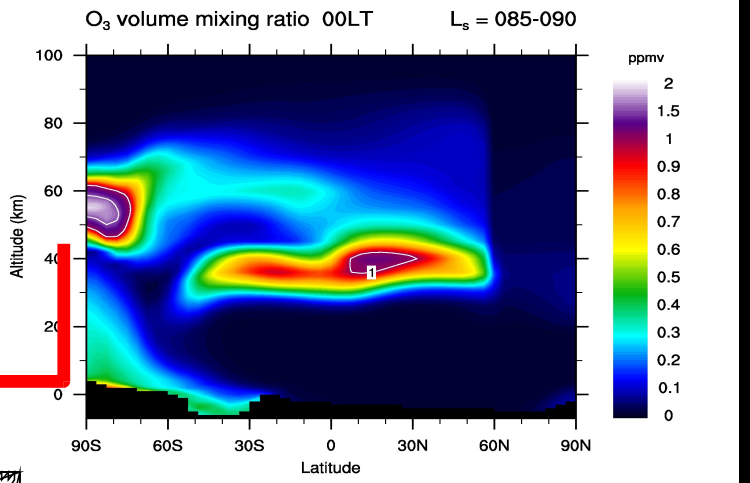


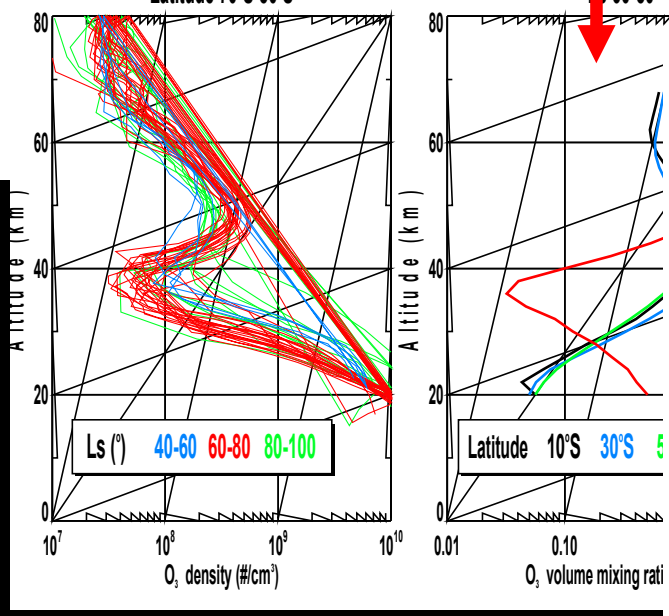
SPICAM limb observations

Fedorova et al., 2012

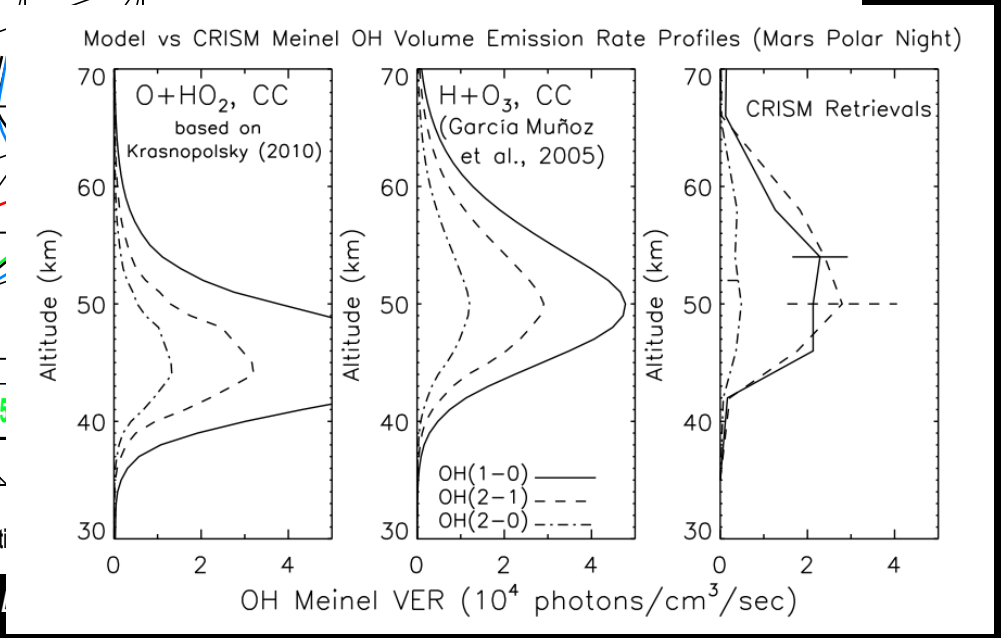
$O + O + CO_2 \rightarrow O_2(1\Delta) + CO_2$





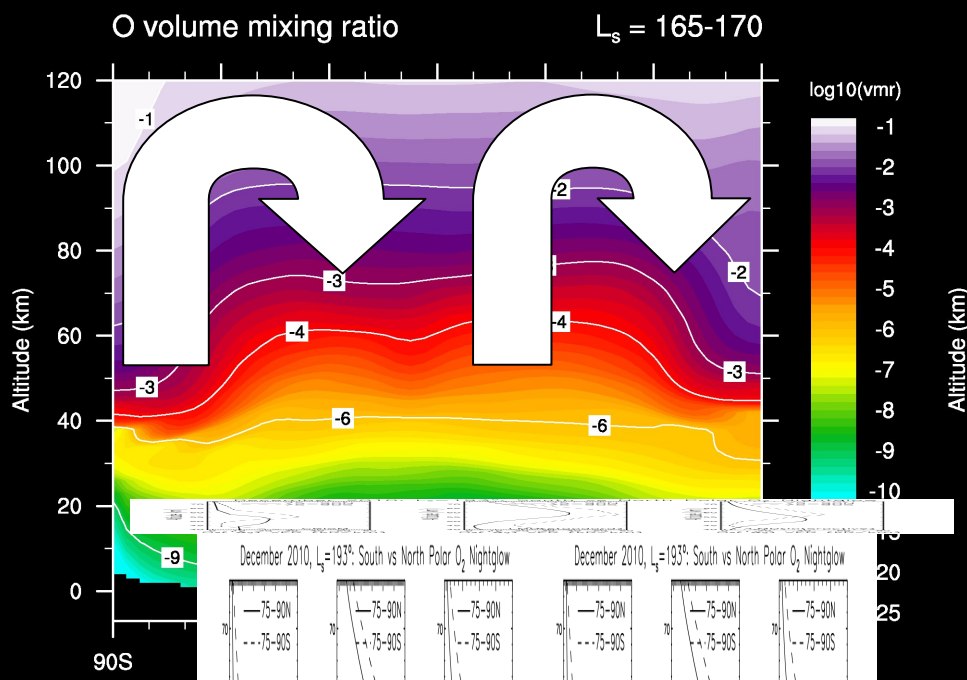


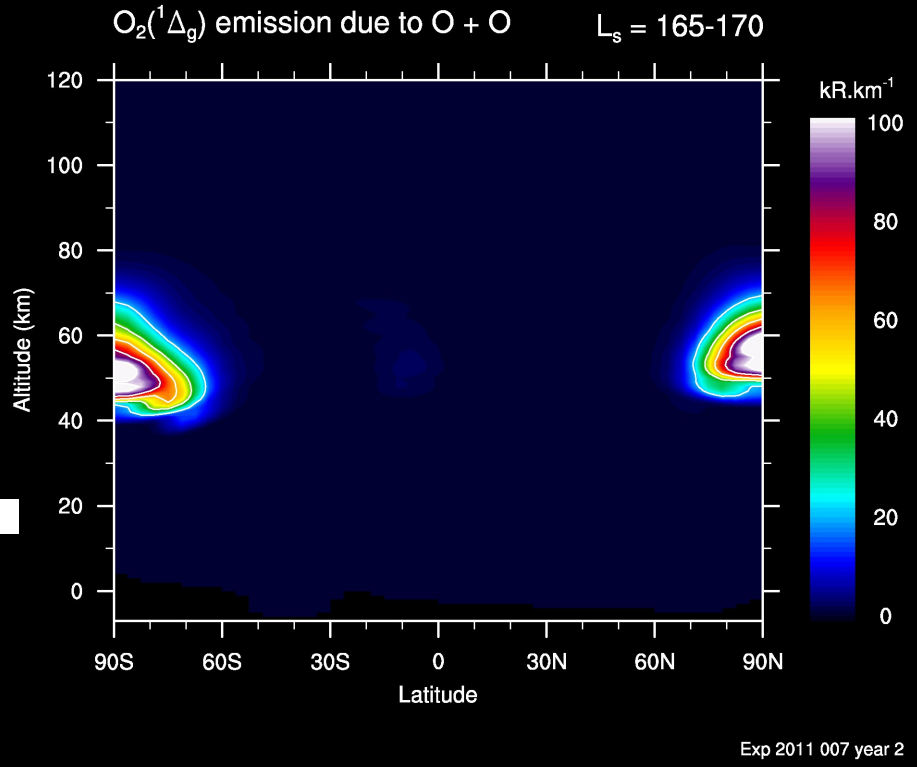
Montmessin and … 2013

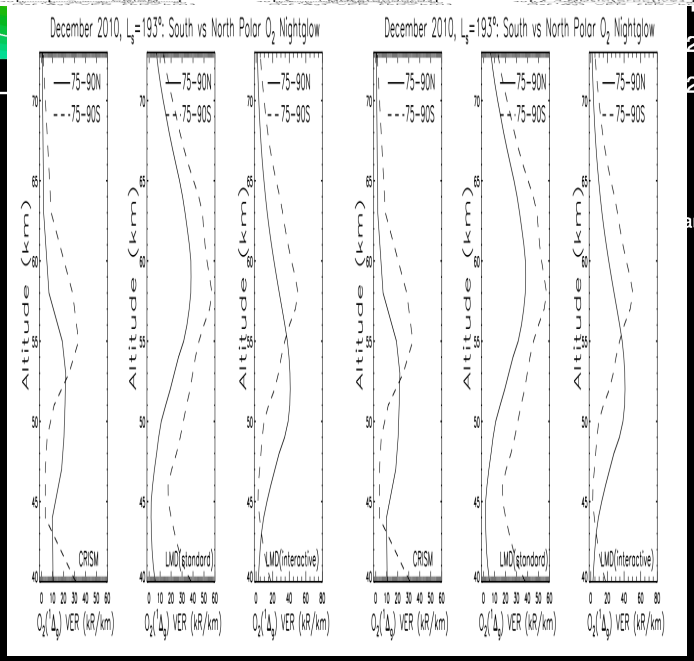


Clancy et al., 2013

$O + O + CO2 \rightarrow O2(1\Delta) + CO2$



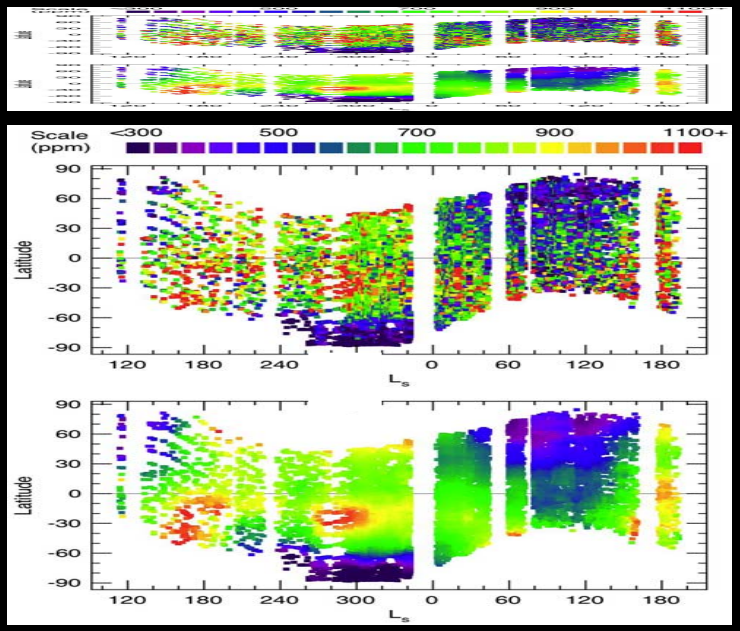




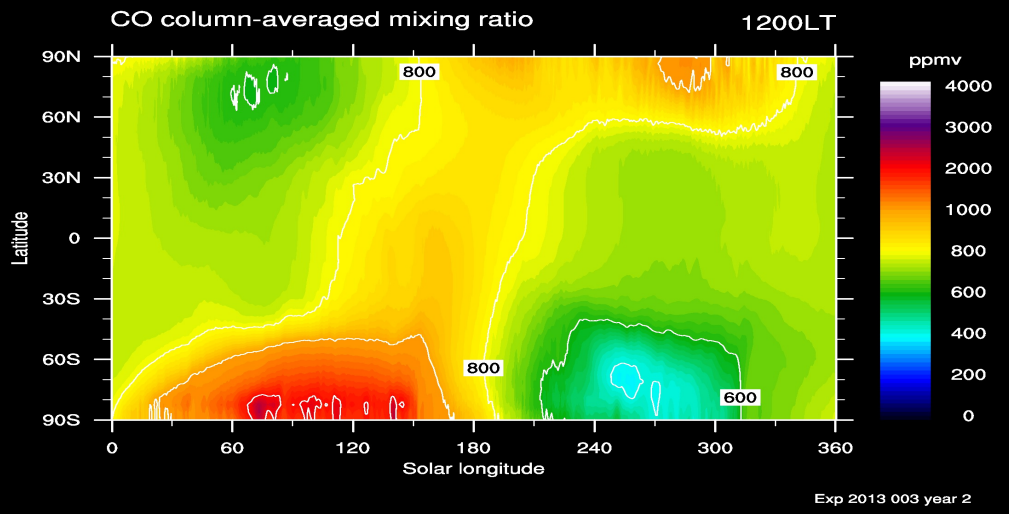
CRISM limb observations

Carbon monoxide CO

integrated column



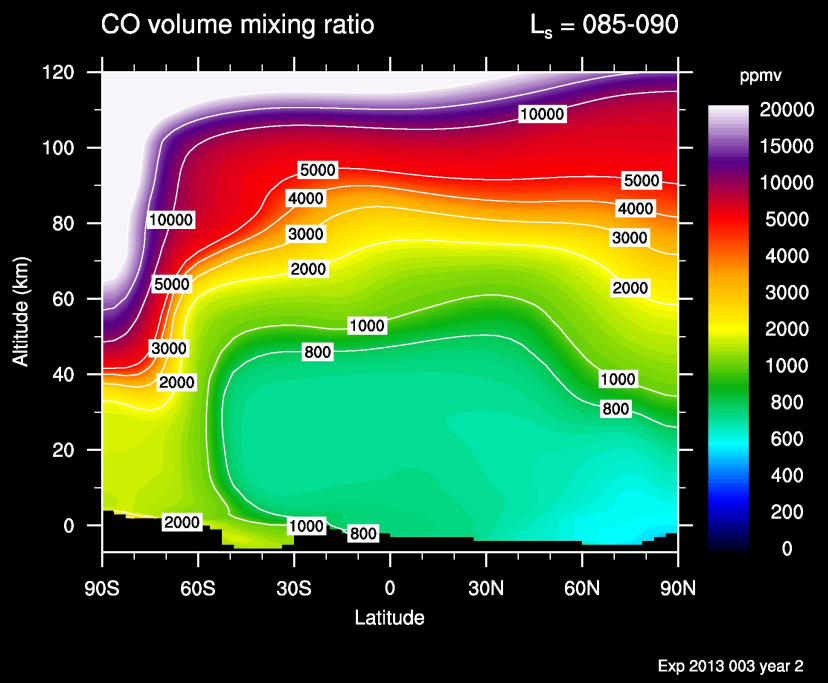
Smith et al., 2009

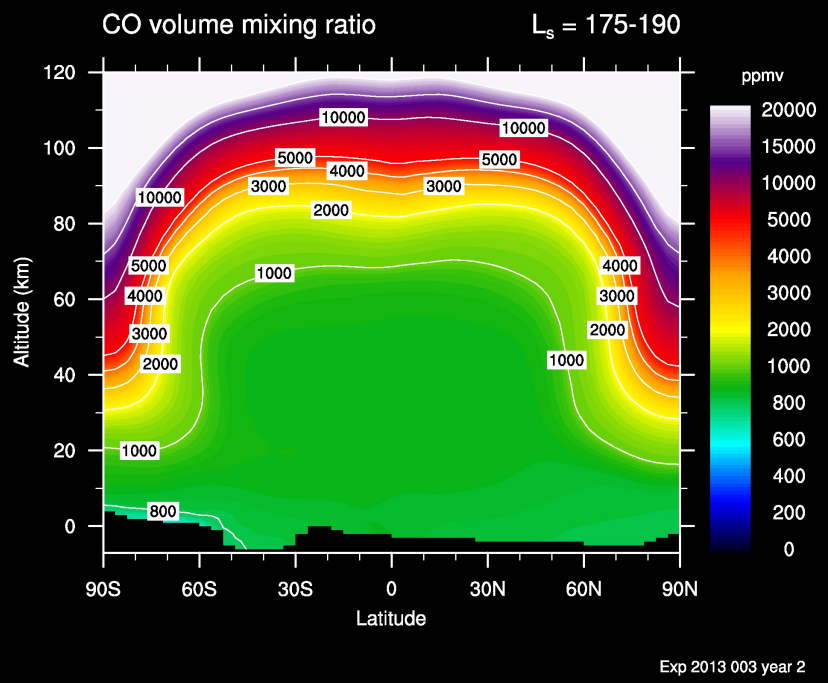


- ~ 5 year photochemical lifetime in the lower atmosphere
- good tracer of CO2 condensation/sublimation
- ACS detection limit: 4 ppmv (SO), 100 ppmv (nadir)

Carbon monoxide CO

vertical distribution

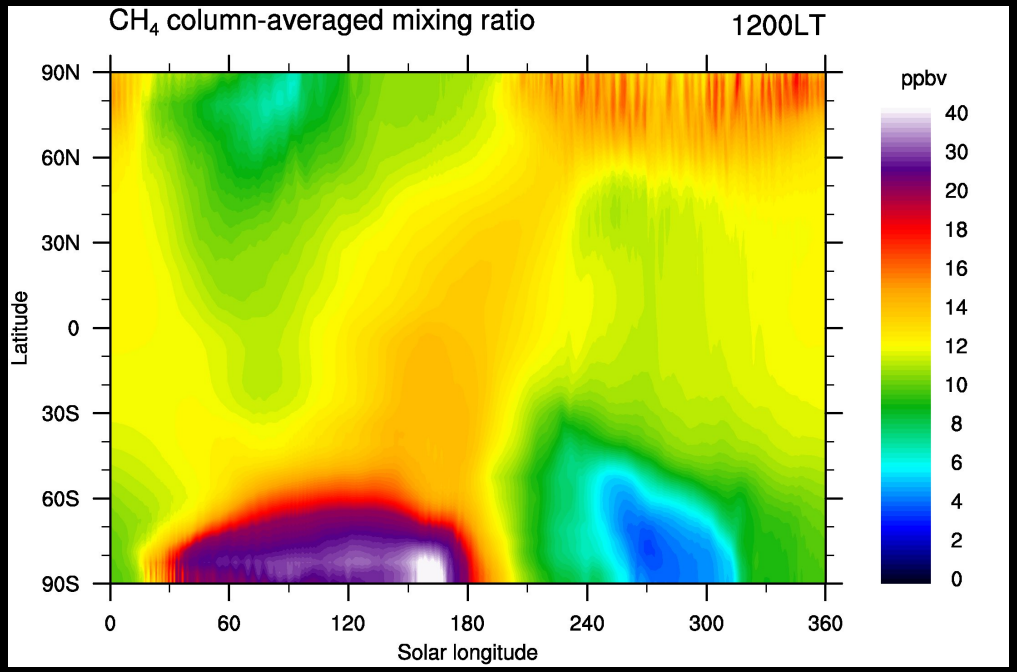




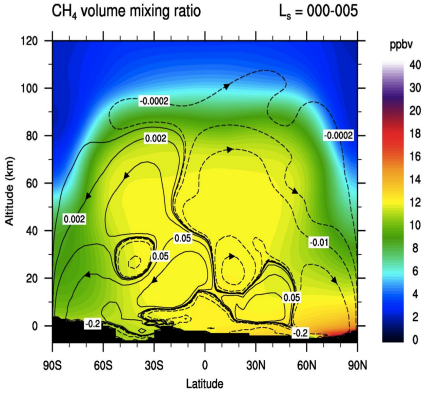
Ls = 90°

Ls = 180°

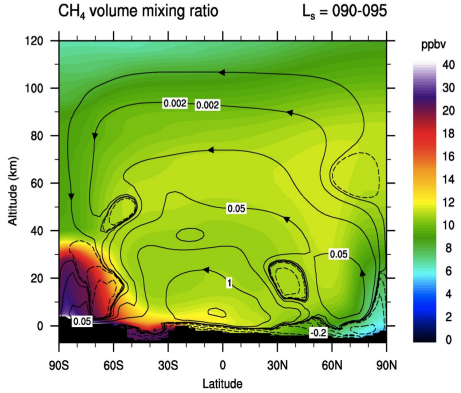
Methane CH4



- SAM/MSL: CH4 < 1.3 ppbv (Webster et al., 2013)
- ACS detection limit : 0.02 ppbv



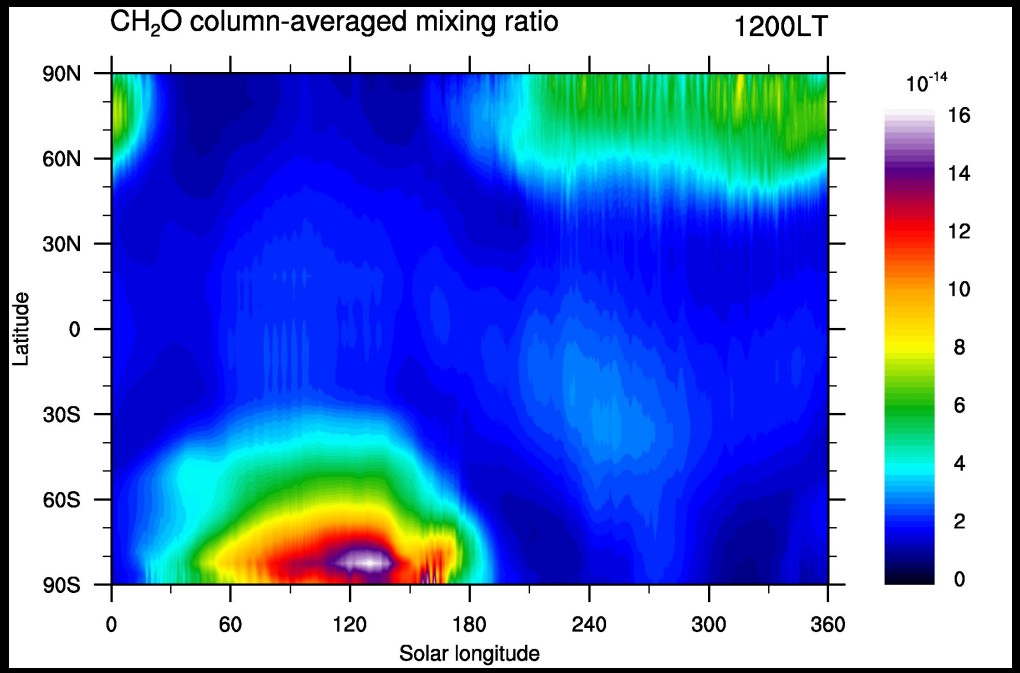
Ls = 000°

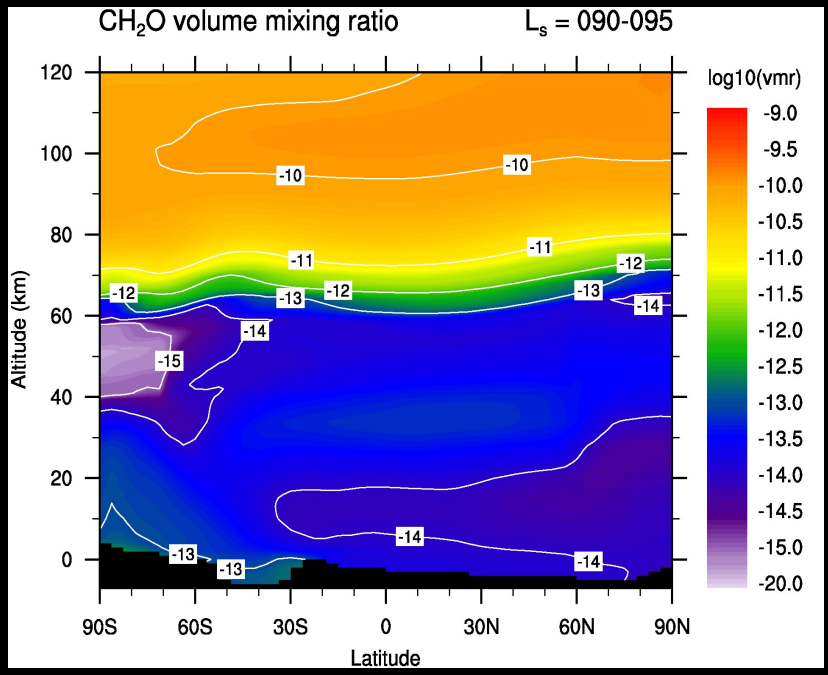


Ls = 090°

Formaldehyde CH2O

- Current upper limit : < 3 ppbv (Krasnopolsky et al., 1997)
- ACS detection limit : 0.03 ppbv



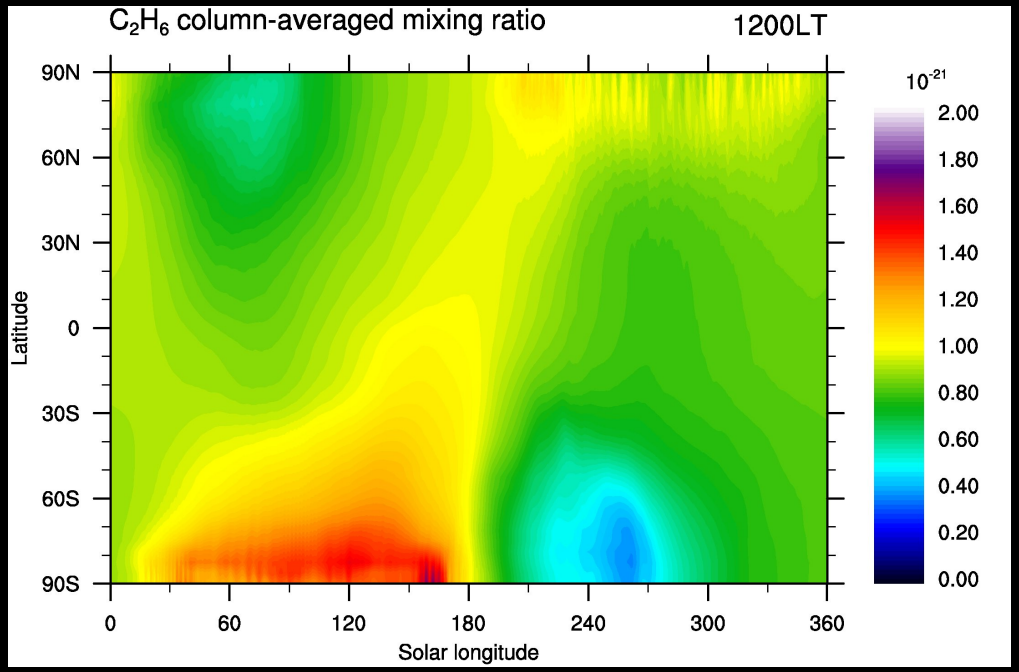


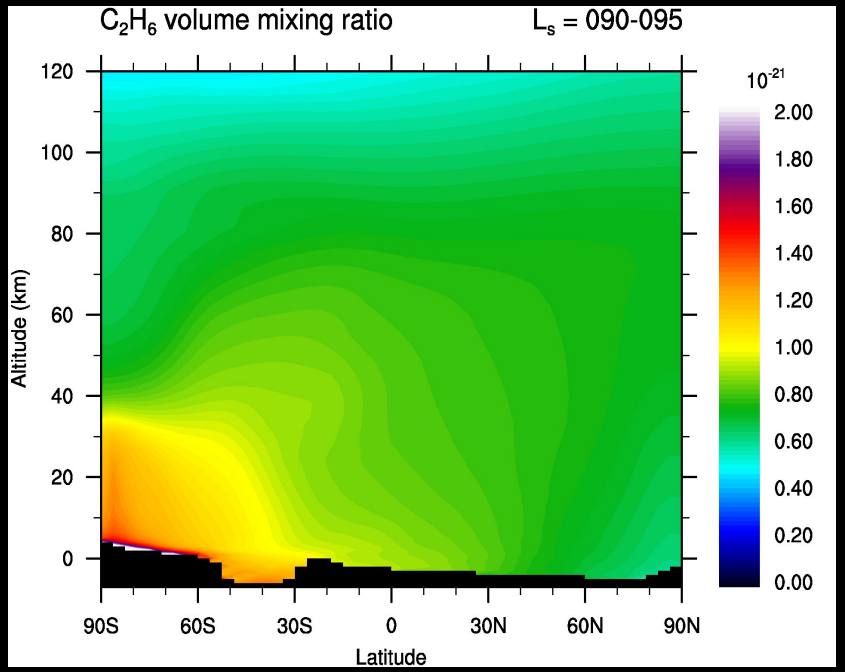
Seasonal variations

Ls = 090°

Ethane C2H6

- Current upper limit : < 0.2-0.6 ppbv (Villanueva et al., 2011; Krasnopolsky et al., 1997)
- ACS detection limit : 0.05 ppbv



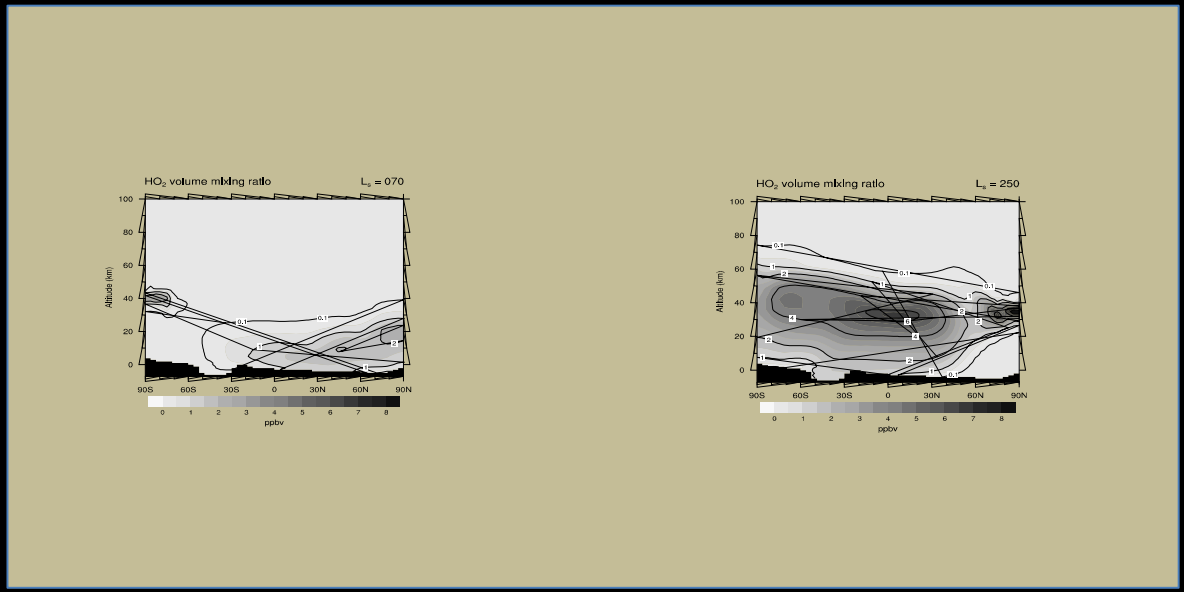


Seasonal variations

Ls = 090°

Hydroperoxy radical HO2

- Main ozone-destroying HOx species
- ACS detection limit : 1 ppbv

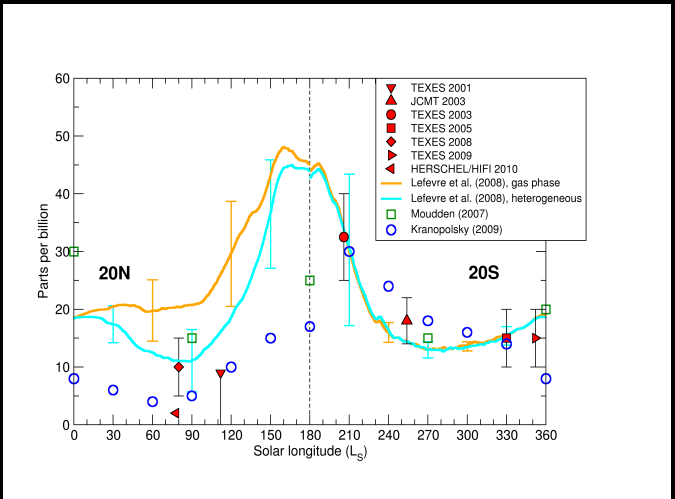


Ls = 070°

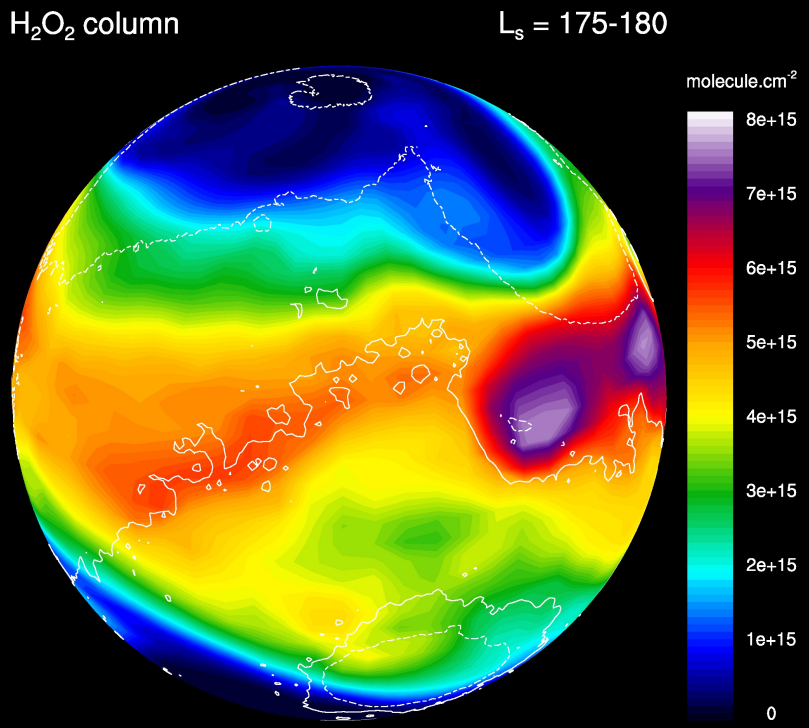
Ls = 250°

Hydrogen peroxide H2O2

- ACS detection limit : ? ppbv

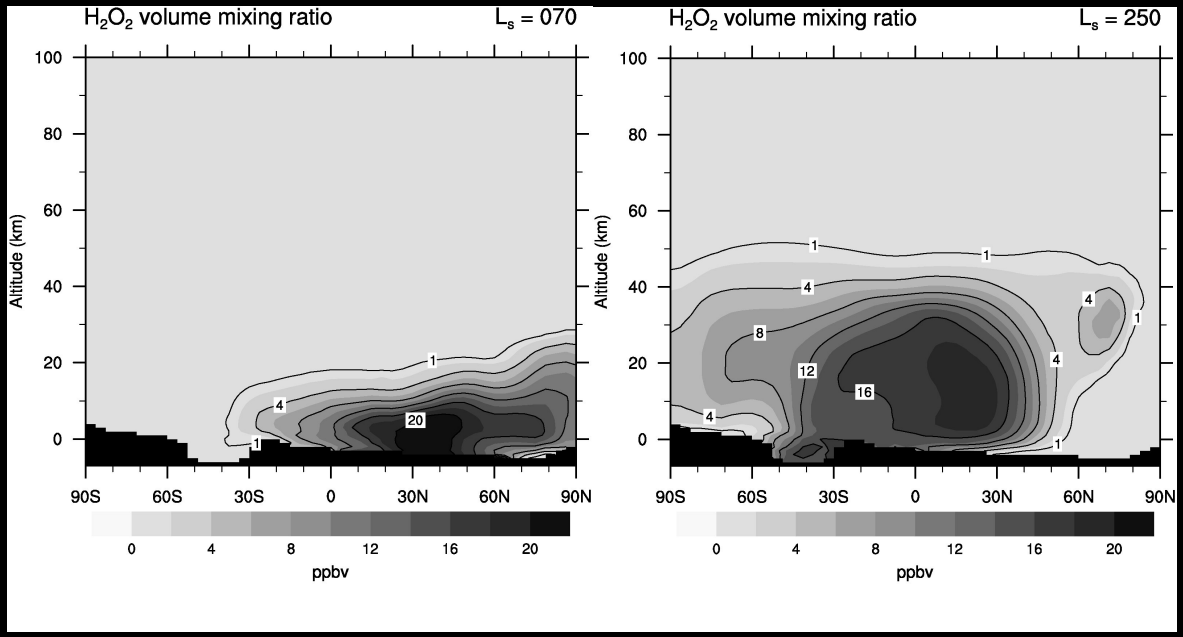


Lefèvre and Krasnopolsky, submitted.



Hydrogen peroxide H2O2

- ACS detection limit : 1 ppbv

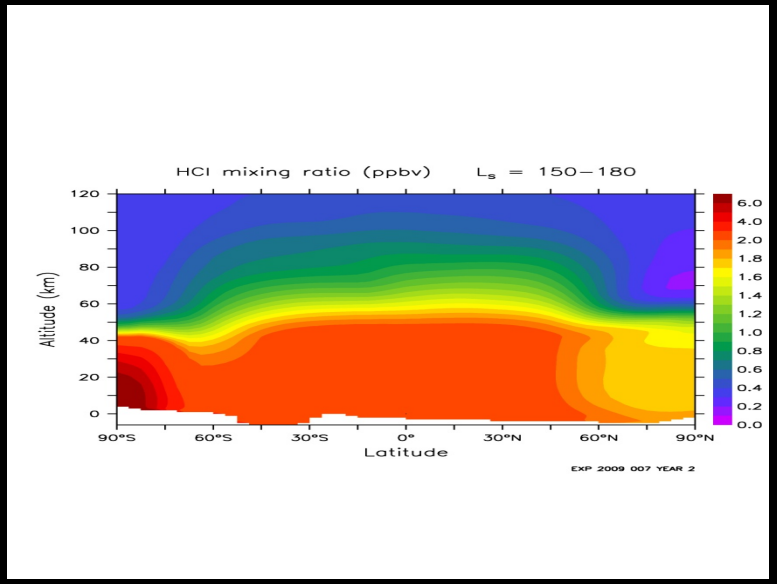


Ls = 070°

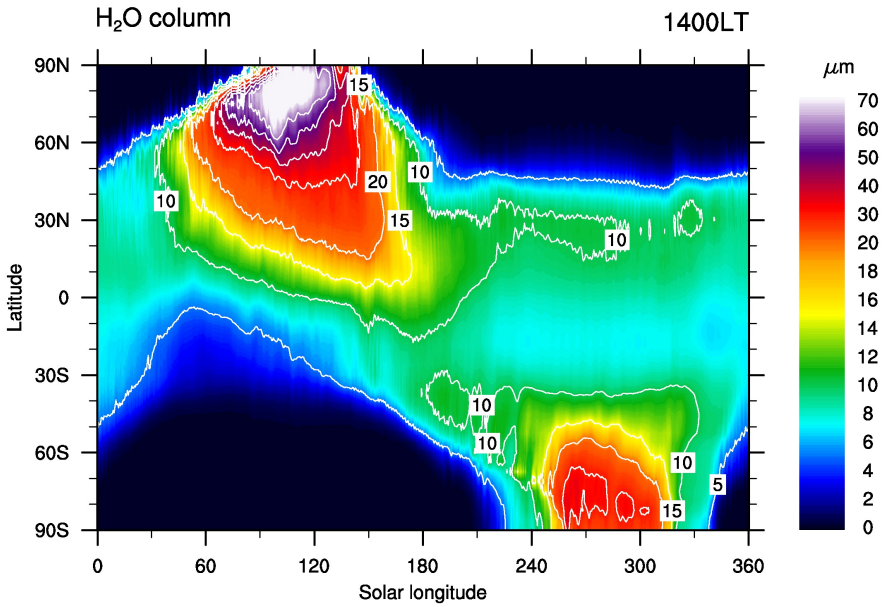
Ls = 250°

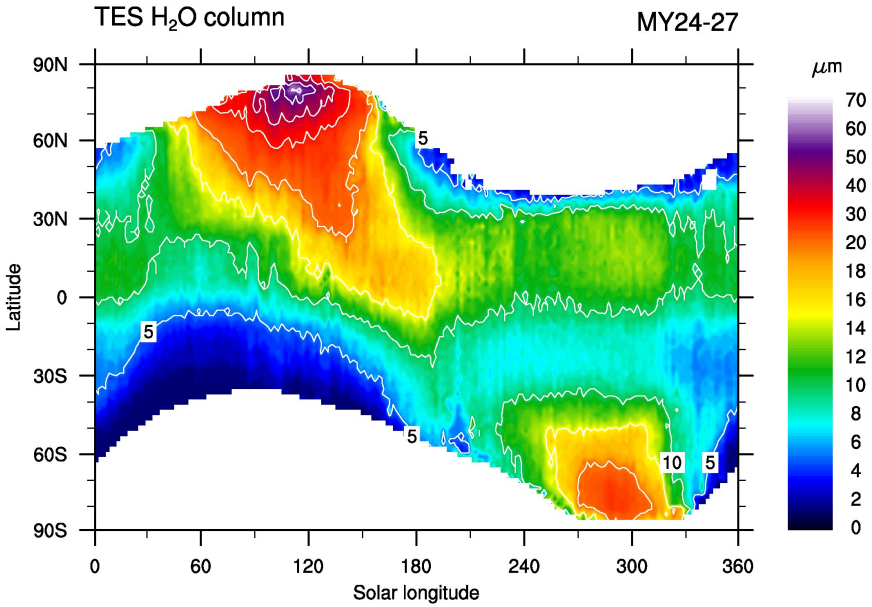
Yet to be identified

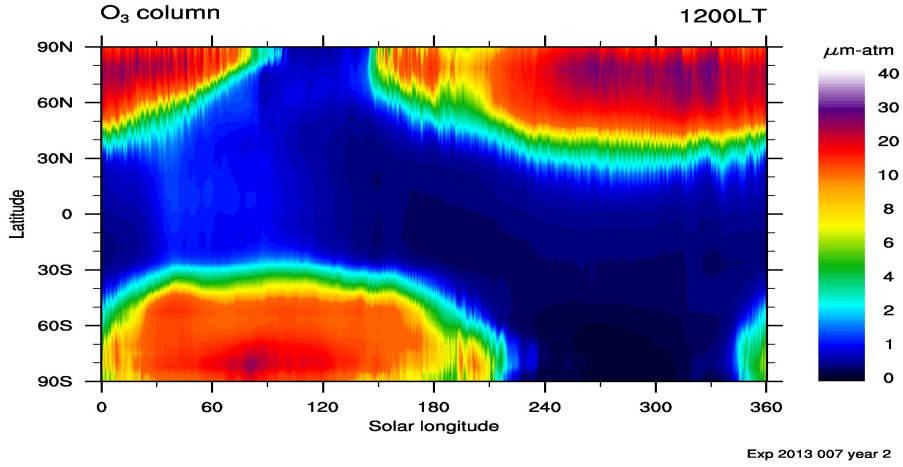
- NO, NO2 NO < 1.7 ppbv ACS detection limit : 3 ppbv
- SO2 < 0.3 ppbv
- H2S < 20 ppbv ACS detection limit : 5 ppbv
- HCl < 0.2 ppbv ACS detection limit : 0.04 ppbv



MY26

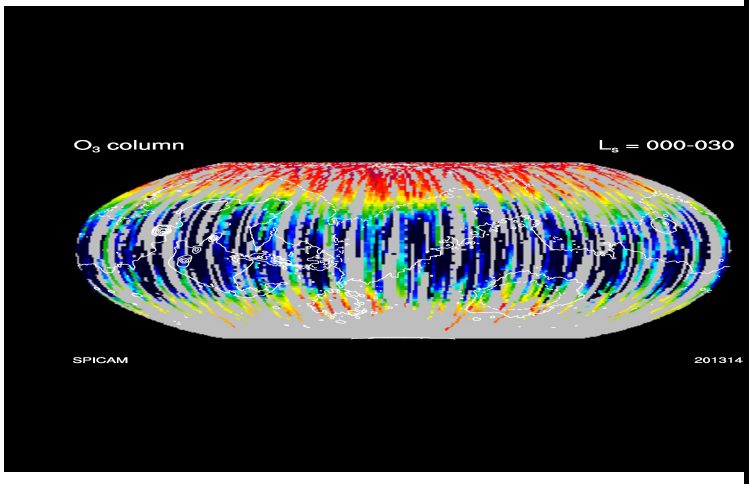




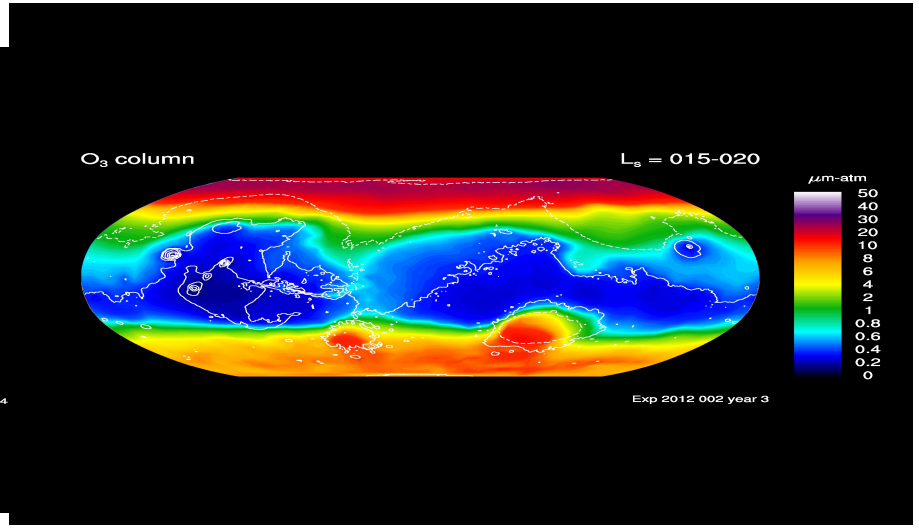


ous-titres du masque

SPICAM



Modèle



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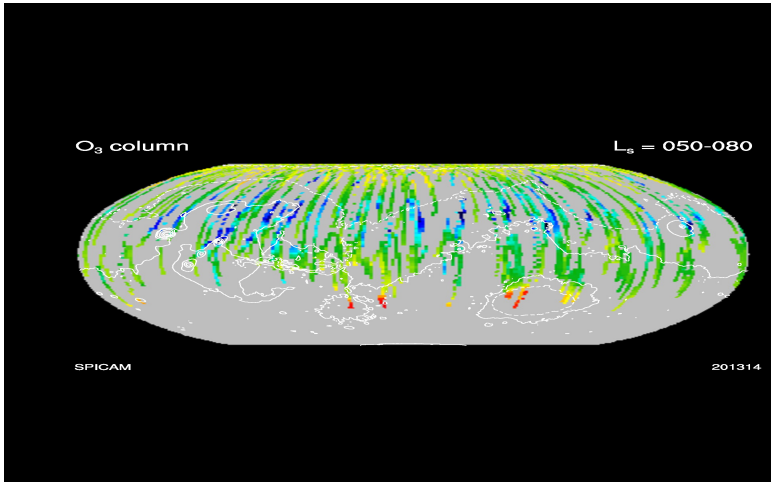
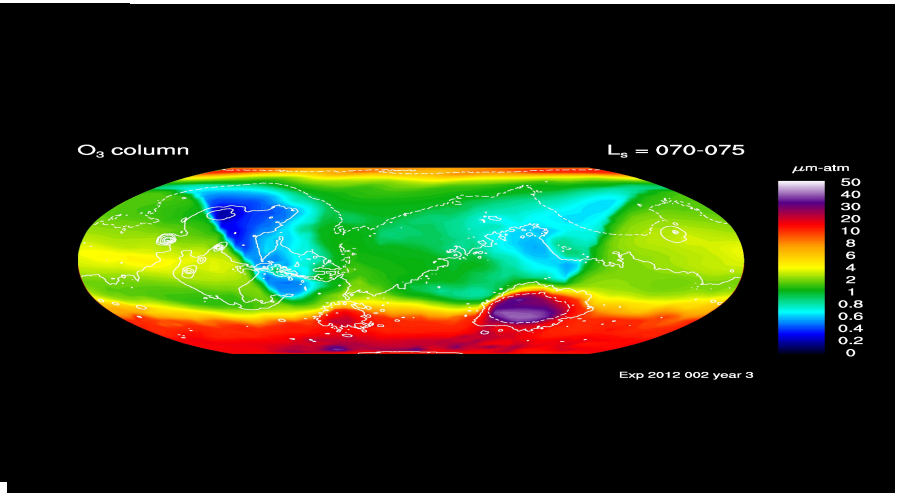


Modèle



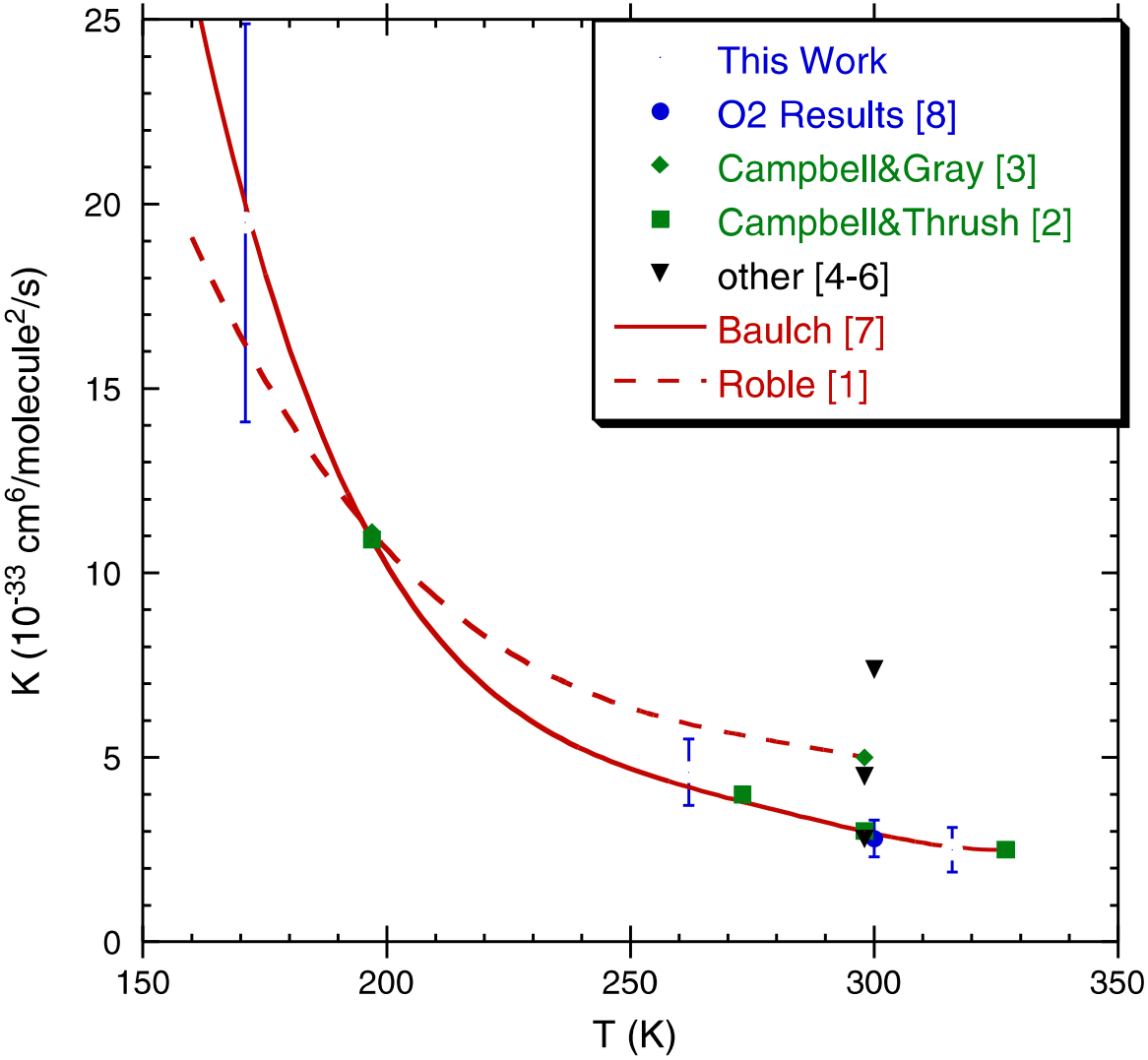


Fig. 5. Temperature dependence of the $O + O + N_2$ recombination rate constant at low temperature, with current experimental measurements, previous literature results, and expressions from evaluators' recommendations. Solid dot O_2 room temperature results from Ref. [8]. Error bars are $1-\sigma$ precision.