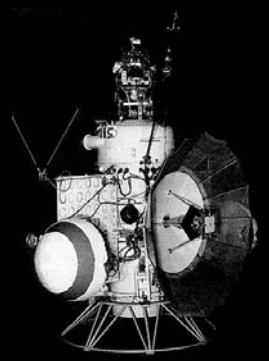
Three-dimensional modelling of Venus photochemistry and clouds

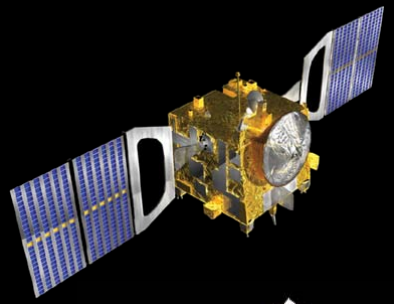
Supporting the “decade of Venus” missions

Venus



Venera Missions:
Venera 9 1st image of Venus surface

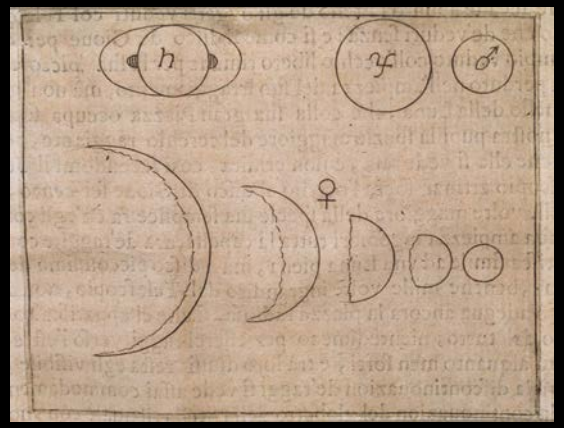
Pioneer Venus:
Orbiter and probes

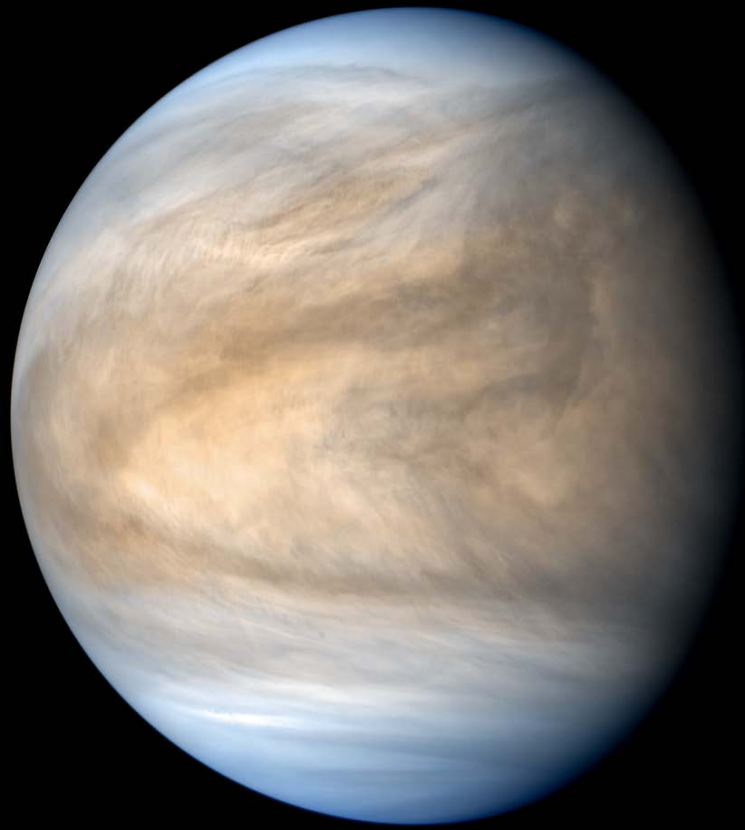


Venus Express:
8 years of atmospheric data

Akatsuki:
Latest orbiter, still in operation

G. Galilei





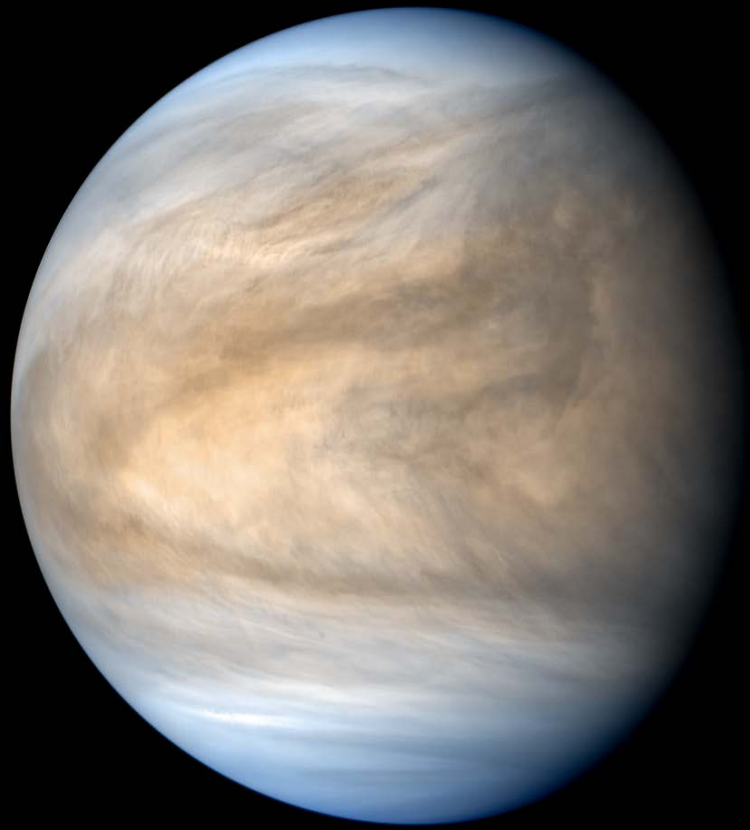
Venus

96.5% CO_2 3.5% N_2 and trace gases (H_2O, H_2SO_4,SO_2,CO, HCl, etc)

Surface temperature of 740K

Atmosphere in super-rotation

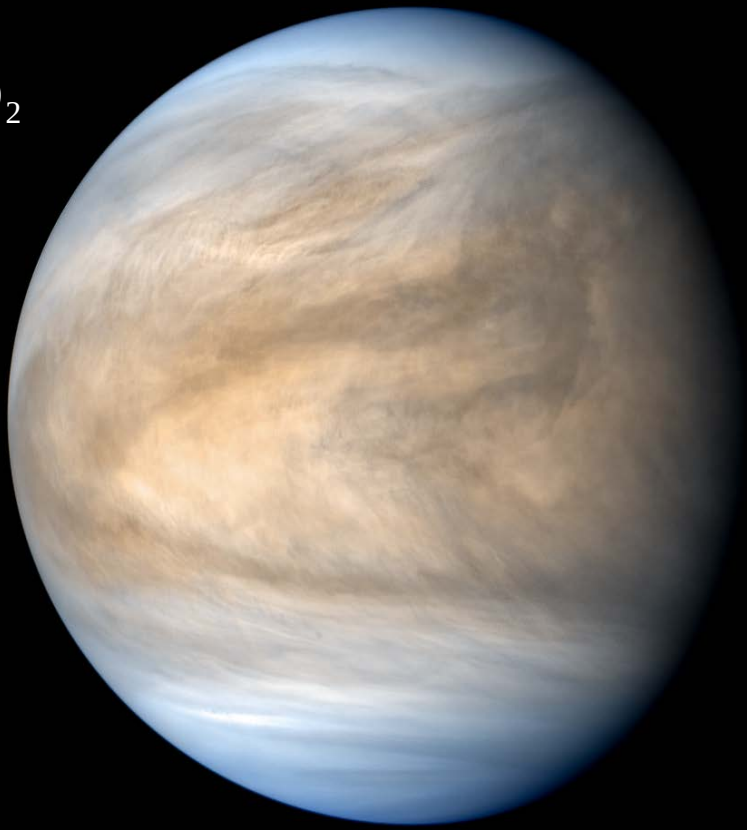
Surface Pressure of 90 bar



Venus

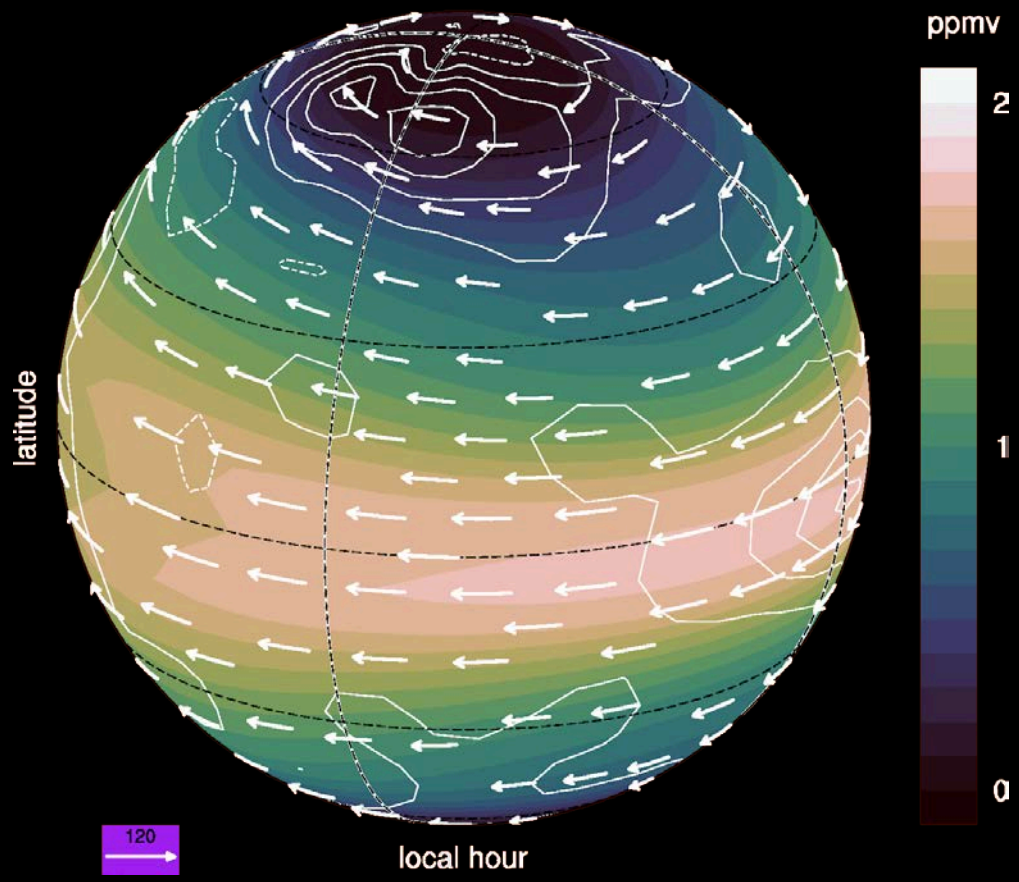
Prinn (1971), Mc Elroy et al (1973) → CO_2
Winninck and Stewart (1980), Yung and DeMore (1982) → SO_2
V. Krasnopolsky's work and the 1D JPL/Caltech model

CO_2 photochemical stability
SO_2 vertical and time distribution
O_2 non-detection
UV absorber



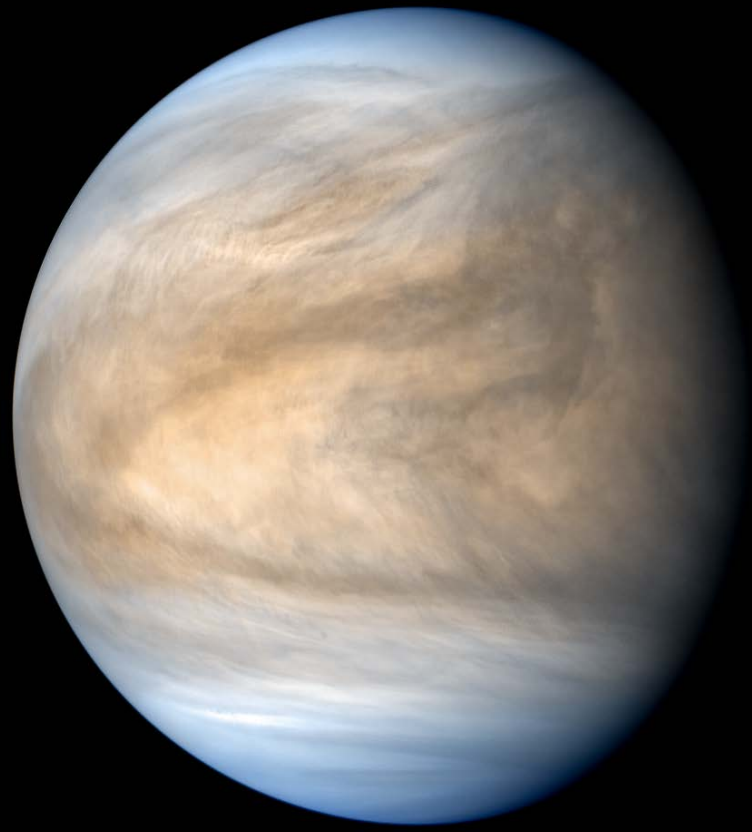
Venus

3D model

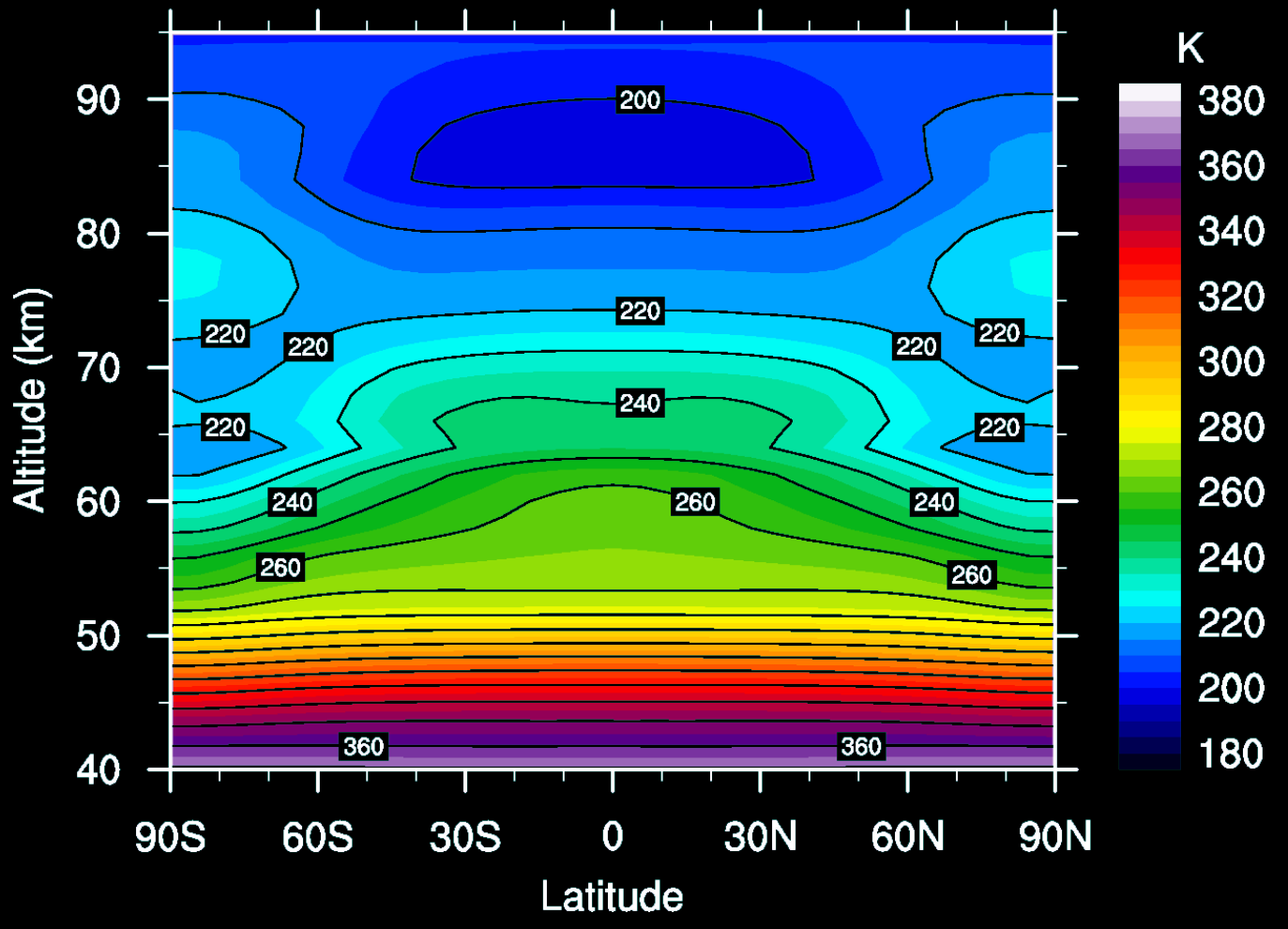


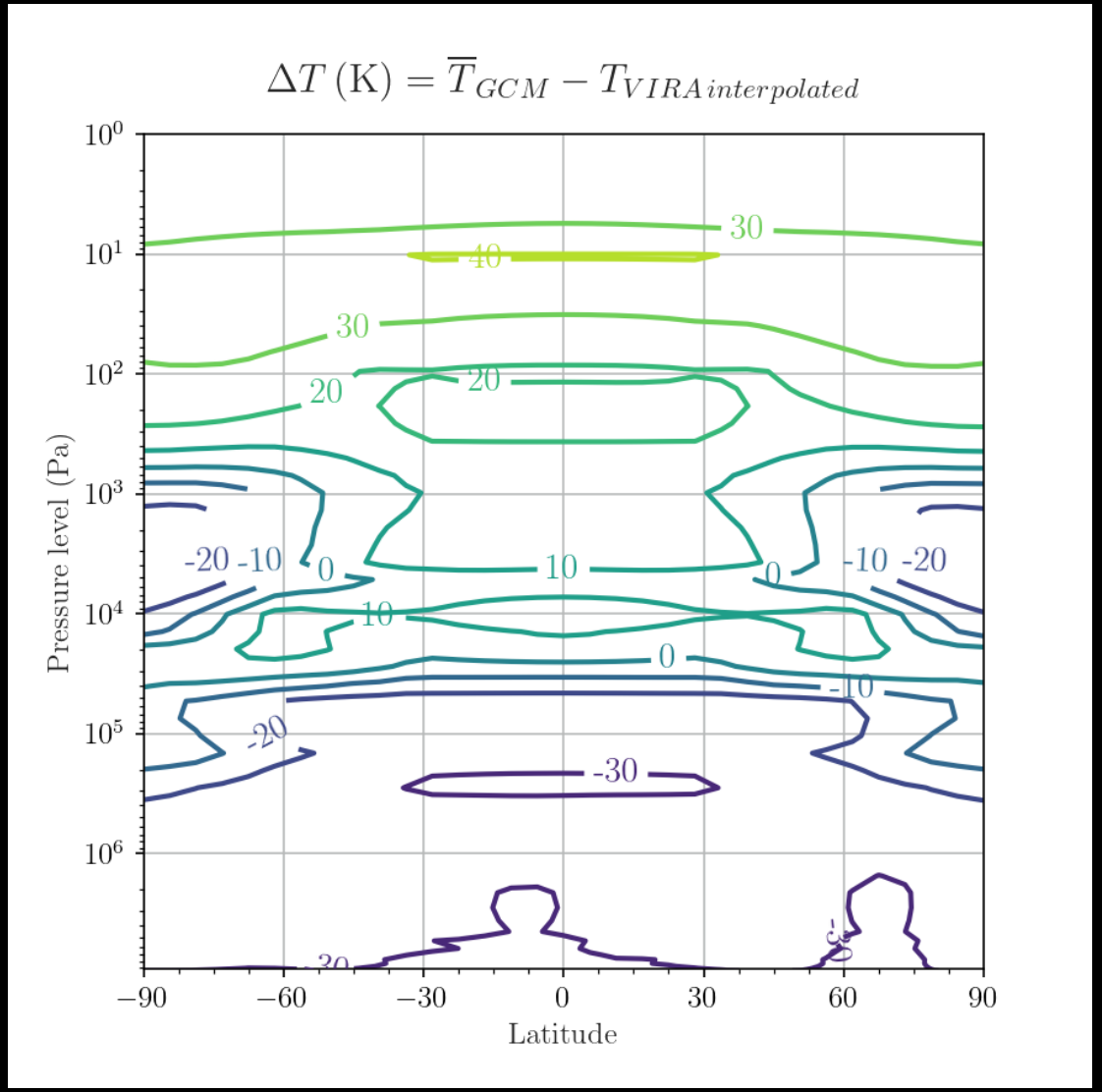
Venus PCM:
48x32x50
Up to 100 km
31 species
Clouds
20 photolysis
101 reactions

Venus PCM Start:
CO 25 ppmv
OCS 3 ppmv
SO_2 12 ppmv
HCl 0.4 ppmv
H_2O 30 ppmv

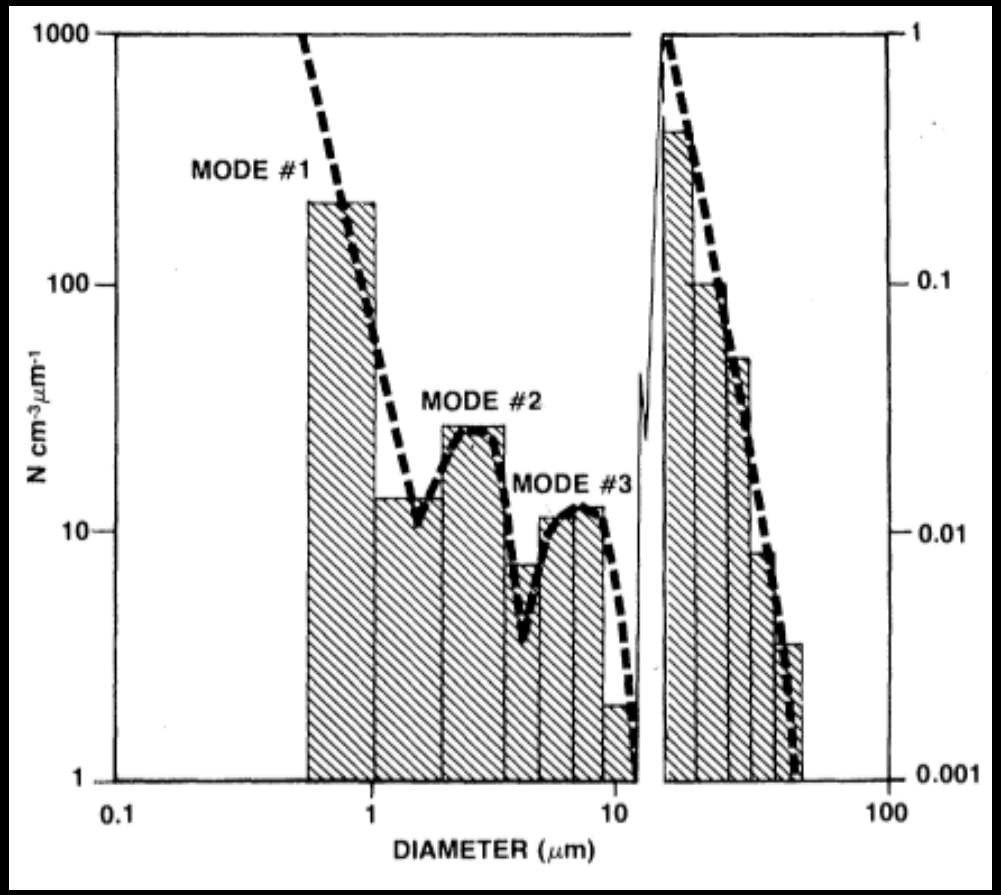


Venus PCM: Temperature



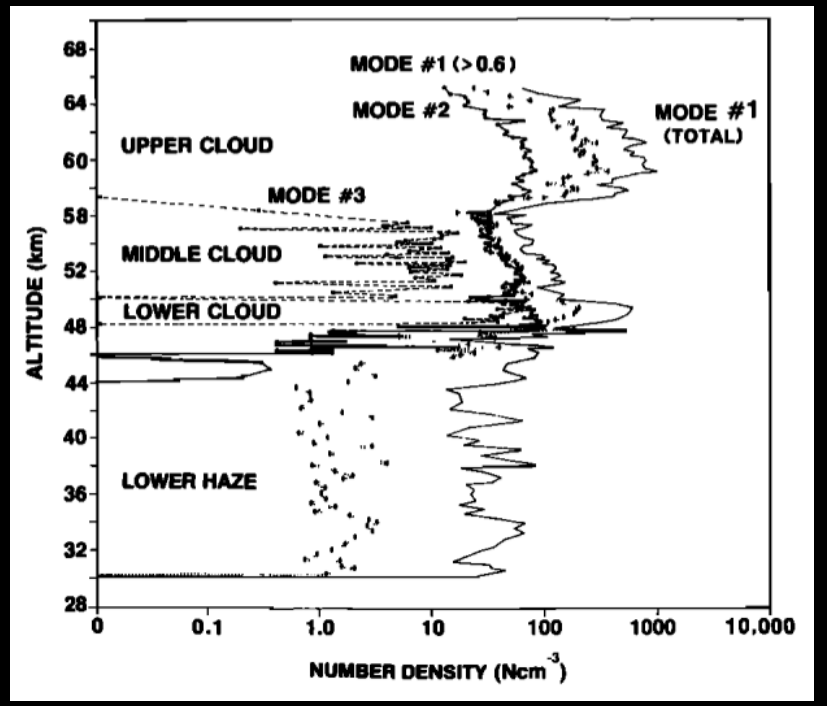


Venus PCM: clouds

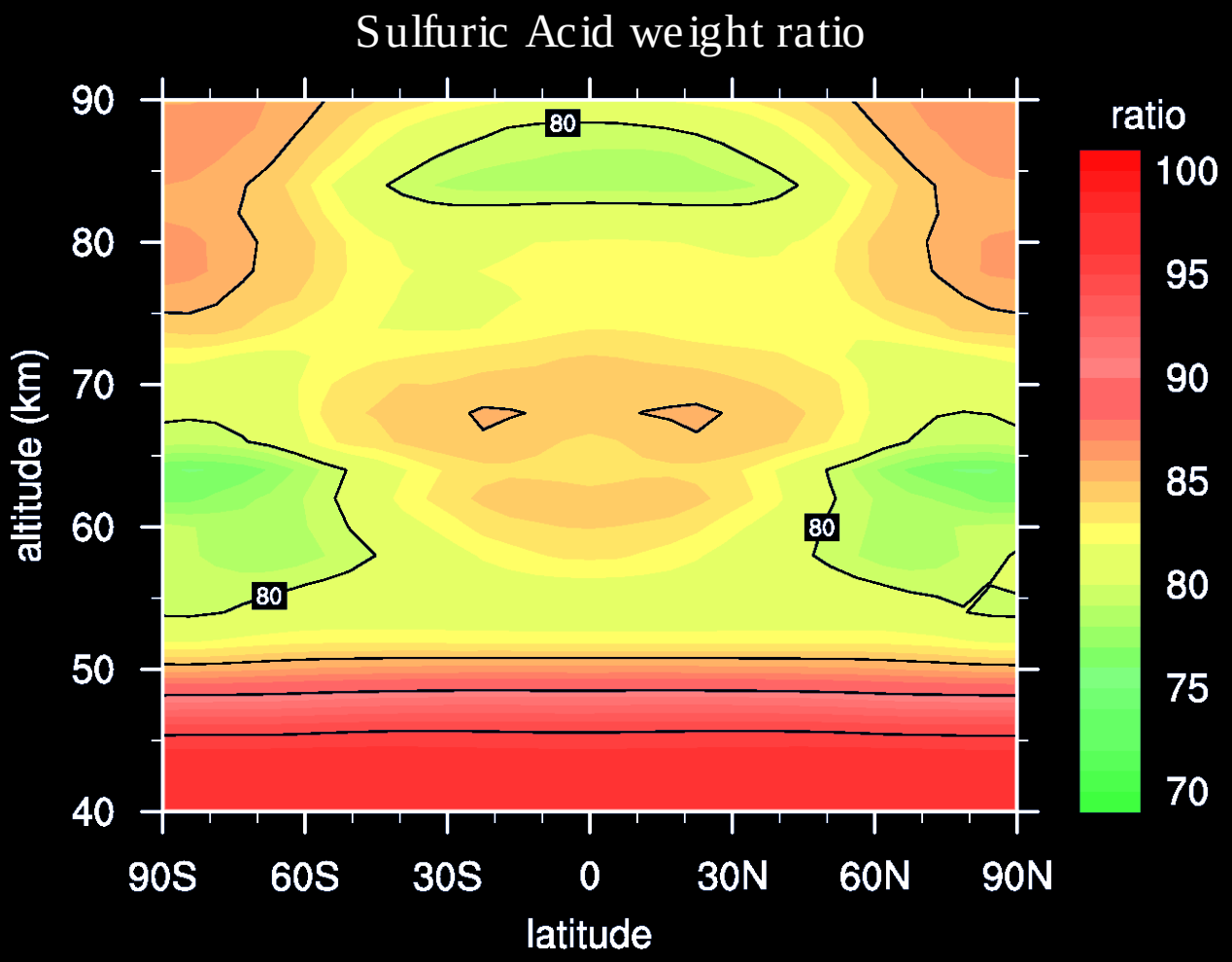


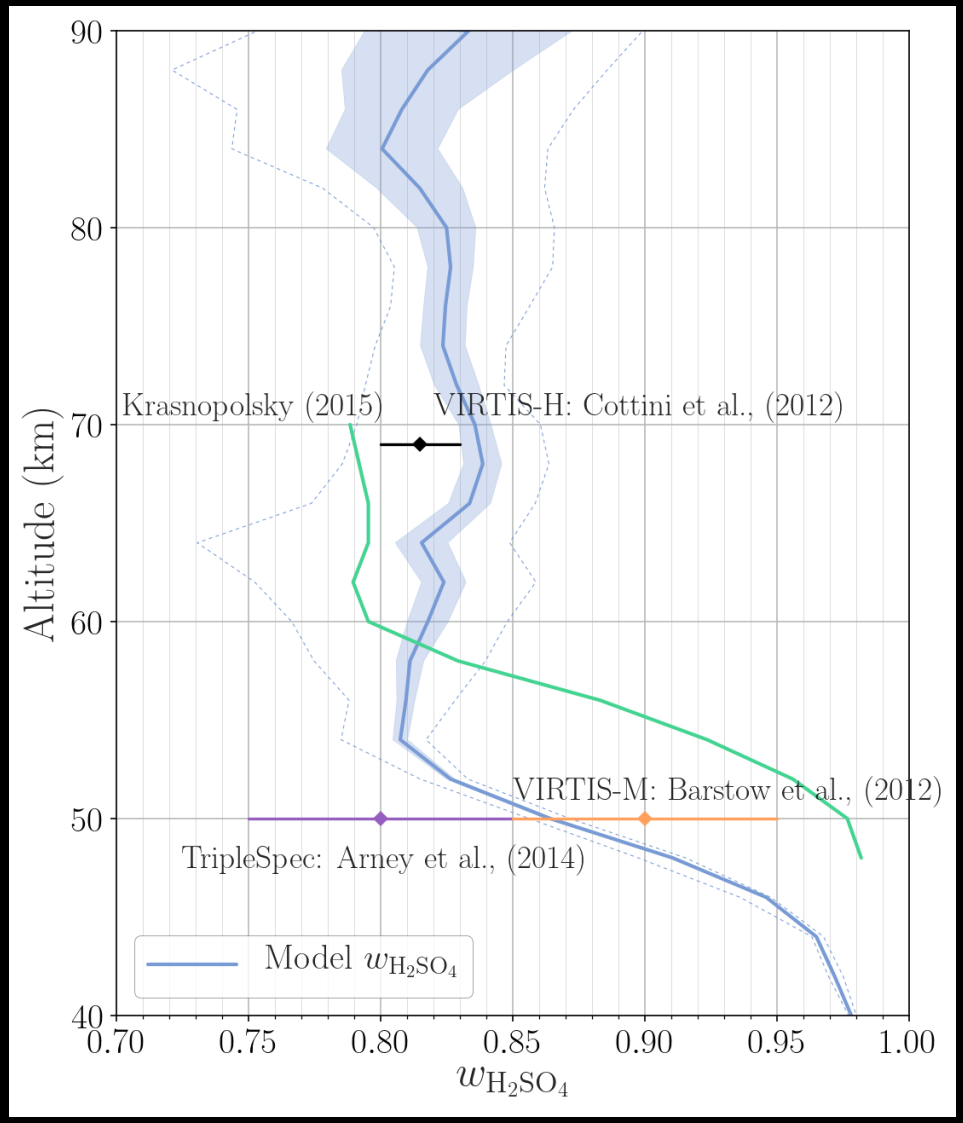
LCPS onboard Pioneer Venus:
3 aerosol modes

Venus PCM:
Fixed vertical structure of the clouds

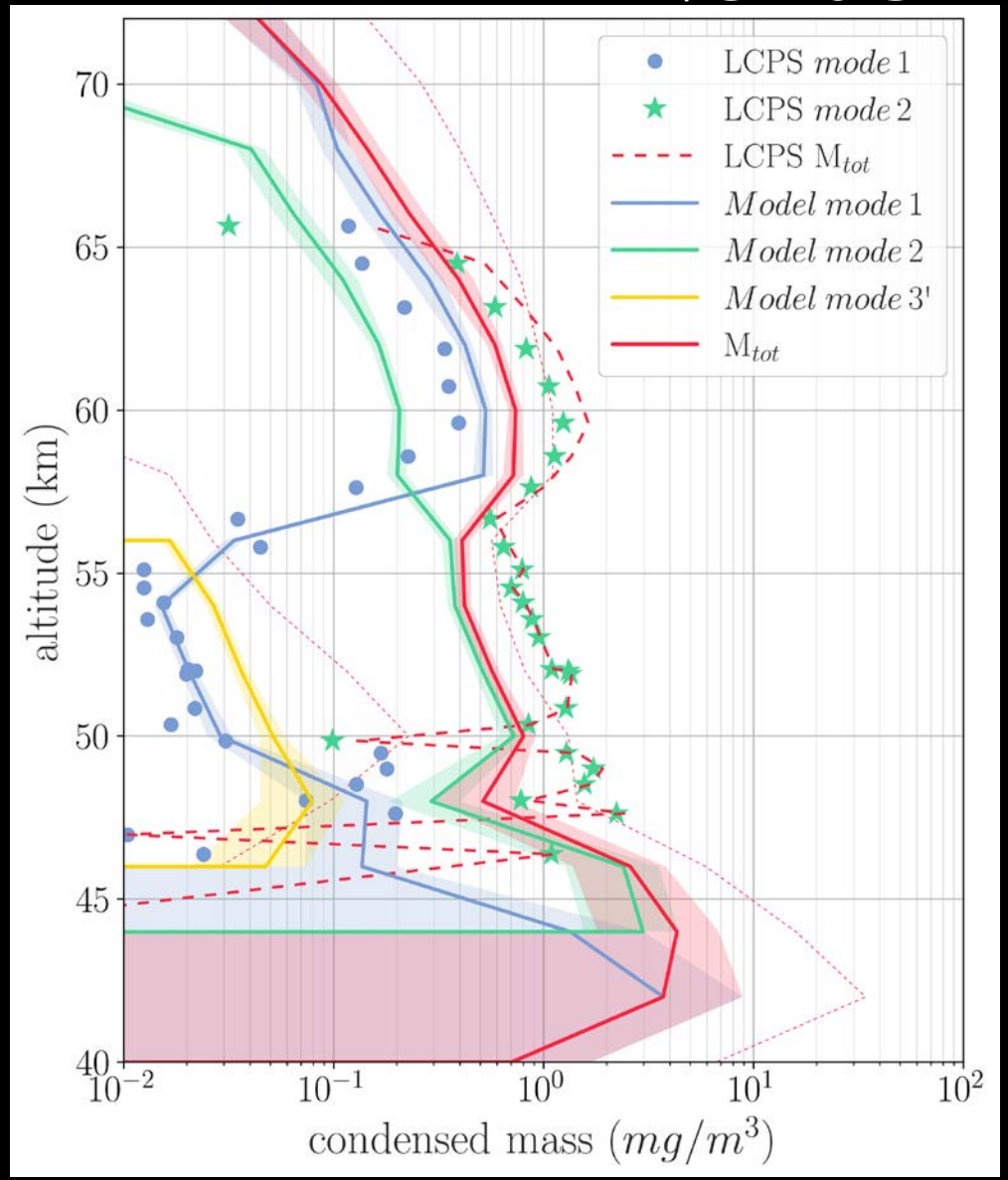


Venus PCM: clouds





Venus PCM: clouds

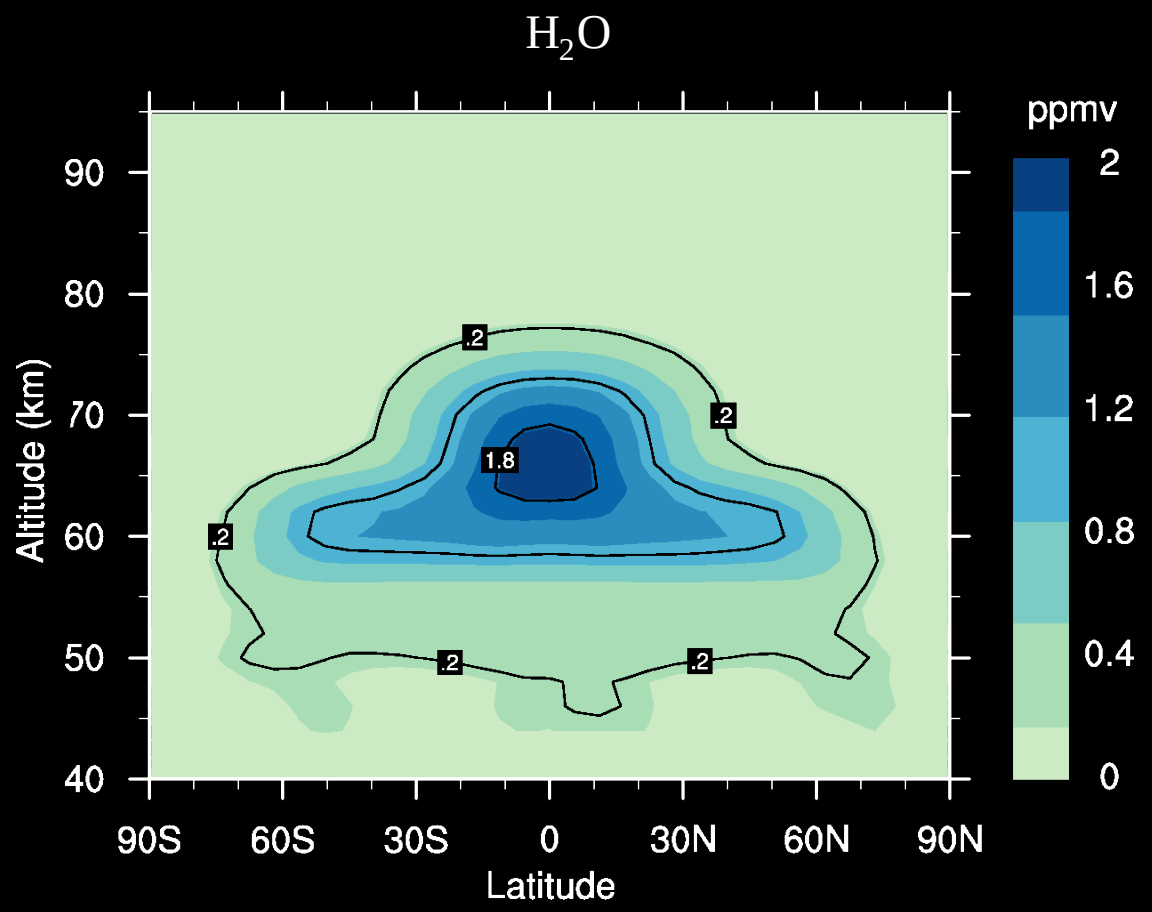


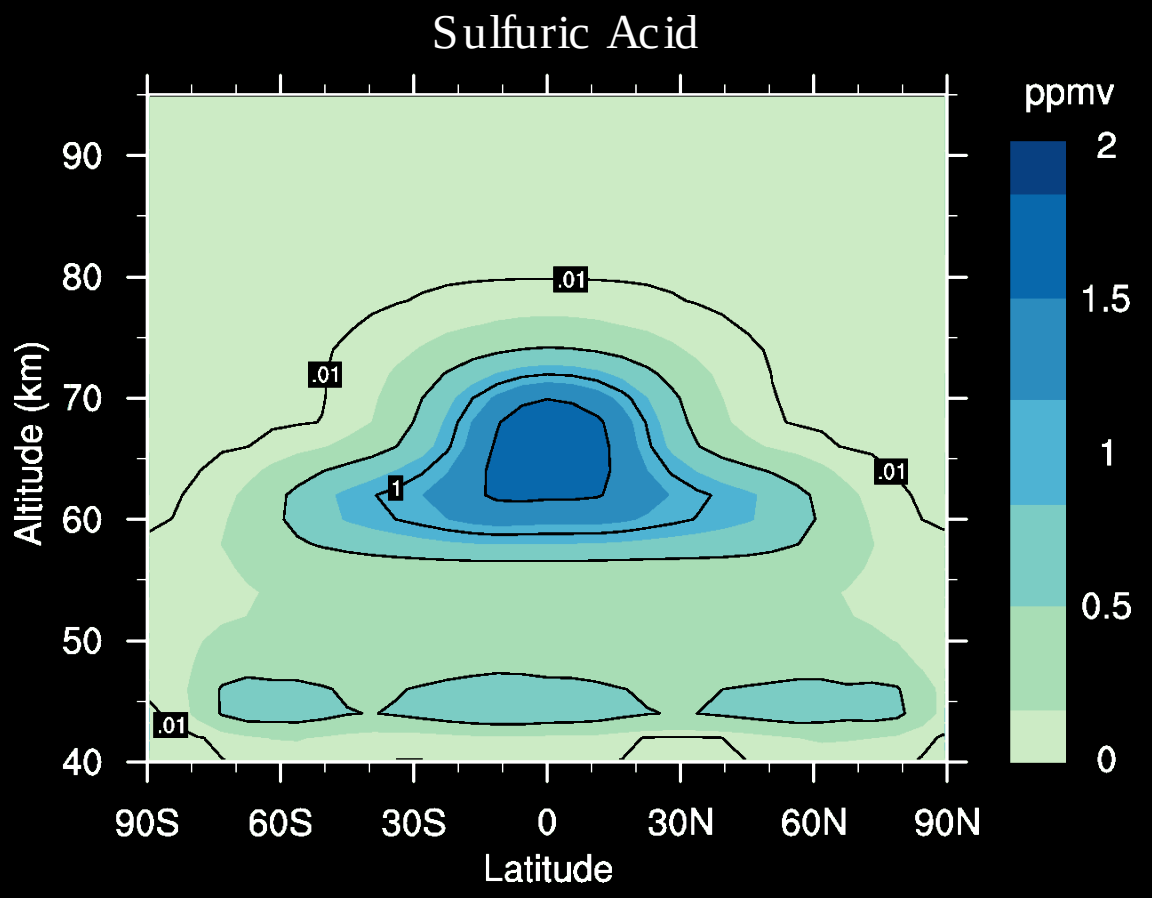
Overall good agreement

Low Total Mass

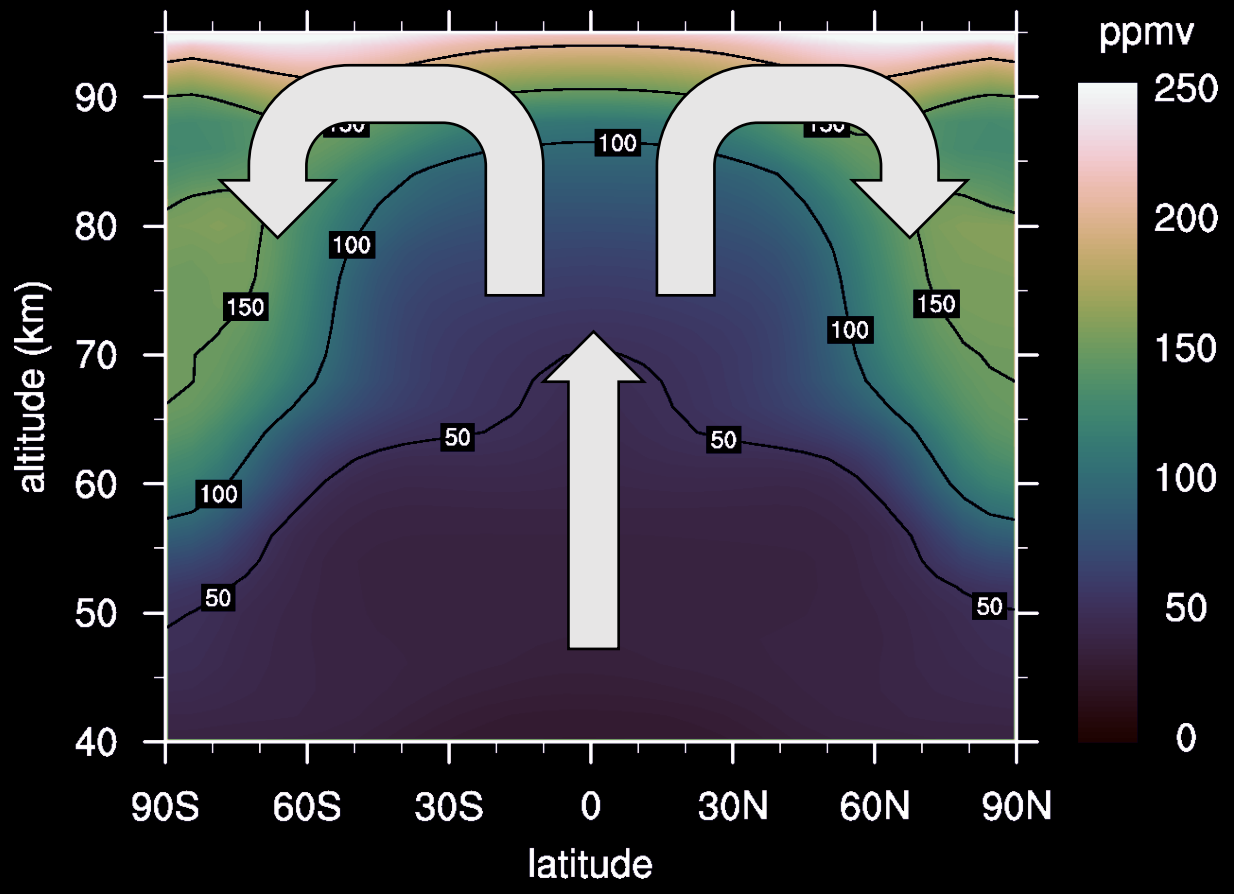
Lower cloud too extended

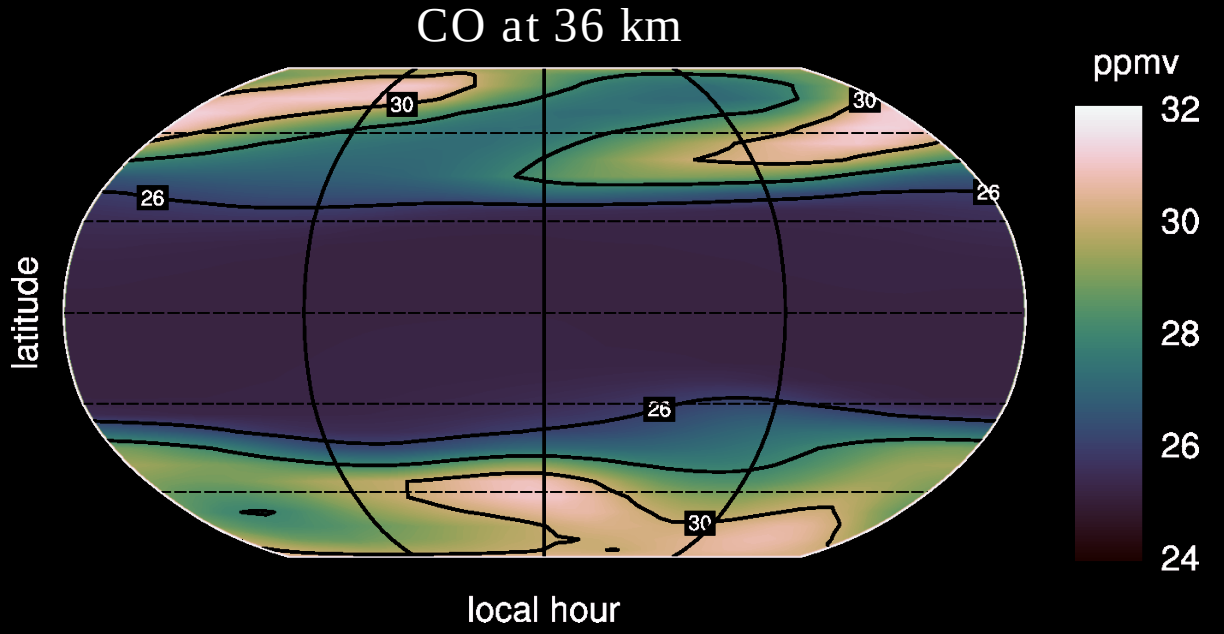
Venus PCM: clouds



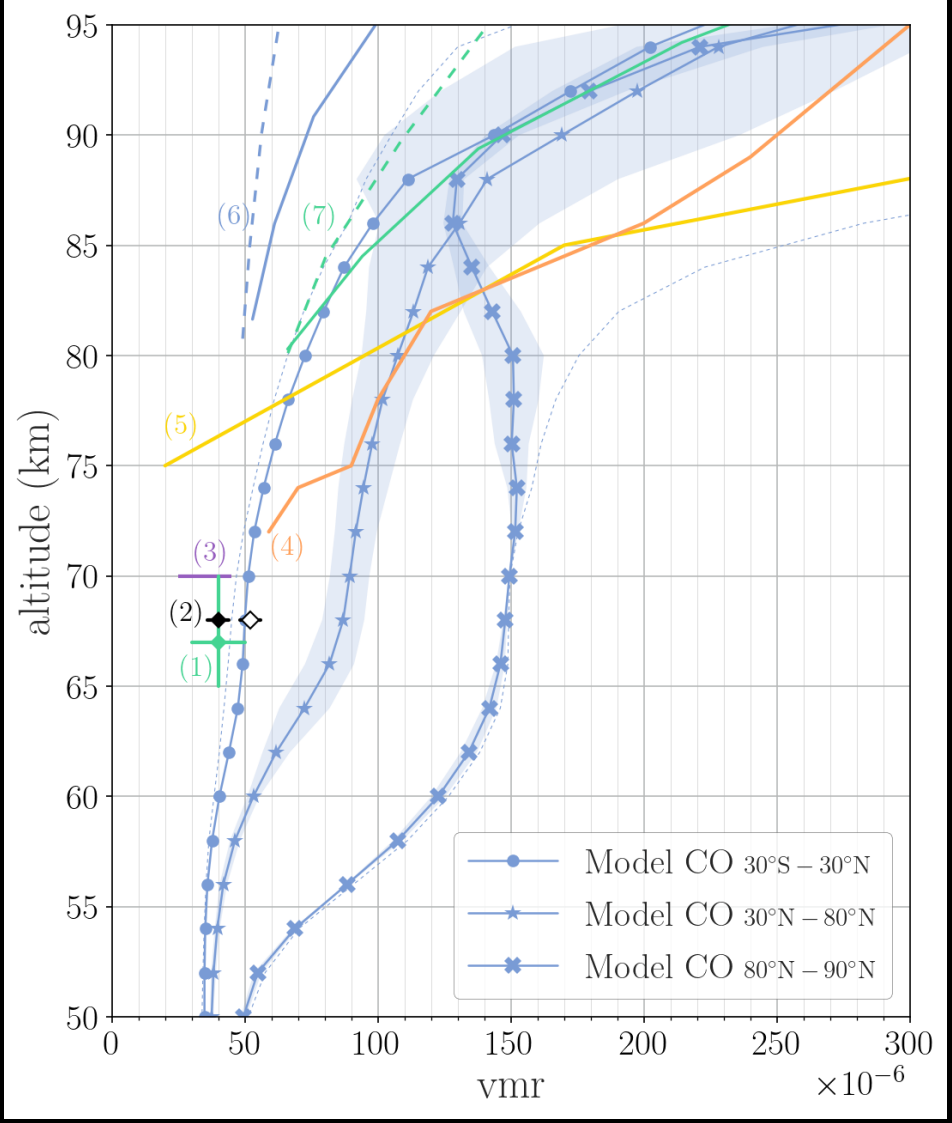


Venus PCM: CO


altitude (km)
90
80
70
60
50
40
100
150
50
90S
60S
30S
0
30N
60N
90N
latitude
ppmv
250
200
150
100
50
0


CO at 36 km
latitude
30
26
local hour
ppmv
32
30
28
26
24

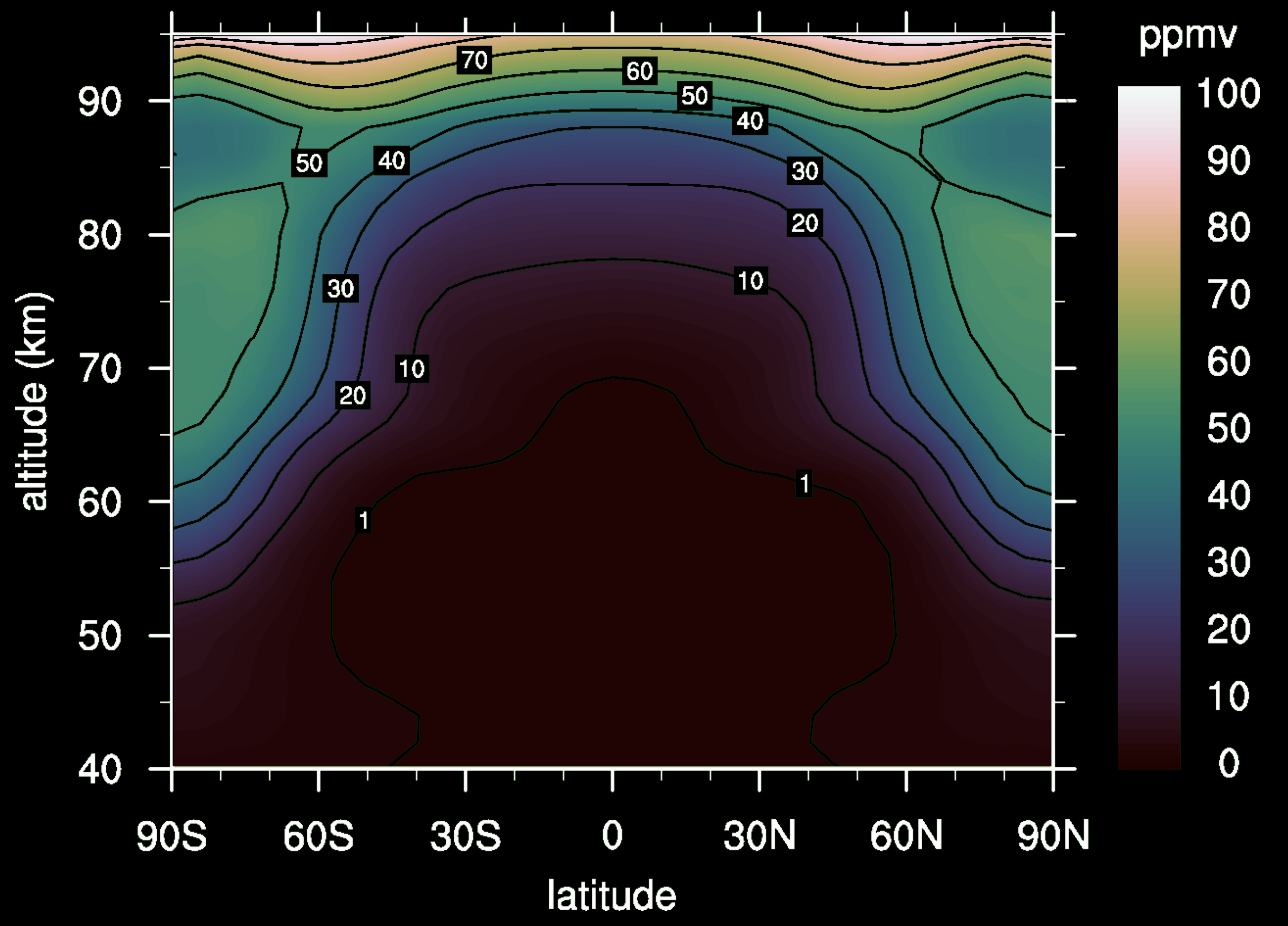
Venus PCM: CO

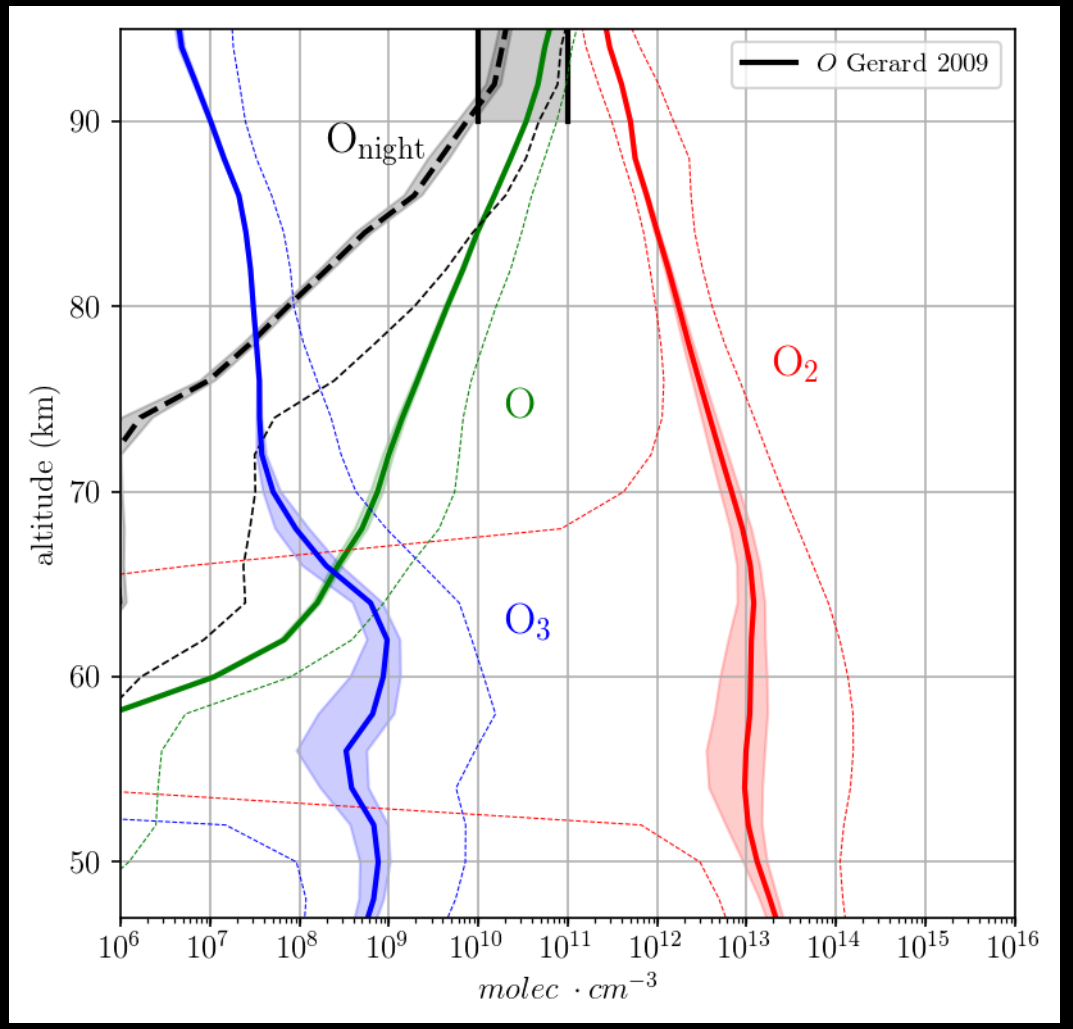


Strong variability in the mesosphere

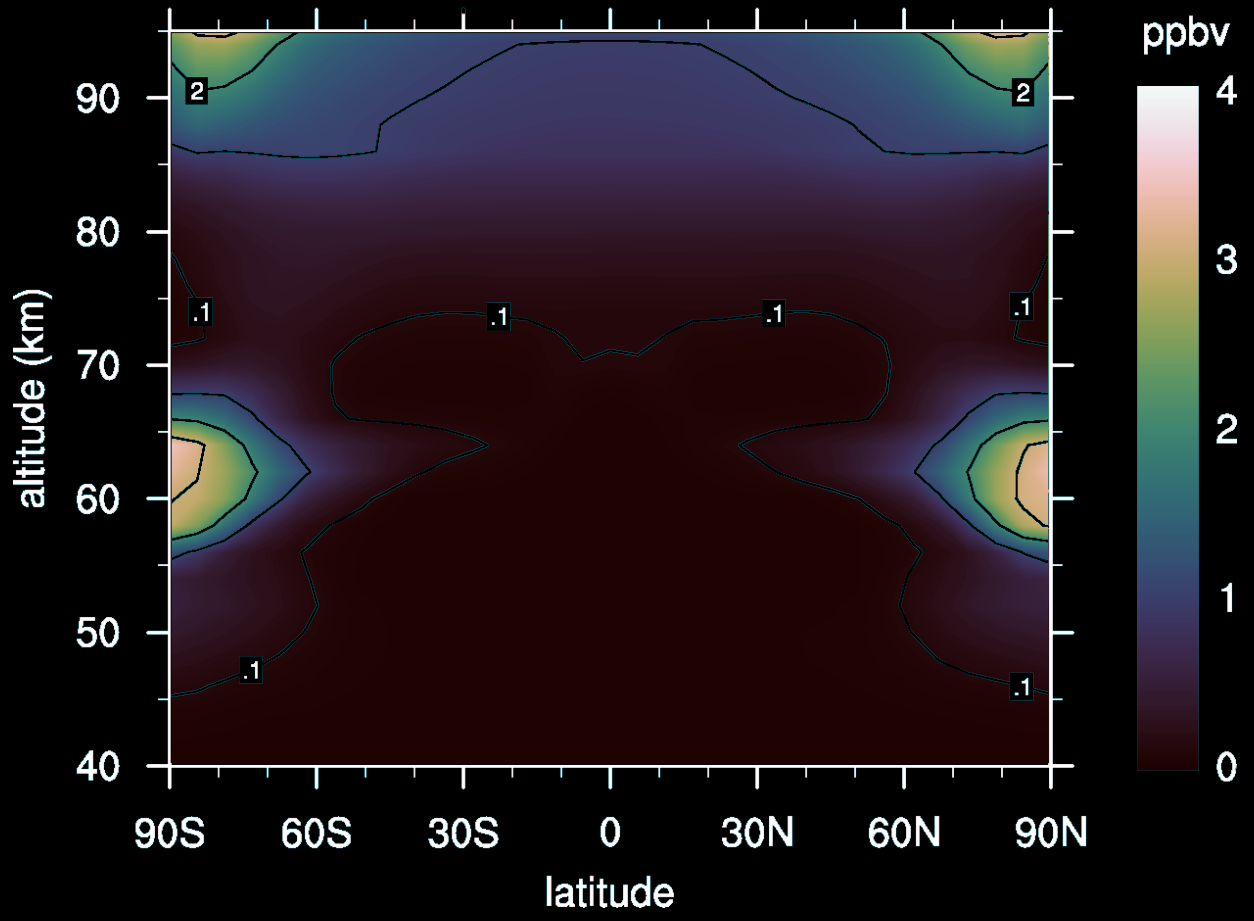
Good agreement with observations

Venus PCM: O_2

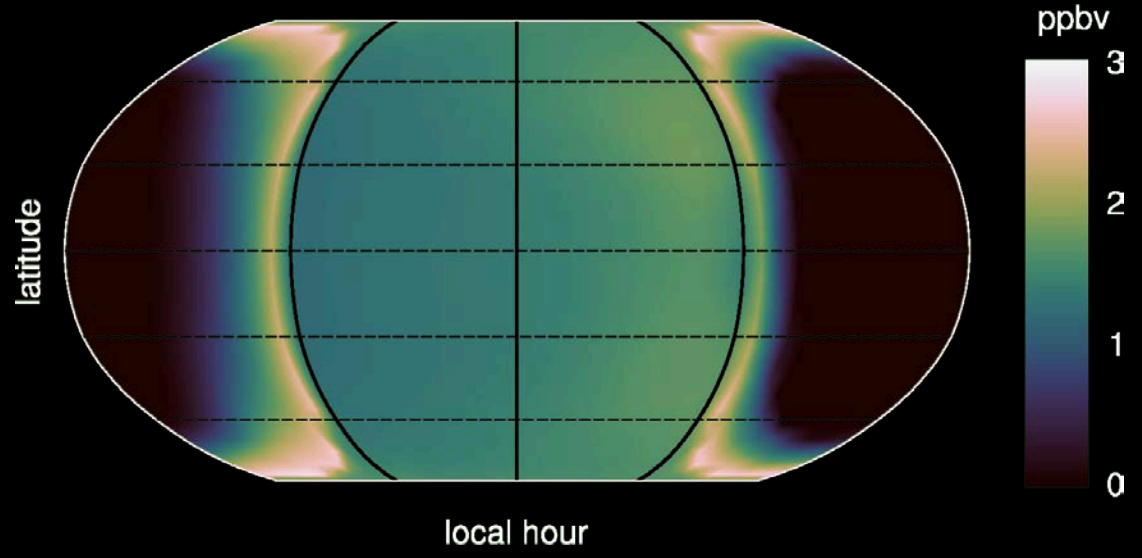

ppmv
100
90
80
70
60
50
40
30
20
10
0
altitude (km)
90
80
70
60
50
40
90S
60S
30S
0
30N
60N
90N
latitude
70
60
50
40
30
20
10
1


O Gerard 2009
O_{night}
O
O_2
O_3
altitude (km)
90
80
70
60
50
10^6
10^7
10^8
10^9
10^{10}
10^{11}
10^{12}
10^{13}
10^{14}
10^{15}
10^{16}
$molec \cdot cm^{-3}$

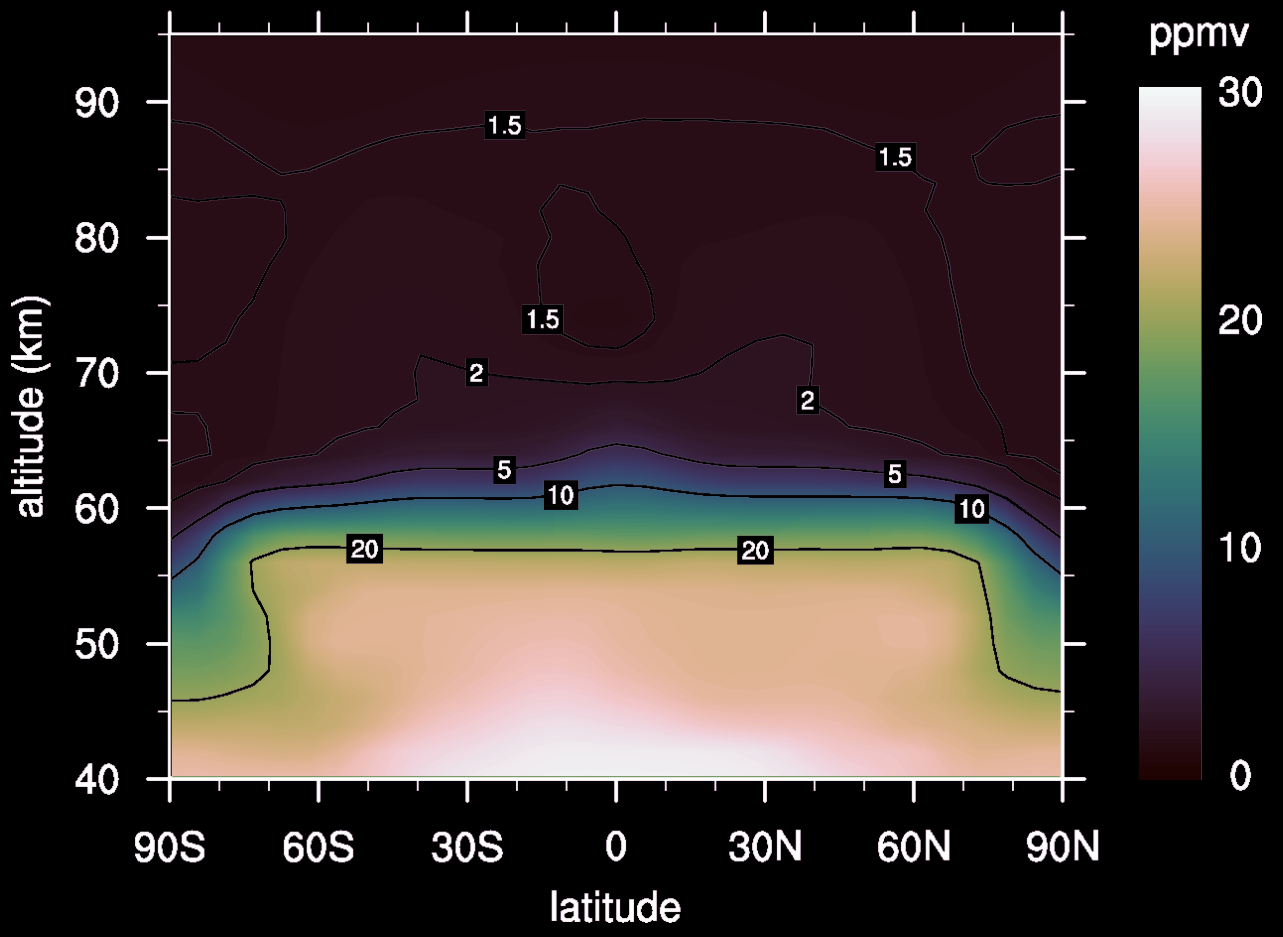
Venus PCM: O_3

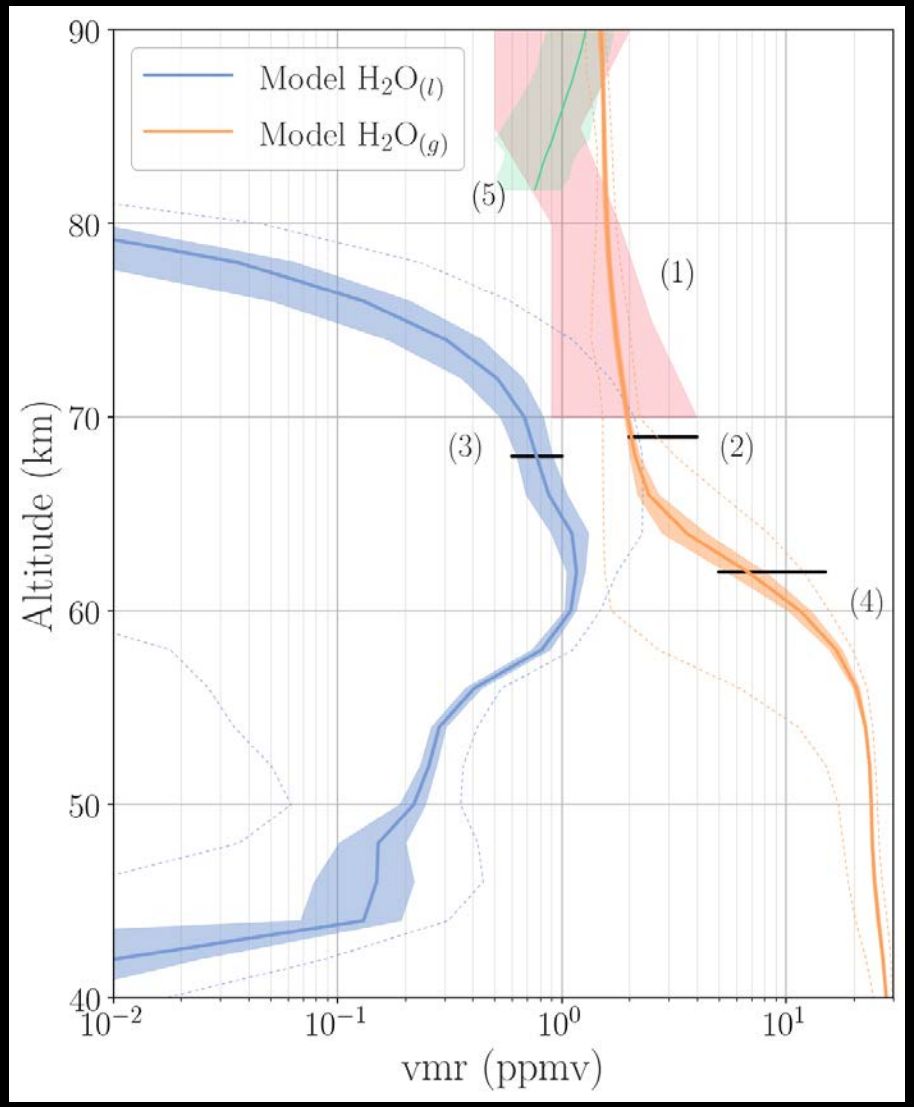


O_3 at 95 km

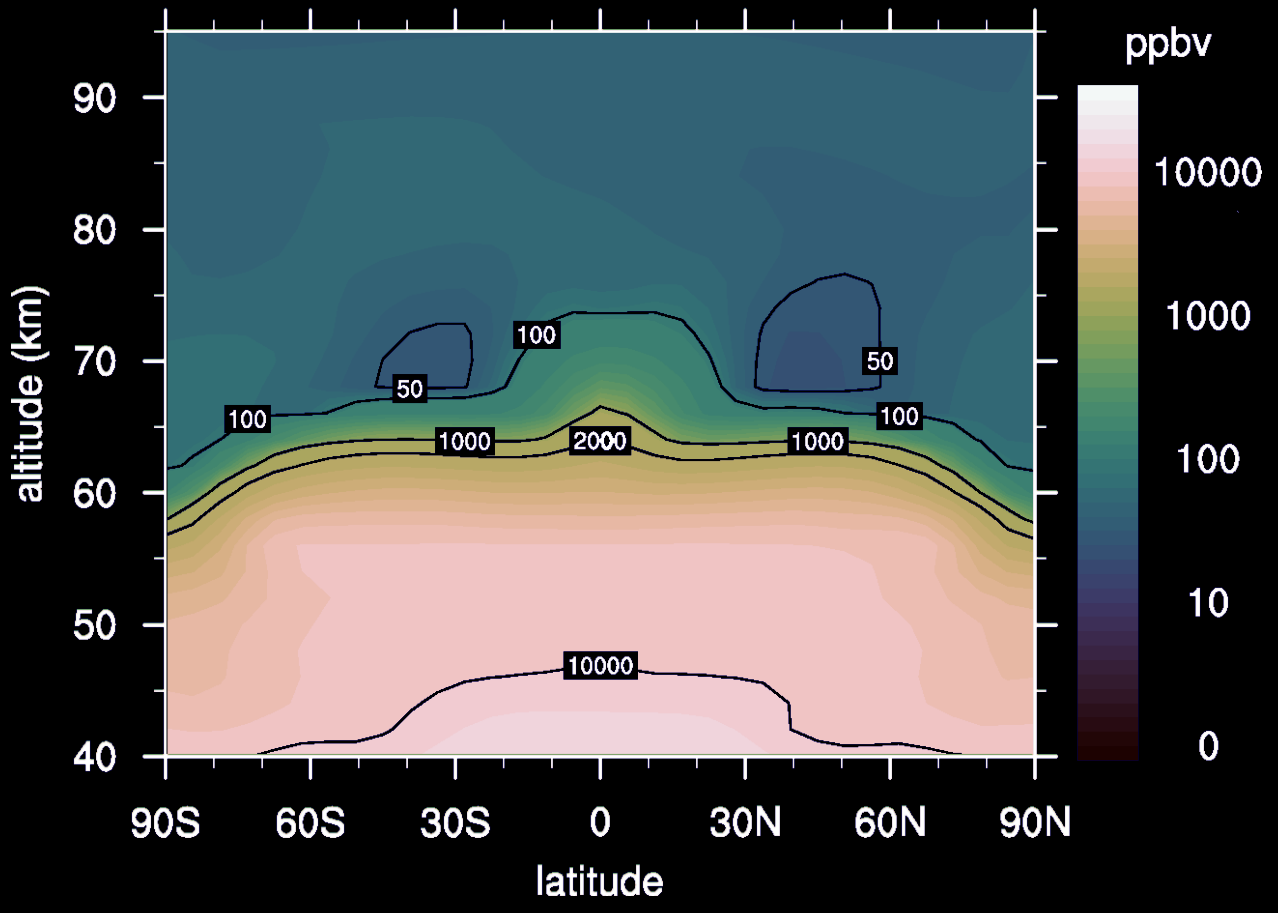


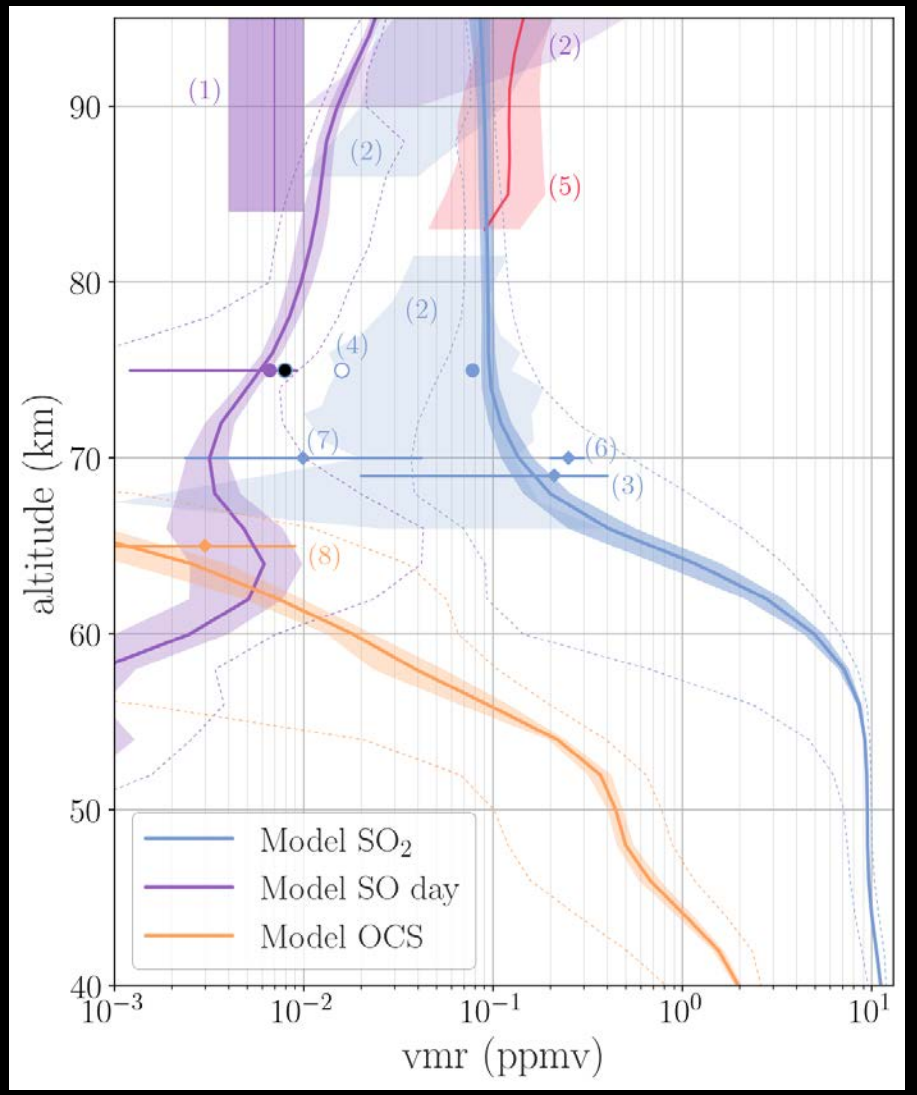
Venus PCM: H_2O



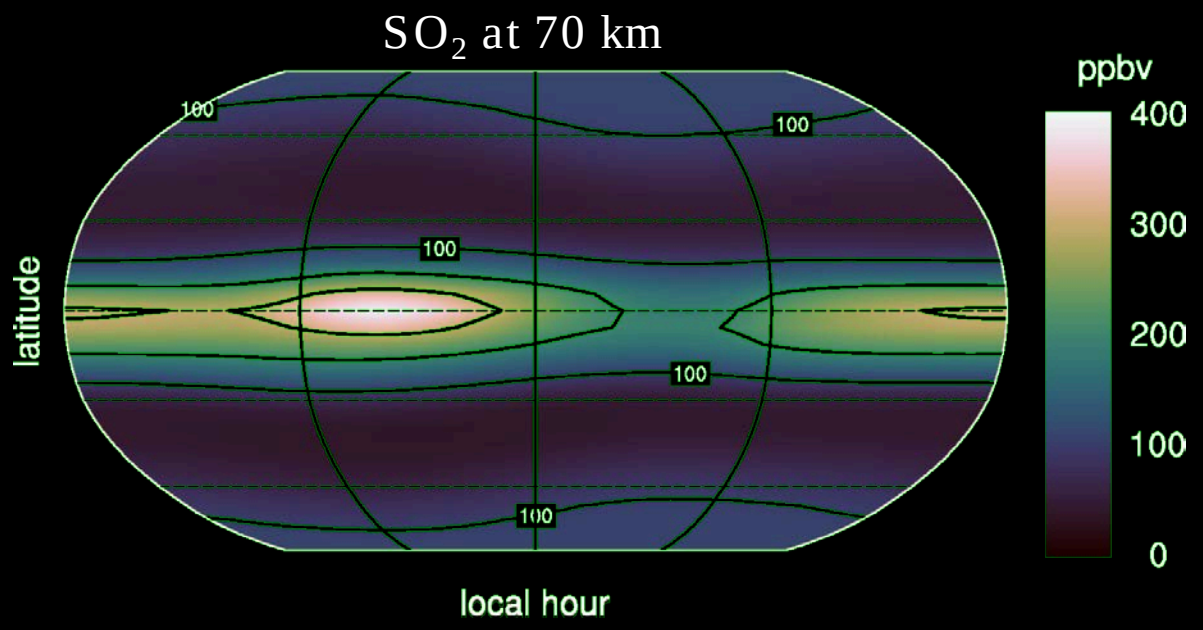


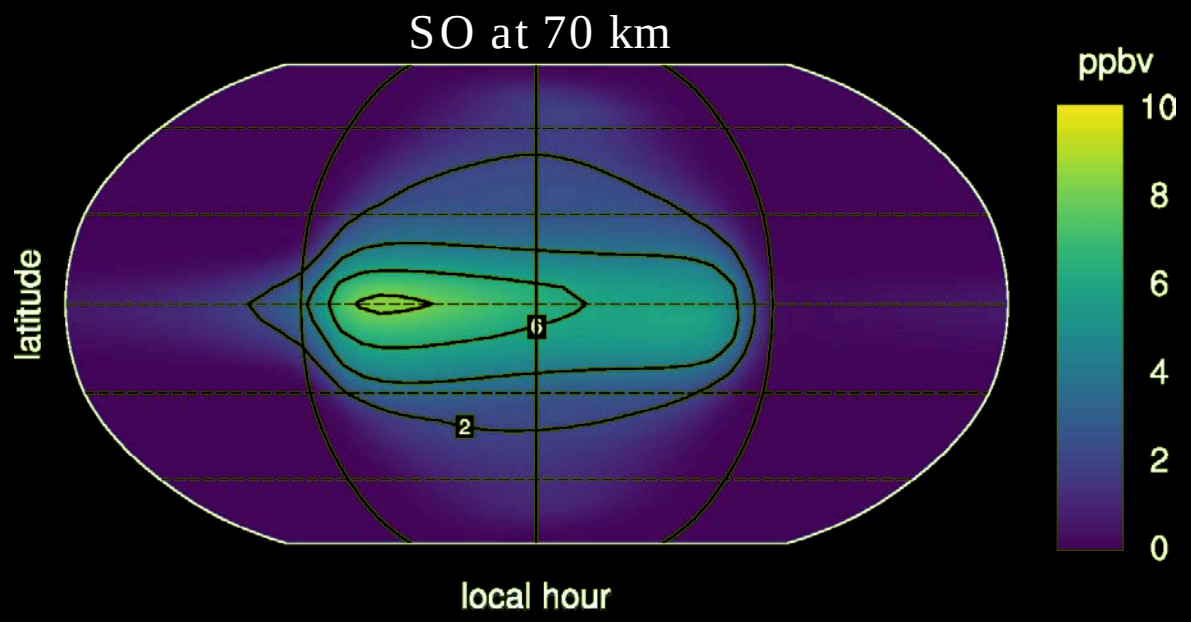
Venus PCM: SO_2





Venus PCM: SO_2





Conclusion

- First 3D Model of photochemistry and clouds for Venus
- Good agreement for all species and clouds characteristics
- Sulfur cycle through SO_2 is a major issue

Perspectives

- Under development at LATMOS, LMD (Paris, France) and IAA (Granada, Spain)
- Nitrogen chemistry and updated photolysis method implemented by Nicolas Streele (PhD. Student at LATMOS)
- Chemical Patways Analysis Program (IAA)
- Heterogenous chemistry (IAA)

Thank you for your attention