

Comparison between LMD-Venus General Circulation Model results and aerobraking data

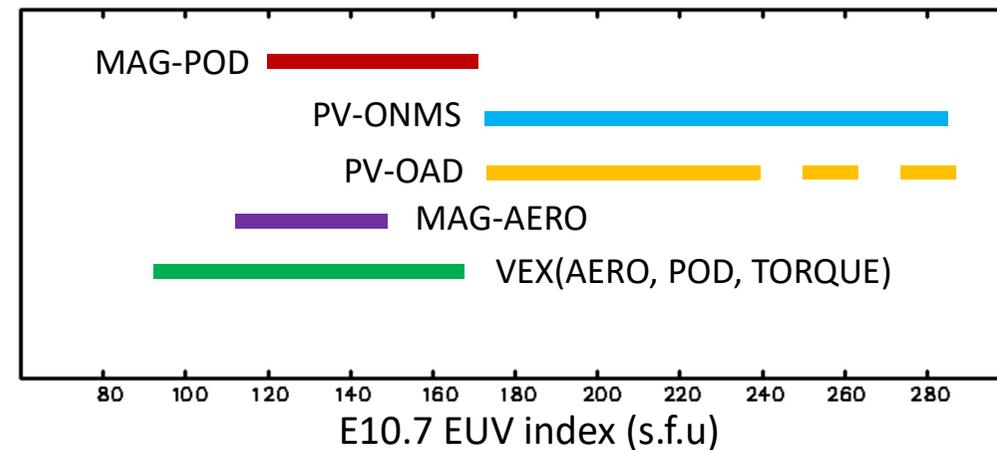
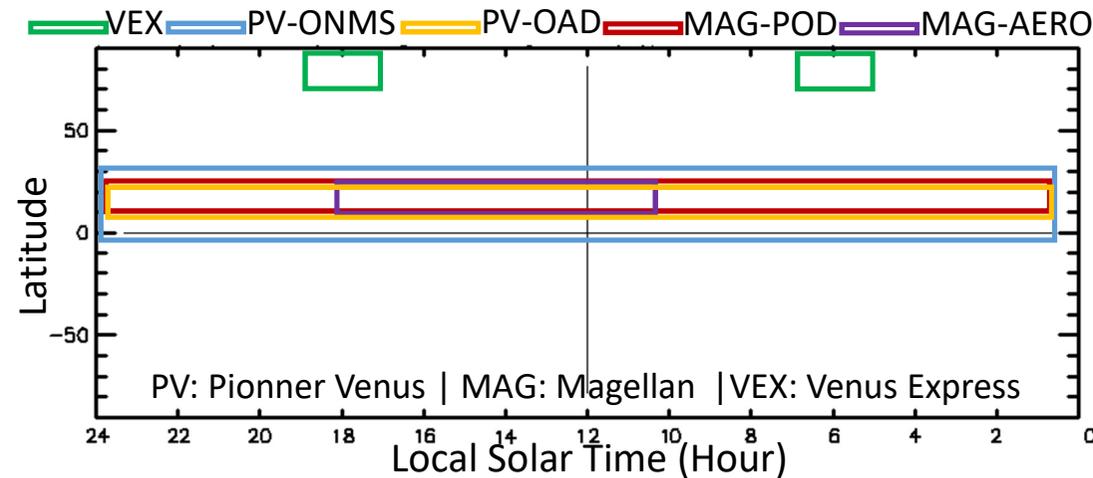
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• LMD-VGCM (Lebonnois et al., 2010; Gilli et al., 2017)

- Developed for fifteen years at IPSL
- Recently extended from 150 km to 200-250 km in altitude
- Used for “Venus Climate Database (VCD) Project”
- **Objective:** “reproduce the evolution and variability of the Venusian atmosphere from the surface to the thermosphere.”
- In order to characterize these variabilities, we use the high altitude data measurements of Magellan, Pioneer Venus and Venus Express:

➤ **T_{exosphere}(LST, EUV)**
➤ **Composition(LST, EUV)**
➤ **Density(LST, EUV, Latitude)**

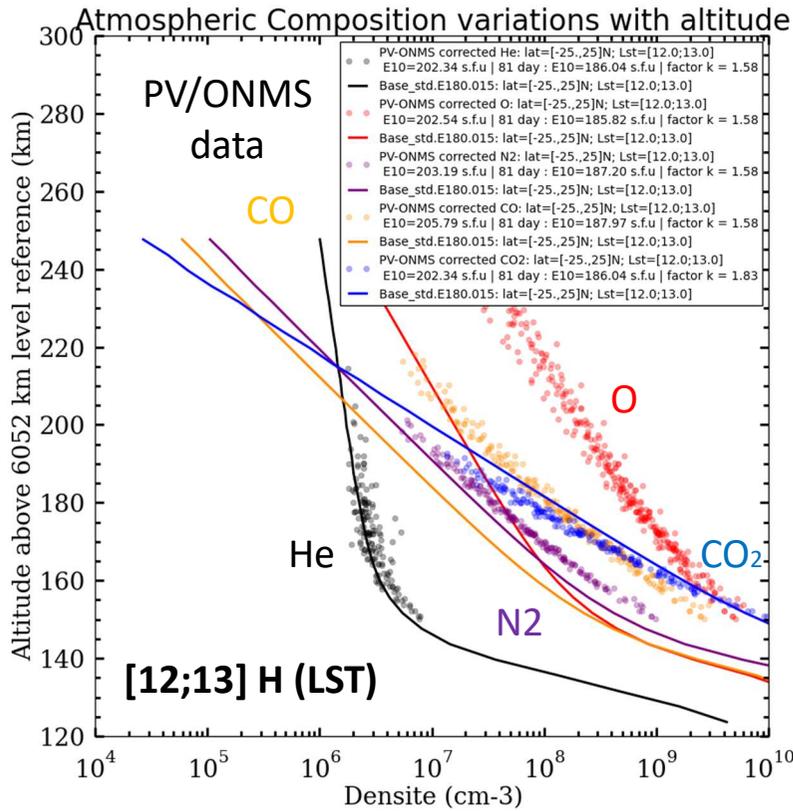


Two simulations

- Base_std:
 - More QR coefficient is high, more the cooling is efficient
 - More EUV heating rate is high, more the EUV heating is efficient
 - Tuning: Only quenching rate coefficient & EUV heating rate
 - → Troubles: underestimation of CO and O densities; Densities number underestimated; exospheric temperature overestimated

- Base_tune:
 - Tuning: Empirical adjustment of CO₂ dissociation into CO + O

Base_std : underestimation of CO and O production



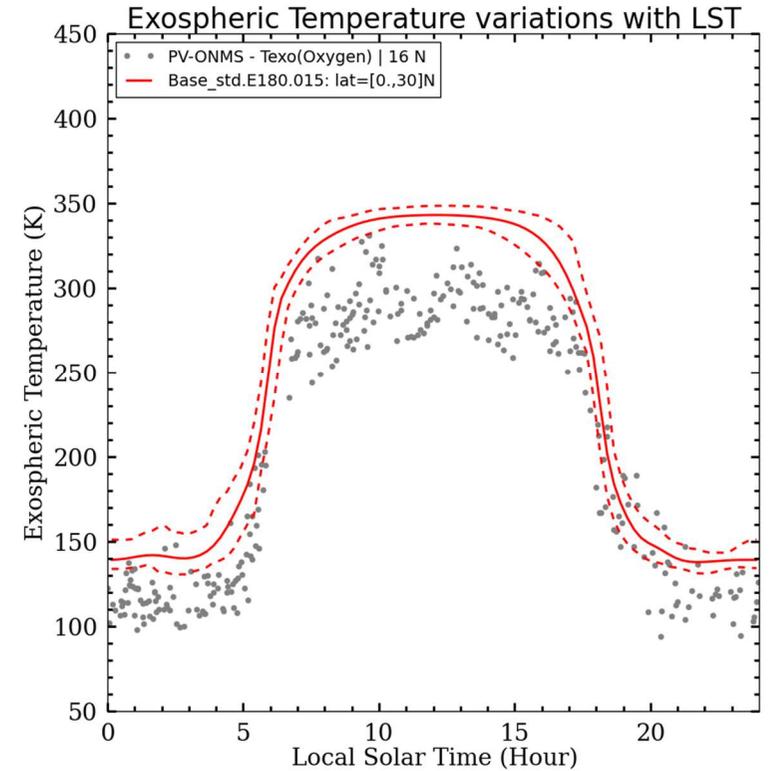
Underestimation of CO and O densities (x10)



15 microns cooling less efficiency

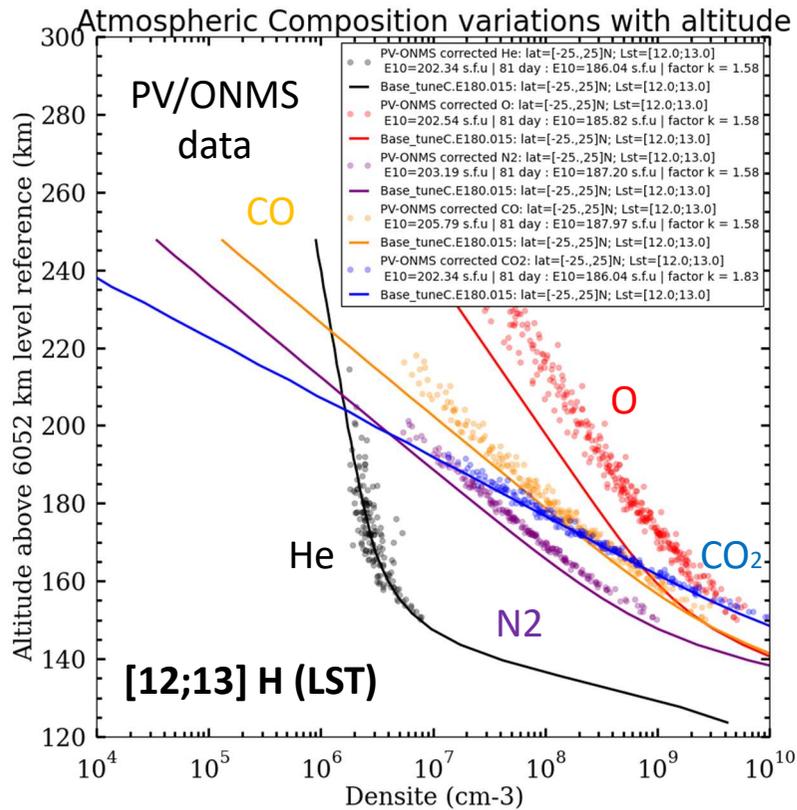


Thermospheric and exospheric temperature overestimated



Quenching rate: $7 \cdot 10^{-1} \text{ cm}^3 \cdot \text{s}^{-1}$
 EFF EUV : 17%

Base_tune : Empirical adjustment of CO2 dissociation into CO + O



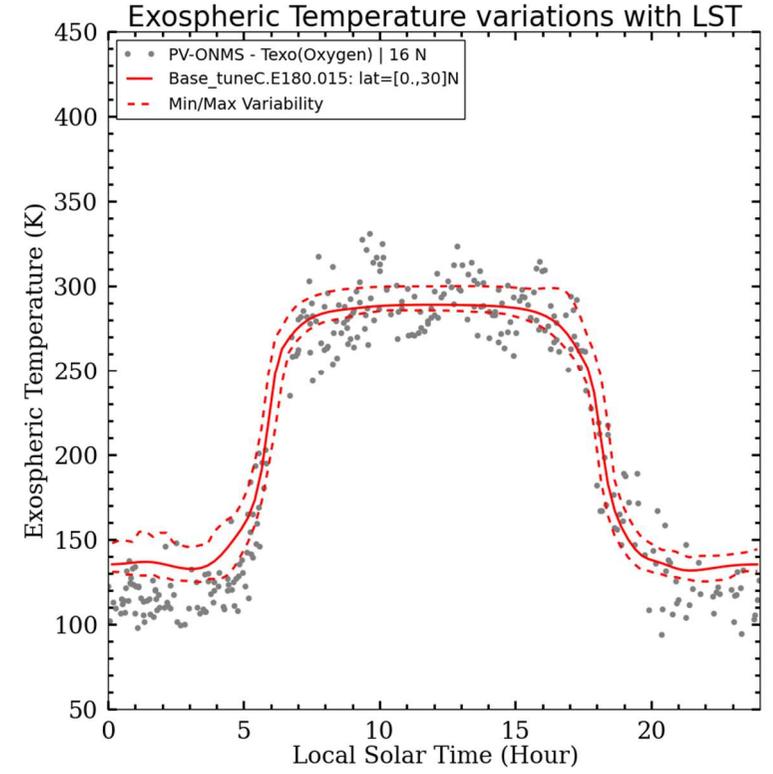
Better estimation of CO and O densities (lack of O density: x2)



15 microns cooling more efficiency



Thermospheric and exospheric temperature are better-estimated



Quenching rate: $4 \cdot 10^{-12} \text{ cm}^3 \cdot \text{s}^{-1}$
 EFF EUV : 20%

Aim: To discover why VGCM underestimates the O and CO productions.

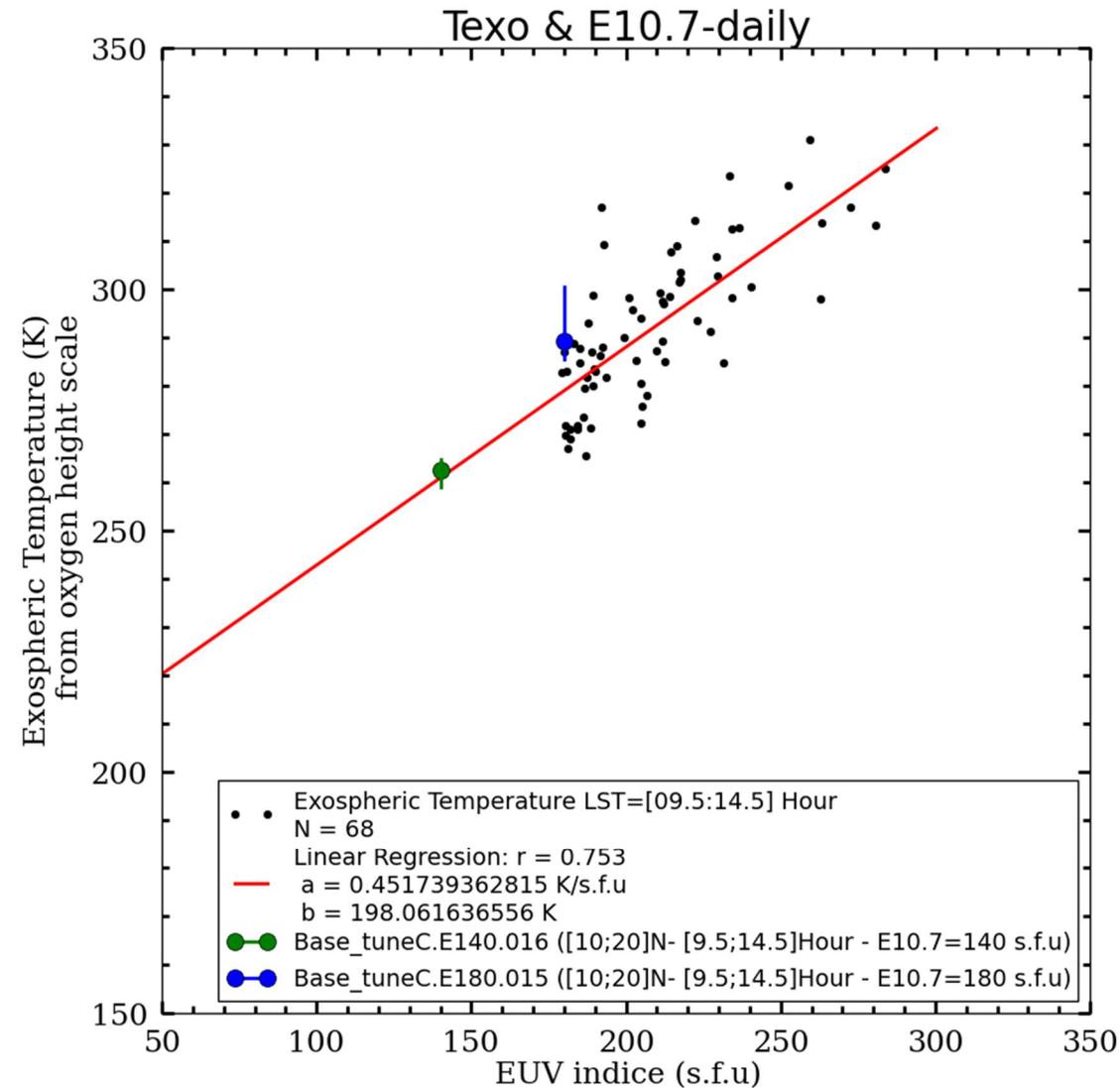
Exospheric temperature (dayside –EUV dependencies)

LMD-VCGM (day): $\frac{dT}{d(E10.7)} = \sim 0.625 \frac{K}{s.f.u}$

Linear regression fit from Retrieved Exospheric Temperature from PV-ONMS O density data:

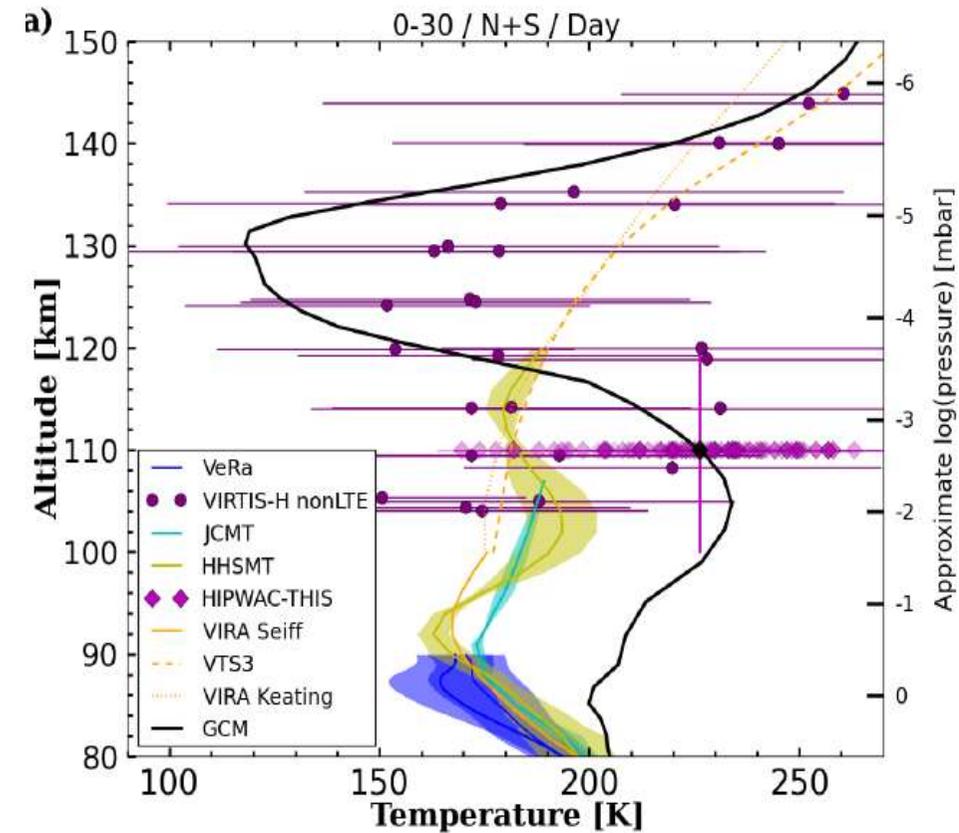
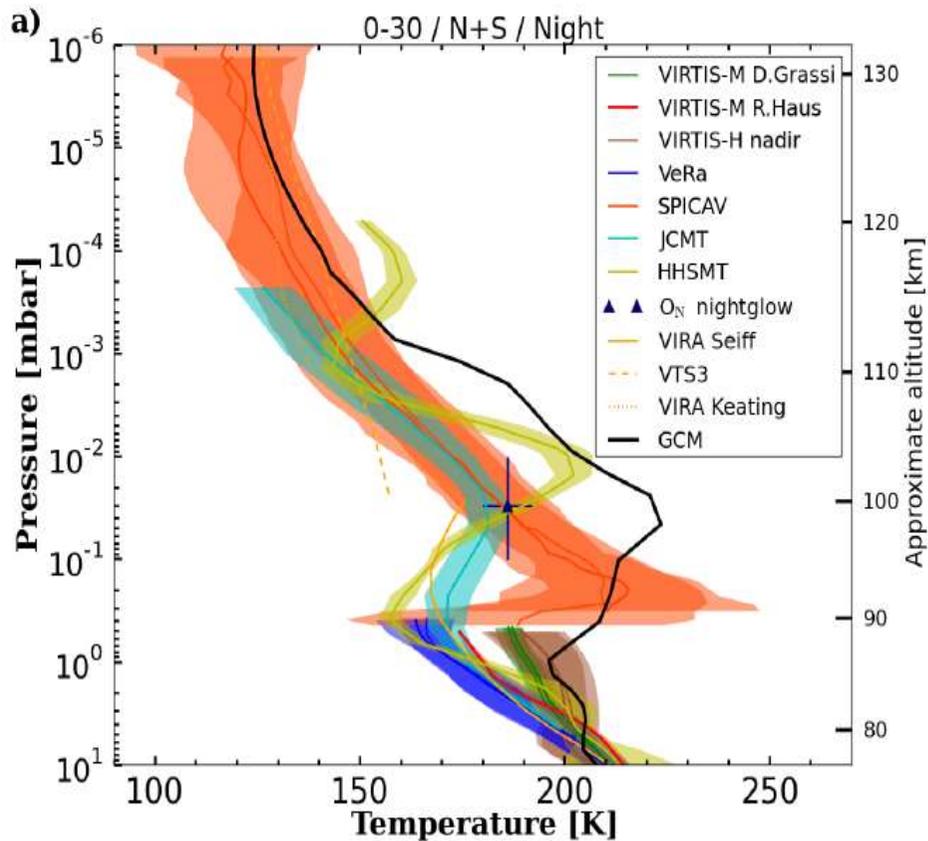
$$\frac{dT}{d(E10.7)} = \sim 0.45 \frac{K}{s.f.u}$$

- Evolution a little too fast, possibly explained by the slight oxygen deficiency



Thermospheric temperature

- Figure extracted from Gilli et al., 2021

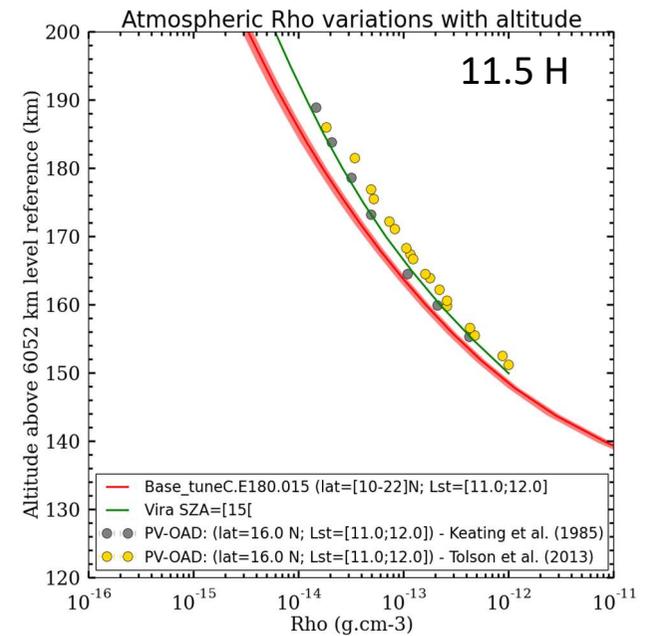
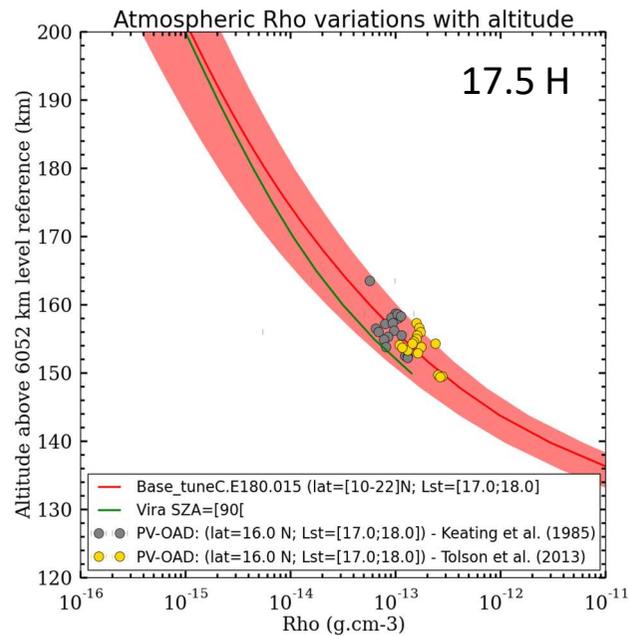
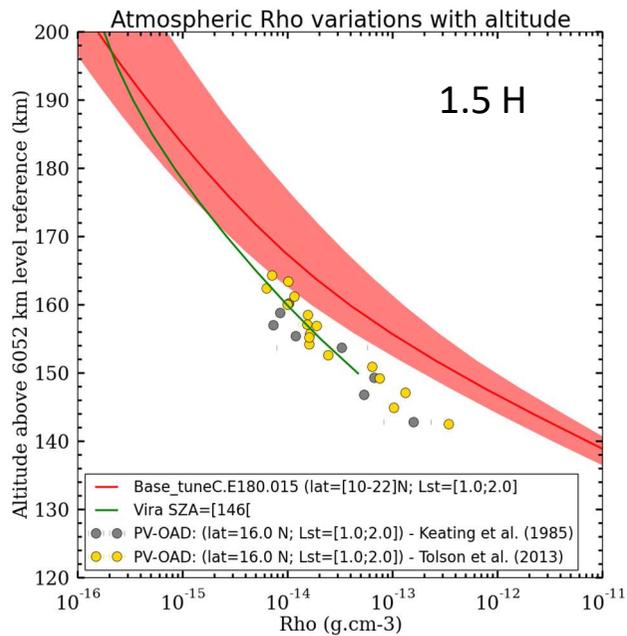


Profil:

- Too warm between (day/night): 90-120 km
- Too cold between (day): 120-140 km
- **YET:** shape similar to terrestrial and VEX observations

Mass density: Local Hour dependency

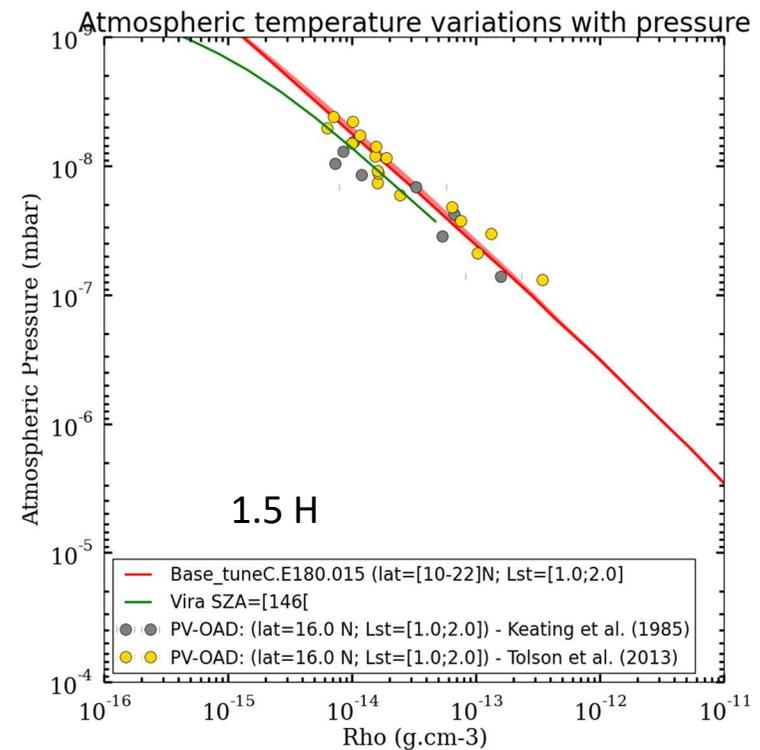
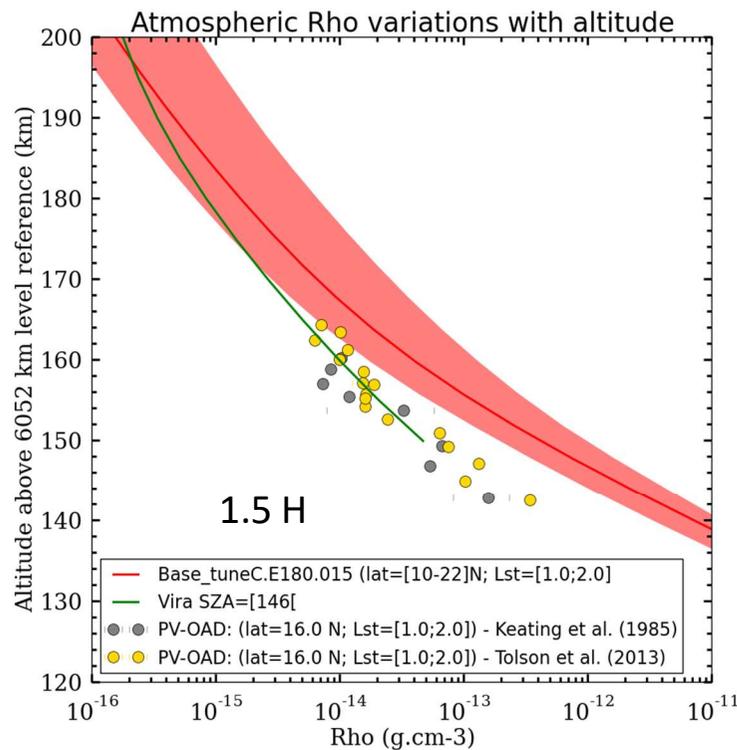
- LMD-VGCM reproduces the observational variability of PV-OAD.



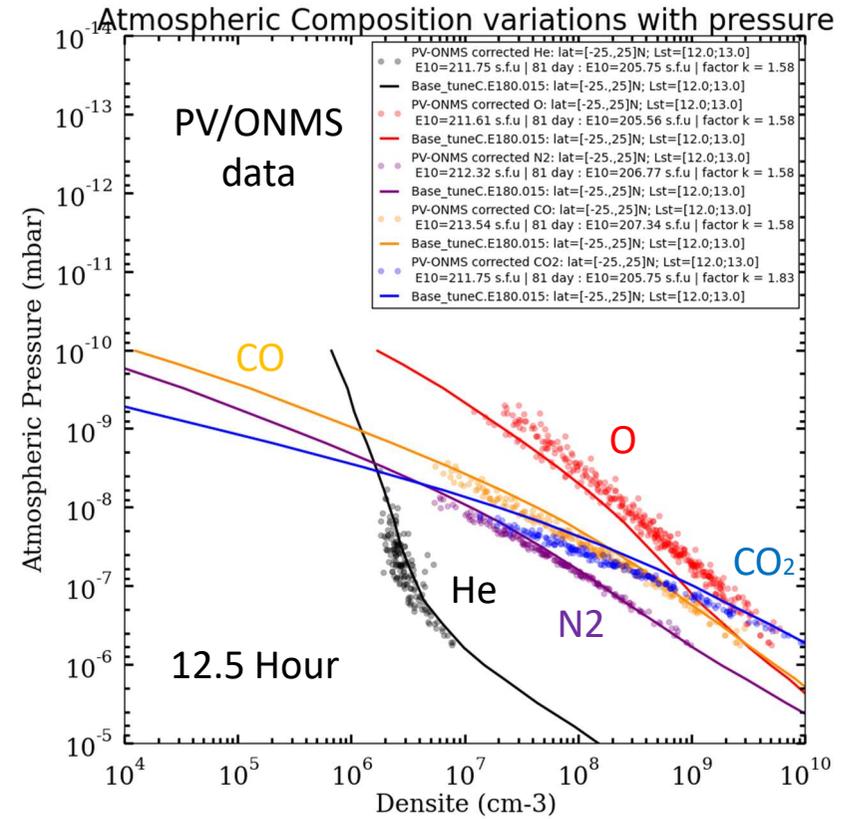
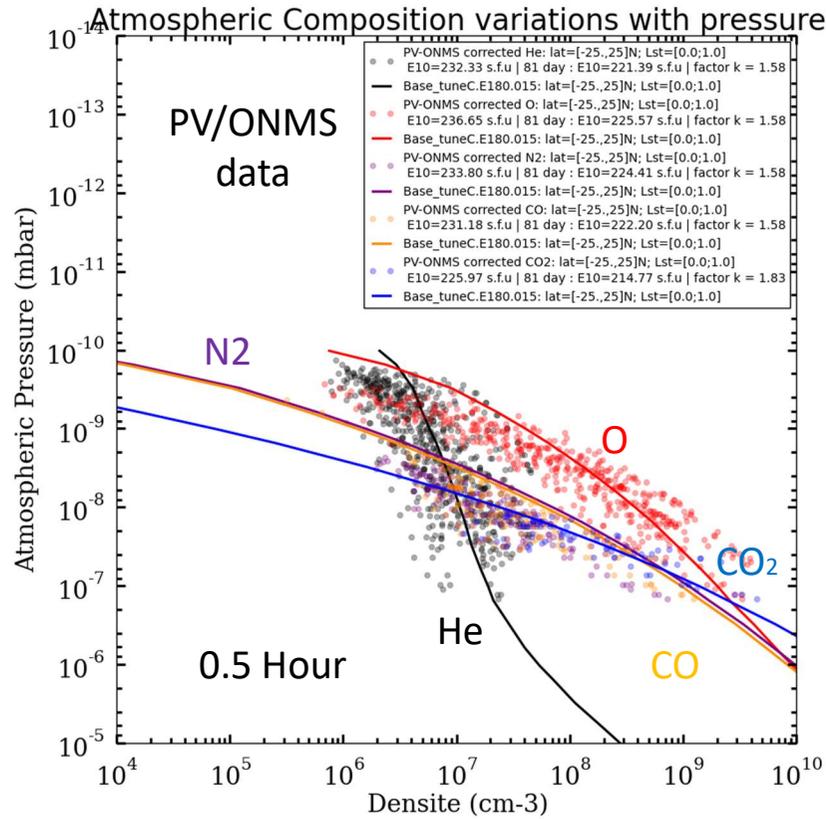
Mass density : altitude shift on the night side

Why ? :

The hot spot between 90 and 120 km in altitude induces an altitude shift because of the higher height scale ($H = \frac{k_B \cdot T}{m \cdot g}$) which reduces the atmospheric decay. If we observe the same figure in pressure scale, we can see that the model is more in agreement with the observations.

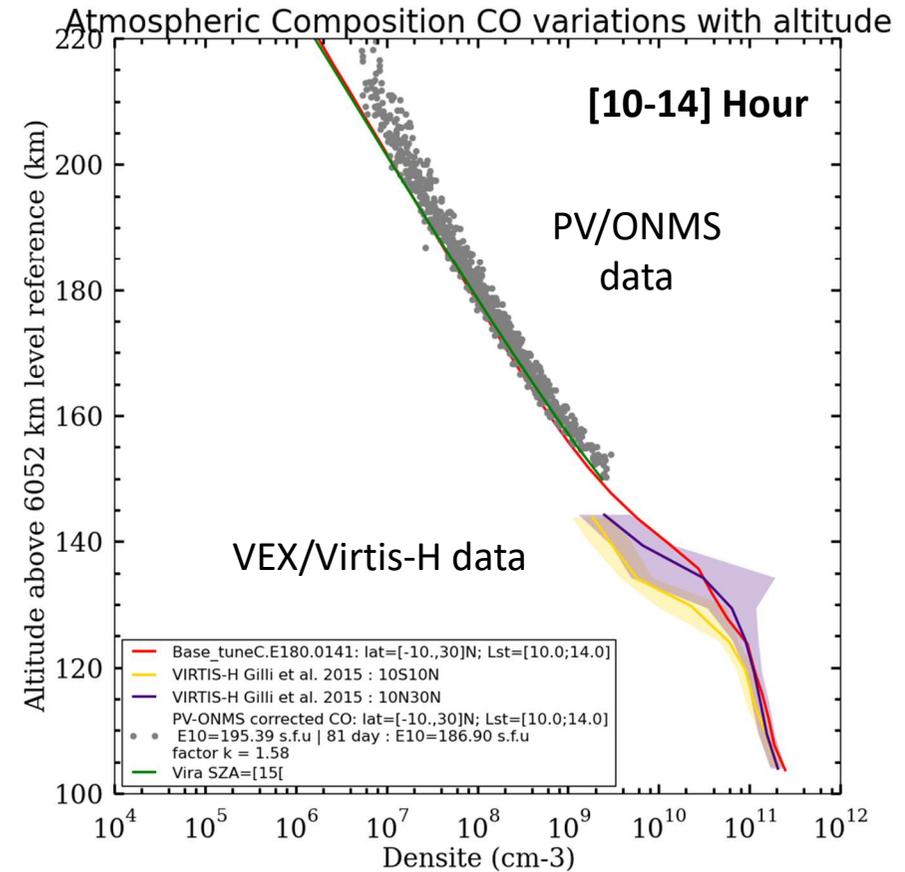
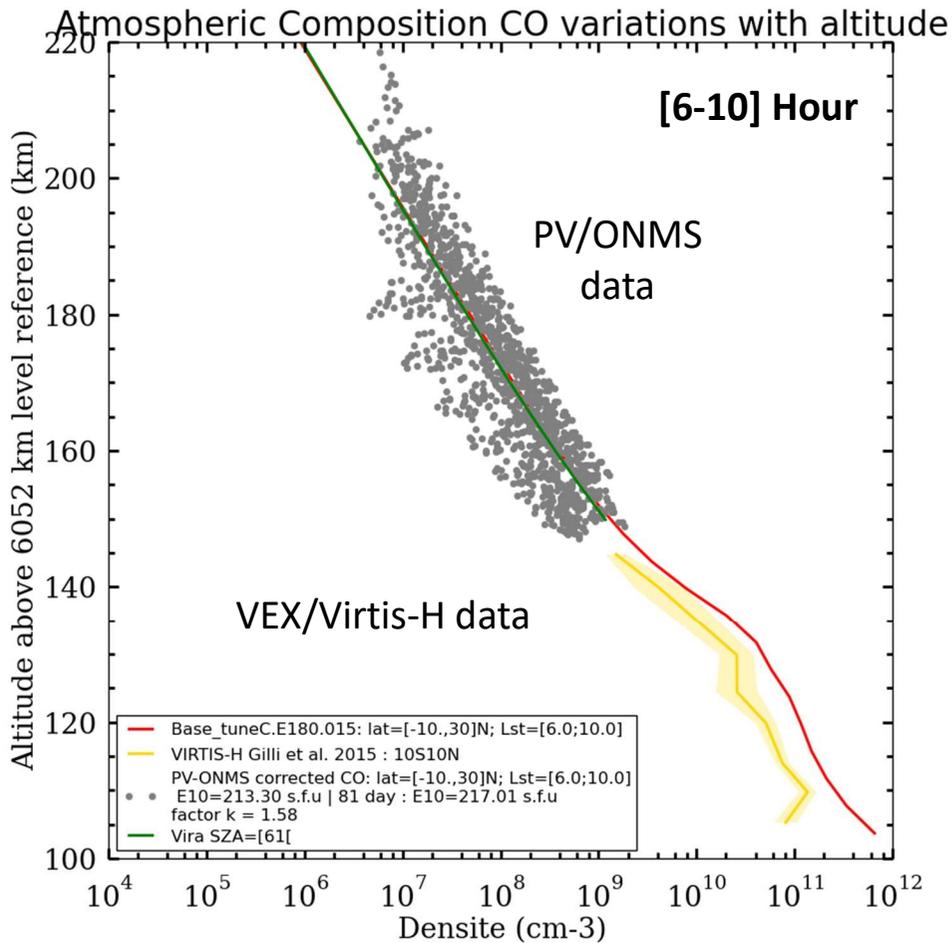


Composition



In pressure scale, the evolution of the composition observed by PV-ONMS is reproduced by LMD-VGCM.

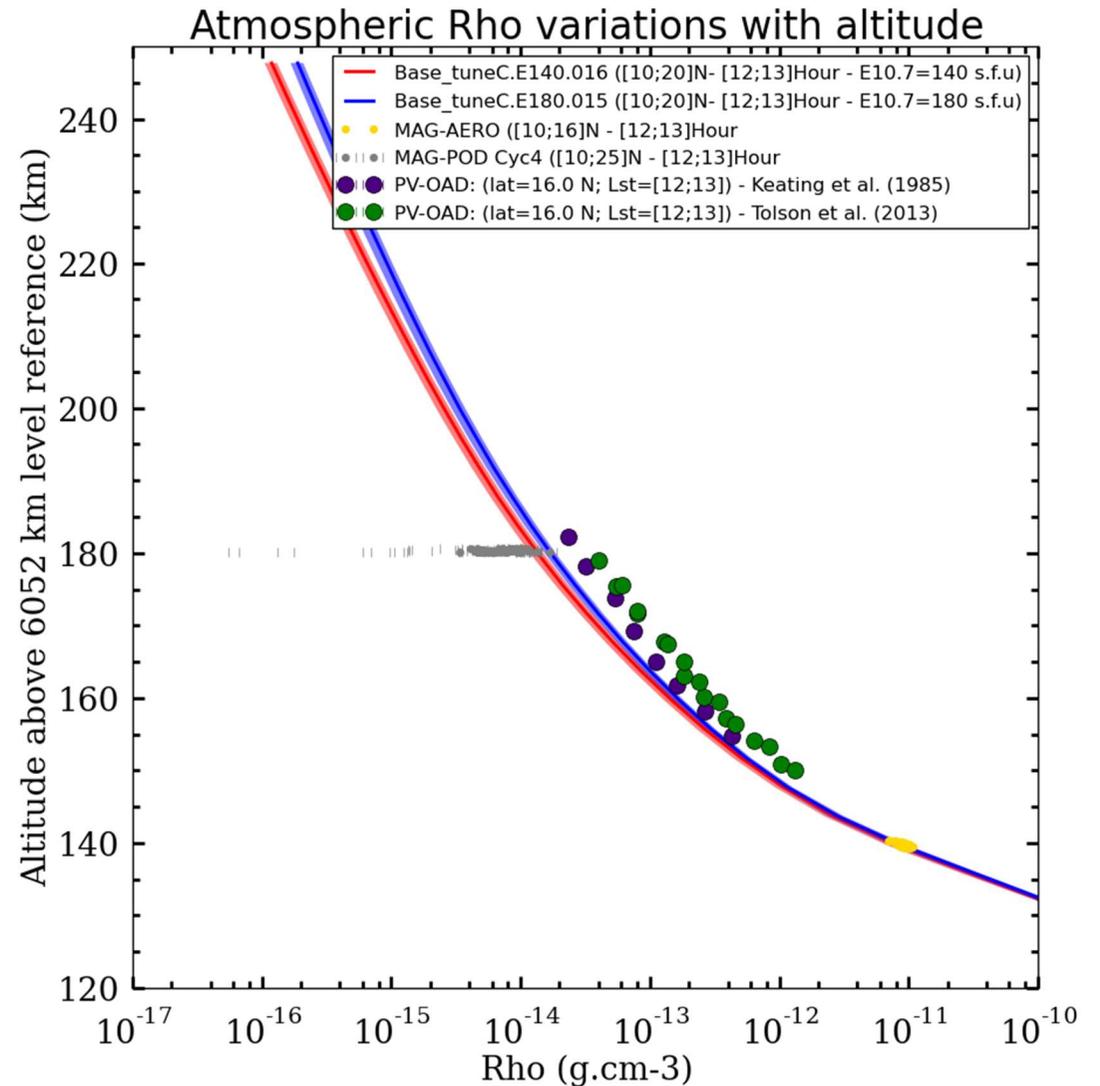
Density number CO : Virtis-H & PV-ONMS



- Excellent fit under 130 km in altitude with VIRTIS-H CO.
- Excellent fit above 150 km in altitude with PV-ONMS data.

Influence of the EUV flux on the mass density at 12.5 hour (LST)

- PV-OAD data: 180-200 s.f.u
- MAG data: 130-150 s.f.u

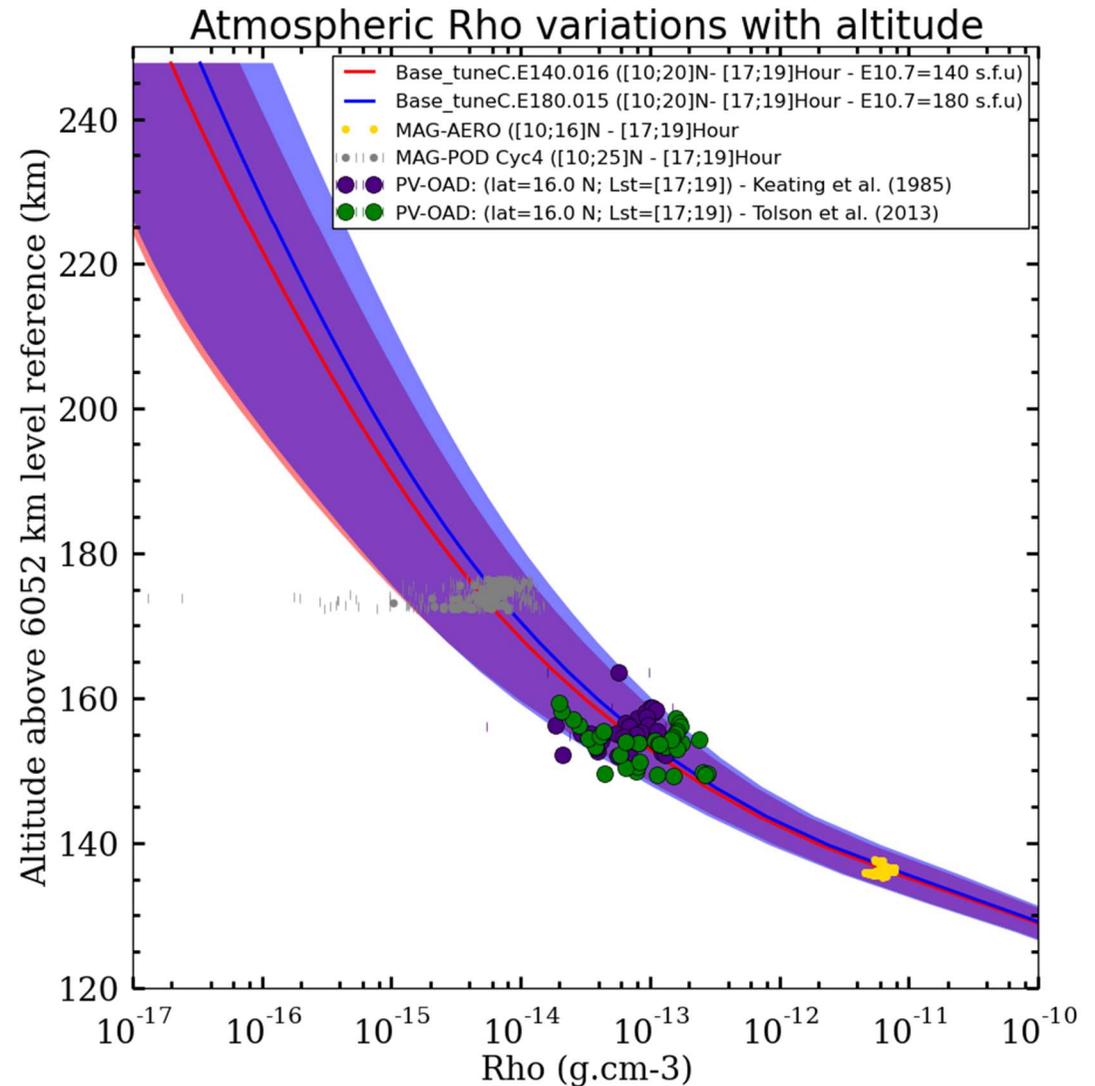


Influence of the EUV flux on the mass density at 18 hour (LST)

- PV-OAD data: 180-200 s.f.u
- MAG data: 130-150 s.f.u

- GCM reproduces the observational variability

- No significant EUV dependencies observed



Mass density at 18 hour (LST) for 140 s.f.u and high latitude

- VEX data: 120-150 s.f.u
- GCM reproduces the observational variability
- Over-estimation of the Mass density for the GCM.
- The mass density seems to be a little lower at high latitude than at low latitude according to the observations.

