Status of the IPSL Venus GCM and the Venus Climate Database

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The IPSL Venus GCM

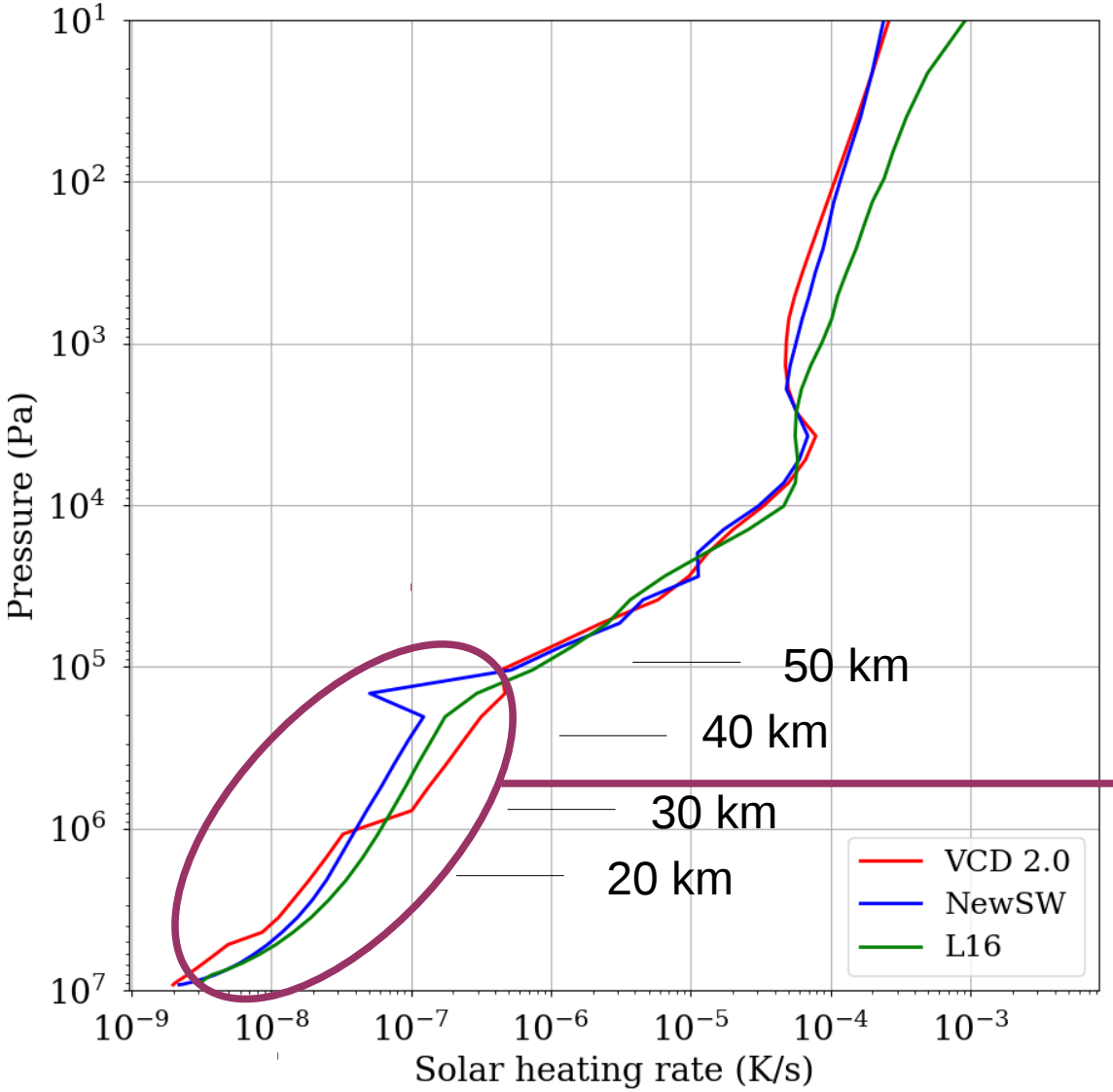
- Three-dimensional: 96x96x
  [50 (0~95 km) / 78 (0~150 km) / 90 (0~250 km)]
- Vertical coordinates: hybrid (sigma/pressure)
- Dynamical core, transport of tracers
- Specific physics:
  - Radiative transfer: Infrared Net Exchange Rates matrix
    Solar heating rates: tables
  - Thermosphere: Non-LTE processes
    EUV heating
    molecular diffusion
  - Parameterizations of sub-grid processes:
    boundary layer (Mellor&Yamada 1982), convection
    non-orographic gravity waves
    orographic gravity waves
  - Topography
- Photochemistry implemented (PhD of Aurélien Stolzenbach)

Gilli et al (2017, 2021) ; Garate & Lebonnois (2018) ; Navarro et al (2018, 2021)
Martinez et al (submitted)

Clouds and below

Radiative transfer sensitivity

Tuning solar heating in the deep atmosphere...



Red : Tuning (VCD 2.0)

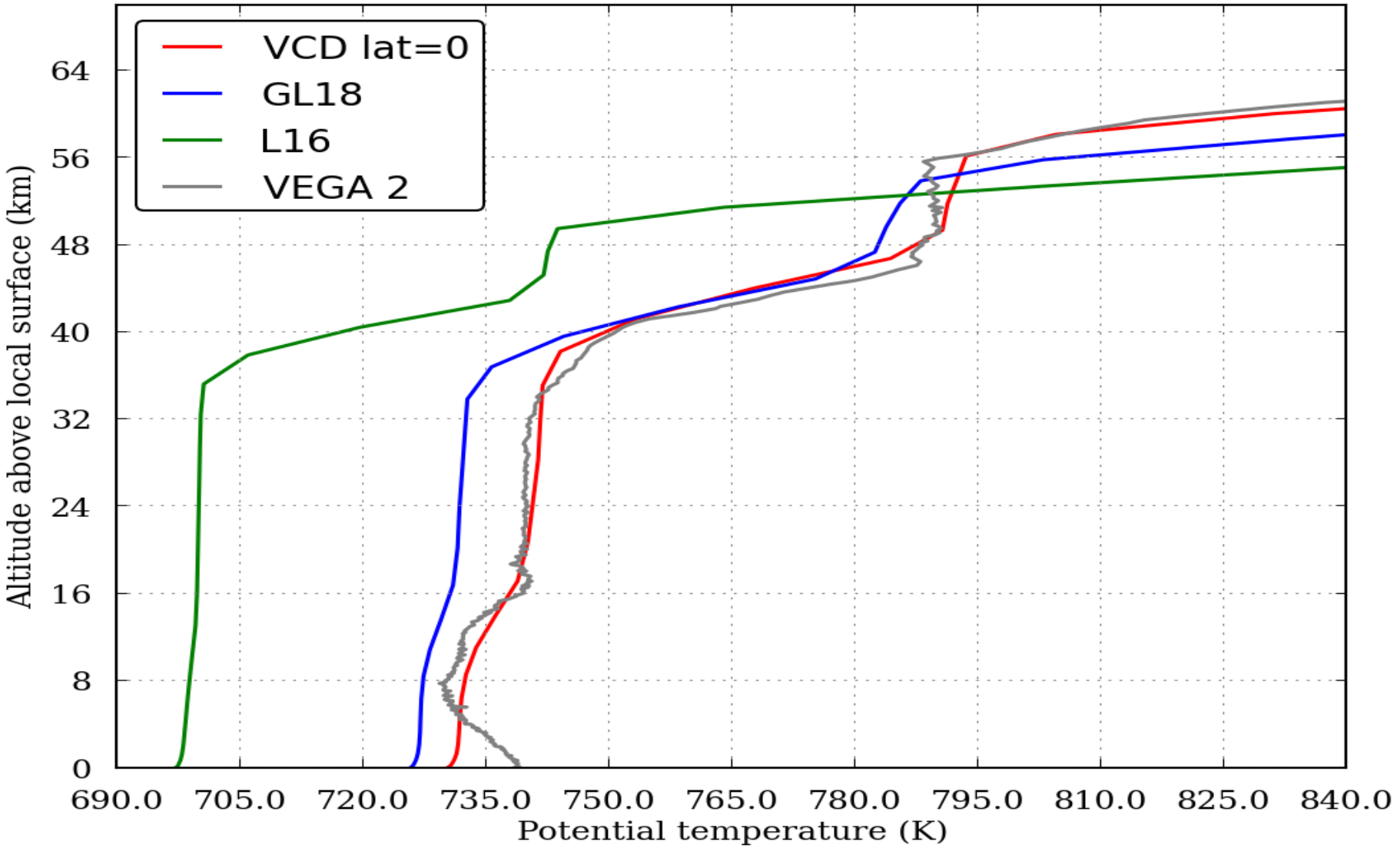
Green : Crisp, 1986 (used in L16)

Blue : New full SW RT
(missing haze below clouds)

Need for additional modeling and confirmation

Radiative transfer sensitivity

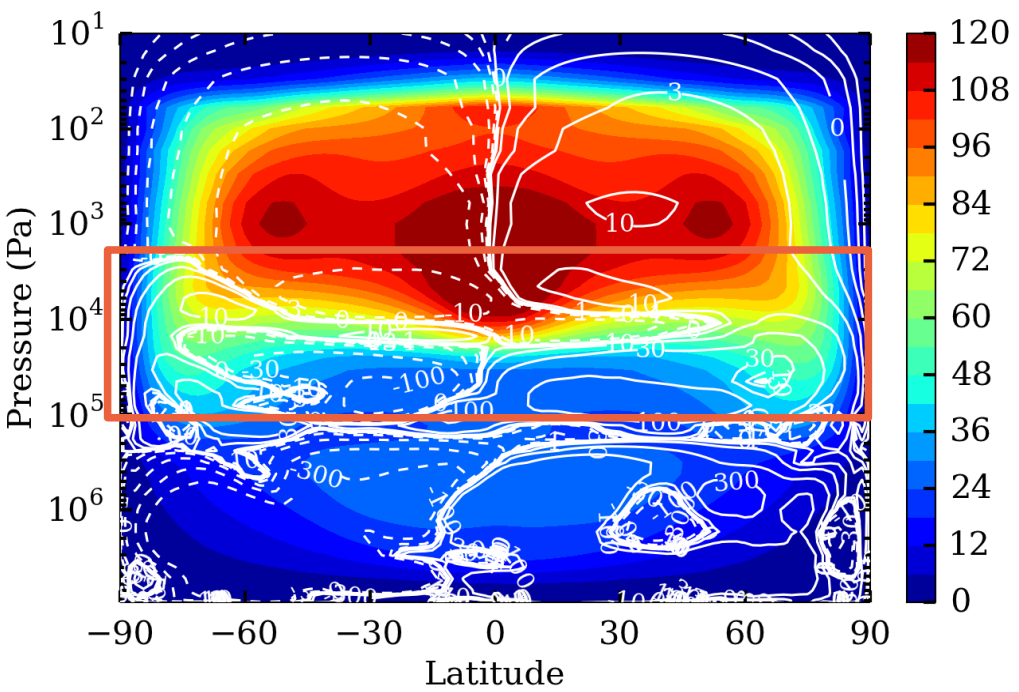
New solar tuning
=> fit of the temperature to Vega 2 profile (stable over 100 Vd)



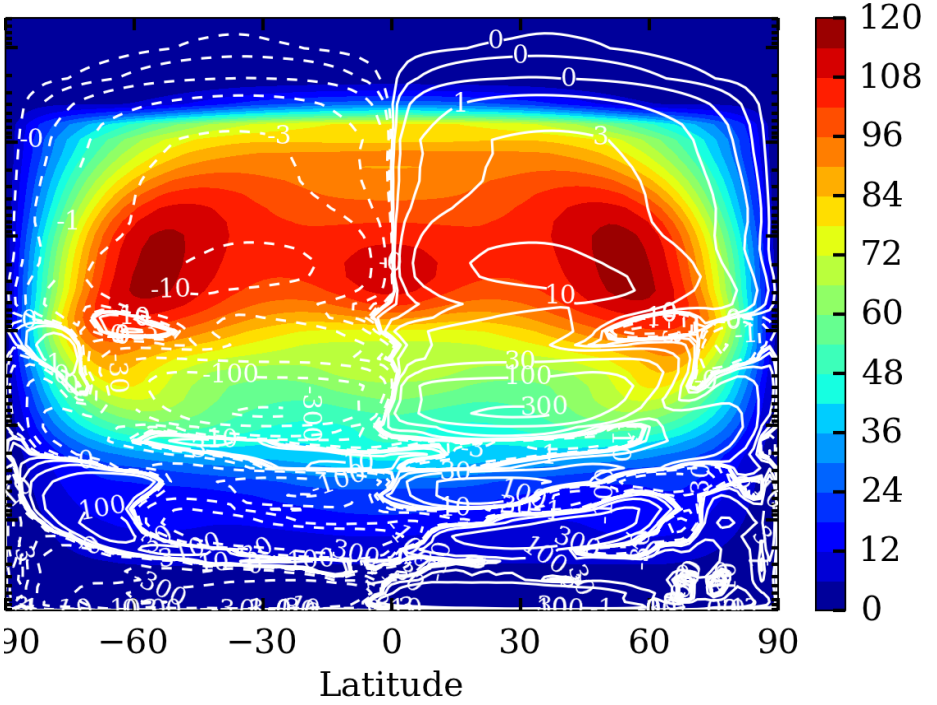
Superrotation

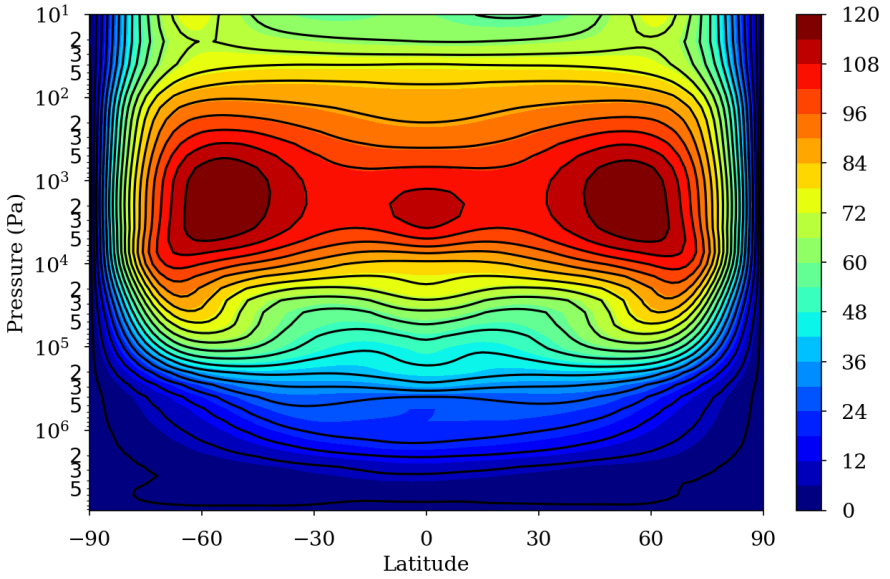
Clouds

Lebonnois et al. (2016)



Garate-Lopez & Lebonnois (2018)

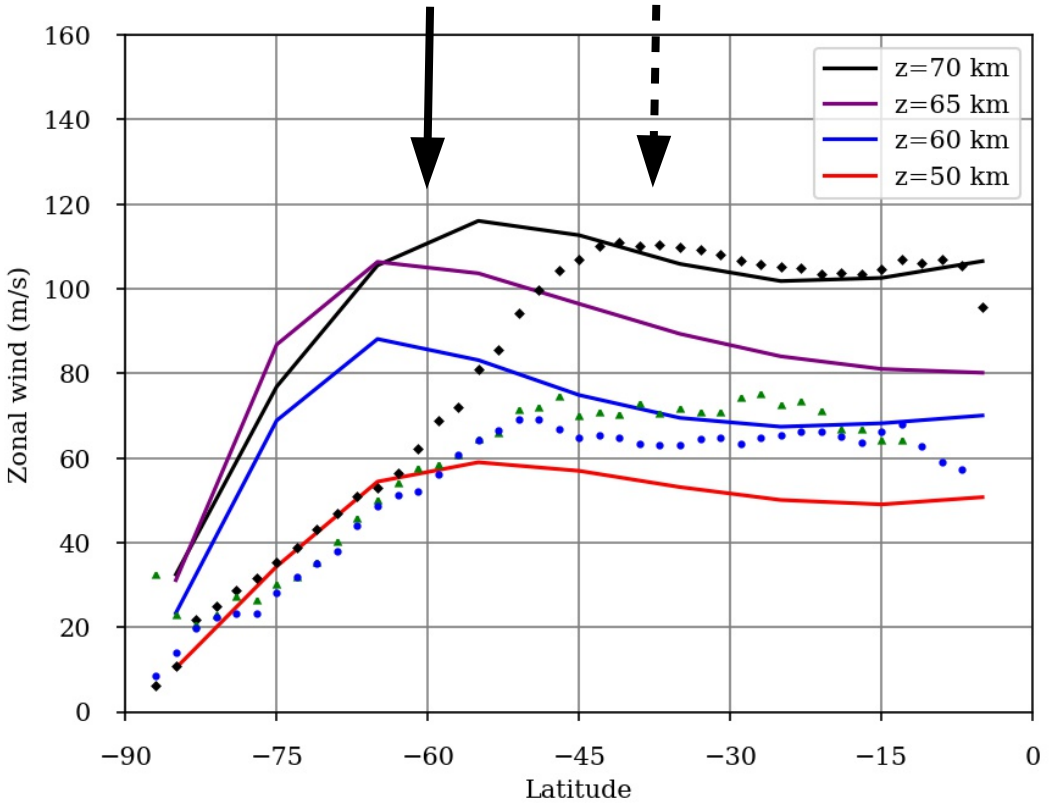


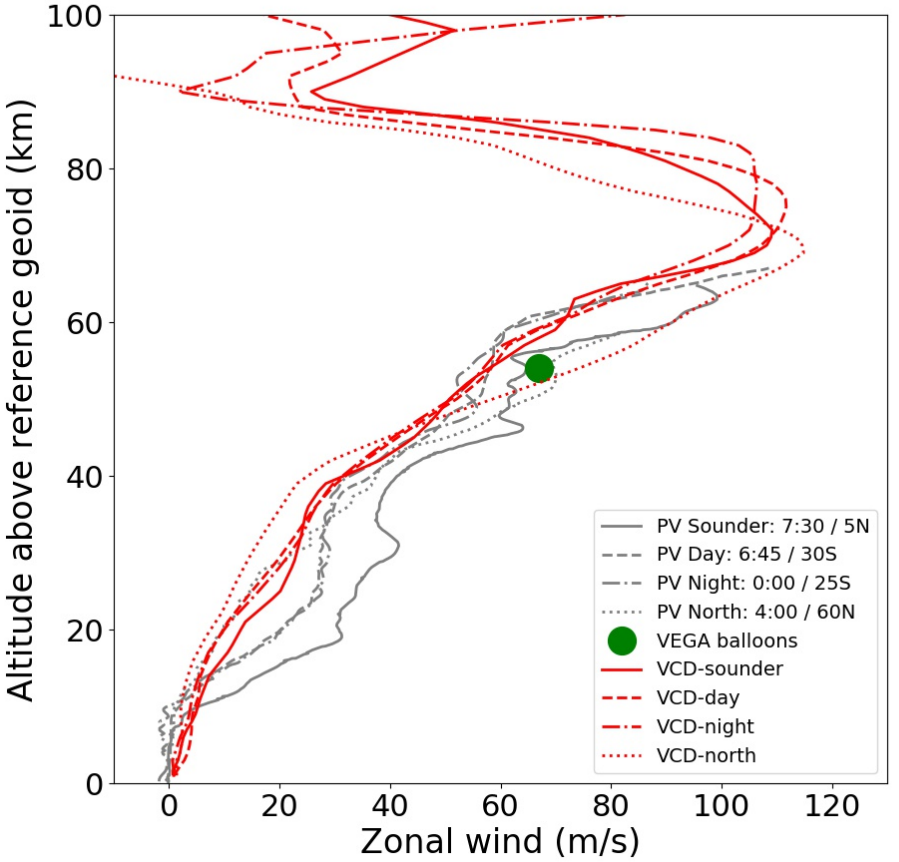


VCD 2.0
(expands higher,
up to 10^{-8} Pa
on 90 levels)

Superrotation

Latitudinal position of the jet is a major problem



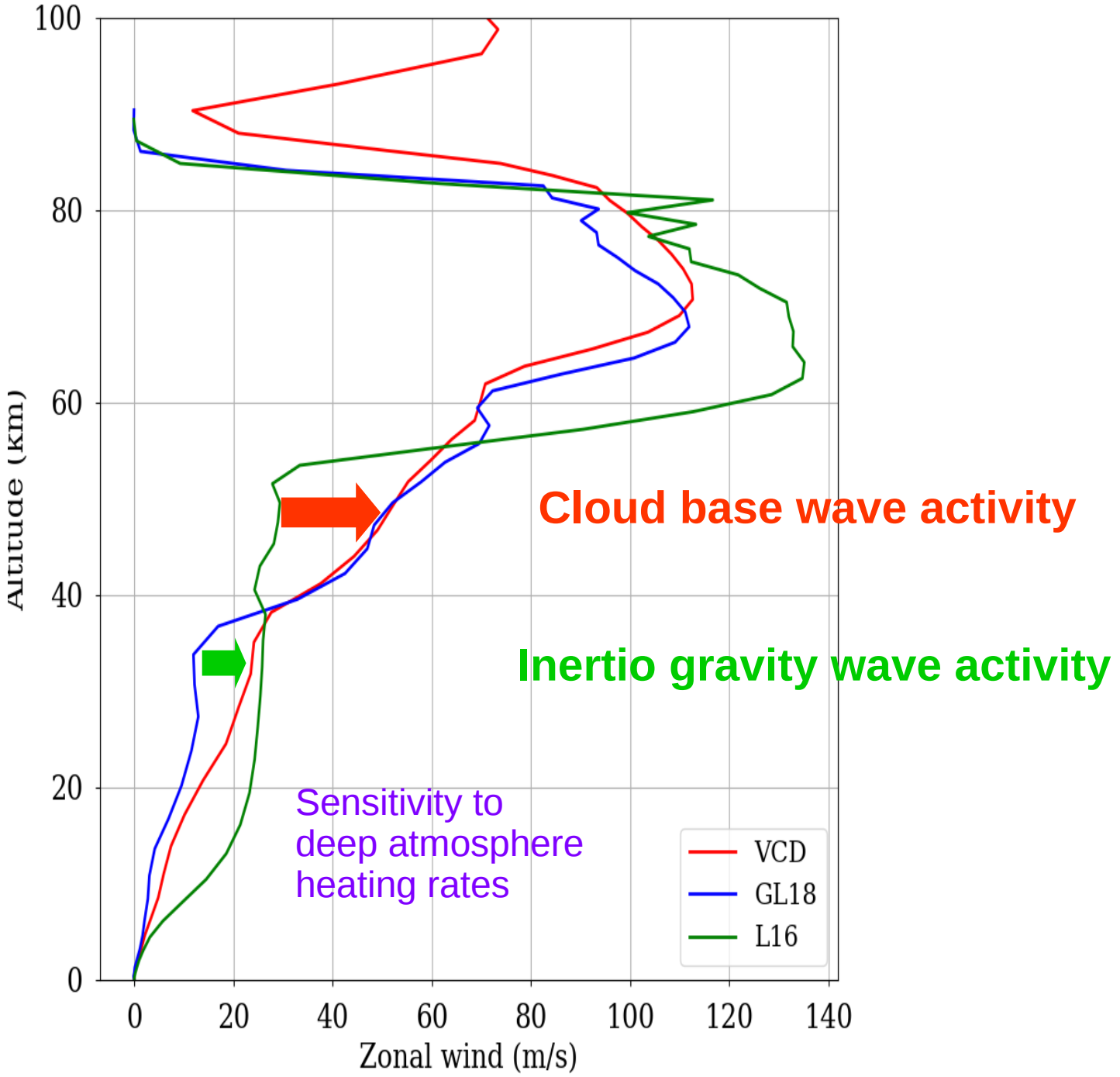


Compared to VIRTIS cloud tracking

Compared to PV probes

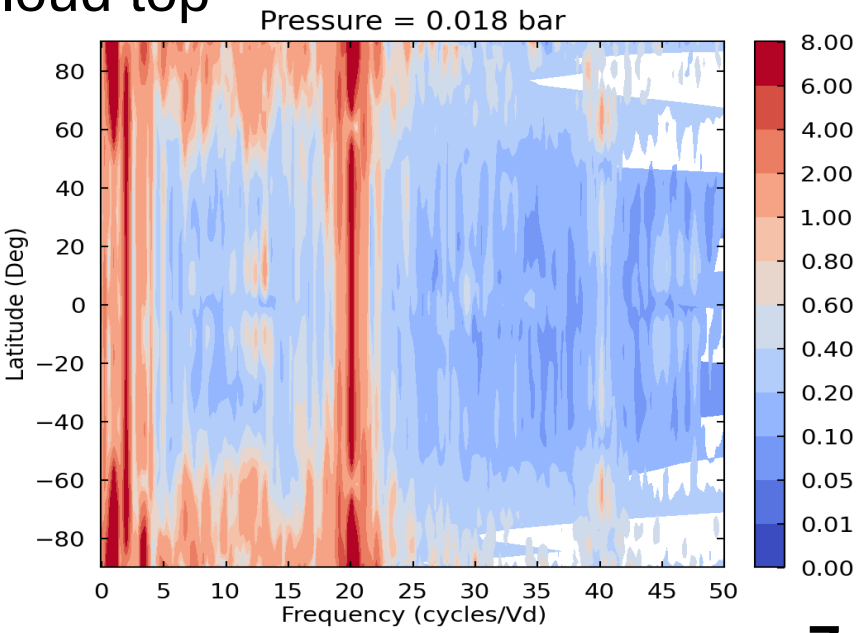
VCD 2.0

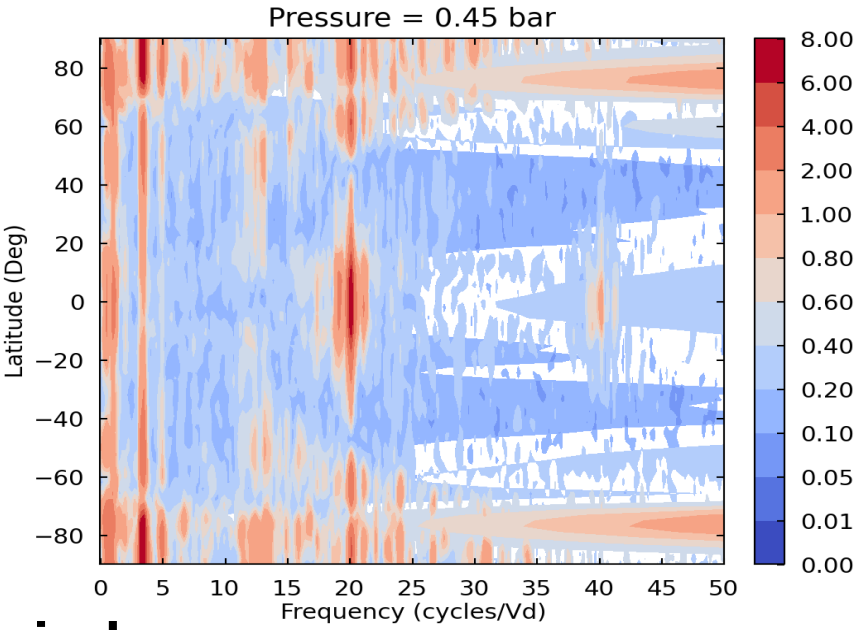
Wave activity in and below clouds



Wave activity in and below clouds

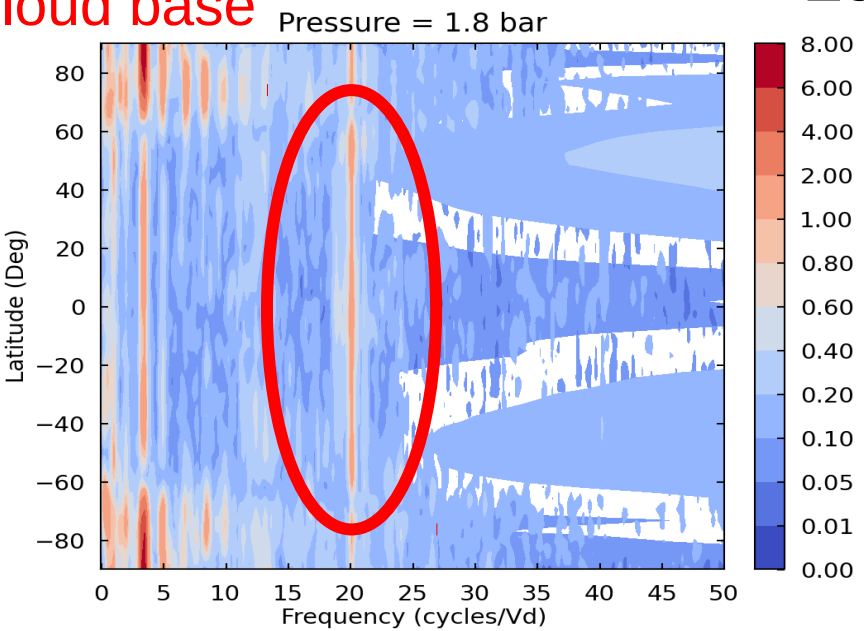
Cloud top

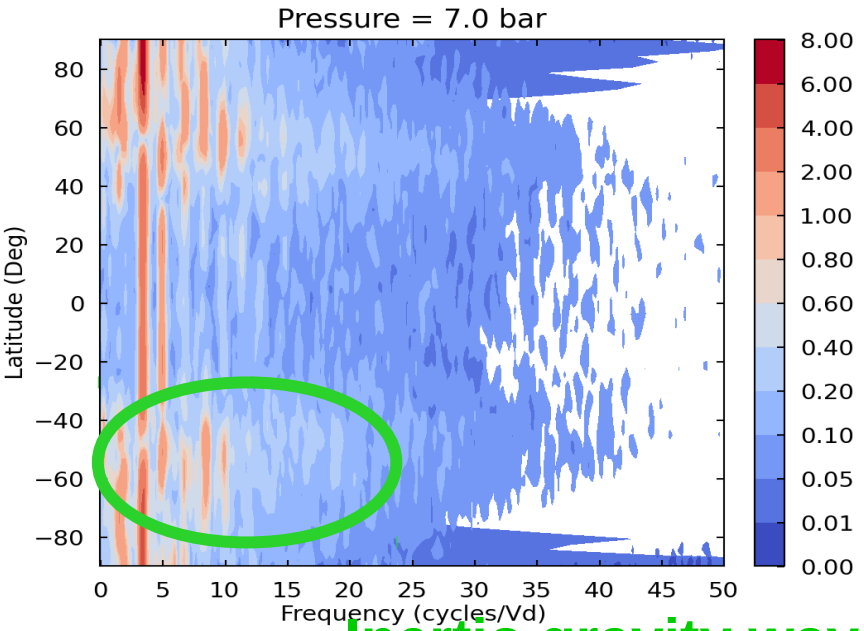




Zonal wind

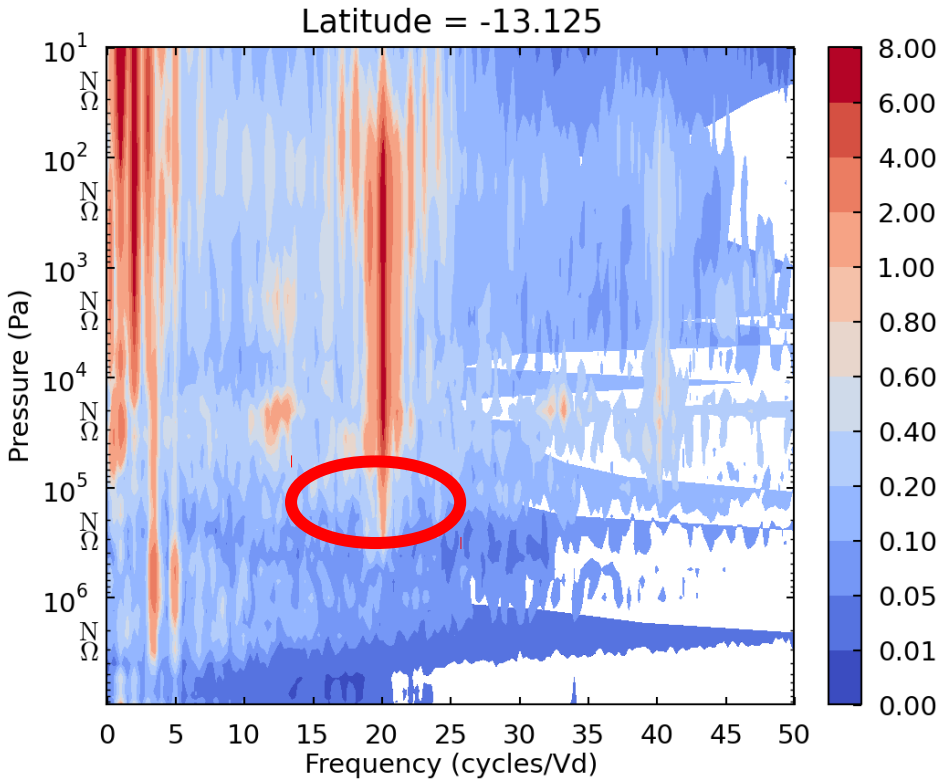
Cloud base





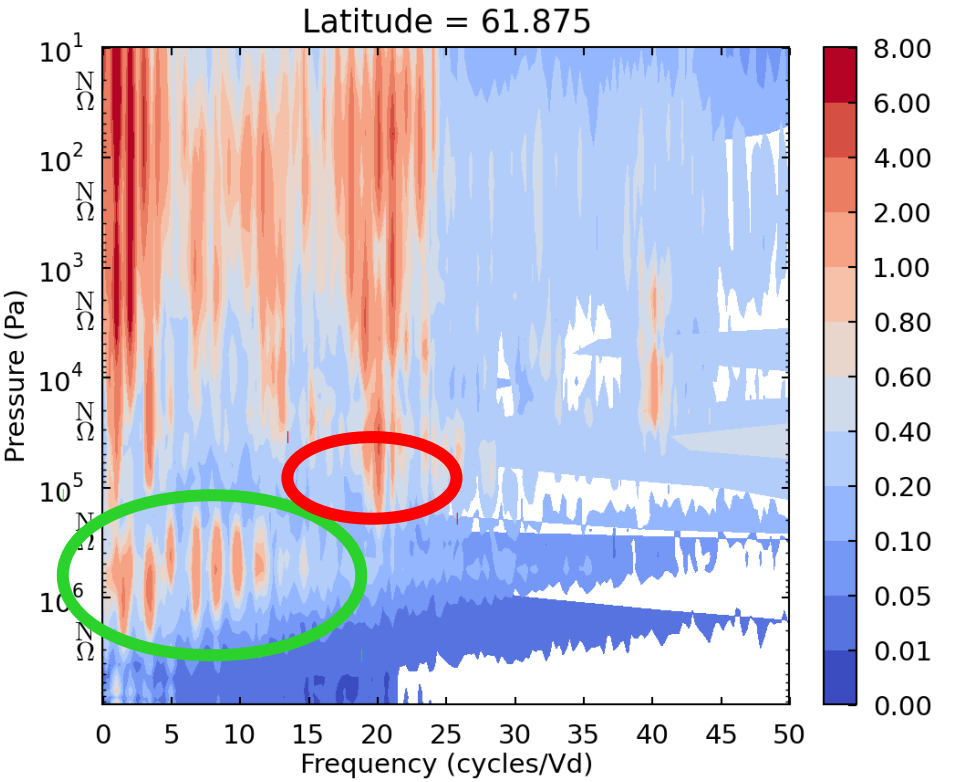
Inertio gravity waves

Wave activity in and below clouds



Cloud base

Zonal wind

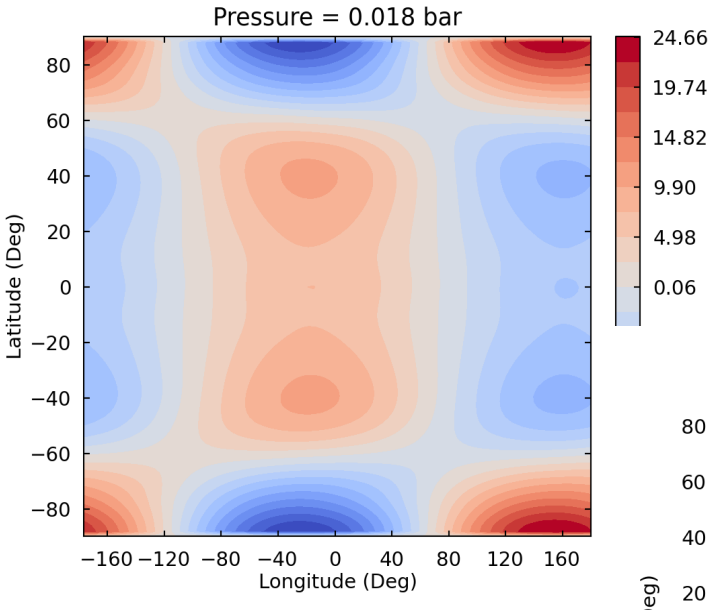


Inertio gravity waves

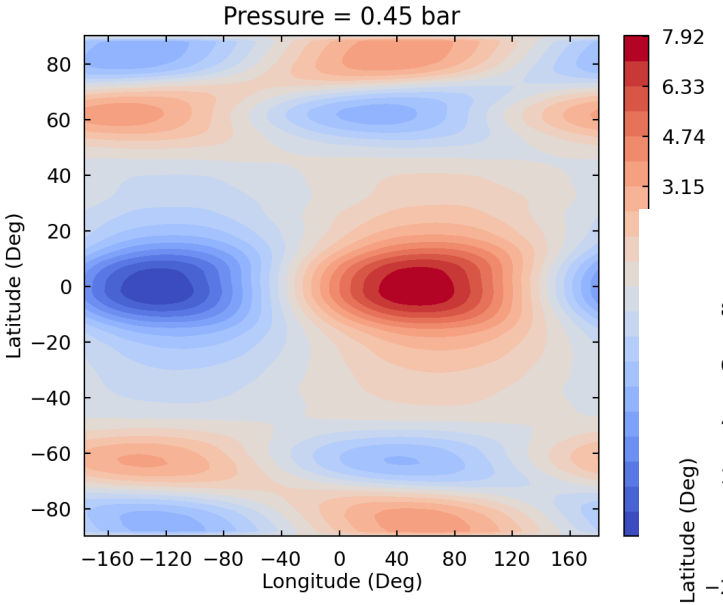
Wave activity in and below clouds

Zonal wind anomaly

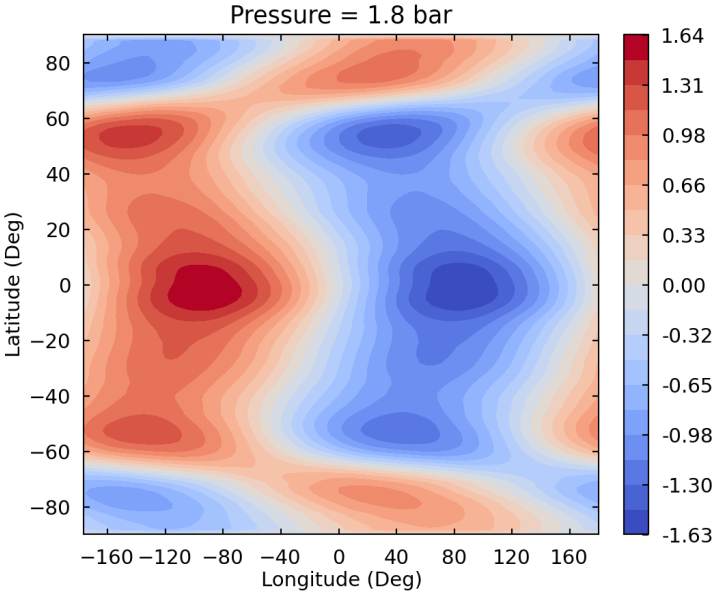
Cloud top



Period = 5.94 d

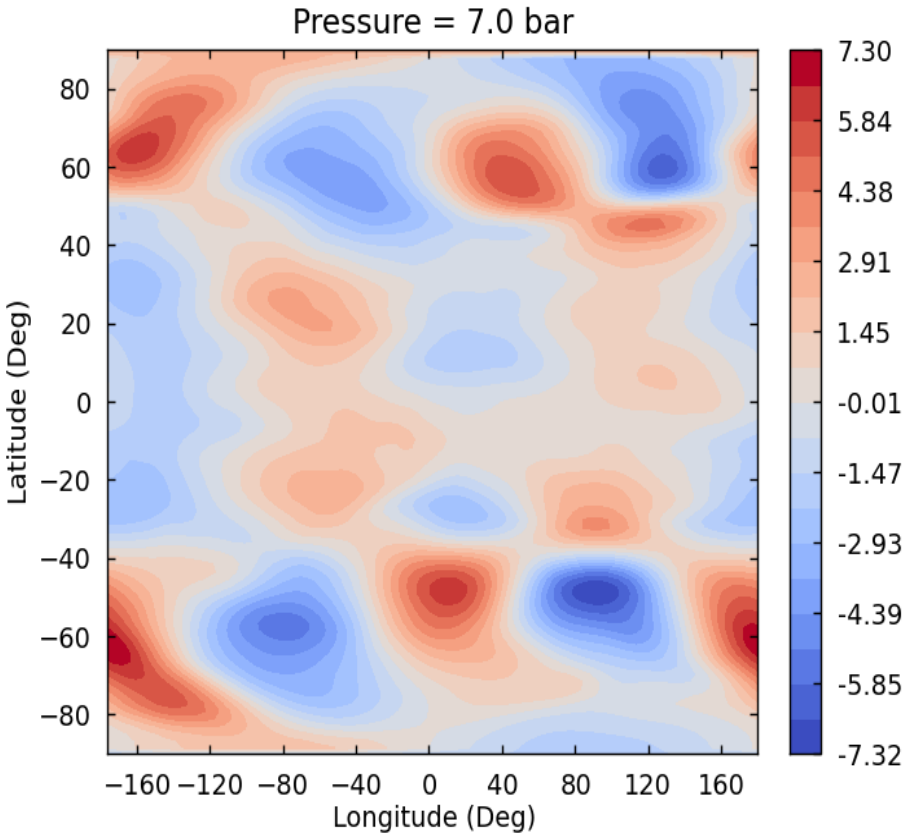


Cloud base



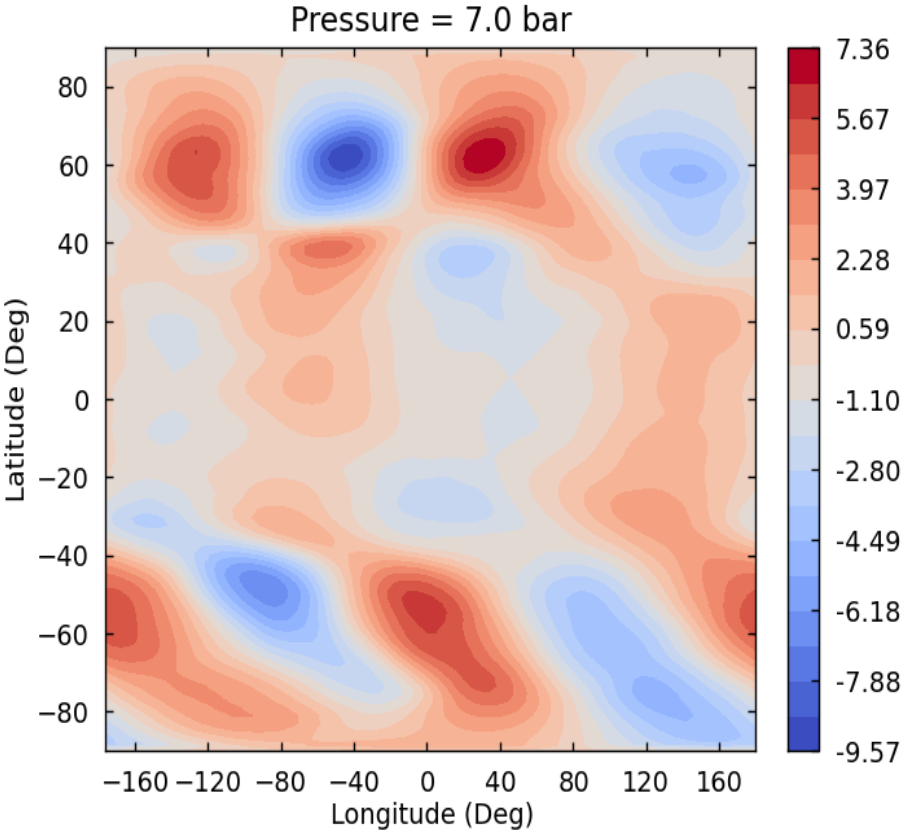
Wave activity in and below clouds

Zonal wind anomaly
Wave activity at 7 bars



Inertio gravity waves

Filtered periods : 8-24 d



The upper atmosphere

The upper atmosphere

Extension to 10^{-8} Pa (~250 km)

Comparison to datasets

Tuning of EUV + non-LTE near-IR CO_2 heating parameters

Tuning of non-orographic gravity waves

Problem of composition :

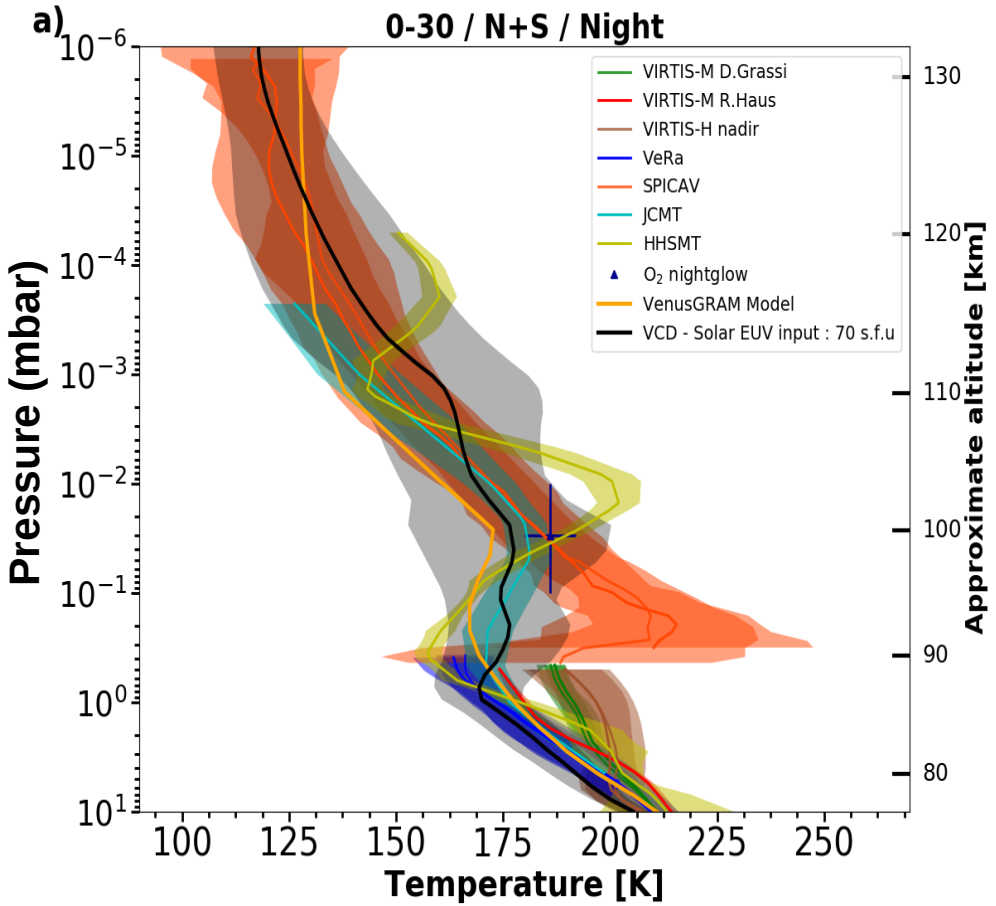
need for large increase of $CO_2 \rightarrow CO + O$

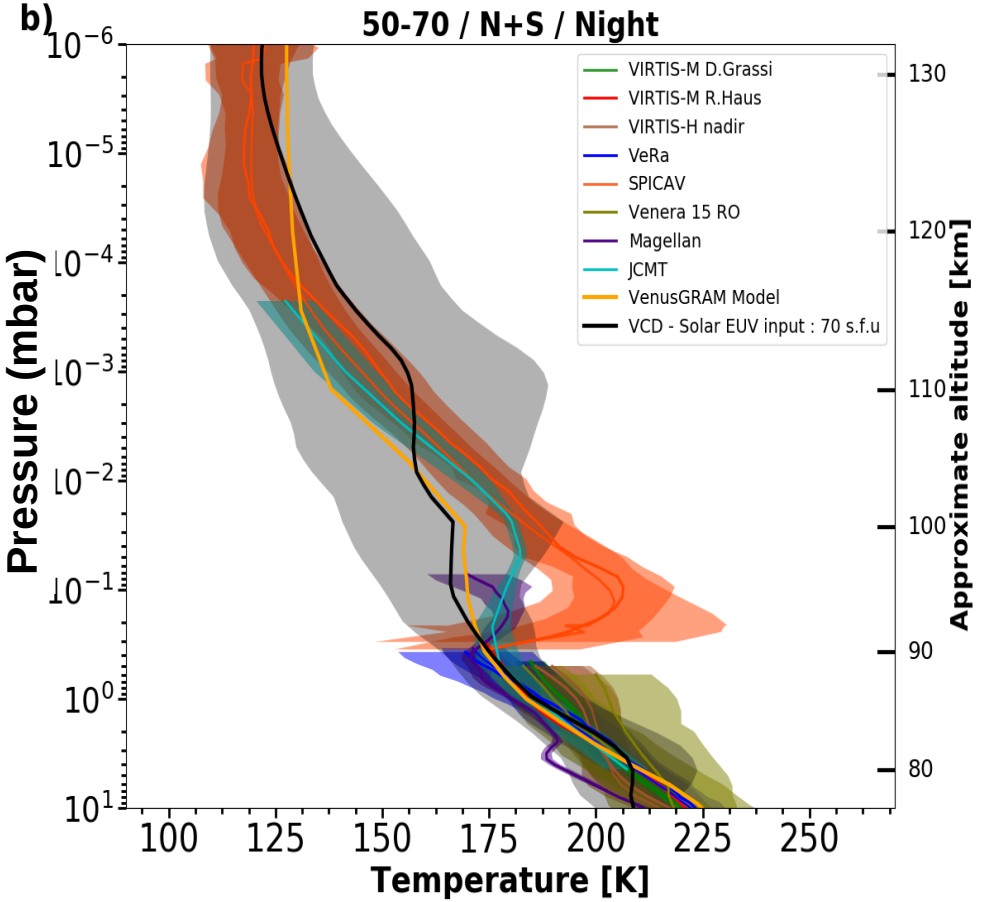
ionosphere ? sensitivity to diffusion ?

Lower thermosphere
Temperatures compared to observations

Near IR CO_2 Non-LTE tuning

NIGHT

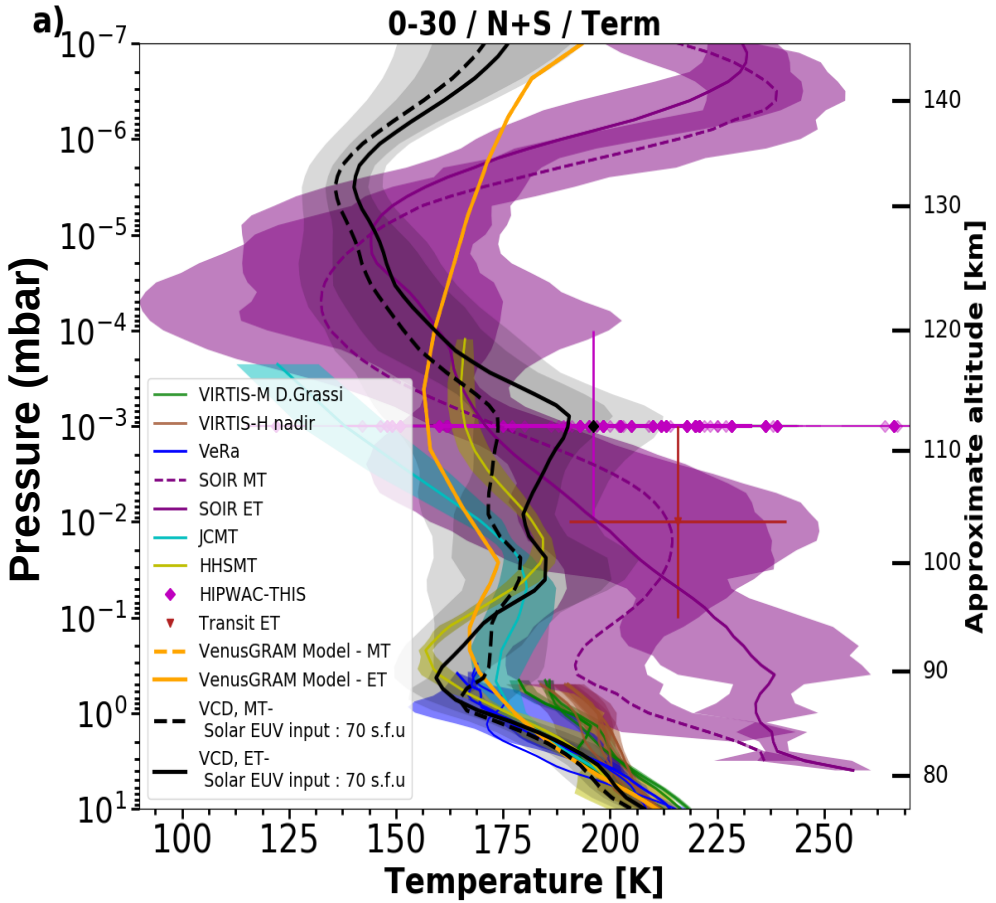


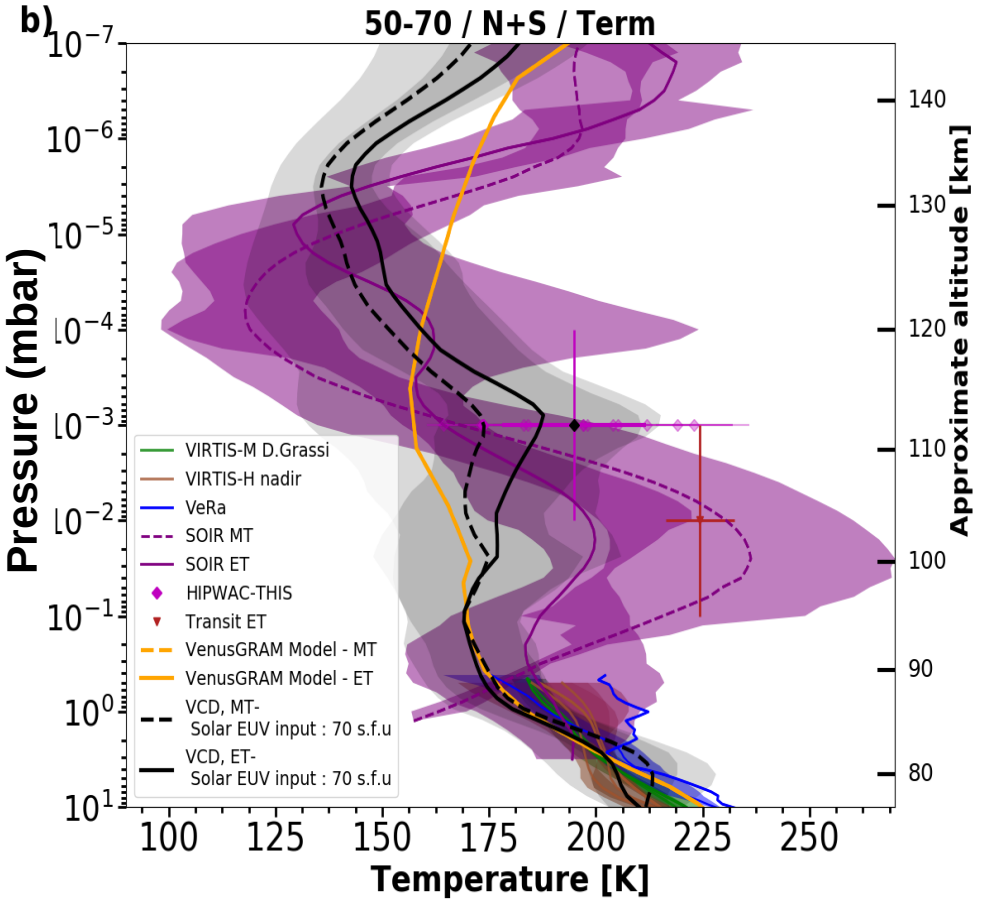


Lower thermosphere
Temperatures compared to observations

Near IR CO_2 Non-LTE tuning

TERMINATORS

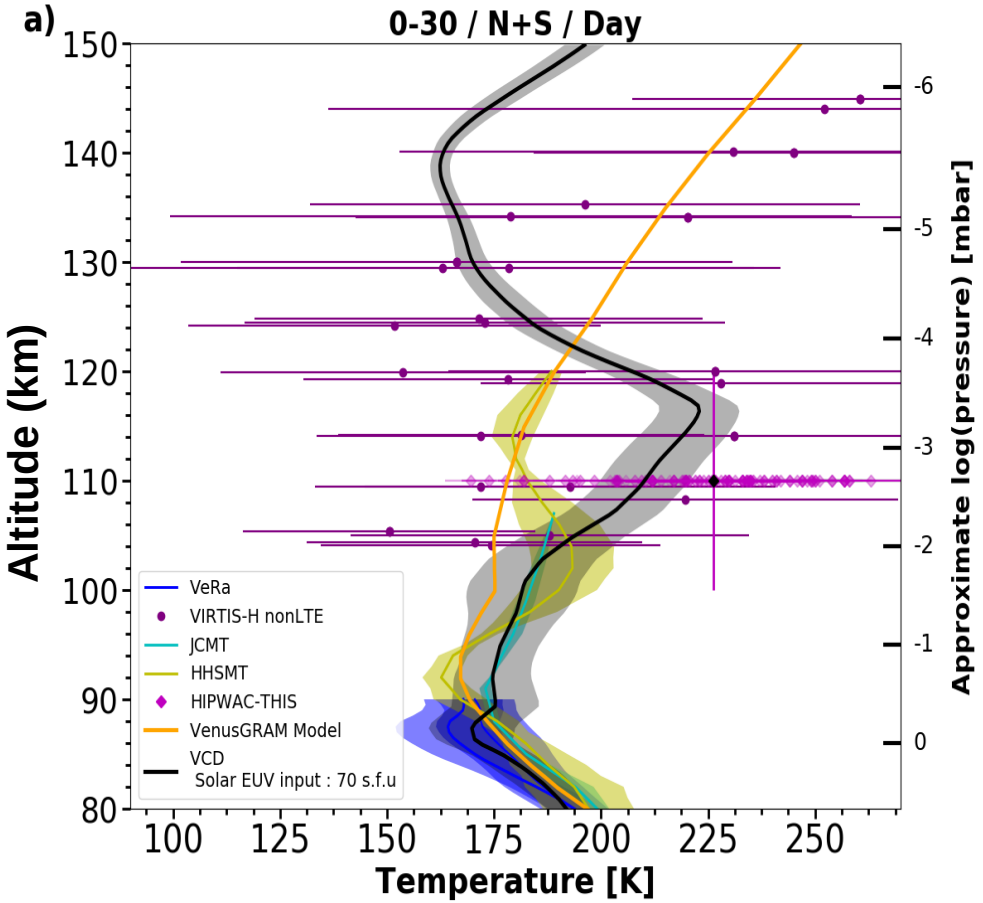


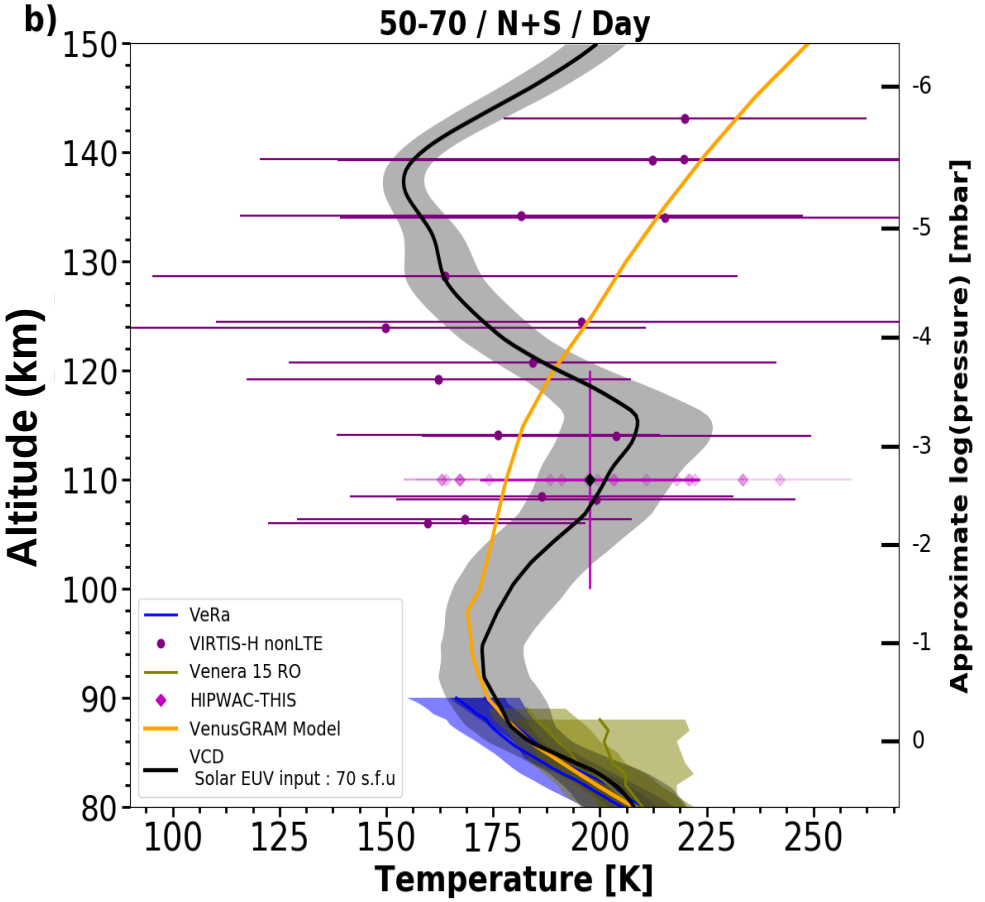


Lower thermosphere
Temperatures compared to observations

Near IR CO_2 Non-LTE tuning

DAY





Above 150 km

Based on datasets from
- Pioneer Venus (OAD, ONMS),
- Magellan (aerobraking, POD)
- Venus-Express (VeXADE),

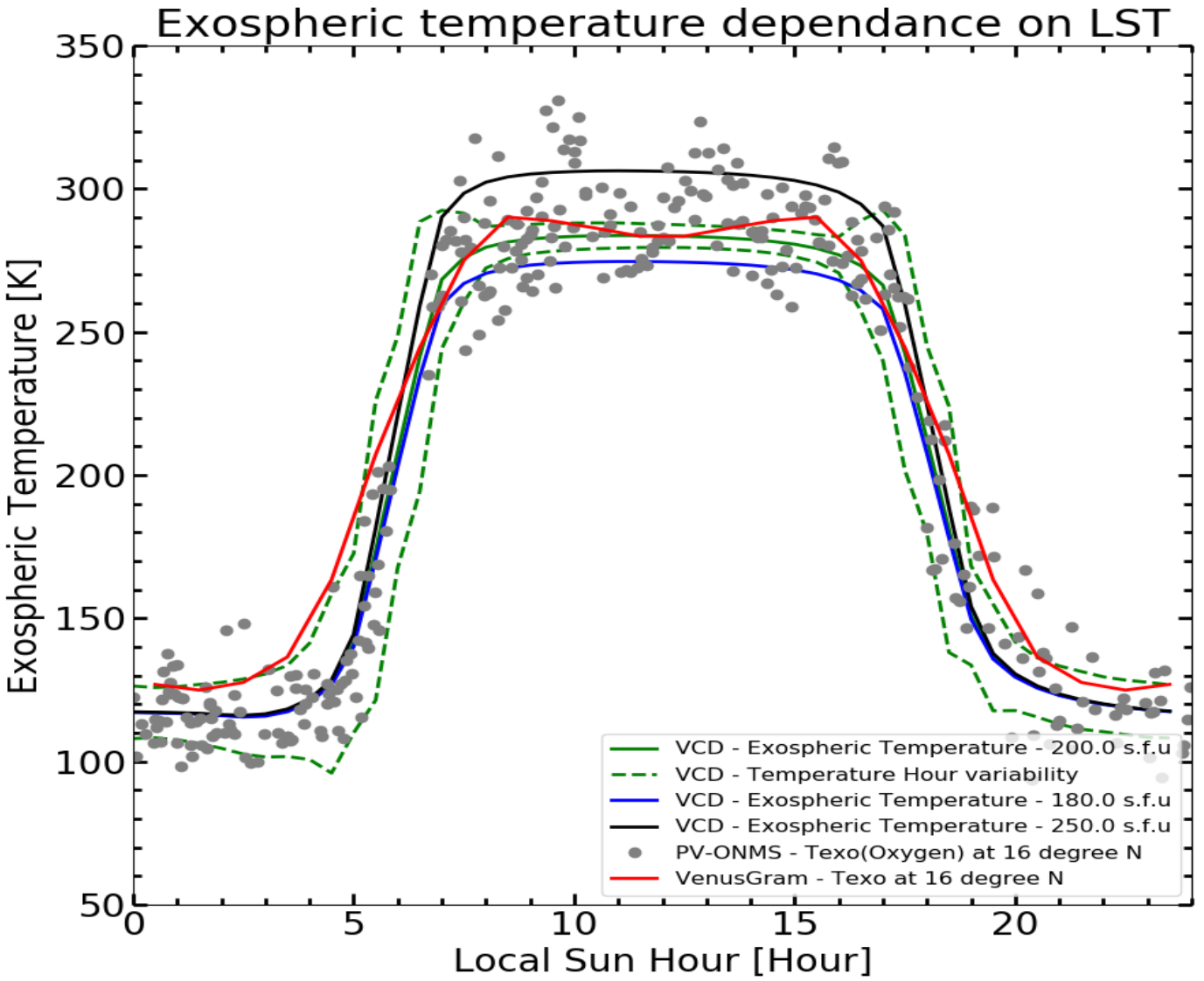
we can investigate temperature, density and composition above 150 km.

Tuning includes :
- EUV efficiency and CO_2-O quenching coefficient
- CO_2 dissociation => major question

Parameter to be taken into account : E10.7

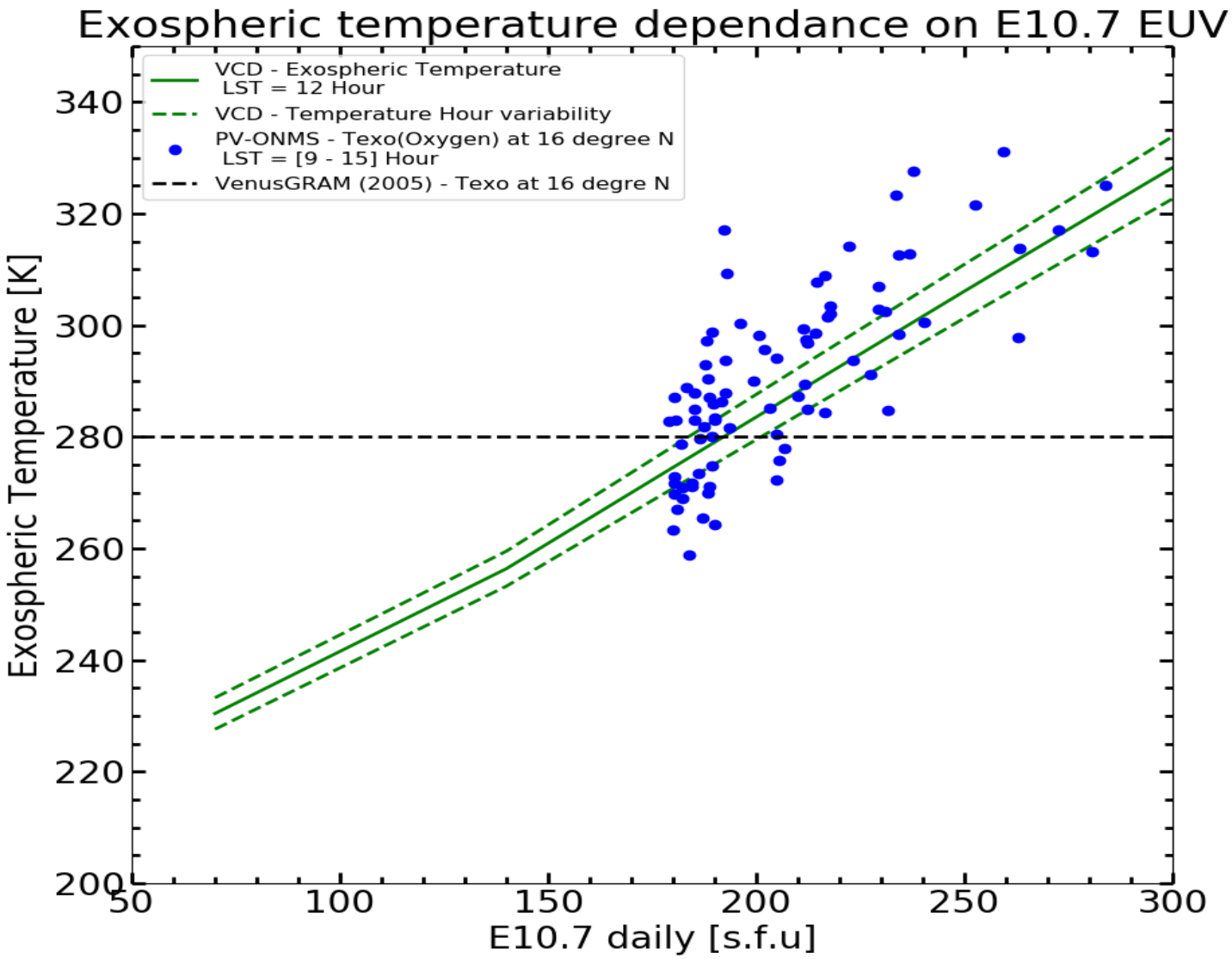
Temperature vs observations above 150 km

Exospheric temperature retrieved from O profiles in PV-ONMS datasets



Sensitivity to E10.7

Exospheric temperature as a function of E10.7



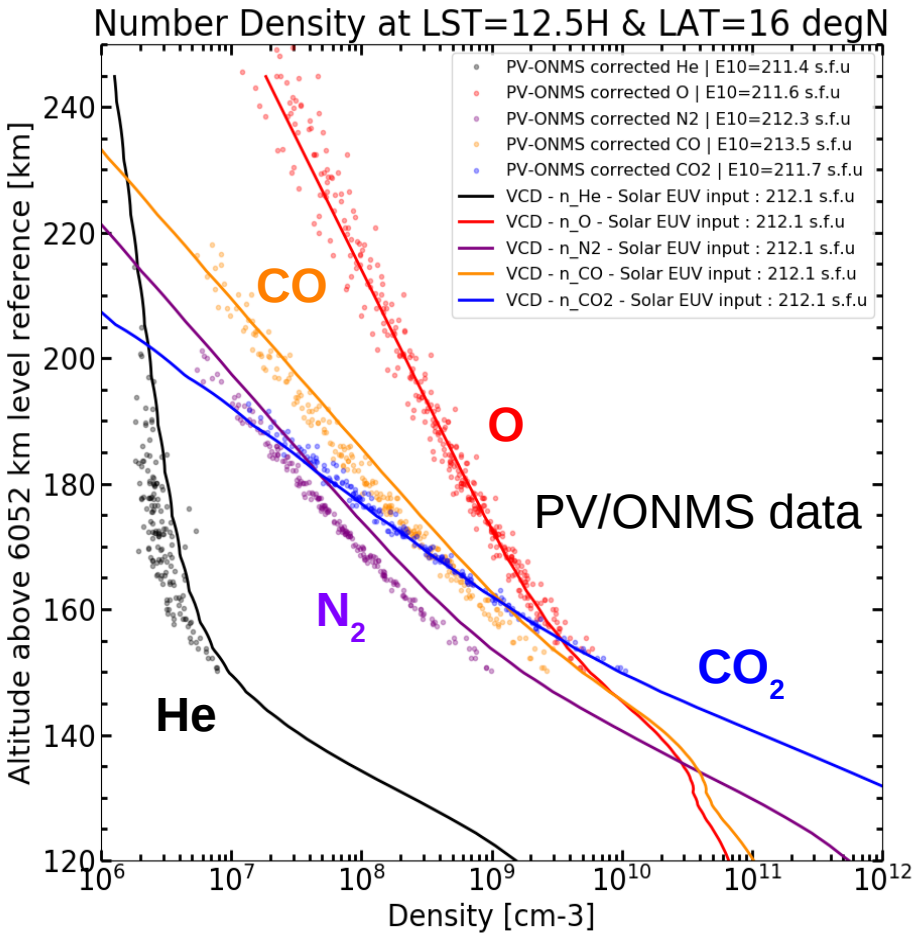
Composition : O and CO

O plays a significant role on temperature !

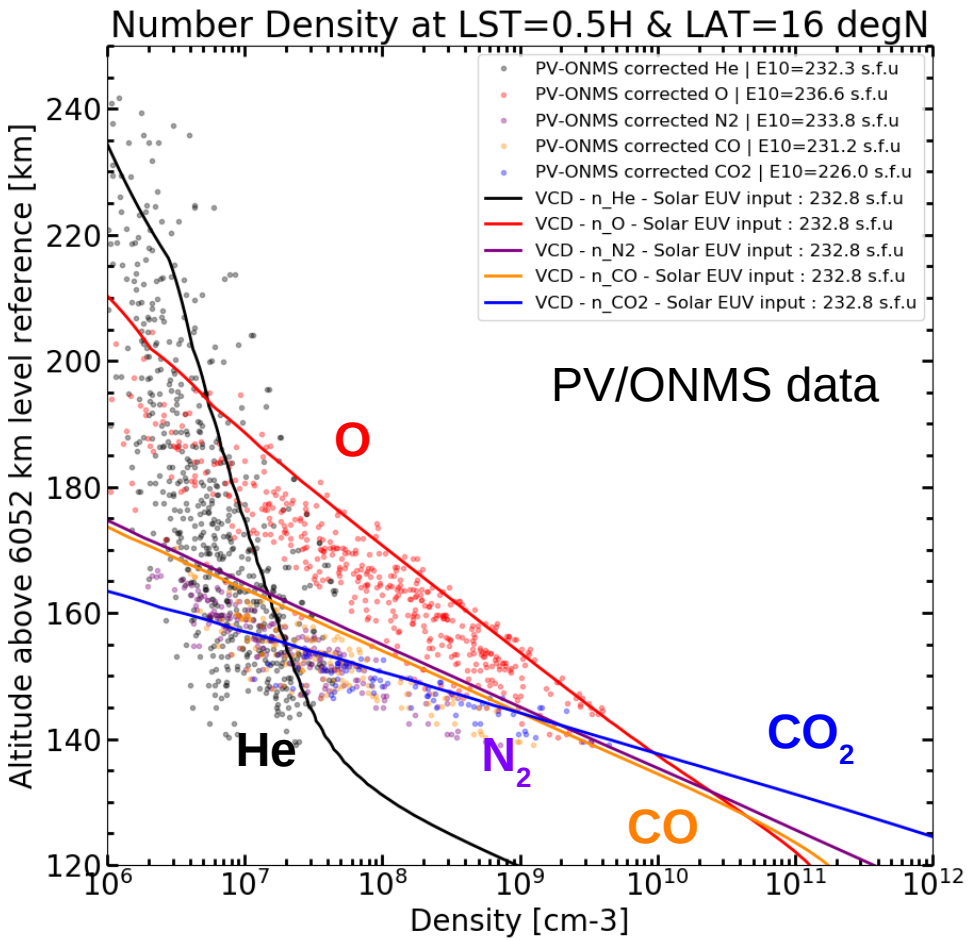
Increasing CO_2 photodissociation improves O and CO…

Investigations ongoing

Noon



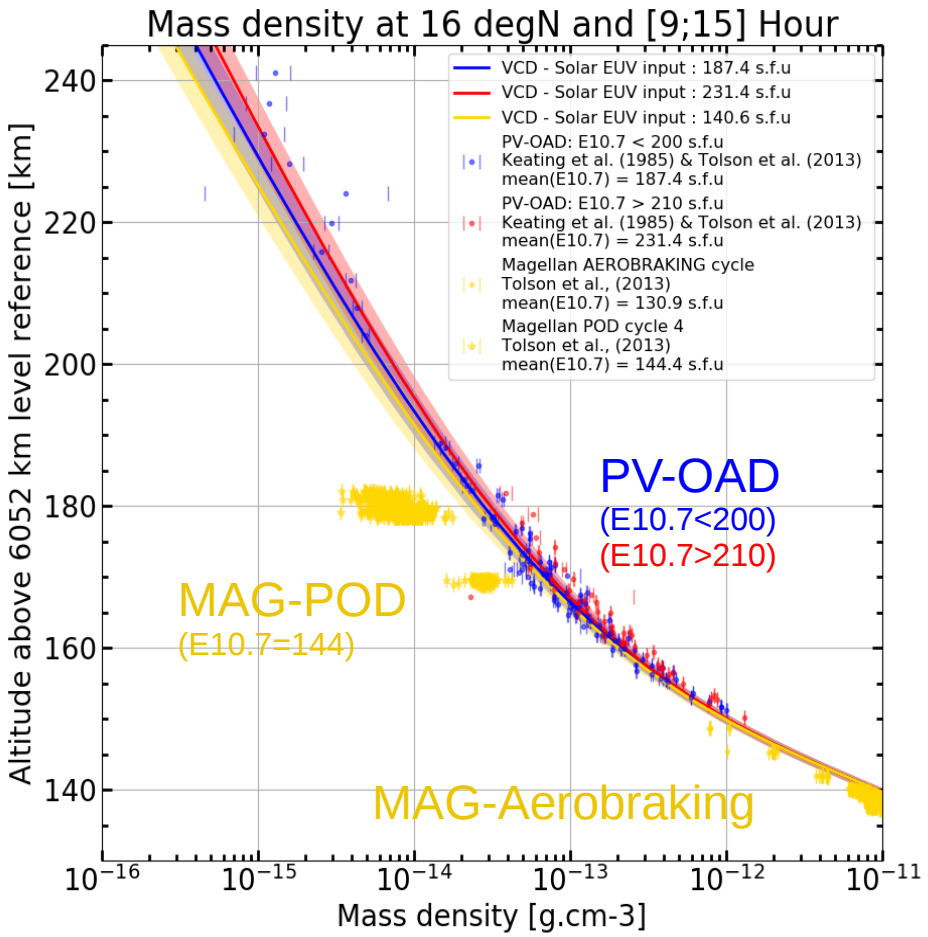
Midnight



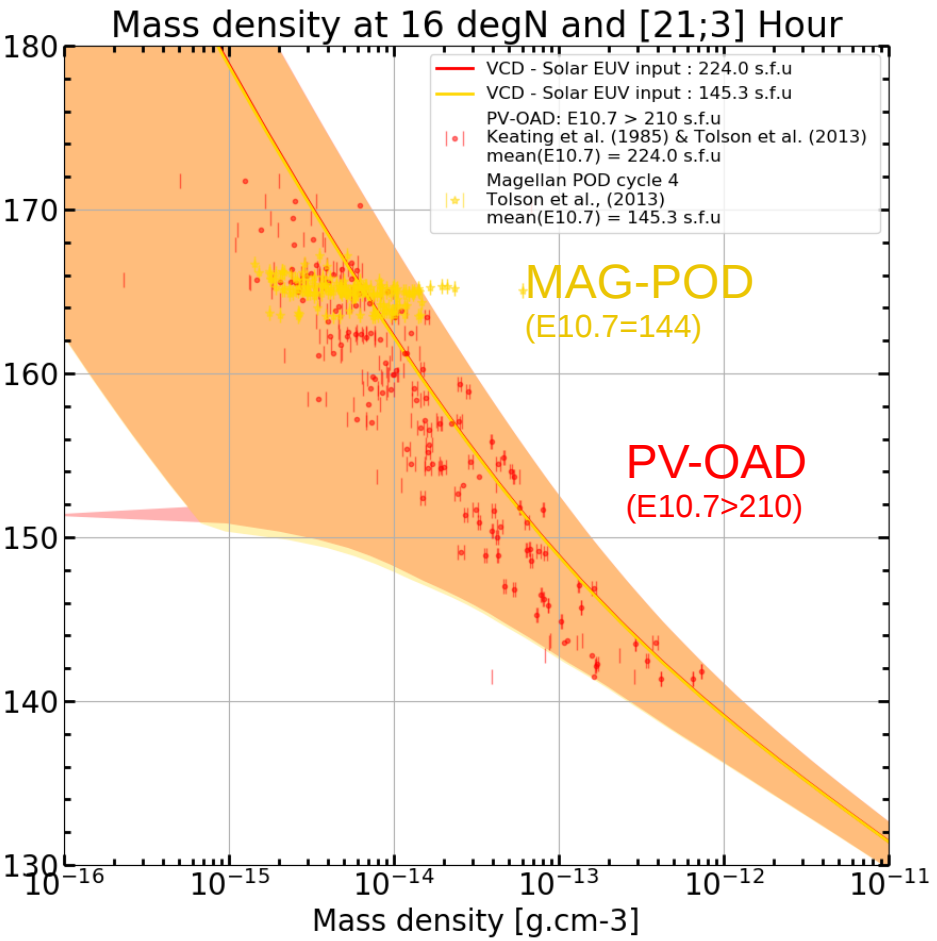
Mass density

Magellan and Pioneer-Venus data : low latitude

Noon



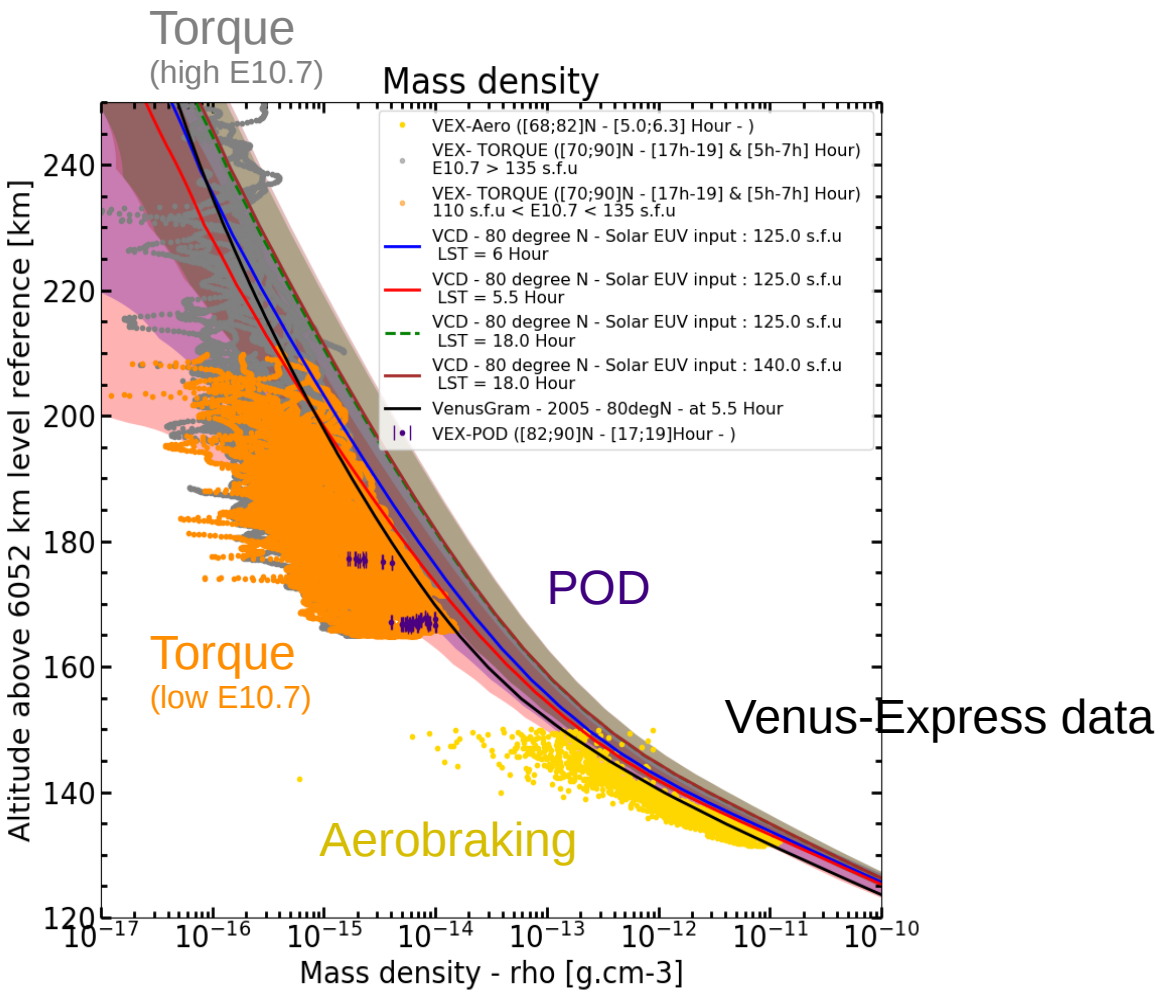
Midnight



Mass density

Venus-Express data : polar latitude

Terminators



Venus-Express data

The Venus Climate Database

The IPSL Venus GCM is a mature tool to study the upper atmosphere of Venus and its variability
=> interest for the EnVision project and aerobraking

ESA is funding our Venus Climate Database
- Engineer and scientific purposes
- Reference simulations for different scenarios (E10.7 / cloud UV albedo)
- Plug-in tools, but also web interface

Vertical extension of GCM simulations up to 250 km
+ analytical exosphere

Sensitivity of temperature and circulation to model parameters and to horizontal resolution still to be fully assessed.

VCD 1.1 released in december 2021. **VCD 2.0 released soon.**

VCD web interface

Darkmode

Venus Climate Database v1.1 : The Web Interface

[Information] [Gallery] [Report issue]

Main settings

CUSTOMIZE TIME COORDINATES

VENUS date

Local Time 0. Venusian hour

write a value (or) a range 'val1 val2' (or) 'all'

EARTH date YY / MM / DD @ hh:mm:ss UTC

2022 / 3 / 25 @ 14 : 24 : 7

Use Earth date to calculate Venus Ls

Earth Julian Date 2459664.100081(

Venus Solar Longitude 353.1

CUSTOMIZE SPATIAL COORDINATES

write a value (or) a range 'val1 val2' (or) 'all'

Latitude all degree North

Longitude all degree East

Altitude 10. m above surface

CUSTOMIZE VARIABLE(S) TO BE DISPLAYED

Variable 1 Temperature (K)

Variable 2 (None)

Variable 3 (None)

Variable 4 (None)

Advanced settings RESET

CUSTOMIZE DATA REQUEST

- Same localtime everywhere off on
- Cloud albedo/EUV scenario Standard cloud albedo ave solar
- High-resolution topography off on
- Averaging *(only for 2D plots for now!)* off zonal diurnal

CUSTOMIZE FIGURES

- Figure format PNG PNG hi-res EPS
- [1D] Log(values) off on
- [2D] Colormap blue green yellow red
- [2D] Values range to
- [2D map] flat proj @ lat lon
- [2D map] Transparency (%)
- [2D map] Wind vectors off on
- [2D map] Add marker at lat lon

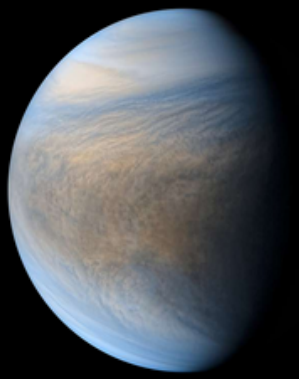
SUBMIT

Venus Climate Database (c) LMD/ESA.
Open source python interface by A. Spiga (LMD).
Javascript time conversion by E. Millour

One-click presets

LANDING SITE & DATE

Now at equator!	PV Sounder	PV North
PV Day	PV Night	Vega2



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