EXPLORING THE VARIABILITY OF THE VENUSIAN ATMOSPHERE ABOVE THE CLOUDS WITH THE IPSL VENUS GCM

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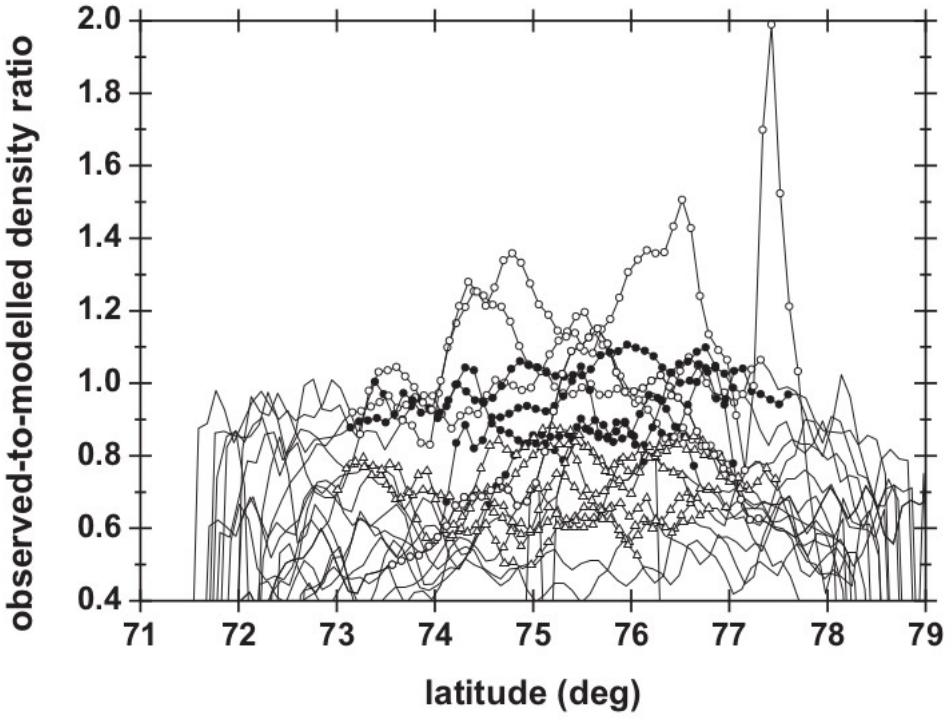
Observed variability above clouds

Venus-Express atmospheric drag experiment :

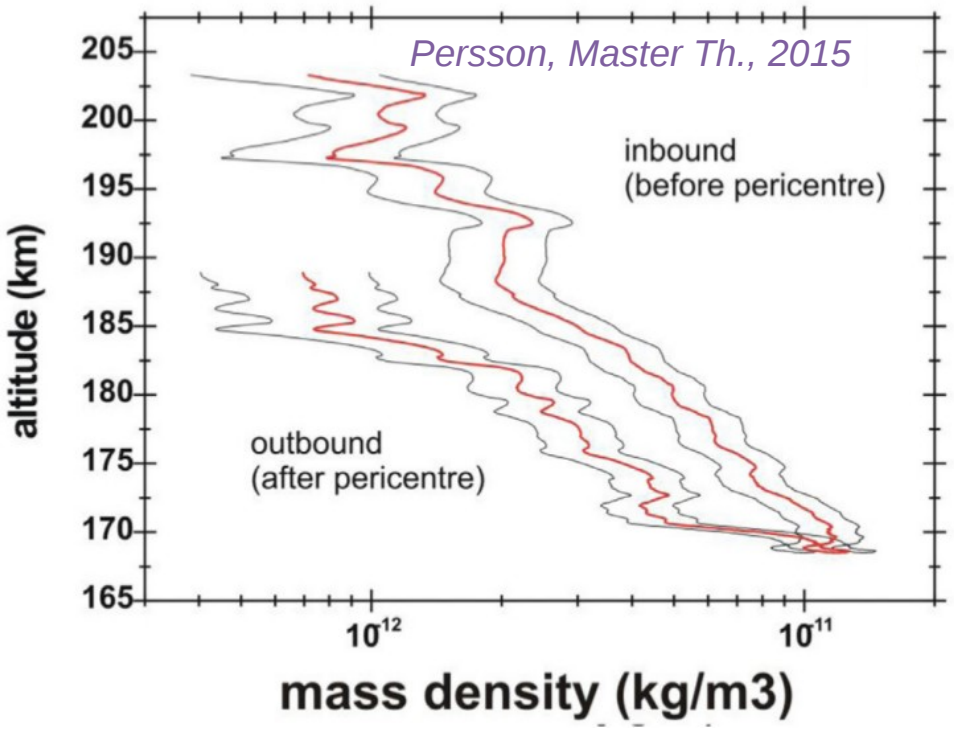
- aerobraking => 130-140 km altitude density profiles

- torque => 165-190 km altitude density profiles

Gravity waves signatures, horizontal wavelengths in 100-300 km range



Müller-Wodarg et al., Nature Physics, 2016



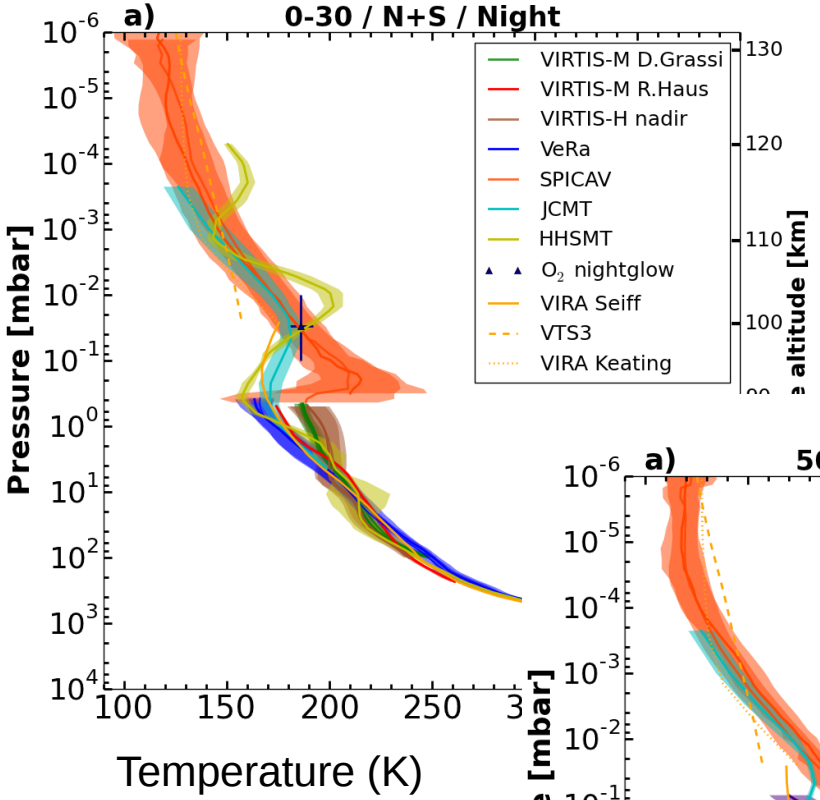
85°N, near terminator
(inbound on dayside)

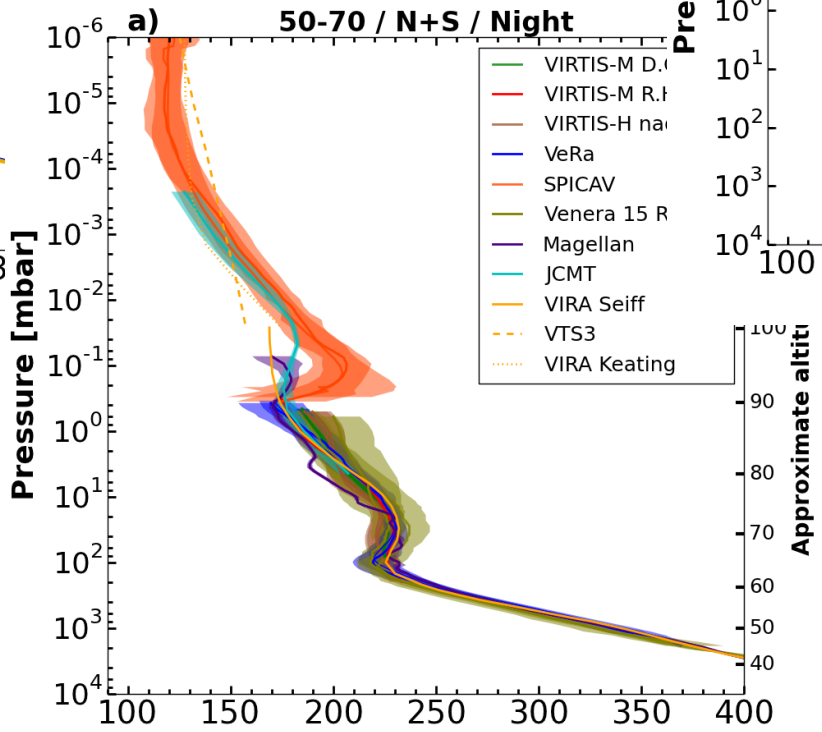
Observed variability above clouds

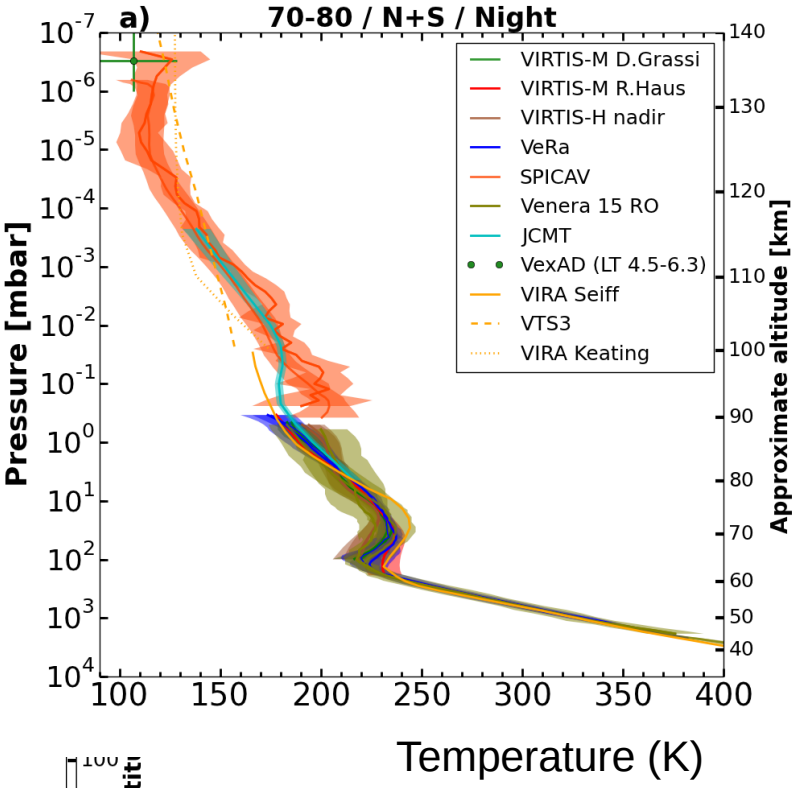
Temperature measurements

Limaye et al., Icarus 294, 2017

NIGHT





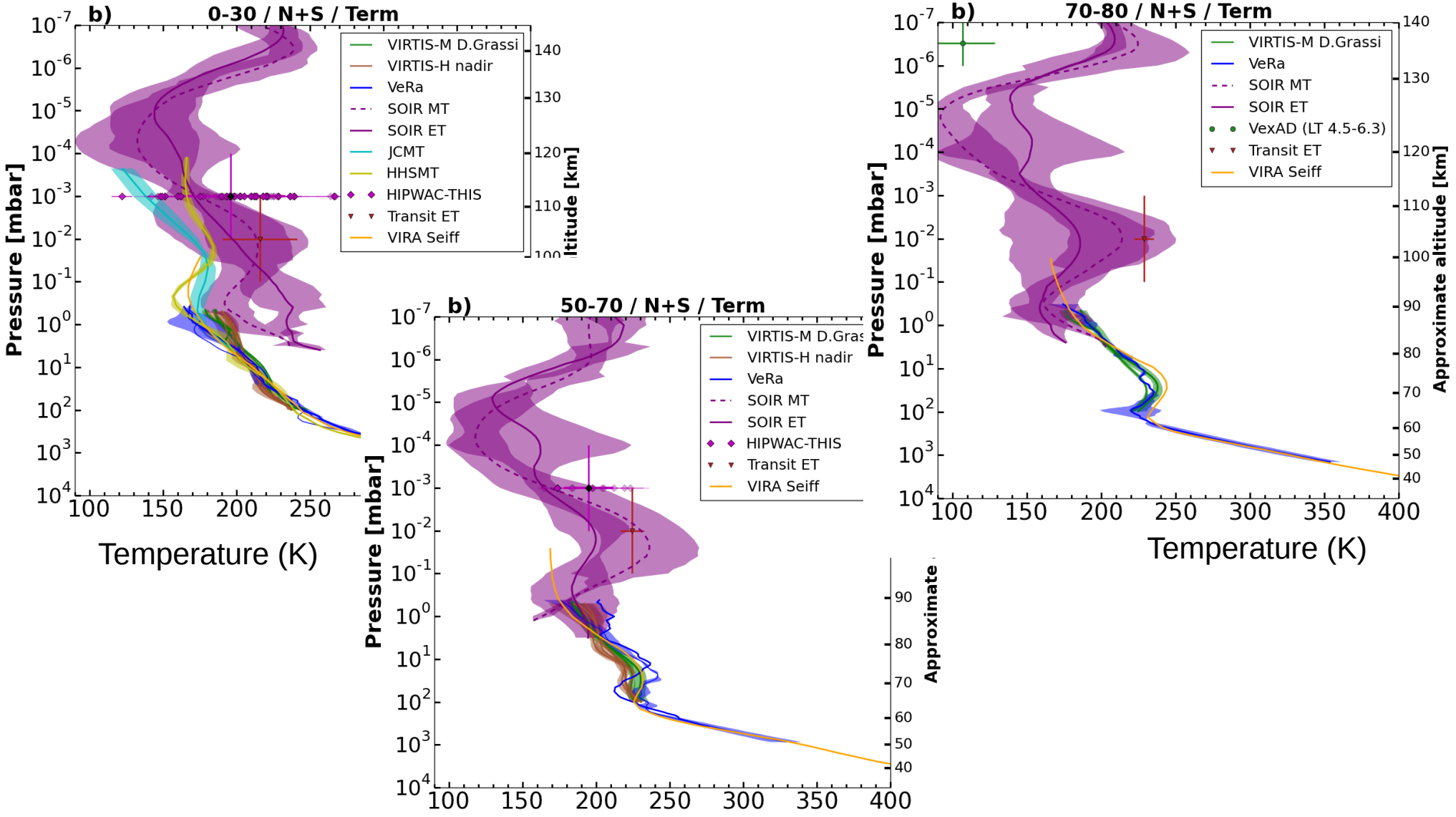


Observed variability above clouds

Temperature measurements

Limaye et al., Icarus 294, 2017

TERMINATORS

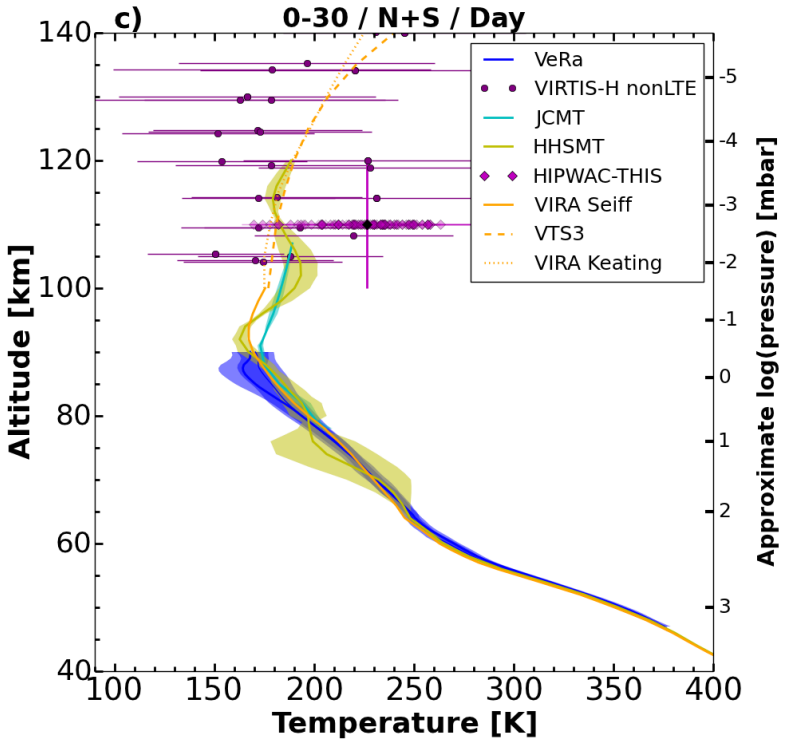


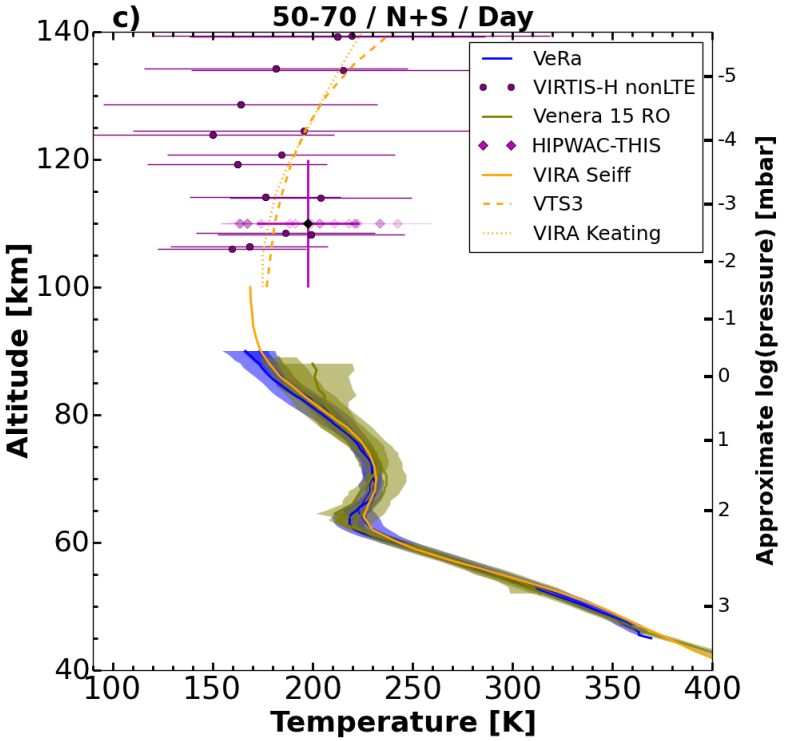
Observed variability above clouds

Temperature measurements

Limaye et al., Icarus 294, 2017

DAY

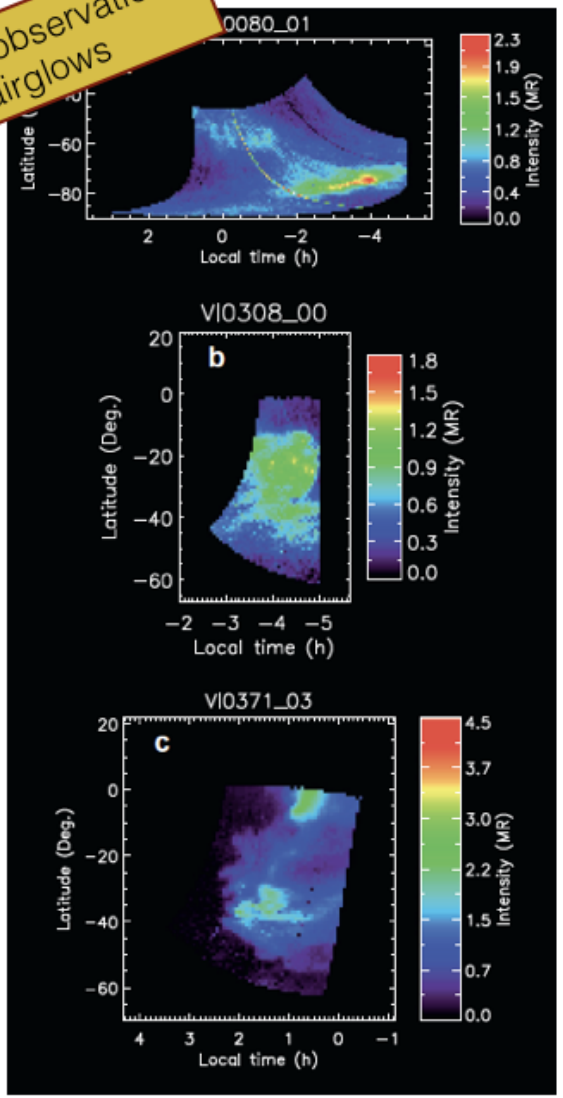




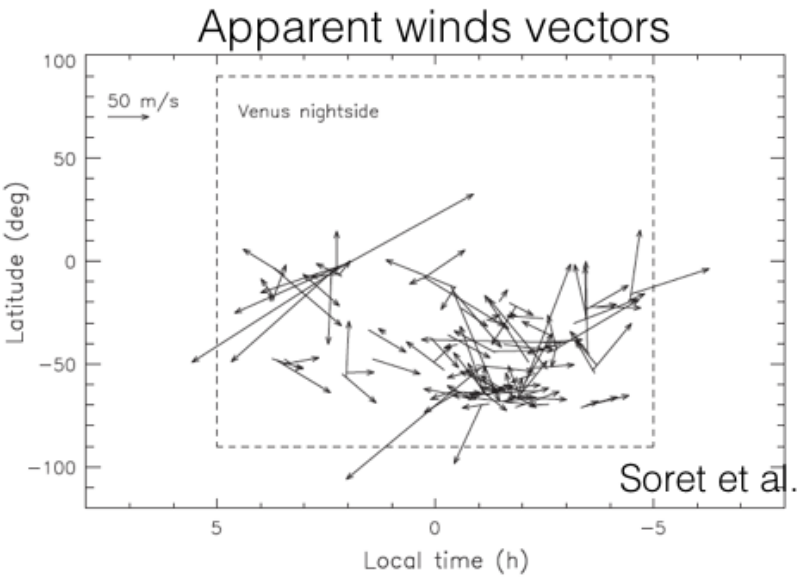
Observed variability above clouds

Distribution of O_2 nightglow brightness observed by VIRTIS/VEx

Individual observations of airglows



Soret et al. 2014



Soret et al. 2014

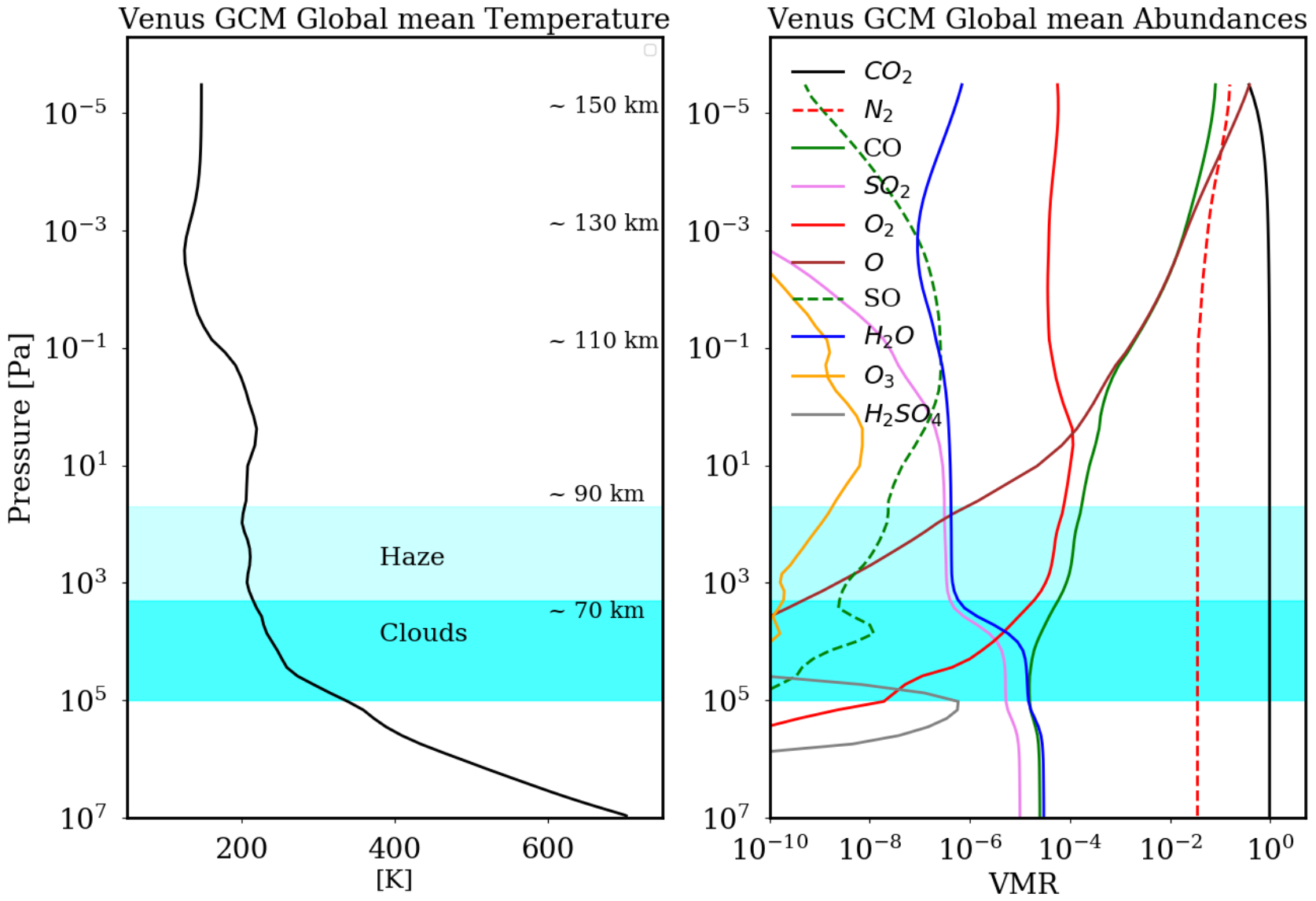
- Bright emission patches also located far form the AS-point
- Spatial and temporal variation of airglow structure

The IPSL Venus GCM

- Three-dimensional: 96x96x78 (0~150 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) ; Garate & Lebonnois (2018) ; Navarro et al (2018)

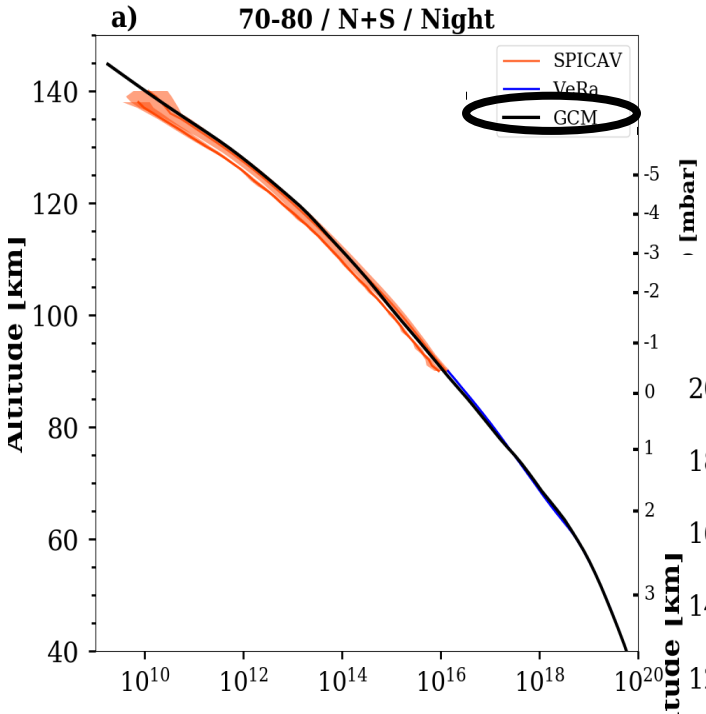
The IPSL Venus GCM

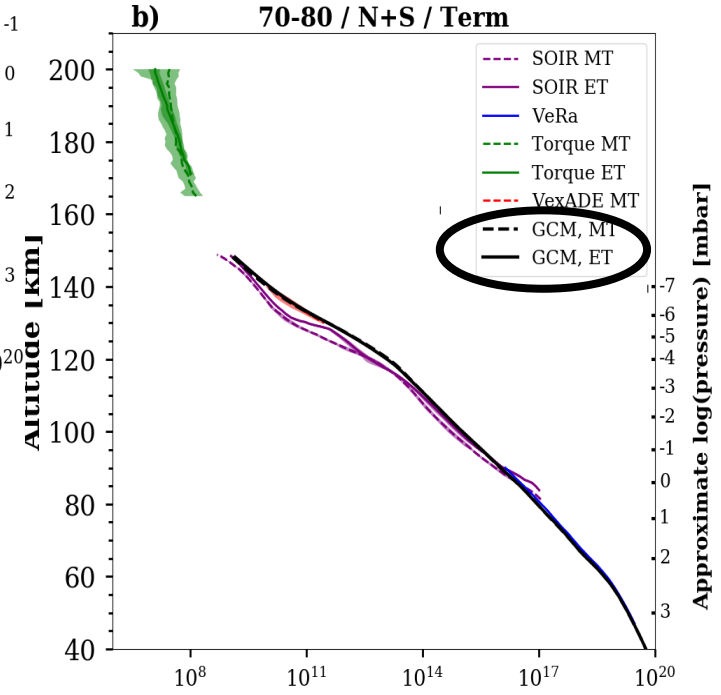


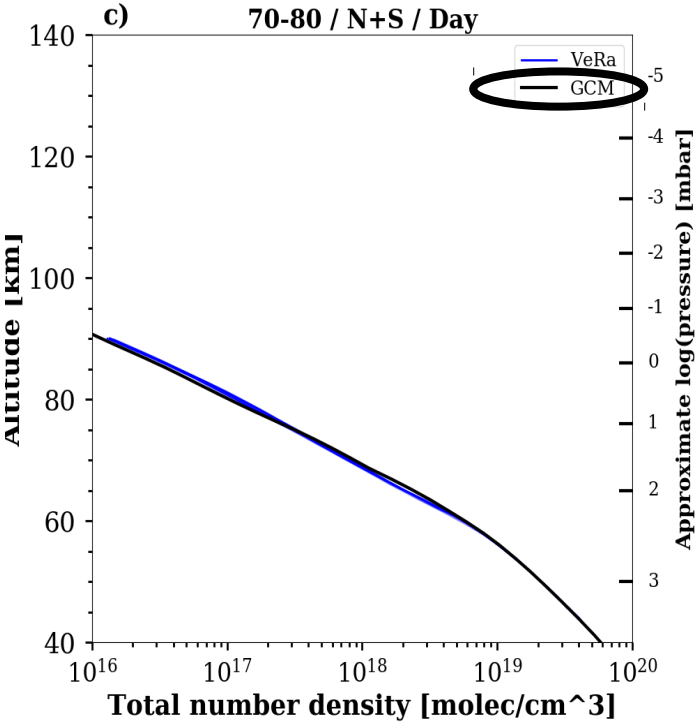
Modeled densities and temperatures compared to observations

Density measurements

Limaye et al., Icarus 294, 2017



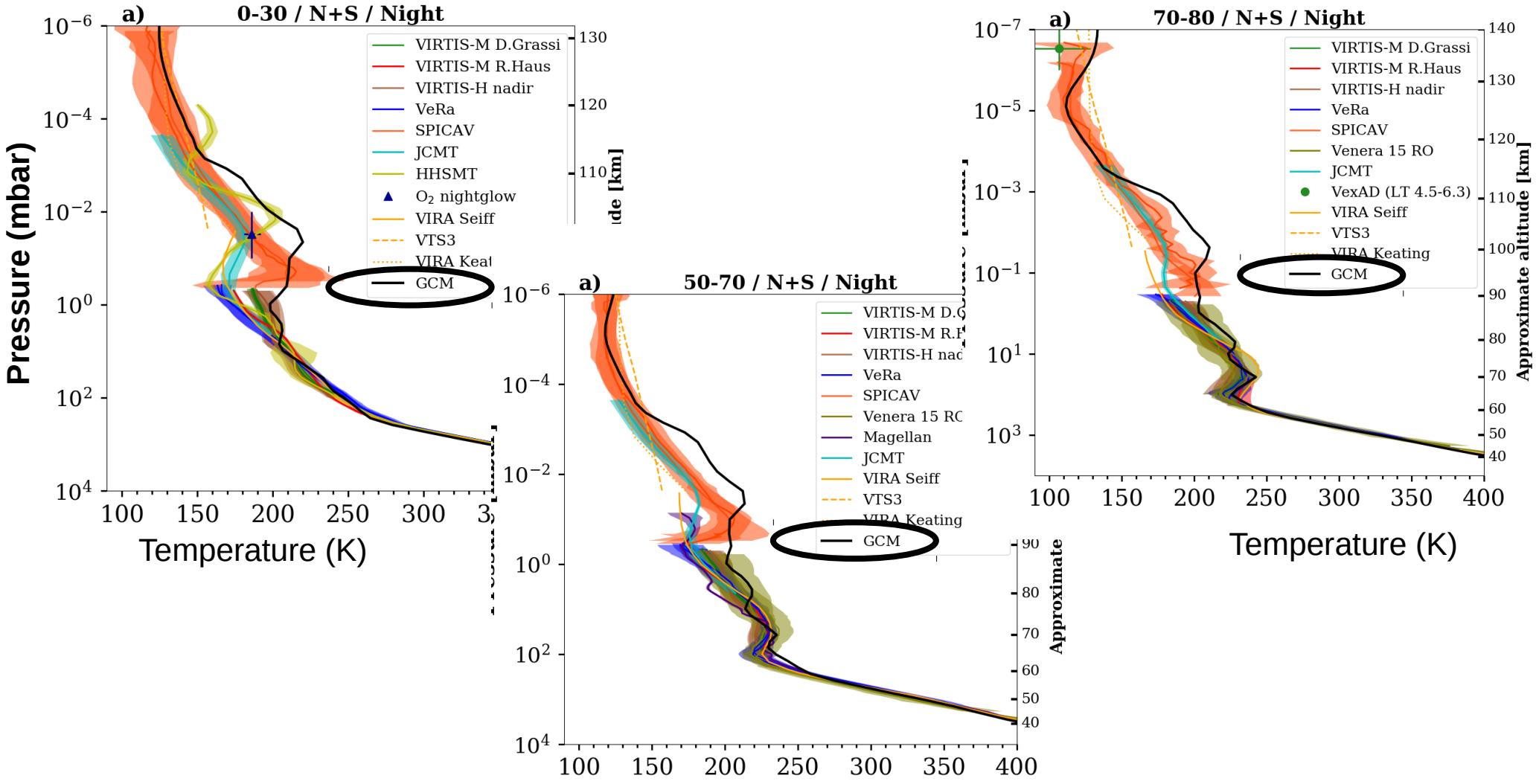




Modeled densities and temperatures compared to observations

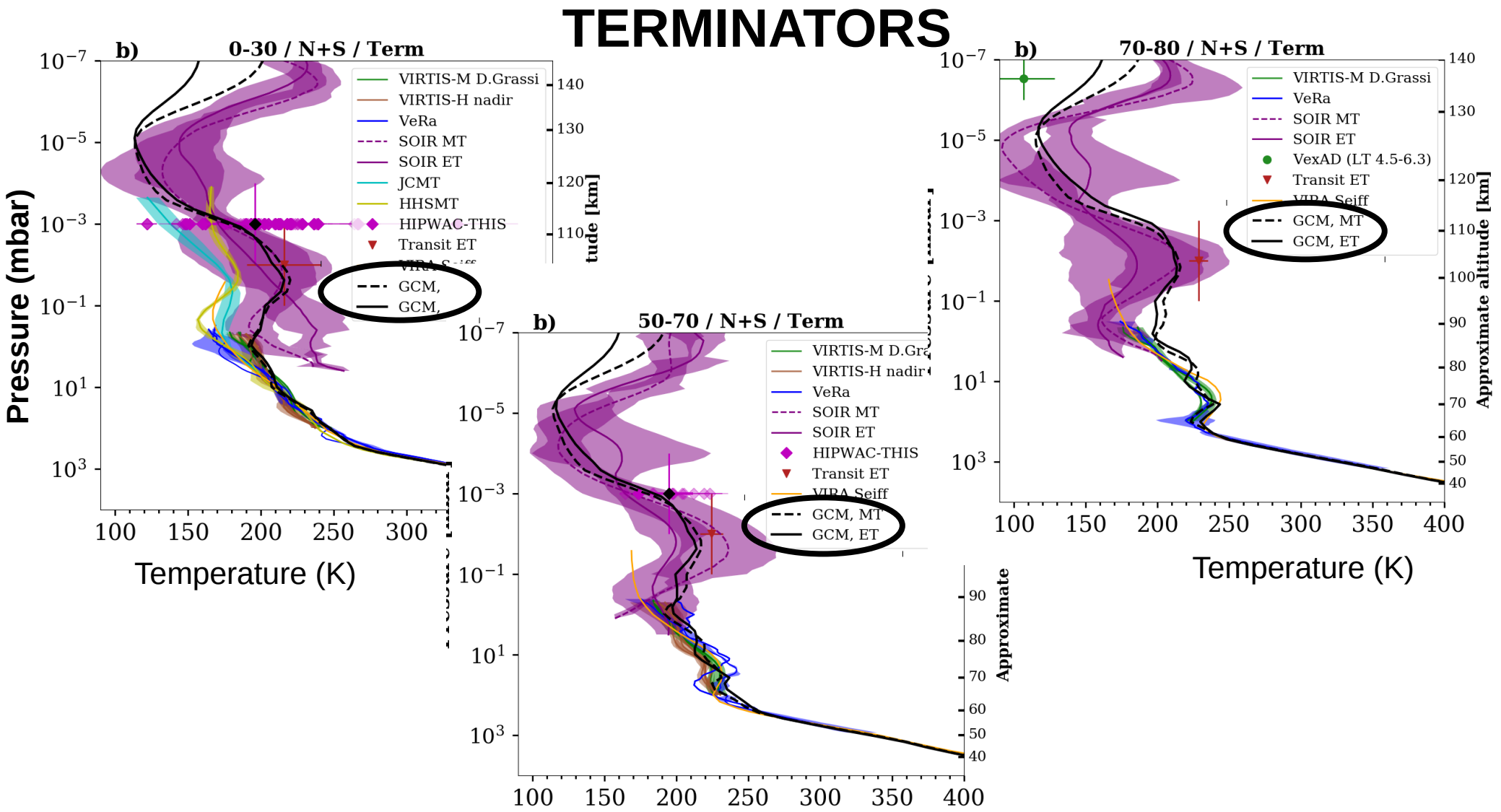
Temperature measurements

NIGHT



Modeled densities and temperatures compared to observations

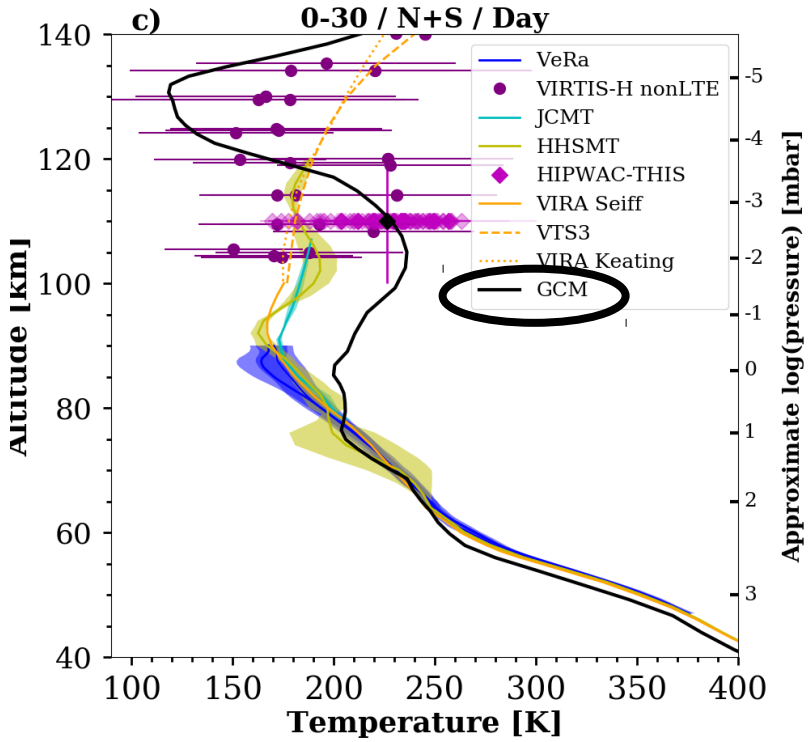
Temperature measurements

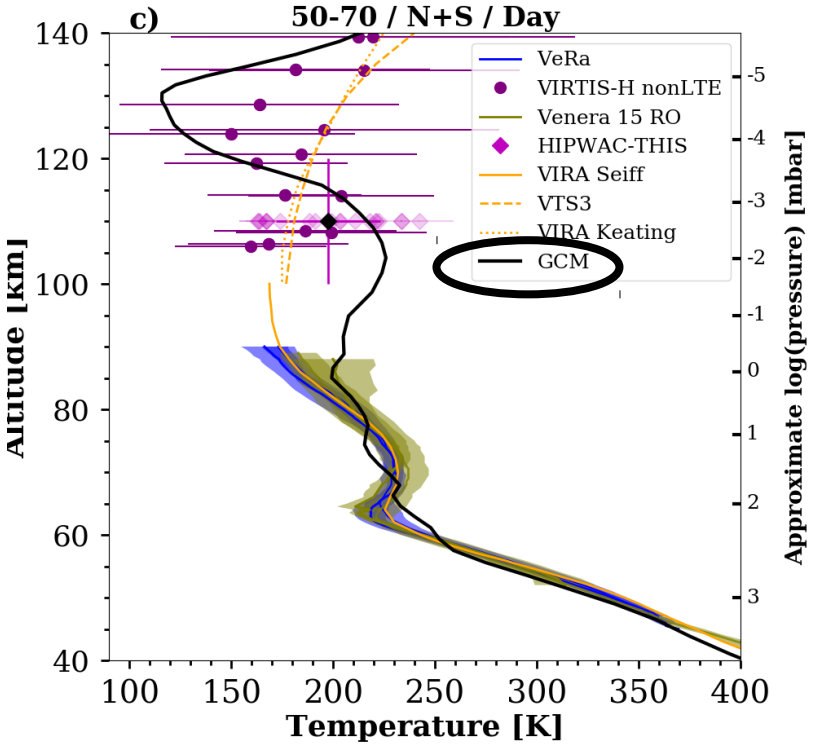


Modeled densities and temperatures compared to observations

Temperature measurements

DAY

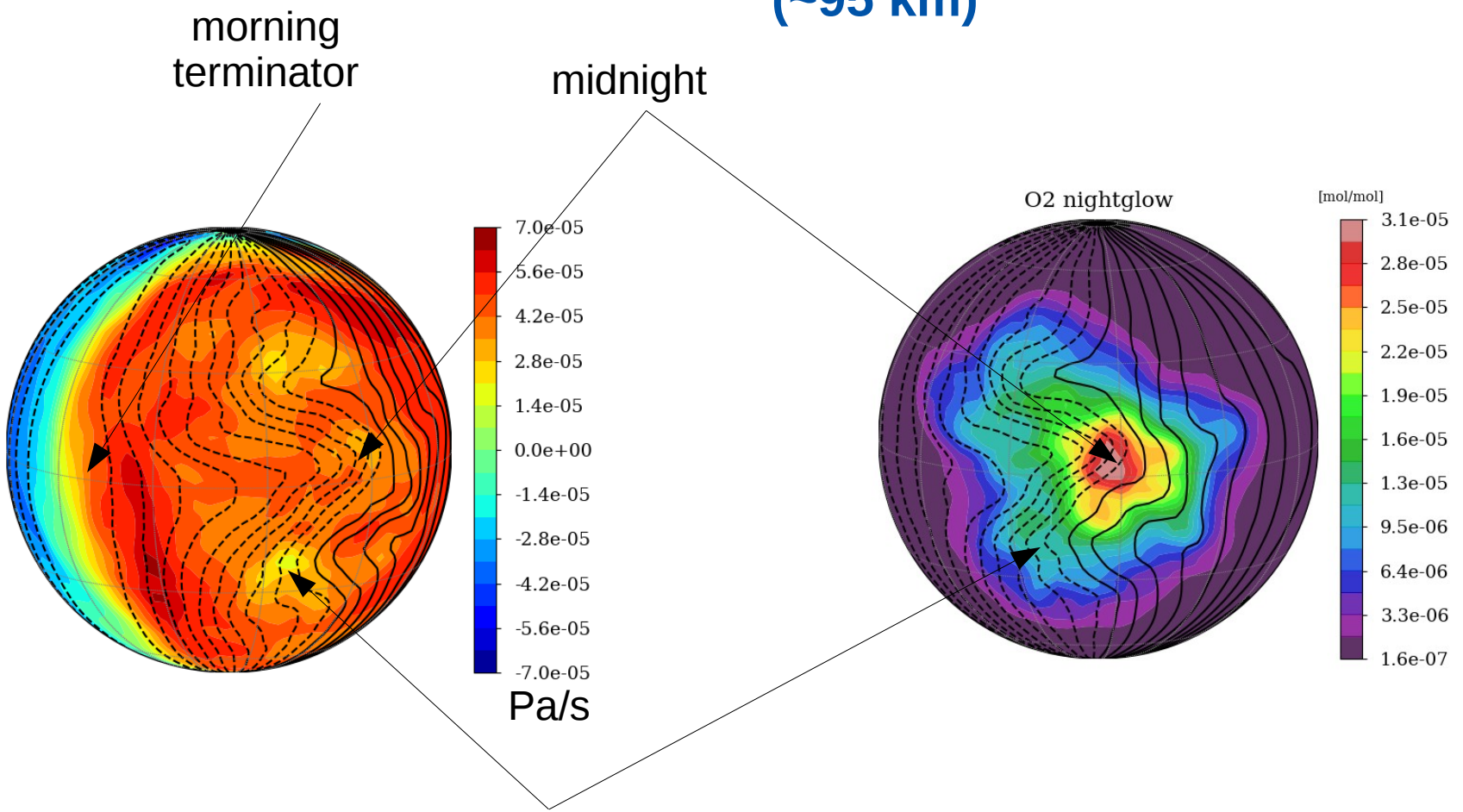




Circulation variability

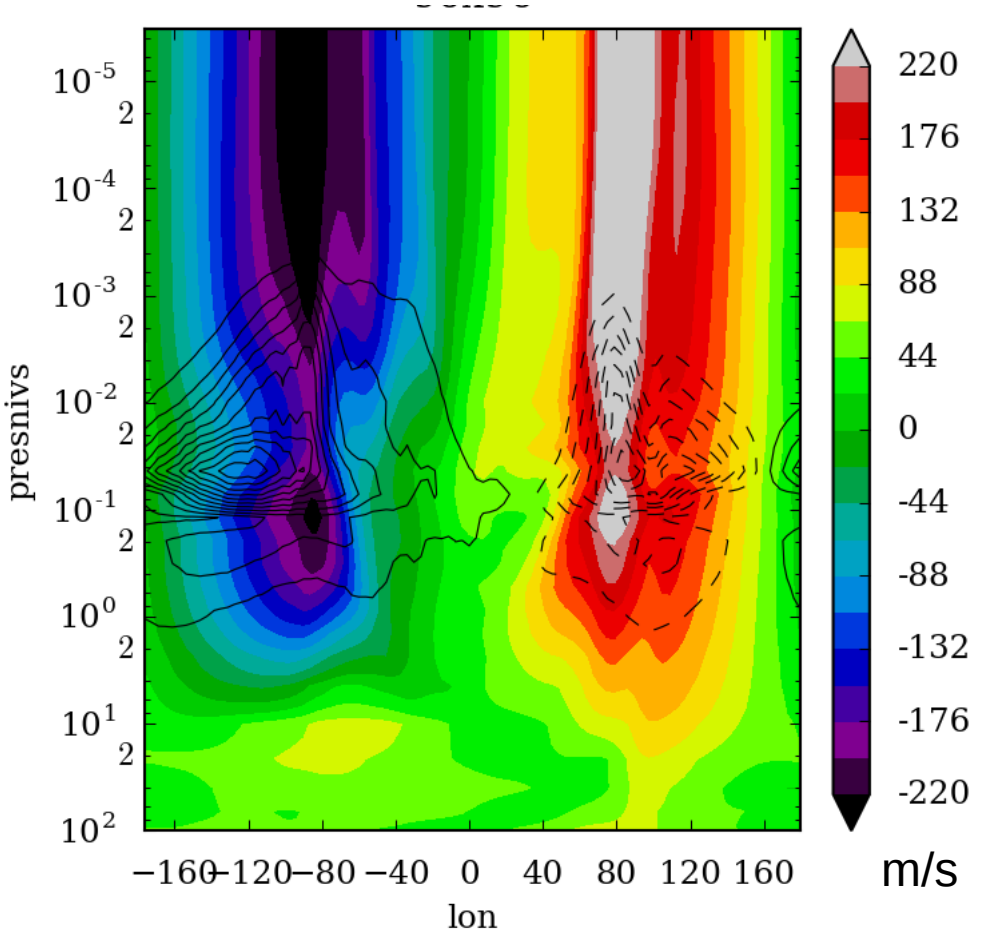
Vertical wind (colors) and zonal wind (contours) at 1 Pa (~105 km)

Oxygen nightglow (colors) and zonal wind (contours) at 10 Pa (~95 km)



Oxygen nightglow occurs in subsidences (positive vertical winds in Pa/s)

Non-orographic gravity waves



Average [40N-40S]

Colors : zonal wind

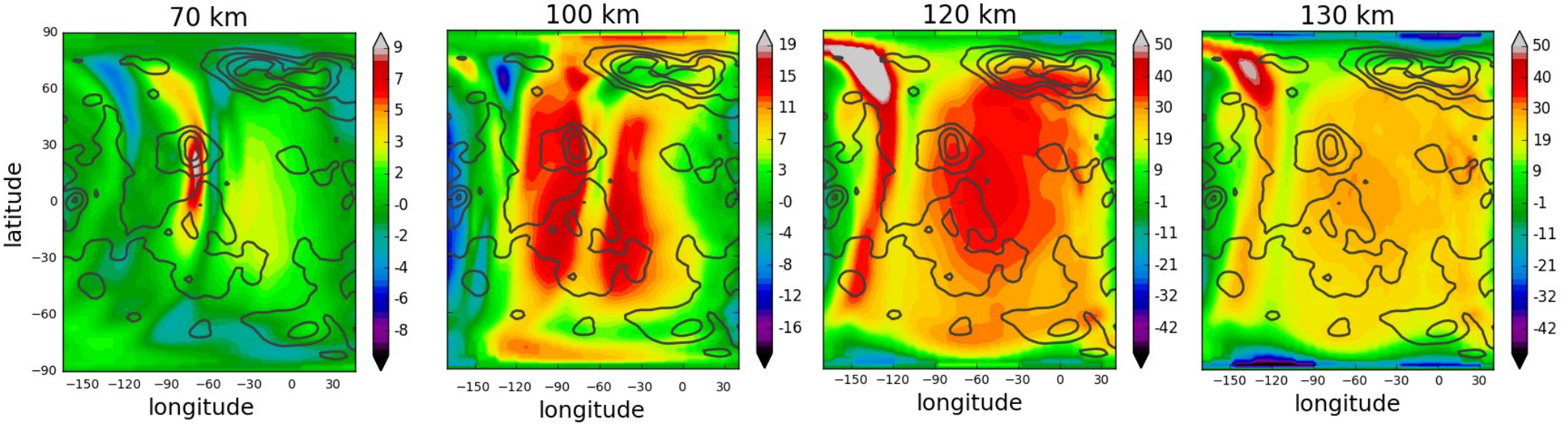
Contours : acceleration due to non-orographic GW

Acceleration of zonal wind due to non-orographic gravity waves generated at cloud top

Stationary waves

Topographic gravity waves parameterization

=> equatorial mountain waves develop in the afternoon and propagate above the clouds



Vertical wind speeds (cm/s)

Conclusion

The IPSL Venus GCM is a mature tool to study the upper atmosphere of Venus and its variability.

- Variability of the descending/ascending winds
- Variability due to orographic and non-orographic gravity waves

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

Open postdoctoral position at LMD

Study of the upper atmosphere of Venus

=> starting in autumn 2020 (for 2 years)

ESA-funded project : **Venus Climate Database** (release : Sept. 2021)

Virtual meeting : wednesday May 6th, 18h-19h (CEST)

Presentation of the VCD, discussion, ideas and needs welcome !

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