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
Persson, Master Th., 2015
Observed variability above clouds

Temperature measurements

Lebonnois et al., Icarus 294, 2017
Observed variability above clouds

Temperature measurements

Limaye et al., Icarus 294, 2017

Lebonnois et al. D2903 – EGU2020-18583
Observed variability above clouds

Temperature measurements

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Observed variability above clouds

Distribution of $O_2$ nightglow brightness observed by VIRTIS/VEx

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

Soret et al. 2014

Lebonnois et al. D2903 – EGU2020-18583
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)

The IPSL Venus GCM

Venus GCM Global mean Temperature

Venus GCM Global mean Abundances

- CO$_2$
- N$_2$
- CO
- SO$_2$
- O$_2$
- O
- SO
- H$_2$O
- O$_3$
- H$_2$SO$_4$

Pressure [Pa]

[200, 600] K

[~ 90 km, ~ 70 km, ~ 130 km, ~ 150 km]
Modeled densities and temperatures compared to observations

Density measurements

Lebonnois et al. D2903 – EGU2020-18583
Modeled densities and temperatures compared to observations

Temperature measurements
Modeled densities and temperatures compared to observations

Temperature measurements

![Graphs showing modeled densities and temperatures compared to observations.](image-url)
Modeled densities and temperatures compared to observations

Temperature measurements

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Circulation variability

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

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

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

O2 nightglow

Lebonnois et al. D2903 – EGU2020-18583
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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