The Venus Climate Database

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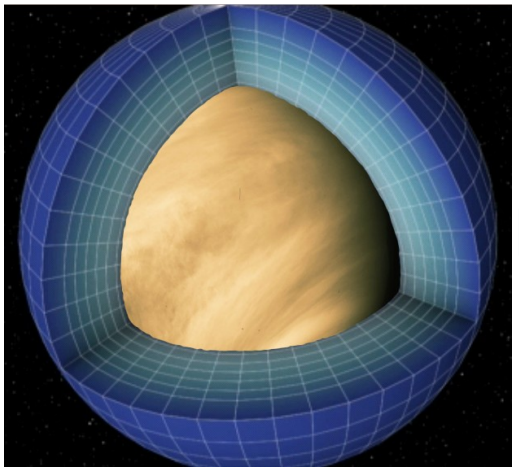
The IPSL Venus GCM



From surface to 250 km

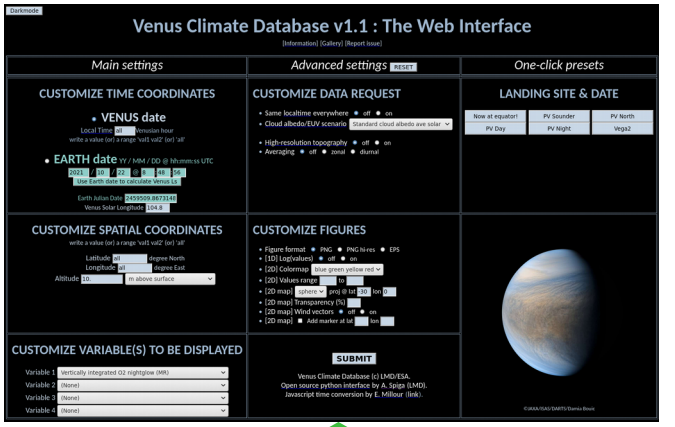
VCD
routine suite

call_vcd(*z_key,z,lon,lat,…,*
T,p,dens,zonwind,...)

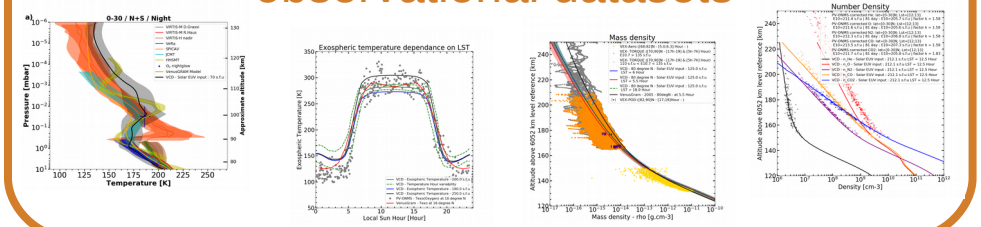
Direct use in users' codes

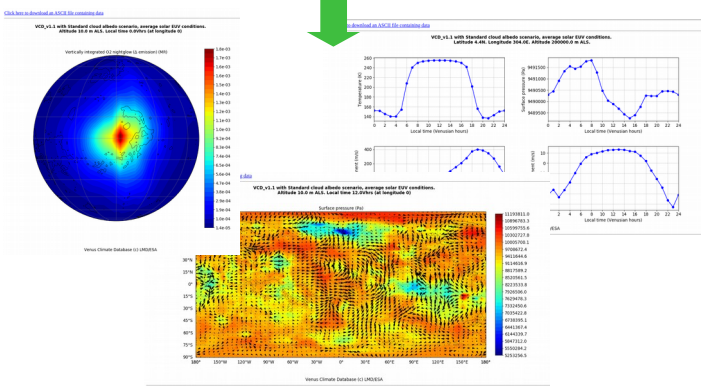
Various langage interfaces

Simple web interface use



Validation with
observational datasets





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)

The Venus Climate Database

- Based on the same principles as the well-known Mars Climate Database (MCD)
- The Venus Climate Database (VCD) is a database **derived from Global Climate Model** (GCM) **simulations**, using the IPSL Venus GCM.
- **ESA is funding the project**, in relation with the EnVision M5 mission
- The VCD is intended to be useful for engineering applications (e.g. Aerobraking studies, Entry Descent & Landing studies) and scientific work which require accurate knowledge of the Venusian atmosphere (e.g. analysis of observations).
- The VCD is freely available
  - **http://www-venus.lmd.jussieu.fr**
    light online access for moderate needs (web interface)
  - **full version** : includes advanced post-processing software (Fortran subroutine call_vcd; examples of C, C++, IDL, MATLAB, SCILAB, Python interfaces are provided).
    Please contact ehouarn.millour@lmd.ipsl.fr

VCD content and main features

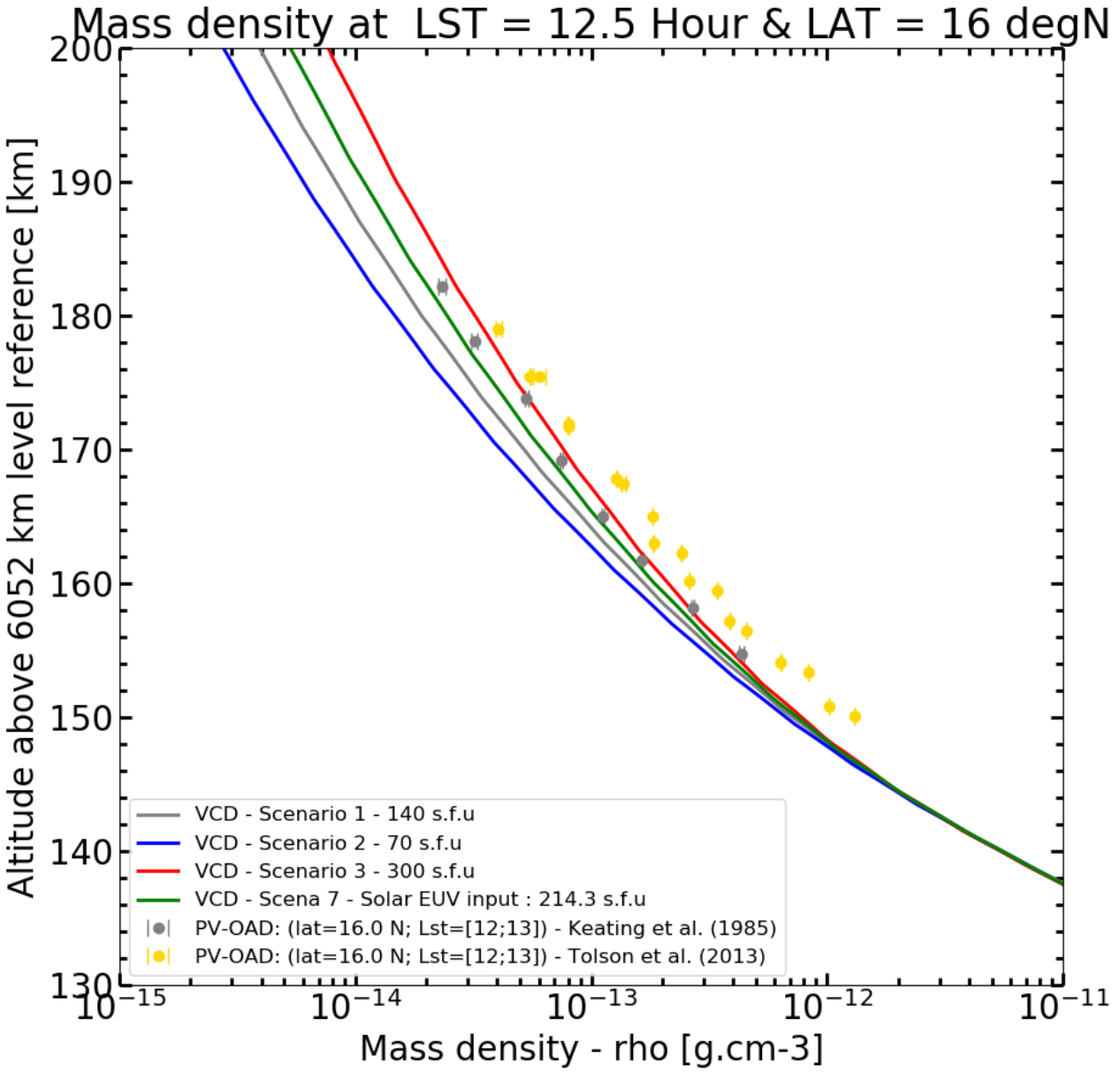
Main access software (**call_vcd**):

- Primarily composed of a Fortran subroutine (benefit from MCD heritage) designed to provide access, with adequate interpolations, to fields and variables as a result of a point-wise (in location and time) query.
- Enabling the user to query along the time dimension either by specifying an Earth date or a Venus Local Time.
- The VCD dataset includes one full climatological Venus day built using 10 Venus days of computations, sampled at 1/24th of a Venusian day to accurately represent the diurnal cycle

Example of the VCD Density profile

VCD vs density measurements

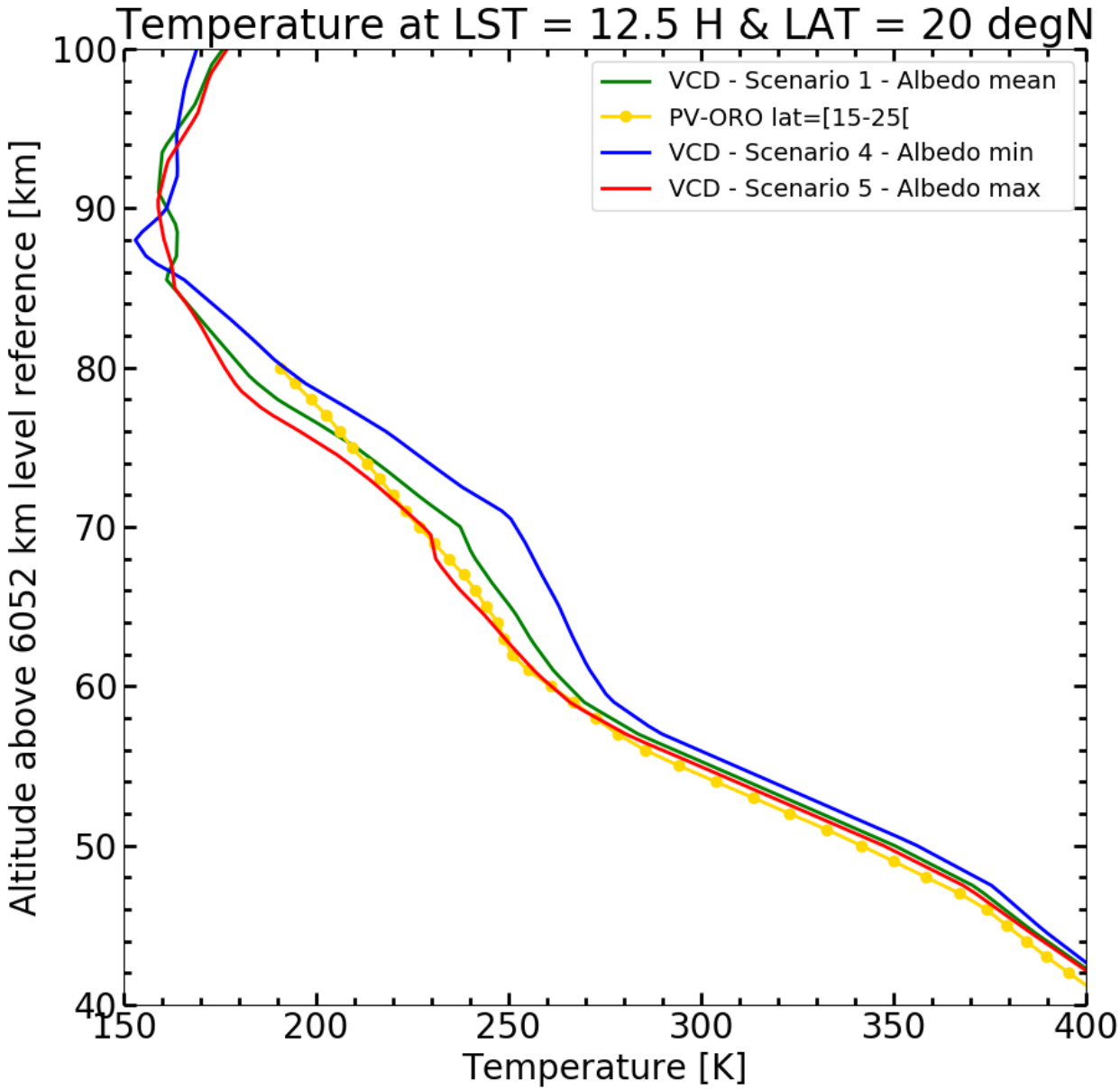
- The **EUV scenarios** of the VCD allow to bracket reality
- The comparison can be more accurate using a **specific EUV with scenario 7**
- PV-OAD: Pioneer Venus Orbiter Atmospheric Drag



Example of the VCD Temperature profile

VCD vs temperature measurements

- The **cloud albedo scenarios** allow to brasket reality
- PV-ORO: Pioneer Venus Orbiter Radio Occultation

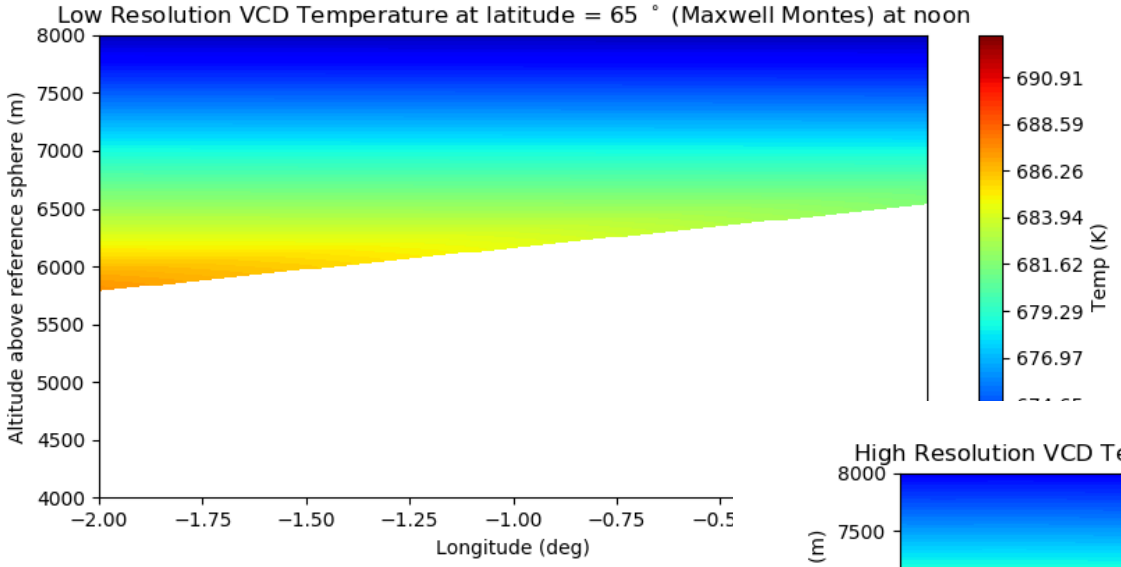


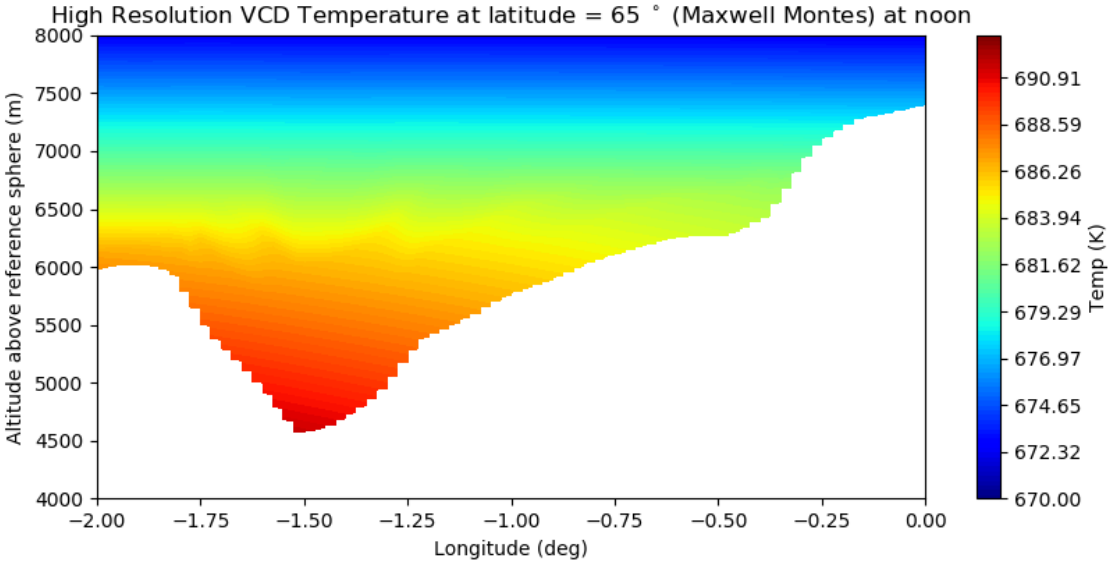
VCD available scenarios

1. Standard cloud albedo and average solar EUV input (E10.7=140 sfu)
2. Minimum solar EUV input (E10.7=70 sfu) and standard cloud albedo
3. Maximum solar EUV input (E10.7=300 sfu) and standard cloud albedo
4. Low cloud albedo and average solar EUV input
5. High cloud albedo and average solar EUV input
6. EUV input as deduced from the input Earth date (Julian date)
7. EUV input as specified by the user

VCD high resolution mode

The access software includes a **high resolution mode** with a 23 pixel/deg topography measured with Magellan radar altimeter (combined with a few topography measurements from Pioneer Venus to fulfill the holes)

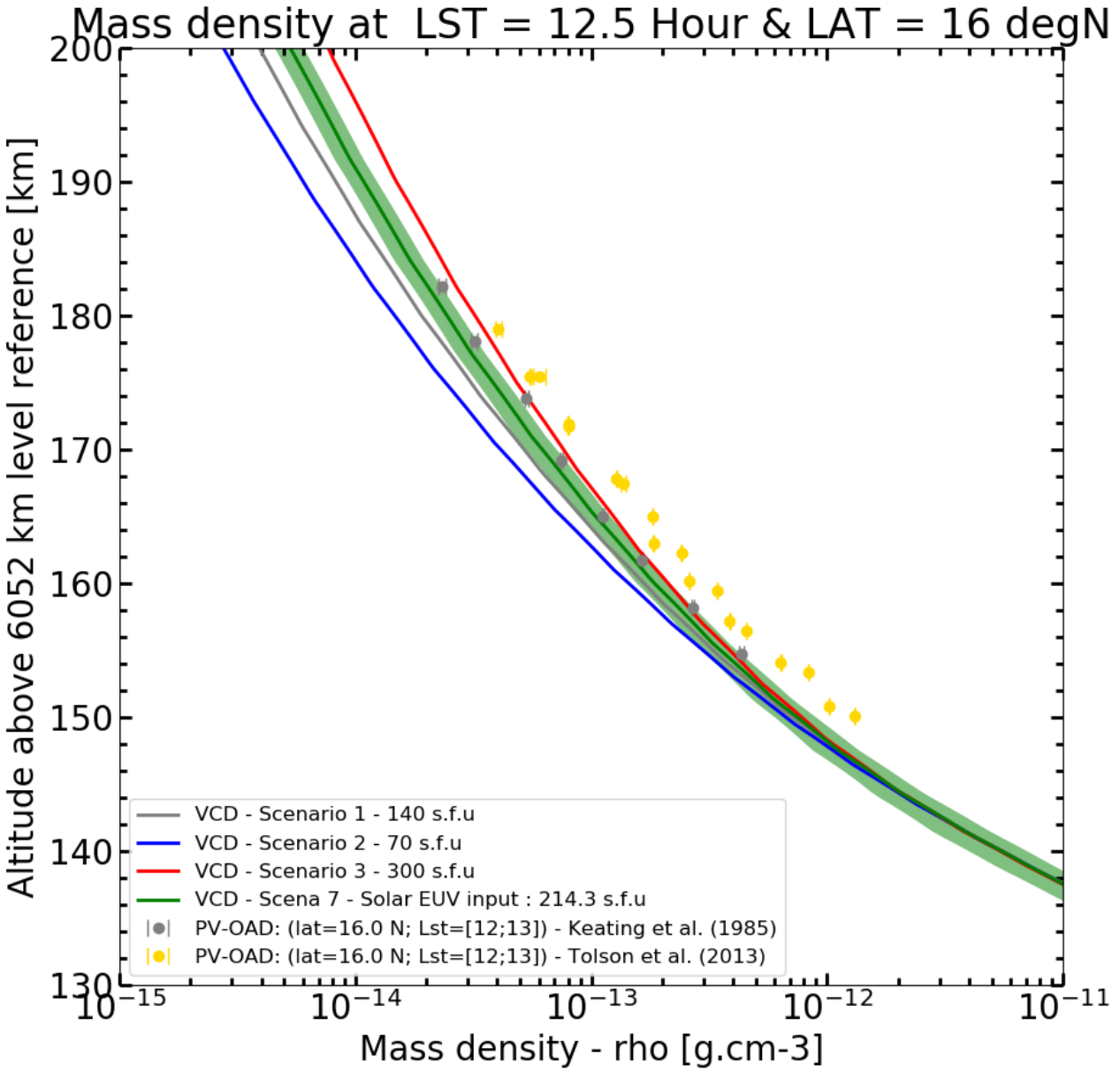




Variability in the VCD
Day-to-day and V-hourly RMS

VCD vs density measurements

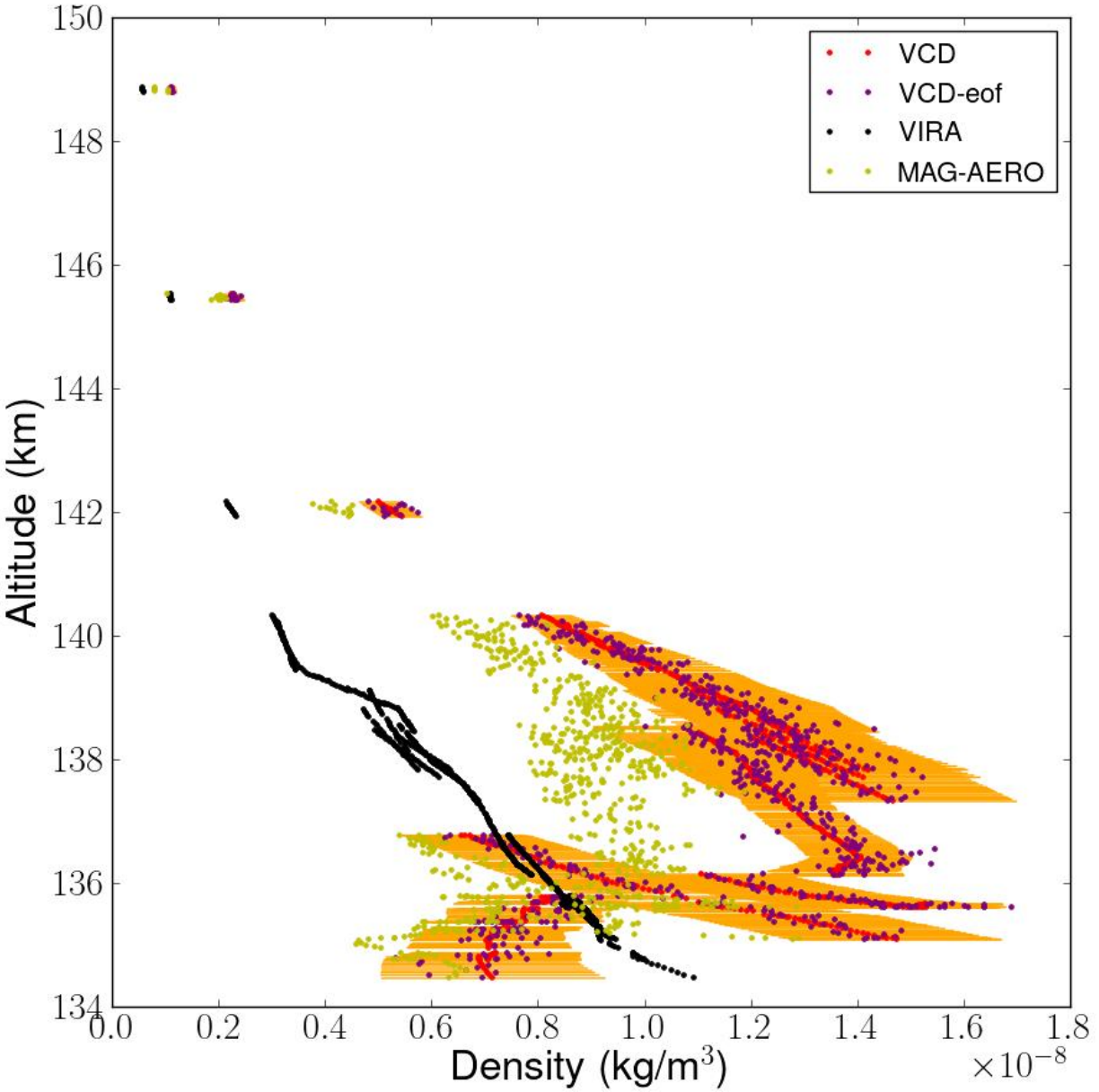
- The **V-hourly RMS** (shaded green area) represents the variability within one venusian hour
- The **day-to-day RMS** represents the variability of the houly averaged value from one Venus day to the next
- PV-OAD: Pioneer Venus Orbiter Atmospheric Drag



Variability in the VCD
EOF-reconstructed perturbations

VCD vs density measurements

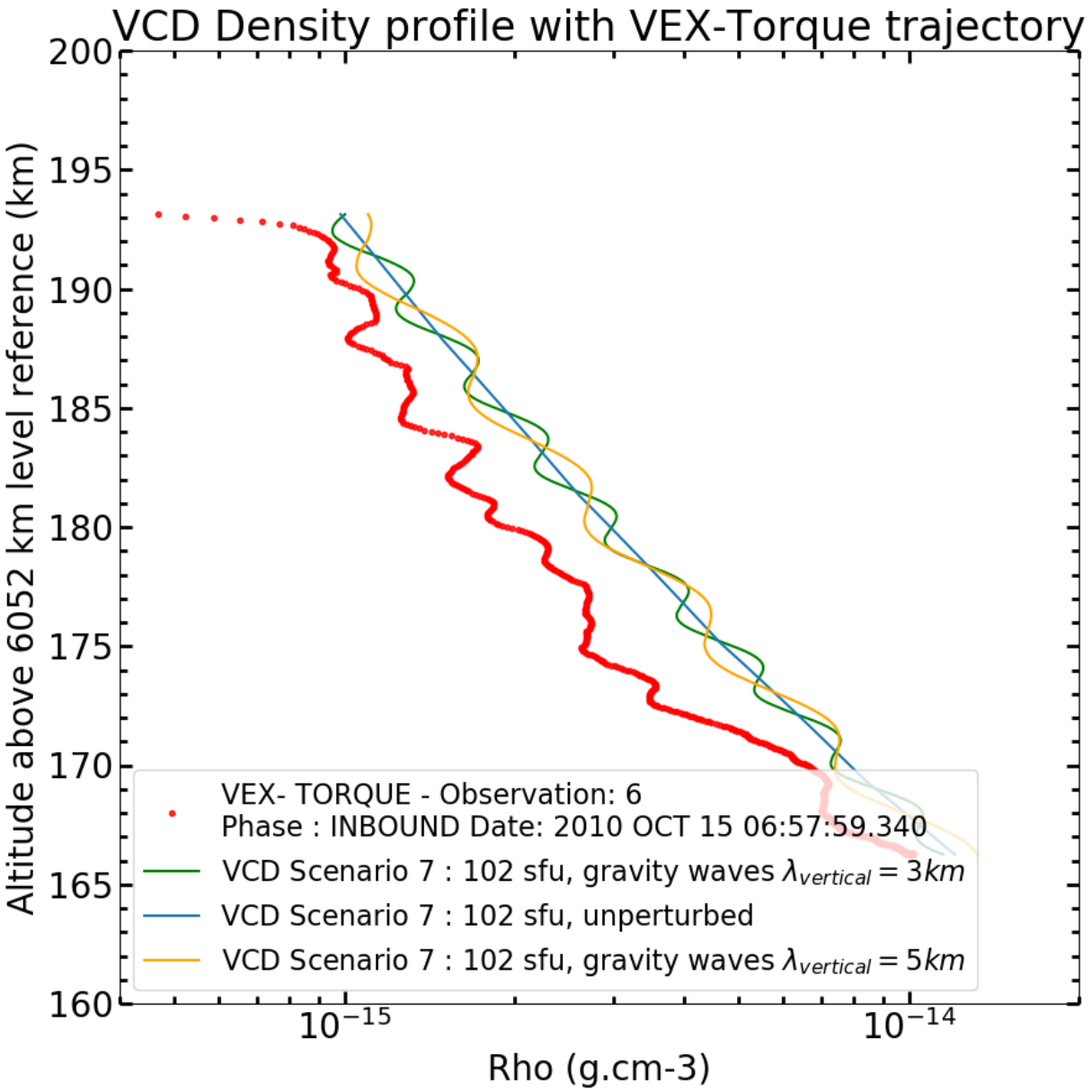
- In addition to the climatology (red dots), the VCD allows to add **perturbations** to reconstruct meteorology, using **EOFs of high temporal resolution GCM simulations** (purple dots)
- MAG-AERO: Magellan aerobraking dataset (yellow dots)
- Orange area: previously mentioned RMS (V-hourly + day-to-day)



Variability in the VCD
Small-scale gravity waves perturbations

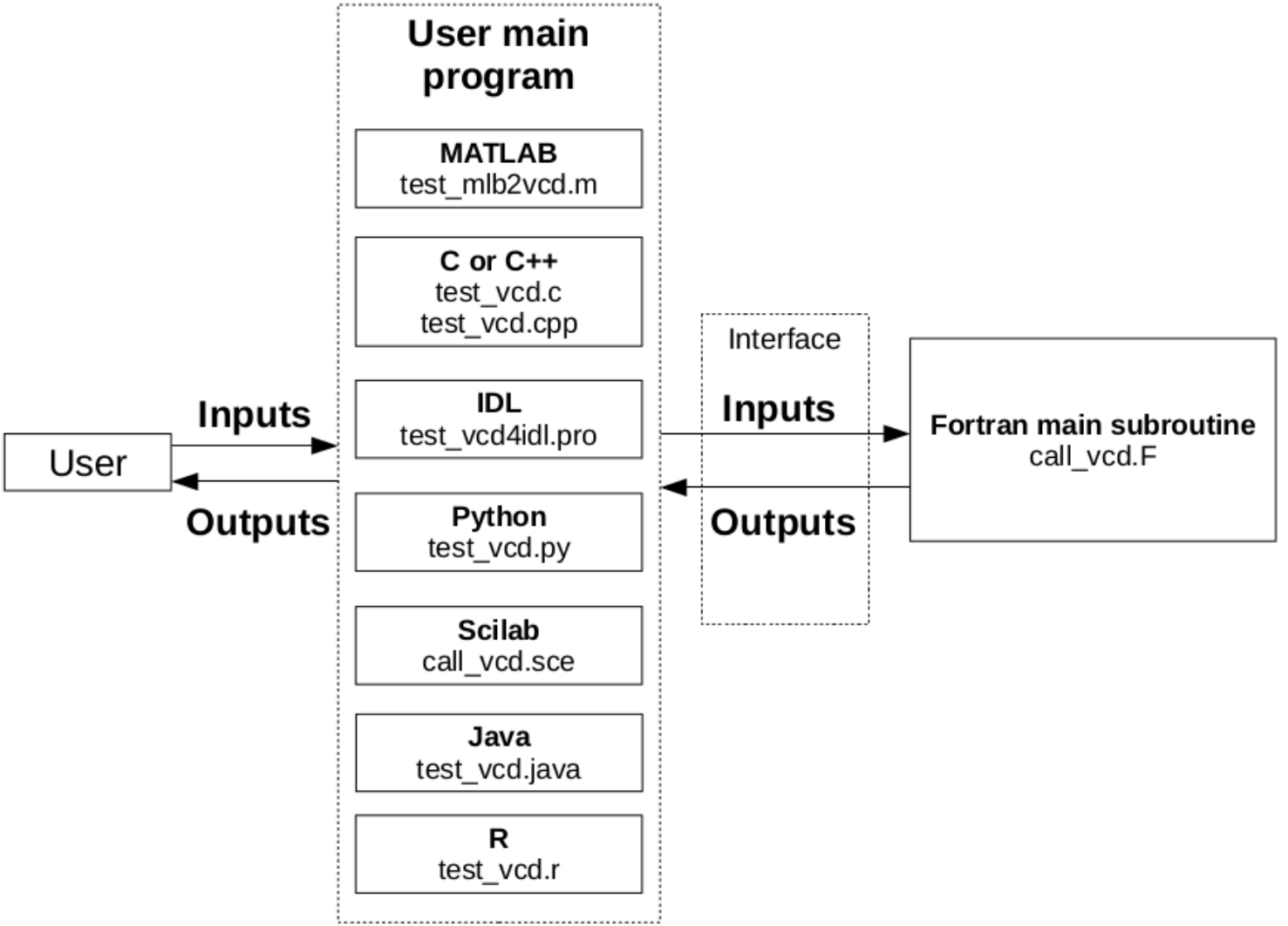
VCD vs density measurements

- In addition to the climatology (blue), the VCD allows to add **small-scale gravity wave perturbations**
- The vertical wavelength is specified by the user (green:3km /yellow:5km)
- VEX-TORQUE: Venus Express Torque experiment (red)



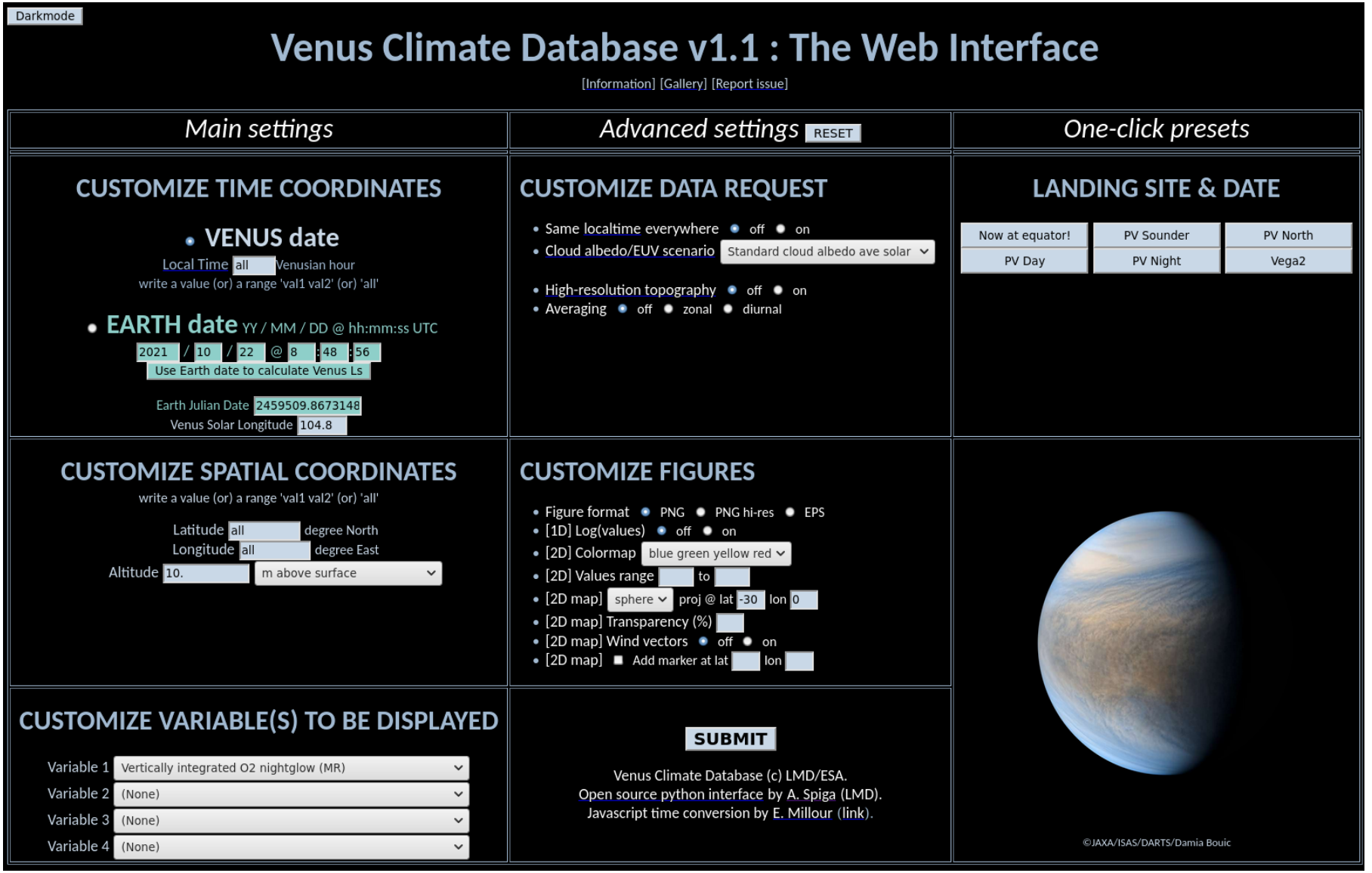
Interfaces to access the VCD

Interfaces with other programming languages (e.g. C, C++, IDL, Matlab, Python3, …) is also provided.



Interfaces to access the VCD

A web interface for quick-looks and plots : **www-venus.lmd.jussieu.fr**



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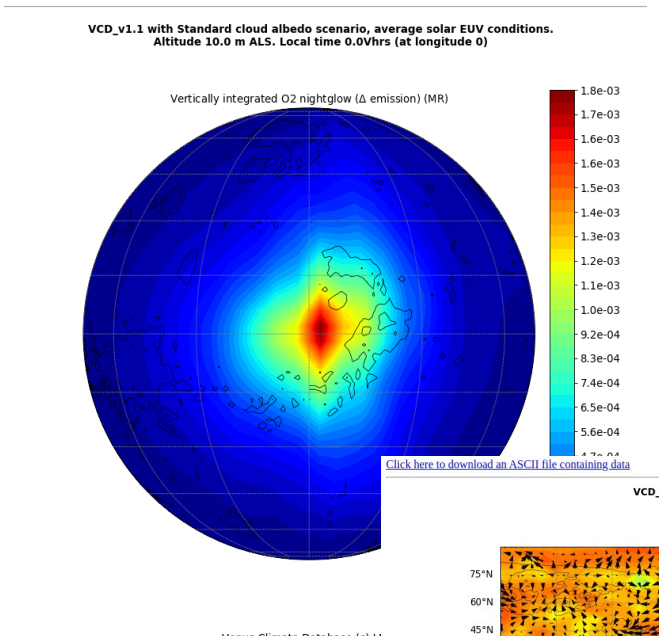

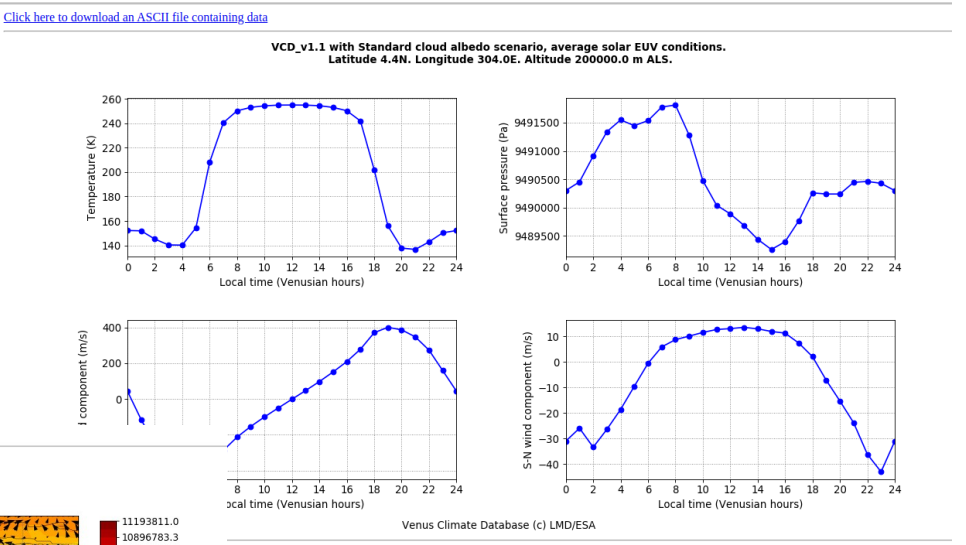

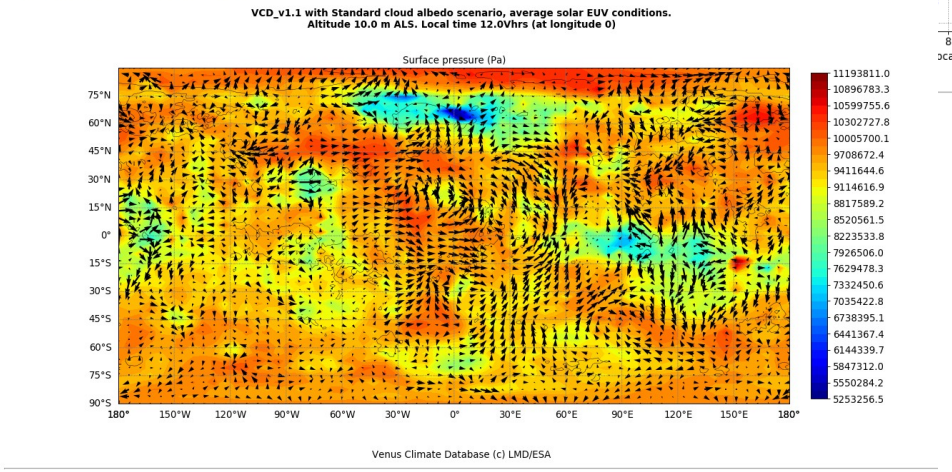

We are also very much interested in the possibility of distributing the VCD as a virtual observatory in the frame of the Virtual European Solar and Planetary Access (VESPA) Europlanet 2020 Research Infrastructure program http://www.europlanet-vespa.eu