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Observation of mesospheric CO in Venus using VIRTIS-H aboard Venus Express

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Abstract

The thermal emission of the dark side of Venus is used to investigate the distribution of CO above the clouds using the VIRTIS-H instrument aboard Venus Express. The objective is to study the latitudinal variations of CO, in particular in the polar regions.

1. Venus-Express and the VIRTIS-H instrument

The ESA Venus Express mission was launched on November 9, 2005, and has been operating in Venus' orbit since April 11, 2006 (Svedhem et al. 2006)[1]. Its polar orbit is highly elliptical and allows a close sounding of the polar regions of the planet. The VIRTIS infrared instrument aboard Venus Express has two main subsystems, one for mapping (VIRTIS-M) and one for high-resolution spectroscopy (VIRTIS-H). VIRTIS-H is an Echelle grating spectrometer which covers the 1.84-4.99 μm range with a spectral resolution of 0.001 μm and an instantaneous field of view of 0.45 x 2.25 mrad. We concentrate on the first order which covers the 4-5 μm range. In this region, the atmosphere of Venus is probed above the clouds. The spectrum is dominated by the very strong ν_3 band of CO_2 at 4.25 μm, the weaker CO_2 ($\nu_1 + \nu_2$) band centered at 4.8 μm, and the (1-0) CO band centered at 4.7 μm. An analysis of the CO spatial variability using VIRTIS-M data in the same spectral range has been published by Irwin et al. (2008) [2]. Our objective is to take advantage of the higher spectral resolving power of VIRTIS-H to better constrain the CO variations, especially near the polar regions.

2. Observation of the CO (1-0) band

In order to avoid the contribution of the reflected daylight component which is strongly affected by scattering, we consider only night-side data. As a preliminary analysis, we have selected two sequences

Table 1: Observing sequences with VIRTIS-H

Sequence number	VT0038_00	VT0067_00
Time UT	28 May 2006 16:46-21:18	26 June 2006 14:48-15:28
Longitude & latitude	E-Long: 40° Lat: 69°S - 83°S	E-Long: 120° Lat: 43°S
Emergence angle	40°	50°
Local time	24h	23h

corresponding to two different latitudes, and also observed with VIRTIS-M[2].
Figure 1 shows averaged spectra in these two sequences. It can be seen that their shape is very different. The mid-latitude spectrum (VT0067_00) shows a strong CO_2 absorption feature around 4.85 μm, while the high latitude spectrum (VT0038_00) shows the same band in emission, as well as an inversion in the wings of the 4.25 μm CO_2 band. This behavior, also observed by VIRTIS-M [2, 3], is the signature of a temperature inversion at high latitudes in the vicinity of the cloud level.

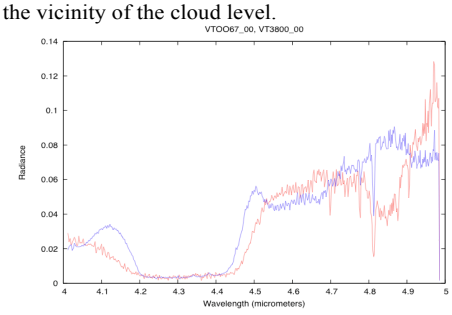

Figure 1: The VT0038_00 spectrum (blue) and the VT0067_00 spectrum (red) in the 4-5 μm region.

Figures 2 and 3 show very preliminary fits of the CO band in the two spectra. As expected, the band appears in absorption at mid-latitudes (VT0067_00) and in emission at high latitudes (VT0038_00). The first spectrum corresponds to a mean CO mixing ratio of 20 ppm above the clouds.

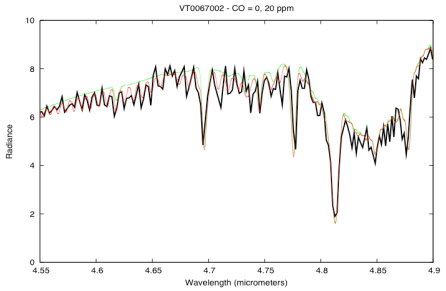

Figure 2: A mean spectrum at mid-latitudes (VT0067_00, bold black line), compared with synthetic models (green: CO =0; red: CO = 20 ppm). The radiance unit is $\mu W/cm^2sr/\mu m$.

The second spectrum is fitted with a CO mixing ratio of 40 ppm above the clouds, but this value is tentative as the spectrum in this case shows little sensitivity to the CO abundance. In addition, the departure between the data and the models at 4.5 μm illustrates that the thermal profile used in this calculation is not optimized and must be improved.

In the future, the analysis will be extended to other night-side sessions, with the objectives of retrieving the latitudinal variations of CO and investigating in more detail the inversion thermal structure in the vicinity of the cloudtop.

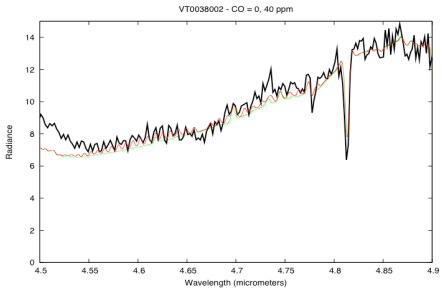

Figure 3: A mean spectrum at high latitudes (VT0038_00, bold black line), compared with synthetic models (green: CO =0; red: CO = 40 ppm). The radiance unit is $\mu W/cm^2sr/\mu m$.

References

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