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A compilation of all CO observations performed by SOIR during the Venus Express mission

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Abstract

The SOIR instrument on board the ESA Venus Express spacecraft has been operational during the complete duration of the mission, from April 2006 up to November 2014. Spectra are recorded in the IR spectral region (2.2 -4.3 µm) using the solar occultation geometry and give access to a vast number of ro-vibrational lines and bands of several key species of the atmosphere of Venus. Here we present the complete set of vertical profiles of carbon monoxide (CO) densities and volume mixing ratios (vmr) obtained during the mission. These profiles are spanning the 65-150 km altitude range. We discuss the variability which is observed on short term, but also the long term trend as well as variation of CO with solar local time (LST) and latitude.

1. Introduction

The SOIR (Solar Occultation in the IR) instrument has been designed to measure spectra of the Venus atmosphere in the IR region (2.2 – 4.3 µm) using the solar occultation technique [1]. This method derives unique information on the vertical composition and structure of the mesosphere and lower thermosphere. The SOIR instrument is unique in terms of spectral coverage and spectral resolution (0.15 cm^{-1}), and is ideally designed to probe the Venus atmosphere, above the cloud deck, for CO_2 as well as trace gases. CO is particularly well covered since the (2-0) band strongly absorbs in the 3900-4400 cm^{-1} range, which is well inside the sensitivity range of the SOIR instrument.

2. Data sets and retrieval technique

The retrieval method has already been described in details elsewhere for CO_2 and temperature [2] and specifically for trace gases [5]. The method determines the number densities, temperature and aerosol extinction profiles using an iterative procedure.

The primary results deduced from the analysis of SOIR spectra are densities. Conversion to volume mixing ratio (vmr) requires the knowledge of the total density, or that of CO_2, if a CO_2 vmr is assumed. Two cases are encountered: either the CO_2 density is retrieved simultaneously from one of the 4 orders dedicated to its detection and is directly used to obtain the vmr, or no information on CO_2 is available from the observation itself. In that case, the CO_2 density will be derived from the VAST model, which has been described in detail in [3] and updated in [4]. In both cases, an assumption is made on the CO_2 mixing ratio, whose values are taken from the VIRA model.

All SOIR observations are performed at the terminator, either on the day side (LST 6 am) or night side (LST 6 pm) and cover both hemispheres from 90S to 90N latitudes. The instrument probes the mesosphere (70 to 95 km) and the lower thermosphere (above 95 km). CO has been observed regularly during the Venus Express mission. Table 1 gives the number of observations for the different latitudinal bins considered in this study (0°-30°, 30°-60°, 60°-70°, 70°-80°, 80°-90°). Day/night difference have been considered, for both North and South hemispheres. The equatorial and mid-latitude regions considered in this study are larger than the more polar ones. This is done to compensate the poorer coverage at low latitude due to the very elliptical orbit of the spacecraft.

Table 1: Statistics of the CO observations for the different latitude bins and on each side of the terminator for both hemispheres.

	North Hemisphere		South Hemisphere	
	AM	PM	AM	PM
0°-30°	8	9	12	18
30°-60°	5	3	16	21
60°-70°	3	7	6	6
70°-80°	14	14	4	5
80°-90°	45	29	6	7
Total	75	62	44	57

3. Results

Individual vertical profiles will be discussed, as well as average profiles obtained for the different latitude bins considered in this study.

A previous analysis of the short term variability of CO [5], has indicated high variability from day to day but also from one occultation season to the other. Timescales involved are small, defined on a day-to-day basis. The region sounded by SOIR (65-150 km) corresponds to a region where different circulation patterns coexist: the SS-AS driven by strong diurnal temperature gradients, which is active essentially above 120 km, and the retrograde zonal circulation. The latter is active in the lower atmosphere (below 70 km). However it has been suggested that gravity waves, generated in the unstable cloud region, could force the retrograde zonal flow well above 70 km extending up to higher altitudes.

A clear correlation was found between CO abundance, CO_2 and temperature for altitudes above 110 km. The correlation is less pronounced for lower altitudes. This confirms that above 110 km the main process is the photodissociation of CO_2 to CO. This is also a confirmation that other processes in which CO is involved, such as cloud formation or participation in the catalytic cycles to recombine into CO_2, occur at lower altitudes.

4. Summary and Conclusions

CO densities and vmr have been measured by the SOIR instrument on board Venus Express on a regular basis since the beginning of the mission. Observations cover both hemispheres from 90°S to 90°N latitudes, but are all obtained at the terminator (LST 6 am and 6 pm). We have investigated the latitudinal variations of CO, as well as the time evolution, over short and long time period. We have analysed the diurnal evolution of the CO abundance at different altitudes. We have also shown some results from a previous study focused on the short term variability of CO [5] to get a complete picture of the CO abundance on Venus.

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