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Observations of CO above Venus cloud top near $4.53\,\mu$m

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Abstract

Introduction

Venus' cloud top region exhibits a higher level of variability both in space and time than previously thought. The interplay between photochemistry, dynamics and cloud microphysics requires more observational constraints in order to be fully grasped. Recent observations of sulfur dioxide (SO_2) variability [2, 8, 7, 9] have evidenced both short-term, long-term and latitudinal variability whose origin remains mysterious (volcanogenic emissions? dynamic variability?). A better knowledge of the variability of other minor species would be highly welcome in this context. Carbon monoxide (CO), whose pattern of sinks and sources is opposite to SO_2, is a prime candidate.

History

CO was detected above the clouds of Venus for the first time by Connes et al.[1] near $2.3\,\mu$m, with a mixing ratio of about 45 ppmv. More recently, Irwin et al.[3] used VIRTIS-M near $4.7\,\mu$m on the nightside, and evidenced no spatial variations, with 40 ± 10 ppmv in the $65-70$ km range. Iwagami et al.[4] found 58 ± 17 ppmv near $2.3\,\mu$ on the dayside, whereas Krasnopolski[5] in the same spectral range found evidence of a CO decrease with increasing local time (52 ± 4 ppmv at 08:00 compared to 40 ± 4 ppmv at 16:30).

Methodology

Following a methodology already tested for SO_2 observations [8], we have observed Venus using the high-resolution ($R = 41500$) spectrometer CSHELL at the IRTF (Mauna Kea, Hawaii) from 2012-08-25 until 2012-08-28, around the greatest western elongation of Venus. These observations faced several intrinsic and extrinsic challenges: (1) A high spectral resolution is required so that we can distinguish between Earth and Venus CO and CO_2 spectral lines thanks to the relative $0.1\,\mathrm{cm}^{-1}$ Doppler shift. This restricts us to a narrow interval between 2202 and $2207\,\mathrm{cm}^{-1}$ including a few spectral lines from CO and CO_2, but with an Earth atmospheric transparency spectrally non uniform, mainly due to N_2O absorption. (2) Our strategy was to acquire spectra during about 30 minutes at several fixed positions of the slit, kept parallel to the morning terminator. But the automatic guider of CSHELL was not functioning properly on such an extended object, so that we had to guide manually, causing some horizontal blurring. (3) Earth sky is quite bright near $4.53\,\mu$m, so that we had to use the guider near $2.3\,\mu$m in order to see Venus and simultaneously avoid saturation by co-adding and subtracting a large number of individual frames. (4) Thermal and solar components are comparable in magnitude. A proper modeling has to take both into account on the dayside.

Preliminary Results

Nightside

The analysis on the nightside is simpler since we only have to take into account the thermal component1. Our preliminary results there, based on the sole 2012-08-27 morning, are: (1) Strong limb darkening is observed, that can be translated into an altitude of emission for the CO_2 lines (whose mixing ratio is known and constant with height in the lower mesosphere). We are able to probe in an altitude range from 65 km (center of the disk) up to 78 km (limb). (2) It then appears that it is increasing with increasing height, with a scale height of about 8 km. This is consistent with a source of photochemical source of CO located at a higher altitude than the thermochemical sink of CO. (3) At a prescribed altitude, we were unable to detect any significant variability. The mixing ratio at 72 km is 20 ± 2 ppmv, somewhat less than measured before[3].

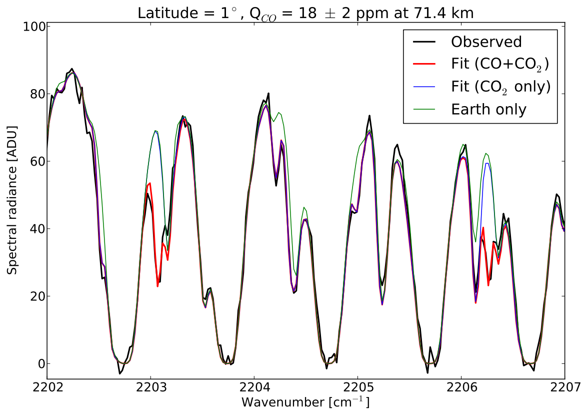

Figure 1: Fit of the nightside thermal emission.

Dayside

On the dayside, our fits are less reliable, since we also have to model the scattered solar component. Some fluorescence of CO is also probably observed, especially near the dayside limb, that makes our measurements less reliable. Close to the terminator, where the fluorescence is not much of a disturbance, the mixing ratio appears to be comparable to (perhaps slightly lower) the nightside values aforementioned, but with a greater spatial variability. This suggests a larger sensitivity of CO to the dynamics and/or local chemistry (shorter lifetime ?)

Perspectives

Our future plan of action consists mainly in: (1) Modeling properly the fluorescence of CO on the dayside; this will enable us to understand better the behavior of CO there. (2) Analysing the data acquired during the 3 other nights of the 2012 August campaign, so that we can investigate into its day-to-day variability. (3) Preparing the next observation campaign, requested for October 2013, during the next evening elongation of Venus. It should allow us to observe the evening terminator of Venus, but the opposite Doppler shift shall be less favorable for the visibility of CO and CO_2 lines if take into account the transparency of the Earth atmosphere.

Acknowledgments

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