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Measurements of carbon monoxide above Venus' cloud top from IRTF/CSHELL observations

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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 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.

CO was detected above the clouds of Venus for the first time by Connes et al. near $2.3\,\mu$m, with a mixing ratio of about 45 ppmv. More recently, Irwin et al. 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. found 58 ± 17 ppmv near $2.3\,\mu\mathrm{m}$ on the dayside, whereas Krasnopolski 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). Following a methodology inspired from previous SO_2 observations, we have observed Venus using the high-resolution ($R = 41500$) spectrometer CSHELL between 4.53 to $4.54\,\mu$mat the IRTF (Mauna Kea, Hawaii) from 2012-08-25 until 2012-08-28 and 2013-10-31 to 2013-11-03, around the greatest western and eastern elongations of Venus.

Our main results (Marcq et al., submitted) 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 CO is increasing with increasing height, with a scale height of about 4 ± 1 km on the night side and 9 ± 0.5 km on the day side. This is consistent with a source of photochemical source of CO located at a higher altitude than the thermochemical sink of CO. (3) Our measurements indicate an increase with increasing latitude on the northern hemisphere day side, as well as with a steady decrease from local noon to local midnight. Both are consistent with previously identified trends, although our mean mixing ratio appears on the lower end of previous estimates. (4) Some high-altitude (~ 140 km) fluorescence of CO is also observed, especially near the subsolar point.

References

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[6] Marcq, E. et al., submitted to Plan. and Space Sci. (2014)