EPSC Abstracts
Vol. 6, EPSC-DPS2011-1487-2, 2011
EPSC-DPS Joint Meeting 2011

Water vapor in Titan's atmosphere observed with Cassini/CIRS data

V. Cottini (1), C. A. Nixon (1,2), D. E. Jennings (1), N. A. Teanby (3), R. de Kok (4), C. Anderson (1), P. G. J. Irwin (3), F. M. Flasar (1)
(1) Planetary Systems Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA (valeria.cottini@nasa.gov); (2) Department of Astronomy, University of Maryland at College Park, College Park, MD 20742, USA; (3)Atmospheric, Oceanic and Planetary Physics, University of Oxford, Oxford, OX1 3PU, UK; (4) SRON, Sorbonnelaan 2, 3584 CA Utrecht, Netherlands

Abstract

In this paper we show the detection of the water lines present in the spectral range (60 – 560 cm^{-1}) observed by the CIRS FP1 detector. The first estimate of water atmospheric abundance gives a value of about 0.14 ppb for a constant water vapour vertical profile, which corresponds to a water column abundance of $4.3x10^{14}$ molecules/cm^2. Using a water profile increasesing with altitude up to 10 ppb at 400 km altitude the retrieved column abundance is $5.8x10^{+14}$ molecules/cm^2.

1. Introduction

Water vapor in Titan's atmosphere has been detected only by whole-disk observations from the Infrared Space Observatory [2], as an early attempt to measure it with the NASA's Cassini Composite Infrared Spectrometer (CIRS, [4]) was unsuccessful [3], apparently due to poor signal-to-noise in early versions of the calibration pipeline.

CIRS, which has orbited Saturn since 2004, can sense water emissions in the far-infrared spectral region near 50 microns. This dataset is now able to provide information on water abundance and its distribution.

2. Data

Cassini-CIRS (Composite Infrared Spectrometer) Titan far infrared spectra are acquired by the Focal Plane 1 (FP1), which is one of the 3 detectors used by CIRS to measure the radiance in the spectral range 10 – 1400 cm^{-1}. To study the water features we focus on the FP1 FIRNADCMP high resolution (0.25 cm^{-1}) nadir data in the range 60 – 600 cm^{-1}.We average these data, acquired from December 2004 to June 2010 in three ~2 years long time periods and in 30 degrees of latitude. Further selection of acquisitions from a maximum distance of 300,000 km and a maximum emission angle of 70˚ are applied in order to avoid large projected footprints.

3. Method

The spectrum at the considered spectral range is characterized by a continuum due to (1) the thermal emission of the planet, (2) the collision induced absorption (CIA) of Titan main atmospheric molecules: N_2, CH_4, H_2 and (3) the stratospheric haze, slowly increasing with wavenumbers. In the spectrum are also present lines of the atmospheric gases absorbing in this spectral range: CH_4, CO, H_2O, HCN, C_4H_2, C_3H_4, C_2N_2, HC_3N.

These quantities (see Cottini et al., 2011 [1] for better description of the model) were used to perform a correlated-k computation of synthetic spectra (Figure 1) using a retrieval code (NEMESIS, developed in Oxford, [5]) based on the method of optimal estimation [6].

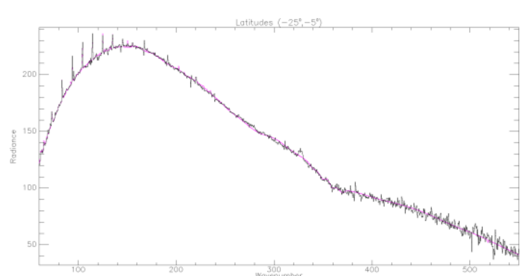

Figure 1: Average of CIRS FP1 data between -25 and 30 degrees of latitude (black) and fit (pink).

We were therefore able to retrieve the water vapor, using both constant water mixing ratio profile of 1 ppb and a model of variable mixing ratio, increasing with altitude from 0 to 10 ppm in the altitude range 90 – 400 Km.

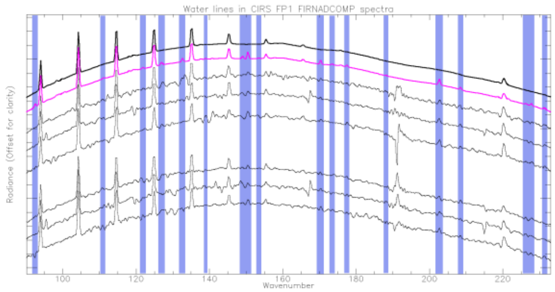

Figure 2: 6 averages of CIRS FP1 data (stacked and in black and thin line) and fit with water (pink) and without (in thick black). The blue vertical lines indicate the water lines positions.

6. Results and Conclusions

The spectrum in the considered spectral range is sensitive to the stratospheric water vapor with a sharp contribution function centered around 100 Km of altitude for (1) the constant water mixing ratio profile which becomes wider for the water profile (2) increasing with altitude.

For case (1) we retrieved an average value of the water vapor abundance from 0.13 to 0.16 ppb. Assuming a constant water mixing ratio of 0.14 ppb and integrating from a minimum pressure of 3.37×10^{-7} bar to a maximum pressure of 0.16×10^{-1} bar we obtain a correspondent water column abundance of 4.3×10^{14} molecules/cm^2, while for case (2) this value raise up to $5.8 \times 10^{+14}$ molecules/cm^2.

In future works we will use the limb data to constrain the water profile at two different altitudes (125 and 250 Km) and recompute the water abundance using an improved vertical profile.

Acknowledgements

VC is supported by the NASA Postdoctoral Program.

References

[1] Cottini, V., Nixon, C.A., Jennings, D.E., de Kok, R., Teanby, N.A., Irwin, P.G.J. and Flasar F.M., 2011. Spatial and temporal variations in Titan’s surface temperatures from Cassini CIRS observations. Planetary and Space Science, doi:10.1016/j.pss.2011.03.015

[2] Coustenis, A.; Salama, A.; Lellouch, E.; Encrenaz, Th.; Bjoraker, G. L.; Samuelson, R. E.; de Graauw, Th.; Feuchtgruber, H.; Kessler, M. F., 1998. Evidence for water vapor in Titan's atmosphere from ISO/SWS data. Astronomy and Astrophysics, v.336, p.L85-L89

[3] de Kok, R.; Irwin, P. G. J.; Teanby, N. A.; Lellouch, E.; Bézard, B.; Vinatier, S.; Nixon, C. A.; Fletcher, L.; Howett, C.; Calcutt, S. B.; Bowles, N. E.; Flasar, F. M.; Taylor, F. W. , 2007. Oxygen compounds in Titan's stratosphere as observed by Cassini CIRS. Icarus, Volume 186, Issue 2, p. 354-363

[4] Flasar, F. M., and 44 colleagues, 2004. Exploring the Saturn system in the thermal infrared: The Composite Infrared Spectrometer. Space Sci. Rev. 115, 169 – 297

[5] Irwin, P.G.J., Teanby, N.A., de Kok, R., Fletcher, L.N., Howett, C.J.A., Tsang, C.C.C., Wilson, C.F., Calcutt, S.B., Nixon, C.A., Parrish, P.D., 2008. The NEMESIS planetary atmosphere radiative transfer and retrieval tool. JQSRT, Vol. 109, pp. 1136-1150

[6] Rodgers, C. D., 2000. Inverse Methods for Atmospheric Sounding: Theory and Practice. World Scientific, Singapore