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Trace gaseous composition of Titan's stratosphere and quest for new molecules by using Cassini/CIRS spectra

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Abstract

The Cassini-Huygens mission has significantly revolutionized our knowledge about Titan, Saturn's largest satellite. The Composite Infrared Spectrometer (CIRS) on board Cassini probes Titan's stratosphere with its two interferometers over time with high spatial resolution and during several (up to 83) Titan flybys so far. It covers the spectral range 10 - 600 cm^{-1}, 600 - 1100 cm^{-1} and 1100 - 1400 cm^{-1}, divided into three focal planes 1 (FP1), 3 (FP3) and 4 (FP4) respectively [1].

We have gathered large averages of nadir spectral selections both in FP3 and FP4 for both medium (2.5 cm^{-1}) and high (0.5 cm^{-1}) resolutions from the beginning of the mission in July 2004 up to December 2011. The averages are binned over 10° in latitude over Titan's globe, with no longitudinal restrictions. The methane ν_4 band located at 1304 cm^{-1} allows us to retrieve vertical temperature profiles for each selection [2, 3]. The methane's mixing ratio is assumed to be at 1.48%, as derived from the recent reanalysis of the Huygens/Gas Chromatograph-Mass Spectrometer (GC-MS) *in situ* measurements [4]. We then import the temperature profile in our line-by-line atmospheric radiative transfer code (ARTT) and we retrieve the abundances of the trace gases and their isotopologues by a best-fit process of the FP3 data. ARTT has been recently upgraded by adding updated spectroscopic files for all molecules and their isotopologues from HITRAN 2008 and GEISA 2009 databases [5, 6] and aerosol distribution modeling from the refractive index of Titan's stratospheric aerosols [7]. In Fig. 1, we show the best fit of 2009 CIRS spectra at 50°N and the position of the trace gaseous species.

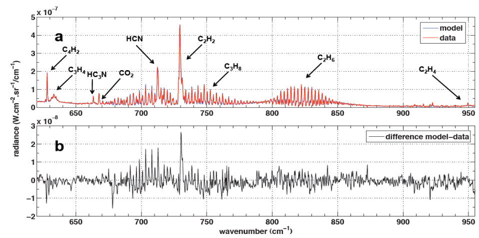

Figure 1: Fit of the 2009 all-year spectral average of CIRS spectra at 50°N in the whole FP3 region. 1306 spectra have been averaged at high resolution (0.5 cm^{-1}). The upper panel (a) shows the best fit (blue) obtained for the observed spectra (red). The major trace gases are also mentioned in the figure. The lower panel (b) depicts the difference between the model and the recorded data, which lie mostly within 3-σ error bars. The fit was obtained with constant-with-height abundances for all the molecules.

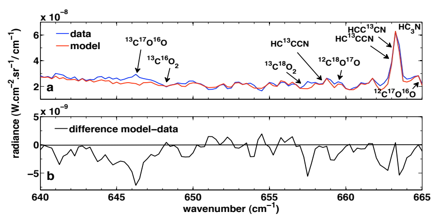

Figure 2: (a) Zoom of the previous fit of the 2009 annual spectral at 50°N average in high resolution. (b) Plot of the difference between the model and the data.

In this work, we present more precise mixing ratios of Titan's stratospheric traces gases and in particular of the weaker and less abundant species as well as of their isotopologues and also a comparison with previous inferences [8-15]. We also discuss the possibility of the existence of new species/isotopologues in very large FP3 CIRS nadir spectra.

Fig. 2 shows part of the spectra of CIRS/FP3 2009 average where the main molecules are fitted. In this plot, the carbon dioxide isotopes as well as the ones from cyanoacetylene are shown. $^{13}CO_2$ at 648.5 cm^{-1} has only been detected at a level of 6-σ by CIRS [16]. Similarly, $HC^{13}CCN$ and $HCC^{13}CN$ at 663.1 cm^{-1} are blended with HC_3N and their discrimination is difficult despite the CIRS high resolution [17]. We will give upper limits for these molecules.

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