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Study of volatile compounds in the atmosphere of Titan

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In Titan, the two major gases - dinitrogen (N_2) and methane (CH_4) are ionized and/or photolyzed at high altitudes by the sunlight and the energetic particles from Saturn's magnetosphere, resulting in rich atmospheric chemistry and a wide variety of carbon and nitrogen-bearing atmospheric compounds. In the present work, we focus on studying the vertical profiles of trace species in the lower atmosphere to obtain a better insight into the atmospheric processes taking place on Titan.

To do so, we reanalyzed the data from the Gas Chromatograph Mass Spectrometer (GCMS) onboard the Huygens probe which executed its mission on 14th January 2005. The GCMS instrument sampled for nearly three and a half hours from an altitude of 146 km. It recorded data for two and a half hours in the atmosphere of Titan, then landed on the surface and kept on recording for another hour, after which the signal was lost. We analyzed the measurements made by direct sampling of the atmosphere (Niemann et al. 2010). These mass spectra obtained at different altitudes and pressure levels have been recalibrated to account for deadtime and saturation corrections to the measurements, set boundary conditions for the species, and considered sensitivity measurements from Cassini-Ion and Neutral Mass Spectrometer calibrations. We then analyzed the corrected mass spectra using Monte-Carlo deconvolution simulations. The simulations allow us to vary the peak intensities of fragmentation patterns of known species, which usually bears uncertainties on this kind of data, and then use a least-square fitting to deconvolve the mixed signals (Gautier et al. 2020, Serigano et al. 2020, 2022).

We present our ongoing effort to retrieve minor compounds' mixing ratios using this approach. As an example, the vertical profile of one of the trace species ethane (C_2H_6), is shown in figure 1.

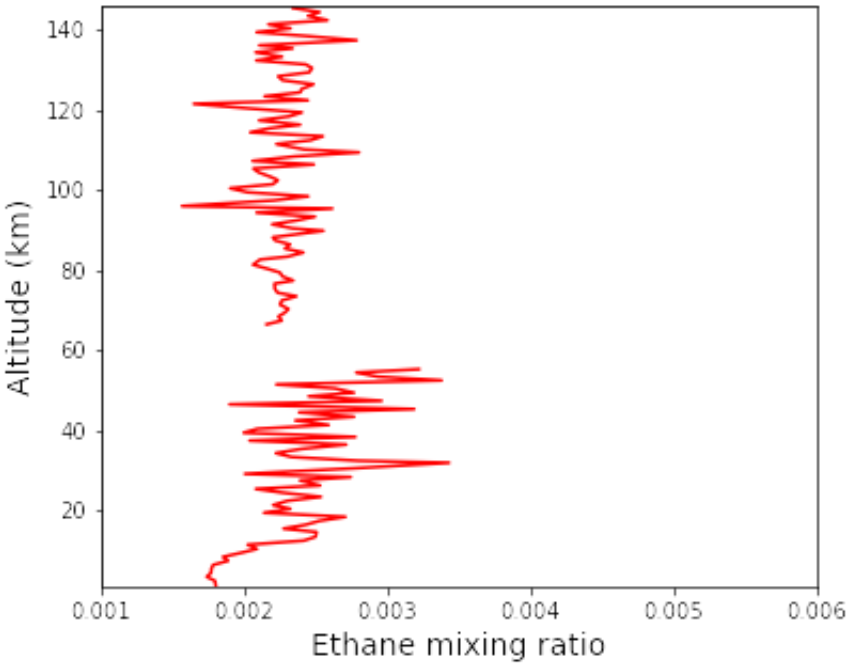

Figure 1: Preliminary vertical profile of ethane (C_2H_6) mixing ratio

In the future, we plan to extend this study to develop a sub-surface model of Titan which will help us understand the outgassing of methane that was observed by the probe upon its touchdown on the surface.

References:

Niemann et al. *Composition of Titan's lower atmosphere and simple surface volatiles as measured by the Cassini-Huygens probe gas chromatograph mass spectrometer experiment*. JGR 115, E12006, 2010

Gautier et al. *Decomposition of electron ionization mass spectra for space application using a Monte-Carlo approach.* Rapid. Com. Mass Spec. 34(8), e8659 (2020)

Serigano et al. *Compositional measurements of Saturn's upper atmosphere and rings from Cassini INMS*. JGR:Planets, 125 (8), E006427 (2020)

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