EPSC Abstracts
Vol. 11, EPSC2017-114-1, 2017
European Planetary Science Congress 2017
© Author(s) 2017

The seasonal evolution of organic chemistry in Titan's stratosphere from CASSINI/CIRS

A. Coustenis[1], D. E. Jennings[2], R. K. Achterberg[2,3], P. Lavvas[4], G. Bampasidis[5], V. Cottini[2,3], C. A. Nixon[2], F. M. Flasar[2]

[1]*LESIA, Observatoire de Paris, PSL-Research Univ., CNRS, Univ. Paris 6, Sorbonne Univ., Univ. Paris-Diderot, Sorbonne Paris-Cité, 5, 92195 Meudon Cedex, France;* [2]*NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA;* [3]*Department of Astronomy, University of Maryland, College Park, MD 20742, USA;* [4]*GSMA, Université Reims Champagne-Ardenne, France.;* [5]*Faculty of Physics, National and Kapodistrian University of Athens, Panepistimioupolis, 15783 Zographos, Athens, Greece.*

Abstract
In the past 5-6 years, we observe the onset and enhancement at Titan's south pole of several trace species such as HC3N and C6H6 previously observed only at high northern latitudes. This is due to the transition of Titan's seasons from northern winter in 2002 to (late) northern spring in 2012 and the advent of winter in the south pole, during which time species with longer chemical lifetimes remain in the north for a little longer undergoing slow photochemical destruction, while those with shorter lifetimes disappear, reappearing in the south. We will present an analysis of nadir spectra acquired by Cassini/CIRS at high resolution in the past years (Coustenis et al. 2016 and references therein) and new searches for more complex molecules in the compositionally enhanced polar regions.

1. Context/Data
Previously, trace gaseous species were found to be enhanced in Titan's North pole, but with the change in seasons and notably since 2012, a dramatic change is found close to the south pole, with a strong decrease in temperature and higher concentrations of gases and condensates. Meanwhile, gases transported north during the previous season remained concentrated around the north pole, undergoing slow photochemical destruction. Following the northern winter, species with longer chemical lifetimes should remain in the north for a little longer while those with shorter lifetimes disappear, reappearing in the south.

2. Analysis
We will present an analysis of spectra acquired by Cassini/CIRS at high resolution from 2010 onwards, in nadir mode [1]. We use a radiative transfer code adapted to Titan's atmosphere (ARTT, [1]) and we extract the temperature profile from the 7.7 micron methane band that we use then in the rest of the spectrum to solve for the abundances of trace gases and their isotopes in the FP3 and FP4 CIRS spectra.

3. Results
We find that as the Southern hemisphere moved into winter after 2010, strong temperature variations are observed essentially in the south pole. Small temperature differences were found for the mid and high northern latitudes. Differences in the 10-15 K range drop in temperature are found for the 50°S (left, full lines). Spectacular T drop by as much as 40 K in 70°S from 2010 to 2014. See [1] for more details. So that it is notable that we see more than 25° decrease in 2 years (2012-2014) near the South pole while at the North it took 3 years to gain 10 K since 2013.

Subsidence gases that accumulate in the absence of ultraviolet sunlight, increased quickly since 2012 and some of them may be responsible also for the haze decrease in the north and its appearance in the south at the same time [2]. For some of the most abundant and longest-lived hydrocarbons the evolution in the past years at a given latitude is not significant until mid-2013 [1]. But in more recent dates, these molecules show a dramatic trend for increase in the south. The 70°S and mid-latitudes show different behavior indicative of different dynamical processes in and out of the polar vortex region. While the 70°N data show generally no change with a trend rather to a small decrease for most species within 2014 the 70°S results indicate a strong enhancement in trace stratospheric gases after 2012. This is a strong indication of the rapid and sudden buildup of the gaseous inventory in the southern stratosphere during 2013-2014, as expected as the pole moves deeper into winter shadow. The limb spectra also show variations in time with altitude, with in particular, in early 2016, a zone depleted in molecular gas and aerosol in the entire northern hemisphere between 400 and 500 km, suggesting a complex unknown dynamical effect [3].

Subsidence gases that accumulate in the absence of ultraviolet sunlight, increased quickly since 2012 and some of them may be responsible also for the haze decrease in the north and its appearance in the south at the same time [4]. For some of the most abundant and longest-lived hydrocarbons the evolution in the past years at a given latitude is not significant until mid-2013 [1,2]. But in more recent dates, these molecules show a dramatic trend for increase in the south. The 70°S and mid-latitudes show different behavior indicative of different dynamical processes in and out of the polar vortex region.

Due to the rapid increase of trace gases in the South and the advantage of large spectral averages now available from CIRS measurements, we are in the process of searching for complex molecules predicted by photochemical models (by P. Lavvas) to exist in Titan's stratosphere (such as butane, acetonitrile, acrylonitrile, proprionitrile, etc) and not yet observed at all or with Cassini. We will describe the results and infer the possible highest degree of organic chemistry available on Titan.

4. Conclusion and future work

Following the northern winter, species with longer chemical lifetimes linger in the north while those with shorter lifetimes disappear, and reappear in the south. The northern composition decrease sets in only about 3 years after the South enhancement has began its dramatic increase

Where we have data, we search for signatures of weak gases in large spectral averages around the poles stratospheres and determine abundances and link to the upper atmosphere and better definition of chemical paths

We plan to search for condensate signatures of these weak gases to match with available data. We stress the need for reliable and complete spectroscopic data to analyse the observations both for gas and solids

This work helps set strong constraints on photochemistry and circulation models

The lack of observations of Titan's atmosphere near the poles begs for return to Titan with dedicated mission, after the upcoming end of the fabulous Cassini-Huygens mission in Sept. 2017 !!!!

References

[1] Coustenis, et al., Icarus 207, 461, 2010 ; Icarus, 270, 409, 2016 ; [2] Jennings et al., ApJ 804, L34, 5, 2015; [3] Vinatier et al. Icarus 250, 95, 2015.[4] Bampasidis et al., Astroph. J., 760, 144, 2012