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Complex organic chemistry in Titan's stratosphere near the poles from Cassini/CIRS

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We witness since 2010 the appearance at Titan's South pole of several trace species for the first time, in particular for complex hydrocarbons such as HC3N and C6H6, observed previously only at high northern latitudes. Moreover, since 2012 this situation has rapidly evolved with a strong enhancement of some gases and condensates in the South pole (Coustenis et al. 2010; 2016; Vinatier et al. 2015; Jennings et al. 2015). 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 this time, the reversal of Titan's main atmospheric circulation cell is expected to channel fresh photochemical products from mid latitudes towards the South pole. Meanwhile, gases transported north during the previous season remain 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. We will present an analysis of spectra acquired by Cassini/CIRS at high resolution in nadir mode. We investigate here latitudes poleward of 50°S and 50°N since the Southern Autumnal Equinox. 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 (Jennings et al. 2015). 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 (Coustenis et al. 2016). But in more recent dates, these molecules show a dramatic trend for increase in the south, by several orders of magnitude in some cases (as for C6H6 and HC3N). 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. This finding applies both for nadir and for limb spectra. Subsidence gases that accumulate in the absence of ultraviolet sunlight, evidently increased quickly since 2012 and some of them may be responsible also for the reported haze decrease in the north and its appearance in the south at the same time (Jennings et al. 2015). We will describe here a search for complex molecules predicted by photochemical models to exist in Titan's stratosphere and not yet observed at all or with Cassini (such as butane, acetonitrile, acrylonitrile, proprionitrile, etc).
References: Coustenis, et al., Icarus 207, 461, 2010 ; Coustenis et al. 2016, Icarus, 270, 409, 2016 ; Jennings et al., ApJ 804, L34, 5, 2015; Vinatier et al. Icarus 250, 95, 2015.