On the observational constraint on time and spatial variation of Titan's atmospheric trace gases driven with the ALMA solar system big-data

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Titan's atmosphere is characterized by the presence of the number of trace gases such as hydrocarbons and nitriles produced with complex photochemical processes. Cassini spacecraft, which completed its works in 2017, has played an important role to illustrate the dynamic variation of the trace gases. For example, on the high-latitudinal region of the southern hemisphere, both hydrogen cyanide (HCN) and benzene (C_6H_6) exhibited ~1000 times enhancement of their atmospheric abundances from 2011 to 2015 (Coustenis et al. 2016). For the understanding of complicated photochemical processes of Titan, long-term observation of the spatial distribution of such trace gases are crucial.

ALMA is a suitable tool for that purpose. We have constructed a large spectroscopic data-set of Titan's trace gases by converting ALMA's archival data obtained for the calibration purpose into the scientific data known as "FITS cube", which contains calibrated spectra in each 2-D image pixels. Extracted number of Titan's FITS data is more than 3000. Many trace gases such as carbon monoxide (CO), HCN, acetonitrile (CH_3CN), cyanoacetylene (HC_3N) and their isotopologues and other complex molecules are detected clearly. For the illustration of the time distribution, spectral intensity distribution maps of all detected species were produced.

From the analysis of the spectral intensity distribution map, from mid 2015, intensities of HC_3N measured on southern hemisphere is stronger than that of northern hemisphere. In turn, northern hemispheric CH_3CN and HCN intensities are still stronger than that of south in 2015 and 2017, respectively. Newly found difference of the time variation between the nitriles possibly reflects their photochemical production/destruction timescale against the seasonal variation of UV influx and atmospheric circulation. Currently, we are attempting to develop the semi-automated atmospheric retrieval code to reproduce the 3-D distribution of trace species to constrain the photochemical processes.

Keywords: Titan, ALMA, Planetary atmosphere

