ALMA Observations of Titan's Dynamic Atmosphere into the Post-Cassini Era

*Alexander E Thelen[1], Martin A Cordiner[1], Conor A Nixon[1], Steven B Charnley[1], Zbigniew Kisiel[2], Patrick G J Irwin[3]

1. NASA Goddard Space Flight Center, 2. Polish Academy of Sciences, 3. University of Oxford

Saturn's largest moon, Titan, experiences long seasonal cycles (~29.5 yr) that can be traced through variations in its atmospheric composition and dynamical state. Roughly half of Titan's seasonal cycle has been observed throughout the Cassini-Huygens mission, primarily through the infrared emission of many molecular species formed by Titan's N_2 and CH_4-based atmospheric photochemistry. During Titan's northern spring and summer, the Atacama Large Millimeter/submillimeter Array (ALMA) provides a means by which to study seasonal variations in Titan's atmosphere through its high spatial resolution capabilities and coverage of numerous rotational transitions of the trace hydrocarbon (C_XH_Y) and nitrile ($C_XH_Y[CN]_Z$) species produced in Titan's atmosphere. Here, we present the new results in the investigation of Titan's atmospheric dynamics and composition during its northern summer solstice and into the post-Cassini era.

ALMA observations of Titan in May 2017 with moderate spatial resolution (~0.2") enabled mapping of atmospheric thermal structure and composition from the stratosphere through the mesosphere (~100 - 800 km) with latitude. By employing radiative transfer analysis, we found variations in temperature by up to 15 K and up to an order of magnitude in nitrile species abundances. ALMA's high spectral resolution also permits the measurement of Doppler shifts in molecular transitions, translating directly to line-of-sight wind speeds; through various chemical species, we found wind speeds significantly decreased in Titan's upper atmosphere (700 - 1000 km) since 2015. Finally, we present the preliminary results of our investigation into isotopic and previously undetected species in recently acquired data from late 2019. Through these observations and the ongoing use of submillimeter facilities such as ALMA, we may continue to monitor Titan's dynamic atmosphere throughout its full seasonal cycle.

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