



HAL
open science

Ground-based monitoring of atmospheric species on Titan and a search for new nitriles with IRTF/TEXES

Athena Coustenis, Therese Encrenaz, Thomas Greathouse, David Jacquemart, Conor Nixon, Panayotis Lavvas, Rohini Giles, Nicholas Lombardo, Bruno Bezard, Krim Lahouari, et al.

► To cite this version:

Athena Coustenis, Therese Encrenaz, Thomas Greathouse, David Jacquemart, Conor Nixon, et al.. Ground-based monitoring of atmospheric species on Titan and a search for new nitriles with IRTF/TEXES. Europlanet Science Congress 2024, Sep 2024, Berlin, Germany. 10.5194/epsc2024-96. hal-04774719

HAL Id: hal-04774719

<https://hal.science/hal-04774719v1>

Submitted on 28 Nov 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



Ground-based monitoring and search for new species in Titan's atmosphere

Athena Coustenis¹, Therese Encrenaz¹, Thomas K. Greathouse², David Jacquemart³, Conor Nixon⁴, Panayotis Lavvas⁵, Rohini Giles⁶, Nicholas Lombardo⁷, Bruno Bezard¹, Krim Lahouari³, Pascale Soulard³, Benoit Tremblay³, Sandrine Vinatier¹, Antoine Jolly⁸, and Brendan Steffens⁹

¹Paris Observatory, CNRS, PSL Univ., LESIA, Meudon, France (athena.coustenis@obspm.fr)

²Southwest Research Institute, San Antonio, TX 78232, USA

³MONARIS, Sorbonne Université, CNRS, 75005 Paris, France

⁴Planetary Systems Lab., NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

⁵GSMA, Université Reims Champagne Ardenne (URCA), Reims, France

⁶SWRI, Southwest Research Institute, Boulder, CO 80302 USA

⁷Dept of Earth and Planetary Sciences, Yale Univ., New Haven, CT, USA

⁸LISA, Univ. Paris XII—Val de Marne et Paris VII, 94010 Créteil Cx, France

⁹Max Planck Inst. for Chemistry, Hahn-Meitner-Weg 1, Mainz, 55128, Germany

Titan's organic chemistry has been partly revealed from Cassini-Huygens and recent ground-based observations so far, but the full degree of its complexity is not yet fully understood (e.g. Coustenis, 2021; Nixon, 2024). Several hydrocarbons and nitriles have already been detected in the atmosphere and their seasonal variations studied in particular by the CIRS instrument aboard Cassini. Other minor species have been detected from the ground mainly in the millimeter range or space-borne observatories like ISO (Coustenis et al., 1998). These results have been included in photochemically models (Lavvas et al. 2008, and this work) that have also predicted the presence of other minor species, among which some have infrared transitions in the 5-25-mm spectral range, where propane (C_3H_8) and allene (CH_2CCH_2) have already been detected. We have started an observing campaign using the TEXES thermal infrared imaging spectrometer at the Infrared Telescope Facility (Mauna Kea Observatory) to monitor the infrared signatures of hydrogen cyanide (HCN) and cyanoacetylene (HC_3N), along with acetylene (C_2H_2 and C_2HD). In addition, we have been searching for cyanopropyne (C_4H_3N) and isobutyronitrile (C_4H_7N) in the 20-micron region. High-resolution spectra of Titan have been obtained in September 2022 in the following spectral ranges: (1) $498-500\text{ cm}^{-1}$ (C_2HD , HC_3N , search for C_4H_3N); (2) $537-540\text{ cm}^{-1}$ (C_2HD , search for C_4H_7N); (3) $744-749\text{ cm}^{-1}$ (C_2H_2 , HCN); (4) $1244-1250\text{ cm}^{-1}$ (CH_4). Data are presently under reduction and preliminary results presented (Coustenis et al., 2023). In 2023, laboratory spectra of cyanopropyne and isobutyronitrile have been recorded in the $495-505\text{ cm}^{-1}$ and $510-570\text{ cm}^{-1}$ spectral ranges, respectively, with a spectral resolution of 0.01 cm^{-1} and 0.056 cm^{-1} by our team (Jacquemart et al., in preparation). Cross sections have been derived for these two molecules and upper limits will be derived for these two molecules in the atmosphere of Titan. TEXES data will also be used for a study of the variations of HCN and HC_3N since the end of the Cassini mission, and for a retrieval of D/H from C_2HD/C_2H_2 . We now plan to use the TEXES instrument in conjunction with other larger telescopes in order to optimize the search range and to acquire detection or upper limits for some of these new molecules. We are also exploring Cassini/CIRS data to check for possible new detections

or for establishing an upper limit to some of the nitriles.

References

- Coustenis, A., 2021. "The Atmosphere of Titan". In Read, P. (Ed.), Oxford Research Encyclopedia of Planetary Science. Oxford University Press. doi:<https://doi.org/10.1093/acrefore/9780190647926.013.120>
- Nixon, C. A., 2024. The Composition and Chemistry of Titan's Atmosphere. ACS Earth and Space Chemistry 2024 8 (3), 406-456. DOI: 10.1021/acsearthspacechem.2c00041
- Coustenis, A., Salama, A., Lellouch, E., Encrenaz, Th., Bjoraker, G., Samuelson, R. E., de Graauw, Th., Feuchtgruber, H., Kessler, M. F., 1998. Evidence for water vapor in Titan's atmosphere from ISO/SWS data. Astron. Astrophys. 336, L85-L89.
- Lavvas, P., Coustenis, A., Vardavas, I. M., 2008. Coupling photochemistry with haze formation in Titan's atmosphere. Part I: Model description. Plan. Space Sci. 56, 27-66.
- Coustenis, A., Nixon, C. A., Encrenaz, Th., Lavvas, P., 2023. Titan's chemical composition from Cassini and ground-based measurements. IUGG 2023, Berlin, Germany, 11-20 July.