EPSC Abstracts
Vol. 9, EPSC2014-553, 2014
European Planetary Science Congress 2014

Titan's South Polar Cloud

D. Toledo (1), P. Rannou (1) , R. A. West (2), P. Lavvas (1), A.D. Del Genio (3), J. M. Barbara (3), M. Roy (2) and E. P. Turtle (4)
(1) GSMA, Université de Reims, France, (2) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA, (3) NASA Goddard Institute for Space Studies, New York, USA, (4) Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland, USA, (daniel.toledo-carrasco@etudiant.univ-reims.fr)

Abstract

Cassini/ISS cameras detected a newly formed large cloud in the south polar region of Titan on 2012-178 (June 27). Images of this cloud in the continuum filters at 889 nm (MT3) and 935 nm (CB3) clearly reveal different characteristics relative to the 'detached haze' layer that extends over all south latitudes. **Figure 1** shows I/F at 889 nm, where the cloud patch is observed beyond the latitude -77º and with values of the SZA higher than 90º. In this work, we analyze different MT3/CB3 images taken by ISS cameras, in order to characterize the optical properties of this cloud as well as its altitude. We first analyze images in the MT3 filter at different angles of observation in order to have some constraints on the altitude of the cloud, and subsequently the cloud optical properties are estimated by using radiative transfer simulations.

1. Description of the model

The cloud simulation requires the use of the full three-dimensional radiative transfer model in spherical geometry since the plane-parallel approximation breaks down for the high SZA values observed in latitudes where the cloud is localized.
To model the outgoing intensity, we first use the source function computed in the atmosphere including the effect of haze and methane, but without cloud. Then, we add the cloud as a lower boundary condition, with a specific term of scattered intensity. We then re-integrate the radiative transfer equation from the cloud level to the top of the atmosphere to obtain outgoing intensity in the presence of the cloud. Doing that, the cloud is treated as an additive term.

Source function at each atmospheric level is obtained by using a Monte-Carlo radiative transfer model in spherical geometry. The haze optical properties are taken from Tomasko et al. (2008), and the methane absorption is taken from the band model of Karkoschka and Tomasko (2012). The phase function and single scattering albedo of the cloud are calculated by the Mie theory. The effective size of particles is allowed to vary between 3 µm and 5 µm, whereas the effective variance is fixed at 0.2.
As the south pole moves into winter a large number of gaseous species are expected to condense more efficiently, as was observed in the winter north pole. Cassini CIRS observations demonstrate that the abundances of HCN (and other hydrocarbons) are increasing in this part of the atmosphere due to the changes in the atmospheric circulation (Vinatier et al. 2013). HCN will be the first among the most abundant species that will condense, due to its low saturation vapour pressure. Hence, in our calculations we assume that the observed cloud is formed by the rapid condensation of the increased abundance of HCN in this region. Therefore, we assume in our calculations that the cloud particles have the real refractive index of the HCN ice, while for the imaginary part, due to lack of information, we test values between 10^{-2} and 10^{-4}.

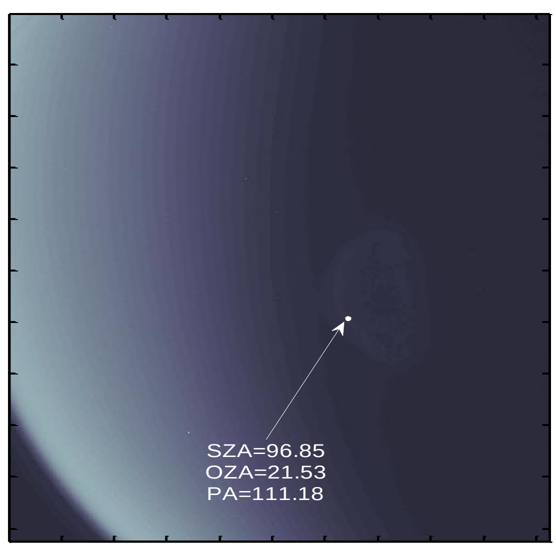

Figure 1*: I/F in the methane MT3 filter using image N1719446402. The numbers provide the solar zenith angle (SZA), the observing zenith angle (OZA), and the phase angle (PA) for the specific geometry.*

2. Main results

Figure 2 shows the variation of upward intensity at the top of the cloud as a function of the cloud optical depth, for different values of both, the effective radius (r=3 and r=5 µm) and the imaginary part of the refractive index ($k=10^{-2}$, $k=10^{-3}$ and $k=10^{-4}$).

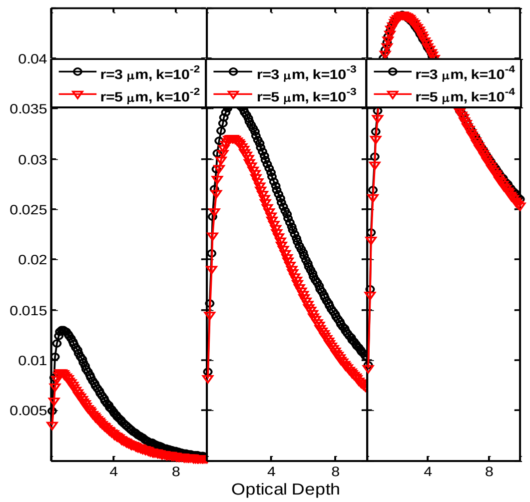

***Figure 2**: Variation of the cloud source function with the optical depth for different properties of the cloud.*

Figure 3 shows the variation of I/F simulated in the MT3 filter as a function of the cloud altitude and for a value of the cloud optical depth equal to 1. The angles of observation are indicated in **Figure 1**. The continuous line represents the value of I/F given by the image for these angles of observation.

Results show that a cloud with $k > 10^{-2}$ can not give the correct observation. With low values of k ($k < 10^{-3}$), we find that the altitude of the cloud is around 300 km while cases with intermediate values ($k \sim 10^{-3}$ - 10^{-2}) are consistent with all the possible altitudes above 300 km. An independent estimation of the cloud altitude comes from other images taken in the MT3 filter at Titan's limb, which clearly show that the top of the cloud is at or near 300 km Therefore, by fixing the altitude of the cloud at 300 km, we are now able to give constraints on the optical and physical properties of this cloud (droplet size, optical constants, and opacity). We find, for instance, that the optical depth of the cloud can only take values between 0.9 and 5.5, and that k values must be below 10^{-2}.

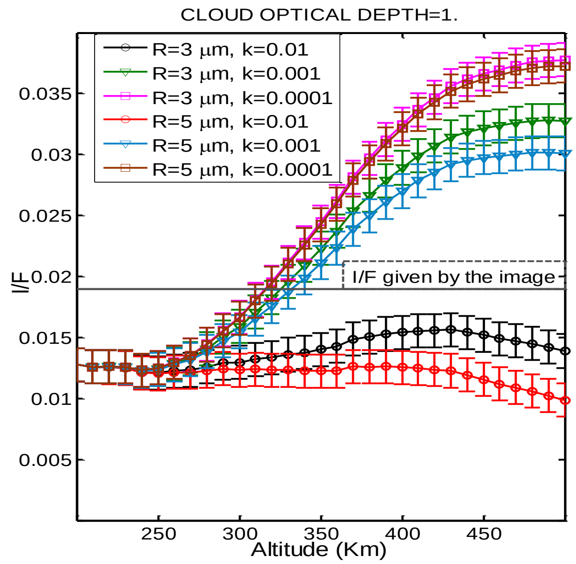

***Figure 3:** I/F as a function of the cloud altitude for different properties of the cloud. The observed I/F at the top of the atmosphere is shown with the horizontal line.*

References

[1] Tomasko et al., "A model of Titan's aerosols based on measurements made inside the atmosphere ", *Planet. & Space Sci*. 56, 669–707, (2008).

[2] Karkoschka and Tomasko., "Methane absorption coefficients for the jovian planets from laboratory, Huygens, and HST data", *Icarus* 205, 674–694, (2010).

[3] Vinatier et al., "Seasonal variations in Titan's stratosphere observed with Cassini/CIRS: temperature, trace molecular gas and aerosol mixing ratio profiles", *European Planetary Science Congress (EPSC)*, London, United Kingdom (2013).