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Possible evidence of seasonal variation in Titan's tropospheric methane distribution from Cassini radio occultation data

T. Tokano (1)
(1) Institut für Geophysik und Meteorologie, Universität zu Köln, Köln, Germany (tokano@geo.uni-koeln.de / Fax: +49-221-4705198)

Abstract

The retrieval of Titan's atmospheric surface pressure from Cassini radio occultation data is sensitive to the tropospheric methane abundance, whose latitudinal distribution is not precisely known. For all available radio occultation datasets, we calculate the surface pressure under various hypothetical global methane distributions in an effort to constrain combinations of the global distribution of surface pressure and tropospheric methane abundance, which are meteorologically plausible. The Cassini data definitely rule out that the surface pressure and tropospheric methane abundance are globally uniform, so that a latitudinal variation in at least surface pressure or methane abundance is implied. The most internally consistent pair of surface pressure and methane abundance consists of a lower surface pressure and higher methane abundance in the summer hemisphere compared to the winter hemisphere. This is possible evidence of seasonal variation in the tropospheric methane distribution and may be a result of condensation and global methane transport across the equator by the meridional circulation.

1. Introduction

The global distribution of methane in Titan's troposphere is a fundamental piece of information for our understanding of Titan's methane hydrological cycle, along with observations of clouds and surface appearance. The methane abundance in Titan's troposphere is precisely known at the Huygens entry site [1]. The methane humidity in the equatorial region may not have changed between the Voyager and Huygens era [2]. On the other hand, previous analyses of thermal and near-infrared spectra indicated the possibility of some latitudinal variations in the tropospheric methane abundance [3, 4].

This study addresses the question as to the surface pressure data from Cassini radio occultation experiments [5, 6], whose retrieval is sensitive to the tropospheric methane distribution, can be used to constrain the likely tropospheric methane distribution on Titan. This would also constrain the meridional circulation pattern in the troposphere.

2. Surface pressure data from Cassini

Cassini radio occultation experiments yielded vertical atmospheric profiles at several places across Titan [5, 6]. Since the surface at different places is located at different altitudes above the equipotential surface ('sea level') the surface pressure has to be barometrically corrected to the sea level. The sea-level pressure obtained in the previous season generally increases from north to south, i.e. from winter to summer, by ~15 hPa if a globally uniform atmospheric composition is assumed. However, such a latitudinal profile is difficult to reconcile with the observed seasonal timing of convective clouds since the pressure data would indicate a high pressure at the summer pole, where most clouds were observed. Convective clouds along the seasonal convergence zone require a surface low pressure instead. Furthermore, this latitudinal surface pressure gradient is much larger than and opposite to that predicted by the Cologne Titan GCM (Fig. 5 of [7]).

3. The case for a methane abundance variation with latitude

The retrieved surface pressure would change if a non-uniform global methane distribution is assumed. We recalculate the Cassini surface pressure assuming different, meteorologically plausible global methane distributions. The Cassini radio occultation data definitely rule out that the surface pressure and tropospheric methane mole fraction are both globally uniform and seasonally invariant. This means that there is at least a latitudinal variation in the surface pressure or methane abundance. While several pairs of the latitudinal profile of surface pressure and methane abundance can theoretically explain the radio occultation data, most of them are meteorologically inconsistent. The only meaningful pair of surface pressure and methane abundance consistent with the Cassini data exhibits a latitudinal profile with a higher methane abundance and lower surface pressure in the southern (summer) hemisphere compared to the northern hemisphere. Given the paucity of lakes near the south pole it appears rather unlikely that the inferred high methane abundance near the south pole is a perennial feature caused by Titan's geography. A more natural explanation is that methane is transported near the surface from the winter hemisphere to the summer hemisphere by cross-equatorial Hadley-like meridional circulation as predicted by a global circulation model [8].

Acknowledgements

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References

[1] Niemann, H. B., et al.: Composition of Titan's lower atmosphere and simple surface volatiles as measured by the Cassini-Huygens probe gas chromatograph mass spectrometer experiment, J. Geophys. Res., Vol. 115, E12006, 2010.

[2] McKay, C. P., et al.: Comparing methane and temperature profiles on Titan in 1980 and 2005, Planet. Space Sci., Vol. 57, pp. 1996-2000, 2009.

[3] Samuelson, R. E., Nath, N. R., and Borysow, A.: Gaseous abundances and methane supersaturation in Titan's troposphere, Planet. Space Sci., Vol. 45, pp. 959-980, 1997.

[4] Penteado, P., et al.: Latitudinal variations in Titan's methane and haze from Cassini VIMS observations, Icarus, Vol. 206, pp. 352-365, 2010.

[5] Schinder, P. J., et al.: The structure of Titan's atmosphere from Cassini radio occultations, Icarus, Vol. 215, pp. 460-474, 2011.

[6] Schinder, P. J., et al.: The structure of Titan's atmosphere from Cassini radio occultations: occultations from the Prime and Equinox missions, Icarus, Vol. 221, pp. 1020-1031.

[7] Tokano, T.: Are tropical cyclones possible over Titan's polar seas? Icarus, Vol. 223, pp. 766-774, 2013.

[8] Tokano, T.: Impact of seas/lakes on polar meteorology of Titan: simulation by a coupled GCM-sea model. Icarus, Vol. 204, pp. 619-636, 2009.