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The atmospheric vertical structure in the Saturn polar hexagon: Insights from Cassini and ground-based data in the visible and near-infrared

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Abstract

Saturn's polar hexagon is a very stable atmospheric feature discovered by the Voyager spacecraft at the boundary of the northern polar cap. Many studies have been devoted to the measurement of wind speed across this structure, but detailed quantitative retrievals of atmospheric parameters and their vertical distribution is actually missing. We will report a work in progress based on the analysis of data from Cassini (VIMS, ISS) and ground-based observations (IRTF-SpeX). We will mainly focus on the variations of clouds and hazes vertical profiles and microphysics, and those of the abundances of trace gases to which the near-infrared wavelengths are sensitive (phosphine, ammonia, CH3D, water, etc.). These quantities can also be used as tracers of atmospheric motions and can help in constraining a comprehensive dynamical framework.

1. Introduction

The northern latitudes of Saturn host a remarkable atmospheric structure which survived exceptionally stable for at least the 30 years passed since the Voyager encounter: the polar hexagon, which marks the boundary of the northern polar cap at a latitude of about 75°N. When the Cassini spacecraft reached the Saturn system, allowing unprecedented investigations of the atmosphere in terms of spatial resolution and coverage, the regions poleward of about 80N were in permanent night, and new information about the polar cap only came from thermal and non-LTE emissions. These studies allowed comprehensive descriptions of the atmospheric thermal field in the troposphere and stratosphere by means of mid- and far-infrared wavelengths (Cassini-CIRS [1]) as well as the measurement of tropospheric wind velocities by tracking the motion of the deeper small discrete clouds revealed by Cassini-VIMS [2] in the 5 micron window [3]. Dynamical implications were deduced from these investigations (e.g. the confirmation of a stable jet stream embedded in the hexagon track [4]) and moderate seasonal trends were inferred from temperatures retrieved passing the 2009 northern spring equinox [5].

The better and better illumination condition taking place by approaching the next 2017 northern solstice makes very effective the investigation of atmospheric properties by means of reflected sunlight spectroscopy, in the whole UV to near-infrared spectral range. This kind of observations are mostly devoted to the measurement of radiative absorption by atmospheric gases and anisotropic scattering by gases and particulates. They are made very sensitive to the vertical distribution of atmospheric components in the tropo-stratosphere by the very large spectral variation of the methane absorption coefficient in this spectral range.

However, recent studies of the polar hexagon in reflected light (using VIMS [3] and ISS [6] data) were mainly devoted to describe the horizontal motions and the meridional wind profile, while a comprehensive inclusion of the changes in vertical structure and vertical motion tracers (minor gases and particulates) is still lacking.

2. Data and methods

The primary dataset useful for our investigation is that of Cassini-VIMS. We have searched the VIMS data relative to the polar hexagon in order to select a set of observations covering a wide range of observing conditions and times. Particular attention has been paid to observations at high solar phase angle, since spatial and temporal changes in vertical distribution are more evident in forward scattering configurations.

VIMS data usually offer good spatial resolution at Saturn due to the close observing range, but on the other hand suffer of a moderate spectral resolution (about 17 nm in the IR). Ground-based observations of Saturn at NASA-IRTF Telescope at Hawaii have been acquired in the last months, using the SpeX spectrograph, in order to achieve a better understanding of the VIMS spectra in the 3-4 micron range. Thanks to the higher spectral resolution of this instrument (about 11 times the VIMS one) we are able to investigate subtle changes in the methane bands shape and discriminate the effects of variations of temperature and vertical cloud structure.

Plane-parallel multiple-scattering 1D radiative transfer models have been used to explore the dependencies of spectral variations through sensitivity studies, and to retrieve the most significant atmospheric parameters. Retrievals are based on both chi-square best fit and Bayesian inversion approaches [7].

3. Summary and Conclusions

Here we will report about in progress investigations of spectral data (both from spacecraft and ground-based) covering the Saturn's polar hexagon in different times and observing conditions, aimed to describe the distribution of particulates at the upper troposphere-lower stratosphere altitudes. The retrieved quantities can put further constraints to the dynamical framework of the hexagon. The synergistic use of data from several instruments (e.g. Cassini-VIMS , Cassini-ISS, and ground-based) is expected to strengthen the outcomes of retrieval models at all latitudes and hence also improve our understanding of Saturn's atmospheric dynamics and seasonal changes.

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