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Haze and clouds properties of Saturn's 2011 giant vortex retrieved from Cassini VIMS-V data.

F. Oliva (1), A. Adriani (1), M. L. Moriconi (2), G.L. Liberti (2), E. d'Aversa (1).
(1) INAF-IAPS, Rome, Italy (fabrizio.oliva@iaps.inaf.it), (2) CNR-ISAC, Rome, Italy

Abstract

This work is focused on the retrieval of the microphysical and geometrical properties of the clouds and hazes overlying the giant vortex observed in 2011 at Saturn, by the *Visual and Infrared Mapping Spectrometer* (VIMS) on board of Cassini. The retrieval algorithm is based on the optimal estimation technique [15] and takes advantage of a forward radiative transfer model developed by adapting the *LibRadtran* code [13] to the atmosphere of Saturn. For each of the retrieved parameters - that are effective radii, top pressures and total number densities for each considered deck – a 2D spatial map has been produced.

1. Introduction

On December 2010 a huge storm erupted in Saturn's North springtime hemisphere [6,8,17]. A giant vortex formed in the storm wake and persisted after its principal outburst exhausted on July 2011 [9]. The vortex has been imaged several times by VIMS, starting from May 2011, and it was still present in the December 2012 observations. VIMS is a multi-channel hyperspectral imaging spectrometer, consisting of an IR-channel ranging from 0.85 to 5.1 μm and a VIS-channel operating in the wavelength range 0.3 – 1.05 μm. The VIS-channel (VIMS-V), whose data are being used in this analysis, has a nominal spectral resolution of 7.3 nm and a nominal angular resolution of 500 μrad [4]. So far, the vertical structure of the clouds and hazes above the vortex has been only qualitatively addressed [18]. Here we present a quantitative analysis, that allows to make comparisons between the results previously obtained by other authors for different regions and dynamic contexts of Saturn's atmosphere [10,14], and the ones obtained in this study, relative to the vortex.

2. Analysis

In the VIMS-V wavelength range, four main gases are responsible for absorption in Saturn's atmosphere, and have therefore been considered in our model: H_2 [5], He [5], CH_4 [7,11] and H_2O [7,16]. The first two gases are responsible for the Collision Induced Absorption (CIA) by the H_2-H_2 [1] and H_2-He [2,3] interactions. The forward model we have developed relies on the following assumptions: plane parallel atmosphere, multiple scattering discrete ordinate solver DISORT [20], Mie theory to compute single scattering properties of clouds and haze components, Rayleigh scattering adapted to Saturn's atmosphere. Scenarios including up to 4 clouds have been tested to describe the clouds and haze stratifications. For each cloud/haze type different sets of microphysical properties have been used to represent scatterers. In stratosphere and in the upper troposphere, towards the tropopause, we used a "grey" component, whose refractive index has the real part constant (1.4) in the considered spectral range and the complex part fixed on a 0.015 value at 300 nm and then scaled with a power law for increasing wavelengths [10]. These two "grey" decks, have turned out to be always necessary to correctly reproduce the observed spectra. We tried also configurations with a deeper ammonia ice cloud [12] with base pressure greater than 1 bar, or coated particles layers [19] just below the tropospheric "grey" deck, but we verified that these additional layers are not really necessary to obtain reliable fits, very likely due their low contribution to the upwelling radiances. We used the forward model to find reasonable background values for the free parameters, to be used as starting state vector in the retrieval process. The inversion algorithm is then applied to obtain the best fits to the observations, by means of a least square analysis between observed and simulated radiance spectra. We have run the retrieval process on a region more than 200 pixels wide, and we have produced spatial maps for each parameter: this has allowed to find correlations between our results, and the structures evident at different wavelengths, and therefore at different altitudes in the atmosphere.

3. Conclusions and future work

The inversion algorithm developed for this study has been applied on a single observation of Saturn's 2011 giant vortex, dated August 2011. The differences between our results and the ones obtained by other authors, seem to suggest different atmospheric processes behind the regions studied. Now that the vortex vertical structure has been mapped our next step is to e extend this study to the successive VIMS observations, to track the temporal evolution of the vortex through that of the parameters identifying it. Moreover, the extension of the model toward the IR range (VIMS-IR channel), is also planned to complete the vertical structure model study deeper in the atmosphere, taking advantage of the thermal part of the spectrum.

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