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Vertical cloud structure of Saturn's Great Storm 2010

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Abstract

In December 2010, a small storm emerged in Saturn's temperate latitudes. Although it could initially be considered as a small-scale seasonal phenomenon, in the following weeks it grew up to become a planetary scale phenomenon. This kind of process is known to happen in Saturn every 20 to 30 years and it is usually referred as a Great White Spot (GWS). In this work we present an analysis of the vertical cloud structure in the upper bar of the atmosphere as inferred from ground-based and Cassini ISS observations in the near ultraviolet to near infrared spectral range. The results show a central nucleus towering over its surrounding and a number of peculiar structures associated to the intense storm dynamics.

1. Introduction

By the time the 2010 GWS was starting to develop the previous 1990 GWS [6] remained as the best characterized of such events. In the context of this work, the vertical cloud structure in the upper troposphere and lower stratosphere was also retrieved from ground-based observations [1]. The hazes and upper clouds in the Equatorial band were seen to be substantially higher and thicker than the surrounding latitudes [5], a configuration that lasted for years [4].

The 2010 GWS was witnessed with unprecedented spectral and spatial detail, including radio emissions [2]. The 2010 GWS was demonstrated to have a profound impact on the atmospheric thermal structure [3] and be linked to the general flow below the observable level [7].

In this work, we use observations from ground-based telescopes and from the Cassini ISS camera onboard the Cassini spacecraft to characterize the observed reflectivity in the visual wavelengths. Reproducing the dependence of reflectivity on geometry and wavelength we are able to retrieve the vertical cloud structure of hazes and aerosols above the 1 bar level.

2. Observations

The first set of observations used in this work were taken from Pic-du-Midi (France) and Calar Alto (Spain) observatories using using 1-m and 2-m class telescopes. Those observations [8] have a low spatial resolution (around 5,000 km/pix) but cover a number a increasingly deep methane bands, therefore allowing to sound different atmospheric levels at the same time. These images were taken December 2010 and January 2011.

The second set of observations has a much greater spatial resolution but it covers a more limited number of filters. Observations were taken on December 5, 23 and 24, 2010 and on February 26, 2011.

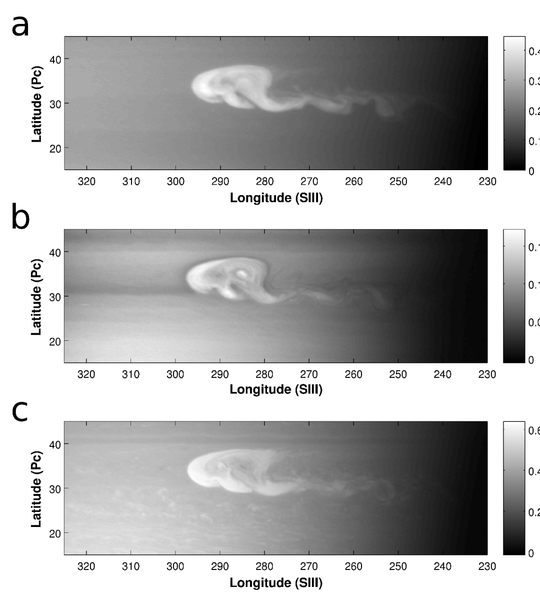

Figure 1: Cassini ISS December 24 sample observations: (a) blue BL1 filter; (b) intermediate methane band MT2 filter; and (c) adjacent continuum CB2 filter.

3. Analysis and preliminary results

All the observations described in the previous section were photometrically calibrated in absolute reflectivity. Ground-based observations were calibrated by reference to previous similar observations. Cassini ISS observations were calibrated using the CISSCAL software.

Figure 1 shows a sample of Cassini ISS calibrated observations. The information contained in such observations was later reproduced by means of a radiative transfer code based on the doubling adding technique as in previous works [4].

The observed reflectivity was analyzed in two different ways. Wherever we had information on how the reflectivity depends on the observation and illumination geometry, the center to limb variation of the reflectivity was modeled. For other locations, where the geometrical information was poor, the data was fitted as low-resolution spectra, giving emphasis to the spectral content of the information.

Preliminary results from ground-based observations [8] show that the cloud top in the region disturbed by the storm is located at around 300 mbar, about 40 km higher than the cloud-top in the surrouding locations. Those observations also require the particles located in the upper troposphere to be substantially more reflective, in good agreement with the expected ascent of fresh material from deeper levels of the atmosphere.

The Cassini ISS observations allow a better characterization of particular features in the storm head that could be seen from the very initial steps of the GWS event (see Fig. 1). In particular, local variations of the cloud-top height and particle absorption can be retrieved from the analysis of such observations.

4. Summary and Conclusions

In this work we have used observations of the GWS 2010 event to retrieve the vertical distribution of clouds and hazes in the upper bar of the atmosphere. This information is required to understand the formation and semi-periodicity of GWS events and the way they interact with the local and global circulation of the atmosphere. This is a work in progress that is also intended to cover the effects of the disturbed aerosol distribution in the radiative energy budget of the planet.

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References

[1] Acarreta, J.R. and Sánchez-Lavega, A.: Vertical cloud structure in Saturn's 1990 Equatorial storm, Icarus, Vol. 137, pp. 24 - 33.

[2] Fischer, G., Kurth, W.S., Gurnett, D.A. et al.: A giant thunderstorm on Saturn, Nature, Vol. 475, pp. 75 - 77, 2011.

[3] Fletcher, L.N., Hesman, B.E., Irwin, P.G.J. et al: Thermal structure and dynamics of Saturn's Northern springtime disturbance, Science, Vol. 332, pp. 1413-1417, 2011.

[4] Pérez-Hoyos, S., Sánchez-Lavega, A., French, R.G., and Rojas, J.F.: Saturn's cloud structure and temporal evolution from ten years of Hubble Space Telescope images (1994-2003), Icarus, Vol. 176, pp. 155-174, 2005.

[5] Pérez-Hoyos, S. and Sánchez-Lavega, A.: On the vertical cloud structure of Saturn's equatorial jet at cloud level, Icarus, Vol. 180, pp. 161-175, 2006.

[6] Sánchez-Lavega, A., Colas, F., Lecacheux, J., Laques, P., Miyazaki, I., and Parker, D., 1991: The great white spot and disturbances in Saturn’s Equatorial atmosphere during 1990, Nature, Vol. 353, pp. 397–401, 1991.

[7] Sánchez-Lavega, A., del Río-Gaztelurrutia, T., Hueso, R. et al.: Deep winds beneath Saturn's upper clouds from a seasonal long-lived planetary-scale storm, Nature, Vol. 475, pp. 71-74, 2011.

[8] Sanz-Requena, J.F, Pérez-Hoyos, S., Sánchez-Lavega, A. et al.: Cloud structure of Saturn's storm from ground-based visual imaging, Icarus, Vol. 219, pp. 142-149, 2012.