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The storm alley in the southern hemisphere: Analysis of Saturn's mid-scale storm dynamics in the Cassini era

T. del Río Gaztelurrutia, R. Hueso, A. Sánchez-Lavega
Departamento de Física Aplicada I, ETS Ingeniería de Bilbao, UPV-EHU, Alda Urquijo s/n. 48013, Bilbao, Spain

Abstract

We investigate the occurrence of mid-scale storms in Saturn's southern hemisphere, analyzing both Cassini ISS images and images captured from Earth. We characterize the frequency, size and lifetime of events, and their correlation with lighting. We consider their seasonal dependence and their potential role injecting energy into Saturn's jets. Finally, we explore the different mechanisms that could trigger these events, looking for peculiarities in the dynamics of the narrow latitudinal bands where midscale storms tend to occur.

1. Introduction

In the study of convective activity in Saturn it is useful to distinguish between GWS episodes and mid-scale storms. The first ones are rare and huge convective events that occur with an approximate periodicity of 30 years, and lead to planet-wide disturbances that last for months and alter the atmosphere of the planet for even longer periods [1]. Their appearance dominates the visual aspect of Saturn's atmosphere and dwarfs other smaller scale convective phenomena. The last such event started at the end of 2010 [2] and is still the object of thorough investigation.

In this work we concentrate in the second kind of convective events. Mid-scale storms are much more common in Saturn. Voyagers' flybys in the eighties detected mid-scale storms in a narrow latitude band in the northern hemisphere, and since Cassini spacecraft arrived to the planet in 2004, several mid-scale storms have been detected in an equivalent latitude band in the Southern hemisphere. Moreover, modern technology, with the use of CCDs and lucky-image technique, has allowed for the detection of these smaller storms from Earth even using modest telescopes. With sizes of the order of a few thousand of kilometres and lifetimes of the order of weeks, these mid-scale Saturn storms are still huge events compared to storms in Earth, but they extend only a few degrees in longitude and latitude in the atmosphere of the giant planet Saturn.

2. Characterization of the storms, statistics and movements

We have surveyed Cassini's ISS images from the arrival of the spacecraft to Saturn in 2004 till the eruption of the later GWS event in 2010, detecting at least seven different events. In high resolution images captured with the continuum CB1 and CB2 filters, storms appear as bright irregular clouds, and whenever temporal coverage is sufficient, they are seen to evolve rapidly, with significant changes in shape and size in a few days [3].

The statistics is completed with a systematic search of images in the IOPW-PVOL database that collects a planetary images contributed by amateur astronomers who collaborate with the International Outer Planets Watch (IOPW) [4]. While the spatial resolution of these images is obviously poorer, they allow a detailed temporal coverage, and a quite precise determination of the storms' drift velocities.

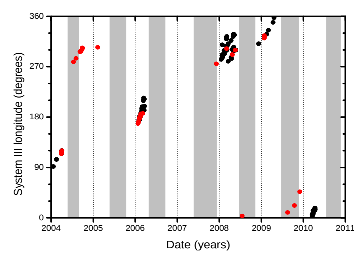

Figure 1: Detections of mid-scale storms from 2004 till 2010. Black dots represent observations from Earth, red dots detections by Cassini ISS and shadowed regions indicate intervals with no observations from the PVOL_IOPW database.

The storms occur in a narrow band of latitudes around 36º South (planetocentric), the so-called “storm alley”, next to the peak of a weak westward jet. An analysis of the longitudinal drift of different storms shows that they basically move with the ambient winds, following the wind profile. It can be appreciated from Figure 1 that the occurrence of mid-scale storms is intermittent, with an initial approximate periodicity of two years, but becoming more frequent near the equinox in 2009. Moreover, there is a strong correlation between the appearance of bright clouds in the storm alley and the detection of SEDs by the RPWS instrument onboard Cassini, indicative of lighting activity [3].

3. Wind variability

In order to test if mid-scale storms inject momentum to Saturn’s Jets, we have used images obtained by the Cassini ISS instrument to measure and compare the zonal wind profiles in the relevant latitudes, both for longitudes preceding and following a convective storm while the storm is active, and in images obtained before and after an eruption occurs. In both cases, we obtain a negative result, since the retrieved profiles are identical within the precision of our measurements.

4. Thermal and dynamical stability at the relevant latitude

There is a tantalizing symmetry in the occurrence of mid-scale storms in the Voyager and Cassini eras. Cassini arrived to Saturn during the southern hemisphere summer, and detected mid-scale storms in a narrow band of temperate latitudes in this hemisphere, while the Voyager storms were observed in a symmetric latitude location in the northern hemisphere, during the northern hemisphere spring.

We have sought for dynamical instabilities of the wind profile in the relevant regions, looking for similarities in the structure of the zonal wind profiles and their first and second derivatives, comparing the northern hemisphere during the Voyager era and the southern hemisphere during Cassini era. Within the limitations imposed by the different latitudinal resolutions of the wind profiles in both eras, we have not been able to extract any peculiarity shared by the two relevant regions.

Cassini CIRS instrument has allowed a detailed characterization of Saturn’s vertical temperature structure at different latitudes and dates [5]. We have analyzed these thermal profiles looking for signs of static instability at the depths where storms are expected to develop but again the result is negative.

5. Summary and Conclusions

We analyze the occurrence of mid-scale storms during the first seven years after the Cassini spacecraft arrived to the Saturn. During this period, storms developed mainly in a narrow temperate latitude band in the southern hemisphere of the planet. Given that similar convective activity in the Voyager era was observed in equivalent latitudes in the northern hemisphere, we explore analogies and differences in zonal wind profiles and vertical thermal structure in the two hemispheres and at the two different periods.

Acknowledgements

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