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Convective Storm Activity in the Saturn's Southern Hemisphere during the Cassini Mission

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Abstract

We present a review of all mid-scale convective activity in the Southern hemisphere of Saturn during the Cassini era, using both Cassini Imaging Science Instrument and ground based observations. We present statistics on lifetime, size and drift rates and simulate their behavior using a shallow water model.

1. Introduction

Convective storms, similar to those in Earth, but of much larger scale, develop often in Saturn's atmosphere. Storm occur at very different scales. Most remarkable of all are the Great White Spots (GWS), large-scale convective eruptions that encircle the planet longitudinally. These events been observed from Earth with an approximate periodicity of 30 years, the last one during the Cassini mission in 2010 [1]. Smaller scale storm activity is more common. It was first observed during the Voyagers' flybys of Saturn in 1981, and was frequent during Cassini Primary and Equinox missions. A number of these mid-scale convective events have been analyzed in detail [2,3]. Recently, and intermediate type of convective activity, in-between the planet-encircling GWSs and mid-scale storms has been reported and modelled [4]. In this work, we concentrate in the mid-scale activity, reviewing all the events detected in the Southern hemisphere of Saturn until the outbreak of the GWS in the north, presenting overall statistics and providing details of previously unreported events.

2. Observations

We have combined a thorough survey of Cassini Imaging Science System volumes (COISS) with a search of databases of amateur astronomers to monitor the occurrence of mid-scale storm activity.

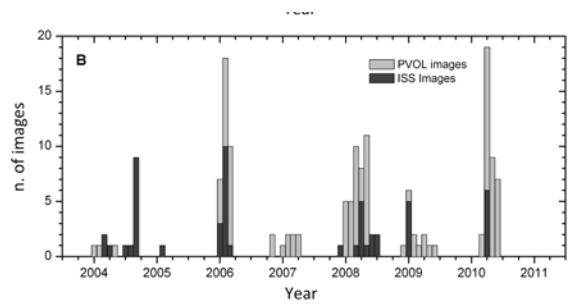

Figure 1. Light gray, number of PVOL images. Dark grey, number of Cassini ISS images.

In figure 1 we indicate the period analyzed and the number of images used in this work. Middle scale storms are quite distinctive in CB1 and CB2 Cassini high resolution images (Figure 2), appearing as bright compact areas, often with irregular shapes, providing contrasted structures in otherwise quite flat atmosphere.

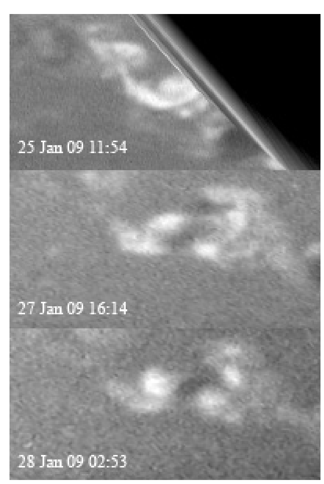

Figure 2: Three middle resolution rectangular projections of the early 2009 event captured with the ISS WAC instrument with CB3 filter.

The storms evolve in short intervals of time, as can be appreciated in Figure 2, which illustrates a convective event occurring in Dec 08 - Jan 09. This event provides also a confirmation of the reported intermittent character of these mid-scale storms [1], with two detected eruptions in December 2008 and January 2009 separated by a period in which no activity (or vortex) is present in the region (See Figure 3)

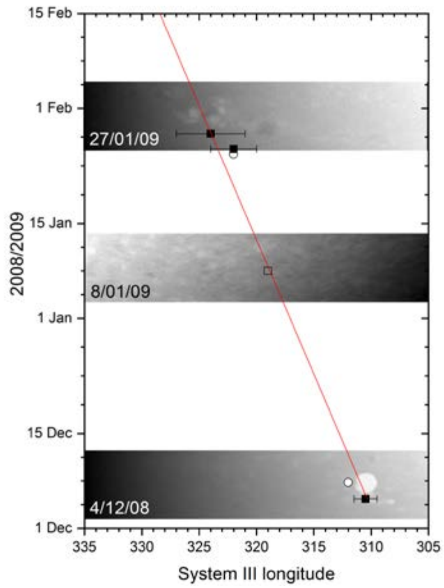

Figure 3: Intermittent character of the 2009 storm. Cassini detections (black squares), Earth detections (white circles)). Images correspond to the early 2009 event captured with the ISS WAC instrument using the CB3 filter.

3. Statistics and properties of the storms

All detected storms occur in a narrow latitudinal band of latitudes around 36º South (planetocentric), the so-called "storm alley", next to the peak of a weak westward jet, and symmetric to the northern latitudes where Voyager storms were detected and where the 2010 storm erupted. An analysis of the longitudinal drift of different storms shows that they basically move with the ambient winds, following the wind profile at velocities $u \sim -5\ \mathrm{ms}^{-1}$. The activity in the region is discontinuous, with an initial approximate periodicity of two years, but becoming more frequent near the equinox in 2009. Duration of convective events ranges from ~40 days to more than 180 (in an event captured from Earth in a 2009). We have characterized their initial stages, finding that they grow in area at rates of ~$2\mathrm{x}10^{6}$ km^{2} day^{-1} Finally, the strong correlation reported in [2] between the appearance of bright clouds in the storm alley and the detection of SEDs by the RPWS instrument onboard Cassini, which is indicative of lighting activity, continues until the outbreak of the 2010 GWS.

4. Numerical modelling

In previous works, both GWS [5] and intermediated events [4] have been successfully simulated with a shallow water model that introduces the storms as localized injections of mass resembling the characteristics of the simulated storm. In this work, we will present the results of new simulations that reproduce the measured behavior of the mid-scale storms.

Acknowledgements

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