Saturn Northern hemisphere's atmosphere and polar hexagon in 2013

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Abstract

In 2013, two years after the dramatic events of the Great White Spot (GWS) which occurred in the northern hemisphere (cf. [1], [2], [3]), amateur astronomers continued to follow the evolution of the "GWS zone" centered around 41° planetographic on Saturn, in particular the dark oval created by the GWS. They could also recover a long lived Saturn Electrostatic Discharge (SED) source and detect the hexagonal wave surrounding Saturn's north pole with a spot at its edge.

Data

Amateur data comes mostly from reflectors with an aperture from 15 to 40 cm. Their image coverage is good during 6 months around Saturn's opposition. The data comes from different sources (French Astronomical Society, ALPO Japan, IOPW, Facebook Astronomy Planetary Imaging group, …). 1360 images (usually in visual wavelengths or in near infrared up to 830nm long-pass filters) by 160 observers from all around the world, from end of November 2012 to mid of August 2013 have been studied. After selecting 177 images based on quality, features visibility and time coverage (taken on different Saturnian days), 514 individual measurements of white or dark spots could be done, and the polar hexagon studied.
Additionally 72 images from Cassini ISS (from Nov. 2012) were used to measure the position of a dark oval on 16 Saturnian days and identify a storm source, detected by RPWS, as well as mid-infrared observations of Saturn in 2013 from professional telescopes (IRTF, Subaru) to image the higher part of the atmosphere.
This allowed to cover in detail the evolution of Saturn's northern hemisphere's atmosphere in 2013.
WinJUPOS software, used by amateur astronomer associations on Jupiter and Saturn (cf. [4]), was used to measure the position of features, and derive their drift rates in longitude.

Dark oval in Northern tail

Throughout the 2013 apparition, a dark spot was clearly visible at a planetographic latitude around 44.1° (see *figure 2*). It drifted at -3.44° (Longitude system III)/Julian Day (estimated from 22 observations). As shown in *figure 1*, this is the dark oval originally spawned by the 2010/11 storm (cf. [5]), drifting northwards and into a prograde jet stream, and also observed in the previous 2012 apparition (cf. [6]), with a variable drift rate between -2.9°/JD and -3.8°/JD.

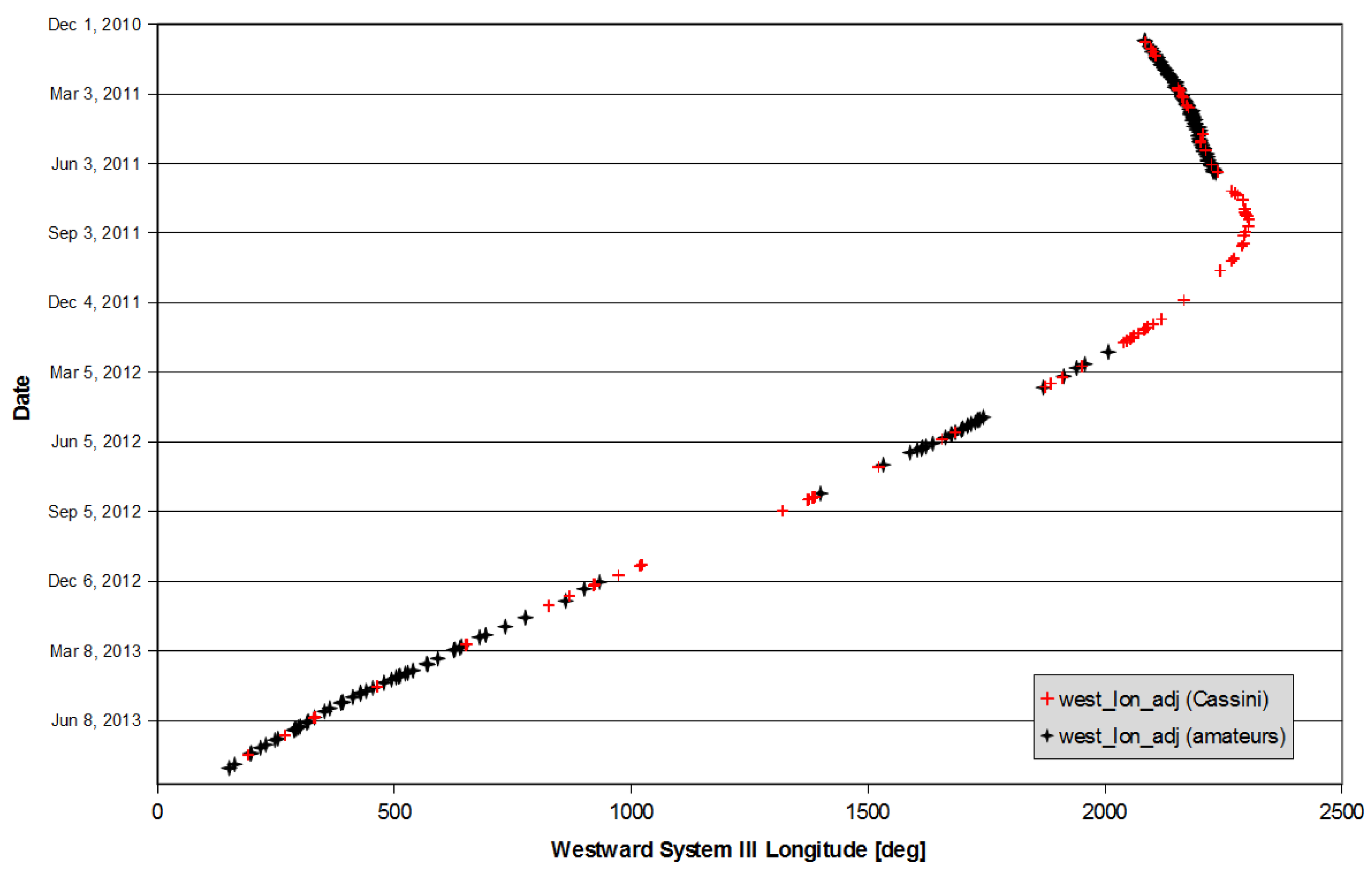

Figure 1: Tracking of GWS dark oval longitude since the 2010 GWS complementary covered by amateur data (black) and Cassini data (red)

The drift of the dark oval varies over the time. A closer look to 2012/2013 data shows even smaller variations in drift rate *(see figure 3)*, due to the anticyclone changing back and forth latitude (between 34°N and 39°N), hence submitted to different wind speeds.

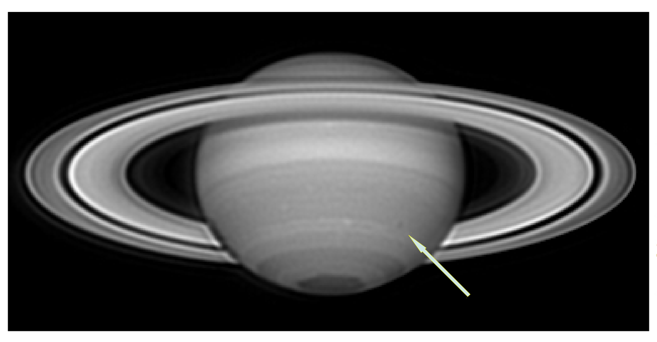

Figure 2 (top): Image of the dark oval (pointed by the arrow)by Trevor Barry, on Apr. 26th 2013 thru a red filter. The North polar hexagon can be clearly distinguished.

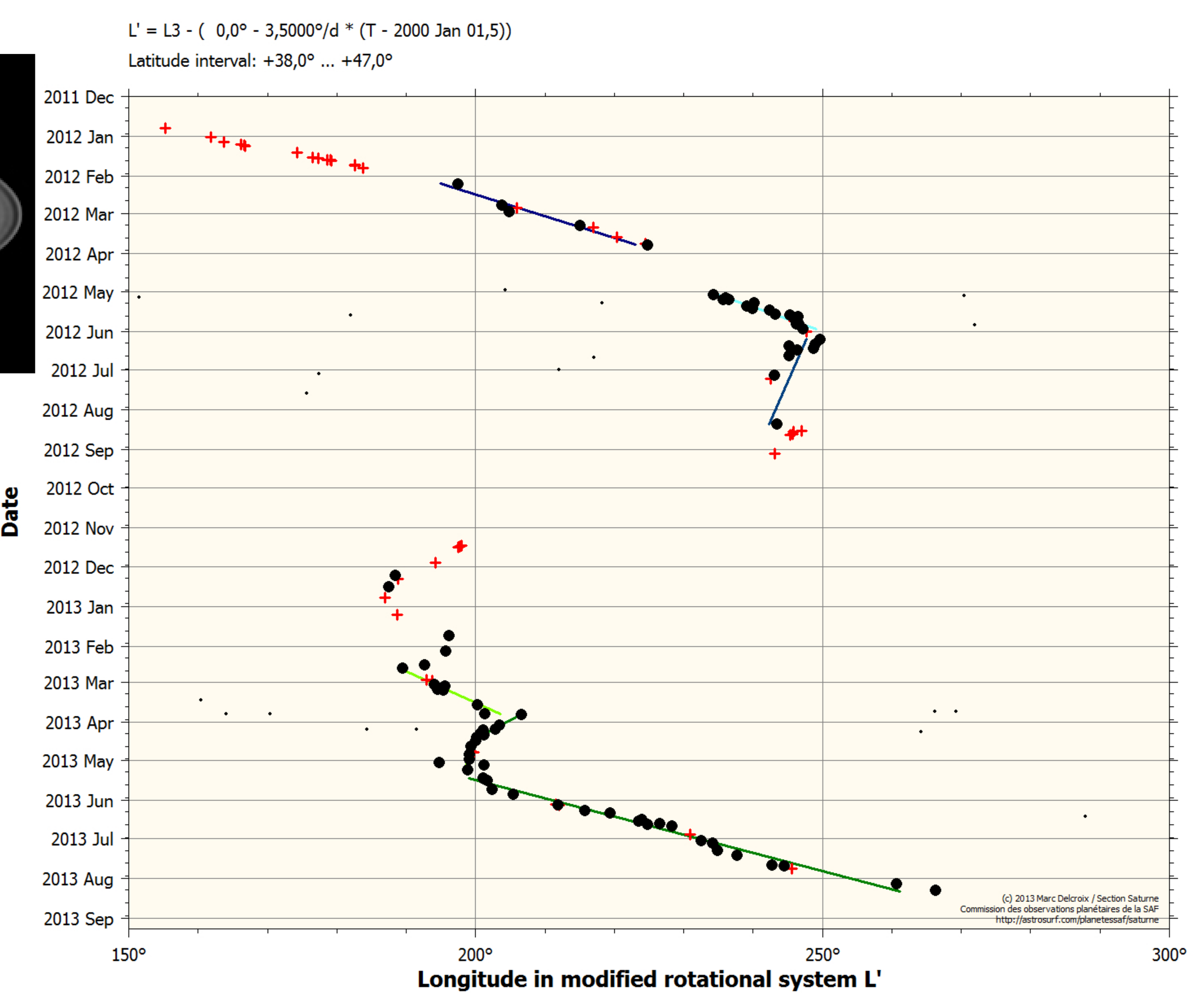

Figure 3 (right): Tracking of GWS dark oval longitude in 2012 and 2013 by amateur data (black) and Cassini data (red) in a modified rotational system to show small variations in its drift rate.

In 2013 mid-infrared observations of Saturn from professional telescopes still indicate a strong emission from the stratospheric anticyclonic vortex spawned by the 2010 GWS, now cooling and shrinking, and continuing to drift westward at 3°/JD with a weaker response in the troposphere. It does not appear to be associated with features tracked by amateurs in visible light (cf. [7]). No direct thermal signature of the visible dark anticyclone (observed both by amateurs and Cassini imaging system) was evident.

Long lived storm

Between June and August 2013, at the end of the apparition, a bright spot around 50°N was visible in a few amateurs images (see *figure 4*), drifting at an approximate rate of 0,21° LIII/JD.

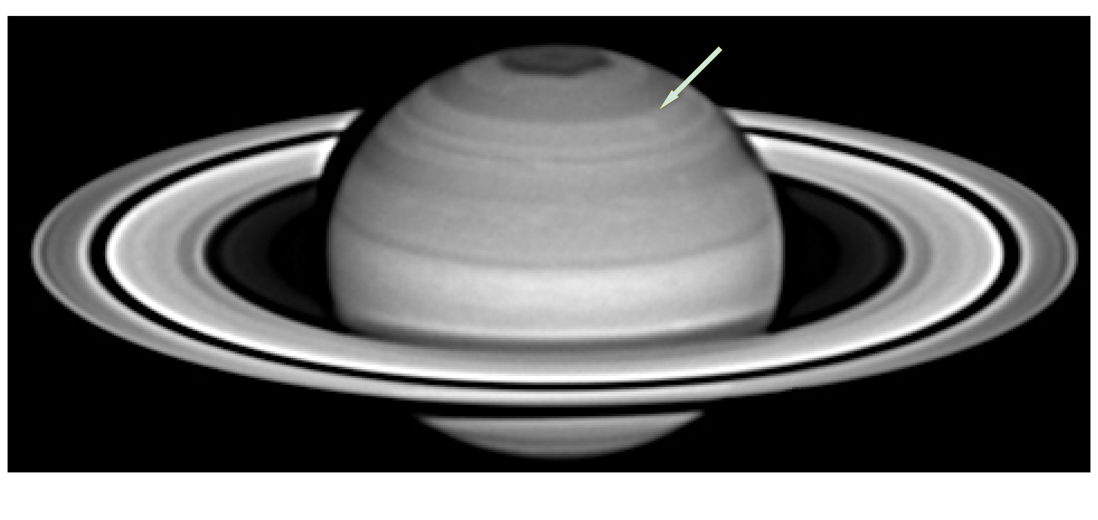

Figure 4: Saturn on June 30th 2013, at Pic du Midi with the one meter telescope with a long-pass red filter
(c) S2P/IMCCE/OMP/M/Delcroix/F.Colas

The arrow points at the long lived storm which is the brightest northern white spot. The North hexagon is clearly viewed, as well as the feature at its center.

A comparison to the spots observed by amateurs in 2011 and 2012 showed that it is the same source as the one observed in the past 2 years (see *figure 5*). Furthermore, Cassini RPWS data shows SED episodes in July/August 2013 (cf. [8]), as well as when it was observed in 2011 and 2012 (see *figure 6*). Cassini ISS also imaged that spot.

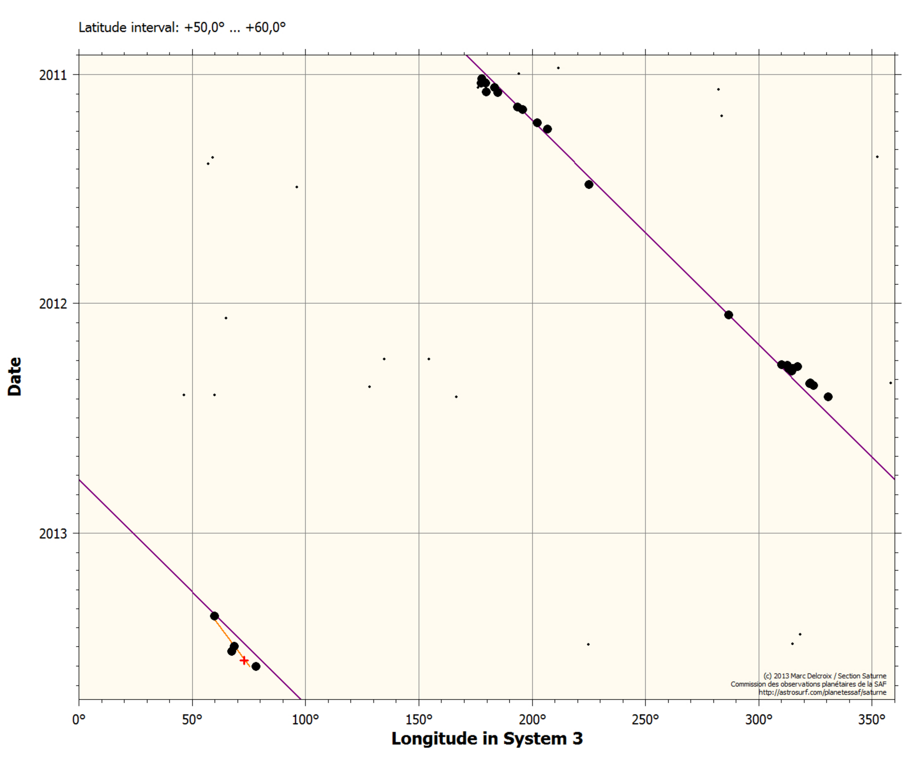

Figure 5: Tracking of the dark spot longitude at 50°N since the 2011 covered by amateur data (black) with a single Cassini ISS measured position (red)

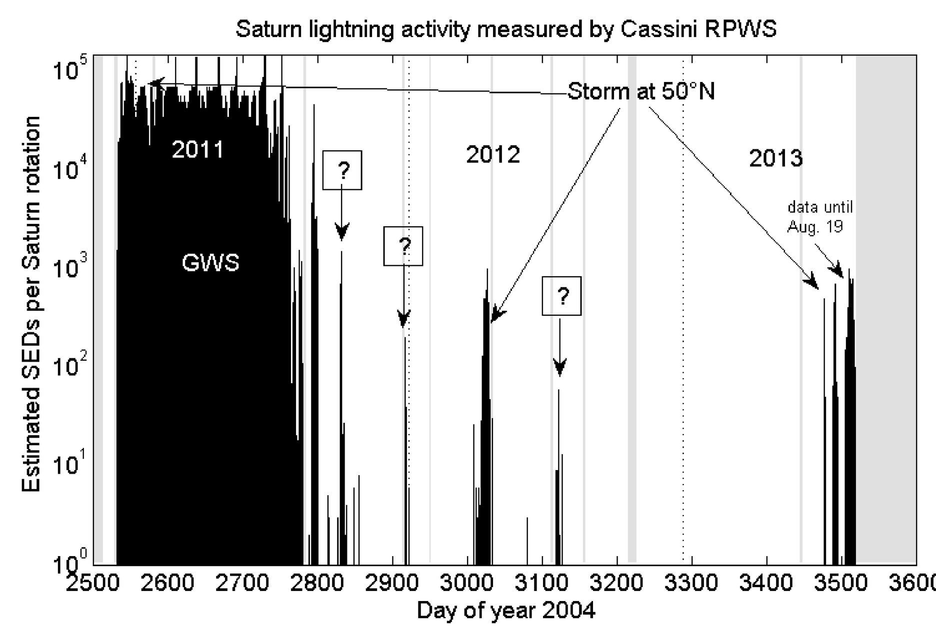

Figure 6: SED activity from 2011 to 2013. The 3 arrows show episodes matching the dark spot observations at 50°N on figure 4, while for the question marks the SED source could not be identified (Sept/Oct. and Dec. 2011 were too close to conjunction to be visible from earth, while Jul. 2012 was at the end of the apparition with Saturn being hardly observed.

White spot in the southern tail

During the entire apparition, the zone where the southern tail had developed in 2011 showed an intriguing aspect, with several very diffuse brighter zones spread both in longitude and latitude, similar to the aspect it had in 2011 (cf. [6]). A single persistent white spot could be made out more clearly at 37° latitude, drifting at +0,07°/JD from March.

Polar hexagon observations

In the beginning of the 90's professional observations (from Pic du Midi or HST) could clearly make out the large hexagon centered on the North pole. Cassini took stunning images of that hexagon, and for the first time in 2012/13 amateurs also imaged it clearly (see *figure 2 and 4*). North polar projections allowed them to tentatively measure its 6 vertices. Using a selection of 6 high quality images from Trevor Barry between February and August 2013, despite the lack of accuracy due to the position on the edge of Saturn viewed from Earth, vertices longitudes have been measured based on an geometrical hexagon manually fitted to the real one on a polar projection (see *figure 7)*. The results show that the 6 vertices are in average separated by about 60°, and drift in average at a extremely very low drift rate of -0,003° LIII/JD (see *figure 8)*. Given the approximation of the measures, these vertices are seem fixed in system III longitude, suggesting that the hexagon is a stationary wave in Saturn's atmosphere.

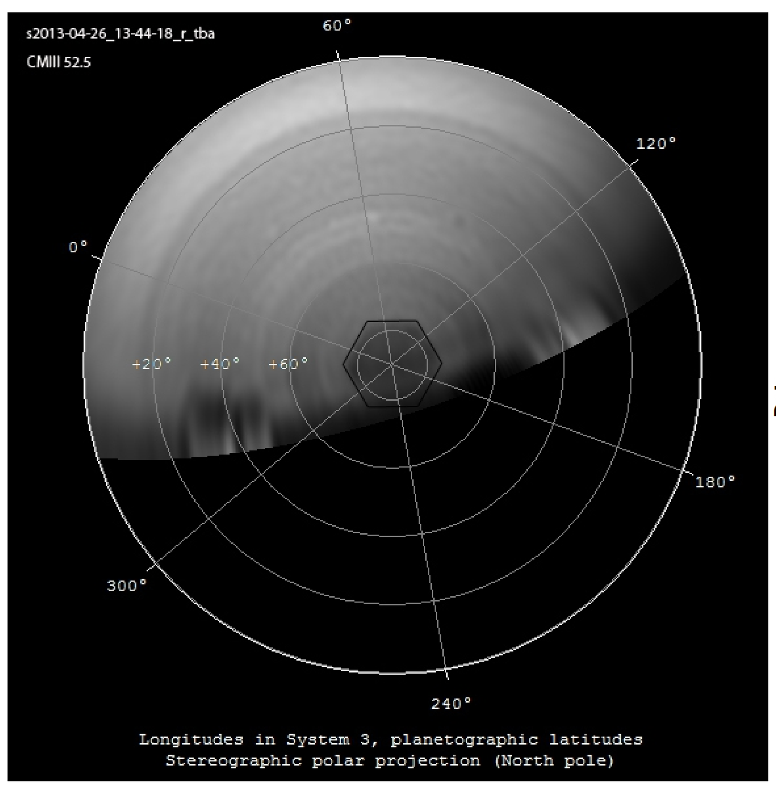

Figure 7: North polar projection from an image taken by Trevor Barry on Apr. 26th 2013. A geometrical hexagon (black line) has been manually fitted to Saturn's hexagon in order to measure the position of its vertices

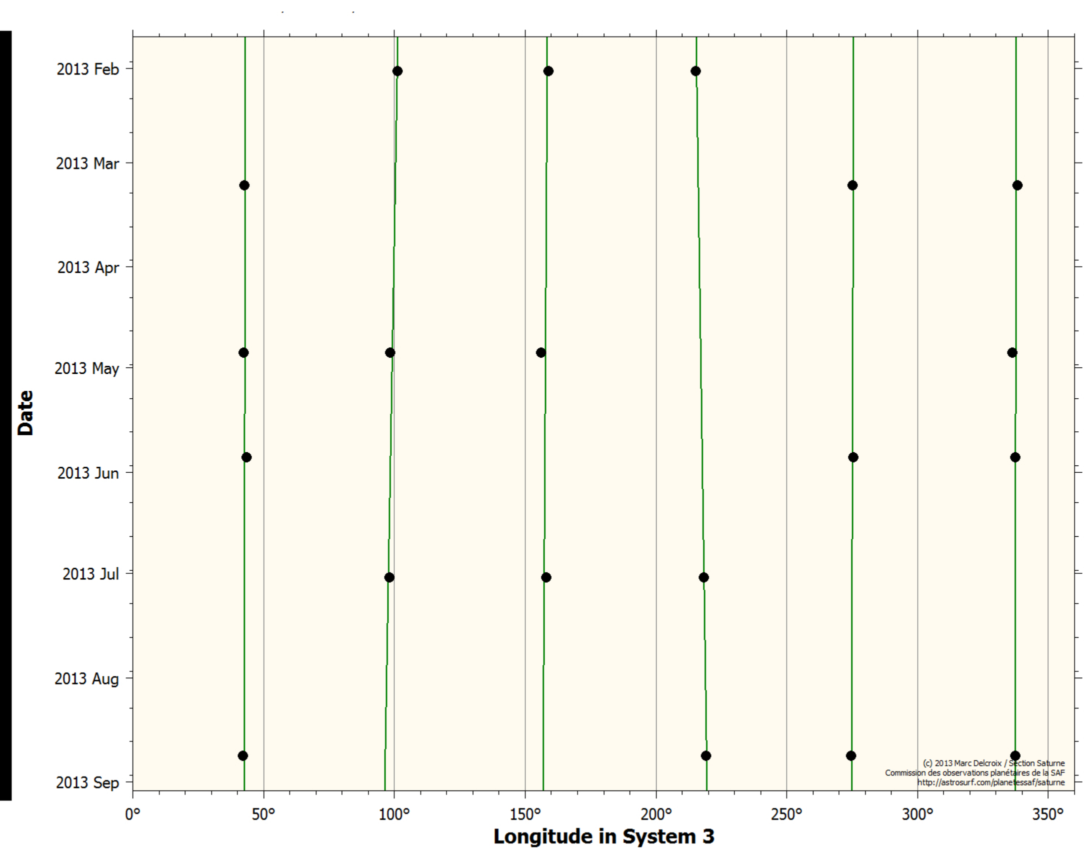

Figure 8: The longitude position measures, over 7 months, of each vertice of the North polar hexagon fit well to drift lines almost vertical, showing that it is very close to beeing stationary in longitude system III.

The North Polar hexagon feature boundary is evident in the stratosphere; while the North Polar Hot Spot is observed in the stratosphere and barely defined in the troposphere. No SEDs were detected by Cassini's RPWS during this apparition up to May 2013. Nonetheless it seems coherent with the fact that no very bright white spot was observed during this time frame.

A small white spot at the edge of the polar hexagon was observed twice at the end of March/beginning of April, despite its northern 72.9° latitude making it difficult to observe. It was drifting at -0,9°/JD.

Summary and Conclusions

Amateur observations proved useful to observe the whole latitude range where the 2010 GWS occurred. The aspect of this zone is very similar during this apparition as the last, with many small white spots in the northern tail and diffuse white spots in the southern tail. The remarkable dark spot in the northern tail monitored throughout 2012/13 is the remnant of the vortex spawned by the GWS in 2011. A long lived storm, northward of the GWS, appeared for the third year around 50°N.

Additionally with the higher inclination of Saturn, the polar zone including the polar hexagon could be detailed by amateurs, showing that the hexagon is a stationary wave within Saturn's atmosphere. The synergy between observations of professional and amateur astronomers provides stronger insight into Saturn's atmosphere.

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