

# Observations of contemporaneous lightning storms in Saturn's atmosphere

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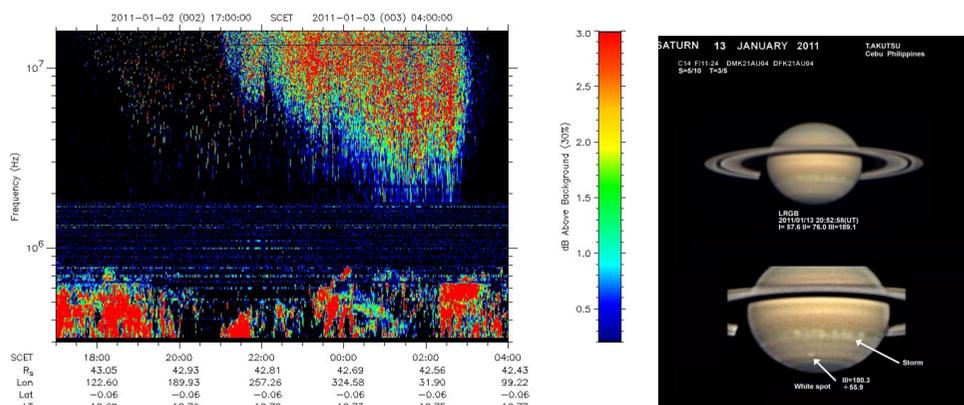


## Abstract

To date, Saturnian lightning storms have only been observed at the equator, and at the planetocentric latitudes of 35° and 50° in both hemispheres. The typical situation at Saturn is that there is only one months-long lightning storm at one time since their occurrence probability is lower than at Jupiter where usually multiple lightning storms are present. However, in this poster we show the details of four situations where multiple contemporaneous SED storms (SED=Saturn Electrostatic Discharges, radio emissions from Saturn lightning) were also present at Saturn.

## The most recent case of the 50°N thunderstorm

The most recent case was in early 2011, when a 2000-km sized storm at 50° north was initially overlooked due to the spectacular presence of the 2010/2011 Great White Spot (GWS) around 35° north [1].

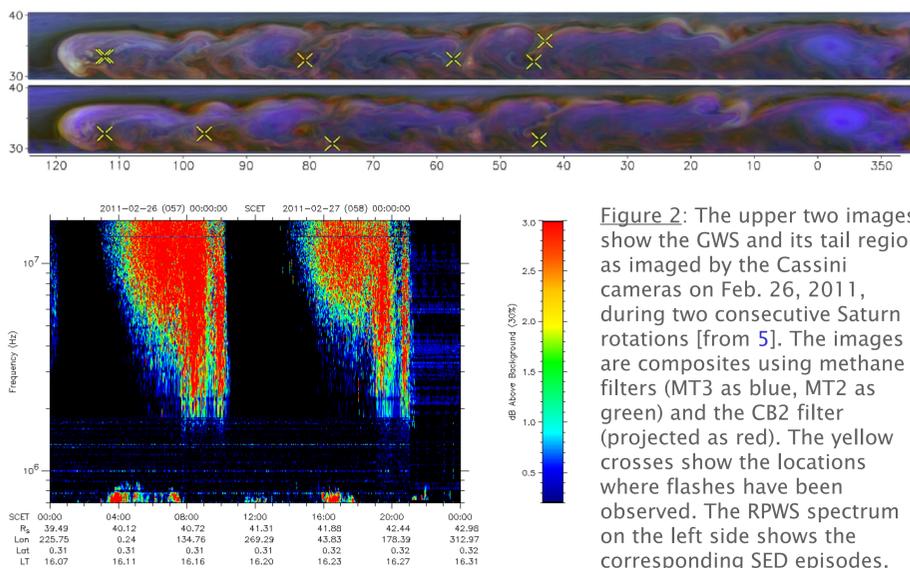


**Figure 1:** Dynamic spectrum (radio wave intensity as a function of time and frequency) measured by the Cassini RPWS (Radio and Plasma Wave Science) instrument on 2 January 2011 during the GWS event. The high SED rate from 21:00 to 03:00 SCET is due to lightning activity in the GWS head region. The low SED rate before comes from a smaller white spot located at a kronocentric latitude of 50° north. The GWS and the small 50°N spot are indicated in the ground-based Saturn image by T. Akutsu from 13 January 2011 on the right side.

Interestingly, the spot at 50°N has re-appeared at least two times showing SED activity in April 2012 and July/August 2013. It showed a drift of  $\sim 0.28^\circ/\text{day}$ , and it went from  $\sim 180^\circ$  in mid-January 2011 to  $\sim 315^\circ$  in mid-April 2012 [2] and to  $\sim 70^\circ$  western longitude at the end of July 2013.

## The case of the Great White Spot

In general, the giant GWSs raging at Saturn usually only once per Saturn year [3], must consist of multiple thunderstorm cells at adjacent longitudes and latitudes. It is likely that the presence of a strong thunderstorm cell can trigger the development of others around the same location on Saturn. Similar to observations at Earth, the triggering mechanism could be the propagation of convectively generated atmospheric gravity waves [4].

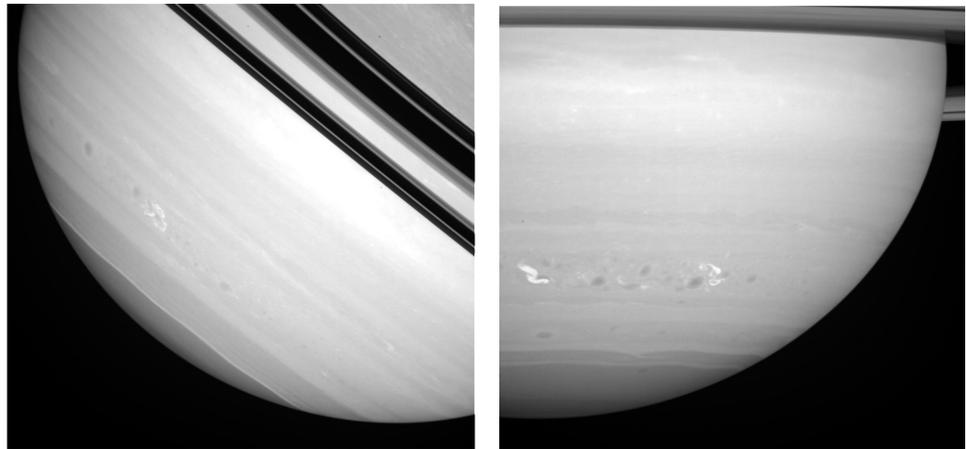


**Figure 2:** The upper two images show the GWS and its tail region as imaged by the Cassini cameras on Feb. 26, 2011, during two consecutive Saturn rotations [from 5]. The images are composites using methane filters (MT3 as blue, MT2 as green) and the CB2 filter (projected as red). The yellow crosses show the locations where flashes have been observed. The RPWS spectrum on the left side shows the corresponding SED episodes.

A small single thunderstorm cell can be seen as a point source from which SEDs should be detected for just about half a Saturn rotation ( $\sim 5.3$  h) from a spacecraft that does not change its local time. (The so-called over-the-horizon effect allows to detect SED radio waves from sources beyond the horizon. This typically extends the episode duration by  $\sim 1$  hour.) Multiple thunderstorm cells extending in longitude can be detected with RPWS by an increased longitude range (duration) over which SEDs are observed. E.g. the SED episodes in Fig. 2 lasted 7–8 hours, and SEDs occurred over  $\sim 80^\circ$  in longitude eastward from the head. This is consistent with the images in Fig. 2 that show flashes distributed over  $\sim 70^\circ$  in longitude.

## Spring 2008: One storm splits into two storms

The third case was in spring 2008, when a single lightning storm at 35° south split into two distinct thunderstorm cells that resided at the same latitude but separated by about 30° in longitude.

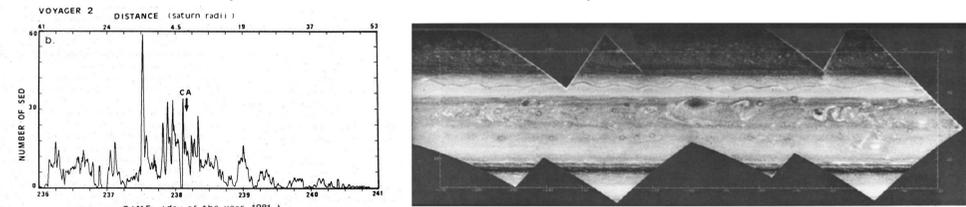


**Figure 3:** Two Cassini camera images of Saturn from spring 2008. The left image was taken on March 4, and it shows a single white spot at 35° south. The right image was taken on June 18, and there are two white spots separated by about 30° in longitude. The dark spots at the same latitude are thought to be caused by carbon particles at the  $\sim 1$  bar level that might stem from lightning-induced dissociation of methane [6].

The storm might have split from March 4–10 when SEDs were detected continuously for 9 Saturn rotations implying another unidentified SED source. It is likely that both white clouds were SED sources since later the SEDs were detected over a somewhat extended longitude range.

## The historical case of SEDs observed by Voyager 2

The fourth case is inferred from the irregular occurrence of SEDs during the Voyager 2 encounter in 1981 [7]. The almost permanent presence of SEDs during the whole flyby suggests the contemporaneous existence of multiple storms, most likely located at 35° north, the equator or both.



**Figure 4:** Number of detected SEDs (in 10-minute intervals) as a function of time, during the 5 days around Voyager 2 closest approach on August 26, 1981 [left side, taken from 7]. Mosaic of Saturn's northern mid-latitudes extending over 140° in longitude taken by the Voyager 2 camera 4–5 days before encounter [right side, taken from 8]. The vortex street at 60° west longitude ( $-60^\circ$  east long.) is one likely source of SEDs.

## Summary

- In most cases there has been just one Saturn lightning storm of  $\sim 2000$  km in size at one time. In this poster we show four cases of contemporaneous SED storms or thunderstorm cells.
- For the GWS and in spring 2008 we have multiple thunderstorm cells raging at the same latitude, whereas in January 2011 there were the GWS at 35°N and a smaller storm at 50°N in parallel. For the historical case of the Voyager 2 flyby it remains to be investigated if the SED sources were located at the equator or at 35°N or maybe at both latitudes.

## References

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Images: The image by T. Akutsu was downloaded from <http://www.pvol.ehu.es>. NASA is the source of the Cassini and Voyager images, which were processed by [5] and [8].