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SATURN LIGHTNING ACTIVITY FROM A CYCLONE AT 50°NORTH LATITUDE

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LIGHTNING STORMS AT SATURN

- Radio emissions from Saturn lightning in the high frequency range (above ionospheric cutoff) are called SEDs (Saturn Electrostatic Discharges)
- Measured by Voyager and Cassini radio instruments and from ground (UTR-2 radio telescope) due to their large intensity (10,000 more intense than terrestrial lightning around a few MHz)
- SED storms from 2004-2010 were mostly located at the storm alley at 35°S
- Great White Spot (GWS) from Dec. 2010 to August 2011 was located at 35°N
- SED storms in storm alley had diameters ~2000 km with flash rates of a few SEDs per minute compared to ~10,000 km North-South extension (with longer tail) for the GWS with flash rates up to 10 SEDs per second
- After the GWS (until late 2013) almost all SEDs came from a cyclone located at 50°North latitude with a diameter of ~3000 km and flash rates of a few SEDs per minute
- 50°N cyclone was observed from 2007 until end of 2013, but its first SED activity was in late December 2010 (during the GWS)

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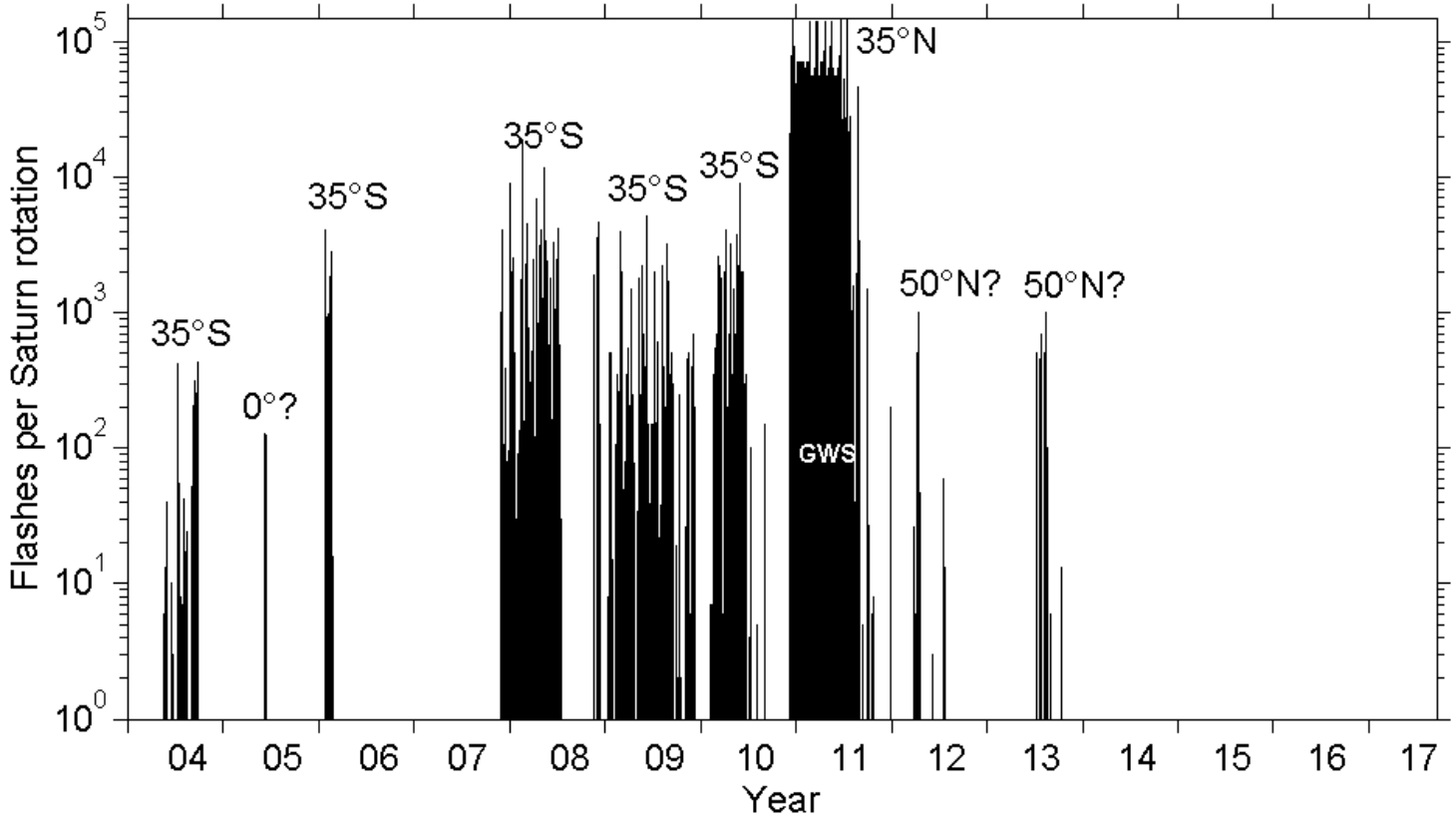
SED ACTIVITY DURING CASSINI'S SATURN TOUR FROM 2004 UNTIL 2017



SEDs per Saturn rotation as a function of year detected by Cassini RPWS throughout Cassini's orbital tour around Saturn. Are the storms after the GWS caused by a storm at 50°N planetocentric latitude? YES!

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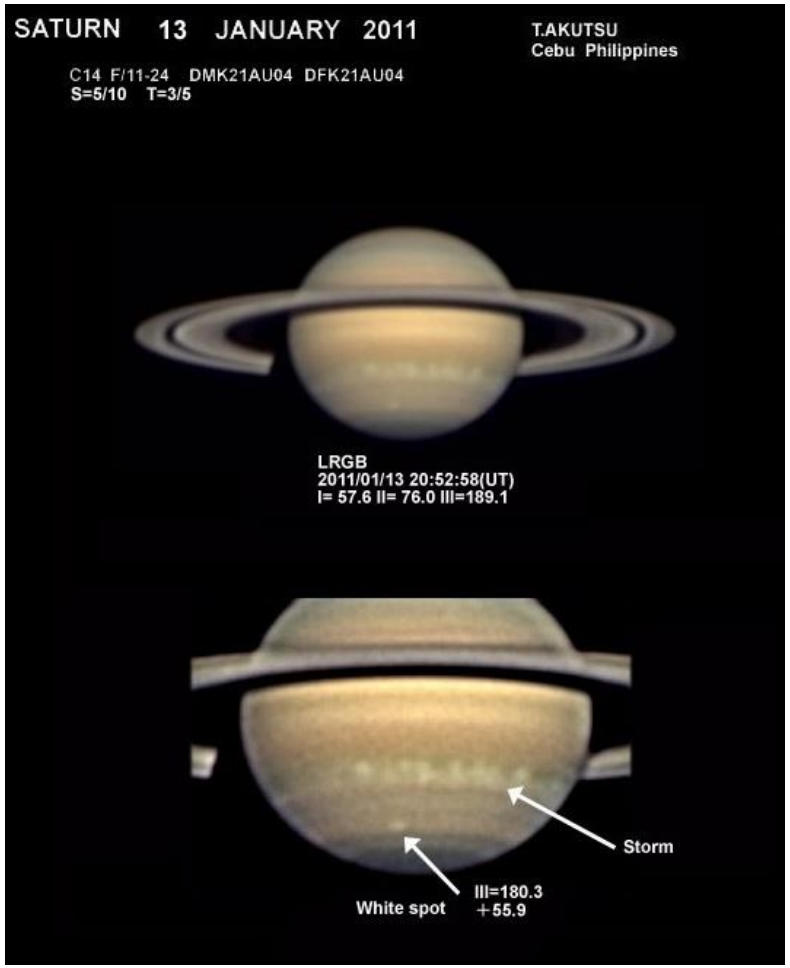
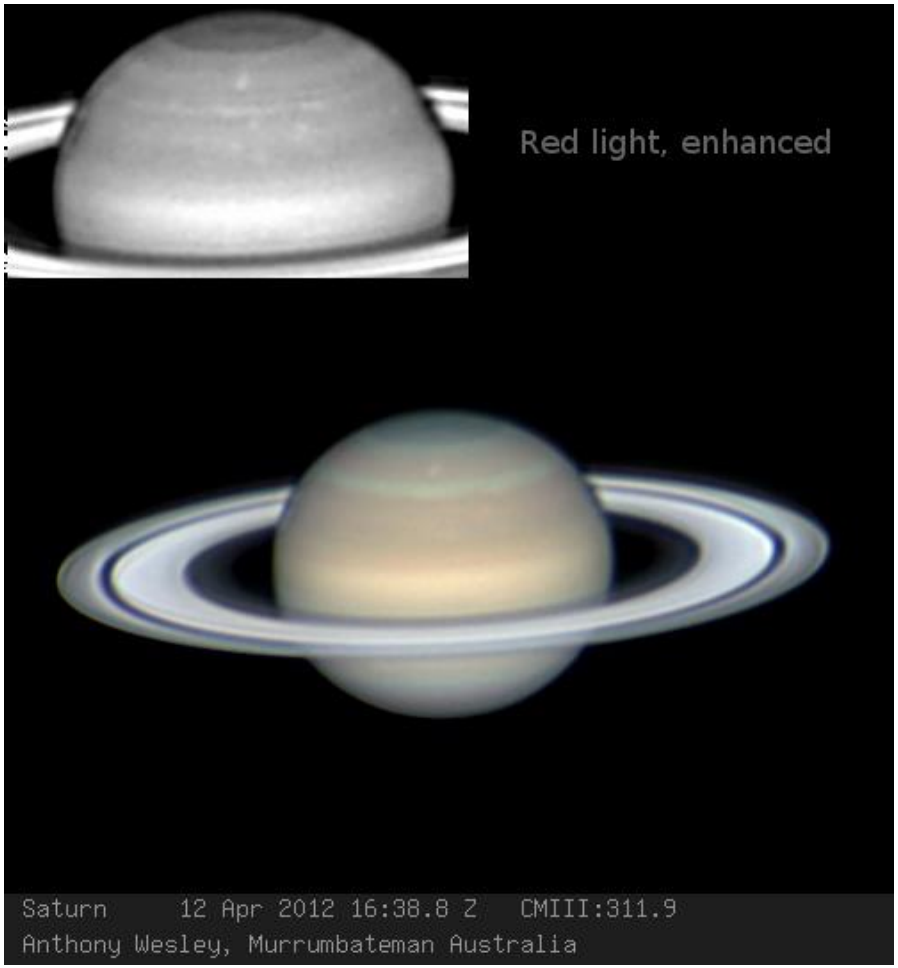
AMATEUR IMAGES OF 50°N CYCLONE (AND GWS)





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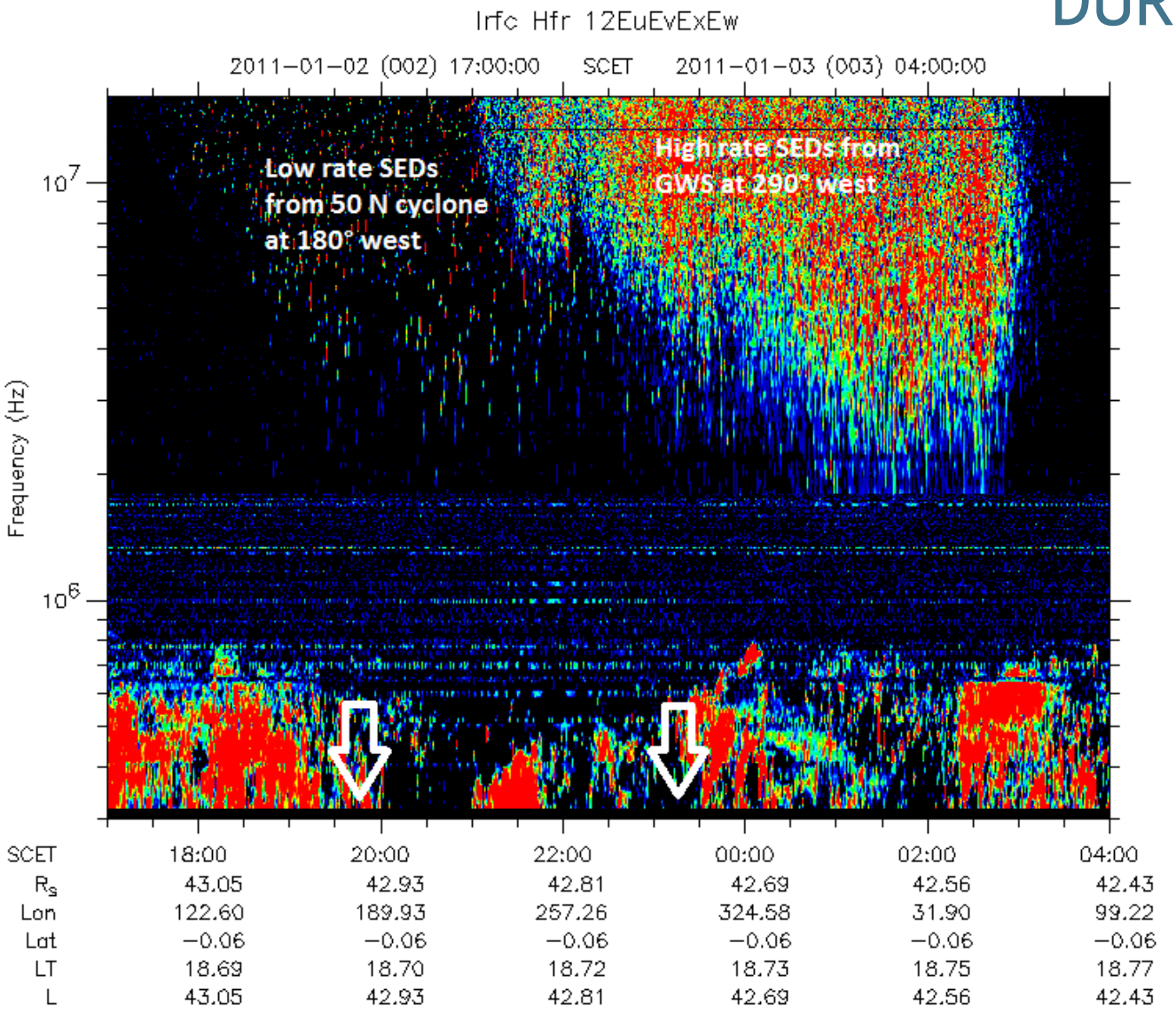
SED ACTIVITY OF 50°N CYCLONE DURING GWS



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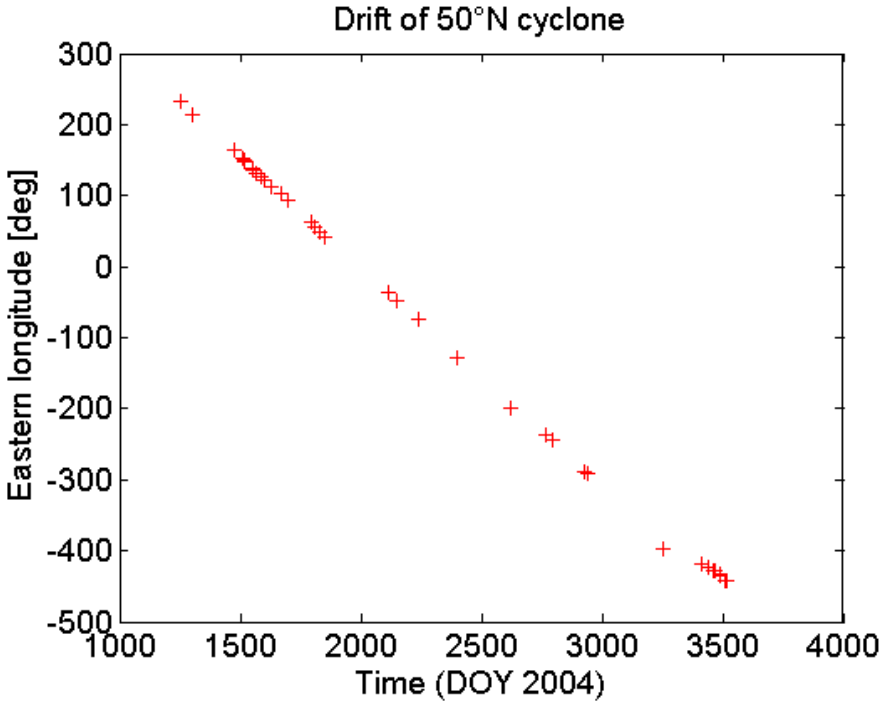
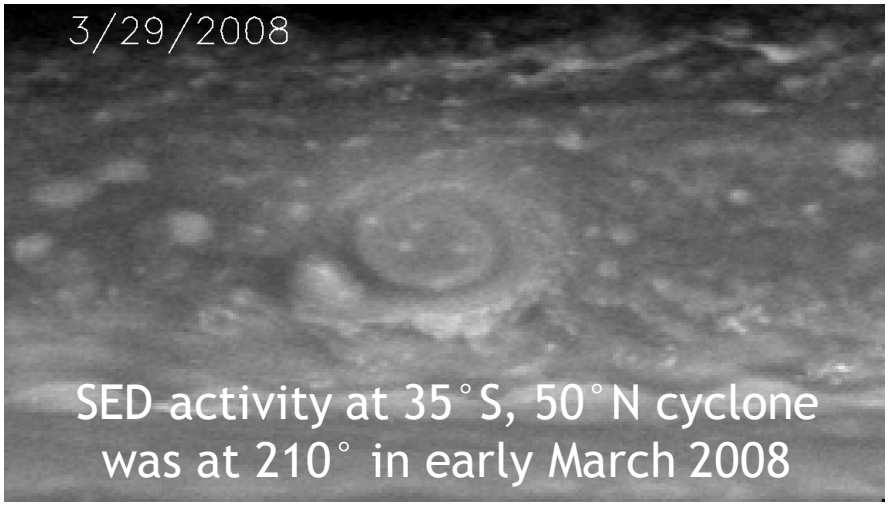
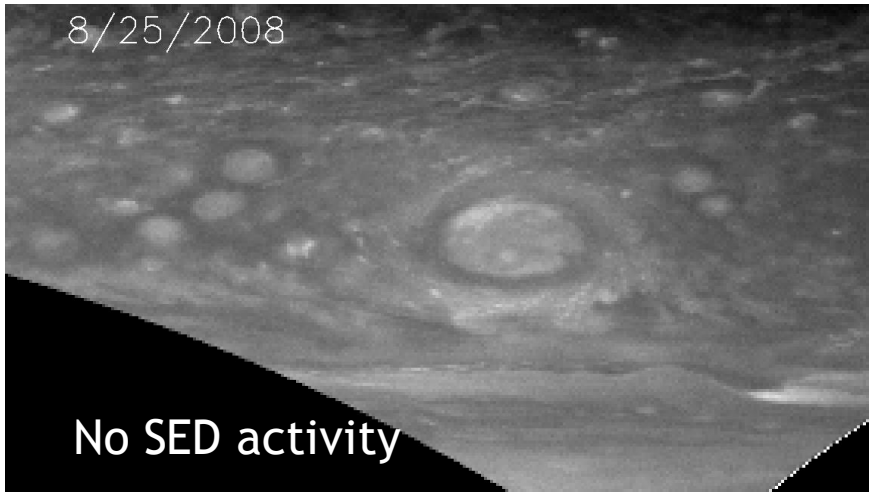
THE CYCLONE AT 50°N LATITUDE



- Cyclone at 50°N is long-lived (mid-2007 to autumn 2013)
- Westward drift of ~0.3°/day (most SED storms drift with 0.2-0.6°/day except GWS with 2.7°/day)





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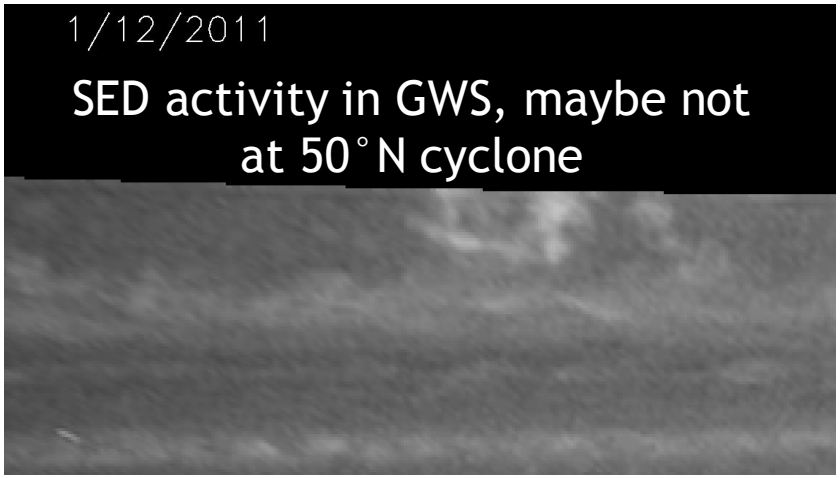
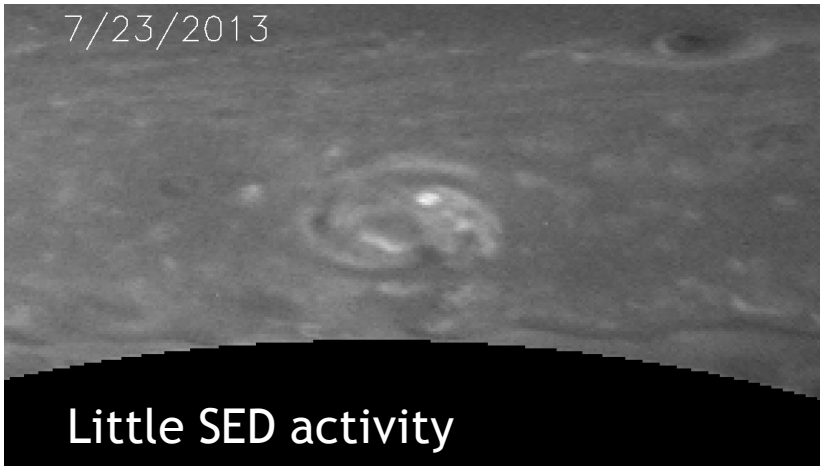
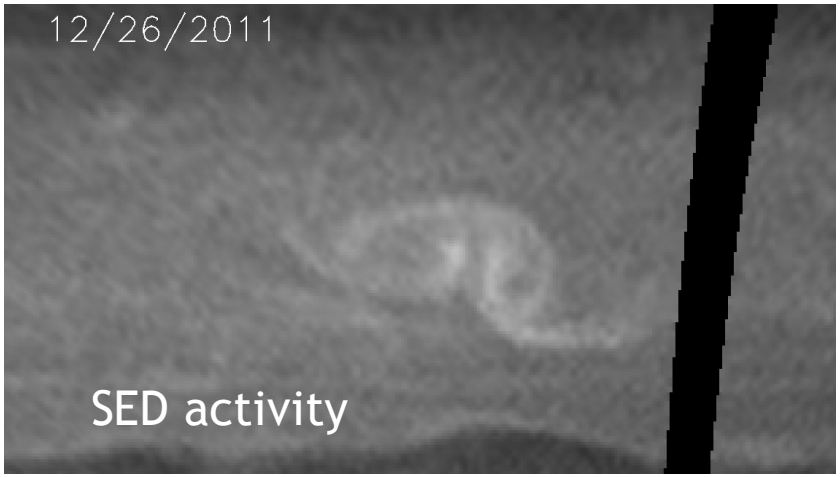
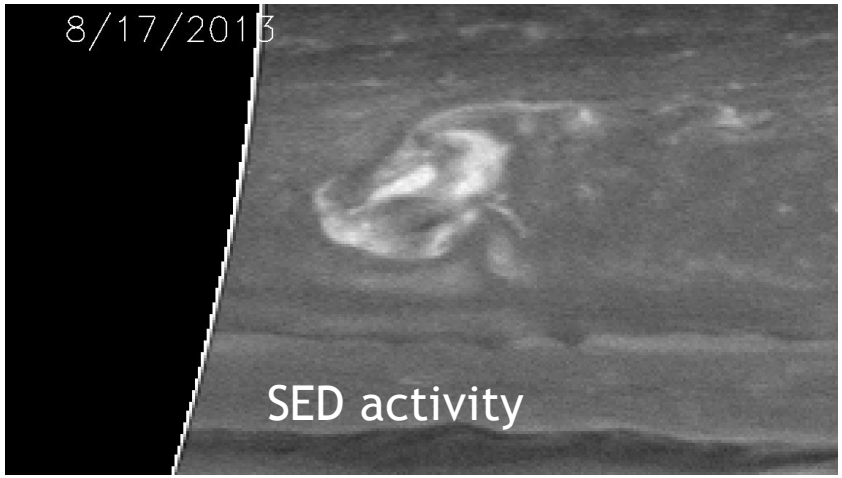
SOME IMAGES OF THE CYCLONE









[All images provided by Jacob Gunnarson]

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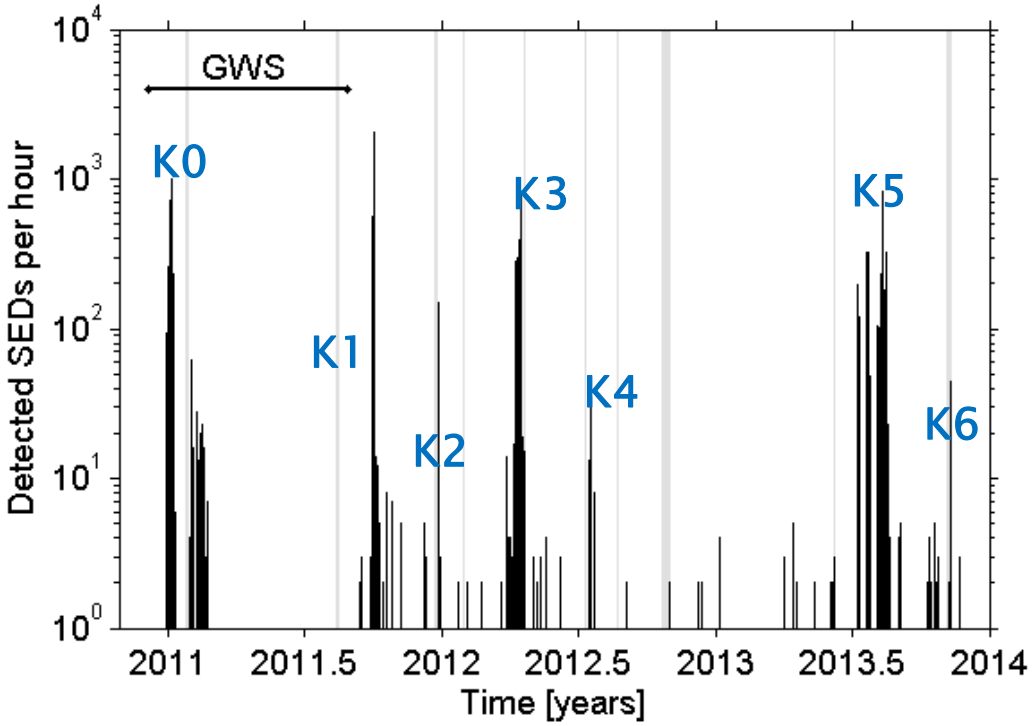
THE 50°N CYCLONE AND SED ACTIVITY

SED storm	Start date	End date	Storm latitude
O	26 May 2004	31 May 2004	35°S ?
A	13 July 2004	27 July 2004	35°S
B	3 Aug. 2004	15 Aug. 2004	35°S
C	4 Sep. 2004	28 Sep. 2004	35°S
D	8 June 2005	15 June 2005	equator?
E	23 Jan. 2006	23 Feb. 2006	35°S
F	27 Nov. 2007	15 July 2008	35°S
G	19 Nov. 2008	11 Dec. 2008	35°S
H	14 Jan. 2009	13 Dec. 2009	35°S
I	7 Feb. 2010	14 July 2010	35°S
J	5 Dec. 2010	28 Aug. 2011	35°N
K0	28 Dec. 2010	23 Feb. 2011	50°N
K1	27 Sep. 2011	9 Oct. 2011	50°N
K2	26 Dec. 2011	30 Dec. 2011	50°N
K3	26 March 2012	21 Apr. 2012	50°N
K4	15 July 2012	23 July 2012	50°N
K5	8 July 2013	2 Sep. 2013	50°N
K6	12 Oct. 2013	10 Nov. 2013	50°N

Table with all SED storms of Cassini era (name, date, and storm latitude)



SED activity as function of time from end of 2010 until end of 2013: 7 outbreaks (K0-K6) occurred during those 3 years. SEDs from GWS, up to 10^5 SEDs per hour, are NOT shown. Gray background indicates an RPWS data gap.

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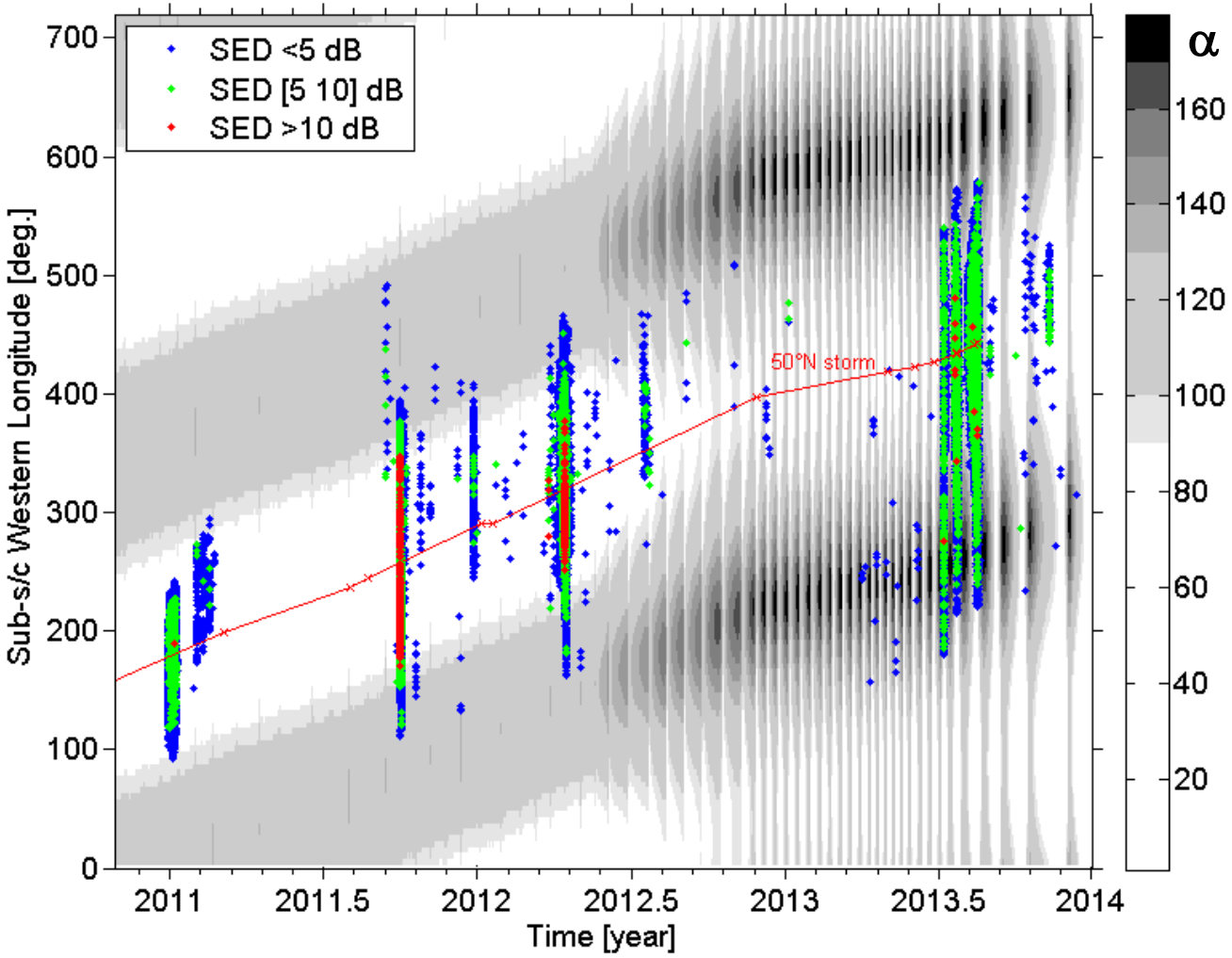
WESTERN LONGITUDE RANGE OF SED EPISODES AND 50°N CYCLONE VISIBILITY



SEDs mostly occur when the 50°N cyclone (red line) is visible (white range) from the position of Cassini. Emission angle α defined at position of storm going from local zenith to Cassini. But there is also OTH (over-the-horizon) effect up to $\alpha<120°$. SED activity from GWS is removed here.

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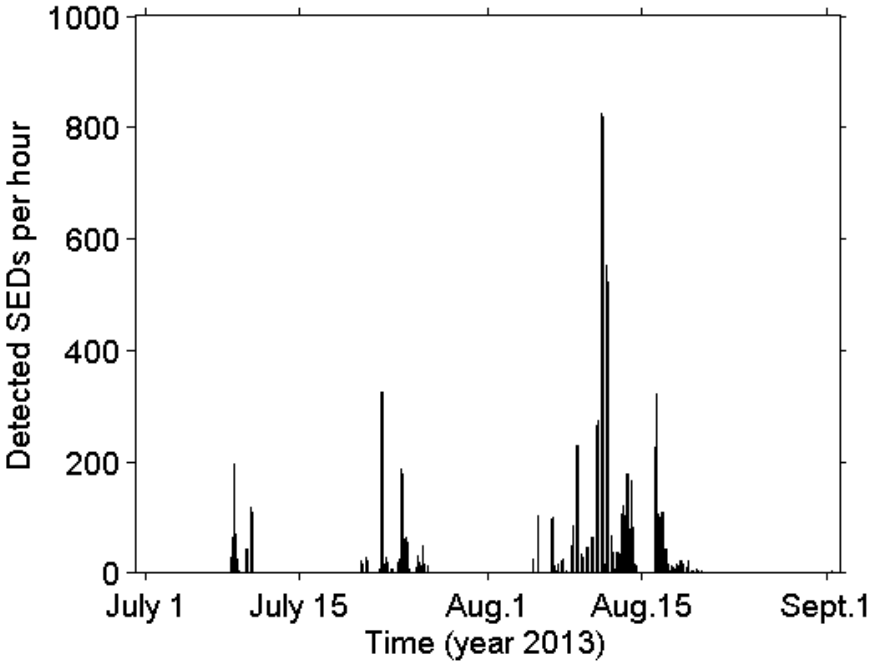
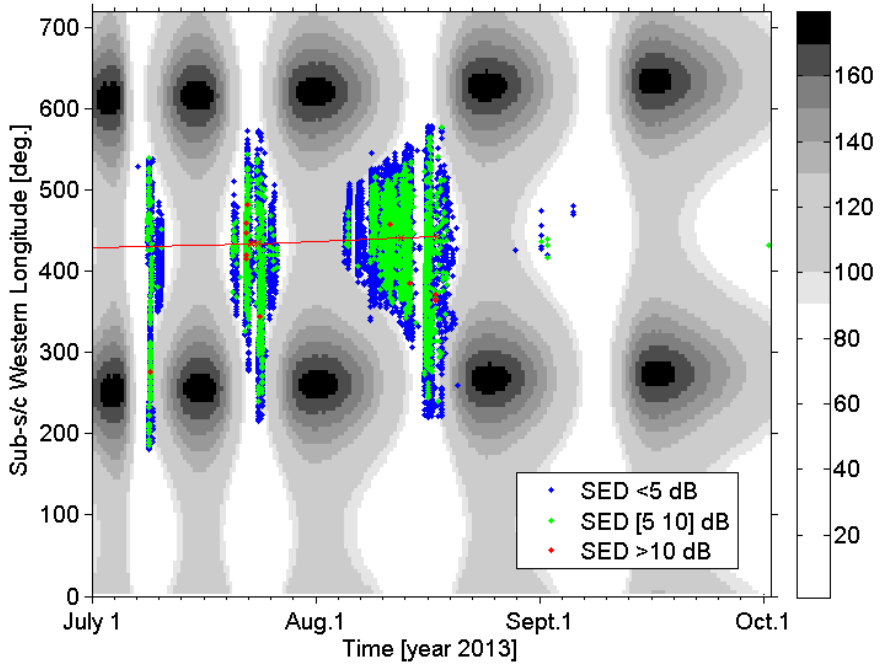
SED EPISODES FROM SUMMER 2013

Emission angle α depends on position of storm in relation to Cassini, whose latitude has a large influence: For high northern latitude, the 50°N cyclone is visible all the time (western longitude range of SED episodes can go up to 360°), whereas for high southern latitudes the 50°N cyclone is invisible all the time. SED episodes of summer 2013 show good match with respect to storm visibility.





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SUMMARY

- Long-lived cyclone at 50°N (diameter ~3000 km) was observed by Cassini ISS from mid-2007 until the end of 2013 with a westward drift of ~0.3° per day
- First time it showed SED activity was in late 2010 and early 2011 during a time when the Great White Spot (GWS) raged at 35°N
- It is partly possible to separate the SEDs of the 50°N cyclone (low rate: few SEDs per minute) from the SEDs of the GWS (high rate: up to 10 SEDs per second) due to the different storm longitudes
- There were 6 more outbreaks of SED activity: in autumn 2011, December 2011, spring 2012, July 2012, summer 2013, and autumn 2013.
- Western longitude range of SED episodes is matching the visibility of the 50°N cyclone, so that practically all SEDs after the GWS come from 50°N cyclone
- Last SED episode of Cassini mission was observed on 10 November 2013. Since then, no more SED storms were detected (also not by UTR-2 or ground-based images, even after the end of Cassini mission)
- Paper about 50°N cyclone is in preparation (Gunnarson et al.)
- Final paper about non-detection of Titan lightning submitted to JGR Planets