Overview of Saturn lightning observations

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Abstract

The lightning activity in Saturn’s atmosphere has been monitored by Cassini for more than 6 years. The continuous observations of the radio signatures called SEDs (Saturn Electrostatic Discharges) combined favourably with imaging observations of related cloud features as well as direct observations of flash-illuminated cloud tops. The Cassini RPWS (Radio and Plasma Wave Science) instrument and ISS (Imaging Science Subsystem) in orbit around Saturn also got ground-based support: The intense SED radio waves were also detected by the giant UTR-2 radio telescope, and committed amateurs observed SED-related white spots with their backyard optical telescopes. Furthermore, the Cassini VIMS (Visual and Infrared Mapping Spectrometer) and CIRS (Composite Infrared Spectrometer) instruments have provided some information on chemical constituents possibly created by the lightning discharges and transported upward to Saturn’s upper atmosphere by vertical convection. In this presentation we summarize the main results on Saturn lightning provided by this multi-instrumental approach and show how it correlates to the SED activity as measured by RPWS as a function of time throughout the Cassini mission.

Observations by Cassini RPWS over 6 years

Until now the Cassini RPWS instrument has recorded 10 storms of Saturn lightning (named 0, A, B, C, D, E, F, G, H, I), which are displayed in Figure 1. Such SED storms can last from a few days up to several months. There was also an interval of 21 months between storms E and F with no SED activity. The last years around Saturn equinox (August 11, 2009) were characterized by strong SED activity which might be a seasonal effect.

Figure 1: Numbers of SEDs per Saturn rotation as a function of time. The gray background denotes data gaps and the SED numbers from 2009 and later are first estimates.

Direct optical observations of Saturn lightning flashes

The first direct optical observation of Saturn lightning was performed by Cassini ISS on August 17, 2009 [Dyudina et al., 2010]. The reduced ring shine around equinox allowed the cameras to detect illuminated cloud tops on Saturn’s night side, which are displayed on the left side of Figure 2. The size of the spots of a few hundred kilometers allowed the determination of the SED source depth which should be located 125–250 km below the cloud tops, most likely in the water cloud layer.

Figure 2: The left side shows images of Saturn lightning flashes observed by Cassini ISS in 2009 (from Dyudina et al., 2010). Longitude, latitude and time of the observations are given. The right side shows the corresponding RPWS dynamic spectrum which shows the radio wave intensity as a function of time and frequency.

Cassini ISS and ground-based optical observations

For 8 of the 10 SED storms Cassini ISS and/or ground-based observers detected an associated cloud feature in the so-called “storm alley” at a latitude of 35° south. For only two short storms (0 and D) no associated storm cloud could be found. The relation between the SEDs and the storm clouds is characterized by consistent longitudes and drift rates, and the clouds are brighter when SED rates are high [Dyudina et al., 2007; Fischer et al., 2007].

Cassini image from March 4, 2008, in infrared, green and violet filters. © NASA.

Figure 4: Ground-based telescopic observations of Saturn with SED storm cloud by Camden Peach, Anthony Wesley, and Trevor Barry (South is up here). Observations were done on Dec. 7, 2008; March 6, 2009; and June 3, 2010; and they show the storm clouds of SED storms G, H, and I, respectively.

Cassini raw image from June 18, 2008. © NASA.

Figure 5: False color image taken by Cassini VIMS of bright storm cloud with dark spots in 1 µm wavelength range (from Baines et al., 2009).

Summary and acknowledgement

This poster gives an overview of the SED activity measured by Cassini RPWS within the last 6 years. It shows that studying Saturn lightning has become a multi-instrumental task involving the Cassini instruments RPWS, ISS, VIMS, CIRS as well as ground-based optical observations and measurements by giant radio telescopes like UTR-2 (the latter not shown in this poster).

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References

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