



Data User Guide

LIS/OTD Gridded Lightning Climatology Data Collection

Introduction

The LIS/OTD Gridded Lightning Climatology Data Collection contains a variety of gridded climatologies of total lightning flash rates obtained from two lightning detection sensors - the spaceborne Optical Transient Detector (OTD) on Orbview-1 and the Lightning Imaging Sensor (LIS) onboard the Tropical Rainfall Measuring Mission (TRMM) satellite. The long time series of TRMM LIS consisting of observations between +/- 38 degree latitude makes the merged climatology more robust in the tropics and subtropics where observations from both instruments exist. At higher latitudes (>38 degrees) observations are obtained entirely from OTD during 1995 to 2000. The gridded climatologies include annual mean flash rate on a 0.5 degree grid, mean diurnal cycle of flash rate on a 2.5 degree grid with 24 hour resolution, mean annual cycle of flash rate on a 0.5 degree or 2.5 degree grid with daily, monthly, or seasonal resolution, mean annual cycle of the diurnal cycle on a 2.5 degree grid with two hour resolution for each day, and a time series of flash rate over the entire record with roughly three-month smoothing. For some of these products (e.g., annual cycle of the diurnal cycle), more smoothing is used to produce robust results. The data sets are described in greater detail in the following paper: [Gridded lightning climatology from TRMM-LIS and OTD: Dataset description](#).

Citation

Cecil, Daniel J. 2015. LIS/OTD Gridded Lightning Climatology Data Collection, Version 2.3.2015, [indicate subset used]. Dataset available online from the NASA EOSDIS Global Hydrology Resource Center Distributed Active Archive Center, Huntsville, Alabama, U.S.A. doi: <http://dx.doi.org/10.5067/LIS/LIS-OTD/DATA311>.

Notice: This data collection contains multiple products. If the entire collection is accessed, use the citation listed above. If a specific product is accessed, use the citation provided on the GHRC data product landing page for that data product. The entire data collection reprocessed in 2016 to add the 2015 TRMM LIS data and the version number was changed from V2.3.2014 to V2.3.2015. The doi for each of the updated datasets remains the same.

Keywords:

NASA, GHRC, LIS/OTD, Climatology, Flash Rate, Lightning, global, atmospheric electricity, TRMM, OrbView-1, LIS, OTD, raw flashes, scaled flashes, flash rate time series

Campaign

This data collection contains data products made using observations from two long-operating lightning satellite instruments. Both instruments operated on satellite platforms under the guidance of the NASA Lightning Science Team. There is no official campaign or project for this data collection. The first sensor is the Optical Transient Detector (OTD) that flew on the OrbView-1 (previously named MicroLab-1) satellite launched in April 1995. OTD ceased operating in March 2000. The second sensor is the Lightning Imaging Sensor that flew on the Tropical Rainfall Measuring Mission (TRMM) satellite launched in November 1997. TRMM LIS ceased operating in April 2015 when the TRMM satellite was removed from orbit.

Instrument Descriptions

The Optical Transient Detector (OTD) was a scientific payload on the OrbView-1 (previously named MicroLab-1) satellite, which was launched in April of 1995. The primary mission of the OTD was to improve the understanding of thunderstorm distributions, cloud processes, and storm variability by detecting and locating lightning activity over large areas of the Earth's surface. The OTD detected both intra-cloud and cloud-to-ground discharges during day and night conditions with a high detection efficiency. The OTD located the lightning discharges that occurred within its field-of-view, marked the time of occurrence of the lightning, and measured the radiant energy. The concept for this instrument was developed at NASA's Marshall Space Flight Center in the 1980s after which it was selected for development as part of NASA's Earth Observing System (EOS). More information about the OTD is in Christian et al., 2003 and at <https://ghrc.nsstc.nasa.gov/home/micro-articles/earth-observations-optical-transient-detector-otd>.

The OTD instrument was a flight-qualified engineering model for the Lightning Imaging Sensor (LIS). LIS was launched in November of 1997 on the Tropical Rainfall Measuring Mission (TRMM) satellite and operated until April 2015 at which time it was turned off before the TRMM satellite was removed from orbit. A backup LIS sensor was placed on the International Space Station (ISS) in February 2017, but data from ISS LIS are not included in this product. LIS is an optical staring telescope designed as an on-orbit lightning detector that can detect lightning in day or night conditions. LIS is used to detect the distribution and variability of total lightning (cloud-to-cloud, intra-cloud, and cloud-to-ground lightning). The TRMM LIS detected total lightning in the tropical and subtropical regions. LIS observations included the time of occurrence, radiant energy, and location of lightning events within the field-of-view. Data products include geolocated background images, lightning event area, flash, group, and point data, as well as 2.5 degree and 500 km

gridded summaries. More LIS information is at <https://ghrc.nsstc.nasa.gov/home/micro-articles/earth-observations-lightning-imaging-sensor> and in Albrecht et al., 2011.

The TRMM LIS and OTD sensors monitor the 777.4 nm atomic oxygen multiplet, detecting pulses of illumination (produced by lightning) above background levels. Both were onboard satellites operating in low earth orbit, viewing any earth location for about 3 minutes (OTD) or 1.5 minutes (LIS) during overhead passing. Individual orbit data files, 14 (OTD) or 16 (TRMM LIS) files per day, are available from the Global Hydrology Resource Center (GHRC DAAC). Lightning flash times and locations are recorded with approximately 10 km (OTD) and 5 km (TRMM LIS) resolution. For a 0.5 degree x 0.5 degree latitude-longitude grid cell, the orbit files contain which grid cells are within the field of view with the instrument for which the quality control flags indicate acceptable operating conditions for each second of the orbit. Many other lightning attributes and instrument information are included in the orbital files (for example, flash duration, radiance, and areal extent of the illumination).

For each grid cell, the total view time (observation duration) and flash counts are summed over all orbits, and sorted by time of day and day of year. Flash counts are scaled by each instrument's detection efficiency which varies with time of day. For the OTD, detection efficiency also varies with geographic location and sensor threshold settings. The optical sensors can more easily discriminate lightning from the background scene at night, but have more difficulty with bright daytime cloud tops. The LIS detection efficiency ranges from about 69% near local noon to 88% overnight. Different sensitivity thresholds were used with the OTD during the course of its mission, with the detection efficiency adjusted accordingly. The OTD detection efficiency is reduced roughly in half over the South Atlantic Anomaly. The detection efficiency values as a function of sensitivity thresholds, geographic location, and time of day are available in the data files for the gridded climatology.

Investigators

Daniel J. Cecil
NASA Marshall Space Flight Center
Huntsville, Alabama

File Naming Convention

The LIS/OTD Gridded Lightning Climatology Dataset products have the following naming convention:

Data: LISOTD_XXXX_V2.3.2015.[hdf|nc]

Browse: XXXX_COM_FR_V2.3.2015.png

Table 1: File naming convention variables

Variable	Description	
XXXX	Acronym	Dataset Description
	HRFC	LIS/OTD 0.5 Degree High Resolution Full Climatology
	HRAC	LIS/OTD 0.5 Degree High Resolution Annual Climatology
	HRMC	LIS/OTD 0.5 Degree High Resolution Monthly Climatology
	LRFC	LIS/OTD 2.5 Degree Low Resolution Full Climatology
	LRAC	LRAC - LIS/OTD 2.5 Degree Low Resolution Annual Climatology
	LRDC	LIS/OTD 2.5 Degree Low Resolution Diurnal Climatology
	LRADC	LRADC - LIS/OTD 2.5 Degree Low Resolution Annual Diurnal Climatology
	LRTS	LRTS - LIS/OTD 2.5 Degree Low Resolution Time Series
	LRACTS	LRACTS - LIS/OTD 2.5 Degree Low Resolution Annual Climatology Time Series
	LRMTS	LRMTS - LIS/OTD 2.5 Degree Low Resolution Monthly Time Series
	.hdf	Hierarchical Data Format
.nc	netCDF-4	
.png	Portable Network Graphics	

Data Format Description

Lightning flash times and locations are recorded with approximately 10 km (OTD) and 5 km (LIS) resolution. For a 0.5 degree x 0.5 degree latitude-longitude grid cell, the orbit files contain which grid cells are within the instrument field of view for which the quality control flags indicate acceptable operating conditions for each second of the orbit. Many other lightning attributes and instrument information are included in the orbital files (for example, flash duration, radiance, and areal extent of the illumination).

For each grid cell, the total view time (observation duration) and flash counts are summed over all orbits, and sorted by time of day and day of year. Flash counts are scaled by each instrument’s detection efficiency which varies with time of day. For the OTD, detection efficiency also varies with geographic location and sensor threshold settings. The optical sensors can more easily discriminate lightning from the background scene at night, but have more difficulty with bright daytime cloud tops. Detailed detection efficiency values for both LIS and OTD are provided in the data files as a function of time of day, sensitivity threshold, and geographic location.

Table 2: Data Characteristics

Characteristic	Description
Platform	TRMM (LIS) and OrbView-1 (OTD)
Instrument	Lightning Imaging Sensor (LIS) and Optical Transient Detector (OTD)
Projection	n/a
Spatial Coverage	N: 90 , S: -90, E: 180, W: -180
Spatial Resolution	Data are provided on 0.5 and 2.5 degree grids
Temporal Coverage	Start date: May 4, 1995 Stop date: December 31, 2014
Temporal Resolution	HRAC: Annual Climatology HRFC: Annual Climatology HRMC: Monthly Climatology LRAC: Annual Climatology LRACTS: Annual Time Series LRADC: Annual Diurnal Climatology LRDC: Diurnal Climatology LRFC: Annual Climatology LRMTS: Monthly Time Series LRSTS: Time Series
Sampling Frequency	5 milliseconds
Parameter	HRAC: flash rate annual climatology HRFC: flash rate climatology, raw flashes, scaled flashes HRMC: flash rate monthly climatology, flash rate seasonal climatology LRAC: flash rate climatology, raw flashes, scaled flashes LRACTS: flash rate time series LRADC: scaled flash counts, flash rate climatology LRDC: flash rate climatology, raw flashes, scaled flashes LRFC: flash rate climatology, raw flashes, scaled flashes LRMTS: flash rate monthly time series LRSTS: flash rate time series
Version	2.3.2015
Processing Level	3

Data Parameters

There are 10 Gridded Lightning Climatology data product files within this LIS/OTD climatology collection. The LIS/OTD Gridded Lightning Datasets consist of flash rate climatology, raw flashes, scaled flashes, flash rate, and flash rate time series data. Table 2 shows which parameter is in each dataset.

Each is described in detail in the Gridded lightning climatology from TRMM-LIS and OTD: Dataset description (see Cecil, et al., 2014) and summarized in Table 1 below.

Table 3. Products within LIS/OTD gridded climatology files

File	Product name	Product description	Units	Product	Bin sizes	Smoothing
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identifier				dimensions		
HRFC	HRFC_COM_FR HRFC_OTD_FR HRFC_LIS_FR	Mean annual flash rate	Flashes km-2 year-1	720 x 360	0.5° x 0.5°	none
HRFC	HRFC_OTD_RF HRFC_LIS_RF	Raw flash count	Flashes	720 x 360	0.5° x 0.5°	none
HRFC	HRFC_OTD_SF HRFC_LIS_SF	Flash count scaled by detection efficiency	Flashes	720 x 360	0.5° x 0.5°	none
HRFC	HRFC_OTD_VT HRFC_LIS_VT	Viewtime (observation duration)	s km2	720 x 360	0.5° x 0.5°	none
LRFC	Same products as HRFC	Low-resolution version of HRFC	Flashes km-2 year-1	144 x 72	2.5° x 2.5°	none
LRDC	Same products as HRFC	Mean diurnal cycle, in local solar time	Flashes km-2 hour-1	24 x 144 x 72	1 hr x 2.5° x 2.5°	none
HRAC	HRAC_COM_FR HRAC_OTD_FR HRAC_LIS_FR	Annual cycle of flash rate	Flashes km-2 day-1	365 x 720 x 360	1 day x 0.5° x 0.5°	2.5° x 2.5° boxcar moving average, 111-day boxcar moving average, 110-day digital filter
LRAC	Same products as HRFC	Low spatial resolution annual cycle	Flashes km-2 day-1;	365 x 144 x 72	1 day x 2.5° x 2.5°	none
HRMC	HRMC_COM_FR HRMC_OTD_FR HRMC_LIS_FR	Mean flash rate in middle of each month, with monthly smoothing	Flashes km-2 day-1	12 x 720 x 360	1 month x 0.5° x 0.5°	2.5° x 2.5° boxcar moving average, 31-day boxcar moving average, 30-day digital filter
HRMC	HRSC_COM_FR HRSC_OTD_FR HRSC_LIS_FR	Mean flash rate in middle of each month, with seasonal smoothing	Flashes km-2 day-1	12 x 720 x 360	1 month x 0.5° x 0.5°	2.5° x 2.5° boxcar moving average, 91-day boxcar moving average, 91-day digital filter
LRADC	LRADC_COM_SMFR	Annual cycle of diurnal cycle (UTC) of flash rate	Flashes km-2 day-1	365 x 6 x 144 x 72	1 day x 4 hours (UTC) x 2.5° x 2.5°	7.5° x 7.5° boxcar moving average, 111-day boxcar moving average
LRADC	LRADC_COM_SMFR2	Annual cycle of diurnal cycle (UTC) of flash rate	Flashes km-2 day-1	365 x 12 x 144 x 72	1 day x 2 hours (UTC) x 2.5° x 2.5°	As in SMFR, but with 55-day boxcar moving average
LRADC	LRADC_COM_SF	Flash count scaled by detection efficiency	Flashes	365 x 12 x 144 x 72	1 day x 2 hours (UTC) x 2.5° x 2.5°	n/a
LRADC	LRADC_COM_VT	Viewtime (observation duration)	days km2	365 x 12 x 144 x 72	1 day x 2 hours (UTC) x 2.5° x 2.5°	n/a
LRTS	LRTS_COM_FR LRTS_COM_VT	Daily time series of flash rate and viewtime, 28 June 1995 - 08 April 2014	Flashes km-2 day-1; days km2	5716 x 144 x 72	1 day x 2.5° x 2.5°	7.5° x 7.5° boxcar moving average, 111-day boxcar moving average, 110-day digital filter
LRTS	LRTS_OTD_FR	Daily time series of	Flashes km-2 day-1;	1676 x 144 x 72	1 day x 2.5°	7.5° x 7.5° boxcar

	LRTS_OTD_VT	flash rate and viewtime, 28 June 1995 -08 April 2014	days km ²		x 2.5°	moving average, 111-day boxcar moving average, 110-day digital filter
LRTS	LRTS_LIS_FR LRTS_LIS_VT	Daily time series of flash rate and viewtime, 25 February 1998 - 08 April 2014	Flashes km ⁻² day ⁻¹ ; days km ²	4749 x 144 x 72	1 day x 2.5° x 2.5°	7.5° x 7.5° boxcar moving average, 99-day boxcar moving average, 98-day digital filter
LRMTS	LRMTS_COM_FR	Monthly time series of flash rate (weighted more toward LIS than other products)	Flashes km ⁻² day ⁻¹	204 x 144 x 72	1 month x 2.5° x 2.5°	Weighted average of LRTS_OTD_FR and LRTS_LIS_FR
LRACTS	Same products as LRTS	Mean daily flash rate from time series product	Flashes km ⁻² day ⁻¹	366 x 144 x 72	1 day x 2.5° x 2.5°	Same as LRTS

Quality Assessment

Flash counts are scaled by each instrument's detection efficiency which varies with time of day. For the OTD, detection efficiency also varied with geographic location and sensor threshold settings that were adjusted during the period of sensor operation. The optical sensors can more easily discriminate lightning from the background scene at night, with bright daytime cloud tops being more difficult. The LIS detection efficiency ranges from about 69% near local noon to 88% overnight. Different sensitivity thresholds were used with the OTD during the course of its mission, with the detection efficiency adjusted accordingly. The OTD detection efficiency is reduced roughly in half over the South Atlantic Anomaly. The OTD detection efficiency values ranged between 37% near local noon and 52% overnight for areas outside of the South Atlantic Anomaly. The detection efficiency values as a function of sensitivity thresholds, geographic location, and time of day are available in the data files. More information about the quality assessment of the OTD and LIS data is available in Boccippio et al., 2002, Albrecht et al., 2011, and Blakeslee et al., 2014.

Software

No special software is required to read HDF-4 format data files; however, [Panoply](#) can make it easier to examine file contents. No special software is needed to view the browse images.

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Contact Information

To order these data or for further information, please contact:

NASA Global Hydrology Resource Center DAAC

User Services

320 Sparkman Drive

Huntsville, AL 35805

Phone: 256-961-7932

E-mail: support-ghrc@earthdata.nasa.gov

Web: <https://ghrc.nsstc.nasa.gov/>

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