Global Hydrology Resource Center

Data User Guide

Optical Transient Detector (OTD) Lightning

Introduction

The Optical Transient Detector (OTD) recorded optical measurements of global lightning discharges within its field-of-view and measured the radiant energy. The OTD was launched on April 3, 1995 aboard the OrbView-1 (formerly MicroLab-1) satellite into a near polar orbit with an inclination of 70 degrees with respect to the equator, at an altitude of 740 km. The OTD mission ended March 23, 2000. The OTD detected both intra-cloud and cloud-to-ground discharges during day and night conditions with a spatial resolution of 10 km and a temporal resolution of 2 ms. The data files include individual point (lightning) data, satellite metadata, and several derived products. The OTD was a predecessor of the TRMM LIS instrument.

Notice:
After unzipping the data file, there is no extension; however, these files are HDF files. For data to be read correctly in software, please rename the file with the extension ".hdf".

Citation

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Keywords:

GHRC, NASA, LIS, OTD, Optical Transient Detector, Lightning, OrbView-1, lifetime of flash, size of flash, flash location, flash density, number of flashes;

Mission/Instrument Description

The Optical Transient Detector (OTD) was a scientific payload on the OrbView-1 (previously named MicroLab-1) satellite, which was launched into orbit by a Pegasus rocket in April 1995. The primary mission of the OTD instrument 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 concept for this instrument was developed at NASA's Marshall Space Flight Center in the 1980s, and was selected for development as part of NASA's Earth Observing System (EOS). The OTD instrument was a flight-qualified engineering model for the Lightning Imaging Sensor (LIS) on the Tropical Rainfall Measuring Mission (TRMM) satellite.

The OTD instrument detected and 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 OTD detected both intra-cloud and cloud-to-ground discharges during day and night conditions with a high detection efficiency. Due to the 128 x 128 pixel photo-diode array and wide field-of-view lens, the OTD instrument viewed a total area of 1300 km x 1300 km. The instrument mission ended March 23, 2000. More information about the OTD instrument can be found at https://ghrc.nsstc.nasa.gov/home/micro-articles/earth-observations-optical-transient-detector-otd.

Investigators

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File Naming Convention

The Optical Transient Detector (OTD) Lightning data files have the following naming convention:

Tarred Data Files: otdlip_YYYY.JJJ_daily.tar
Untarred Data Files: mlab.otd.1_1.YYYY.JJJ.xxxx.hdf
Browse Files: mlab.otd.1_1.YYYY.JJJ.gif

Table 1: File naming convention variables

Variable	Description
mlab	MicroLab-1 satellite, now called OrbView-1
YYYY	Four-digit year
JJJ	Three-digit Julian day
xxxx	Orbit number
.tar	Tape ARchive
.hdf	Hierarchical Data Format
.gif	Graphics Interchange Format

Data Format Description

The data obtained from the OTD instrument are stored in a Hierarchical Data Format (HDF) format files. For the definitions and full descriptions of the data fields please refer to the Algorithm Theoretical Basis Document (ATBD) for the Lightning Imaging Sensor (LIS).

The data obtained by the OTD instrument includes the background images, as well as the lightning data. A background image is roughly a "snapshot" of the field-of-view of the instrument. These images are recorded about once every minute by the instrument, although the time between images varies according to the amount of lightning data being processed. The lightning data is simply the optical pulses that the OTD detects while passing over active thunderstorms. These optical pulses are assembled into individual classes, referred to as "EVENTS", "GROUPS", "FLASHES", and "AREAS".

An EVENT is the smallest granule of OTD data that is recorded as soon as a lightning flash is observed. A GROUP is defined as one or more adjacent events in the same 2 millisecond time frame. A FLASH is defined as one or more GROUPS sufficiently close in space in time to be classified as a single FLASH. An AREA is defined as a grouping of one or more FLASHES that are sufficiently separate from existing AREAS. For more details of the lightning data classes, see the Algorithm Theoretical Basis Document (ATBD) for the Lightning Imaging Sensor (LIS).

Table 2: Data Characteristics

Characteristic	Description
Platform	OrbView-1
Instrument	Optical Transient Detector (OTD)
Projection	n/a
Spatial Coverage	N: 70 , S: -70 , E: 180, W: -180 (Global)
Spatial Resolution	10 km
Temporal Coverage	Start date: April 13, 1995 Stop date: March 23, 2000
Temporal Resolution	daily
Sampling Frequency	2 milliseconds
Parameter	Flash density, flash count, flash location
Version	1
Processing Level	1B

Data Parameters

The Optical Transient Detector (OTD) Lightning data consists of lightning flash density, lightning flash count, lightning flash location, and lightning flash duration. Table 3 shows the parameter and the units of each parameter.

Table 3: Data parameters description

Parameter	Unit
Lightning flash density	Flashes per 2.5° Flashes per 500 km Flashes per view time
Lightning flash count	n/a
Lightning flash location	degrees

Quality Assessment

OTD exists in a noisy space environment. It also responds to a number of optical signals, not all of which are necessarily lightning related. A significant amount of software filtering has gone into the production of science data distributed to the science community. The filters maximize both detection efficiency and confidence level so that each datum is signal, and not noise. More information about the quality of the Optical Transient Detector (OTD) Lightning data are available at http://eospso.nasa.gov/sites/default/files/atbd/atbd-lis-01.pdf.

Each OTD lightning event in an OTD file is tagged with four low-level quality indicators, while each OTD data file is assigned four high-level flags that were designed to notify potential users of possible irregularities in the data file. An automated process is used to tag each optical event in the OTD data file with a set of four numbers that indicate the relative likelihood that the event was produced by lightning, as opposed to solar glint, energetic particles in the Van Allen radiation belts, or electronic noise. These low-level tags are as follows:

1. Non-noise Probability (the probability that the event is not caused by random noise or energetic particles).
2. Solar Glint Factor (a number that indicates the likelihood that the event was caused by direct reflected solar radiation).
3. Event Rate Ratio (a number that represents the ratio of "accepted" events to the raw detected events during a one-second period at the time of the event).
4. Probability Density (a number that indicates whether the event is geolocated in the vicinity of other events that are likely to be lightning).

In addition, each OTD data file is manually inspected for irregularities in the data set. The data files that fail specific quality assurance are flagged. The high-level quality flags assigned to each OTD HDF data file are contained in the file OTD_QA.dat included with the LISOTD software. The structure of each line in this ascii file is as follows:
YY JJJ XXXX A B C D E
where YY is year, JJJ is julian day of year, XXXX is orbit number, and A,B,C,D and E are as follows:
A. This file has no valid data and shouldn't be used (not supposed to be distributed)
B. The file contains an irregular number of events that appear not to have been caused by lightning.
C. The file contains an instrument view time that is inconsistent with the period of the orbit or the periods of data availability.
D. The file contains data beyond normal orbit length or the file is tagged with an irregular orbit start or stop time.

E. The ephemeris used to geolocate some or all lightning events in the file is questionable and/or the satellite is out of control.

It is recommended that if any values occur in A-E that the file not be used for climate applications since they may skew flash rate calculations. These files are included in the distribution because useful data occur within some portion of the dataset.

Software

A new software package is available which supersedes previous OTD read software. The LIS/OTD Read software can read both OTD and LIS HDF files. While both datasets are in slightly different HDF formats, both can be read by this software package.

The following is from the introductory chapter of the user manual for the software package:

> "This document serves as a guide to the software intended for use with satellite data from the Optical Transient Detector (OTD) and Lightning Imaging Sensor (LIS). The software suite consists of both fully featured GUI (Graphical User Interface) driven applications, and collections of high- and low-level APIs (Application Programming Interfaces). The software is designed to simplify, as much as possible, user access to the OTD and LIS lightning data sets, which are currently distributed in HDF (Hierarchical Data Format) files. The suite is designed with four goals in mind: simplicity, reusability, compatibility and deployment. By providing software strongly tailored to these goals, we hope to minimize each user's time spent accessing and managing the datasets, and maximize the time spent actually analyzing them."

The software package and documentation is available at https://ghrc.nsstc.nasa.gov/pub/doc/otd/.

All of the lightning data recorded by the OTD was geolocated using the SPICE Toolkit software, which was developed at the Navigation Ancillary Information Facility at Caltech's Jet Propulsion Laboratory. The SPICE Toolkit provided a means to conveniently store and access the ephemeris data for the OTD instrument using data sets called "kernels". The OTD "kernels" were constructed with SPICE software by combining the fixed sensor/platform geometry with the continuous stream of navigational information supplied by the OrbView-1 satellite. More information about the SPICE Toolkit software can be found at http://naif.jpl.nasa.gov/naif/.

References

Christian, H. J., R. J. Blakeslee, and S. J. Goodman, The Detection of Lightning from Geostationary Orbit, J. Geophys. Res., Vol. 94, pp. 13329-13337, 1989.

Christian, H. J., R. J. Blakeslee, S. J. Goodman, and D. M. Mach, Algorithm Theoretical Basis Document (ATBD) For the Lightning Imaging Sensor (LIS), Earth Observing System (EOS) Instrument Product, only available at

http://eospso.gsfc.nasa.gov/eos_homepage/for_scientists/atbd/docs/LIS/atbd-lis-01.pdf.

Christian, H.J., R.J. Blakeslee, and S.J. Goodman, Lightning Imaging Sensor (LIS) for the Earth Observing System, NASA Technical Memorandum 4350, MSFC, Huntsville, AL, February, 1992.

Contact Information

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

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

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