LIS/OTD 2.5 Degree Low Resolution Annual Climatology Time Series (LRACTS)

1. Name

LIS/OTD 2.5 Degree Low Resolution Annual Climatology Time Series

2. Version

0.1 Dataset size ~59.2Mb

3. Short Description

The product is a 2.5 deg x 2.5 deg gridded composite of daily time-series of total (IC+CG) lightning bulk production, expressed as a flash rate density (fl/km$^2$/day), representing a climatological year from the OTD, LIS and combined OTD/LIS missions. It is similar to the Low Resolution Annual Climatology (LRAC) product but uses the space-and-time smoothing procedure employed for the Low Resolution Time Series (LRTS) daily gridded products, hence, it is appropriate as a baseline against which to compute anomalies in the LRTS product. Data are generated from the OTD (5/95-12/97), OTD/LIS combined (12/97-3/00) and LIS (12/97-2/03) missions. See paragraph 6a. below for more detailed information.

4. Format

The product is distributed in HDF (Hierarchical Data Format). HDF is accessible from C or Fortran using interfaces provided by NCSA (http://hdf.ncsa.uiuc.edu), or through various commercial software packages, such as IDL or Noesis (both from http://www.rsinc.com), or MATLAB (http://www.mathworks.com). All data in this product are stored in HDF Scientific Data Sets (SDS). Note that inline (HDF internal) GZIP compression has been applied. Users should verify that their NCSA HDF library distribution or third-party software application versions are current enough to transparently decompress inline-compressed HDF grids.

5. Citation and Acknowledgements

This preliminary dataset is being made available to the community prior to full intercomparison of the overlapping OTD and LIS time series. The variance in the separate products, and in the combined product, has not yet been quantified. Users should note that these data are experimental. Inclusion of the product version number in citations is strongly recommended for traceability. In presentations or publications, users are to acknowledge the dataset as follows:

The v0.1 gridded satellite lightning data were produced by the NASA LIS/OTD Science Team (Principal Investigator, Dr. Hugh J. Christian, NASA / Marshall Space Flight Center) and are available from the Global Hydrology Resource Center (http://ghrc.msfc.nasa.gov).

6. Long Description

a. Approach

Bulk lightning production, expressed in fl/km$^2$/day, is calculated as a “counting experiment”. The calculation procedure is described in the documentation for the Low Resolution Time Series (LRTS) product. The climatological annual cycles (at daily resolution) in this product are generated as the average of the corresponding days-of-year in the LRTS products, conditional upon mission status. Thus, in the combined LIS/OTD product, the annual cycle in the tropics contains daily data from OTD only from 5/95-12/97, data from both OTD and LIS from 12/97-3/00, and data from LIS only from 12/97-2/03. In the extratropics, the annual cycle in the combined product only contains data from OTD from 5/95-3/00.
The final products are thus climatological daily, 2.5 deg resolution maps of estimated flash rate density, whose estimates contain 7.5 deg spatial moving average and [110, 110 or 98] day lowpass filtered observations (approximately 3-month windows), averaged over the appropriate number of mission-years for the ground location.

The grids contain 366 daily maps, one for each day of year (day 366 only includes data from 1996 and 2000). Due to the simple averaging procedure employed, the annual cycles contain some minor discontinuities due to nonuniform mission windows and additional time smoothing by end-users may be desirable.

b. Contents

The HDF file contains 7 Scientific Data Set (SDS) grids compressed internally (and transparently) using GZIP lossless compression. These include:

- LRACTS_COM_FR Combined Flash Rate [366x144x72, float, fl/km²/dy]
- LRACTS_OTD_FR OTD-only Flash Rate [366x144x72, float, fl/km²/dy]
- LRACTS_LIS_FR LIS-only Flash Rate [366x144x72, float, fl/km²/dy]
- LRACTS_COM_VT Combined Viewing [366x144x72, float, km² dy]
- LRACTS_OTD_VT OTD-only Viewing [366x144x72, float, km² dy]
- LRACTS_LIS_VT LIS-only Viewing [366x144x72, float, km² dy]
- LRACTS_AREA Grid cell areas [144x72, km²]

The LRACTS_xxx_FR products are the primary data products. The LRACTS_xxx_VT products are included for user reference to demonstrate the variable instrument viewing; users are encouraged to review these grids to understand the relative variability in the input data sampling. The LRACTS_AREA product is included for convenience.

7. Calibration

Best-available calibrations for instrument detection efficiency (as of 4/22/03) have been applied in the v0.1 product, as a function of mission date, local time of day, and location relative to the South Atlantic Anomaly. These are documented in Boccioppio et al, 2002 and Christian et al, 2003, and summarized in the documentation for the High Resolution Full Climatology (LISOTD_HRFC) product, also available from the GHRC. The HRFC product also contains the spatially and temporally variant detection efficiency grids applied to the LRTS data, which are inputs to the LRACTS product.

Users wishing to cite this calibration procedure may use or modify the following:

Observations in the LIS/OTD v0.1 time series gridded products have been corrected by the LIS Science Team by estimated flash detection efficiency, applied as a function of sensor, local hour, date of mission, and (for the OTD) geographic location. For the entire dataset, these corrections correspond to average flash detection efficiencies of 47% (OTD) and 82% (LIS). The adjustments derive from a combination of laboratory calibration, ground-validation and cross-normalization between the two instruments. Uncertainty in these corrections is estimated as +/-10%. The calibration procedure is described in the dataset documentation. The gridded time series products additionally have been averaged spatially (7.5 deg, at 2.5 deg resolution) and temporally ([select 110 or 98 days as appropriate] low pass filters have been applied).

8. Uncertainty

Consistency between modeled and ground-validated detection efficiency suggests that the applied corrections are know within about +/- 10%. This is thus the minimum uncertainty in the gridded data, arising from possible bias in the correction. A much higher source of uncertainty in the time
series products is undersampling of a given grid location, even with the severe spatial and temporal averaging that has been applied.

9. **Quality Assurance**

All OTD and LIS orbits undergo both automated and manual quality assurance. For the preliminary reanalysis, the most stringent orbit rejection criterion was applied: any orbit which was assigned a manual Q/A “warning” flag has been rejected from the reanalysis.

Each OTD flash is further assigned an automated quality index (the ‘Thunderstorm Area Count’ or ‘Density Index’), indicating its likelihood of being lightning rather than optical or radiation noise. For this reanalysis, only flashes with values of the metric >= 140 have been included. This is the same cutoff value used in all validation and science analysis published by the LIS science team to date. This filter removes most radiation noise from the data; a slight residual “ring” artefact of very low spurious flash rates remains at the periphery of the South Atlantic Anomaly (southeast Pacific and southeast Atlantic).

10. **Recommended Usage**

There are no restrictions on the use of these data. However, v0.1 is an experimental reanalysis, intended to support imminent analysis needs among users and to test the validity of the data product. Users should treat the v0.1 data with caution during quantitative analysis.

Users desiring climatological “seasonal” estimates should recall that moving averages and lowpass filtering have already been applied to these data, even though the data are recorded as climatological daily grids (there is thus much redundancy in the full resolution data product). A “seasonal” estimate for, e.g., DJF would thus be the daily grid corresponding to Jan 15, which would contain data from the previous and following 55 or 49 days (depending on whether the combined, OTD or LIS time series was selected). The daily grid index for this grid would be 14.

Below is a table of useful daily grid indices.

<table>
<thead>
<tr>
<th>DJF center</th>
<th>MAM center</th>
<th>JJA center</th>
<th>SON center</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>104</td>
<td>195</td>
<td>287</td>
</tr>
</tbody>
</table>

11. **Versioning and Updates**

The current product version is v0.1. All subsequent versions of this dataset (both minor and major revisions) will maintain the same product definition, resolution and file format. Additional years of LIS data may be added into the product for future revisions, as minor version updates, but will not alter file format. Product definitional changes will be finalized with the v1.0 release, which will also be contingent upon publication in a refereed journal of the methodology and results. Subsequent major version updates will only occur if later version OTD or LIS orbit data are used as inputs to this product (the currently used orbit data versions are 1.1 for OTD; 4.0 for LIS).

12. **Contact Information**

Questions regarding dataset ordering, media issues, file handling or HDF file access (input/output) should be directed to the Global Hydrology Resource Center (ghrc@msfc.nasa.gov). Questions regarding the science data processing, viewing, calibration and variance should be addressed to Dennis.Boccippio@nasa.gov. Questions regarding the OTD or LIS missions themselves should be addressed to the OTD/LIS Principal Investigator, Hugh.J.Christian@nasa.gov.

13. **References**
Instrument and Calibration/Validation:


Boccippio, DJ; Driscoll, KT; Koshak, WJ; Blakeslee, RJ; Boeck, WL; Mach, DA; Buechler, DE; Christian, HJ; Goodman, SJ (2000): The Optical Transient Detector (OTD): Instrument characteristics and cross-sensor validation. J. Atmos. Oc. Tech. 17, 441-458.

Koshak, WJ; Bergstrom, JW; Stewart, MF; Christian, HJ; Hall, JM; Solakiewicz, RJ (2000): Laboratory calibration of the Optical Transient Detector and Lightning Imaging Sensor. J. Atmos. Oc. Tech. 17, 905-915.


Christian, HJ; Blakeslee, RJ; Goodman, SJ; Mach, DA; Stewart, MF; Buechler, DE; Koshak, WJ; Hall, JM; Boeck, WL; Driscoll, KT; Boccippio, DJ (1999): The Lightning Imaging Sensor. Proc. 11th Intl. Conf. on Atmospheric Electricity (NASA), Guntersville, AL, 7-11 June. 746-749.


Christian, HJ; Driscoll, KT; Goodman, SJ; Blakeslee, RJ; Mach, DA; Buechler, DE (1996): The Optical Transient Detector (OTD). Proc. 10th International Conference on Atmospheric Electricity, Osaka, Japan.


Goodman, SJ; Christian, HJ; Rust, WD (1988): A comparison of the optical pulse characteristics of intracloud and cloud-to-ground lightning as observed above clouds. J. Appl. Met. 27, 1369-1381.
LIS/OTD-Enabled Science & Applications:


Williams,ER; Rothkin,K; Stevenson,D; Boccippio,DJ (2000): Global lightning variations caused by changes in thunderstorm flash rate and by changes in the number of thunderstorms. J. Appl. Met. 39, 2223-2230.


Christian, HJ; Blakeslee, RJ; Boccippio, DJ; Boeck, WL; Buechler, DE; Driscoll, KT; Goodman, SJ; Hall, JM; Koshak, WJ; Mach, DM; Stewart, MF (1999): Global frequency and distribution of lightning as observed by the Optical Transient Detector (OTD). Proc. 11th Intnl. Conf. on Atmospheric Electricity (ICAE), Guntersville, AL, 7-11 June. 726-729.


14. Sample Code

A set of Interactive Data Language (IDL) routines to extract the LIS/OTD Low Resolution Time Series (LRTS) and other gridded products are distributed with the data. The IDL syntax is roughly similar to C or FORTRAN and porting of these routines should be relatively straightforward.

Note: These routines are being provided as a courtesy to the user community. The GHRC and LIS Science Team cannot guarantee technical support or compatibility with IDL version updates or platform-specific implementations.

GETGRID.PRO:
GETGRID, HDF_NAME, SDS_NAME, GRID, [DIMS, DIMNAMES, DIM0…]
Retrieves a scientific data set (and optionally, its dimensions) from one of the HDF climatology files.

LONLAT_TO_XY.PRO:
RESULT = LONLAT_TO_XY([LON,LAT],RESOLUTION)
Converts a [lon,lat] pair to a grid [x,y] index, for a given grid resolution (e.g., 2.5 deg in the LRTS product).
RESULT = XY_TO_LONLAT([X,Y],RESOLUTION)
Converts a grid [x,y] pair to a grid cell center [lon,lat], for a given grid resolution (e.g., 2.5 deg in the LRTS product).