Global Hydrology Resource Center

Data User Guide

TRMM-LBA Lightning Instrument Package (LIP)

Introduction

The TRMM-LBA Lightning Instrument Package (LIP) dataset consists of electrical field measurements of lightning from eight field mills, conductivity probe temperatures from two probes, and navigation data, for the period of January 22 through February 24, 1999. These data were collected by the LIP instrument flown aboard the NASA ER-2 high-altitude aircraft over the Amazon River basin in Brazil during the Tropical Rainfall Measuring Mission-Large-Scale Biosphere-Atmosphere Experiment in Amazonia (TRMM-LBA) field campaign. The LIP instrument was used to validate measurements by the Tropical Rainfall Measuring Mission (TRMM) Lightning Imaging Sensor (LIS). These data are provided in HDF-4 format with browse imagery available in GIF format.

Citation

Blakeslee, Richard J., 2001. TRMM-LBA LIGHTNING INSTRUMENT PACKAGE (LIP) [indicate subset used]. Dataset available online from the NASA Global Hydrology Resource Center DAAC, Huntsville, Alabama, U.S.A.
DOI: http://dx.doi.org/10.5067/LIS/LIP/DATA101

Keywords:

NASA, NASDA, GHRC, TRMM, LBA, ER-2, LIP, atmospheric electricity, air conductivity, PR, TMI, VIRS, CERES, LIS, tropical, Brazil

Campaign

The Tropical Rainfall Measuring Mission (TRMM) was a joint mission between NASA and the National Space Development Agency (NASDA) of Japan (later merged with other organizations to become the Japan Aerospace Exploration Agency or JAXA). The purpose of the mission was to use satellite observations for the study of tropical rainfall and the energy processes that drive atmospheric circulation. The instrumentation onboard the

mission's flagship, the TRMM Satellite Observatory, included the Precipitation Radar (PR), the TRMM Microwave Imager (TMI), the Visible and Infrared Scanner (VIRS), the Cloud and Earth Radiant Energy System (CERES), and the Lightning Imaging Sensor (LIS). These instruments provided extensive measurements of the processes that drive global weather and climate. More information about the Tropical Rainfall Measuring Mission can be found on the TRMM webpage.

The Tropical Rainfall Measuring Mission-Large-Scale Biosphere-Atmosphere Experiment in Amazonia (TRMM-LBA) was a field campaign designed to collect data for validation of TRMM satellite measurements and numerical cloud models. The TRMM-LBA experiment was conducted in the southwestern part of the Amazon basin in the Brazilian state of Rondonia (Figure 1) from November 1, 1998 to February 28, 1999, during the Amazonian wet season. The experiment examined the dynamic, microphysical, electrical and diabatic heating processes of tropical convection in the Amazon region. TRMM-LBA provided detailed observations of precipitating systems from surface and aircraft instrumentation including radars, atmospheric sounding and tethersonde systems, a lightning location and detection network, rain gauges, disdrometers, profilers, and other related instruments. More information about the TRMM-LBA field campaign can be found on the TRMM-LBA webpage.

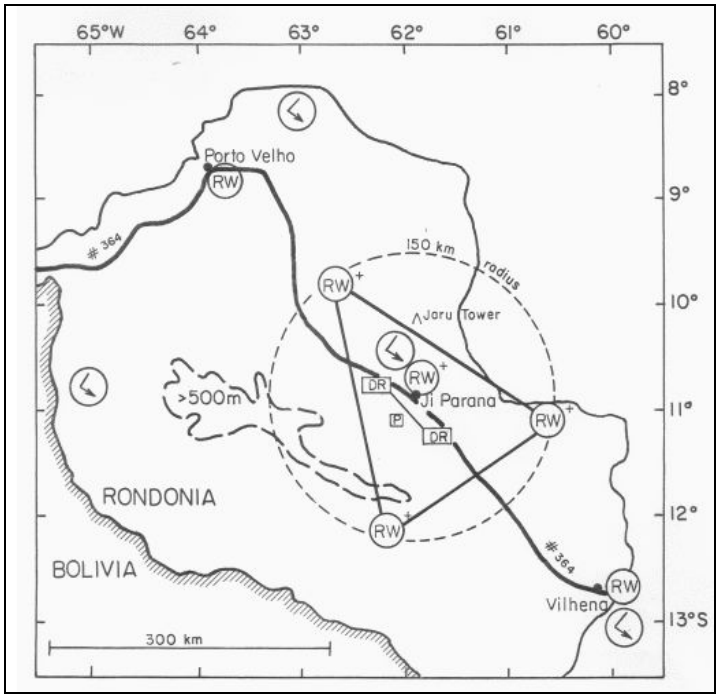

Figure 1. The TRMM-LBA study area with instrument locations annotated. *RW* indicates radiosondes, *DR* indicates the TOGA and S-POL radars, *P* indicates NOAA dual-wavelength profiles, and ↘ indicates lightning detection equipment.
(Image source: TRMM-LBA Brazil webpage)

Instrument Description

The Lightning Instrument Package (LIP) was flown aboard the NASA ER-2 research aircraft during the TRMM-LBA field campaign. The ER-2 LIP instrument consists of eight electric field mills and a dual-tube conductivity probe. The rotating-vane electric field mills are compact sensors, each weighing less than 10 lbs, that are installed on the top and bottom of the aircraft along the plane's centerline and on the superpods (Figure 2). These sensors measure the electric fields in the thunderstorm environment by sampling the three-dimensional components of the electric field (i.e., Ex, Ey, Ez); greatly improving understanding of the electrical structure of storms. The field mills also provide a measurement of the electric charge (Q) on the aircraft. The conductivity probe, consisting of a pair of gerdien capacitor type sensors, is installed on either the right- or left-hand superpod nose cone (Figure 2). The probe measures air conductivity at aircraft flight level by measuring positive and negative ions simultaneously throughout the flight. Storm electric currents can then be derived using the electric field and air conductivity measurements.

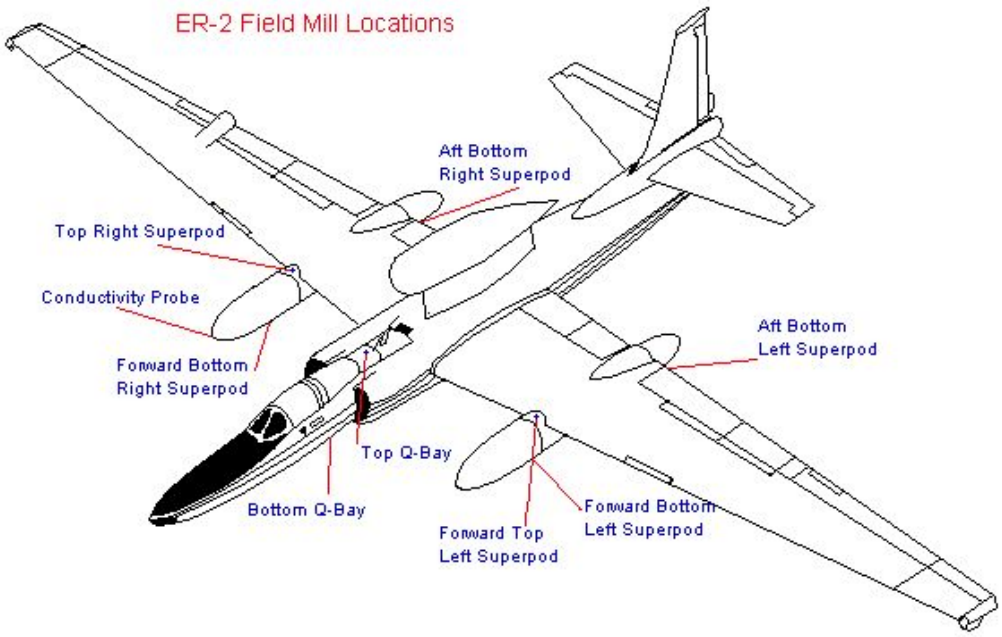

Figure 2. Locations of the eight field mills and the conductivity probe as mounted on the ER-2 aircraft.
(Image source: Richard J. Blakeslee)

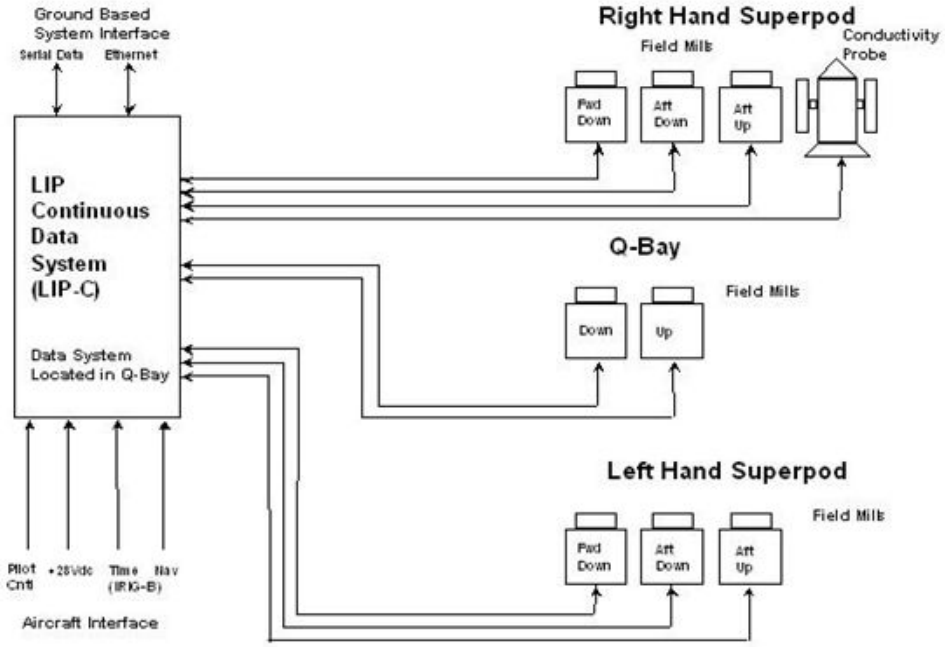

Figure 3. Schematic diagram of the ER-2 LIP instrumentation package.
(Image source: Richard J. Blakeslee)

A schematic diagram of the ER-2 LIP is shown in Figure 3 above. In this configuration, the field mills measure the components of the electric field over a wide range of conditions from fair weather electric fields with a few to tens of volts per meter, to large thunderstorm fields with tens of kilovolts per meter. More information about the LIP instrument can be found on the NASA Airborne Science LIP webpage. To learn more about field mill design and how they work, visit the Mission Instruments Electric Field Mill webpage.

Investigator

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Data Characteristics

The TRMM-LBA Lightning Instrument Package (LIP) dataset files are organized into one file per flight. The data files are available in HDF-4 format at a Level 1B processing level and contain LIP and aircraft measurements. The browse image files are available in GIF format and contain time-series plots of the electric field variables. More information about the NASA data processing levels are available on the EOSDIS Data Processing Levels webpage. Table 1 lists the characteristics of this dataset.

Table 1: Data Characteristics

Characteristic	Description
Platform	NASA Earth Resources 2 (ER-2) aircraft
Instrument	Lightning Instrument Package (LIP)
Spatial Coverage	N: 6 , S: -16 , E: -49 , W: -76 (Brazil)
Spatial Resolution	Point
Temporal Coverage	January 22, 1999 - February 24, 1999
Temporal Resolution	Daily -< Weekly
Sampling Frequency	0.1 second (data oversampled at 50 Hz)
Parameter	Atmospheric electricity, air conductivity
Version	1
Processing Level	1B

File Naming Convention

The TRMM-LBA Lightning Instrument Package (LIP) data are organized into daily (mission) data files in HDF-4 format along with browse images in GIF format. The naming conventions for these files are listed below:

Data files: TRMM_LBA_ER2_LIP_v1_<yyyy>.<ddd>_<xxx>.hdf
Browse files: TRMM_LBA_ER2_LIP_v1_<yyyy>.<ddd>_<starttime> - <stoptime>.gif

Table 2: File naming convention variables

Variable	Description
yyyy	Four-digit year
ddd	Three-digit day of the year (Julian day)
xxx	Three-digit mission number
<startime> - <stoptime>	Start and stop time of data in *hhmm* where: hh = Two-digit hour in UTC mm = Two-digit minute in UTC
.hdf	HDF-4 format (Hierarchical Data Format 4)
.gif	GIF format (Graphics Interchange Format)

Data Format and Parameters

The TRMM-LBA Lightning Instrument Package (LIP) dataset consists of data files in HDF-4 format and electric field plot images in GIF format. The data include electric field measurements of lightning from eight field mills, conductivity probe temperatures from two sensors, and ER-2 flight navigation data. Each HDF-4 data file consists of one Vgroup named “LIP”. There are five Vdata included in the “LIP” Vgroup: summary, header, efm, probe, and navigation. The variables named “sensitive” and “insensitive” in the “efm” Vdata are electric field measurements that can be converted to the vector components of the electric field (i.e., Ex, Ey, Ez) (Koshak, Mach, Christian, Stewart, & Bateman, 2006; Mach & Koshak, 2007). Table 3 outlines the data fields in each Vdata.

Table 3: Data Fields of LIP HDF-4 files

Vdata name	Field name	Data type
summary	startIRIG_B	long integer
	stopIRIG_B	long integer
	pcstart	long integer
	pcstop	long integer
	blockcount	long integer
	efmcount	long integer
	probecount	long integer
	navigationcount	long integer
	channels	byte
	revision	byte
header	IRIG_Btime	long integer
	IRIG_B100nanosecond	long integer
	pctime	long integer
	pctimemillisecond	long integer
	efmpointer	long integer
	probepointer	long integer
	navigationpointer	long integer
	efmcount	byte
	probecount	byte
	navigationcount	byte
	IRIG_Bstatus	byte
	flags	byte
efm	localgaincompensation	float
	localoffsetcompensation	integer
	revision	byte
	flags	byte
	header	byte
	sensitive	integer
	insensitive	integer
	checksum	uint
probe	temperaturecelsius	float
	prob1	integer
	prob2	integer
	temperatureraw	byte
	sum	byte
navigation	UTC	long integer
	latitude	float
	longitude	float

	trueheading	float
	pitchangle	float
	rollangle	float
	groundspeed	float
	trackangletrue	float
	inertialwindspeed	float
	inertialwinddirection	float
	bodylonaceel	float
	bodylataccel	float
	bodynormalaccel	float
	trackanglerate	float
	pitchrate	float
	rollrate	float
	inertialverticalspeed	float
	GPSaltitude	float
	GPSlatitude	float
	GPSlongitude	float
	staticpressure	float
	totalpressure	float
	differentialpressure	float
	totaltemperature	float
	statictemperature	float
	barometricaltitude	float
	machnumber	float
	trueairspeed	float
	windspeed	float
	winddirection	float
	sunelevation	float
	sunazimuth	float
	analogchannels	float
	GPSstatus	byte

Algorithm

LIP is able to detect the electrical activity surrounding storms by observing the changes in the electric field environment. The total lightning (i.e., cloud-to-ground, intracloud) is identified from the abrupt electric field changes in the data; and it is often possible to differentiate between intracloud and cloud-to-ground discharges. Storm electric currents can be derived using the electric field and air conductivity measurements. More information on the relationship between electric field changes and lightning is detailed in Marshall et al. (2005).

Quality Assessment

A calibration matrix is created for the aircraft by performing different aircraft maneuvers and recording the output of the field mills. The matrix is then mathematically inverted to determine the electric fields from the mill data. Each of the LIP field mills incorporates self-calibration capabilities that reduce the time required to obtain a full aircraft calibration. In addition, the electric field signals are digitized at each mill and transmitted as a digital data stream, reducing signal noise and simplifying aircraft integration. More information about aircraft field mill calibration methods can be found in Koshak et al. (2006) and Mach and Koshak (2007).

Software

These data files are in HDF-4 format and may be read using Python, IDL, or other common HDF readers. Panoply can also be used to examine these data files. The GIF image files can be viewed with most image viewers.

Known Issues or Missing Data

There are no known issues with these data or any known gaps in the dataset. The data are airborne and flights did not occur each day of the campaign.

References

Christian, H.J. & Goodman, S.J. (1987). Optical Observations of Lightning from a High-Altitude Airplane. *Journal of Atmospheric and Oceanic Technology*, *4*, 701–711. https://doi.org/10.1175/1520-0426(1987)004<0701:OOOLFA>2.0.CO;2

Gibbs, Y. (2014). NASA Armstrong Fact Sheet: ER-2 High-Altitude Airborne Science Aircraft. https://www.nasa.gov/centers/armstrong/news/FactSheets/FS-046-DFRC.html

Koshak, W. J., Mach, D. M., Christian, H. J., Stewart, M. F., & Bateman, M. G. (2006). Retrieving storm electric fields from aircraft field mill data. Part II: Applications. *Journal of Atmospheric and Oceanic Technology*, *23*, 1302–1322. https://doi.org/10.1175/JTECH1918.1

Mach, D. M., & Koshak, W. J. (2007). General matrix inversion technique for the calibration of electric field sensor arrays on aircraft platforms. *Journal of Atmospheric and Oceanic Technology*, *24*, 1576-1587. https://doi.org/10.1175/JTECH2080.1

Marshall, T. C., Stolzenburg, M., Maggio, C. R., Coleman, L. M., Krehbiel, P. R., Hamlin, T., ... Rison, W. (2005). Observed electric fields associated with lightning initiation. *Geophysical Research Letters*, *32*, L03813. https://doi.org/10.1029/2004GL021802

Related Data

All datasets from the TRMM-LBA field campaign can be considered related to this dataset. Other TRMM-LBA campaign data can be located using the GHRC HyDRO 2.0 search tool and entering the term "TRMM-LBA" in the search box.

LIP was also flown in other field campaigns. The LIP data from other campaigns can be located by searching "LIP" in HyDRO 2.0 and are listed below:

GRIP Lightning Instrument Package (LIP) dataset
(http://dx.doi.org/10.5067/GRIP/LIP/DATA201)

TCSP ER-2 Lightning Instrument Package (LIP) dataset
(http://dx.doi.org/10.5067/TCSP/LIP/DATA101)

GOES-R PLT Lightning Instrument Package (LIP) dataset
(http://dx.doi.org/10.5067/GOESRPLT/LIP/DATA101)

CAMEX-4 ER-2 Lightning Instrument Package (LIP) dataset
(http://dx.doi.org/10.5067/CAMEX-4/LIP/DATA002)

CAMEX-4 DC-8 Lightning Instrument Package (LIP) dataset
(http://dx.doi.org/10.5067/CAMEX-4/LIP/DATA001)

CAMEX-3 Lightning Instrument Package (LIP) dataset
(http://dx.doi.org/10.5067/CAMEX-3/LIP/DATA001)

Contact Information

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

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