Glossary

Event – the basic unit of data from the LIS, it is a single pixel exceeding the background threshold (due to lightning or a false alarm) (Christian et al. 2000)

Group – “one or more simultaneous events (i.e., events that occur in the same time integration frame) that register in adjacent (neighboring or diagonal) pixels in the focal plane array.” Events in the same “picture” are grouped (Christian et al. 2000)

Flash – generally, what we assume to be a case of lightning occurring but officially: “a set of groups sequentially separated in time by no more than 330 ms and in space by no more than 5.5 km” “A flash may include as few as one group with a single event or it may consist of many groups, each containing many events.” “Note that there is no absolute time limit to a flash. That is, as long as subsequent groups are produced in an area within the 330 ms time windows, all groups will be assigned to a single flash.” (Christian et al. 2000)

Area – what we assume to be a thunderstorm, although it can be made up of multiple storms or a single storm could be split into multiple areas “a near contiguous region on the surface of the earth that has produced lightning (defined as a set of LIS flashes) during a single orbit of the LIS. An area thus defined consists of a set of flashes separated in space by no more than 16.5 km (approximately 3 pixels).” (Christian et al. 2000)

Orbit - the data granule for the LIS, (aka one spin mostly around the earth) “Since dividing the LIS data at the equatorial crossing would often split storms, the LIS orbit granule is defined to begin and end at the latitude of the southernmost part of the orbital path.” (Christian et al. 2000)

View time - how long a particular location was viewed by the LIS instrument, can be very short or up to 80 s (Christian et al. 2000)

One second data - a series of one second snapshots of internal and external instrument parameters (Christian et al. 2000)

Parent data – data that belongs to the one higher order of data (i.e., a group’s parent data is the flash it belongs to) (Christian et al. 2000)

Child data – data that belongs to the one lower order of data (i.e., an area’s child data is the flashes within it) (Christian et al. 2000)

Latitude – describes the North-South location on Earth

Longitude – describes the East-West location on Earth

HDF – Hierarchical Data Format - orbit granule data storage structure, there are two for each orbit; one contains the science data (SC) and the other contains the background data (BG) (Christian et al. 2000)

HDF Naming scheme – platform (TRMM or ISS)\_instrument name (LIS)\_file type (SC or BG).version number. revision number\_YEAR. DAY.ORBIT (Christian et al. 2000)

EOS HDF SDF – Science Data Format - HDF organization scheme – “The actual data are stored in Vsets and Vgroups. Indexes are maintained within the Vgroups to link the various Vsets.” (Christian et al. 2000)

SDS – Scientific Data Sets (Christian et al. 2000)

Metadata – a text description of LIS parameters unique to a particular orbit granule (Christian et al. 2000)

NLEs – Non Lightning Events (Christian et al. 2000)

Artifacts – in this case, events recognized due to flaws in data gathering rather than lightning

Noise – data due to random energetic particles which tend to produce temporally and spatially random groups of events (Christian et al. 2000)

Dedupe – a filter than eliminates duplicate events (Christian et al. 2000)

Ghost – a filter that corrects for the sensor version of retina burn (Christian et al. 2000)

Lollypop – a filter that accounts for when bright pulses overload the CCD array. “When there is a bright lightning pulse, vertical streaks (i.e., a set of pixels with the same “y” coordinate) are attached to the top and bottom of the bright pulse.” (Christian et al. 2000)

Track – a filter that removes lines of false readings due to energetic particles (Christian et al. 2000)

Blast – a filter that removes data due to “blasts” (when a significant fraction of the array has events, like 20 groups in the same 2 ms) (Christian et al. 2000)

Ephemeris filtering – a filter that removes anomalous artifacts (Christian et al. 2000)

Particle filtering / noise filtering – a filter that eliminates flashes that do not cluster as they are more likely to be due to charged particles (Christian et al. 2000)

Putback algorithm – a filter that reintroduces flashes that were thought to be noise in the previous filters (Christian et al. 2000)

Contrast filters – a filter that eliminates data due to non-random artifacts such as regions with high brightness contrasts (Christian et al. 2000)

Contrast – a filter that eliminates data due to the LIS FOV moving across a boundary between a light dark boundary (Christian et al. 2000)

Glint filters – a filter that remove data due to solar reflections (Christian et al. 2000)

Johnny Jumper – eliminates an artifact triggered in the 127th row of the pixel array (Christian et al. 2000)

Guilt by association filter – a filter that removes the remaining pixels if 95% in an area are identified as artifacts (Christian et al. 2000)

Single filter – removes remaining single group areas (Christian et al. 2000)

Pre-launch calibration – “These activities include: (1) D.C. uniformity, linearity and false alarm rate tests, (2) field-of-view (FOV) test, (3) A.C. response test, (4) detection efficiency, and (5) spectral test. (Christian et al. 2000)

Post-launch calibration – re-calibration of the LIS if the detection efficiency and false alarm rate are drifting (Christian et al. 2000)

Detection efficiency – “defined as the percentage of lightning flashes occurring in the FOV of the instrument that are detected by the sensor.” (Christian et al. 2000)

False alarm rate – “defined as the percentage of total detected flashes that are not attributable to lightning.” (Christian et al. 2000)

Validation - “is the process of verifying and tuning the performance of both the data processing algorithms”, there is a pre-launch and post-launch portion (Christian et al. 2000)

Anvil region – “An anvil is the flat cloud formation at the top of the storm. An anvil forms when the updraft (warm air rising) has reached a point where the surrounding air is about the same temperature or even warmer. The cloud growth abruptly stops and flattens out to take the shape of an anvil.” (*Severe Weather 101: Thunderstorm basics*)

Graupel – “forms when super-cooled droplets of water collect and freeze on the surface of falling snowflakes,” results in the creation of 0.08-0.2 inch snow pellets or soft hail balls (Migiro, 2018)

Stratiform clouds – “A cloud-type extending a long, low, gray layer with an almost uniform base with extensive coverage at different altitudes. There are three groups of stratiform clouds: high level (above 20,000 ft.), middle level (6,500-20,000 ft.), and low level (below 6,500 ft.).” (*Stratiform or stratus clouds*)

Electrified shower clouds – ESCs – clouds with electric currents but no lightning (Peterson et al., 2017)

Global Electric Circuit – GEC – “a series of electrical connections that describe the large-scale flow of electricity within the atmosphere and serve to maintain the electrical potential of the ionosphere relative to the Earth's surface.” (Peterson et al., 2017)

Wilson currents – conduction currents, part of the global electric field (Peterson et al., 2017)

MCS – Mesoscale convective system –“Mesoscale convective systems (MCSs) are the largest of the convective storms. They form when clouds occurring in response to convective instability amalgamate and organize upscale into a single cloud system with a very large upper cirriform cloud structure and rainfall covering large contiguous rain areas.” - or mesoscale convective complex – can evolve into a cyclone (Houze, 2004)

Intracloud discharges – lightning that does not contact the ground

Cloud-to-ground discharges – lightning that does contact the ground

Cirrus clouds – high wispy clouds, often look like streaks or fibrous due to being made of ice crystals (*Learn about cirrus clouds: High, wispy streaks* 2022)

Sferics - sferics are radio frequencies emitted by lightning (particular emfs) (Christian et al. 2000)

Updraft – an air current moving in an upwards direction

Tropics – region between the latitude lines of the Tropic of Cancer (23.5 degrees north) and the Tropic of Capricorn (23.5 degrees south) around the equator of the earth, (Rutledge et al., 2012)

Subtropics – the areas between roughly 35 degrees N and the Tropic of Cancer and between the Tropic of Capricorn and 35 degrees S. The extent depends on continental influence. (*Subtropics* 2012)

Extratropics – the mid-latitudes beyond the tropics

Congo – lightning capital of the world (Christian H. J. et al. 2003)

NASA ER–2 aircraft – an aircraft used by NASA to conduct overflights of storms and electrified shower clouds which can gather data relating to the movements of currents within clouds/storms (Peterson et al., 2017)

Geostationary Lightning Mapper – GLM – an optical lightning measuring device on the GOES-R satellite (Peterson et al., 2017)

PR – precipitation radar (Peterson et al., 2017)

VIRS - VIS – Visible and Infrared Scanner (Peterson et al., 2017)

VIIRS - Visible Infrared Imaging Radiometer Suite

TRMM – Tropical Rainfall Measuring Mission – a satellite observatory (Christian et al. 2000)

TMI – TRMM Microwave Imager (Peterson et al., 2017)

ICF – Illuminated Cloud Feature (Peterson et al., 2017)

RPF – radar precipitation features – “contiguous raining areas based on TRMM PR reflectivity data. They are typically storm-scale features, but often reach the mesoscale in certain regions and storm types.” (Peterson et al., 2017)

CAPE – convective available potential energy – (Chen et al., 2021)

DMSP satellites – Defense Meteorological Satellite Program satellites - observed lightning with various optical sensors (Christian et al. 2000)

South Atlantic Anomaly (SAA) – a region in the South Atlantic in which charged particles tend to produce noise for satellites like the LIS due to the configuration of the earth’s magnetic field (Christian et al. 2000)

LIS – Lightning Imaging Sensor – an optical lightning sensor (Peterson et al., 2017)

OTD - Optical Transient Detector – an optical lightning sensor (Peterson et al., 2017) OTD can be viewed as a LIS prototype and is based on the LIS instrument for TRMM (Christian et al. 2000)

ATBD – Algorithm Theoretical Basis Document

PCT – polarization-corrected temperatures (Peterson et al., 2017)

RTEP – Real Time Event Processor (Christian et al. 2000)

Contiguous – bordering, next to, touching, adjacent to

NIR – near infrared

UTC – coordinated universal time – the time of day at 0 degrees longitude and not adjusted for daylight savings time and the successor to Greenwich Mean Time (*Current UTC, Time Zone (coordinated universal time)* 2022)

Carnegie Curve – “The Earth’s fair weather atmospheric electric field shows, in clean air, an average daily variation which follows universal time, globally independent of the measurement position. This single diurnal cycle variation (maximum around 19UT and minimum around 03UT) is widely known as the Carnegie curve,” (Harrison, 2012)

Mesoscale – “mesoscale meteorology pertains to weather features with an "intermediate"spatial scale,” “mesoscale weather features are smaller than most of the large-scale weather features (high- and low-pressure systems, etc.), but larger than really small features that span only a few kilometers. What kinds of weather features fit into the mesoscale? Thunderstorms, lake-effect snow, terrain-induced wind circulations, and sea / lake breezes all fall under the umbrella of mesoscale meteorology.” (Babb, 2019)

Ionosphere -  “the ionosphere overlaps the mesosphere, thermosphere, and exosphere. It’s a very active part of the atmosphere, and it grows and shrinks depending on the energy it absorbs from the sun.” “Gases in these layers are excited by solar radiation to form ions.” “Parts of the ionosphere overlap with Earth’s magnetosphere.” “In the ionosphere, charged particles are affected by the magnetic fields of both Earth and the sun.” (*Ionosphere* 2019)

Magnetosphere – “The area around the Earth where charged particles feel Earth’s magnetic field.” (*Ionosphere* 2019) “That area of space, around a planet, that is controlled by the planet's magnetic field. The shape of the Earth's magnetosphere is the direct result of being blasted by solar wind. The solar wind compresses its sunward side,” (Zell & Kaase, 2017)

Troposphere – The troposphere is the part of the atmosphere closest to the surface and is between 8 and 14 km thick depending where you are on Earth. (*Troposphere* 2019)

Intertropical Convergence Zone (ITCZ) – “The Intertropical Convergence Zone, or ITCZ, is the region that circles the Earth, near the equator, where the trade winds of the Northern and Southern Hemispheres come together. The intense sun and warm water of the equator heats the air in the ITCZ, raising its humidity and making it buoyant. Aided by the convergence of the trade winds, the buoyant air rises. As the air rises it expands and cools, releasing the accumulated moisture in an almost perpetual series of thunderstorms.” (Levy, 2000)

ENSO and anti-ENSO - El Nino Southern Oscillation and La Nina - events in the tropical Pacific often result in significant changes in the frequency and movement of storm tracks, precipitation patterns, and cloud cover (Christian et al. 2000)

FOV – field of view

IFOV – instantaneous field of view (Christian et al. 2000)

Charge coupled device (CCD) array – 128X128 on the LIS (Christian et al. 2000)

Temporal resolution – resolution with respect to time, within 2 ms for the LIS (Christian et al. 2000)

Viewtime – the length of the observation time (Christian et al. 2000)

multiple scattering – blurs, delays and time-broadens, the optical signal produced by lightning (Christian et al. 2000)

Conservative scatterer – clouds tends not to absorb lightning’s optical signals but scatter them so most optical energy escapes (Christian et al. 2000)

Albedo – how much solar radiation is reflected by a surface, snow can cause an increase, fire scars can cause a decrease,

Permafrost – ground with a temperature of at most 0 degrees all year

GHG emissions – Green house gas emissions

ESM – Earth system model (Chen et al., 2021)

CMIP5 – Climate Model Intercomparison Project Phase 5 – a way of developing future lightning projections using models (Chen et al., 2021)

TROPOMI – Tropospheric Monitoring Instrument – observes spatial and temporal patterns of NOx pollution (Goldberg, D. L. et al. 2021)

MODIS – Moderate Resolution Imaging Spectroradiometer – a satellite detection device used to detect wildfires (Ying, L. et al. 2019)

VIIRS/NPP – aka VNP - Visible and Infrared scanner, National Polar-orbiting Partnership

Sources

Christian, H. J., R. J. Blakeslee, S. J. Goodman, and D. M. Mach (Eds) (2000), *Algorithm Theoretical Basis Document (ATBD) for the Lightning Imaging Sensor (LIS)*, NASA/Marshall Space Flight Center, Alabama. [Available at http://eospso.gsfc.nasa.gov/atbd/listables.html] posted 1 Feb. 2000.

Why So Cirrus, LLC. (2022). *Learn about cirrus clouds: High, wispy streaks*. whatsthiscloud. Retrieved May 11, 2022, from https://whatsthiscloud.com/cloud-types/cirrus/?msclkid=a917ce01d14011ecbcf8f15b85ee4223

Peterson, M., Deierling, W., Liu, C., Mach, D., & Kalb, C. (2017). The properties of optical lightning flashes and the clouds they illuminate. *Journal of Geophysical Research: Atmospheres*, *122*(1), 423–442. https://doi.org/10.1002/2016jd025312

Houze, R. A. (2004). Mesoscale convective systems. *Reviews of Geophysics*, *42*(4). https://doi.org/10.1029/2004rg000150

NASA. (n.d.). *Stratiform or stratus clouds*. NASA. Retrieved May 12, 2022, from https://www.grc.nasa.gov/WWW/K-12/Aero2000/studweb/glossary/stratcld.html

NOAA. (n.d.). *Severe Weather 101: Thunderstorm basics*. NOAA National Severe Storms Laboratory. Retrieved May 12, 2022, from https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/

Migiro, G. (2018, January 10). *What is graupel?* WorldAtlas. Retrieved May 12, 2022, from https://www.worldatlas.com/articles/what-is-graupel.html

Rutledge, K., Ramroop, T., Boudreau, D., McDaniel, M., Teng, S., Sprout, E., Costa, H., Hall, H., & Hunt, J. (2012, October 9). *Tropics*. National Geographic Society. Retrieved May 12, 2022, from https://www.nationalgeographic.org/encyclopedia/tropics/

American Meteorological Society. (2012, April 25). *Subtropics*. Subtropics - Glossary of Meteorology. Retrieved May 12, 2022, from https://glossary.ametsoc.org/wiki/Subtropics

Christian, H. J. et al. Global frequency and distribution of lightning as observed from space by the Optical Transient Detector. J. Geophys. Res. Atmos. https://doi.org/10.1029/2002jd002347 (2003).

timeanddate. (2022). *Current UTC, Time Zone (coordinated universal time)*. timeanddate. Retrieved May 12, 2022, from https://www.timeanddate.com/worldclock/timezone/utc

Harrison, R. G. (2012). The carnegie curve. *Surveys in Geophysics*, *34*(2), 209–232. https://doi.org/10.1007/s10712-012-9210-2

Levy, R. (2000). *The Intertropical Convergence Zone*. NASA Earth Observatory. Retrieved May 12, 2022, from https://earthobservatory.nasa.gov/images/703/the-intertropical-convergence-zone

Babb, D. (2019). *Lesson 1. meeting the mesoscale*. Penn State Department of Meteorology. Retrieved May 12, 2022, from https://learningweather.psu.edu/node/84

NASA. (2019, June 28). *Ionosphere*. NASA. Retrieved May 13, 2022, from https://spaceplace.nasa.gov/ionosphere/en/

Kaase, A. (2017, August 7). *Earth's magnetosphere*. NASA. Retrieved May 13, 2022, from https://www.nasa.gov/mission\_pages/sunearth/multimedia/magnetosphere.html

NASA. (2019, June 28). *Troposphere*. NASA. Retrieved May 13, 2022, from https://spaceplace.nasa.gov/troposphere/en/

Chen, Y., Romps, D. M., Seeley, J. T., Veraverbeke, S., Riley, W. J., Mekonnen, Z. A., & Randerson, J. T. (2021). Future increases in Arctic Lightning and fire risk for Permafrost Carbon. *Nature Climate Change*, *11*(5), 404–410. https://doi.org/10.1038/s41558-021-01011-y

Goldberg, D. L. et al. [2021] TROPOMI NO2 in the United States: A detailed look at the annual averages, weekly cycles, effects of temperature, and correlation with surface NOx concentrations, Earth’s Future, 9 (4), doi:10.1029/2020EF001665.

Ying, L. et al. [2019] Wildfire Detection Probability of MODIS Fire Products under the Constraint of Environmental Factors: A Study Based on Confirmed Ground Wildfire Records, Remote Sensing, 11, 3031-3048, doi:10.3390/rs11243031.