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User Guide for BLADE_LC_processor.py

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ABSTRACT

`BLADE_LC_processor.py` is an optional script within the BLADE (Bolide Light-curve Analysis and Discrimination Explorer) open-source software package. It converts per-event light curve CSVs plus a metadata table into maps, plots, a per-sample trajectory file, and an aggregate summary. It anchors each trajectory at peak brightness, assumes constant speed and entry angle across the event, and propagates altitude and ground track relative to that anchor. The script converts the input azimuth internally to a travel bearing for the map and trajectory. Outputs include event folders with figures and a consolidated CSV containing start, peak, and end altitudes and all original metadata, sorted newest to oldest. For further background, users are referred to the foundational publication:
Silber, E. A., Sawal, V. (2025), "BLADE: An Automated Framework for Classifying Light Curves from the Center for Near-Earth Object Studies Fireball Database," The Astronomical Journal, doi: 10.3847/1538-3881/adeb55.

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ACRONYMS AND TERMS

Acronym/Term	Definition
BLADE	Bolide Light-curve Analysis and Discrimination Explorer
CNEOS	Center for Near-Earth Object Studies
CSV	Comma Separated Values file, a text-based format for storing tabular data
JPL	Jet Propulsion Laboratory
LC	light curve
NASA	National Aeronautics and Space Administration
UTC	Coordinated Universal Time

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1. OVERVIEW

The *BLADE_LC_processor.py* script provides a lightweight way to visualize and approximate bolide trajectories directly from light-curve intensity data plus a single metadata row per event. The script takes a folder of light-curve files from the National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory (JPL) Center for Near-Earth Object Studies (CNEOS) and turns them into per-event visuals and a single summary table. For each event that has the peak brightness altitude, it anchors the trajectory at the peak-brightness point (time, latitude, longitude, altitude), assumes constant speed and entry angle across the light curve, and computes altitude over time with the simple relation given in Silber and Sawal [1].

This script is provided as is, without any warranty or guarantee of fitness for a particular purpose. It is an optional companion to BLADE; the main BLADE codebase has no runtime dependency on this script.

Please note that BLADE and its derivatives are provided as-is. The software will not receive further updates or maintenance, and there is no designated user support or help contact. Users are responsible for evaluating whether the software meets their requirements and for verifying its application to their specific research or analysis needs. Although the software has been tested for research use, all use is at the discretion and judgment of the user.

The original publication by Silber and Sawal [1] provides the scientific motivation for BLADE, describes its application in bolide research, and includes a detailed interpretation of results with examples.

- Silber, E. A., Sawal, V. (2025), BLADE: An Automated Framework for Classifying Light Curves from the Center for Near-Earth Object Studies Fireball Database, The Astronomical Journal, doi: 10.3847/1538-3881/adeb55.

If you use BLADE and/or its derivatives or any results obtained with it in your research, proper attribution to both the software and the original publication is required. For background information and additional scientific context, users are encouraged to consult the published article.

2. INPUTS

There are two inputs. First, a metadata CSV called `LC_processing.csv` in the working directory provides event details. It should include the split Coordinated Universal Time (UTC) timestamp columns (UTC Year, UTC Month, UTC Day, UTC Hour, UTC Minute, UTC Second), plus Azimuth [deg], Velocity [km/s], Entry Angle [deg] (relative to horizontal), Bolide Altitude [km] at peak brightness, and Bolide Latitude/Longitude [deg]. Any other metadata columns in this file will be carried through to the final summary.

Second, the light-curve files live in `Processed_LC/` and are named `YYYYMMDD_HHMMSS.csv.` It is assumed that the user has downloaded digitized light curves in text format from CNEOS and converted them to the .CSV format. Each of these must contain Time [s] and Intensity [W/sr]; if a filename does not match the pattern, the script still plots the light curve but skips trajectory derivation for that file.

Example files are provided alongside the software package on GitHub:
`https://github.com/sandialabs/BLADE.`

3. OUTPUTS

For each light curve, running the script produces an event folder under `Output_LC_plots/`, containing an intensity-vs-time plot, two altitude-intensity views, a ground track map centered within ±20° of the peak brightness location, and a trajectory_timeseries.csv with time, intensity, derived altitude, and the propagated latitude and longitude along the track. It also writes an aggregate spreadsheet, `Output_LC_plots/altitude_start_end_summary.csv`, which includes all original metadata together with the derived start and end altitude in km and their corresponding times, sorted from newest to oldest.

Example outputs are provided in Figures 1–3. The full derivation of the altitude is given in Silber and Sawal [1].

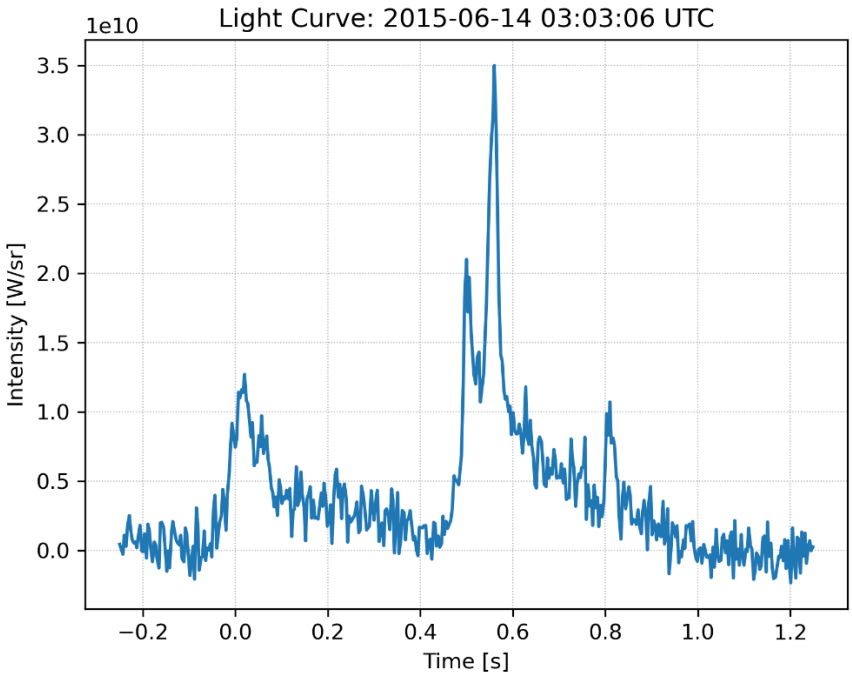

Figure 1: Measured radiative intensity versus time.

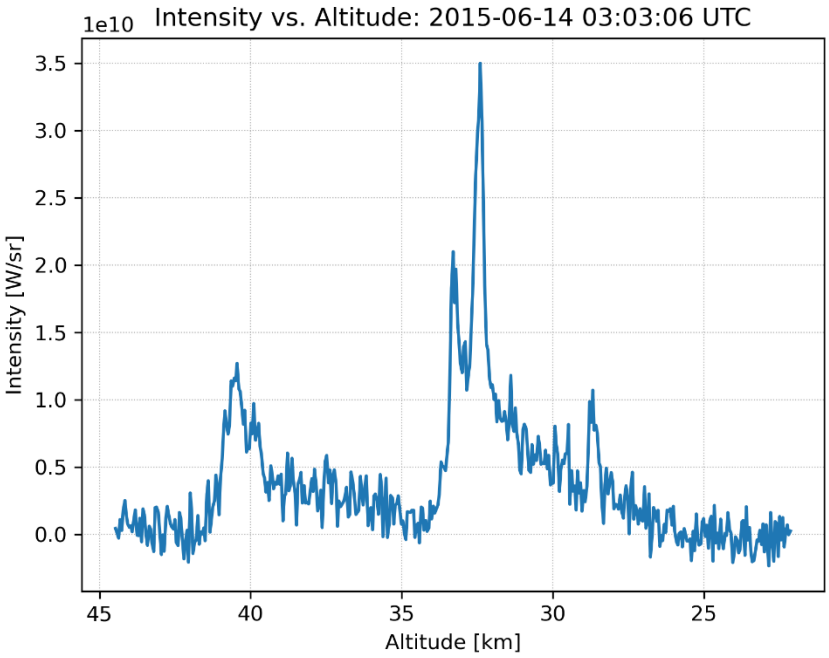

Figure 2: Intensity as a function of derived altitude.

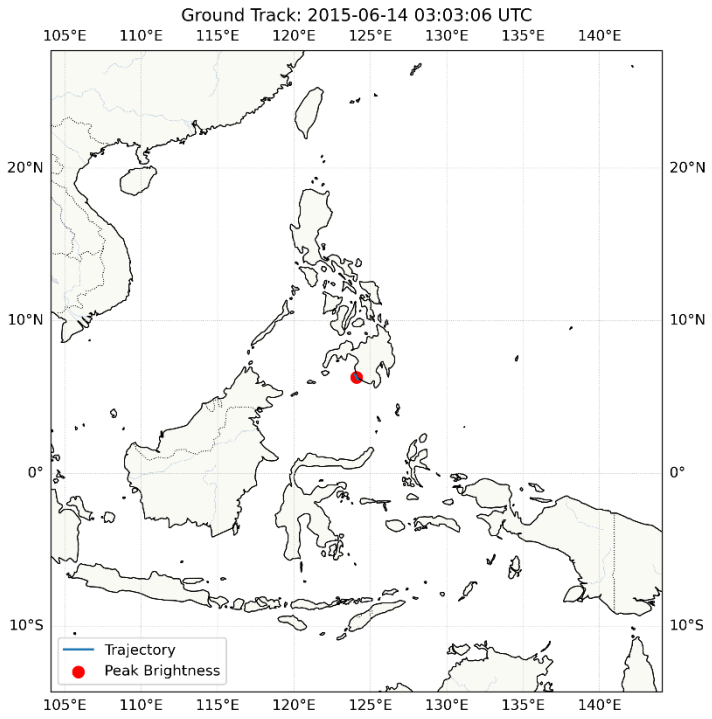

Figure 3: Great-circle ground track derived from the peak-brightness latitude and longitude, entry speed, and entry angle. Red dot marks peak brightness.

4. HOW TO RUN

To use it, place `BLADE_LC_processor.py` beside LC_processing.csv and the `Processed_LC/ folder` and run python `BLADE_LC_processor.py.` The script prints progress to the console, and if cartopy is not installed it still produces a clean longitude and latitude ground-track plot without coastlines.

5. DISCLAIMER AND ATTRIBUTION

5.1. Disclaimer

This program is provided as is, without any warranty or guarantee of fitness for a particular purpose. It is an optional companion to BLADE; the main BLADE codebase has no runtime dependency on this script.

If you use, adapt, modify, build upon, or incorporate any elements of BLADE, whether in whole or in part, the software is provided as-is without any warranty, support, or guarantee of accuracy or suitability for any particular application. The authors and developers assume no responsibility or liability for any outcomes resulting from the use or adaptation of BLADE or any of its components. All users are solely responsible for verifying the fitness and correctness of the software or its components for their intended research or operational needs. All use is at the discretion and judgment of the user.

5.2. Attribution

If you use BLADE, adapt its code, utilize its methods, or generate results based on its workflow in your research, publications, or presentations, you must provide proper attribution to both the software and the original peer-reviewed publication. Appropriate citation is required as follows:

Silber, E. A., Sawal, V. (2025), BLADE: An Automated Framework for Classifying Light Curves from the Center for Near-Earth Object Studies Fireball Database, The Astronomical Journal, doi: 10.3847/1538-3881/adeb55.

Any derivative works, modifications, or applications based on BLADE must also acknowledge the original software and publication.

REFERENCES

[1] E. A. Silber and V. Sawal, "BLADE: An Automated Framework for Classifying Light Curves from the Center for Near-Earth Object Studies (CNEOS) Fireball Database," *The Astronomical Journal,* 2025, doi: 10.3847/1538-3881/adeb55.

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