



# LYRAAFF: LYRA

## Automatic Flare Finder



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### Abstract

Here we outline the LYRA Automatic Flare Finder (LYRAAFF), a new flare detection tool for PROBA-2/LYRA observations.

Originally inspired by the well-known GOES event list criteria, it includes a number of improvements such as dynamic detection of flare end times and recognition of temporally overlapping flares. In the future LYRAAFF will be run as part of the LYRA data pipeline and a regularly updated LYRA flare list will be made publicly available. The algorithm itself will be made available through the SunPy solar physics python software package. LYRAAFF and the associated flare list will be useful for quick and easy identification of well-observed events as well as facilitating large-scale statistical studies of solar flares. In addition, as LYRA becomes part of ESA's Space Situation Awareness programme, this tool will be increasingly valuable for space weather “now-casting” and testing flare forecasting models.

### Method

**Step 1: Produce a time series** for the desired time period of LYRA channel 4 (Zirconium) level 3 (1-min averaged) data.

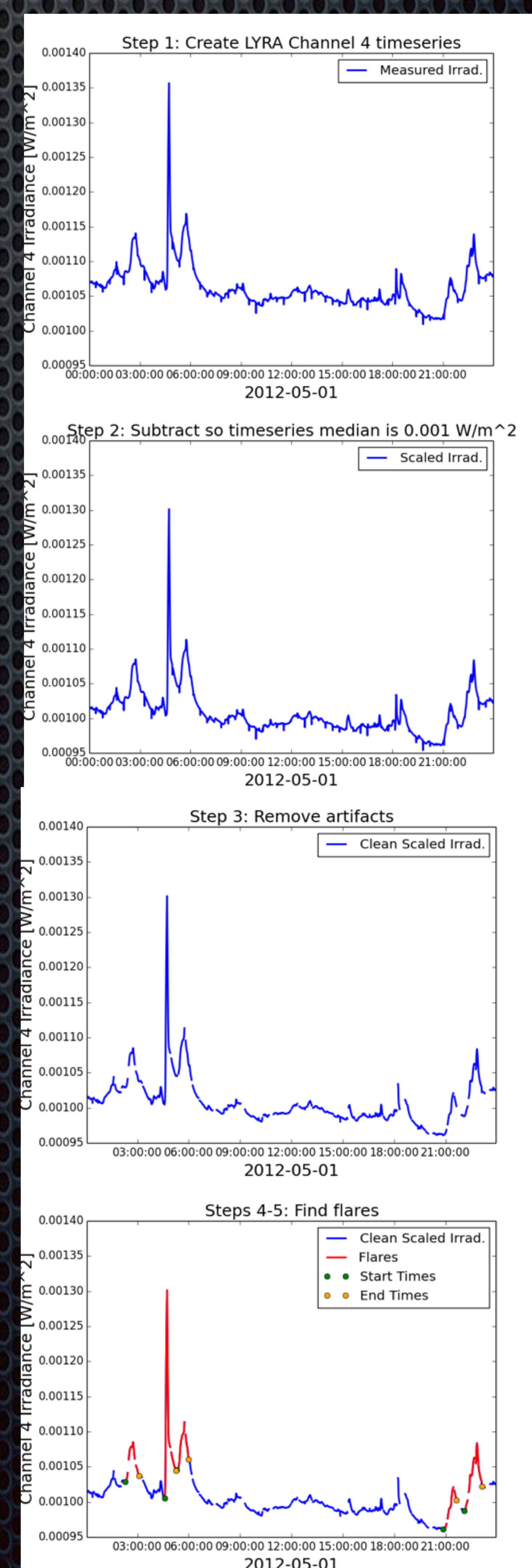
**Step 2:** Use LYRA time annotation files to remove artefacts: **UV occ., Offpoint, LAR, SAA, Calibration, Visible occ., Glitch, ASIC reload, Operational Anomaly, Moon in LYRA, Recovery.** For definitions of these terms see <http://proba2.oma.be/data/TARDIS>

**Step 3:** By subtraction, **scale the cleaned time series** so that the median is equal to the mean daily minimum of the LYRA mission ( $0.001 \text{ W/m}^2$ ). This helps reduce detection bias due to slowly varying background.

**Step 4:** Find **reference start time**, i.e. when time series gradient is positive for 4 consecutive minutes and the irradiance of the 4th minute is at least 1% greater than that in the first. Find **true start time** by tracking back to earliest consecutive positive gradient measurement.

**Step 5:** Find **reference end time**, i.e. when irradiance drops half way between start and peak irradiance **OR** when another reference start time is detected during decay phase. Find **true end time** by tracking forward to last consecutive measurement with a negative gradient.

**Step 6:** Repeat steps 4 and 5 until the **entire period has been searched.**



**Figure 1:** Sample LYRA channel 4 time series for 2012 May 01 showing various steps involved in LYRAAFF. *Top:* Produce time series, *2nd:* Subtraction. *3rd:* Remove artefacts, *Bottom:* Find flares, marked in red.

### Data Product

**Flare list:** LYRAAFF will be run as part of the LYRA data pipeline to produce a daily updated flare list. This will be available at <http://proba2.oma.be/data/LYRA>

**Algorithm:** The LYRAAFF algorithm has been written in Python and will be made publicly available through <http://sunpy.org/>.



### Eclipse Season

**Problem:** LYRAAFF does not work well during eclipse season due to changing attenuation in signal as satellite passes behind Earth's atmosphere.

**Short-term:** LYRAAFF will not be run in LYRA pipeline during eclipse seasons and should not be trusted during these periods if run manually.

**Long-term:** LYRA eclipse season data will be corrected to remove signal attenuation.