Can Geostationary Operational Environmental Satellite (GOES) ultraviolet measurements predict the x-ray properties of flares?

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Outline

INTRODUCTION → AIM & OBJECTIVES → PROBLEM STATEMENT → JUSTIFICATION OF STUDY → INSTRUMENT → METHODOLOGY → RESULTS → FUTURE WORK

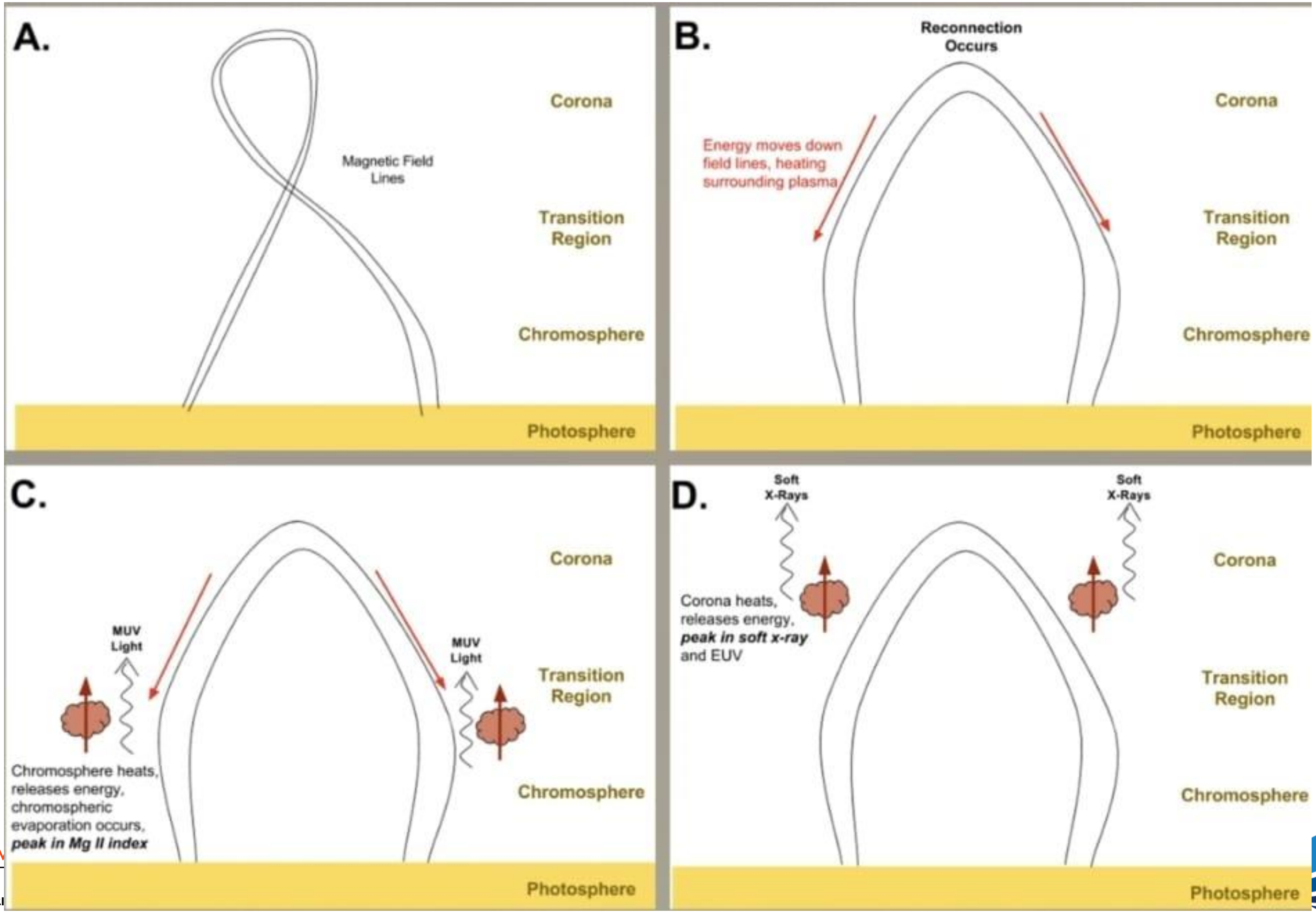
What is a solar flare?

Sun Solar Flare GIF

- A solar flare is a short and intense blast of high energy radiation from the Sun that occurs when the Sun's magnetic field gets entangled and snaps.(Sharma A et al, 2017)

- Richard Carrington discovered solar flares on September 1st, 1859

Physical Explanation



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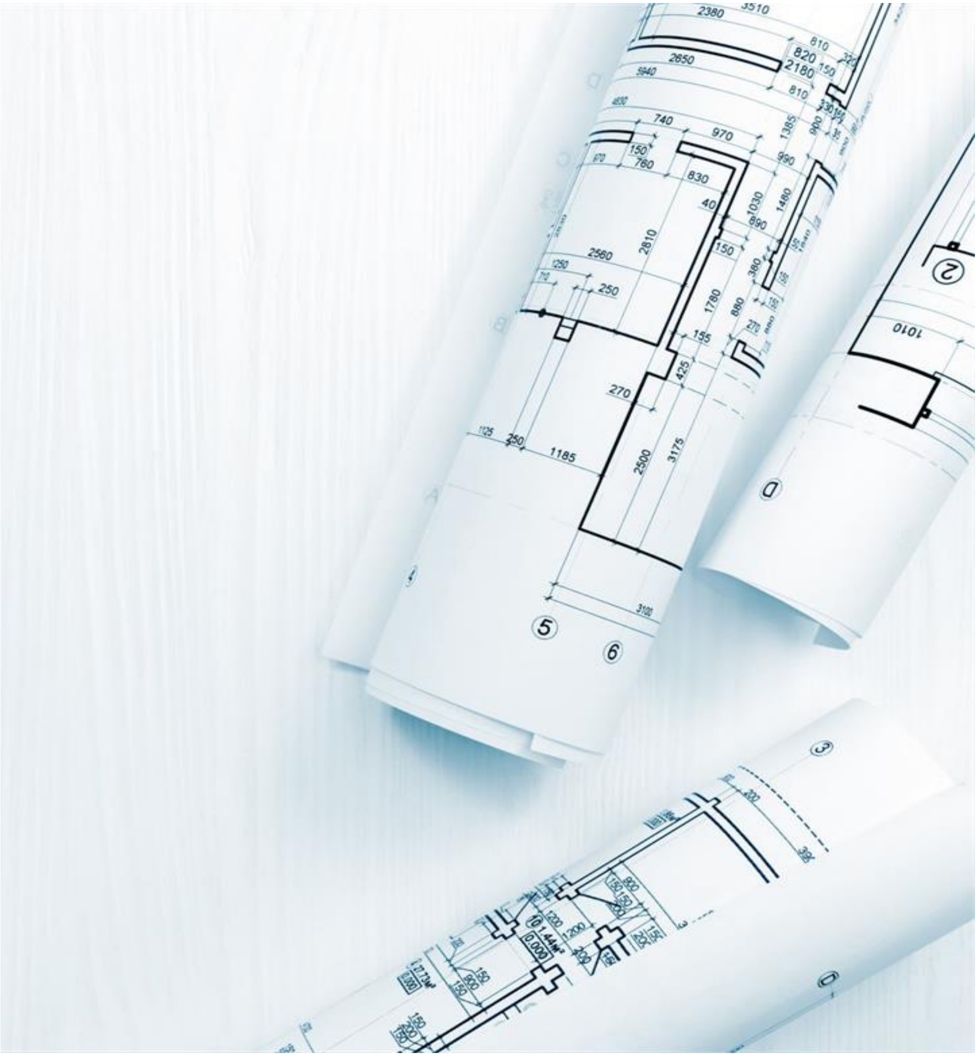
Aim & Objectives

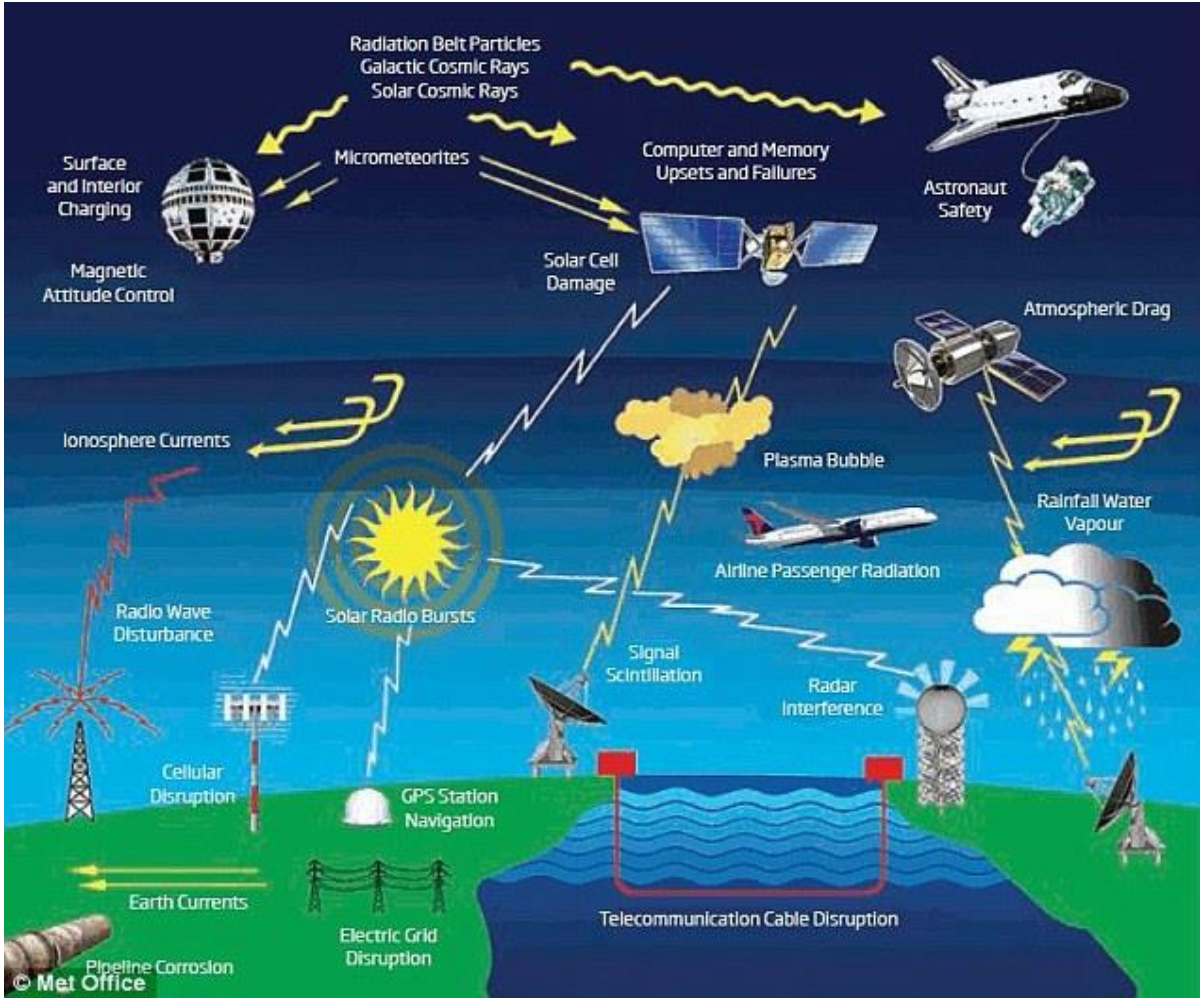
This project seeks to better understand the characteristics of solar flares by analysing ultraviolet solar spectral irradiance measurements from the GOES Extreme ultraviolet and X-ray Sensors (EXIS) instrument. The goal is to use high-cadence operational measurements from EXIS to make a real-time prediction of x-ray flare class and duration based on clues from the He II, Lyman alpha, and Mg II observations. With these real-time predictions, I hope to establish a flare model that will be used by space weather forecasters.

The project aims to answer the following:

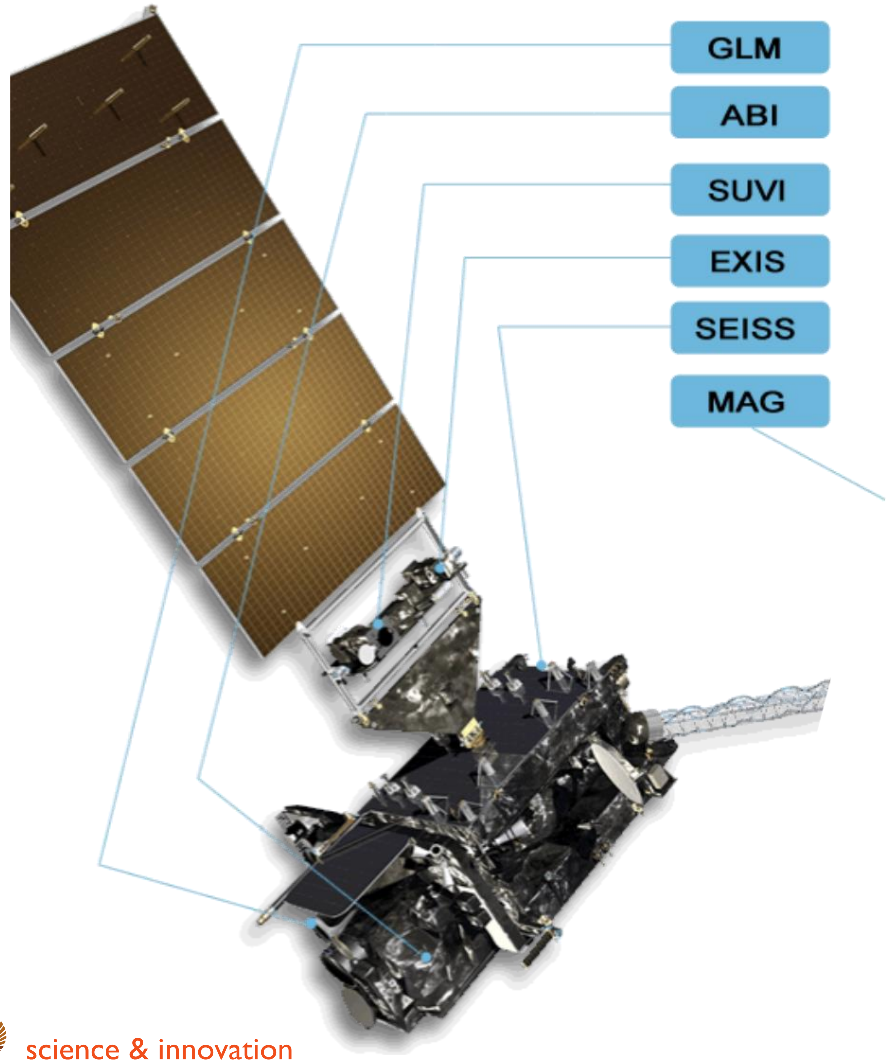
1. Can GOES ultraviolet measurements during flare onset predict the x-ray properties of flares?
2. Can these properties, if found, be used to predict the magnitude and duration of flares?
3. Can a flare model that can be used by space weather forecasters in real time be developed?



Justification of the study



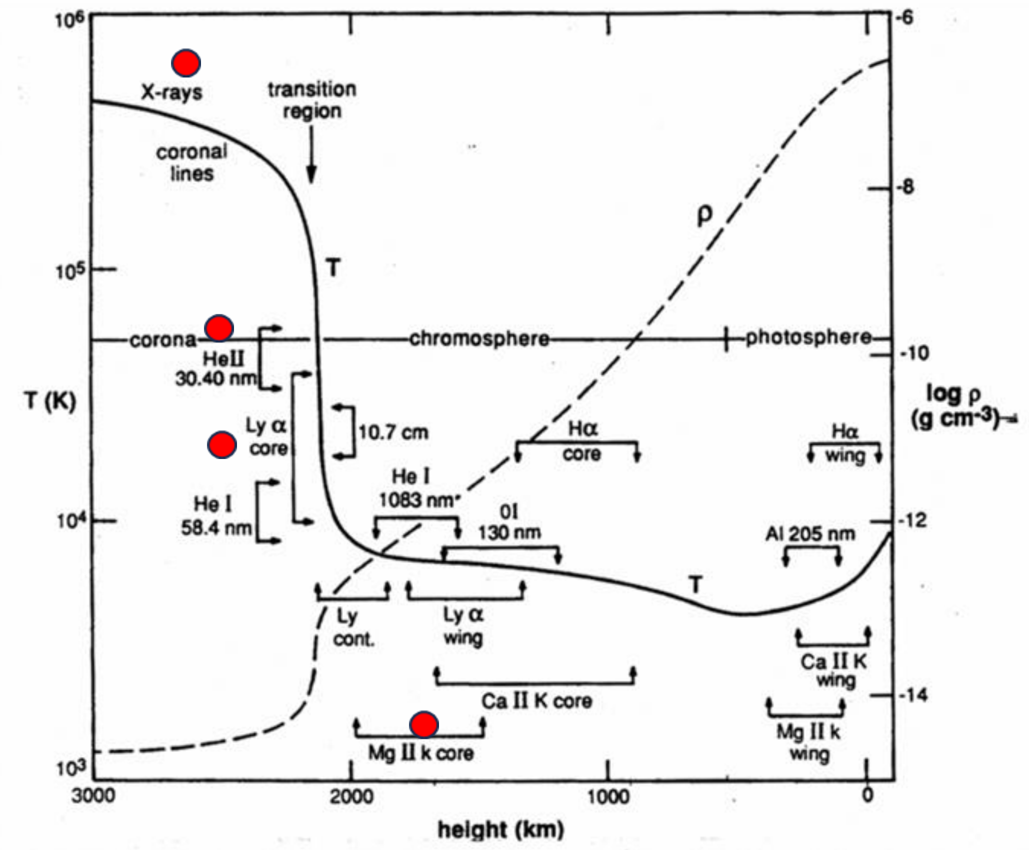
EXIS



- Onboard EXIS there are two sensors, EUVS and XRS.
- XRS monitors solar spectral irradiance (SSI) in the x-ray wavelength range.
- EUVS measurements are made for seven solar lines and the Mg II core-to-wing ratio (Mg II index)(Snow,2009)
- These measurements help monitor and analyse solar flares

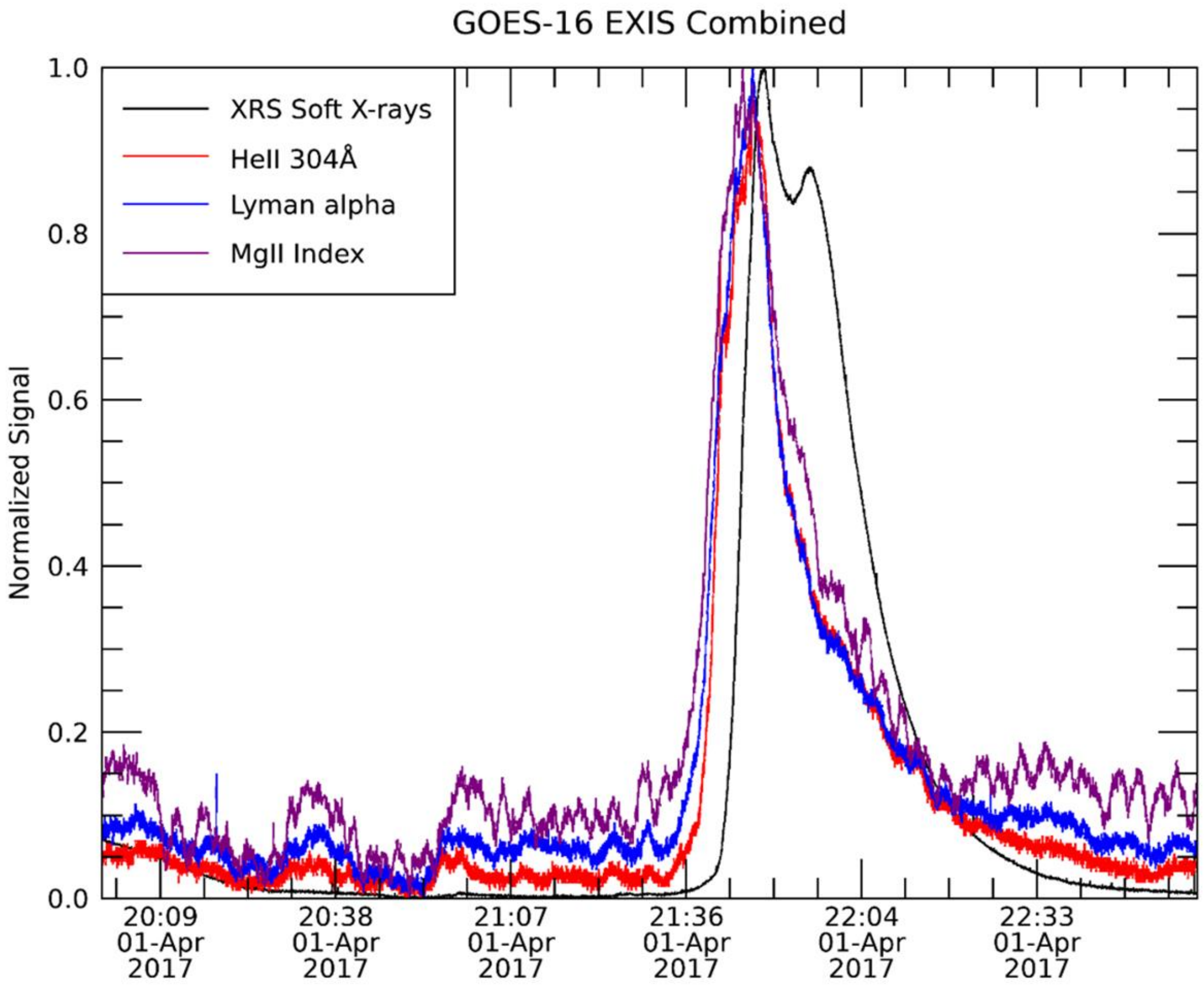
Methodology

This plot shows the formation heights of various spectral features



- For this study the first thing is to collect data from the National Oceanic and Atmospheric Administration (NOAA) web page. https://www.ngdc.noaa.gov/stp/satellite/goes-r.html.
- Then by analyzing these patterns, using time series analysis, curve fitting, interpolation and statistical analysis we can predict the strength of the flares and classify them.

Methodology



- The Mg II index rises first, followed by the Lyman alpha then the He II just before a flare is seen in the soft x-rays (SXR).

- 19 X-class flares
- 458 M-class flares

Analysis

Flare Category

Type I

- Flares peak in Lyman alpha before SXR

$$M(306) \approx 67\%$$
$$X(16) \approx 68\%$$

Type II

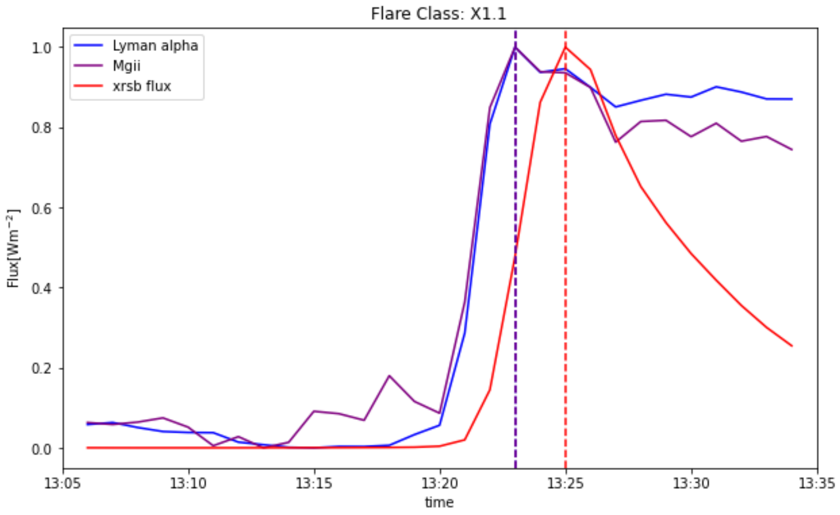
- Lyman alpha peaks at the same time with SXR

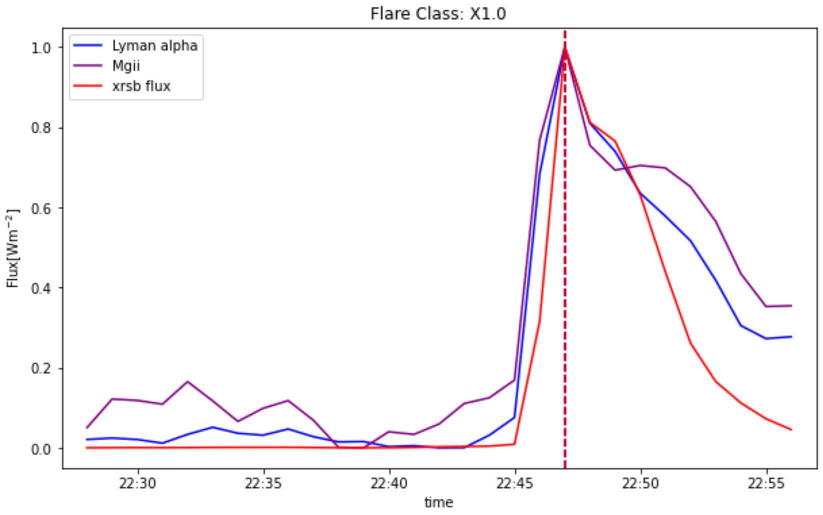
$$M(32) \approx 7\%$$
$$X(2) \approx 11\%$$

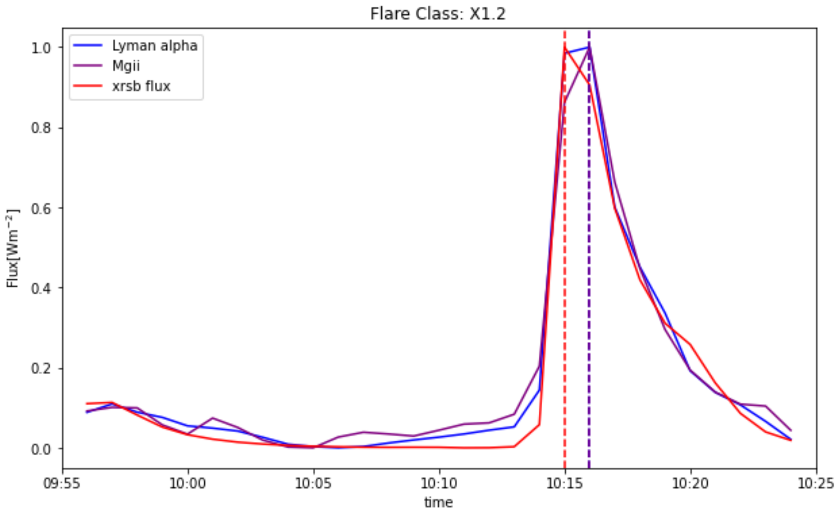
Type III

- Flares peak in the SXR before the Lyman alpha

$$M(121) \approx 26\%$$
$$X(4) \approx 21\%$$







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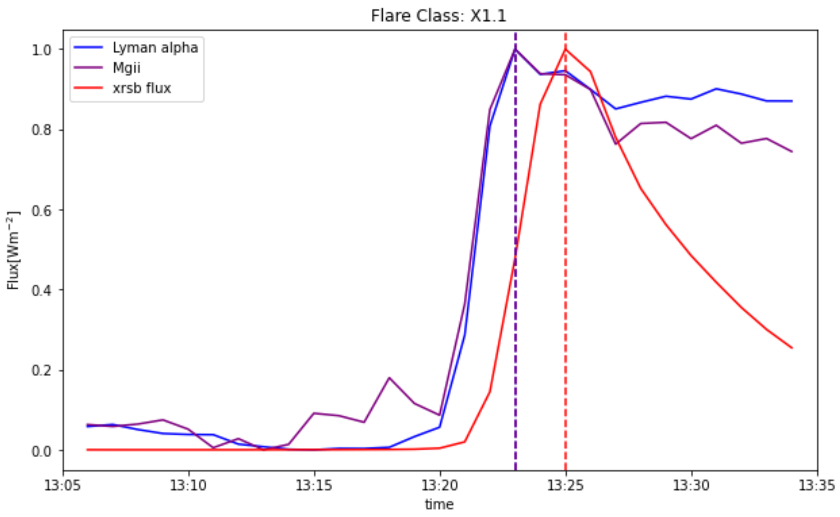
Flare Category

Type I

- Flares peak in Mg II before SXR

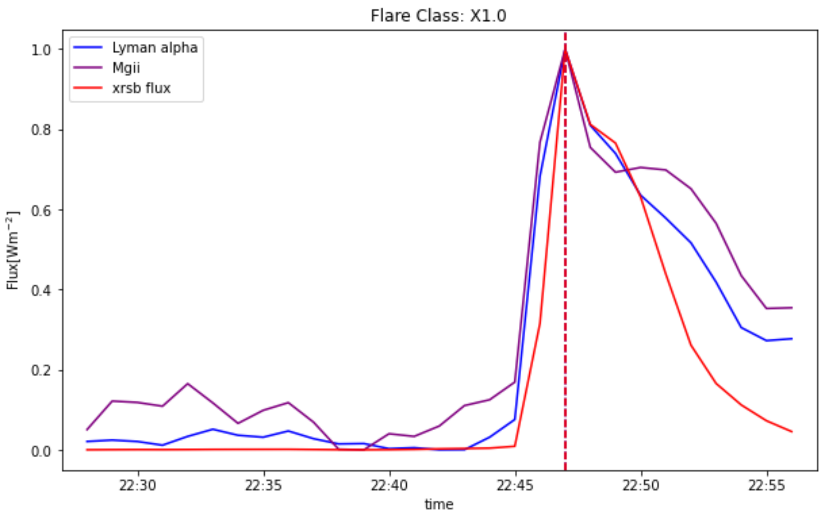
$$M(297) \approx 65\%$$
$$X(9) \approx 45\%$$



Type II

- Mg II peaks at the same time with SXR

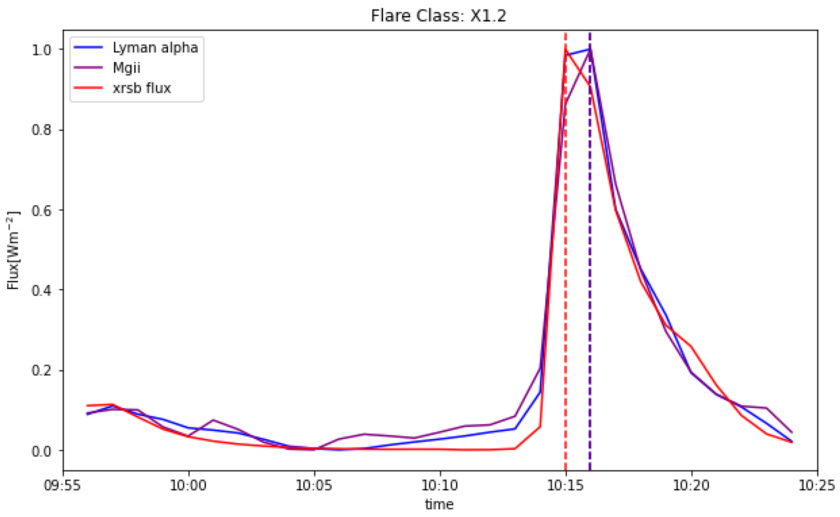
$$M(24) \approx 5\%$$
$$X(4) \approx 20\%$$



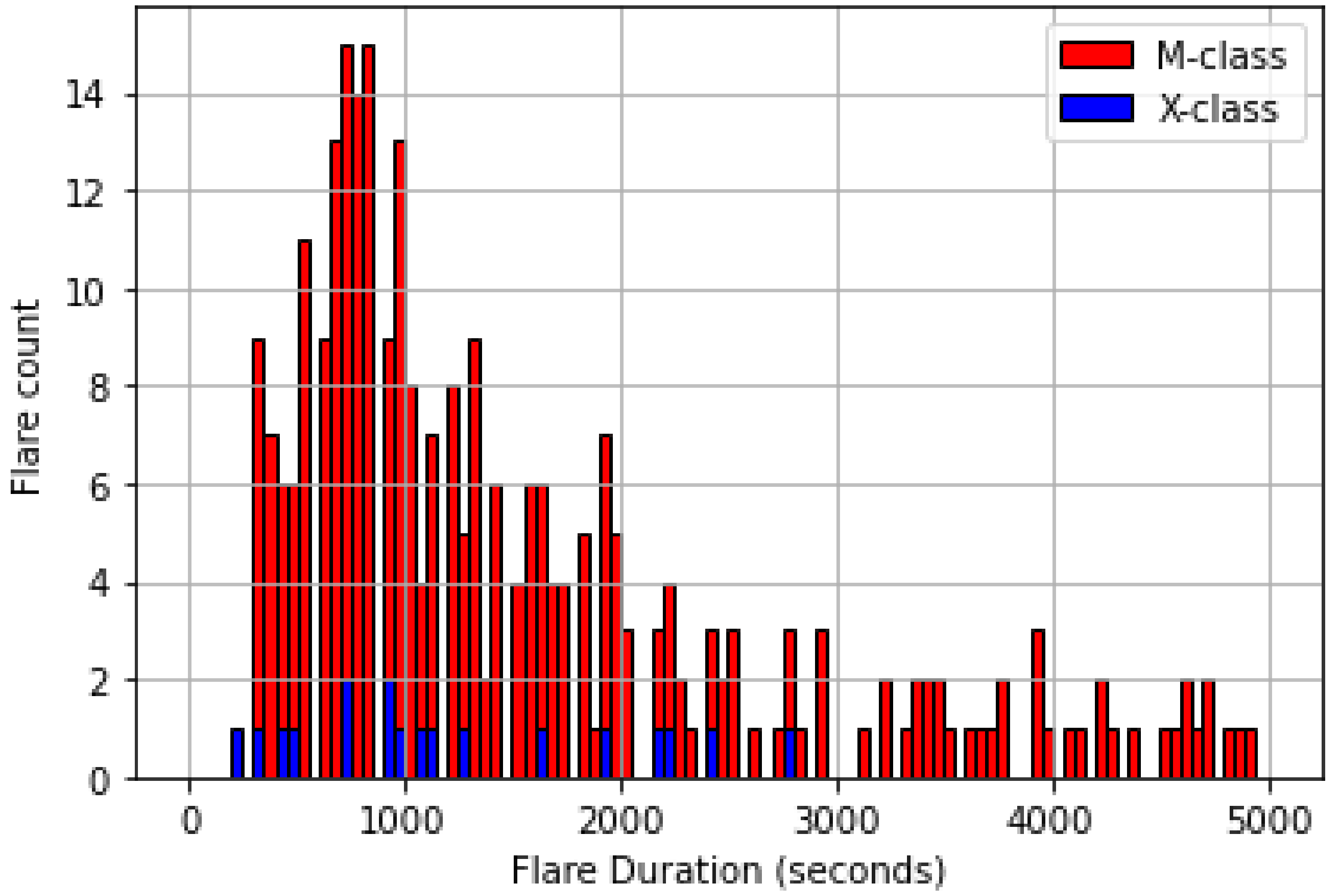
Type III

- Flares peak in the SXR before the Mg II

$$M(138) \approx 30\%$$
$$X(7) \approx 35\%$$



Duration of flares

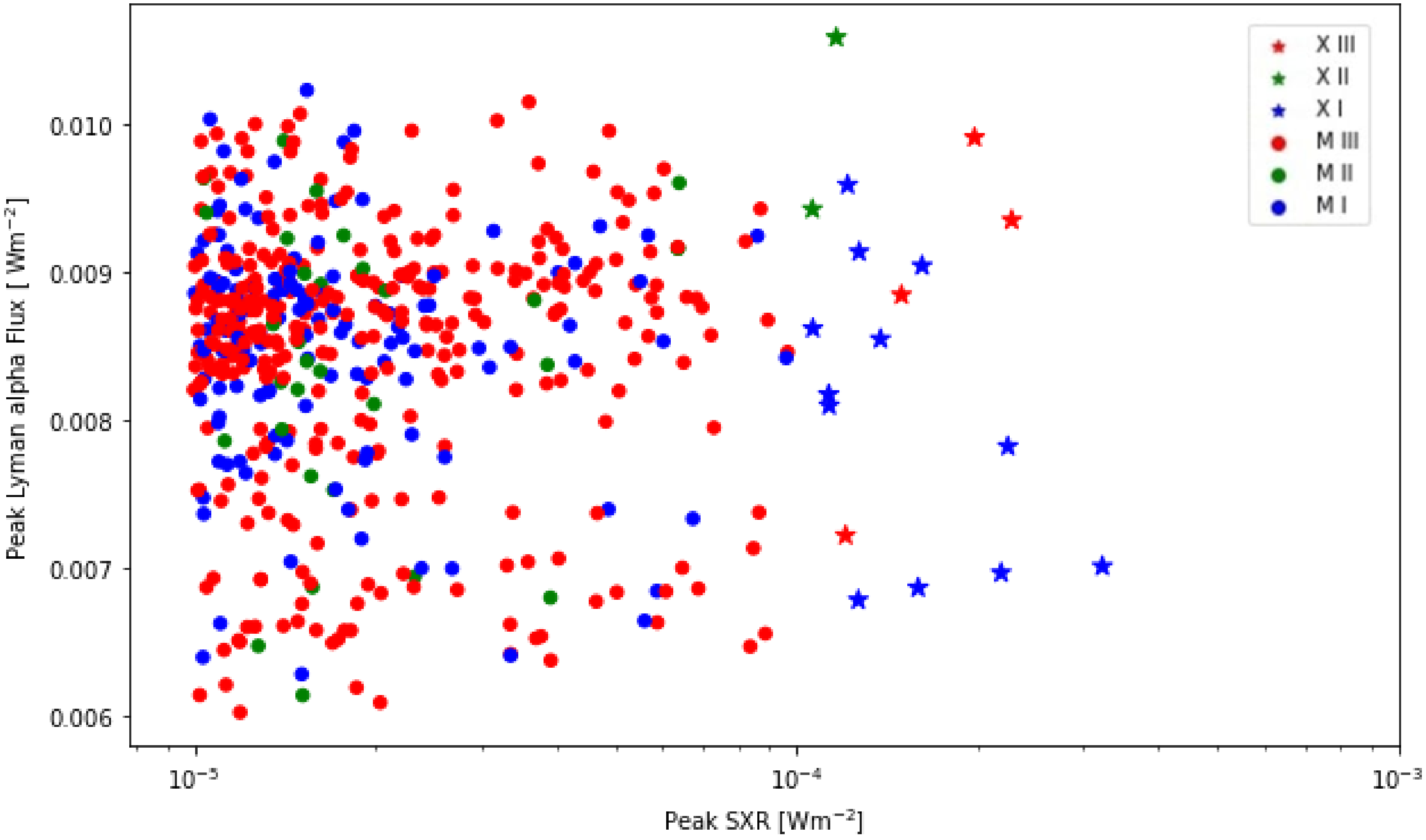


- Duration of flares calculated from the start and end times recorded in the GOES flare list.
- Note that there are 2 X(~ 10%) flares that last for > 90 minutes and are randomly distributed in the time range greater than shown.
- Most of the flare events end within 30 minutes.

Long duration event

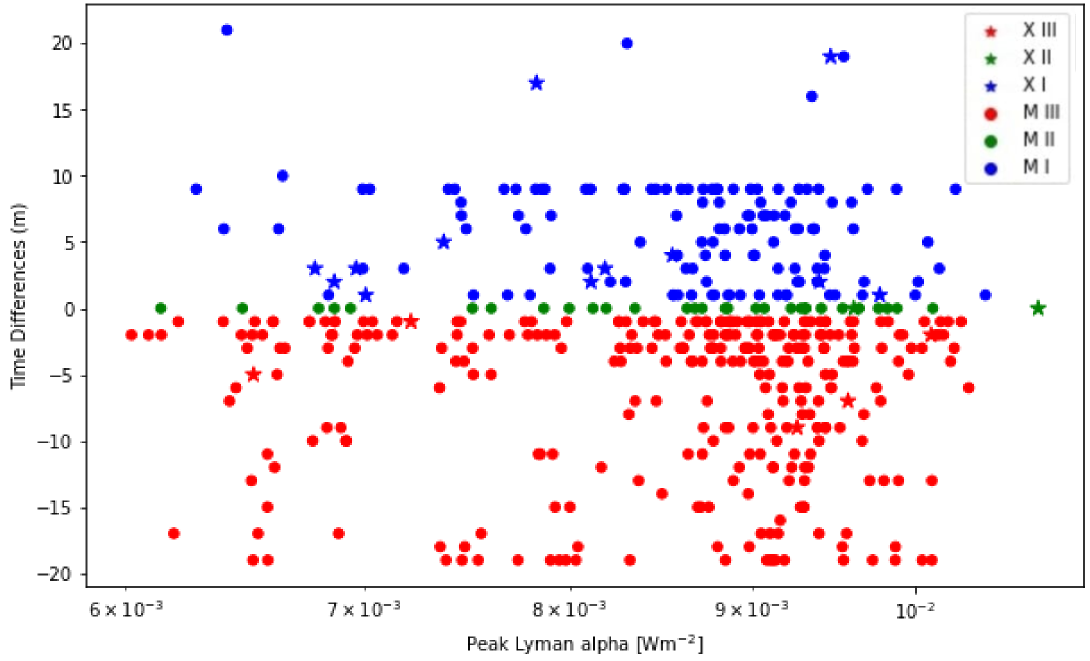
- July 14,2017 X2.2 LDE
- Regular flares have a sharp peak and a rapid decline
- The Long Duration Events (LDEs), are flares lasting more than 30 minutes, they have a gradual decline.

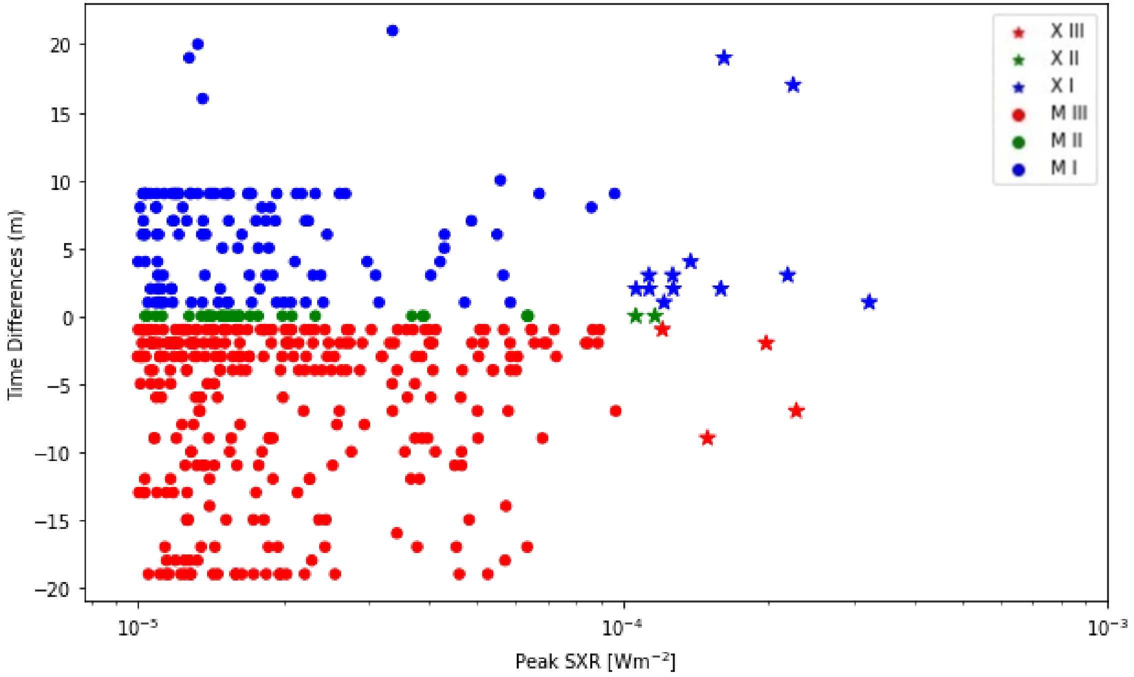
Peak fluxes of the flares



- Plots of the peak Lyα flux versus peak SXR flux for the flares.
- Is there correlation between the Lyα and SXR peak fluxes?

Time Difference Between the Lyα and SXR Emission Peaks





- Only considered Lyα peak that falls into the range between the start and end times of each flare. This might underestimate the time difference value for some flares that have Lyα peak later than the flare end time.

What I can conclude so far

1. There is usually a rapid rise followed by a relatively slow decay in both of the Lyα and SXR emission curves.
2. The Lyα emission can reach its maximum (main peak) earlier or later than the SXR emission.
3. There appear two or even more evident peaks (main peak plus sub-peaks) in numerous flares particularly in the Lyα emission curve.

To do

1. Time Difference Between the Lyα and SXR Emission Peaks
2. Dependence on Flare Duration, Flare Location, and Solar Cycle
3. Delayed Time Check for the Gradual-phase Peak of Lyα
4. Analyze Mg II etc.

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