

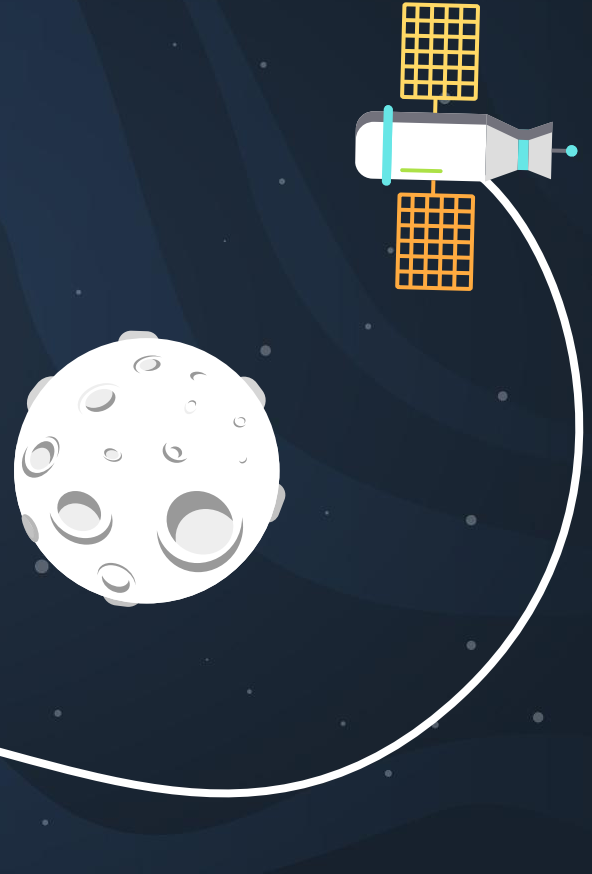
SOLAR FLARES ANALYSIS

ECE 143
Group 5

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OUTLINE

- Motivation and Objective
- Dataset Overview
- Dataset Analysis
- A Machine Learning Example



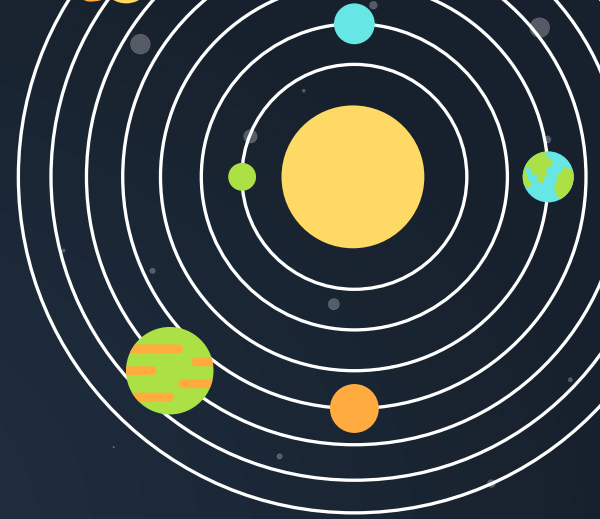
MOTIVATION AND OBJECTIVE

- Solar flares are powerful bursts of energy.
- Flares can impact radio communications, power grids and pose risks to spacecraft and astronauts.
- On Feb 3rd, 2022, 40 of 49 newly launched Starlink satellites have been knocked out of commission due to a solar storm that occurred on Jan 29th, 2022.
- Analyze historical solar data.
- Train a machine learning model to predict its future activities.





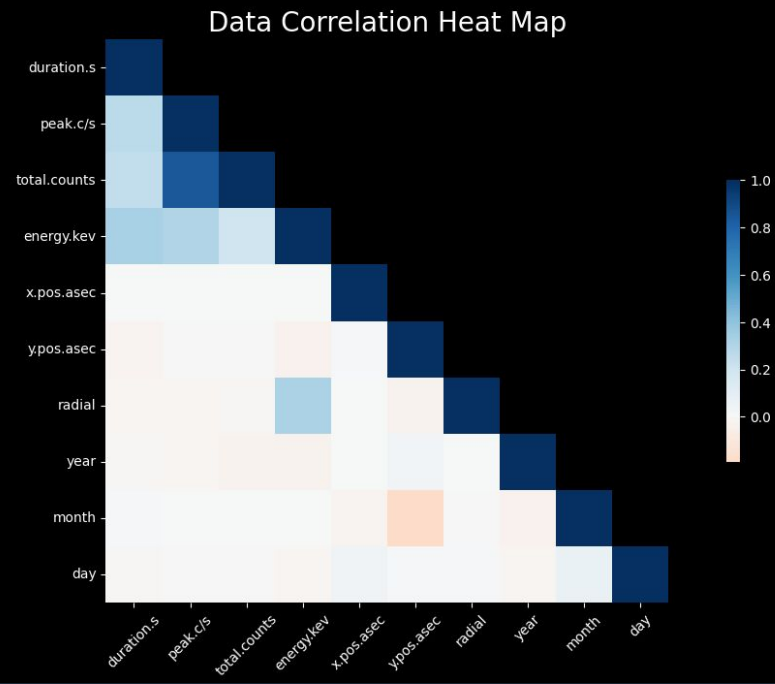
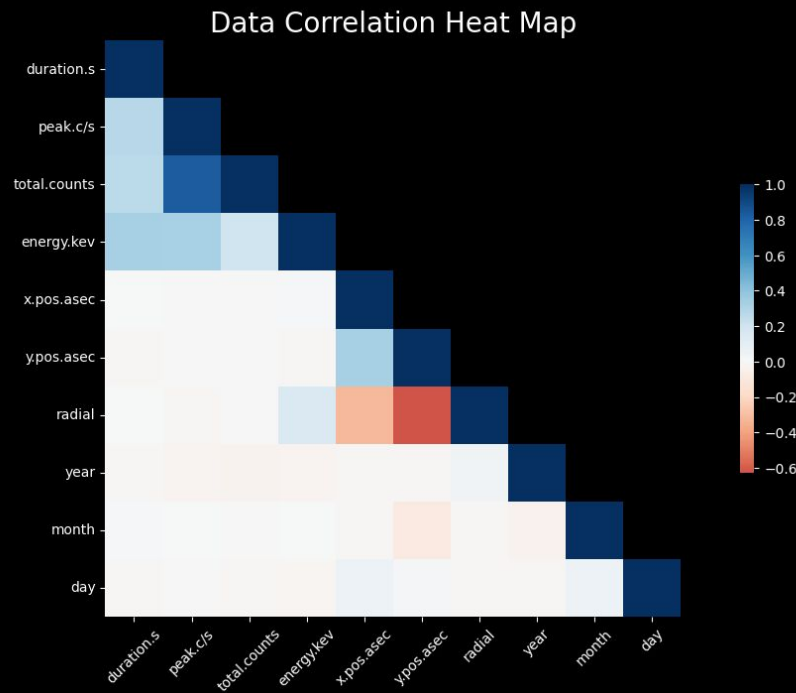
DATASET OVERVIEW



- The data was captured by the Ramaty High Energy Solar Spectroscopic Imager (RHESSI).
- Primary mission is to explore the physics of particle acceleration and energy release in solar flares.
- The data was collected from 2002 to 2018.
- The data includes information about solar flares such as the date, duration, energy levels and the x and y position of the solar flare.



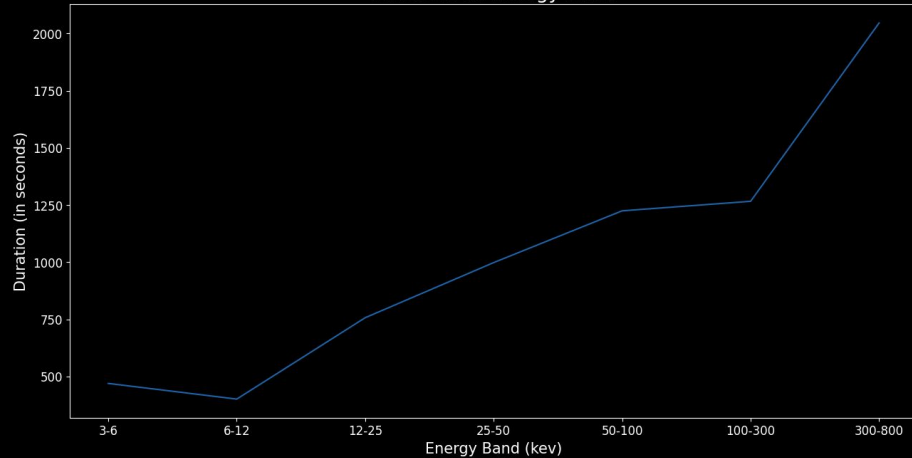
CORRELATION HEAT MAP



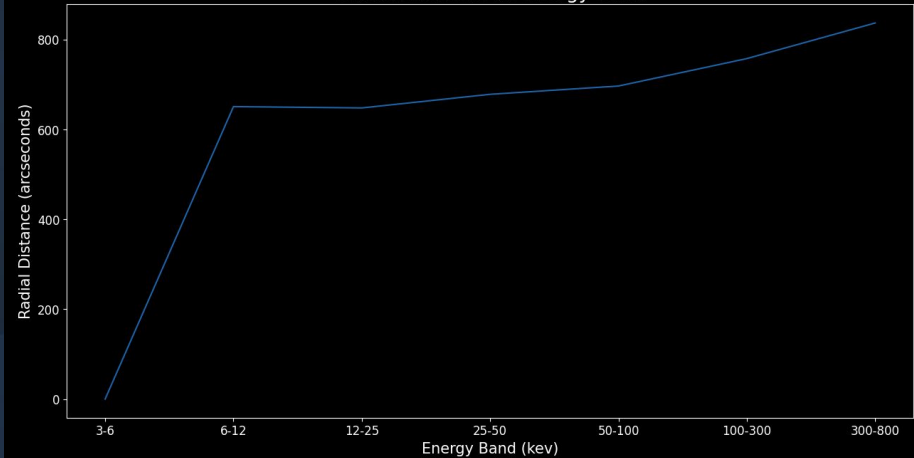
HOW ENERGY BANDS IMPACTS OTHER SOLAR FLARE CHARACTERISTICS

As energy level increases, the duration of the flare and the radial distance from the center of the sun increases.

Duration vs Energy Band



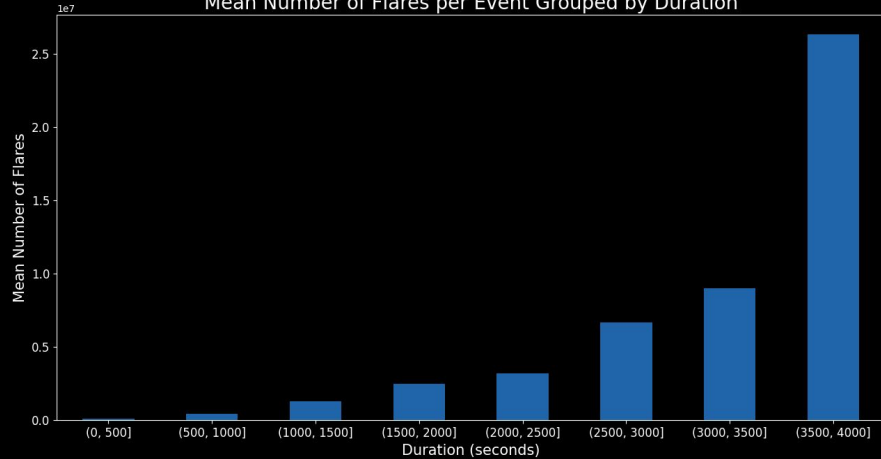
Radial Distance vs Energy Band



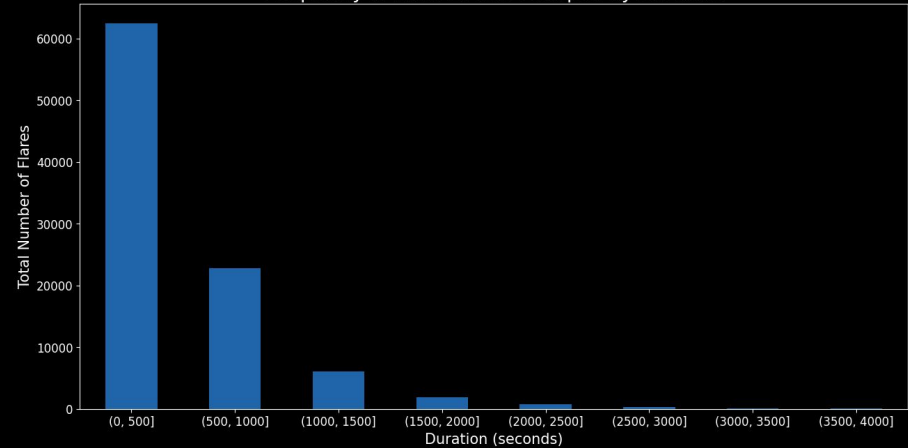
DOES DURATION AFFECT THE NUMBER OF SOLAR FLARES?

Lower duration events have lower amount of solar flares, and such events are higher in frequency.

Mean Number of Flares per Event Grouped by Duration

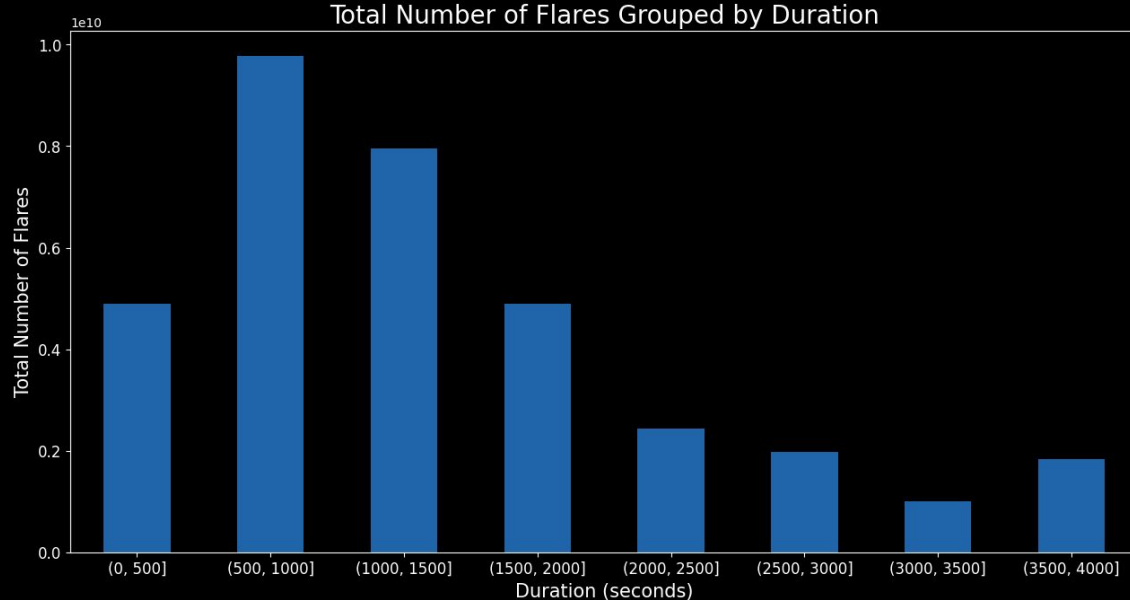


Frequency of Flare Events Grouped by Duration



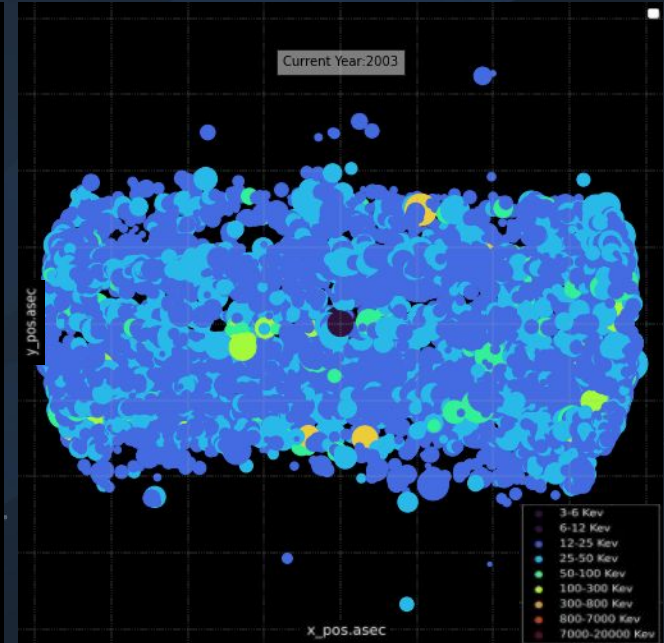
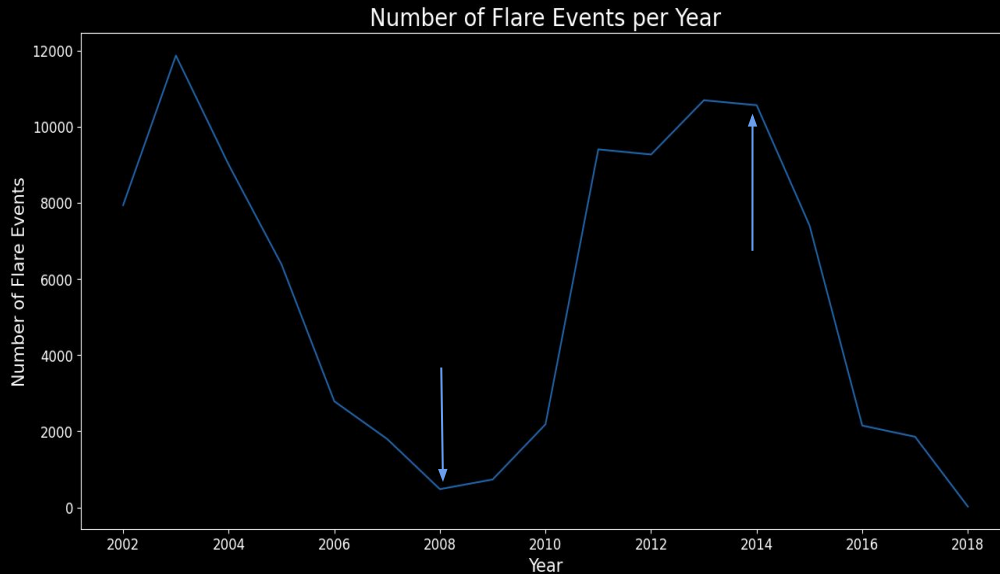
DOES DURATION AFFECT THE NUMBER OF SOLAR FLARES?

Lower duration flare events though emit less flares affect us the most.

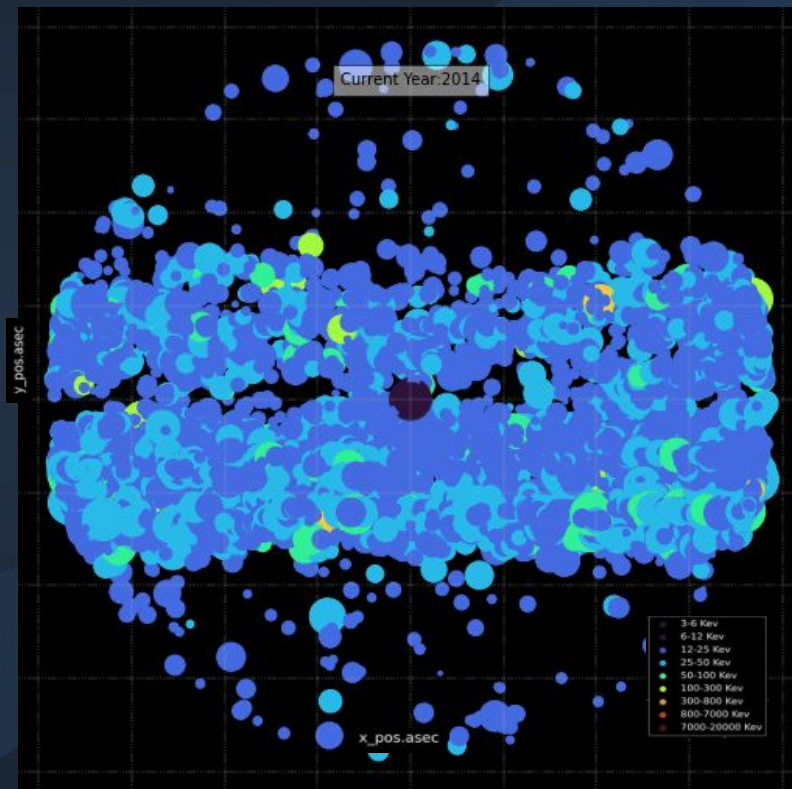
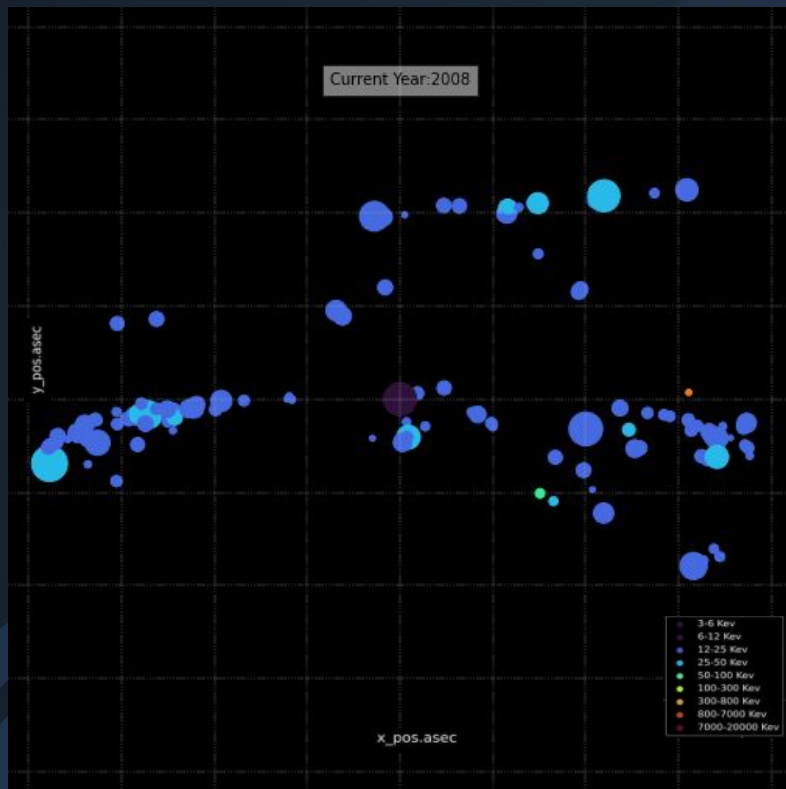


DO SOLAR FLARE EVENTS VARY BY YEAR?

Solar flares follow a periodic cycle of 11 years.

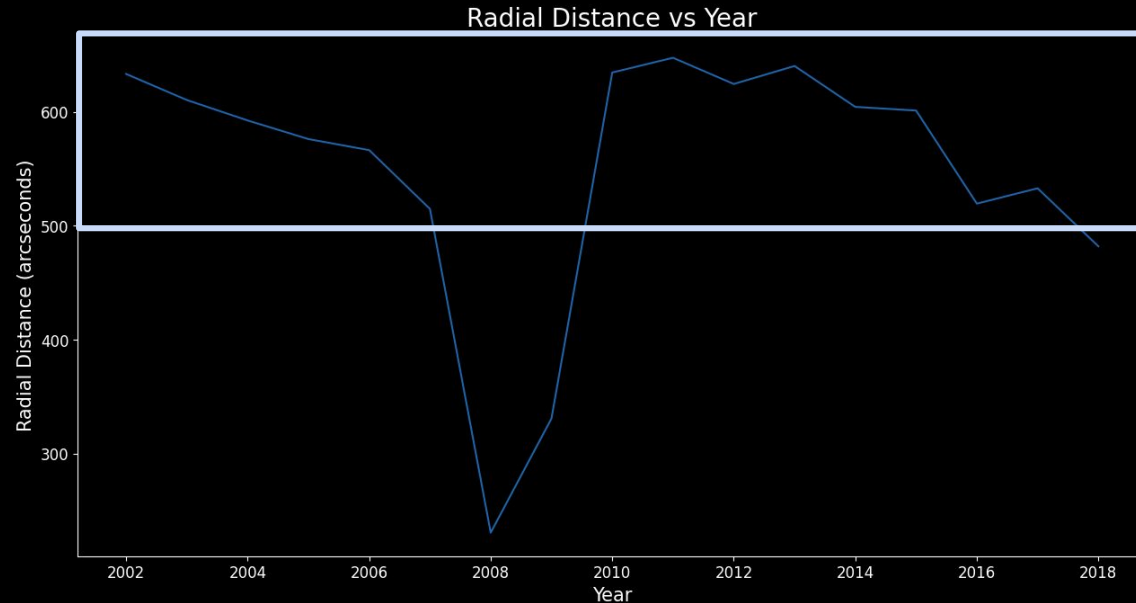


MINIMUM AND MAXIMUM YEAR

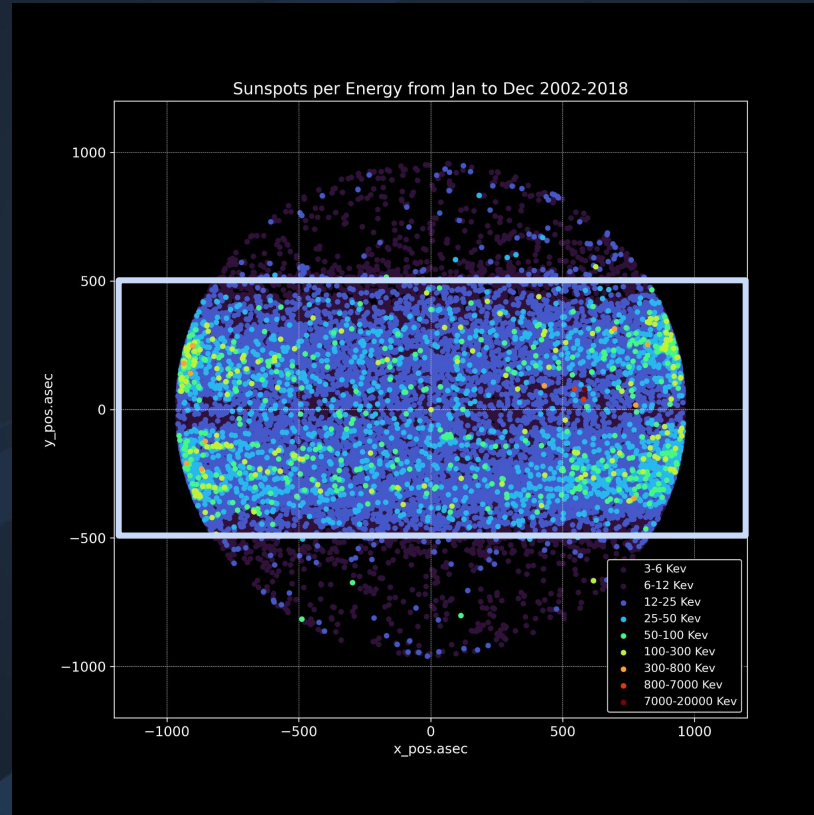


WHAT IS SIGNIFICANT ABOUT RADIAL DISTANCE?

Majority of solar flare events occur at a radius of above 500 arcseconds.



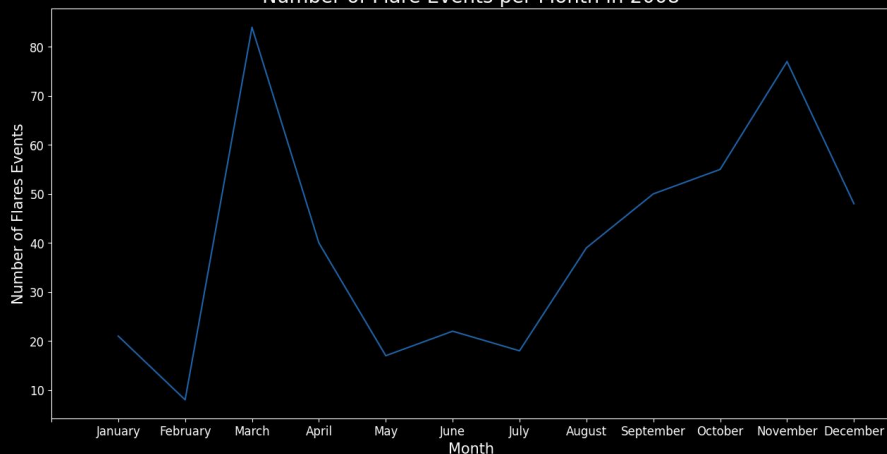
WHAT IS SIGNIFICANT ABOUT RADIAL DISTANCE?



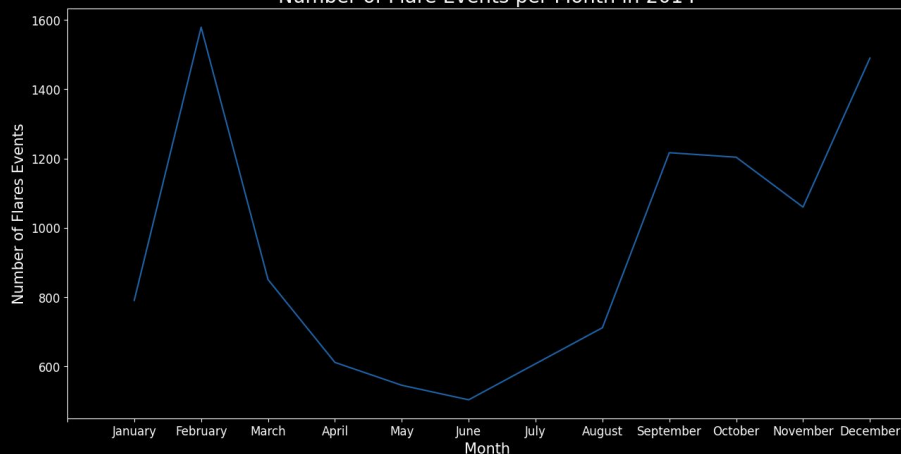
DO SOLAR FLARE EVENTS VARY BY MONTH?

A minimum number of solar flare events occur in February and maximum occur in July

Number of Flare Events per Month in 2008

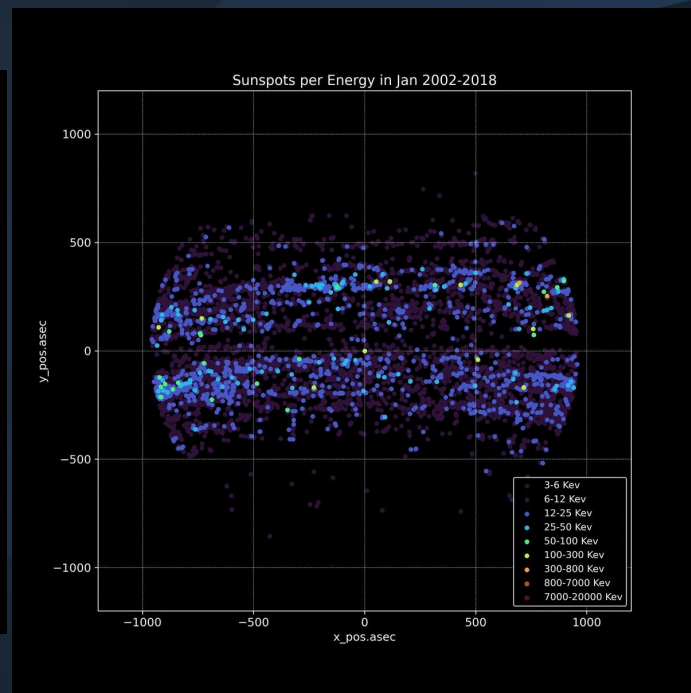
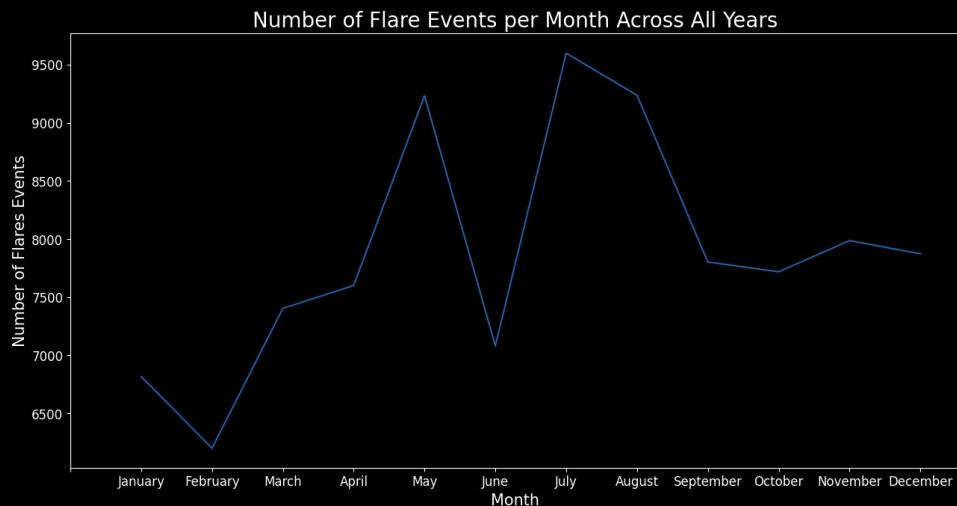


Number of Flare Events per Month in 2014

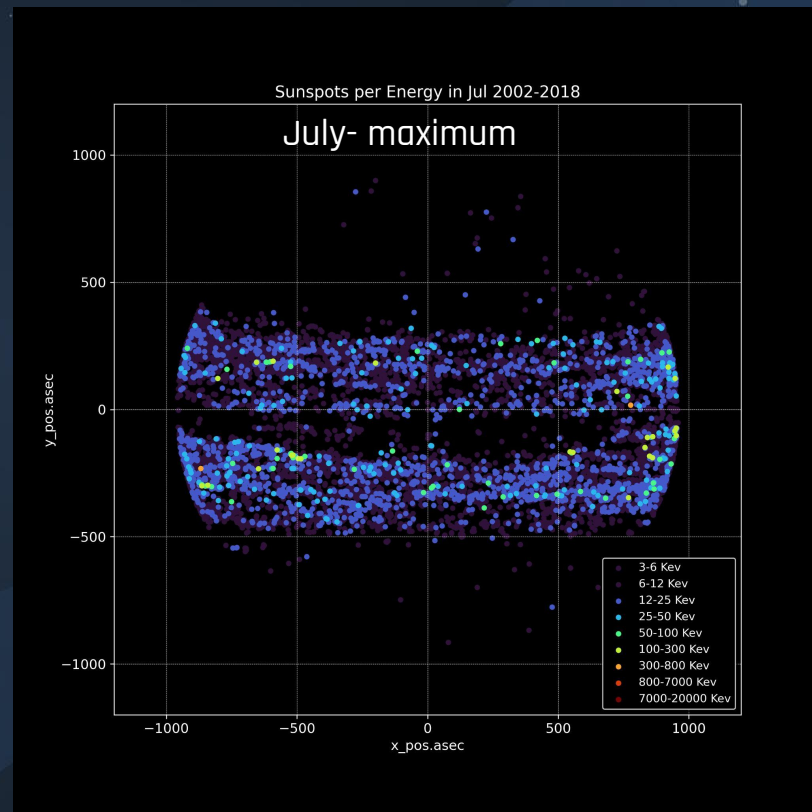
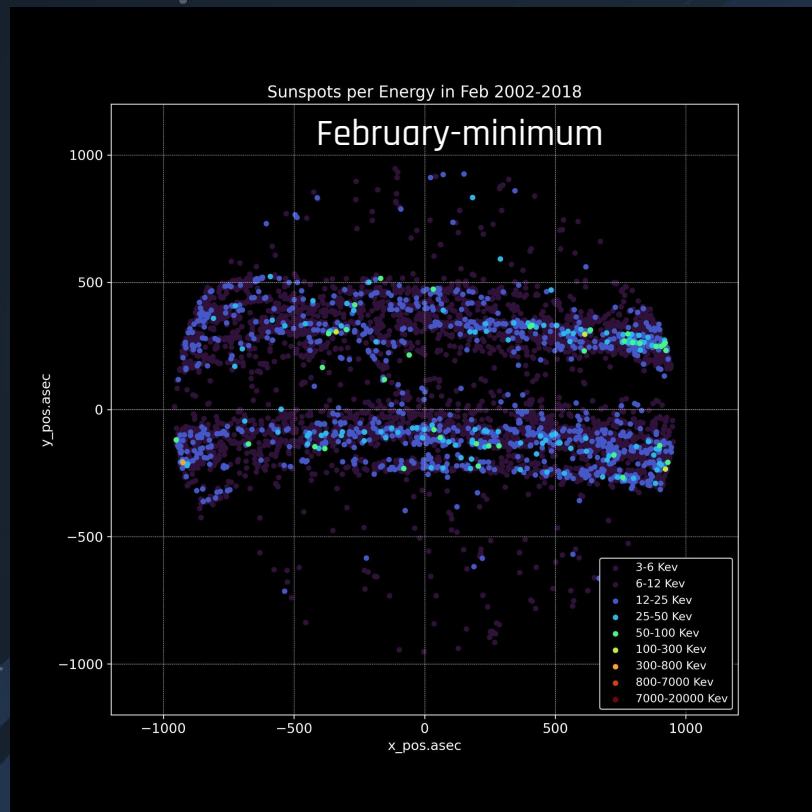


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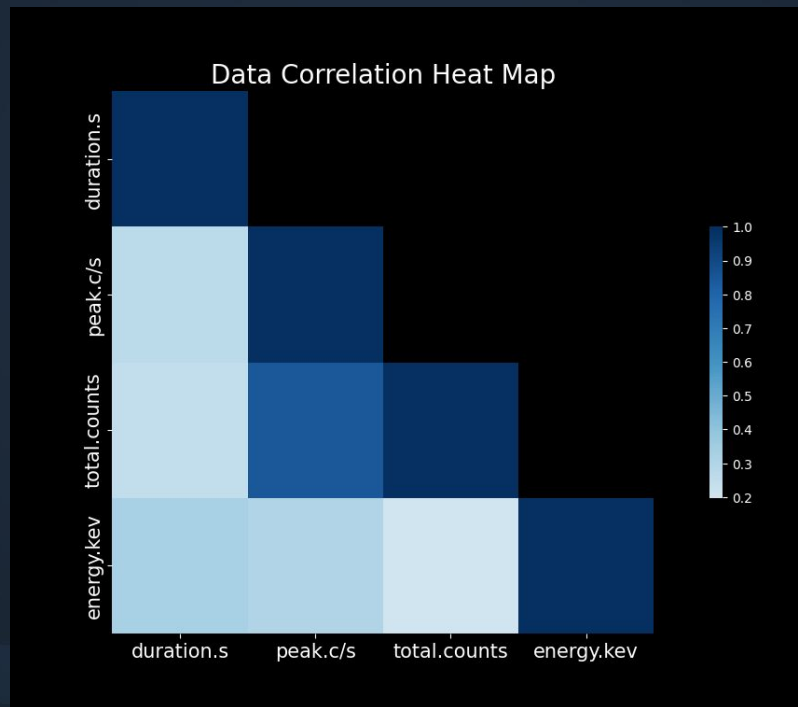


DO SOLAR FLARE EVENTS VARY BY MONTH?



MACHINE LEARNING PREDICTION

DURATION PREDICTION



DURATION PREDICTION

Peak Counts

Total counts

Energy

Radial

Date

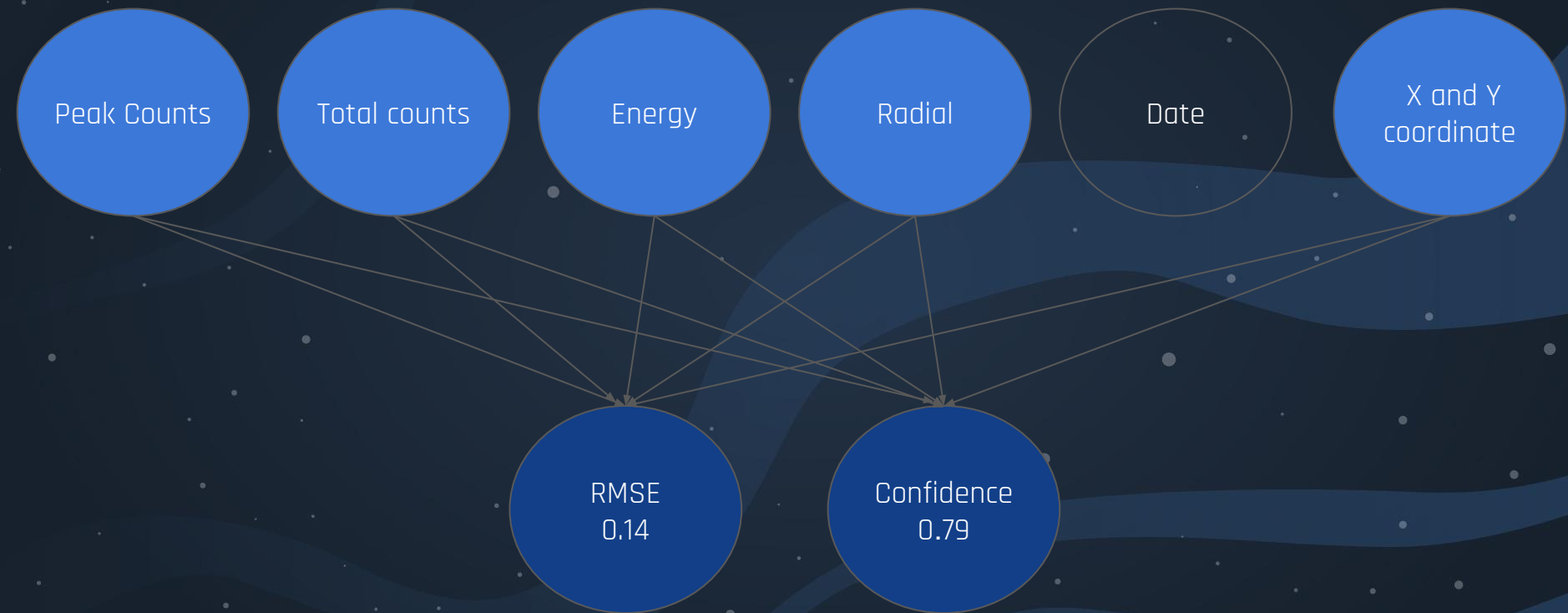
X and Y
coordinate

RMSE
0.10

Confidence
0.86



DURATION PREDICTION



DURATION PREDICTION

Peak Counts

Total counts

Energy

Radial

Date

X and Y
coordinate

RMSE
0.31

Confidenc
e
0.56



DURATION PREDICTION

Peak Counts

Total counts

Energy

Radial

Date

X and Y
coordinate

RMSE
0.54

Confidence
0.22



DURATION PREDICTION

Peak Counts

Total counts

Energy

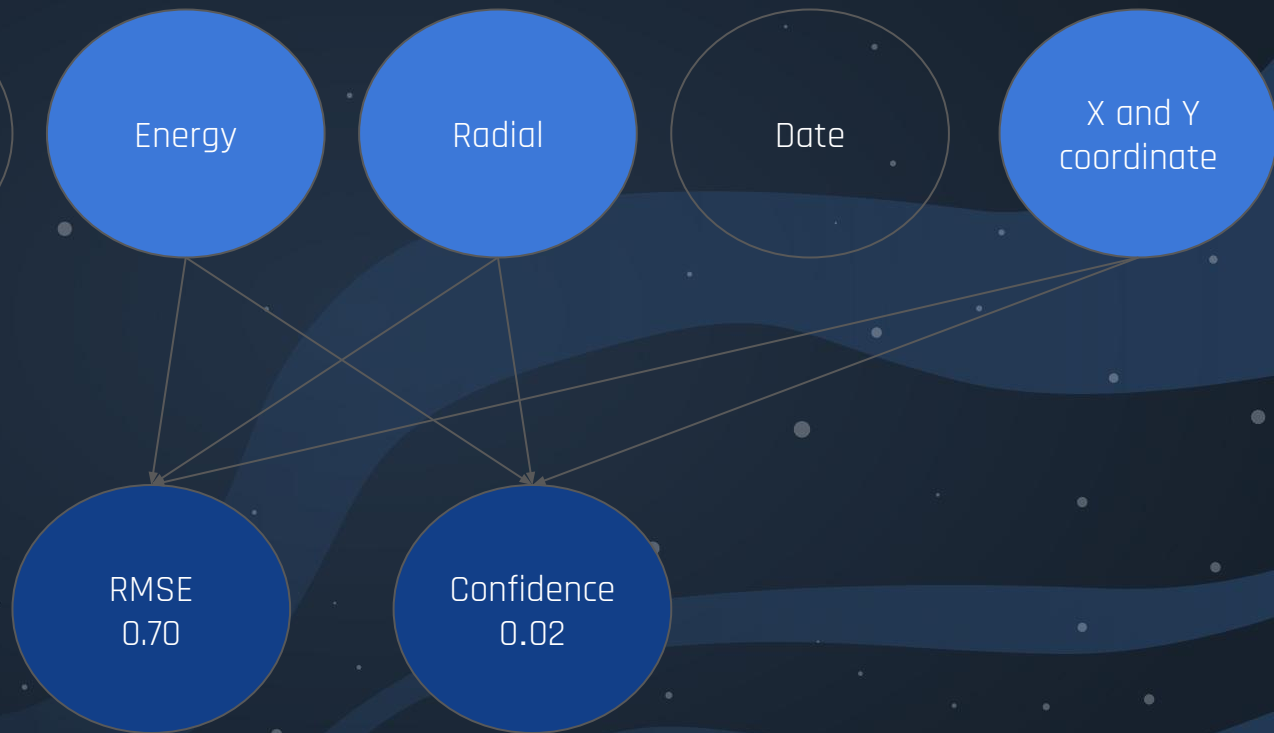
Radial

Date

X and Y
coordinate

RMSE
0.70

Confidence
0.02



DURATION PREDICTION

Peak Counts

Total counts

Energy

Radial

Date

X and Y
coordinate

RMSE
0.15

Confidence
0.78



CONCLUSIONS

- Lower duration flares are equally important as higher duration flares
- Solar flares follow a 11 year solar cycle
- Possible correlation in solar flare activity between solar maximum and minimum years
- Higher correlation among features lead to better prediction results

THANK YOU FOR LISTENING!

