Solar Flare Analysis System

Group Project

Bryan Miramontes

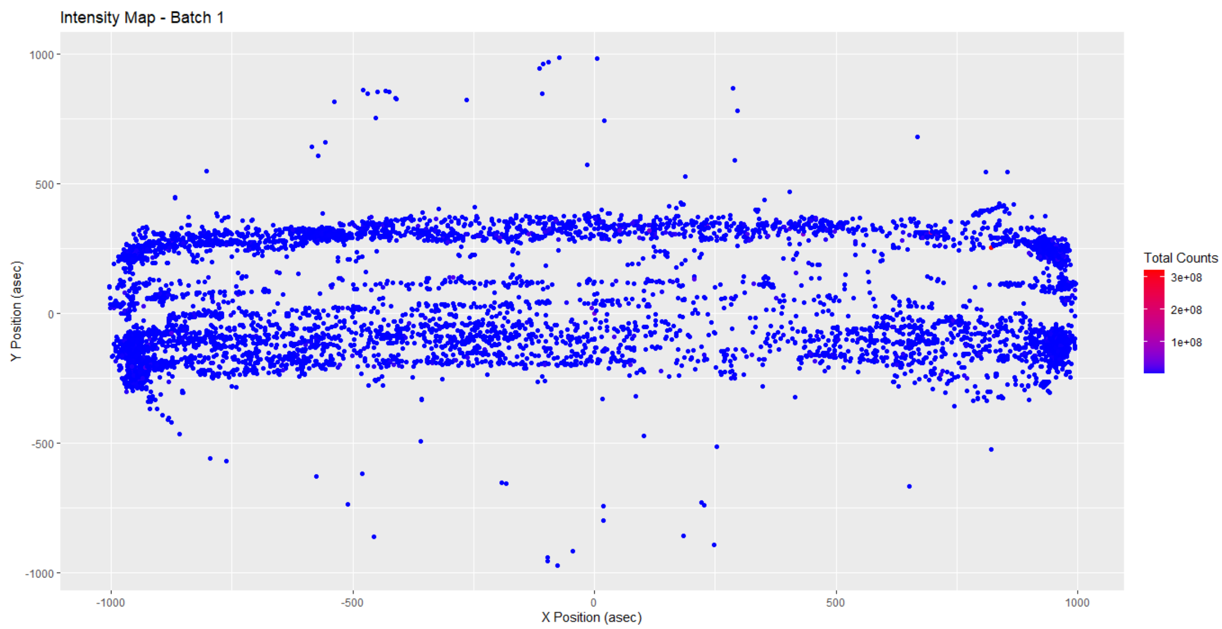
Team Member Responsibilities:

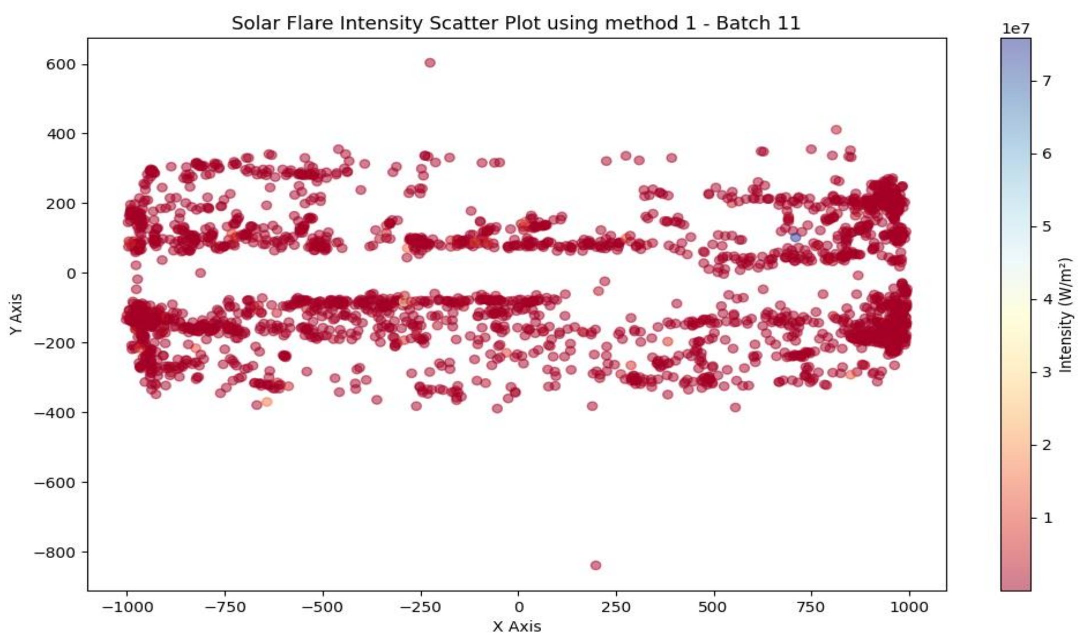
Bryan Miramontes: Helping in development an algorithm for task 1 method 2, as well as analyzing the given intensity maps. In addition, helped develop an algorithm for task 2 subtask e

Subtask A

For subtask a, we are asked to create an algorithm to subdivide subset 1 into smaller batches with each batch have 4 months and 2 months overlap. Our group has divided the task to finish the work, with Tung is responsible to develop method 1 to measure the intensity estimation based on the total.counts attribute. Bryan is responsible to develop method 2 to measure the intensity based on the duration.s and energy.kev attributes.

So far for method 1, the algorithm has successfully divided the batch to batch 1 but it doesn't continue to iterate after batch 6. So, for the result we create intensity maps for batch 1 and



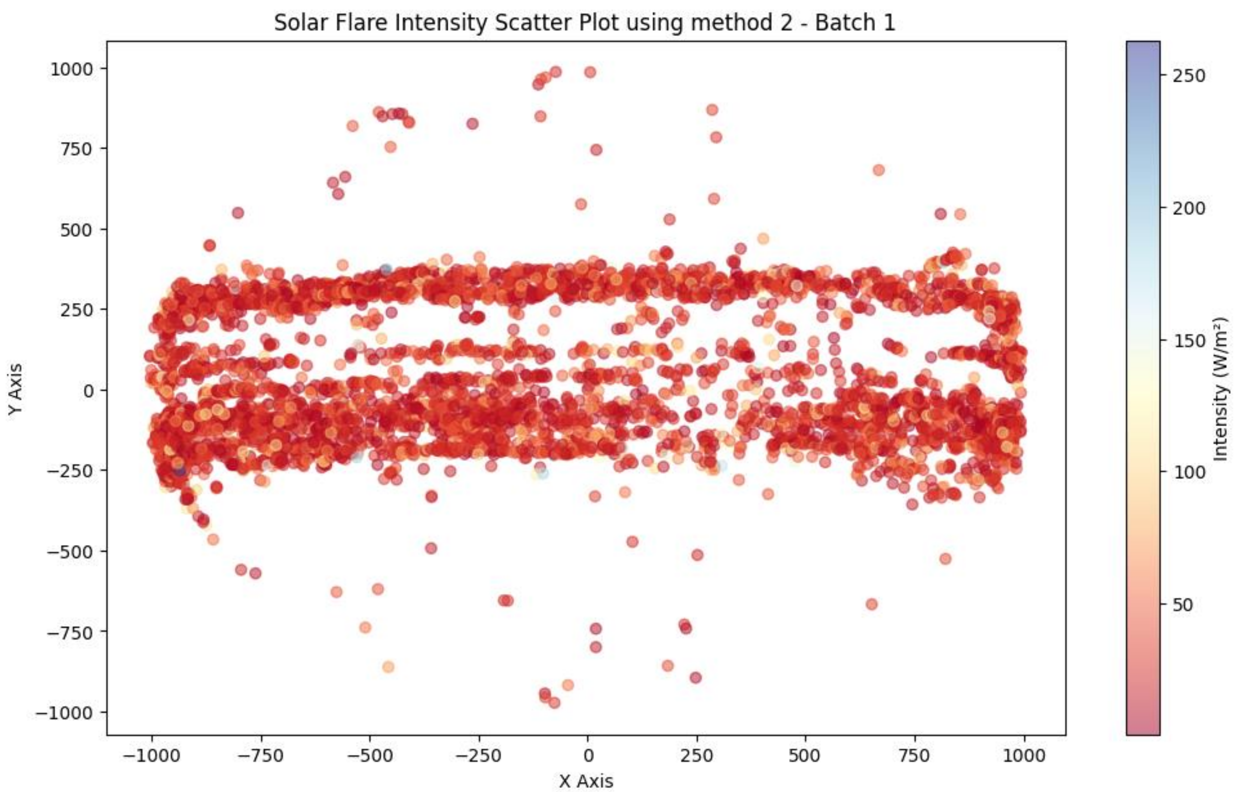


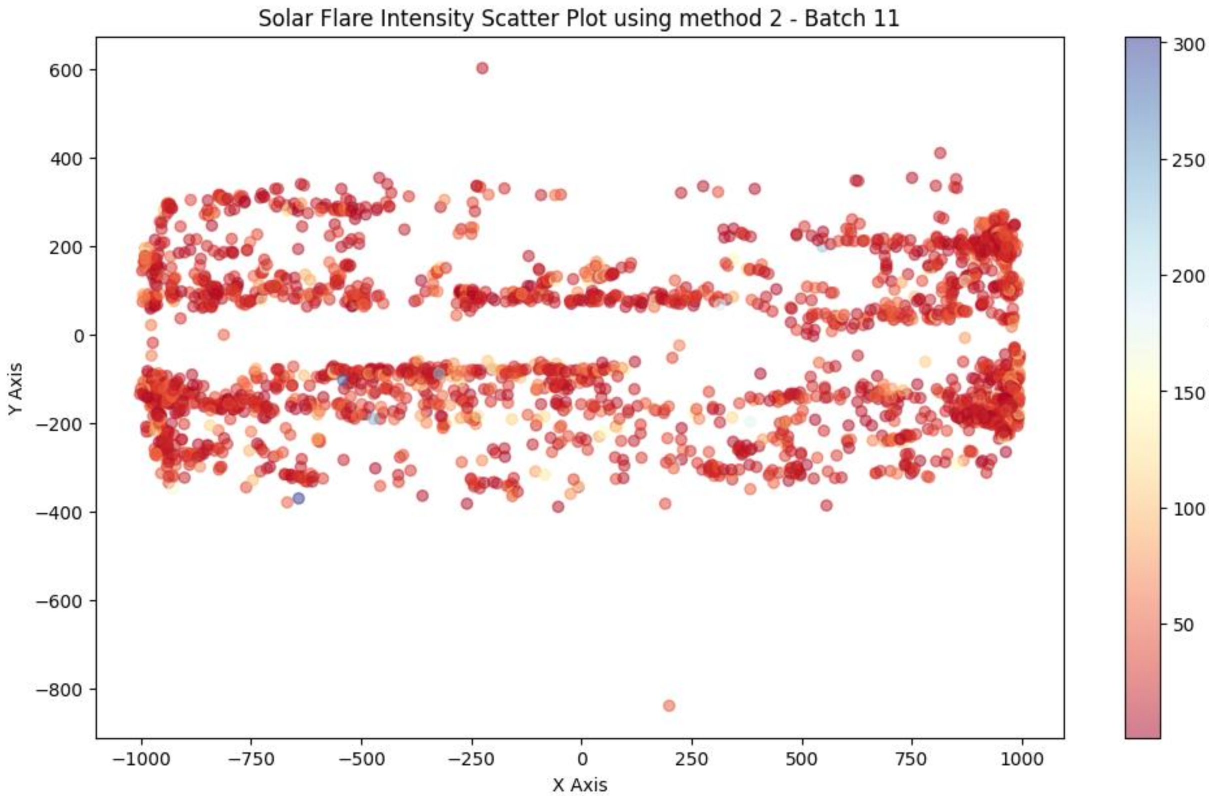
When comparing batch 1 and batch 6, a noticeable pattern emerges regarding the spatial variation and intensity distribution on the sun. Typically, the spatial variation and intensity tend to concentrate in the middle of the sun. Moreover, the higher intensity levels are often observed around the 0 line, where the purple and red dots appear behind the blue dots. Although the image may not clearly depict this phenomenon, it becomes evident upon closer inspection.

Although the middle region may not exhibit a high intensity throughout, it is noteworthy that when high-intensity events do occur, they tend to appear in the middle of the sun. This observation highlights a consistent trend in the distribution of intensity and suggests a certain level of spatial preference for intense solar activity in the central region.

Method 2: Batches 1 and 11 (Bryan Miramontes)

The algorithm that we created processes the solar flare data and generates an intensity scatter plot for the given batches using python. We designed 2 different methods for the generation of these scatter plots. In our case, we designed method 2, which calculates intensity based on the ratio of duration to energy. The algorithm iterates through 4 month batches with an overlap of 2 months, creating intensity maps by mapping flare intensity values to a grid defined by the coordinates of (x.pos.asec, y.pos.asec). The intensity maps give us a visualization of the spatial representation of the flare activity during batches 1 and 11.

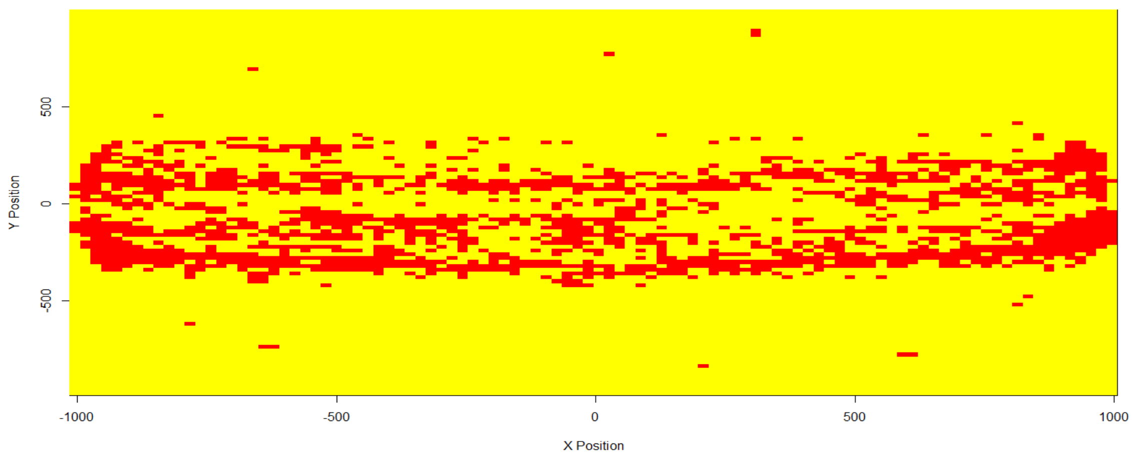


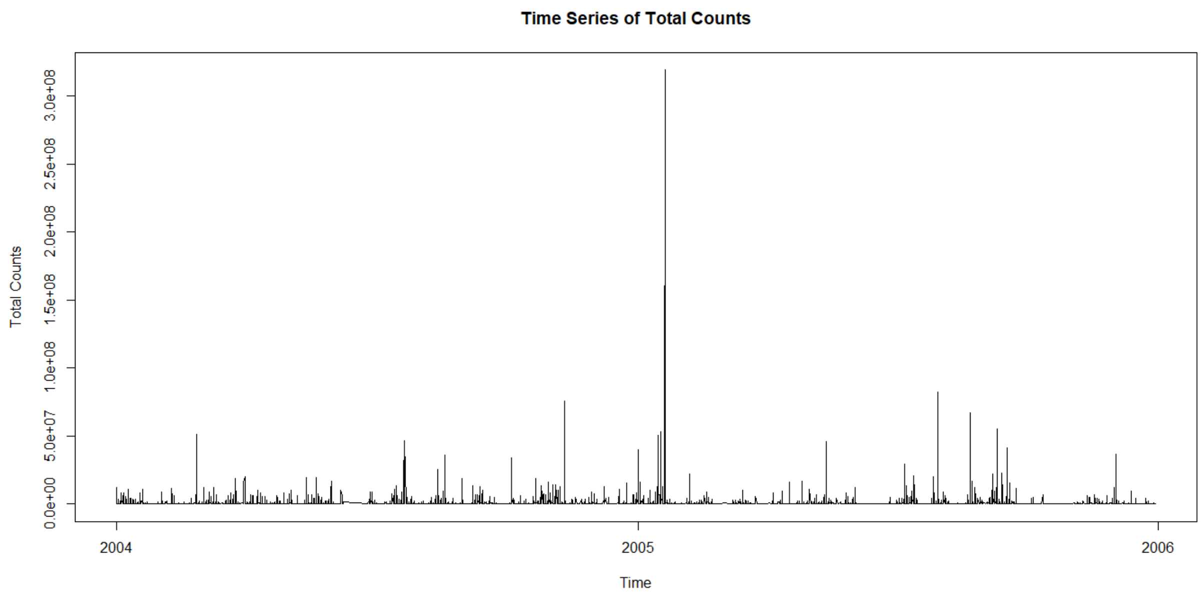


Analysis: When interpreting the given scatter plots, we can see given patterns for spatial distribution and total intensity of the batches. When using method 2 on batch 1 we can see a clear pattern in the total intensity, we can see that intensity levels are clustered through the middle of the sun forming 2 lines though. These clusters are of similar lower intensity signifying spatial similarity, with small instances of high intensity. We can also observe small occurrences of low intensity flares towards the outside of the sun, and falling outside of the 2 defined clusters. When analyzing batch 11 we can clearly see the 2 clusters again with similar intensities to batch 1, we do observe that the 2 clusters are more scattered than batch 1 and there is less flares outside of those 2 clusters. We can also see a higher instance of higher intensity flares in batch 11.

Subtask B

For this subtask we are required to design a hotspot discovery algorithm to create two kinds of hotspots, for this task, we decided to divide the task, where Tung is responsible to develop the algorithm by using intensity threshold d1, Bryan using threshold d2.





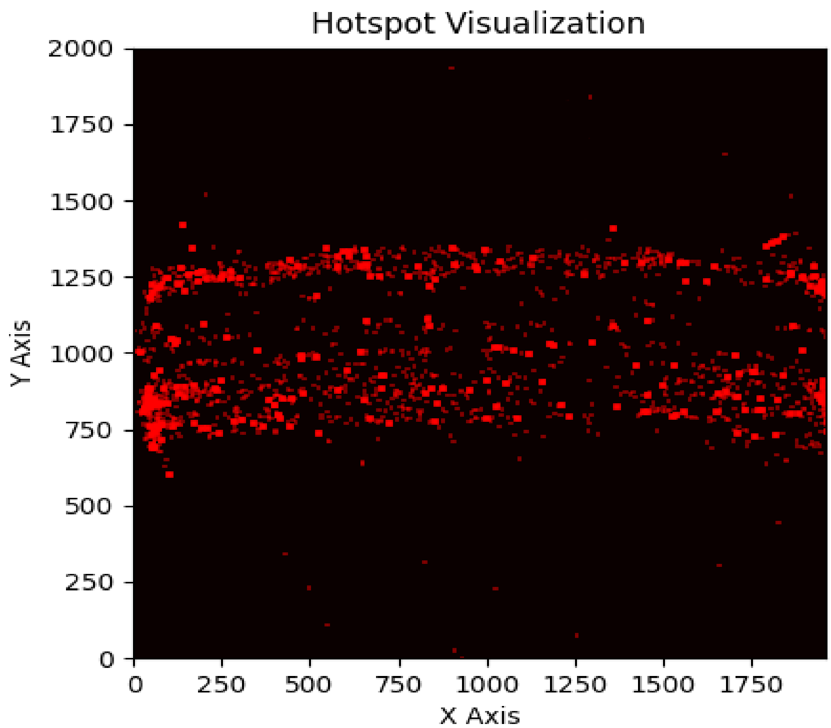
The hotspot discovery algorithm has been successful, as it has identified hotspots that are consistent with the intensity maps generated earlier. Most of the hotspots appear in the middle of the sun, similar to the patterns observed in the intensity maps.

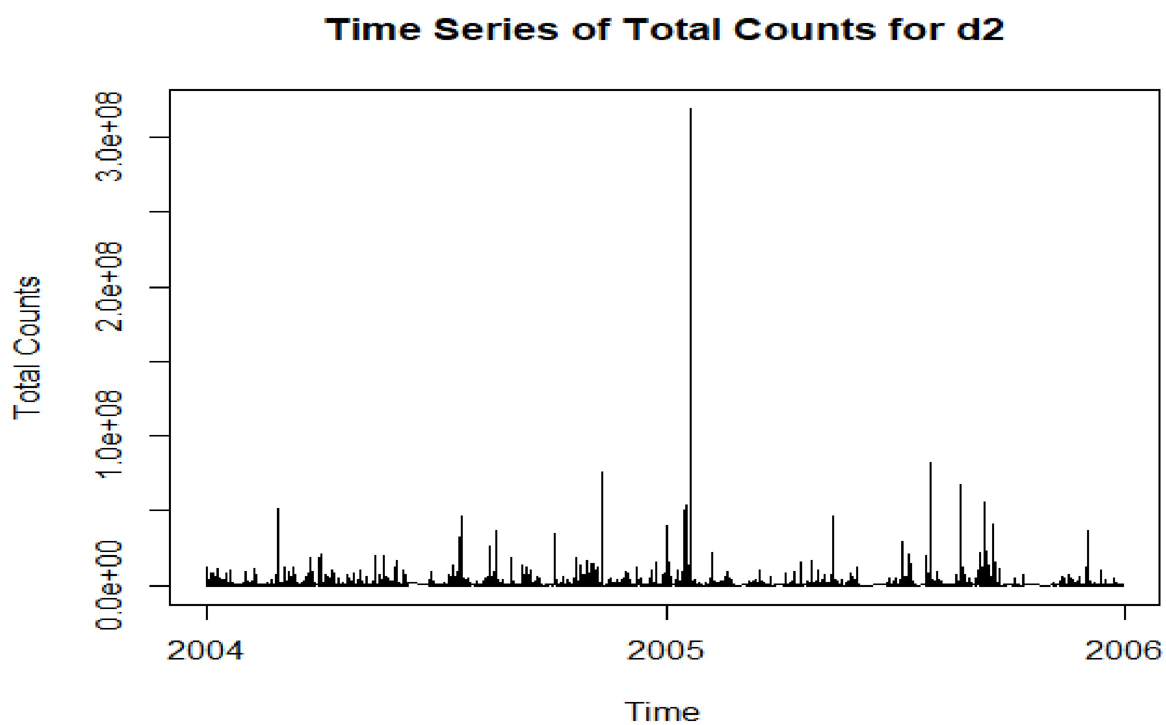
The calculated intensity threshold (d1) for the hotspots is 0.9023029.

The time series plot we created aligns well with the image observations. The highest recorded intensity is found at the central region of the sun, with the sides adjacent to it exhibiting a certain level of symmetry.

This correspondence between the intensity maps, the identified hotspots, and the time series plot reinforces the validity and accuracy of the hotspot discovery algorithm, providing valuable insights into the distribution and behavior of solar flares.

Data for d2 using method 1:

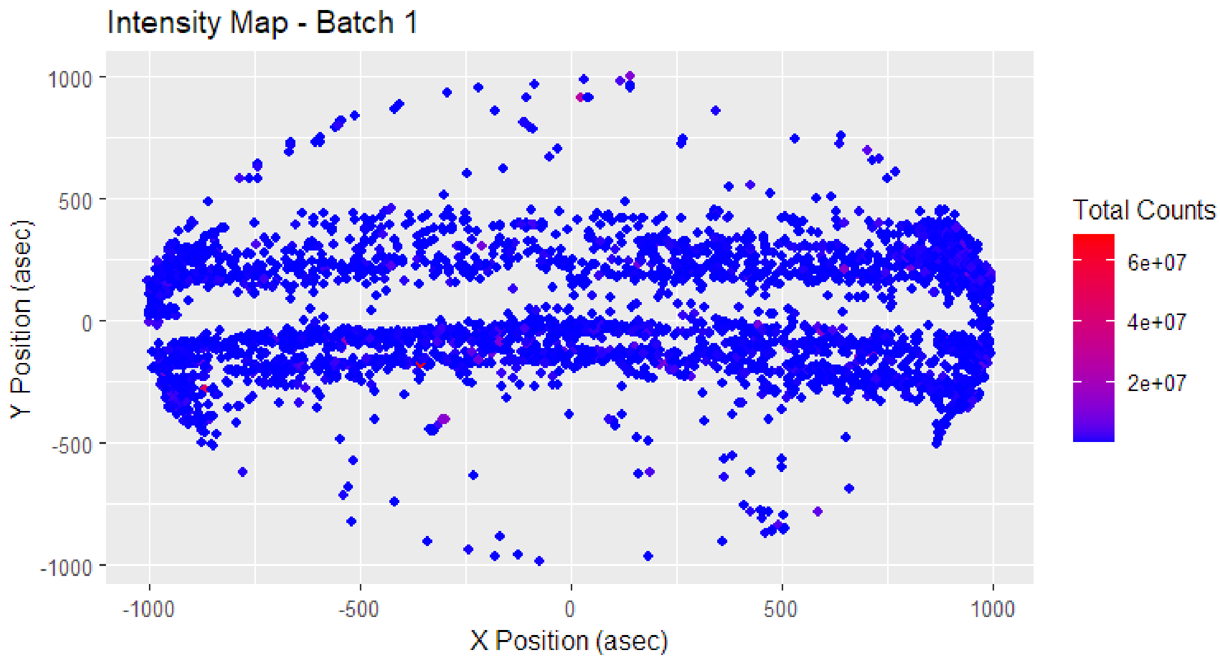


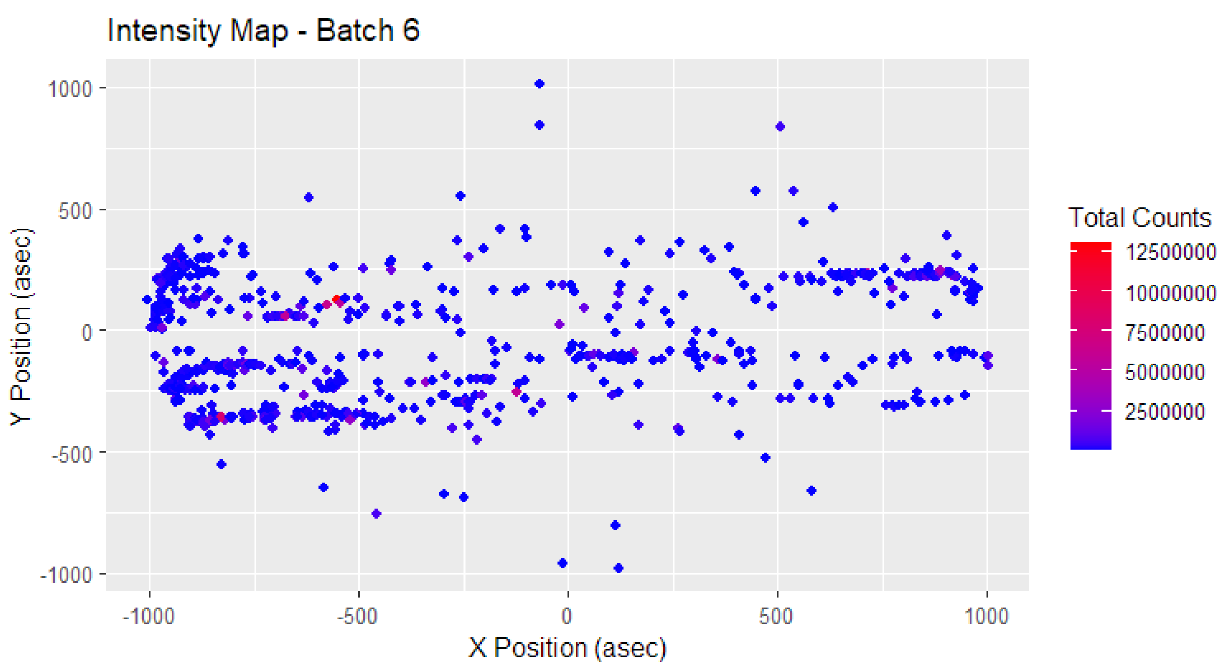


The results above were obtained using an intensity threshold of 500 and the Hotspot discovery algorithm. It is clear that the hotspots that were found also match up with the intensity map created using method 1 since most of them are located at the center of the plot. The intensity threshold (d2) for the hotspots is 0.7489763. The Time series plot for d2 shows a consistent growth between time and total counts with random peaks throughout the plot, with the most substantial peak being during 2005. The time series plot we generated correlates closely with our visual observations of the intensity maps. Notably, the peak intensity aligns consistently with the central region of the sun, demonstrating a symmetric pattern on the sides. This alignment between the intensity maps, identified hotspots, and the time series plot serves to affirm the reliability and precision of our hotspot discovery algorithm. It contributes valuable insights into the distribution and behavior of solar flares, strengthening our confidence in the accuracy of our findings.

d1 emphasizes intensity, suitable for pinpointing specific, high-intensity events, highlighting concentrated regions of high intensity, potentially pinpointing significant solar flare events. d2 emphasizes broader coverage, capturing areas with moderate intensity across regions, outlining larger areas of moderate intensity, providing a broader view of solar flare distribution. This analysis demonstrates the effectiveness of the hotspot discovery algorithm in capturing varying levels of solar flare intensity and spatial distribution, offering a comprehensive understanding of solar activity.

Subtask C


Intensity Map - Batch 1
Y Position (asec)
1000
500
0
-500
-1000
-1000
-500
0
500
1000
X Position (asec)
Total Counts
6e+07
4e+07
2e+07

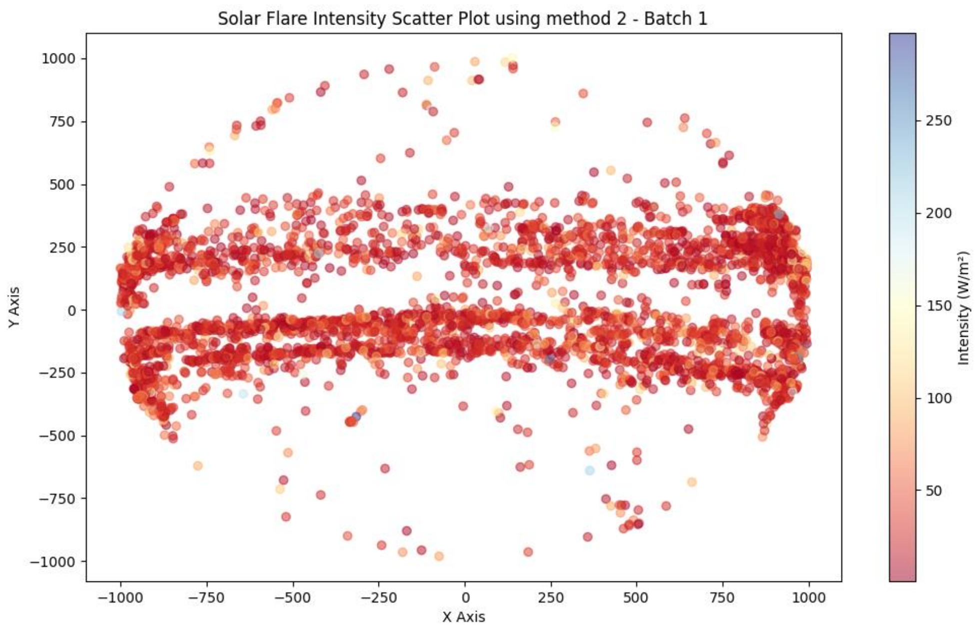

Intensity Map - Batch 6
Y Position (asec)
1000
500
0
-500
-1000
-1000
-500
0
500
1000
X Position (asec)
Total Counts
12500000
10000000
7500000
5000000
2500000

For Batch 1, The distribution of solar flare events across the X and Y axes shows a significant clustering towards the center. This suggests that during the time period of Batch 1, solar flares were more frequently occurring near the sun's equator (Y = 0). Additionally, there is a wide range of intensity levels. This is shown on the color scale, with some of the most intense events (shown as the darker colors) also appearing in the central area. The gradient of variation is more difficult to see in the visualization as some of the colors appear to be covered up by the points of the lower total counts, but some are still visible. To add to this, intense events are not only in the central region. They are spread across the range of the Y axis.

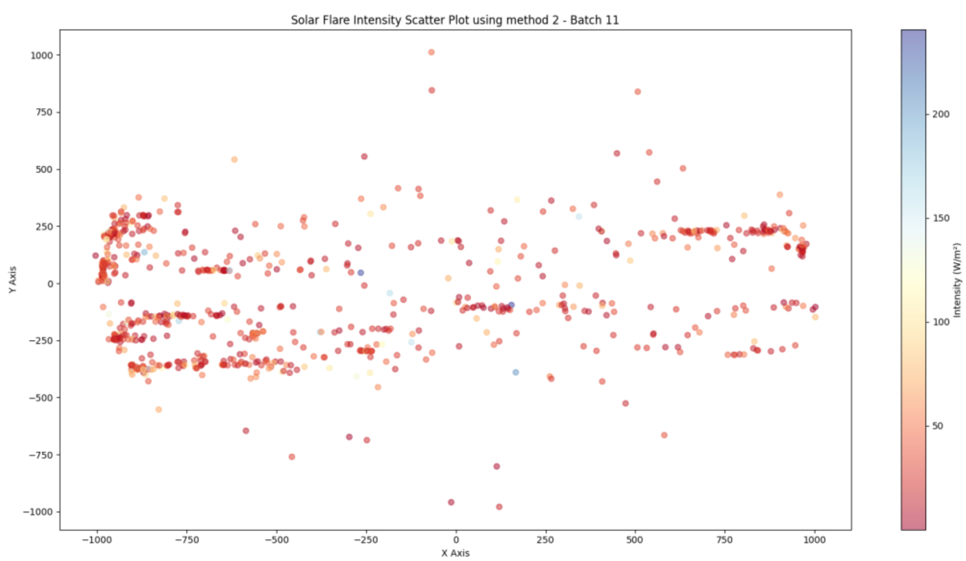
The intensity map for Batch 6 shows a similar pattern of concentration around the center, although not as intensely. This consistent observation between batches helps to demonstrate that the central region of the sun is a key area for solar activity. Similar to Batch 1, Batch 6 shows that the most intense flares (those with the highest total counts) appear close to the center of the visualization. However, compared to Batch 1, the intensity levels are generally lower and less densely packed.

Both batches show that the spatial distribution of solar flares is not random. There appears to be a clear preference for the central area in both batches. This could be related to the sun's rotational axis and equator, where magnetic fields tend to be stronger and more complex, leading to more frequent flare activity. The intensity distribution across both batches indicates that while fl

ares occur across the sun's surface, the central region seems to be a hotspot for higher intensity events. Overall, the differences over eleven years between the two datasets does not appear to be hugely significant. This is in line with the fact that in the lifespan of the sun, a decade of time is barely a blip for it. Thus, we would not expect the datasets to be significantly different.



Solar Flare Intensity Scatter Plot using method 2 - Batch 1
Y Axis
X Axis
Intensity (W/m²)



Solar Flare Intensity Scatter Plot using method 2 - Batch 11
Y Axis
X Axis
Intensity (W/m²)