# Investigating the Correlation between Inclination of Coronal Loops and Solar Flare Activity

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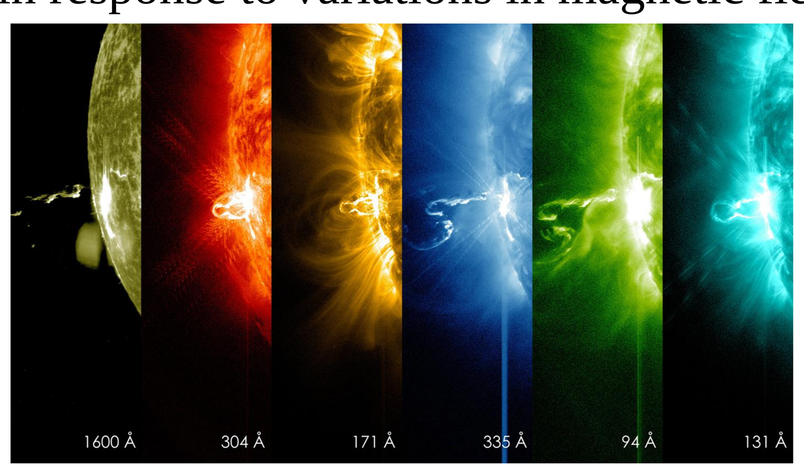
## Introduction:

The purpose of this research is to investigate changes in the coronal loop structures during the life cycle of a solar flare. Coronal loops are intricate magnetic features on the solar surface that are the source of large solar flares. Understanding the dynamics of these coronal loops improves our models for predicting solar flare activity. By obtaining the magnetogram, or magnetic field strength, along with the inclination of these coronal loops the full structure of the coronal loop can be obtained. Therefore, we studied trends between the coronal loops inclination angle, as it emerges from the photosphere, in response to variations in magnetic field strength.




One of the main theories behind the onset of a solar flare is called magnetic reconnection. This is when the upward and downward arms of a coronal loop connect together in the middle to produce a more stable smaller loop while ejected a large coronal mass ejection outwardly. Investigation into the normal conditions during these magnetic reconnections will lead to better understandings of the life cycle of a coronal loop.

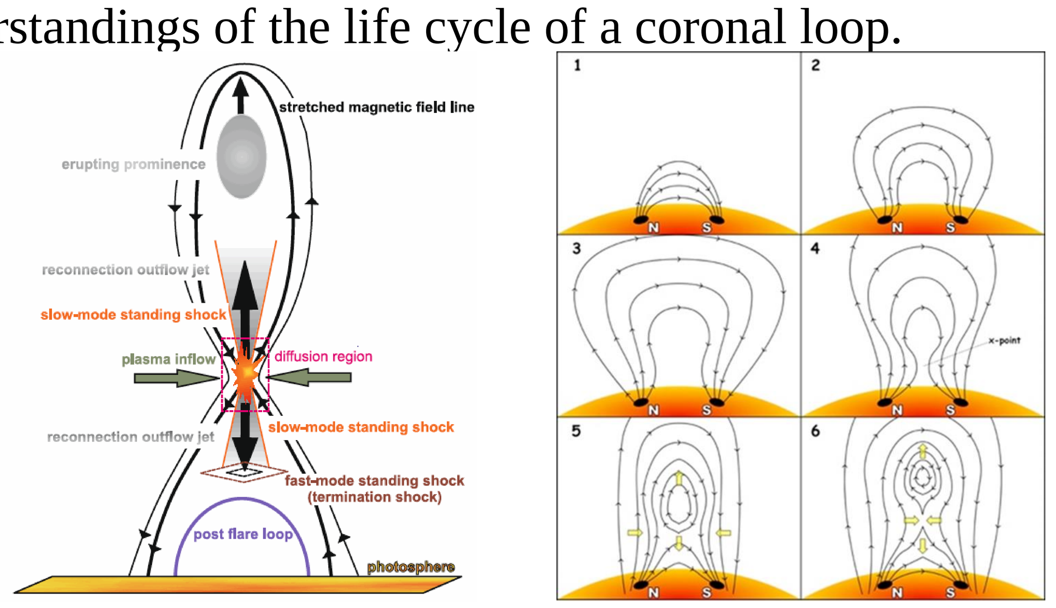
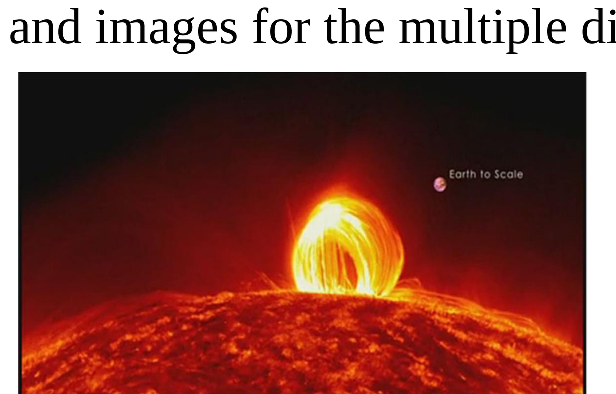


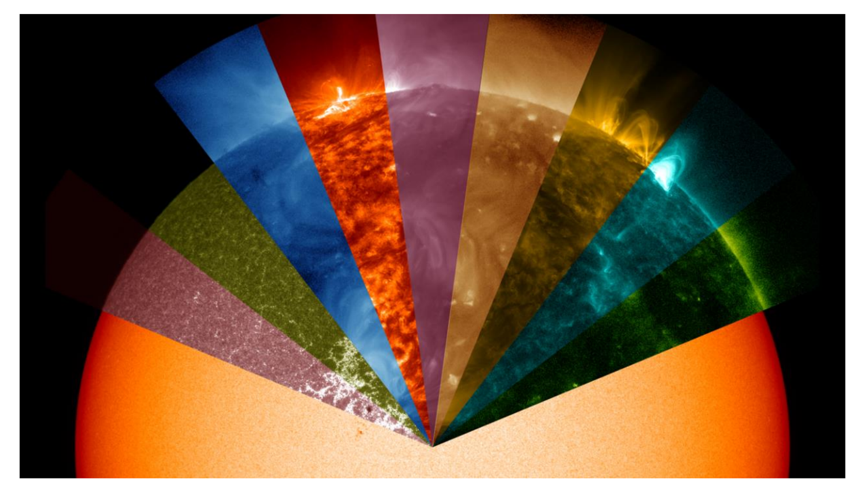
Fig1: Diagrams for general behavior during magnetic reconnection

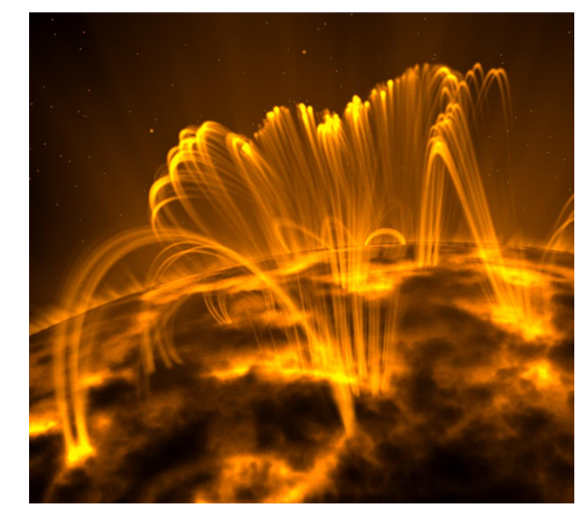
## Methods:

Research data was used from the Helioseismic and Magnetic Imager (HMI) instrument aboard the Solar Dynamic Observatory (SDO). Helioviewer, an online application, was used as a visual database for general viewing and selection of the active regions. Numerical data was then collected for each active region through the Joint Science Operations Center (JSOC) online by Stanford. Finally, Python coding language was implemented in order to manipulate these large data sets and images for the multiple different solar active regions.



The Solar Dynamics Observatory's data set provides directional magnetic field strengths at the photosphere level. This new type of data was important because it allowed the inclination angle to be measured and the observation of movements and shifts of the coronal structure's feet.





Active Regions were chosen by the occurrence of large solar flares, mostly X-class flares, along with availability of full data sets from SDO. Six different Active Regions were identified but only two were considered due to their ideal location of the solar flares happening close to the center of the solar disk..

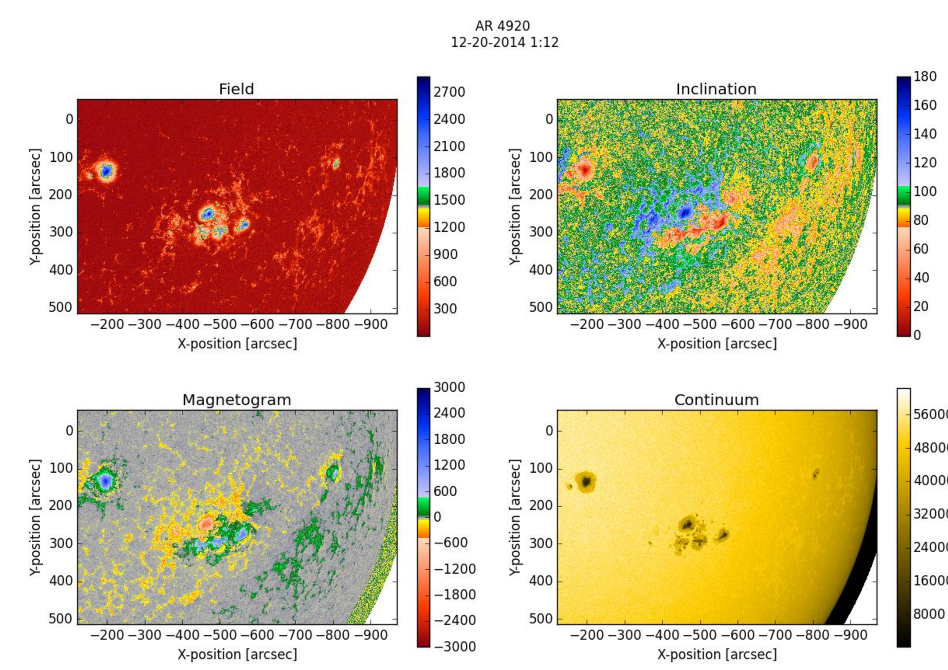


Fig1: Typical Data from SDO-HMI satellite image.

Actual calculations were performed within the python coding language. In this language raw data from SDO was interpreted as arrays of values for the radial, southward, and eastward magnetic field strengths. From these the total magnetic field and inclination angle were calculated for each pixel of the image at each moment of time. Only the sections of the image within the Active Region and with a strong magnetic field (sum of components over 500G) were then averaged. This was then performed every 36mins for the lifetime of an Active Region.

## Data and Results:

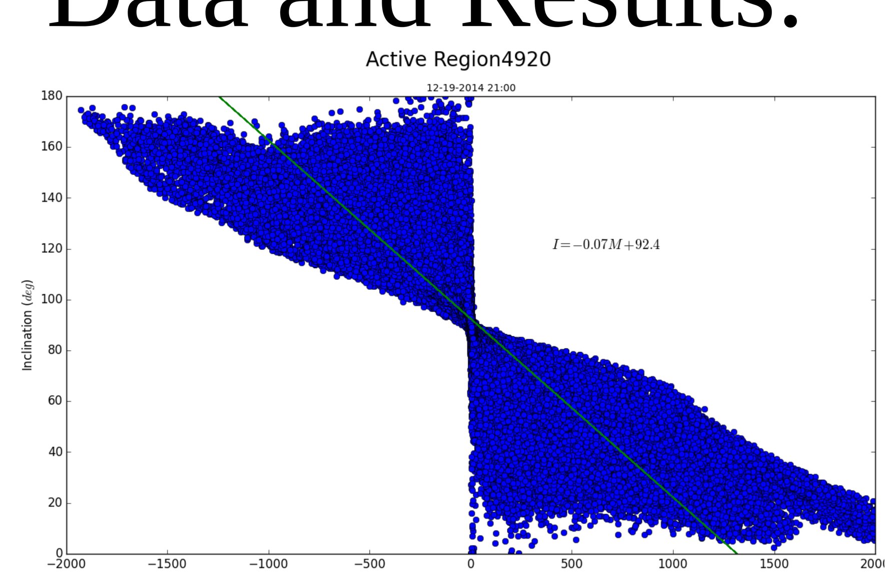


Fig2: All pixels plot of single instant in time with a best fit line

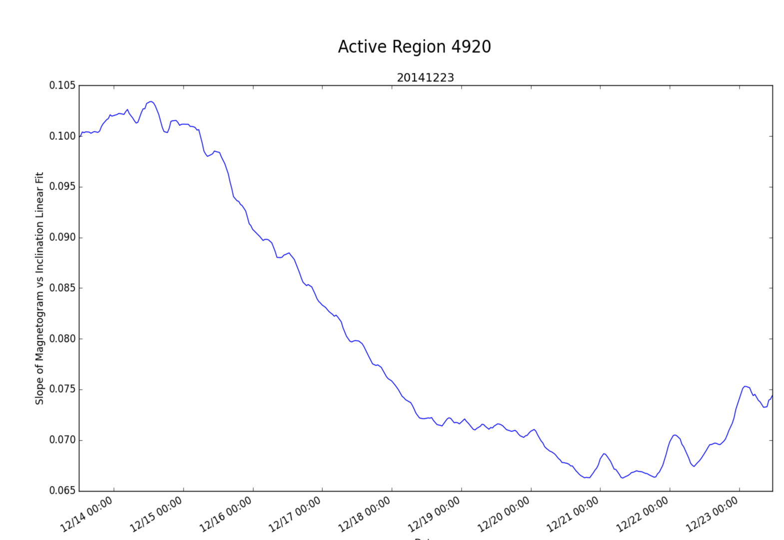


Fig3: Change in slope of inclination magnetogram correlation line over AR lifetime

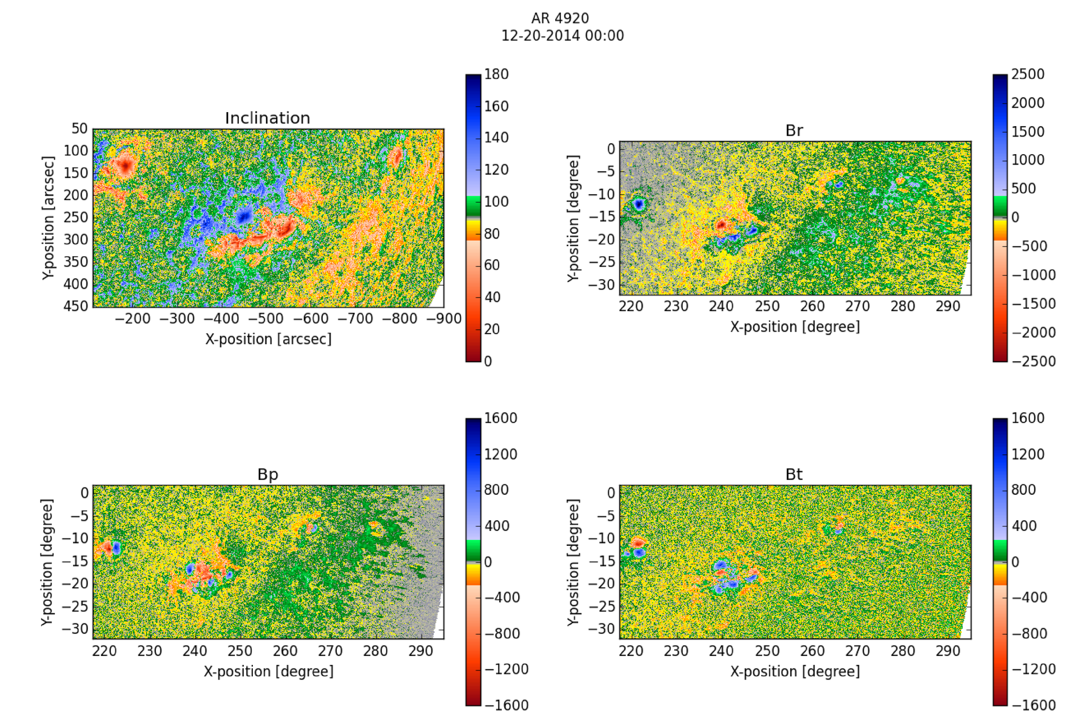


Fig4: Mapped field values 39mins prior to solar flare

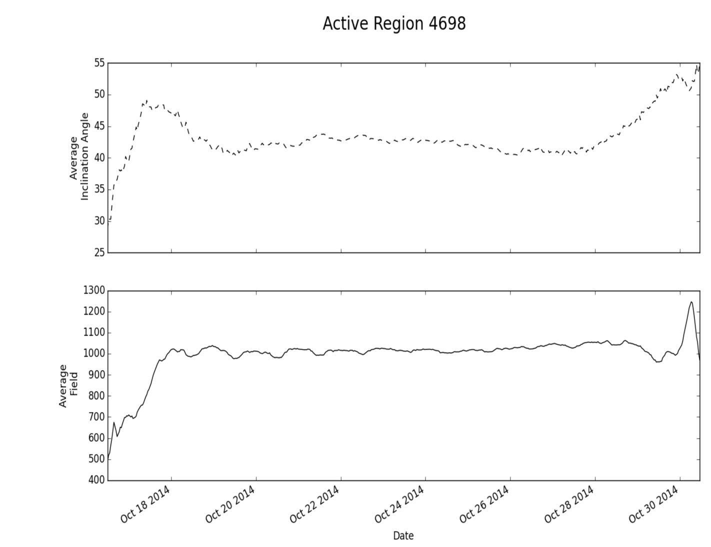


Fig5: Average Inclination & Field over lifetime of AR4698

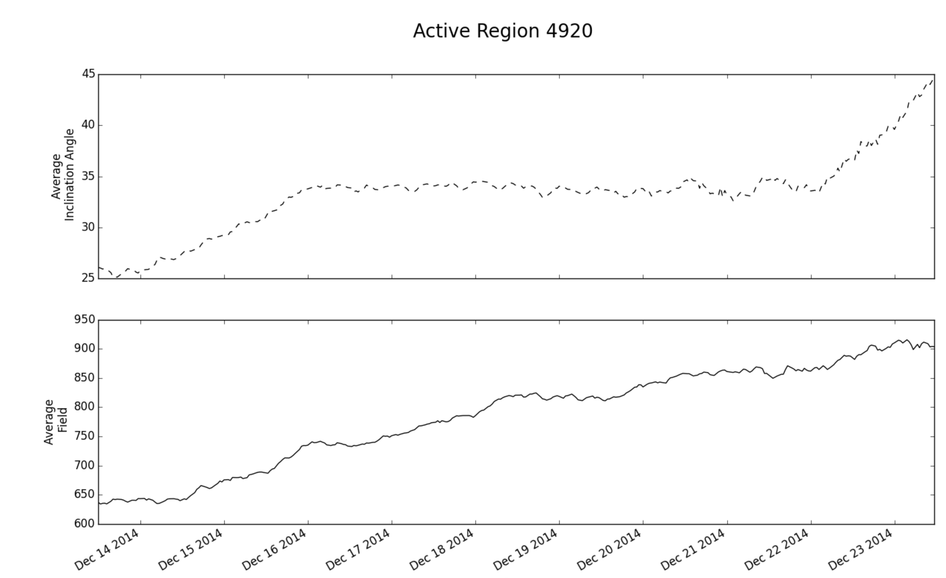


Fig6: Average Inclination & Field over lifetime of AR4920

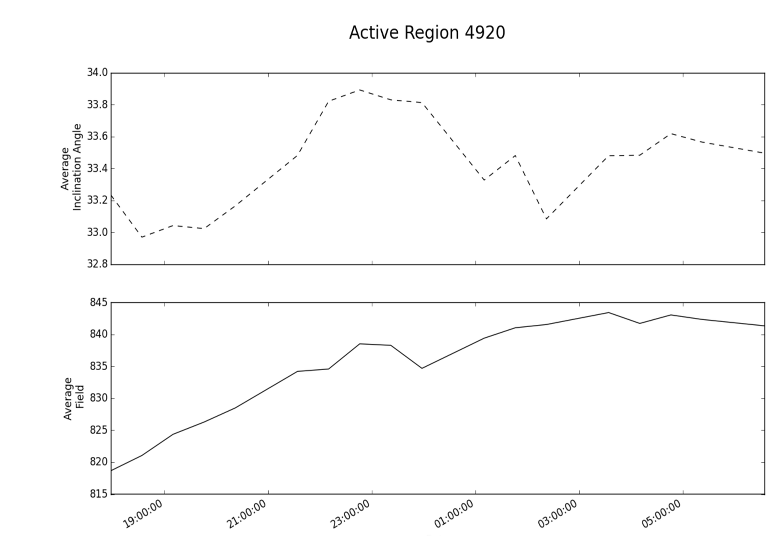


Fig7: Average Inclination & Field 6hrs pre and post X-class solar flare

## Conclusions:

These many different attempts to observe changes in inclination and field strengths during magnetic reconnection and solar flare activities were inconclusive. We believe that due to difficulties of isolating only the high field sunspot regions certain interferences such as noise and quiet regions of the sun were included in calculations for average inclination and field. These inactive areas most likely skewed these calculated values and managed to wash out the desired small variations in inclination and magnetic field.

## Further Work:

- Improve active region isolation techniques to eliminate noise and quite regions of the photosphere
- Investigate additional Active Regions for correlations
- Employ 3-D Magnetohydrodynamic models of coronal loop to compare with to compare with observed trends in SDO photosphere data

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