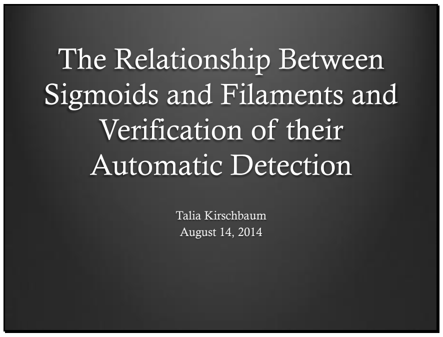
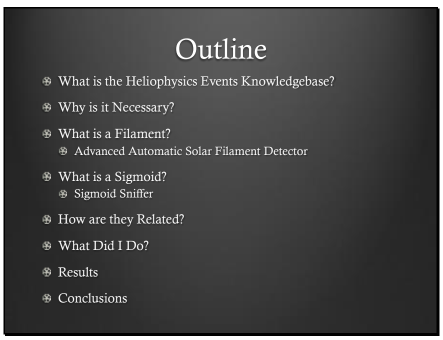
Slide 1



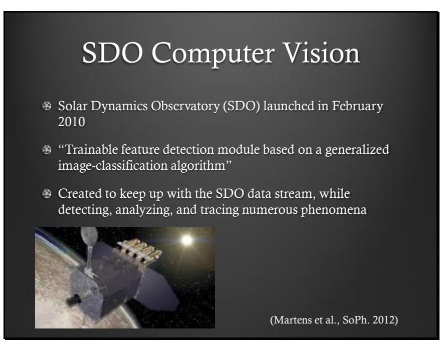
Talia Kirschbaum. High school intern. My research this summer on sigmoids and filaments.

Slide 2



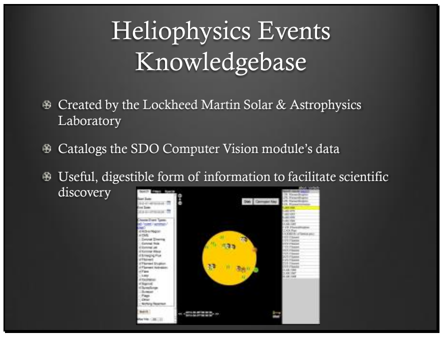
Here is a brief outline of what I will be talking about today.

Slide 3



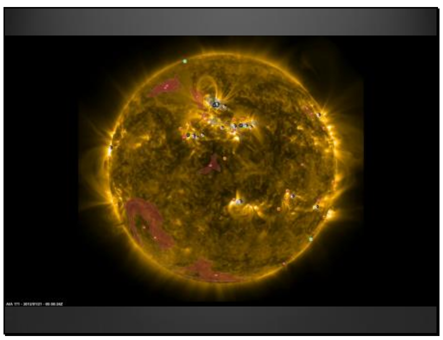
The SDO, with AIA, EVE, and HMI generates about 1.5 terabytes of data per day. Larger than all previous solar missions combined. Over 70,000 images per day. SDO computer vision analyzes these images for different features and events on the sun. Usable to track relationships between events, solar cycles, and even space weather.

Slide 4



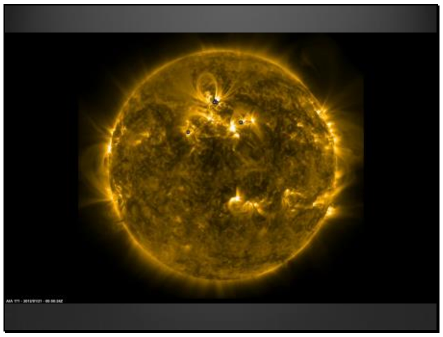
The Heliophysics Events Knowledegebase, or HEK, compiles all of the SDO data to make it easily accessible. Each feature has its own icon that pops up when it is detected. Detections can only occur when the module is active.

Slide 5



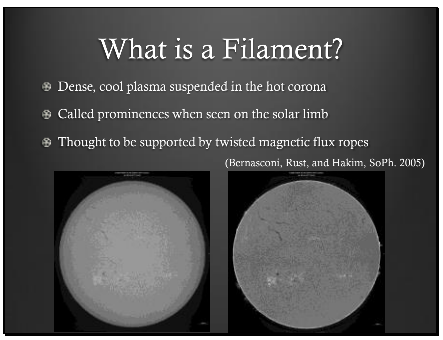
Using HEK, there is obviously a vast amount of information. This could not be done manually each day. All of the SDO vision data cannot even be tracked manually. Algorithms are often used to track the relationships and patterns from HEK.
Flares (Flare Detective), Active Regions (SPoCA), Coronal Dimming (Dimming Detector), Sigmoid (Sigmoid Sniffer), Magnetic Feature Tracking (SWAMIS), PIL Mapping (PIL Finder), Filaments (AAFDCC), CMEs (CME Detector/Tracker), Coronal Holes (SPoCA), Jets (Jet Detector), X-ray Bright Points (BP Finder), Oscillations (Oscillation Finder), Sunspots (SWAMIS), “EIT Waves” (EIT Wave Tracker), Global NLFFFs (Optimization Code for Full Disk), Trainable Feature Recognition

Slide 6



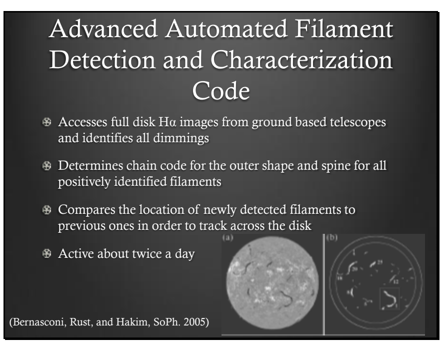
I focused only on two modules, the Advanced Automated Filament Detection and Characterization Code and the Sigmoid Sniffer for my research this summer. The black dots are from the Sigmoid Sniffer and the green lines are the filaments.

Slide 7



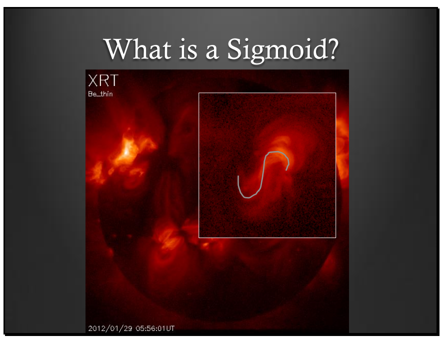
So, what are filaments. They are these black lines. These are both H-alpha images, which are best for observing filaments. On the left is the original image and the right is the image after initial processing to increase contrast. Not much is known about the formation of filaments, but they are often associated with eruptive events.

Slide 8



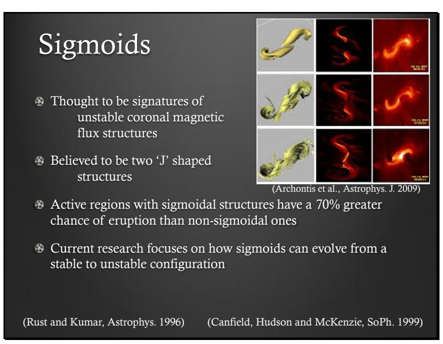
Retrieves latest full disk images from the Global High-Resolution H-alpha network. These are ground based telescopes, meaning that images can only be taken weather permitting. Eliminates very small, round, and very dark features, which are most likely sunspots. Chain code is used for the outer shape of each filament, which means that the program draws a polygon around the detected filament. Also, merges close segments, which are probably part of the same filament. Tracking allows observation of the evolution of the filaments, but only tracks during the time that the module is active. Can be used to study filament properties over solar cycles or near real-time data can be used for space-weather forecasting.

Slide 9



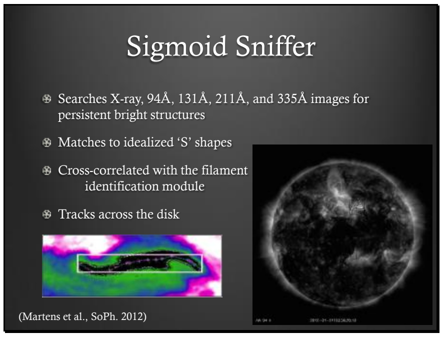
A sigmoid is essentially an S shaped structure. Here is one from January 29, 2012. Here is the ‘S’ outlined on the sigmoid.

Slide 10



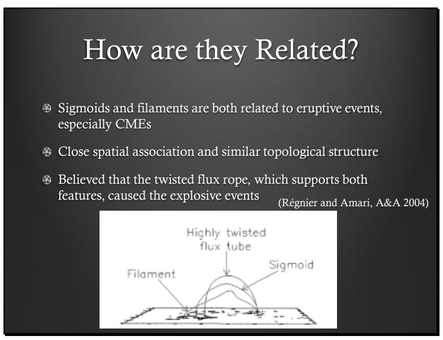
Although sigmoidal active regions are agreed to be 70% more likely to erupt, some studies have seen up to an 84% greater chance. Also, regions with brighter, more transient sigmoids are more likely to erupt. There are models that treat sigmoids as a single flux rope. Many sigmoids have associated filaments, but not all do. Sigmoids erupt when their structure becomes unstable, so understanding how they become unstable will help with understanding forecasting and also the mechanics of the sun.

Slide 11



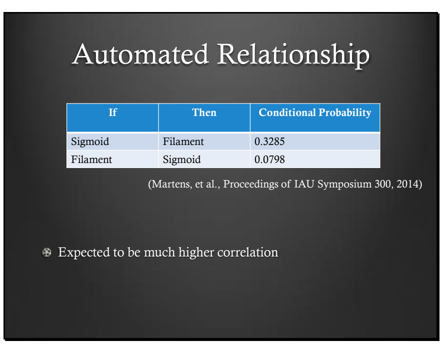
Retrieves full disk images from XRT and AIA. Uses brightness thresholds to determine candidate sigmoids. Noisy data can result in false detections. Draws a box around the sigmoidal region and uses chain code to compare to the idealized S shape. The filament finder is used for the spines of the sigmoids, but this can only be done when both modules are active at the same time. This is an image from January 21, 2012.

Slide 12



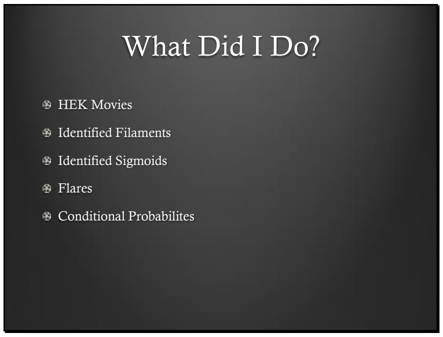
Picture is an extreme simplification, with each feature represented by a single field line. The filament is below the sigmoid, and both are thought to be supported by the highly twisted flux tube. Not all sigmoids have associated filaments. However, algorithms tracking the SDO Vision code for spatiotemporal overlaps for the month of January 2012 found very little association.

Slide 13



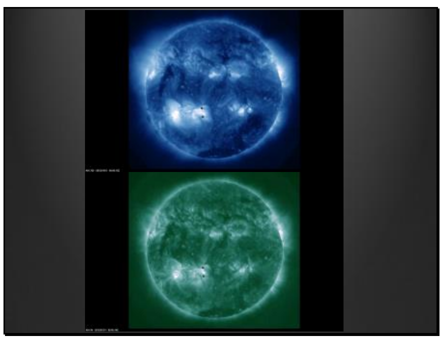
Study was done for October 11, 2010 until March 27, 2011

Slide 14



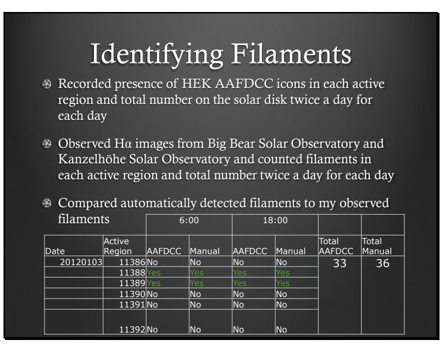
Verify if there was actually very little association between sigmoids and filaments during the month of January 2012, or if it was due to inaccurate modules or a combination of an algorithm tracking other algorithms.

Slide 15



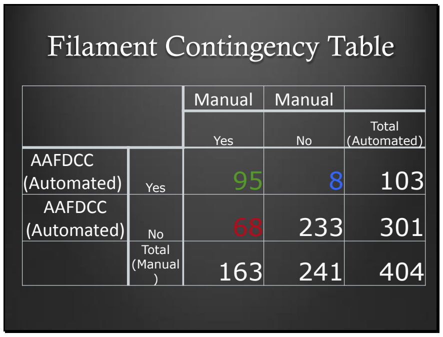
Two videos of the entire month of January 2012 in 335 on the top and 94 on the bottom. Important to note that the sigmoid sniffer is active throughout the day, but the detected sigmoids pop on and off. The filament finder is active only once or twice a day and often the sigmoid icon in the vicinity is off at that time. Temporal differences are a possible reason for the low association found.

Slide 16



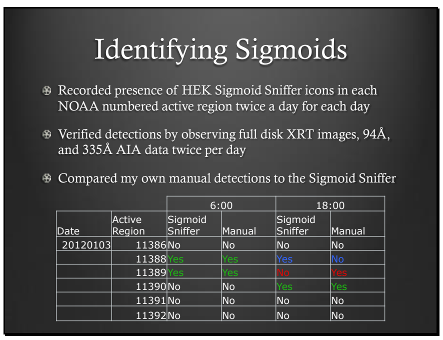
Check each active region and then count total number of automated filament identifications and total for the manually identified filaments when there were images available. I also counted the total number of filaments on the solar disk because most filaments are not found in active regions. Some inflation because some automatically detected filaments were actually just pieces of a larger filament.

Slide 17



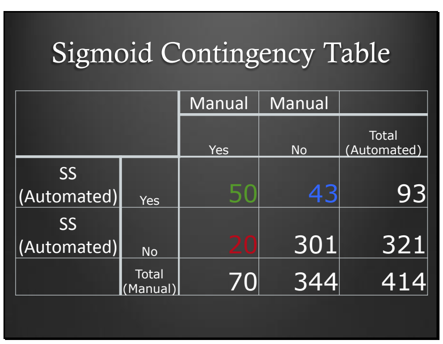
Significantly fewer false positives than false negatives. Totals are for each active region twice a day, every day. Important to know that these are only counting active regions and filaments present in them.

Slide 18



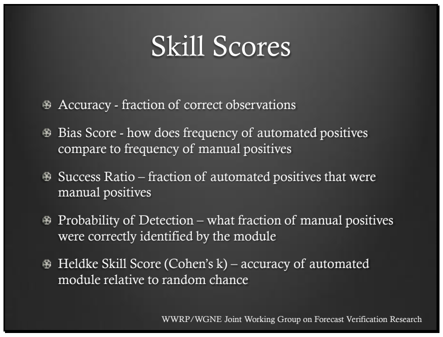
6:00 and 18:00 chosen as times because that is when XRT takes full disk images.

Slide 19



If you noticed, there are 10 more total sigmoid observations than filament observations because one day, with 5 active regions, there was no automated filament data available.

Slide 20



Skill Scores: scaled representations of error that relates accuracy of a model to some reference
How accurate is the Sigmoid Sniffer and AAFDCC?
Assumes that my manual observations are 100% correct
Each score has a slightly different bias

A= (correct positives + correct negatives)/total observations. Heavily influenced by most common outcome

BS= (correct positives + false positives)/(correct positives+ false negatives).
Indicates whether the module has a tendency to under-identify or over-identify

SR= correct positives/(correct positives + false positives). Information on the likelihood of manual positive, given an automated positive. Sensitive to false positives, but ignores false negatives

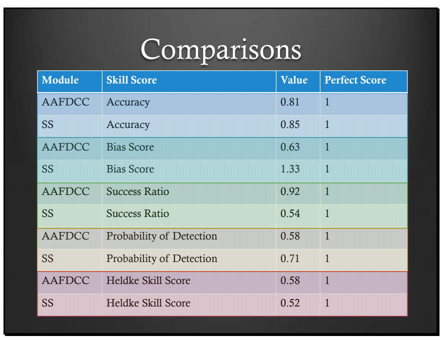
PoD= correct positives/(correct positives + false negatives).
Sensitive to correct positives, but ignores false positives

HSS= [(correct positives+ correct negatives) – (expected correct)$_{random}$]/[N – (expected correct)$_{random}$]

Where (expected correct)$_{random}$ = 1/N [(correct positives + false negatives)*(correct positives + false positives) + (correct negatives + false negatives)*(correct negatives + false positives)]. Where N = total observations

Measures fraction of correct automated observations after eliminating those which would be due to purely random chance. Random chance is not always the best to compare to.

Slide 21



Comparisons

Module	Skill Score	Value	Perfect Score
AAFDCC	Accuracy	0.81	1
SS	Accuracy	0.85	1
AAFDCC	Bias Score	0.63	1
SS	Bias Score	1.33	1
AAFDCC	Success Ratio	0.92	1
SS	Success Ratio	0.54	1
AAFDCC	Probability of Detection	0.58	1
SS	Probability of Detection	0.71	1
AAFDCC	Heldke Skill Score	0.58	1
SS	Heldke Skill Score	0.52	1

Accuracy: SS slightly better, more correct negatives

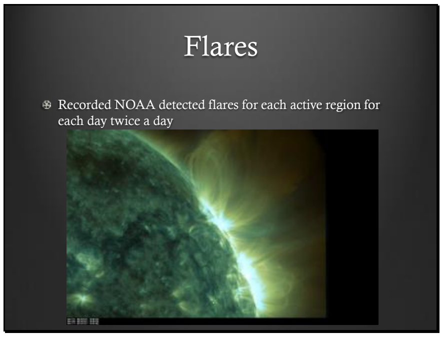
Bias Score: Filament under-identifies, SS over-identifies

Success Ratio: FF normally correct in its identifications, but it does miss (not shown), SS is not correct in its identifications as much, but fewer misses

Probability of Detection: Shows that FF misses a lot more than SS, SS more likely to detect, FF more likely to be correct in detection

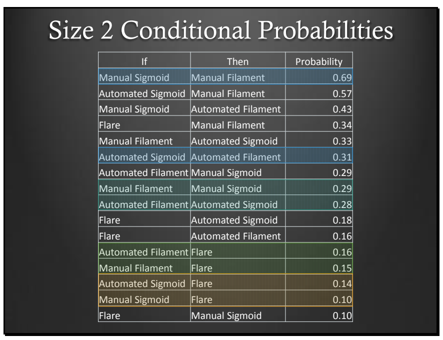
Heldke Skill Score: Interesting because FF is more accurate when chance is taken into account

Slide 22



To see relationship between Sigmoids, Filaments, and flares. X flare on the 27^{th}.

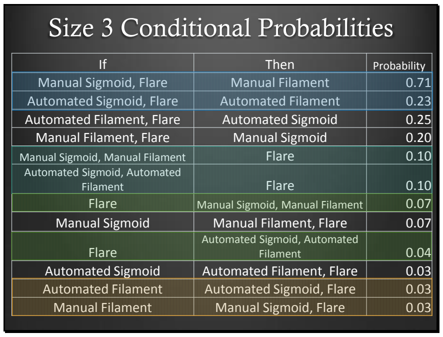
Slide 23



If	Then	Probability
Manual Sigmoid	Manual Filament	0.69
Automated Sigmoid	Manual Filament	0.57
Manual Sigmoid	Automated Filament	0.43
Flare	Manual Filament	0.34
Manual Filament	Automated Sigmoid	0.33
Automated Sigmoid	Automated Filament	0.31
Automated Filament	Manual Sigmoid	0.29
Manual Filament	Manual Sigmoid	0.29
Automated Filament	Automated Sigmoid	0.28
Flare	Automated Sigmoid	0.18
Flare	Automated Filament	0.16
Automated Filament	Flare	0.16
Manual Filament	Flare	0.15
Automated Sigmoid	Flare	0.14
Manual Sigmoid	Flare	0.10
Flare	Manual Sigmoid	0.10

If sigmoid, probability it having an associated filament. Much higher probability for the manual observations because there were more automatically identified sigmoids and fewer identified filaments. However, if a filament was observed in an active region, its chance of having an associated filament is very similar for both the automated and the manual. Possibly due to interaction between the two modules and the fact that there are many more sigmoids observed than filaments, so the chances would be better. If a filament was observed, what is the probability that there was an associated flare. Also very similar, even though fewer filaments were automatically detected. Probably same fraction had an associated flare. If a sigmoid was observed, chance that there was an associated flare. Automated slightly higher, probably due to brightness threshold and higher number of identifications.

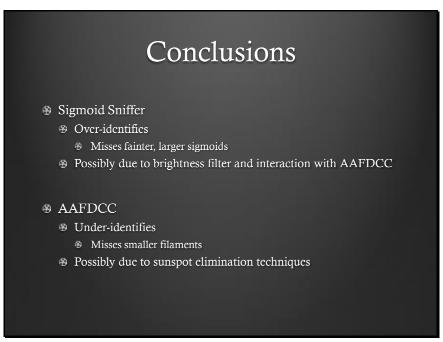
Slide 24


Size 3 Conditional Probabilities

If	Then	Probability
Manual Sigmoid, Flare	Manual Filament	0.71
Automated Sigmoid, Flare	Automated Filament	0.23
Automated Filament, Flare	Automated Sigmoid	0.25
Manual Filament, Flare	Manual Sigmoid	0.20
Manual Sigmoid, Manual Filament	Flare	0.10
Automated Sigmoid, Automated Filament	Flare	0.10
Flare	Manual Sigmoid, Manual Filament	0.07
Manual Sigmoid	Manual Filament, Flare	0.07
Flare	Automated Sigmoid, Automated Filament	0.04
Automated Sigmoid	Automated Filament, Flare	0.03
Automated Filament	Automated Sigmoid, Flare	0.03
Manual Filament	Manual Sigmoid, Flare	0.03

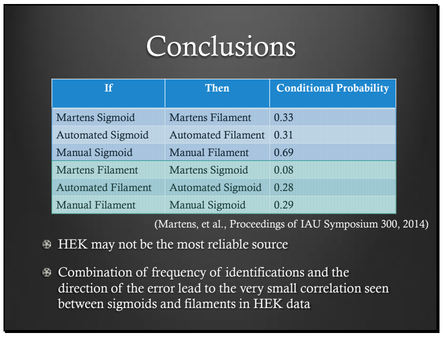
If a sigmoid flared, what is the probability that it had an associated filament. Although both the automated F and S are directly below the manual F and S, there is a large gap from 71% to 23%. Due to more sigmoids and less filaments identified. Should expect high correlation.
If there is an observed filament, what is the chance that there was both an associated sigmoid and flare. Very different from the reverse at the top.
If a sigmoid has an associated filament, what is the probability that it flared. Here the manual and automatic are the exact same. Same flares were also used. Interesting.
It is seen that the automated detections actually have a lower correlation with flares when the opposite is calculated. Shows that it is the same fraction, not numbers.

Slide 25



Just my conjecture that because of the brightness threshold's major role in the sigmoid sniffer code, it misses fainter sigmoids and over-identifies persistently bright, non-sigmoidal regions. The filament detection code and the sigmoid sniffer were not often active at the same time. The sigmoid sniffer was spread out throughout the day, while the filaments were only active once or twice a day for a short period of time. My results showed much more correlation for the automated than the original study did because I continued to track the icons after they had left the screen and was not confined to the times that both modules were active together.

Slide 26



If	Then	Conditional Probability
Martens Sigmoid	Martens Filament	0.33
Automated Sigmoid	Automated Filament	0.31
Manual Sigmoid	Manual Filament	0.69
Martens Filament	Martens Sigmoid	0.08
Automated Filament	Automated Sigmoid	0.28
Manual Filament	Manual Sigmoid	0.29

If Sigmoid then Filament, very close. 2012 was closer to solar max so expected to be lower because more active regions and therefore sigmoids. If filament then sigmoid much higher, expected because fewer active regions in martens study and many more filaments not associated with active regions. The filament detection code and the sigmoid sniffer were not often active at the same time. The sigmoid sniffer was spread out throughout the day, while the filaments were only active once or twice a day for a short period of time. My results showed much more correlation for the automated than the original study did because I continued to track the icons after they had left the screen and was not confined to the times that both modules were active together.

Slide 27