

Coronal Holes

Detection in STEREO/EUVI and SDO/AIA data and
comparison to a PFSS model

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Montana State University Solar Physics REU 2011

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- Coronal Holes
- PFSS Model
- Project Goals

Detection Methods

- Instrumentation
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Results

Conclusions

- REU project conclusions
- Further Research

References

Background

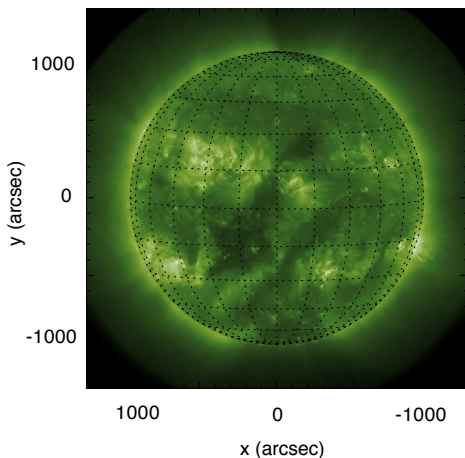
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- ▶ They look like this:

SDO/AIA_2 193 16 - Jul - 2011 08:00:07.840 UT



Coronal Holes Continued

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 1. evacuation of plasma due to the eruption of the magnetic field
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- ▶ CHs that form rapidly are most often associated with coronal mass ejections (CMEs), their formation is primarily thought to be evacuation of material
- ▶ those associated with global magnetic field reconfiguration form more slowly
- ▶ Tracking CHs can tell us more about
 1. the plasma that makes up an associated CME mass
 2. the evolution of the CME post-eruption
 3. open field regions and global magnetic field topology

Observing the Solar Magnetic field: PFSS models

- ▶ Because we cannot observe the magnetic field of the solar corona, we use Potential Field Source Surface (PFSS) models to look at approximate reconstructions based on observations in the photosphere.

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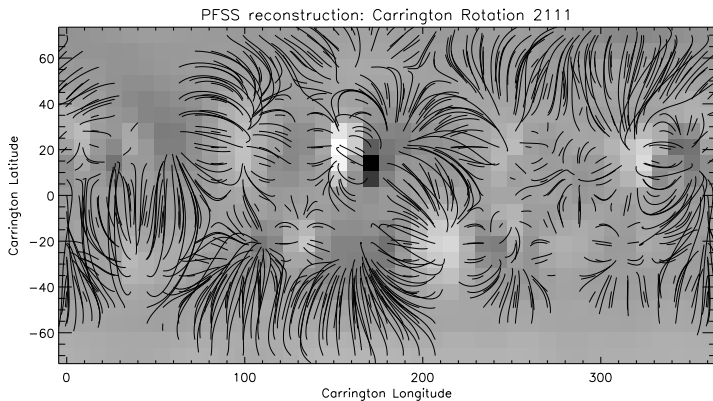
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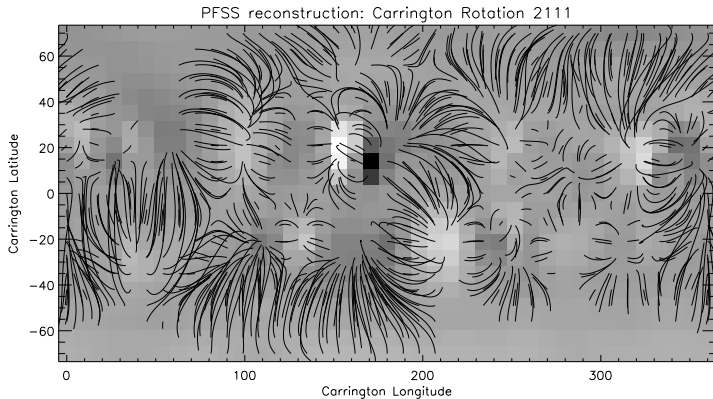
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- ▶ Calculations: with the potential boundary conditions set, we can decompose the photospheric and coronal field into spherical harmonics, then use them to reconstruct the field at any height
- ▶ Outputs: Magnetic field reconstruction from photosphere to the boundary surface, suggested to be 2.5 solar radii.

PFSS Model: output



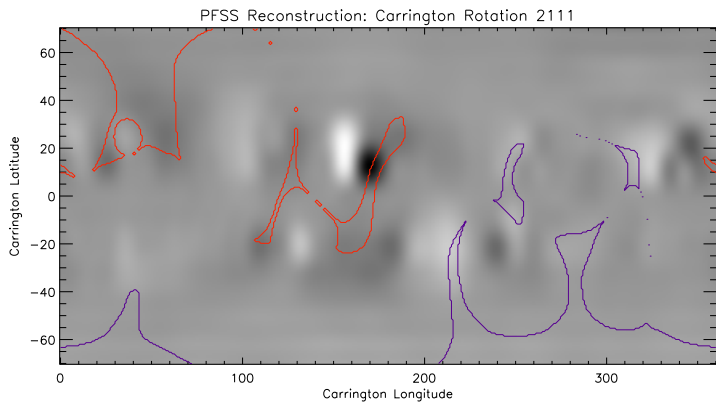
- ▶ field lines drawn on synoptic magnetograms

PFSS Model: output

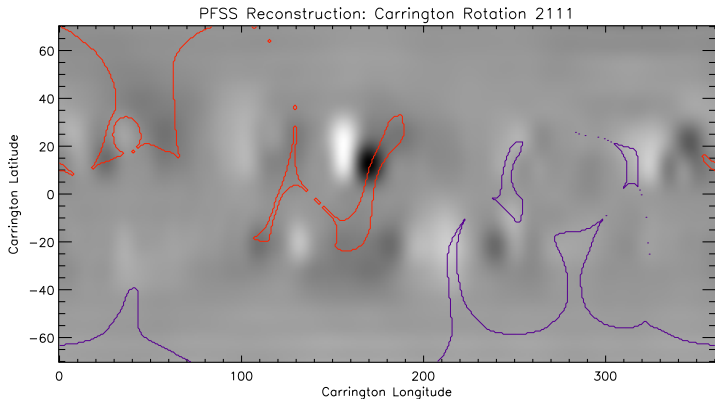


- ▶ field lines drawn on synoptic magnetograms
- ▶ may also generate field of view (fov) reconstruction

PFSS Model: output



PFSS Model: output



- ▶ The red lines outline open magnetic field regions of positive polarity.
- ▶ The blue lines outline open magnetic field regions of negative polarity.

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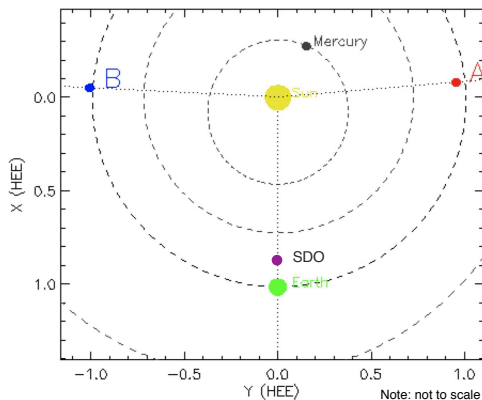
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- ▶ Compare coronal hole boundaries detected by routine and open field regions reconstructed with PFSS model

Detection Methods

Instrumentation

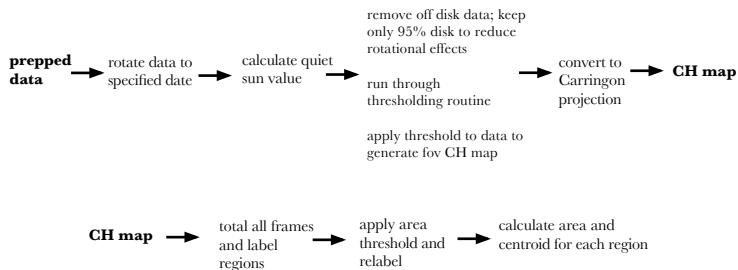
Positions of STEREO A and B, SDO for 2011-06-07 12:00 UT



- ▶ Helioseismic and Magnetic Imager (HMI) and Atmospheric Imaging Assembly (AIA) data from the Solar Dynamics Observatory (SDO) mission
- ▶ the Solar TERrestrial RELations Observatory (STEREO) Extreme UltraViolet Imager (EUVI)

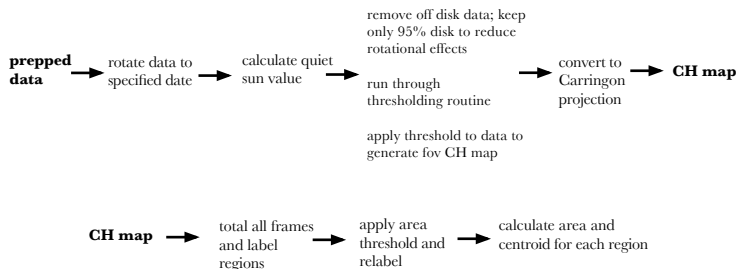
Automated detection

▶ ch_track.pro



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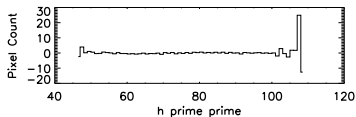
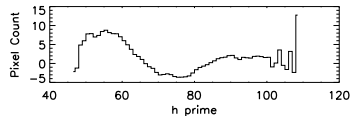
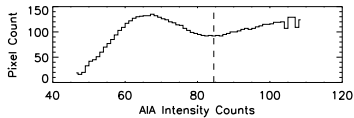
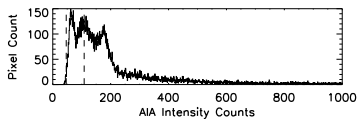
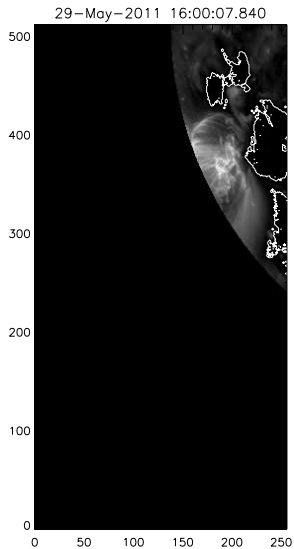


▶ coronal hole characterization

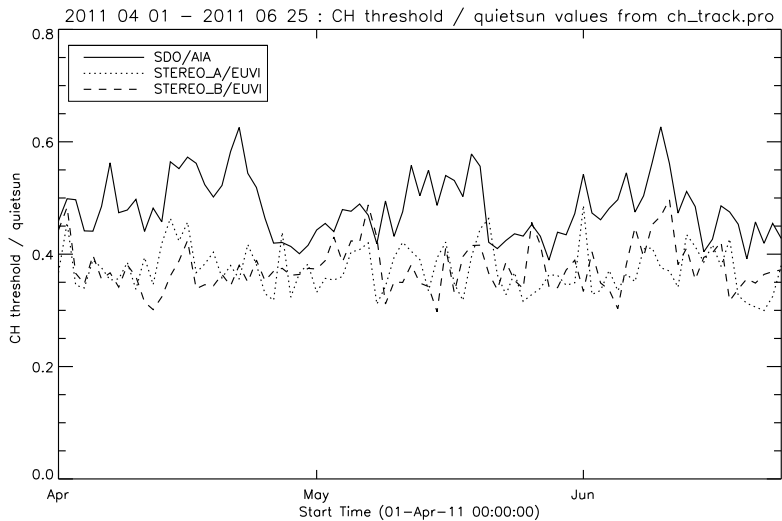
1. area
2. centroid
3. coronal hole maps and evolution

Automated detection

Thresholding routine

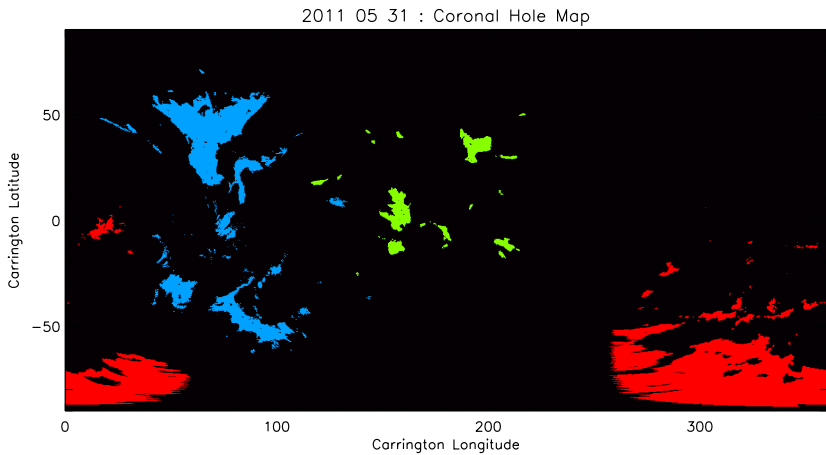


Threshold Values



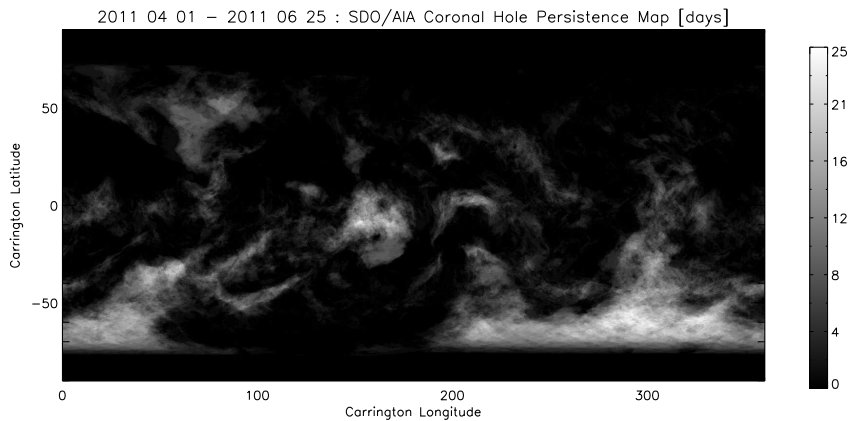
Coronal hole maps

SDO/AIA, STEREO_A/EUVI, STEREO_B/EUVI

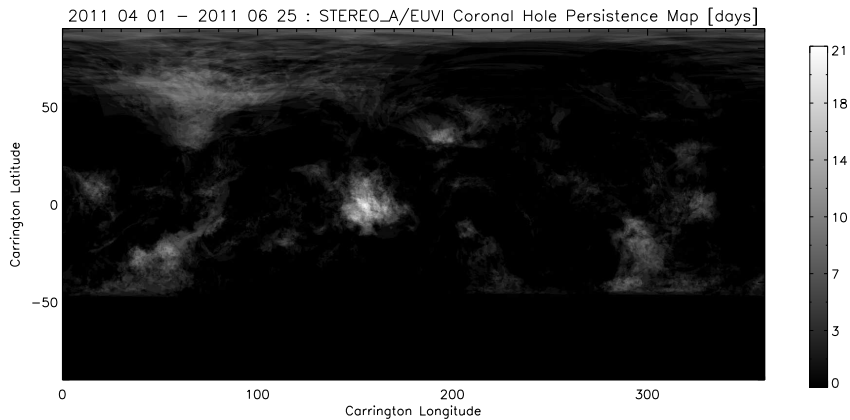


Results

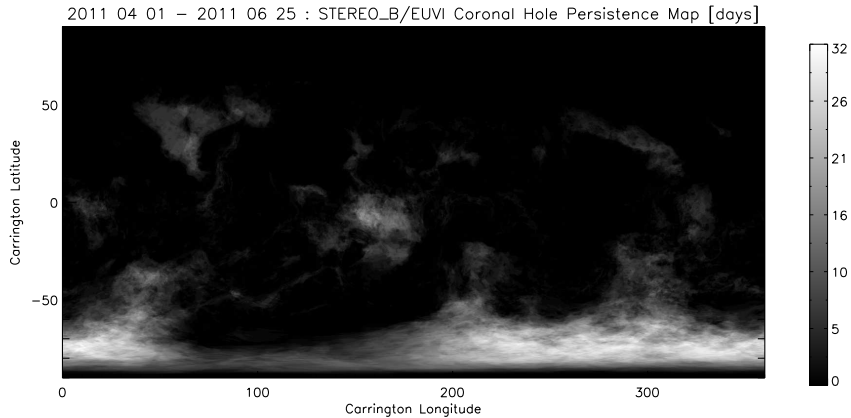
Persistence Maps



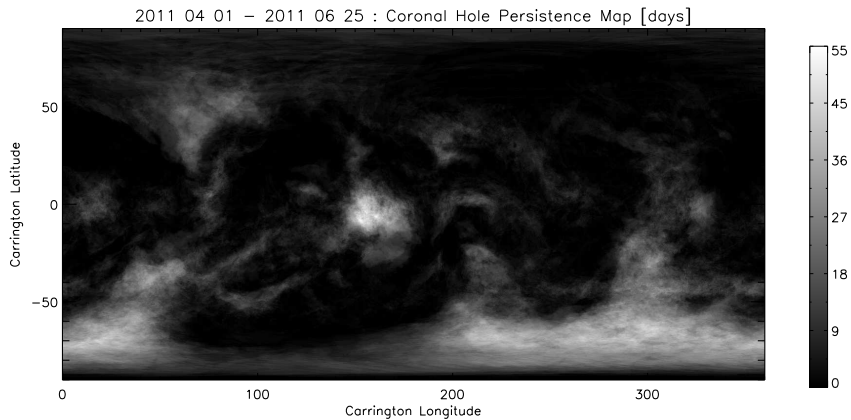
Persistence Maps



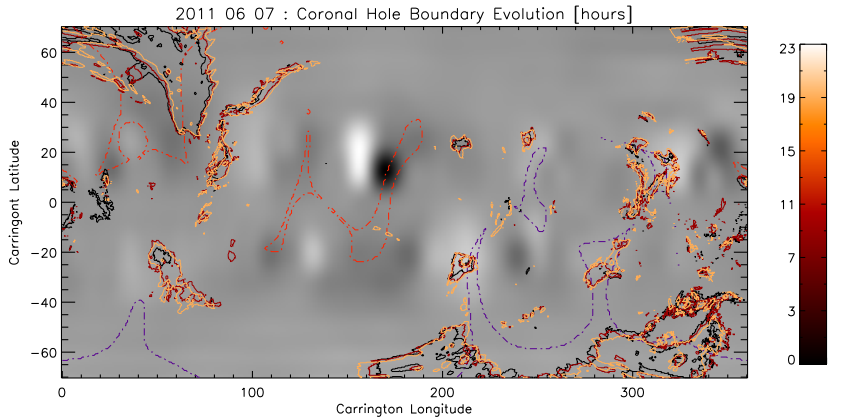
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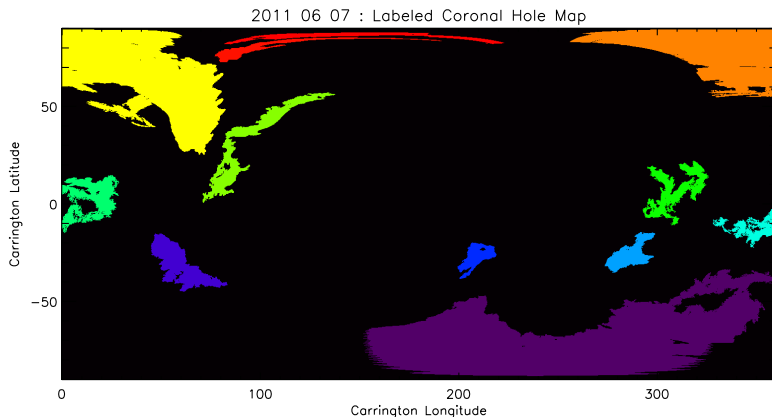


Coronal Hole Boundary Evolution



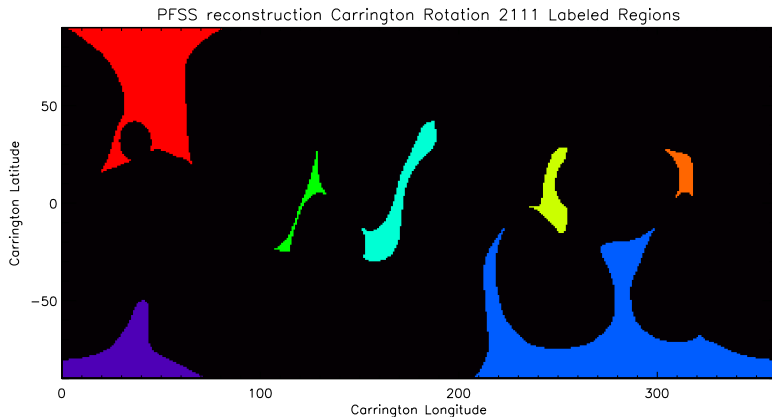
Overlaying coronal hole maps with PFSS reconstruction

We can apply a minimum area threshold to filter out very small features and label the detected coronal holes:



Overlaying coronal hole maps with PFSS reconstruction

We can then do the same to the PFSS reconstruction open magnetic field regions:



Overlaying coronal hole maps with PFSS reconstruction

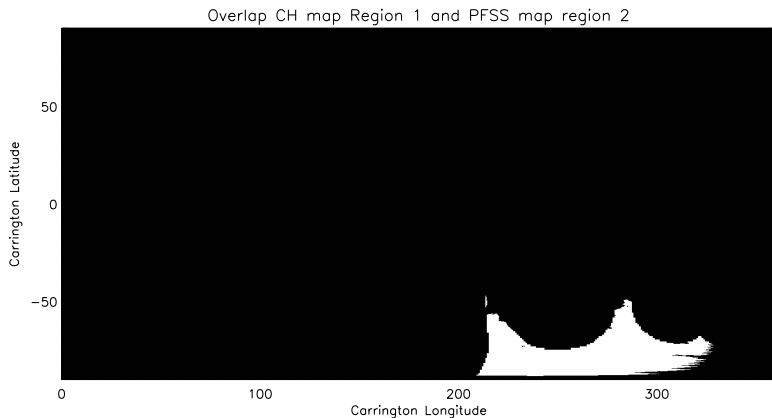
- ▶ How do the coronal holes detected by our routine compare to the open field magnetic regions in the PFSS reconstruction?

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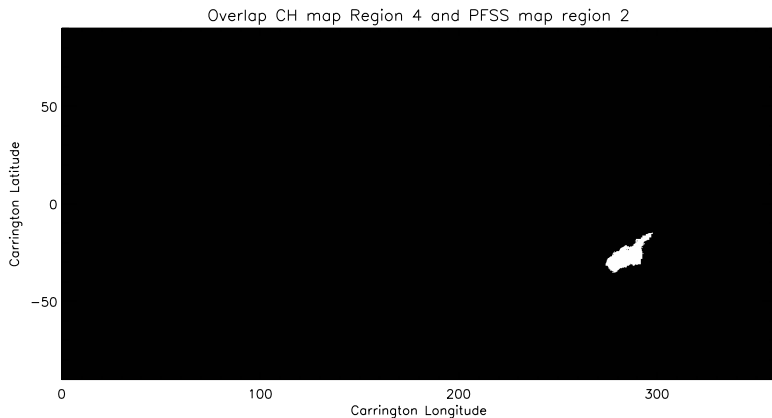
- ▶ How do the coronal holes detected by our routine compare to the open field magnetic regions in the PFSS reconstruction?
- ▶ table of region overlap, in pixel area:

CH map Region	total pixels	total pixel overlap with PFSS open region	percentage CH map in PFSS open region
1	89617	34630	39
2	7107	0	0
3	2566	0	0
4	3701	3112	84
5	3431	0	0
6	6934	0	0
7	6194	1121	18
8	8165	0	0
9	47123	25999	55
10	28801	0	0
11	3118	0	0
12	3783	0	0

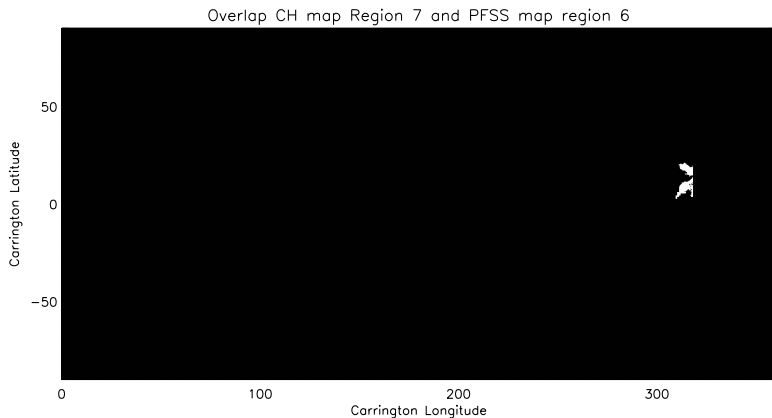
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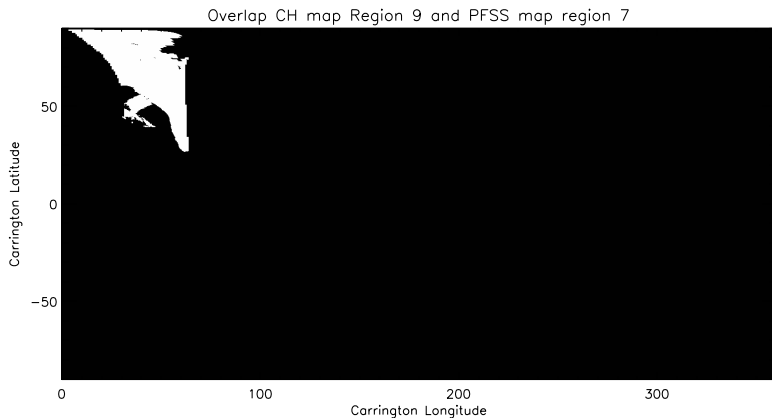
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- ▶ In order to understand the magnetic field of the solar coronal, we require a more realistic model—but they're complicated!
- ▶ We are particularly in need of model that allows us to predict dynamic changes in the coronal magnetic field, such as that around active regions.

Further Research

- ▶ apply routine to very long term studies and other instruments such as the Extreme ultraviolet Imaging Telescope (EIT) on the Solar and Heliospheric Observatory (SOHO), for which data on the line of sight magnetic field is available

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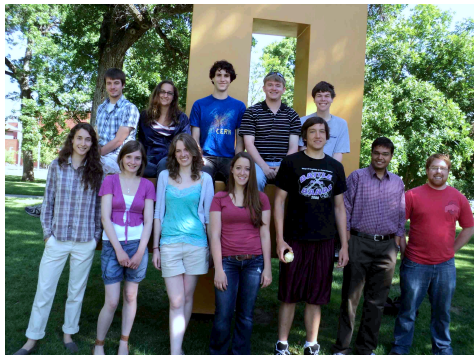
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- ▶ detect and analyze coronal dimmings in high cadence studies
- ▶ continue to observe coronal hole evolution and connection to global magnetic field reconfiguration

Acknowledgements

- ▶ My project supervisor, Chris Lowder
- ▶ My project faculty advisor, and REU program coordinator Jiong Qiu
- ▶ The MSU Solar Physics group
- ▶ National Science Foundation
- ▶ My fellow MSU Solar Physics REU members:



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