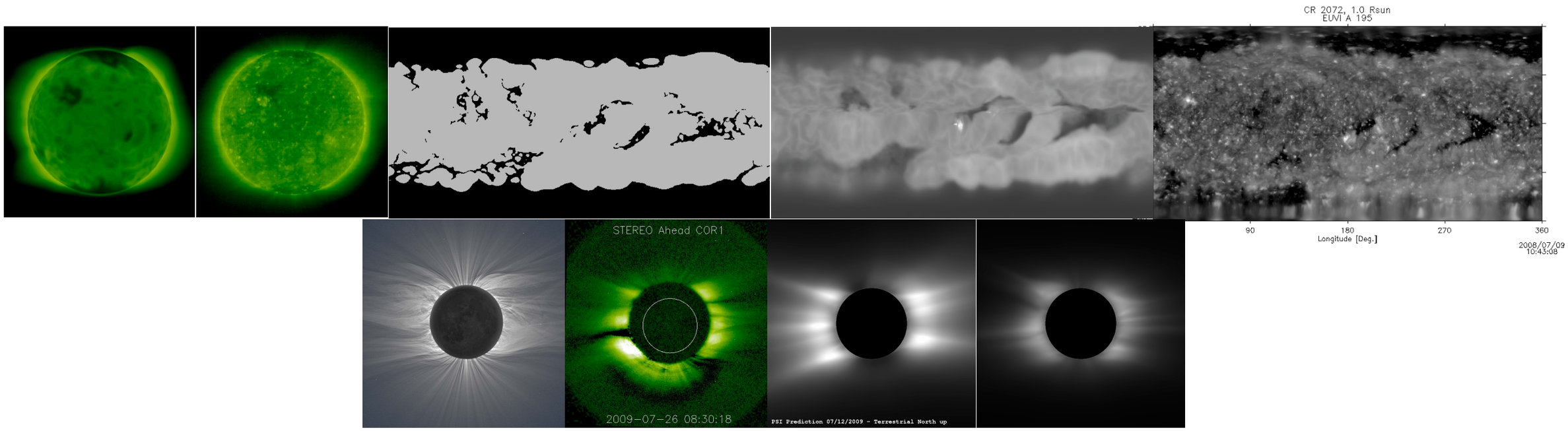
Comparison of High Resolution MHD Models with EUV and White Light Observations*



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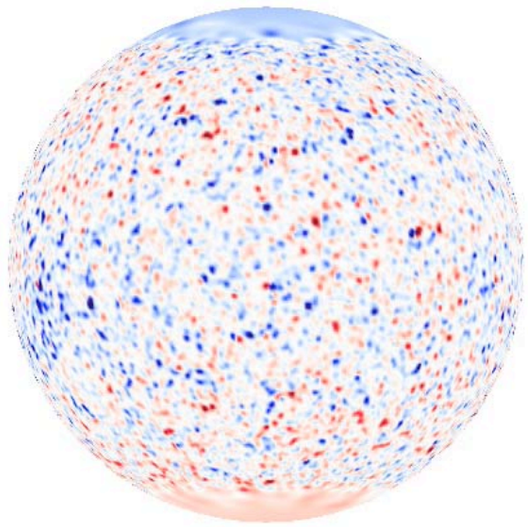
Introduction

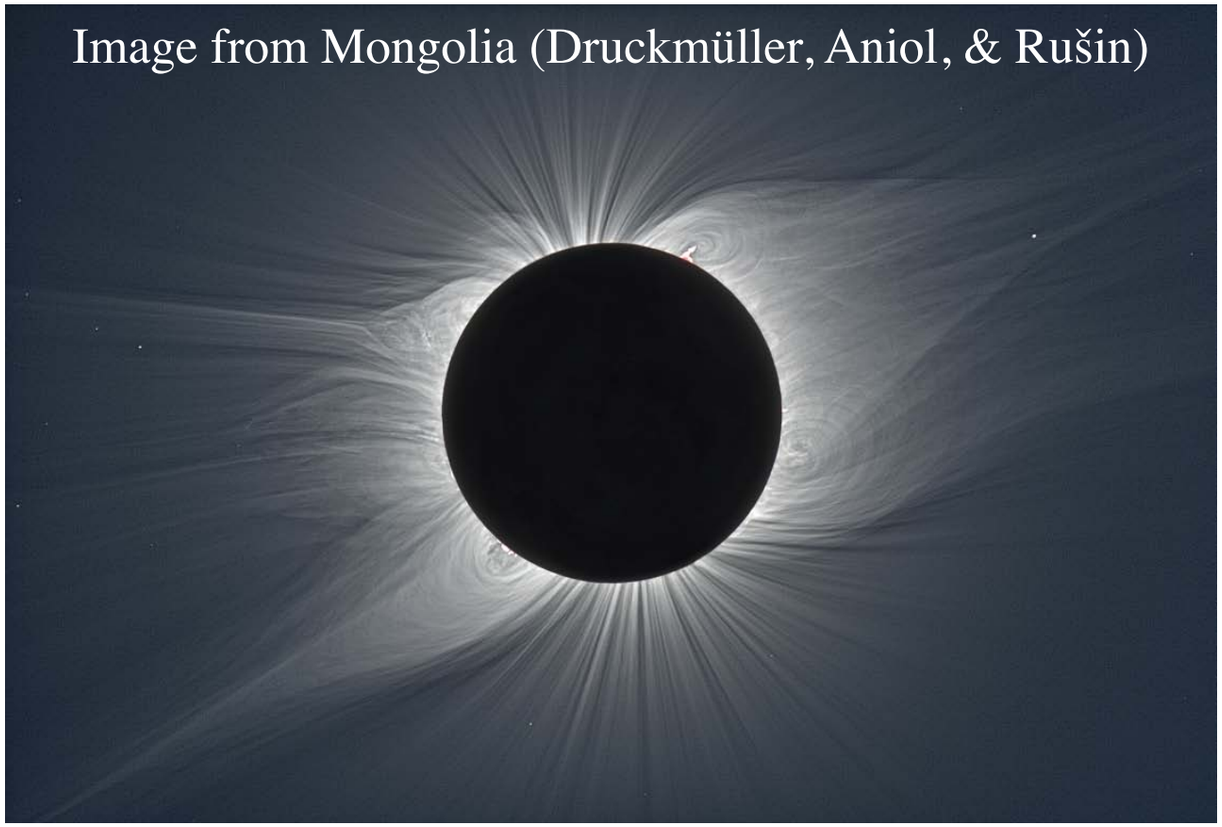
- For ~15 years, our group has predicted the structure of the corona prior to total solar eclipses: **http://www.predsci.com**
- Advances in modeling capability have allowed us to perform the most recent calculations (August 1, 2008; July 22, 2009) at very high resolution

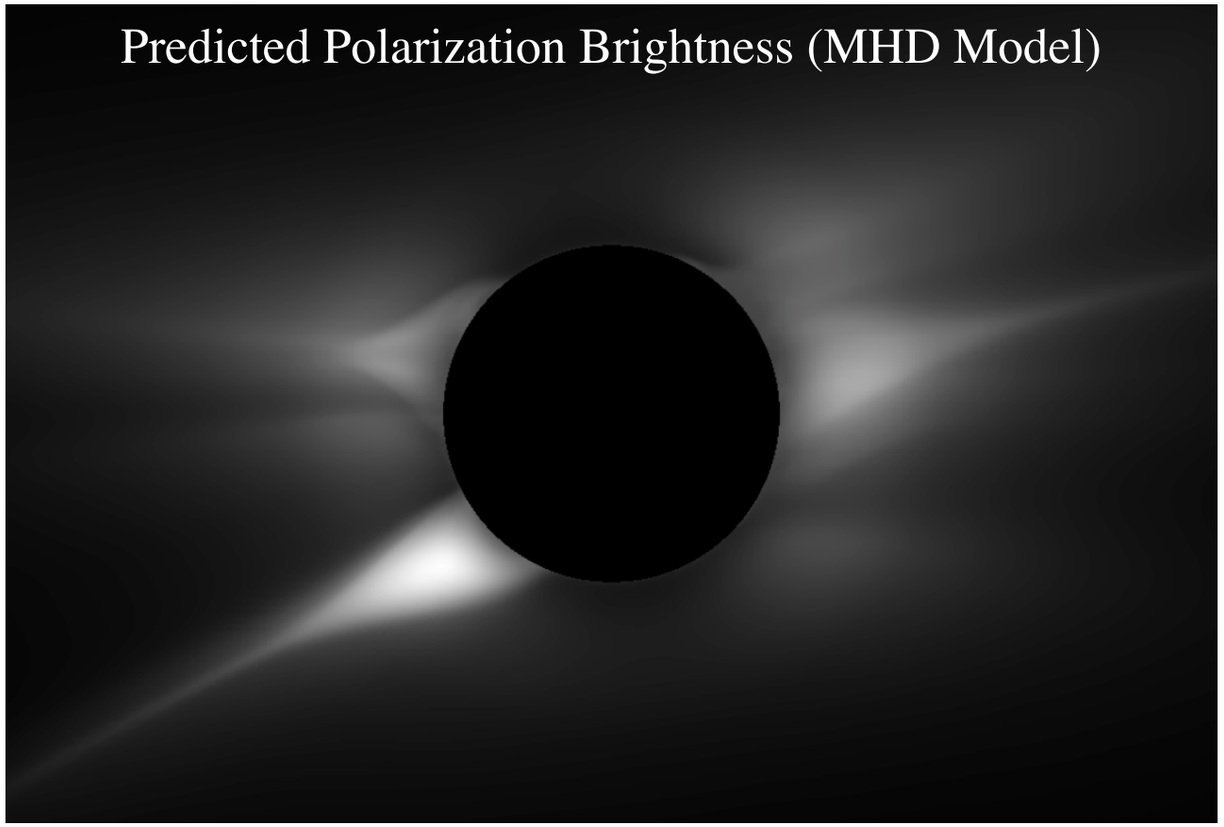


Map based on high resolution MDI magnetograms

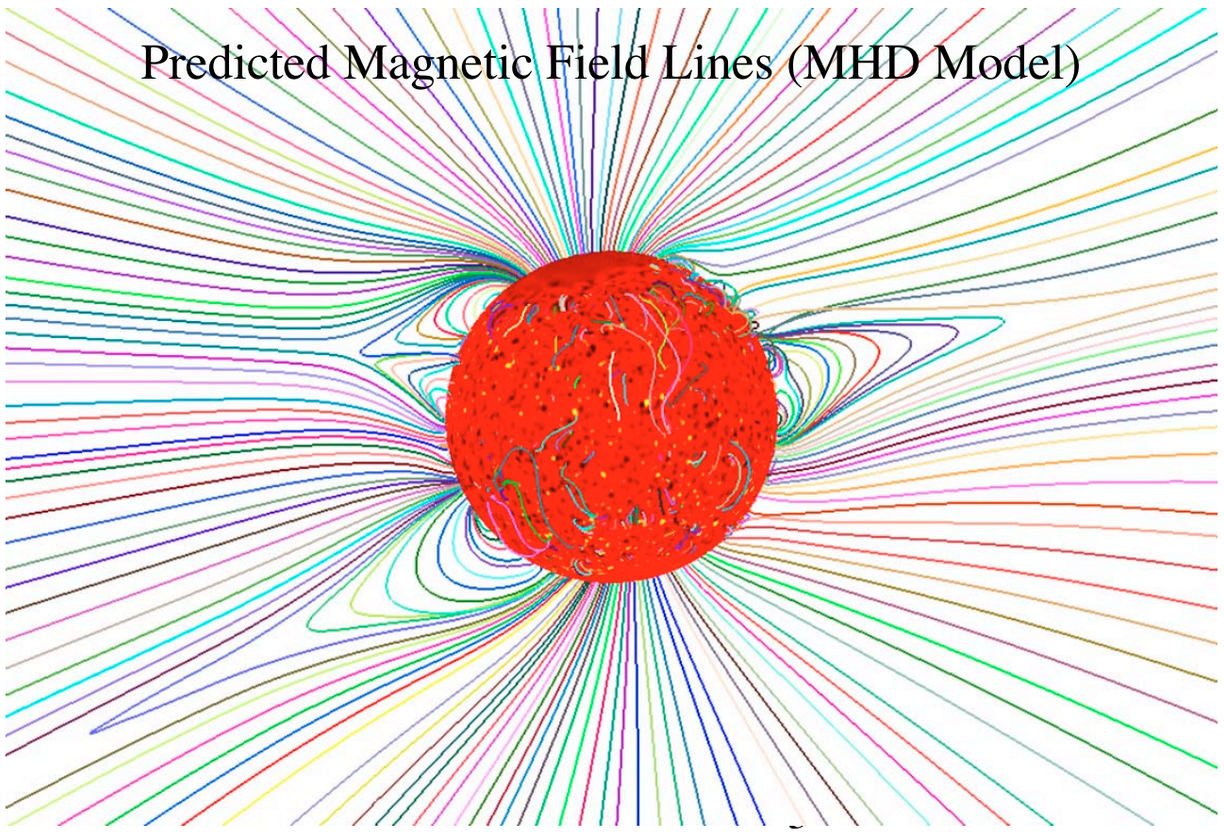
- The August 2008 prediction was very successful.
  - The detailed structure in the simulations has led to new ideas about the origin of the slow wind (not discussed today).
  - We noticed deficiencies in the emission comparison (1st part of the talk)
  - We attempted to improve the heating specification to for the 2009 prediction
  - The result we obtained was somewhat unexpected.... (2nd part of the talk)

August 1, 2008 Total Solar Eclipse





- Eclipse Image:
  - Developed from multiple images, different exposure times
  - Sharpening algorithm applied
  - Brightness/density relation not obvious
  - This is not what the naked eye sees
- Predicted Polarization Brightness:
  - Newkirk filter applied



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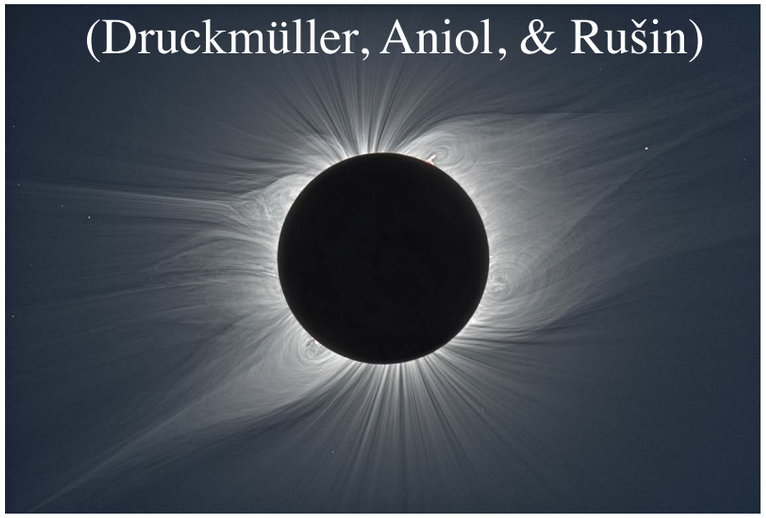
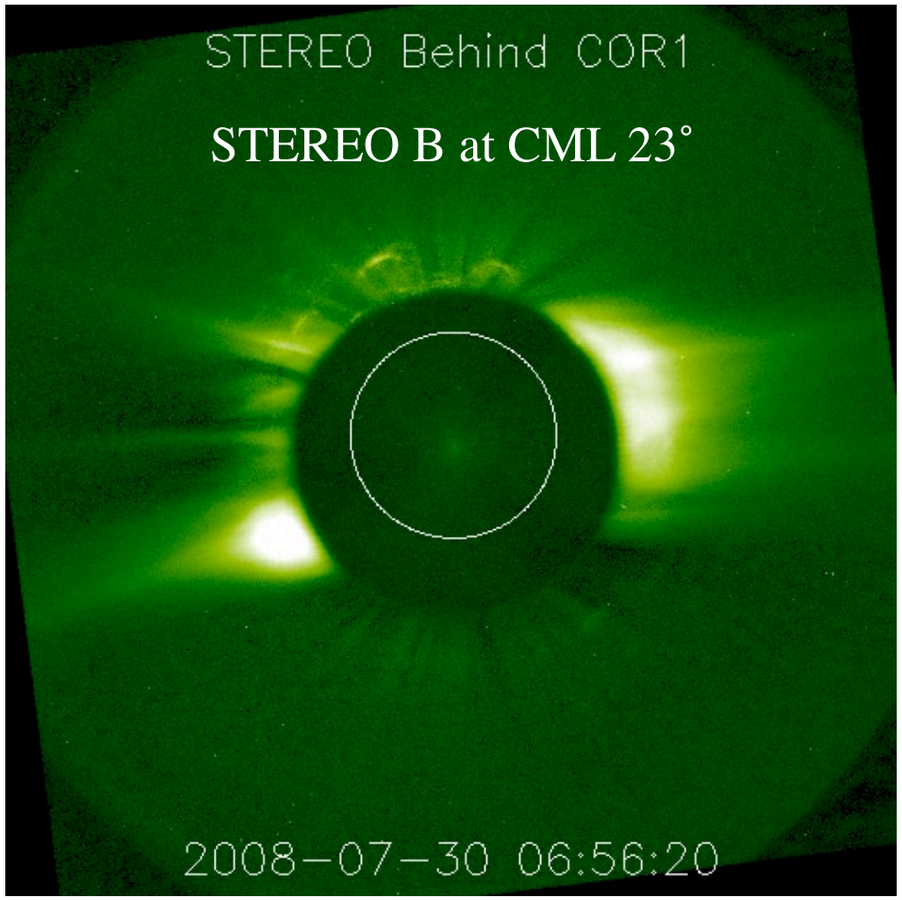
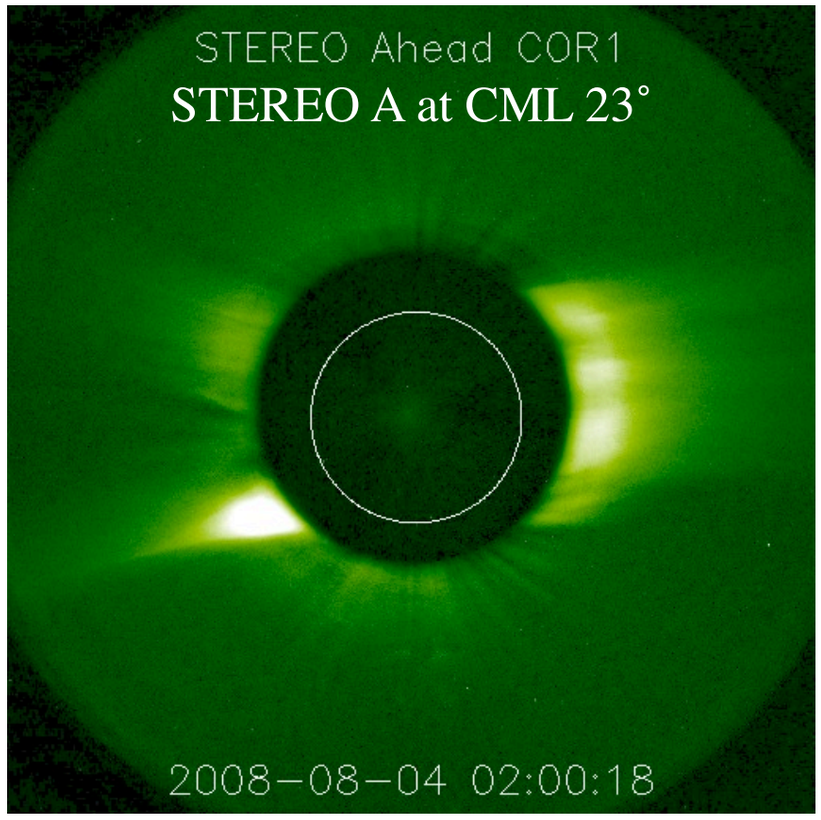
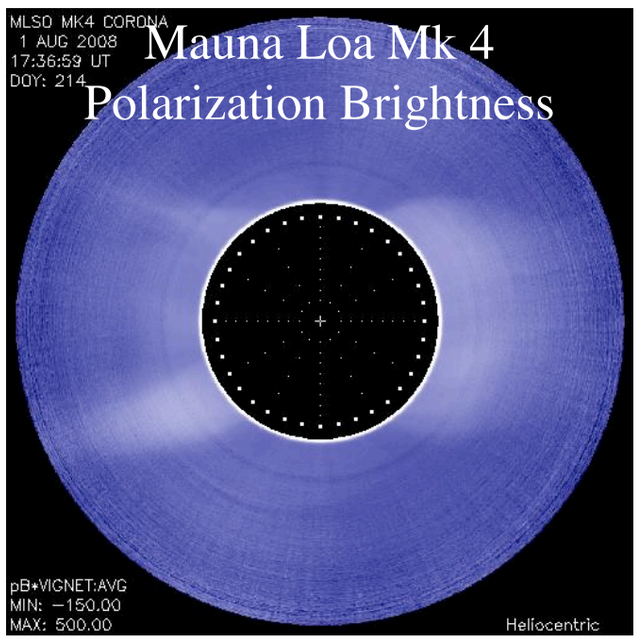
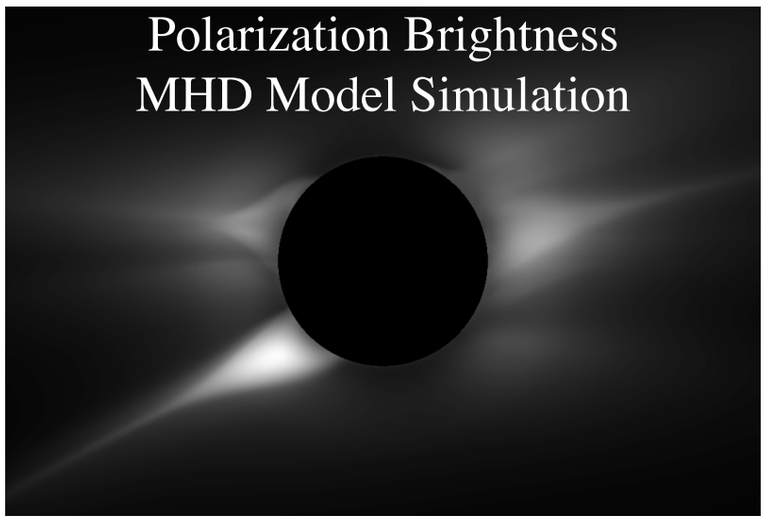
August 1, 2008 Total Solar Eclipse

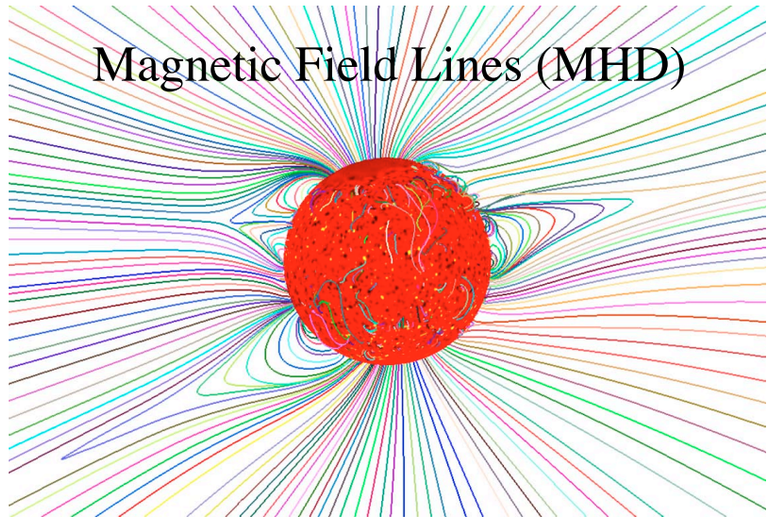












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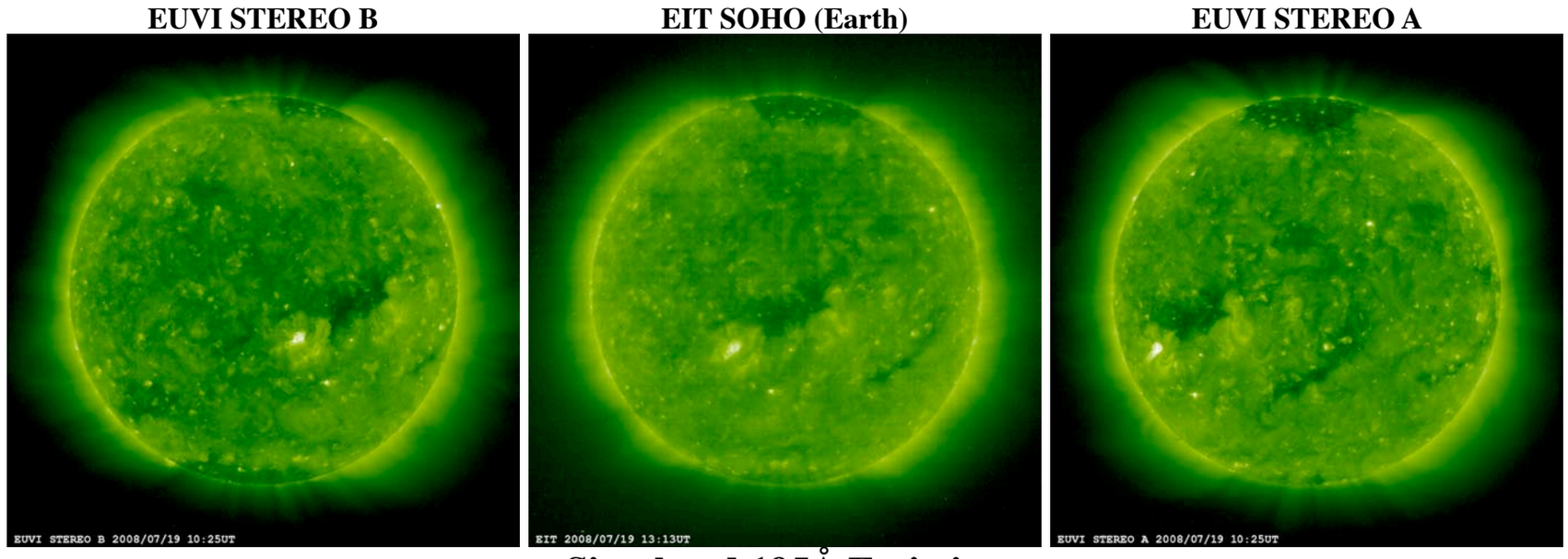
There is Good Correspondence Between the Different White Light observations

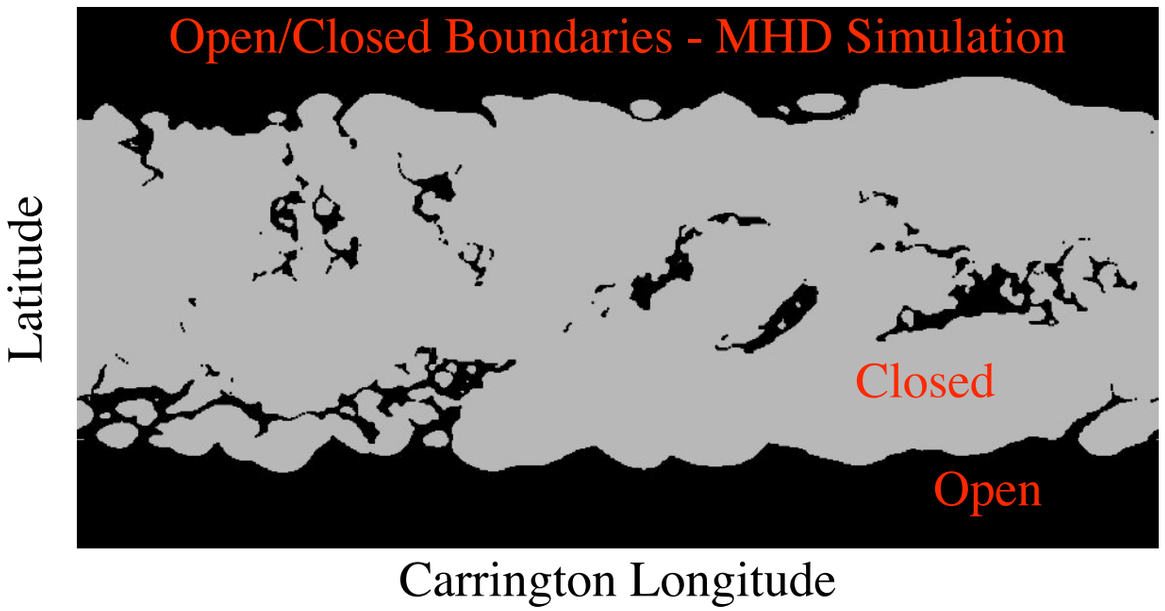
Carrington Rotation 2071+2072 Comparison: SOHO EIT & STEREO EUVI

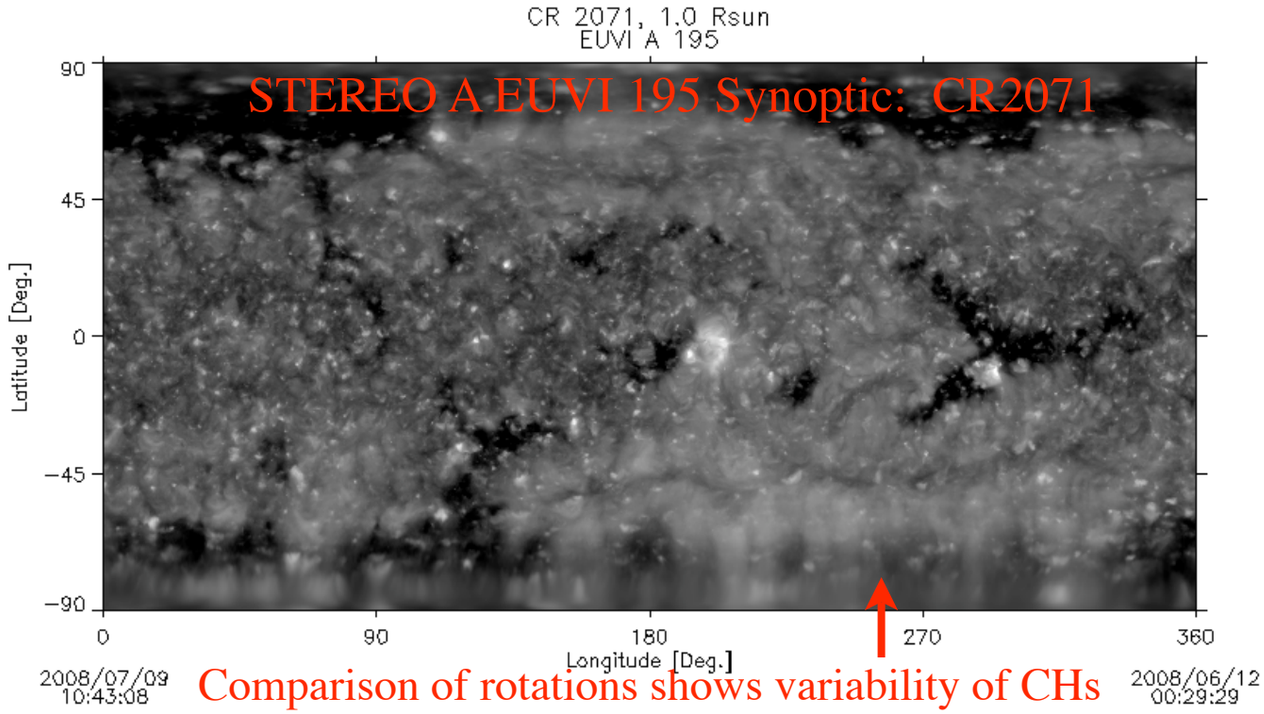
Observed 195Å Emission on July 19, 2008 near 13:06UT



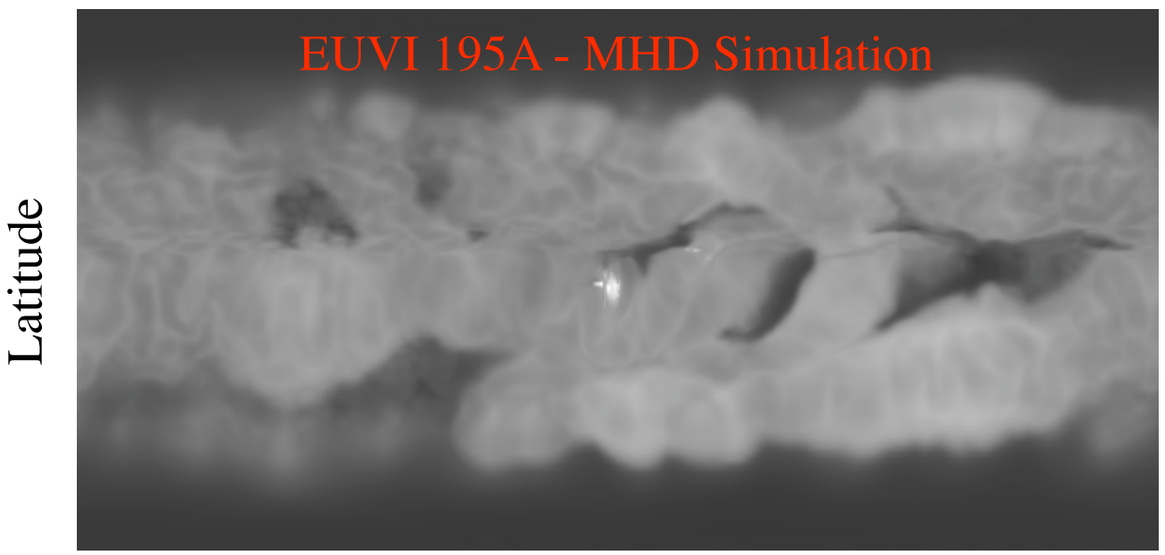
- There is reasonable correspondence between observed and simulated coronal holes.
- Modeled coronal holes are too large and too dark.
- No point spread function - might account for some of the low emission in simulated coronal holes.

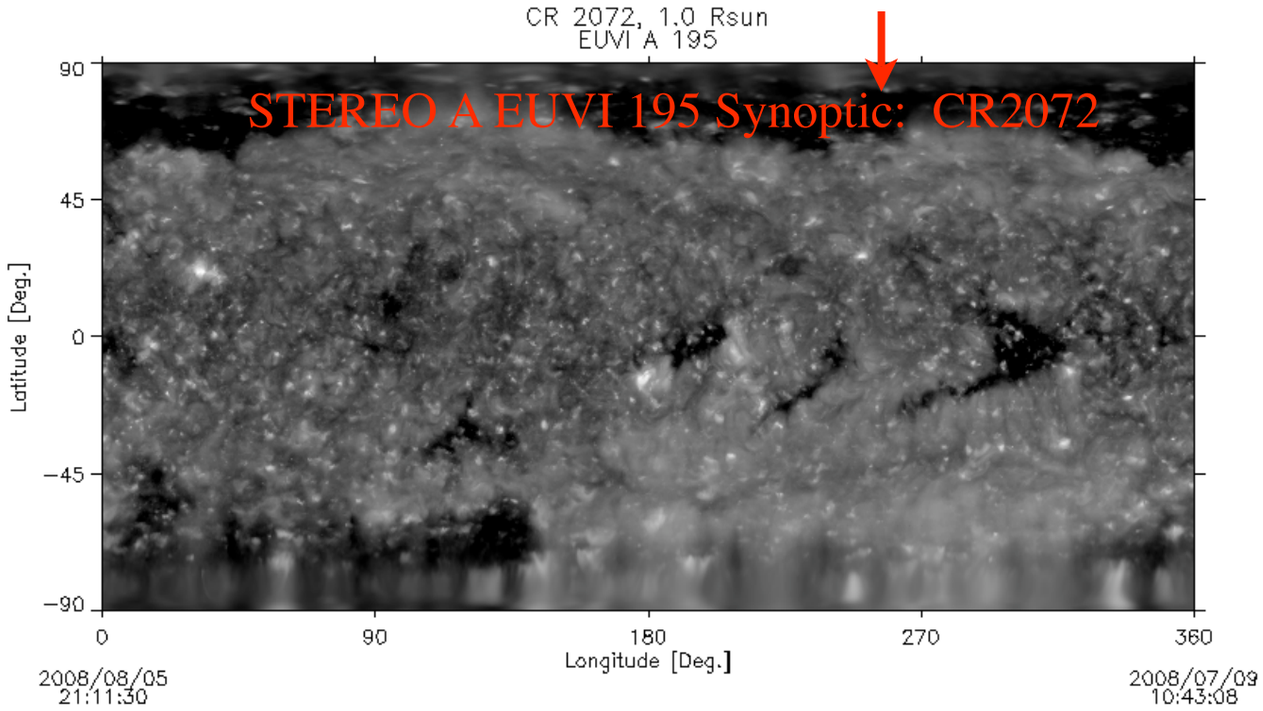
Carrington Rotation 2071+2072 Comparison: "Synoptic" Maps





Comparison of rotations shows variability of CHs

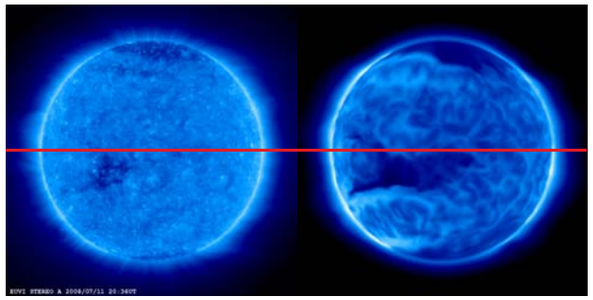


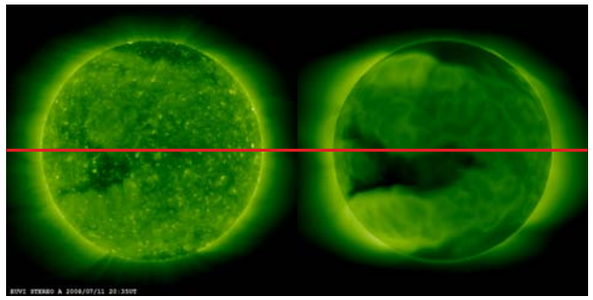


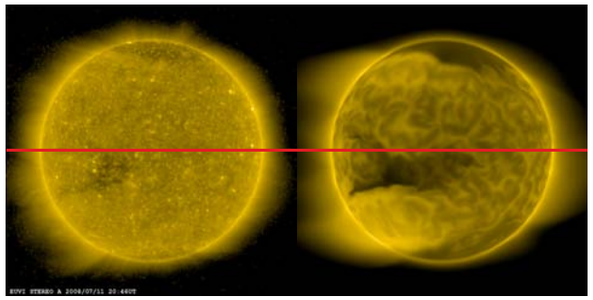
- Simulated "synoptic" emission has no obscuration by overlying structures.
- Dark regions and open fields correspond closely but not exactly in simulations.

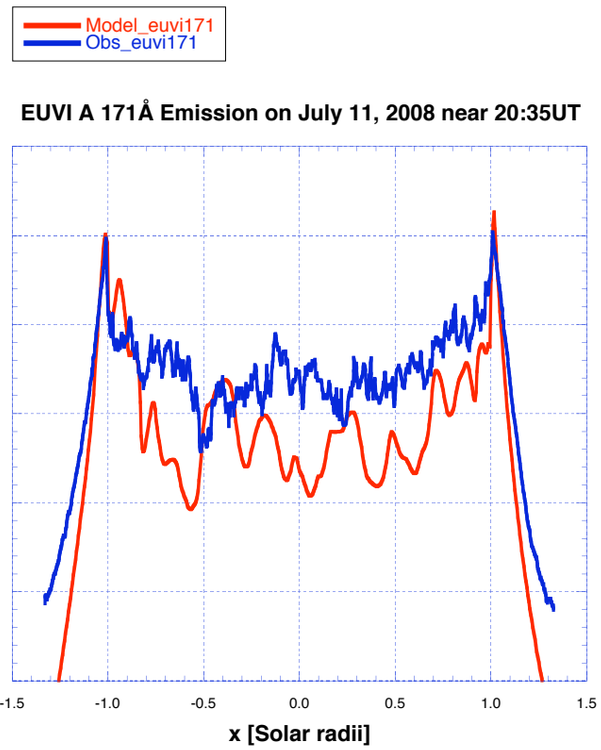
Carrington Rotation 2071+2072 Comparison: STEREO EUVI

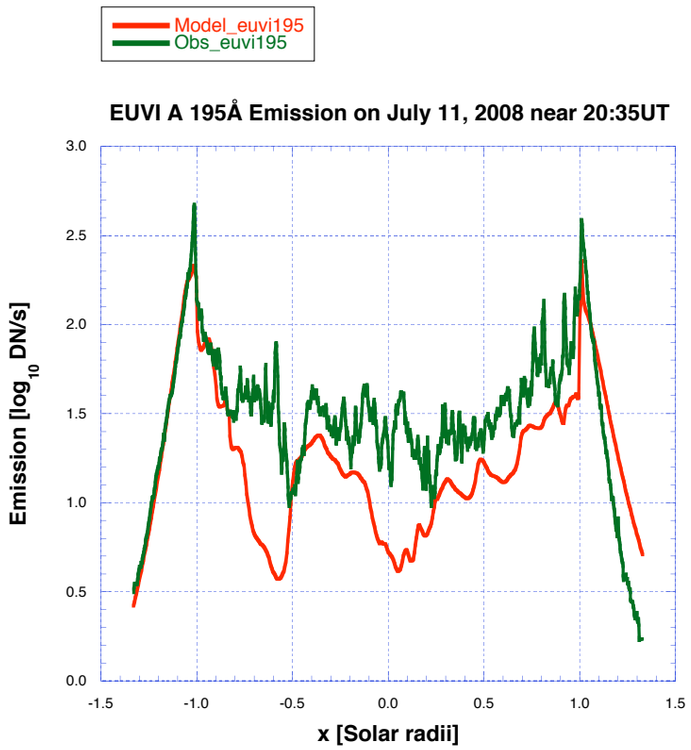
Comparing EUVI A Emission with Simulated Emission on July 11, 2008 near 20:35UT (Equatorial Cut)

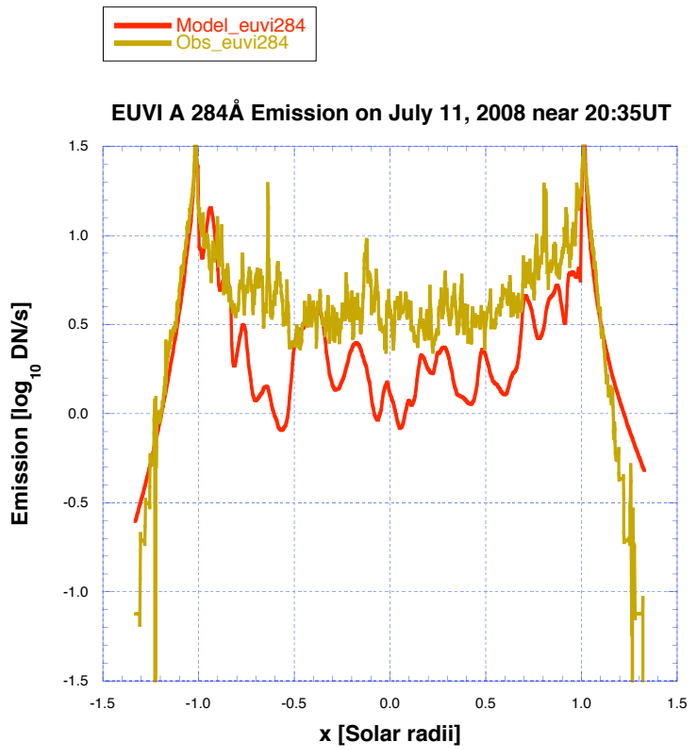






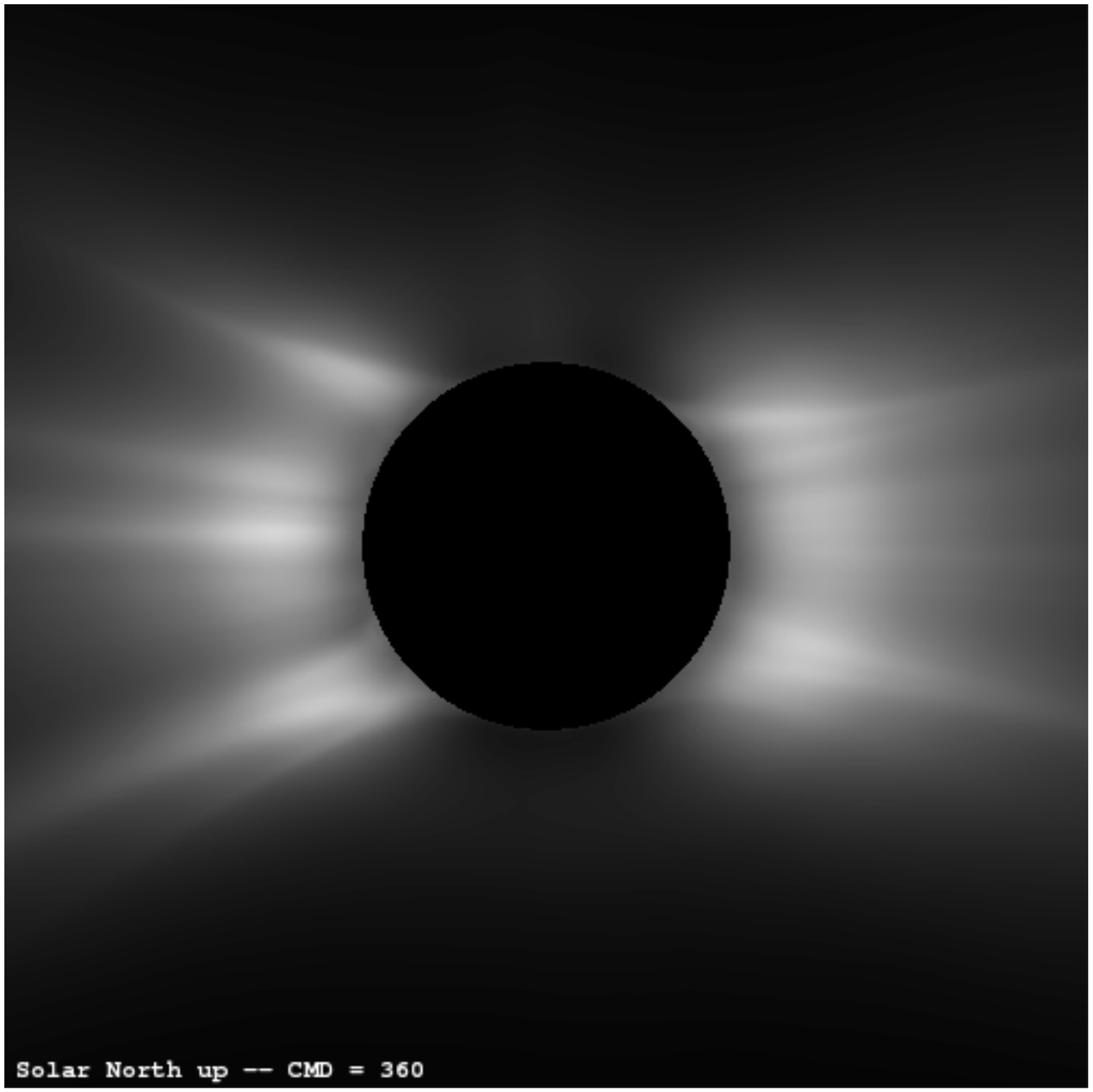


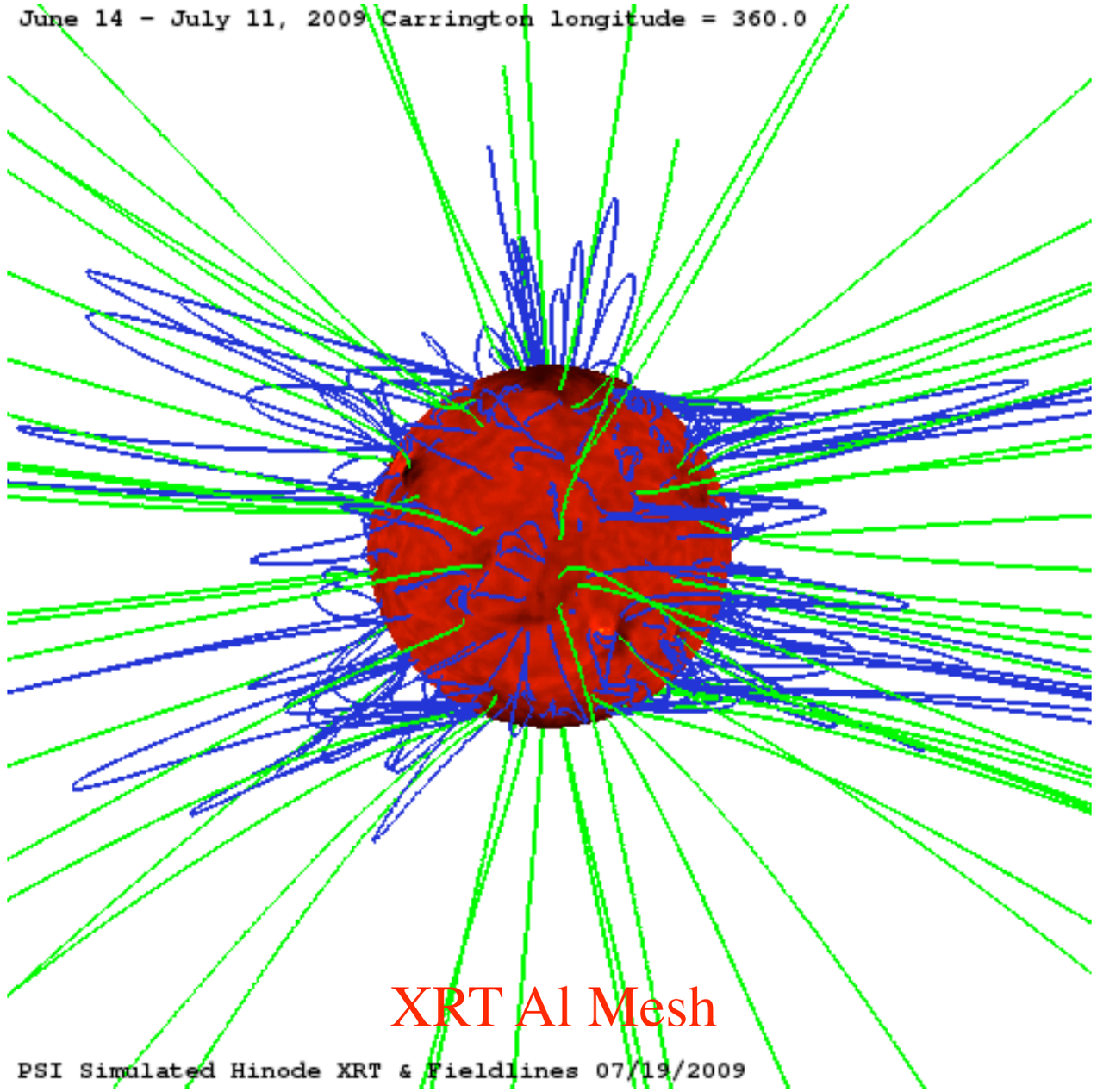




- Background emission is too low - indicates heating model can be improved.

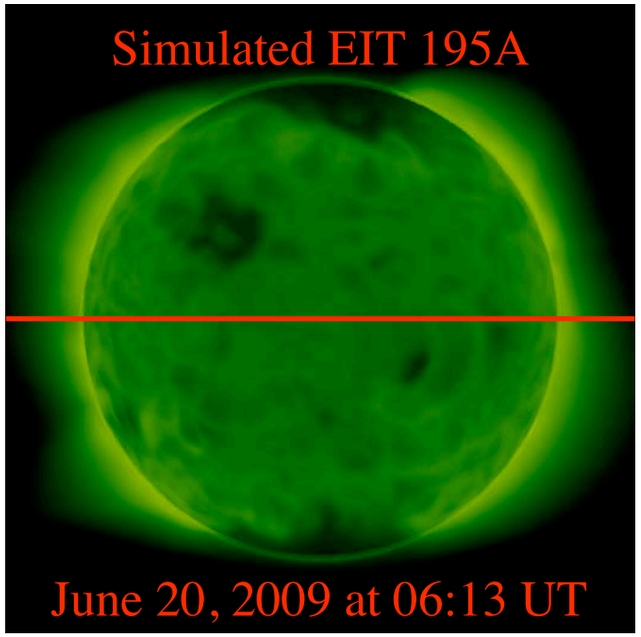
July 22, 2009 Total Solar Eclipse: 3D Structure

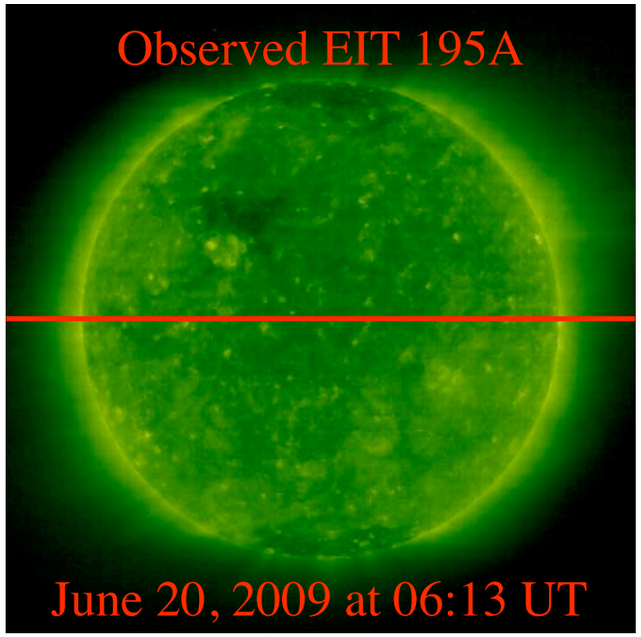


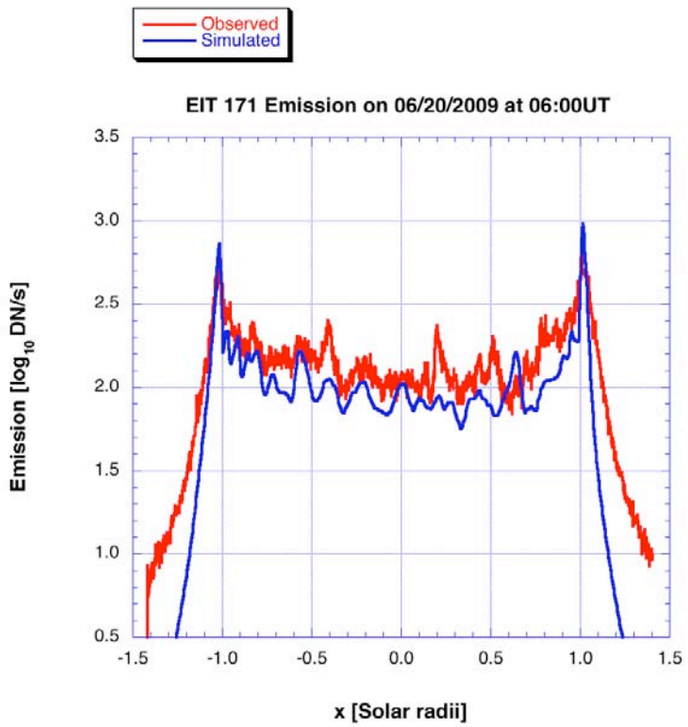


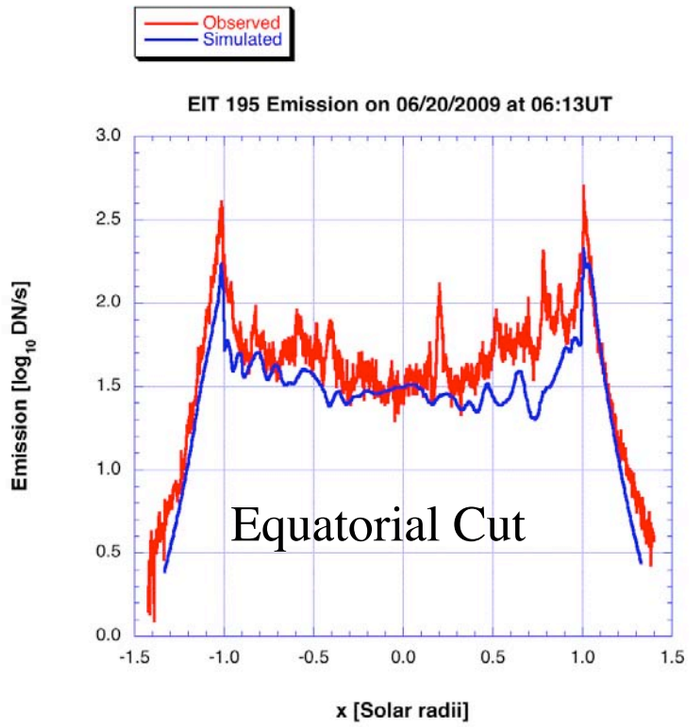
- Blue field lines are closed, green are open
- There are lots of small-scale open fields that don't obviously correspond to coronal holes in simulated emission

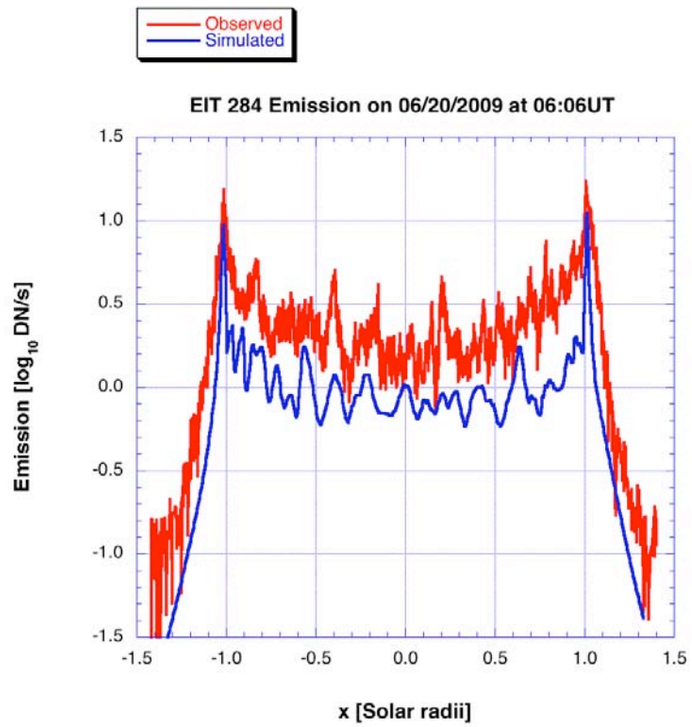
Carrington Rotation 2084+2085 Comparison: SOHO EIT





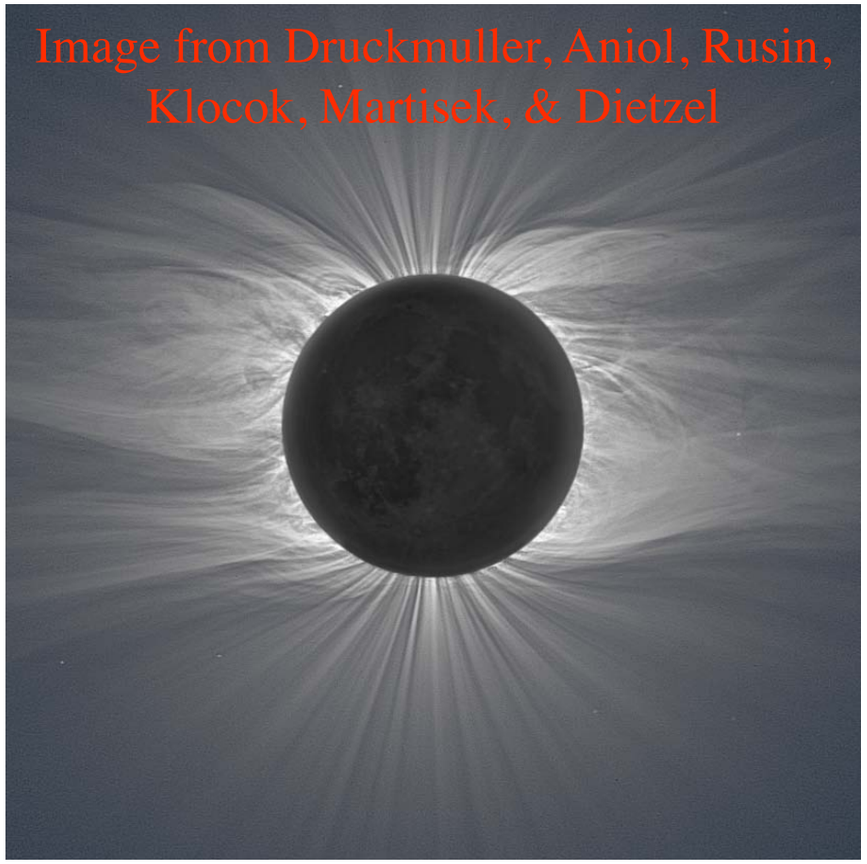


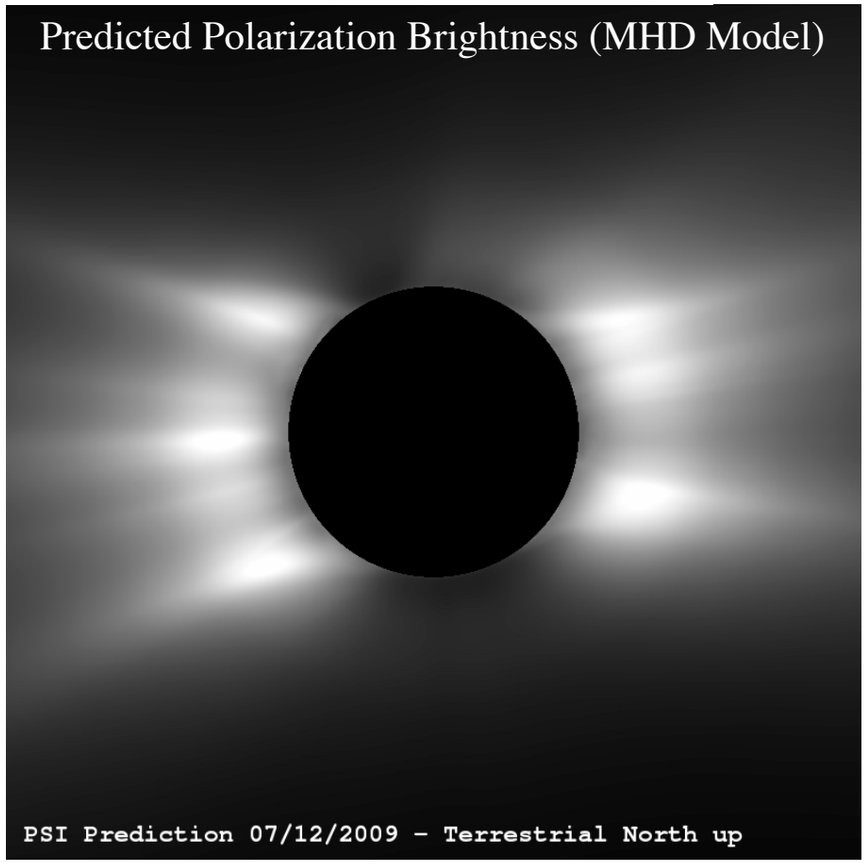




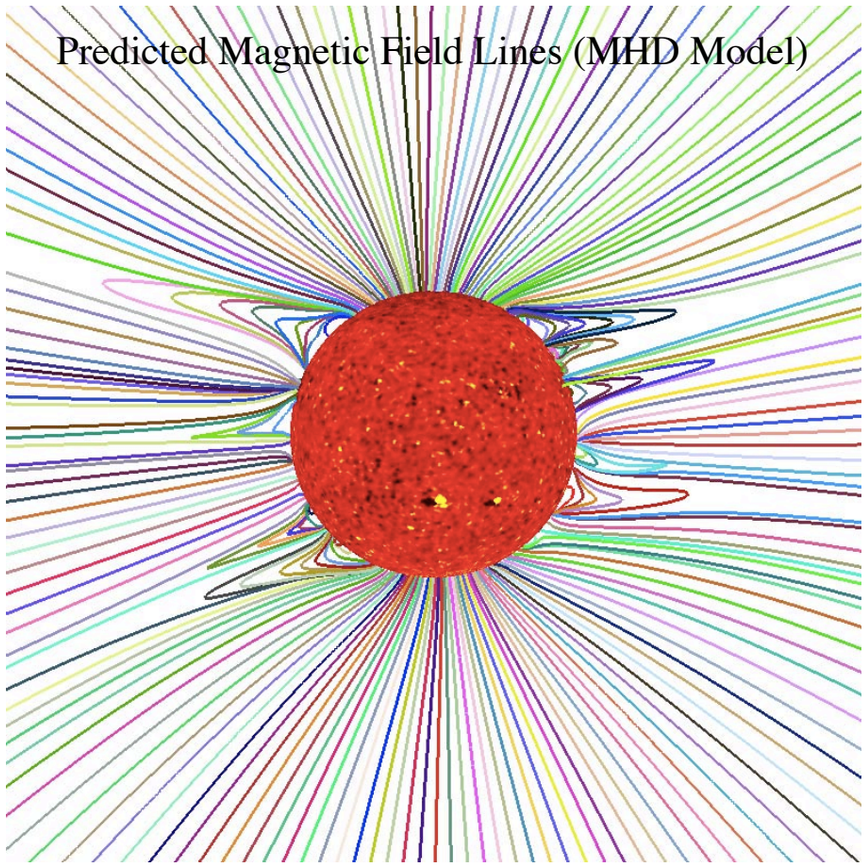
- Simulated emission level matches observed level reasonably well
- The match is improved compared to August 2008

July 22, 2009 Total Solar Eclipse





- Eclipse Image:
  - Approximately rotated to terrestrial north up
  - Sharpening procedure, as in 2008
  - Coronal structures look very non-radial
- MHD Calculation:
  - Streamers look too small and too radial
  - Our corona has a very complex structure, and a poor resemblance to the eclipse image



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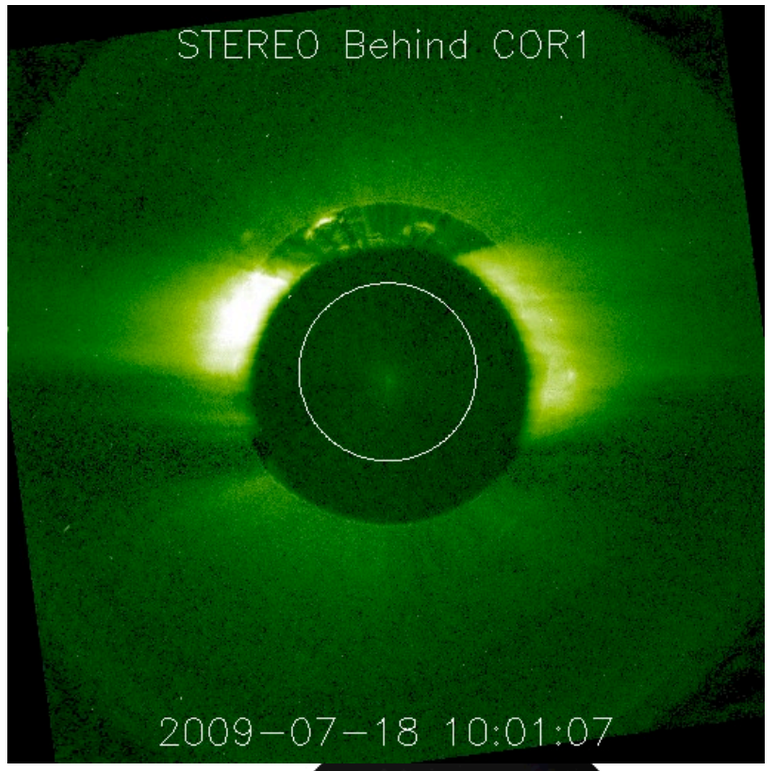
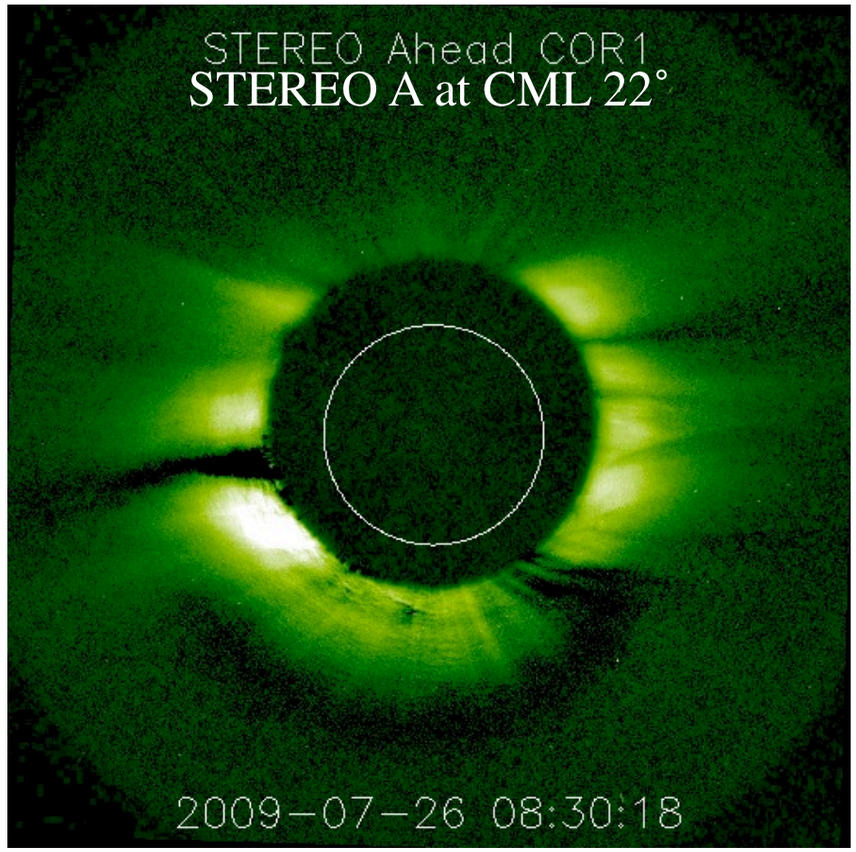
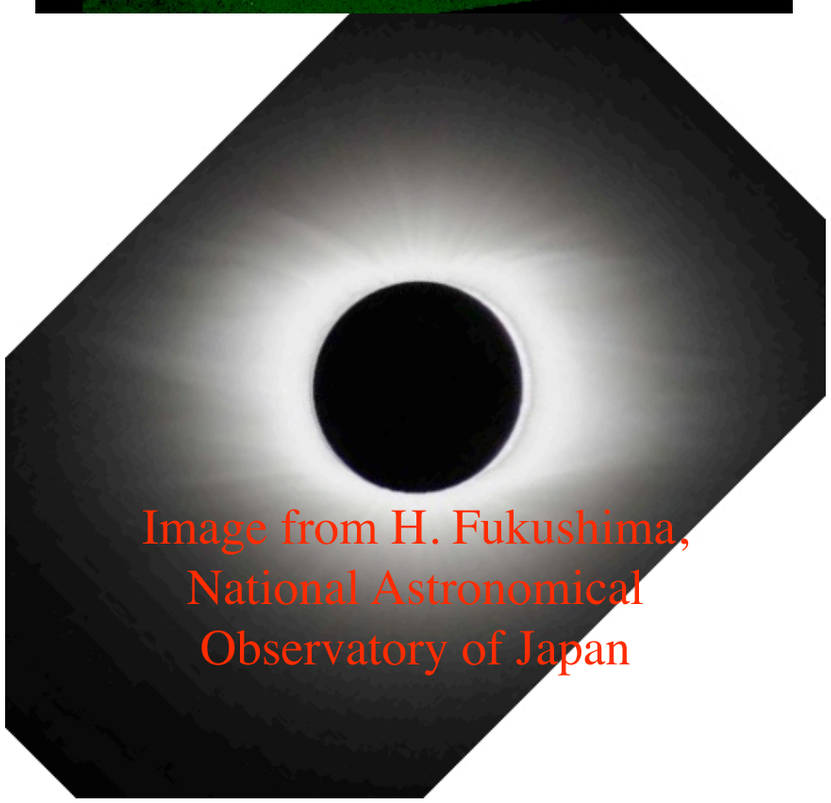
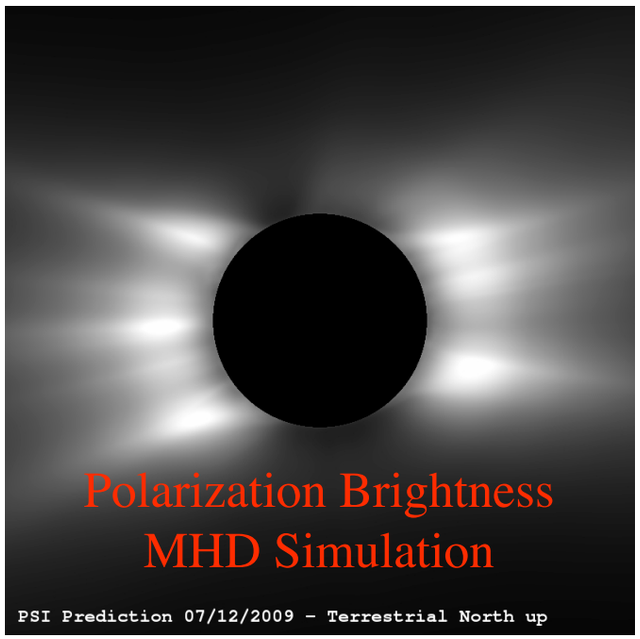
July 22, 2009: Eclipse STEREO, MLSO Comparison









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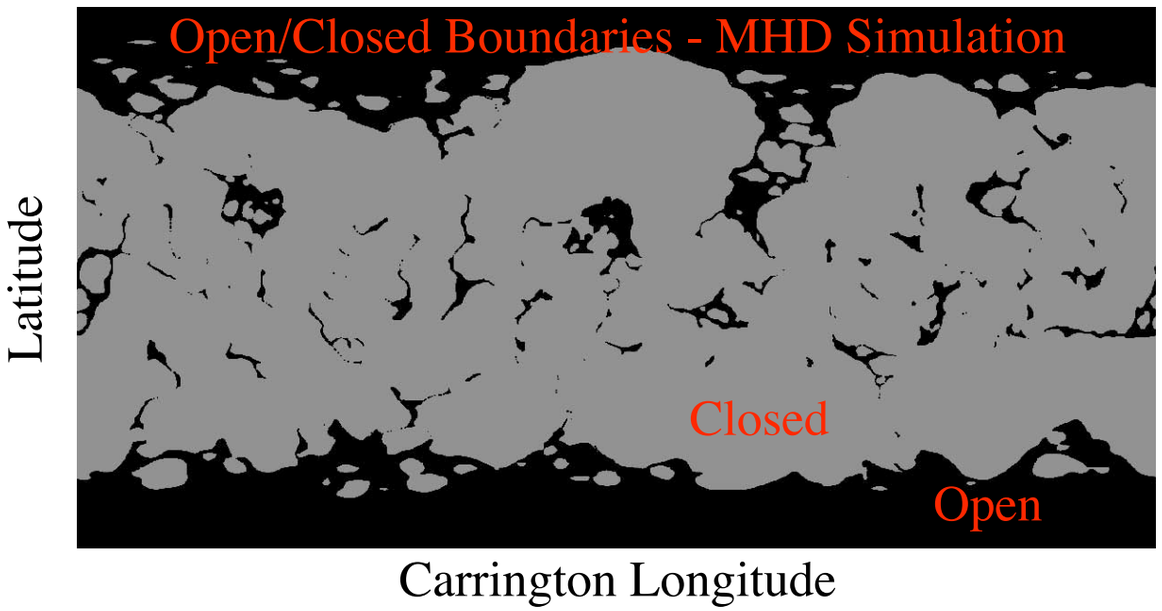
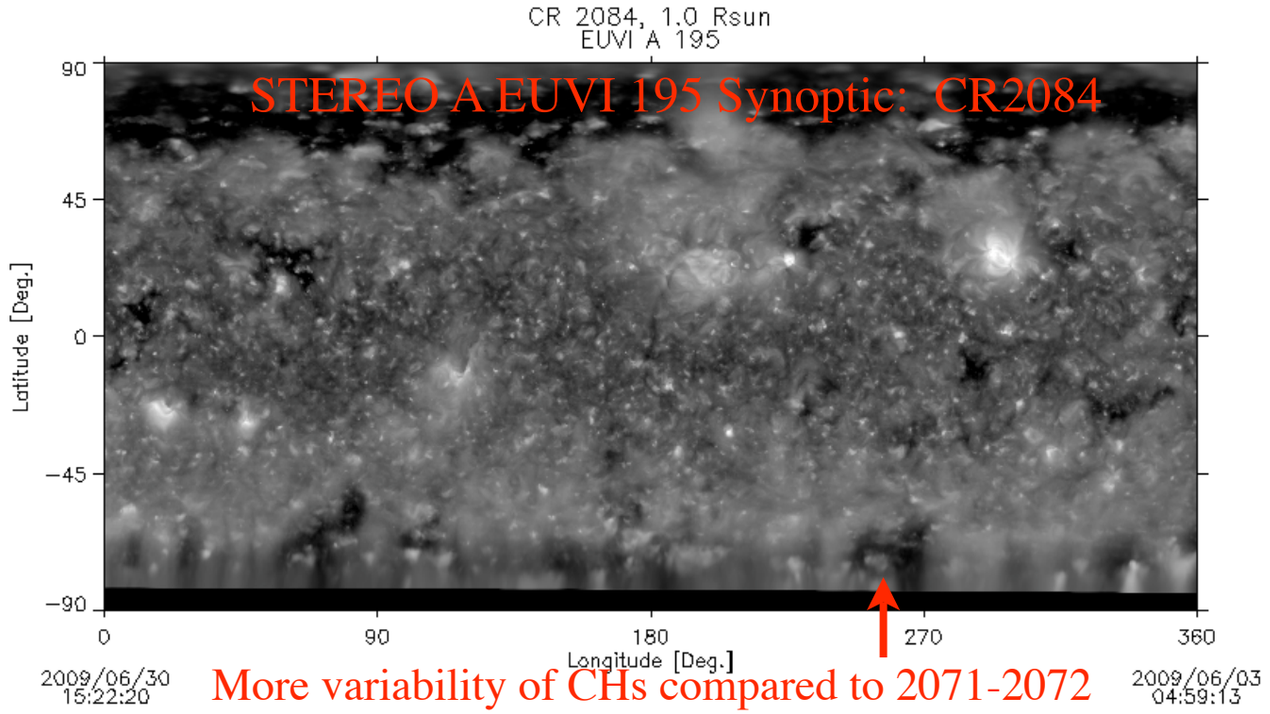
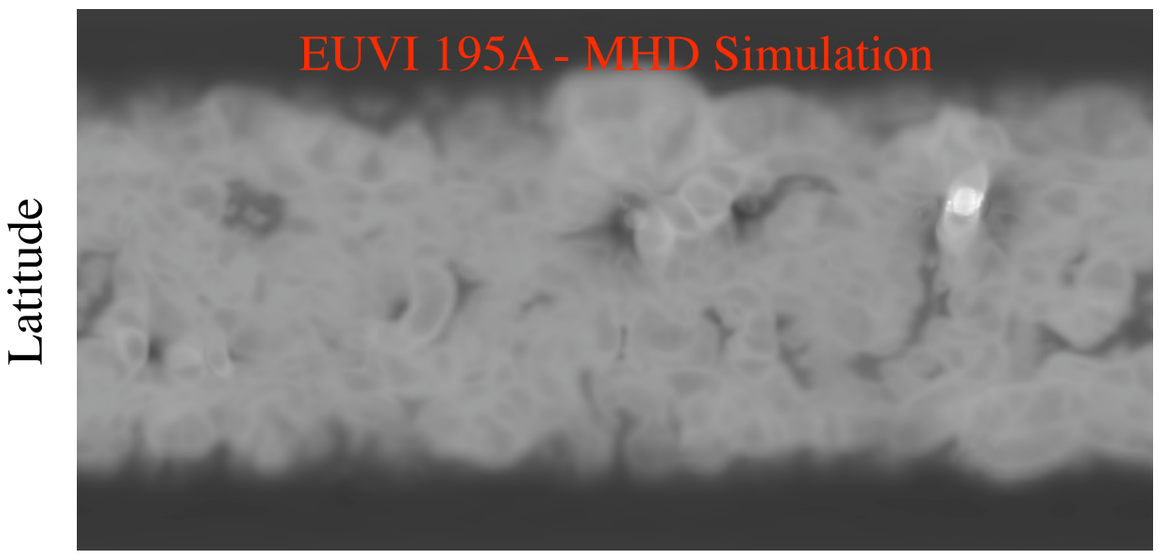
The Correspondence Between the Different White Light Observations is not as clear as 2008

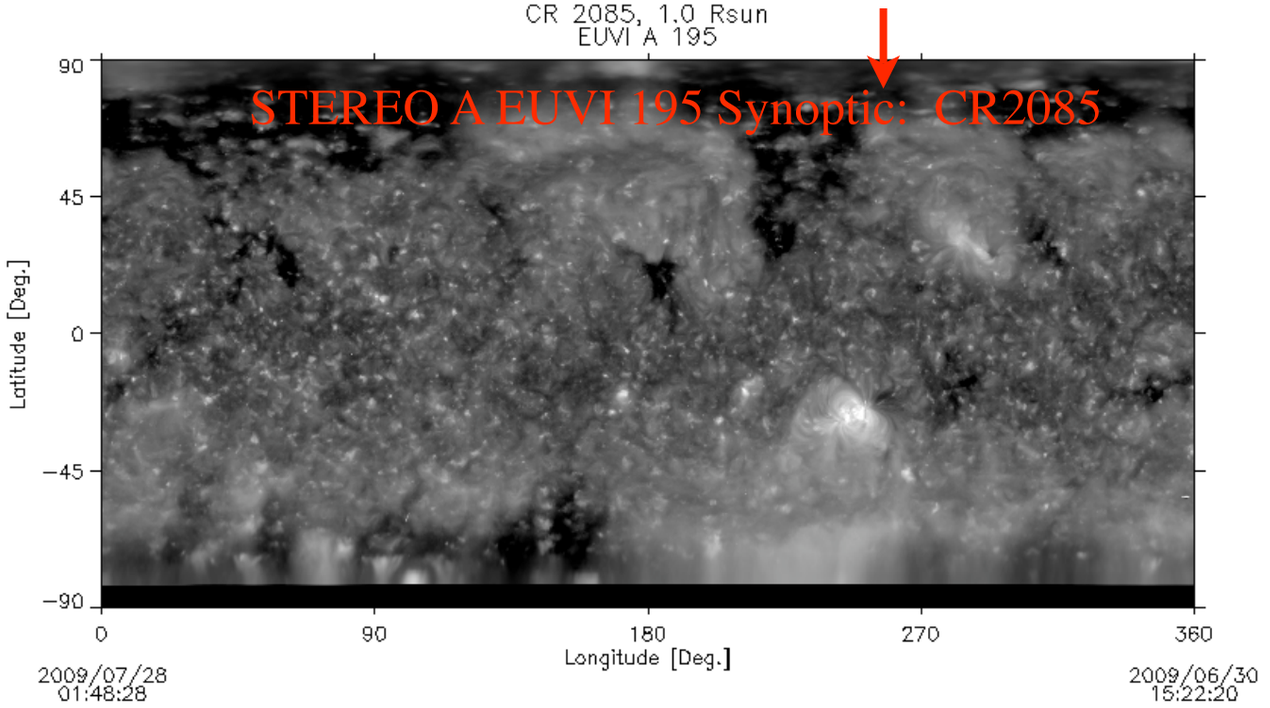
Carrington Rotation 2084+2085 Comparison: "Synoptic" Maps





More variability of CHs compared to 2071-2072

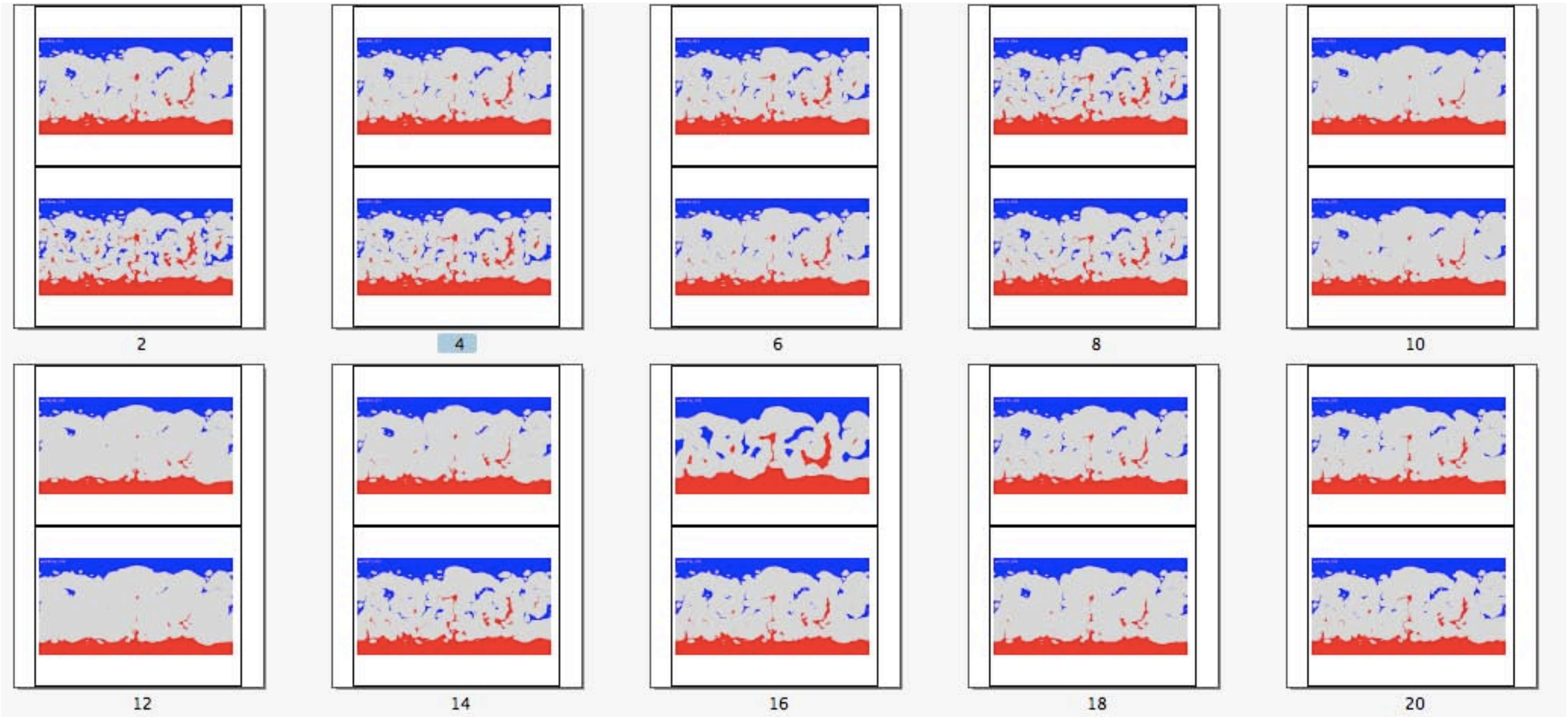




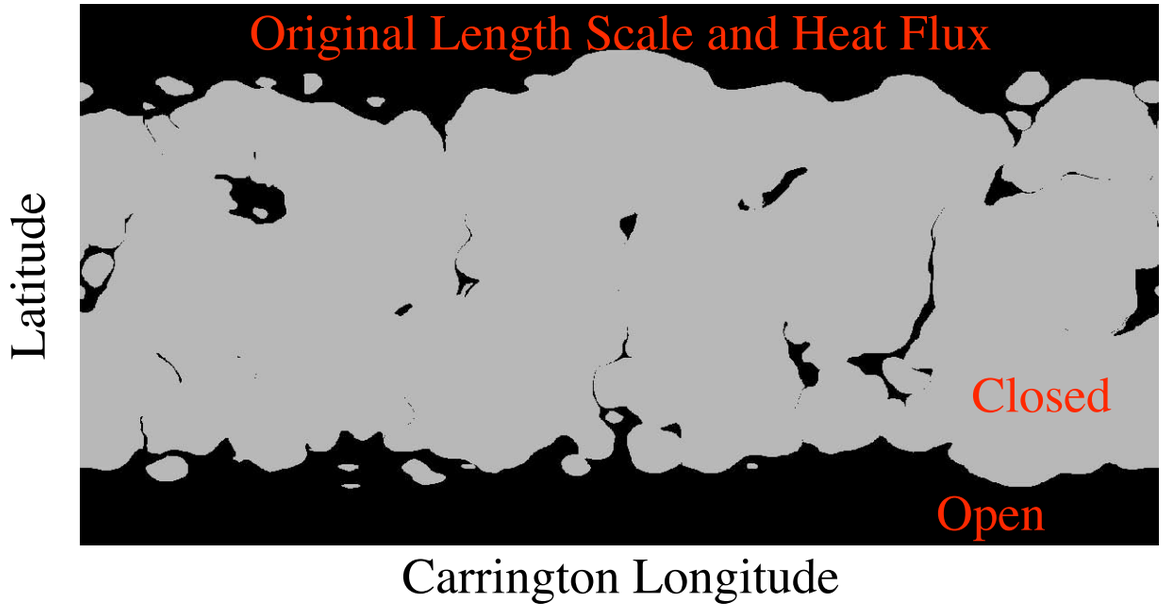
- There are lots of very small scale open fields in the simulation - too many!
- It is very easy to open the weak field of the Sun during this time period.

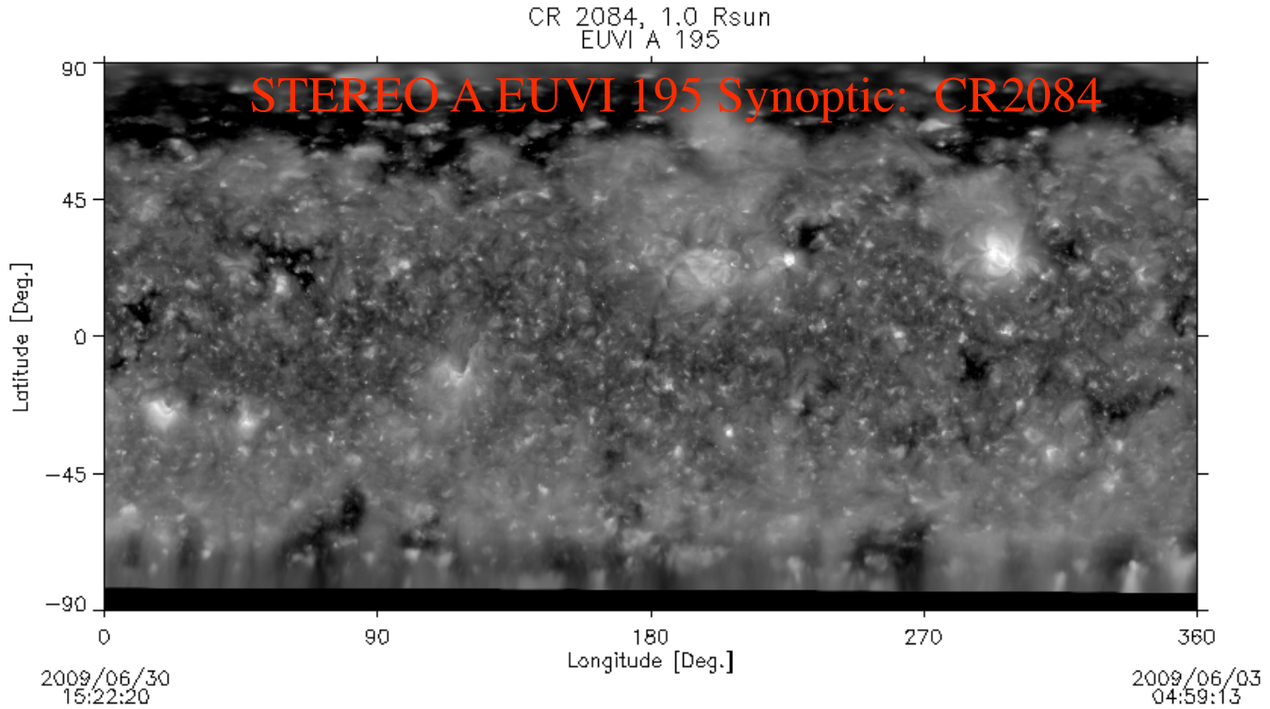
Carrington Rotation 2084+2085 Comparison: Coronal Holes

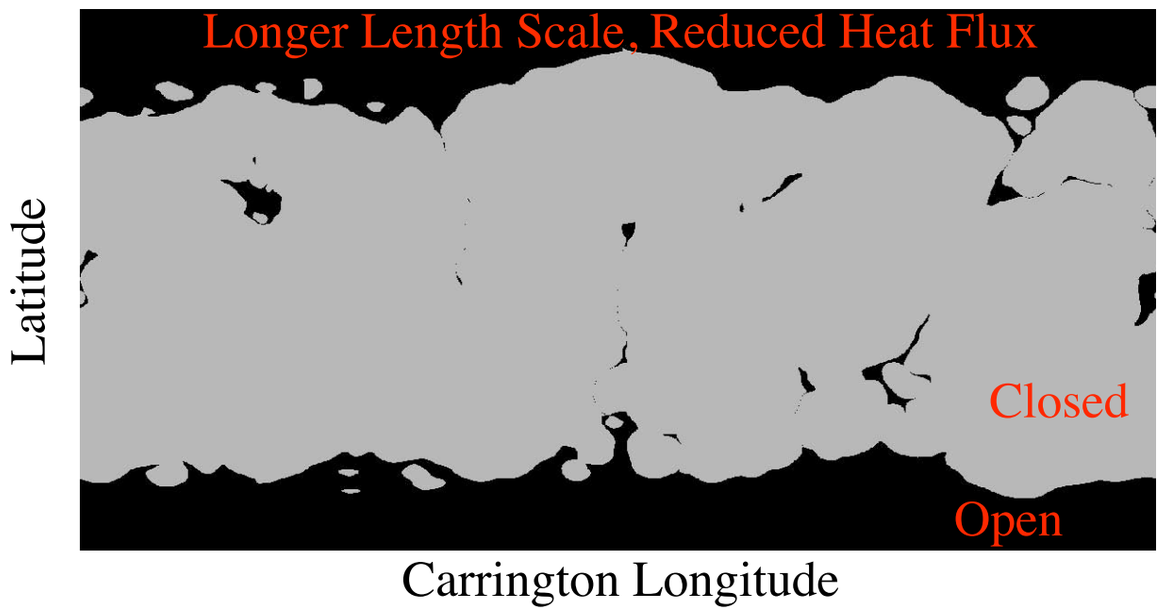
We have now run a number of test cases ....

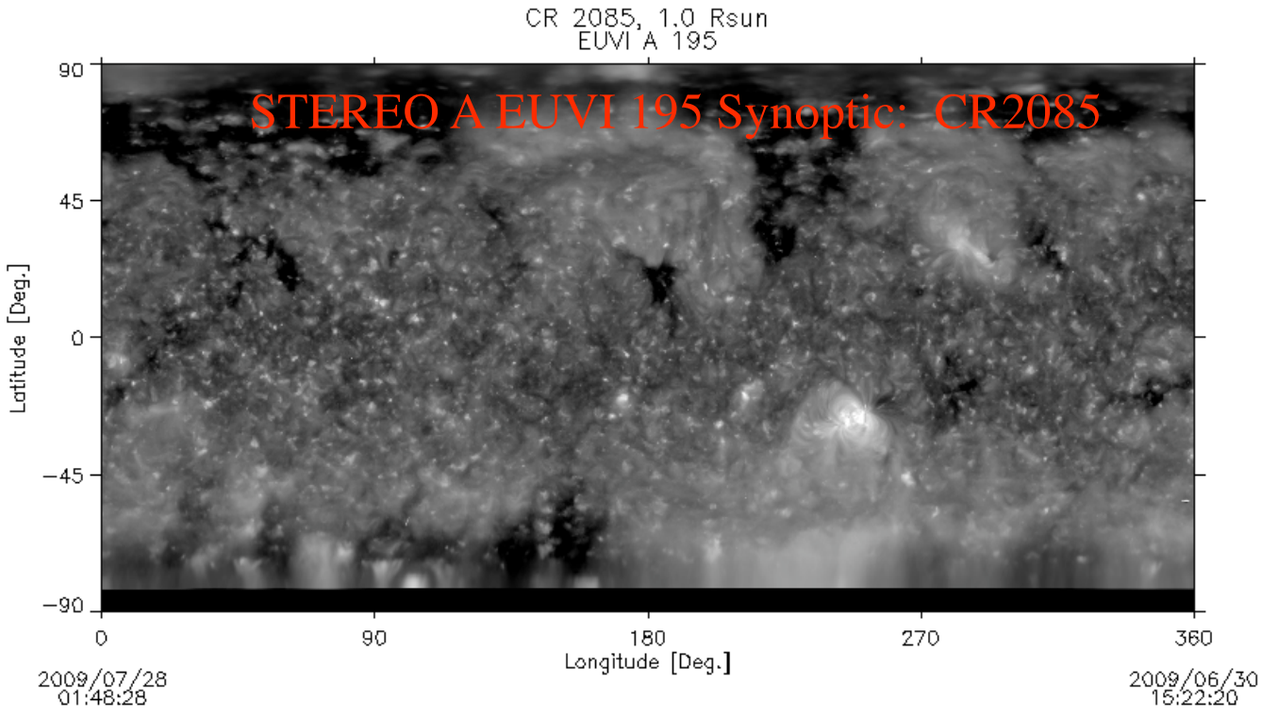


Comparison of Coronal Holes for Fast Wind Heating Alone



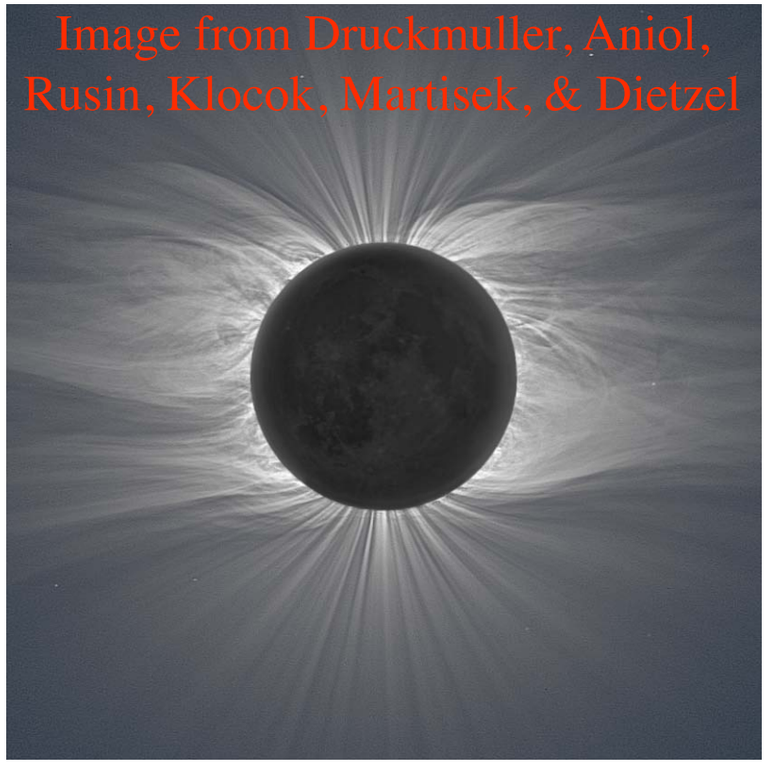


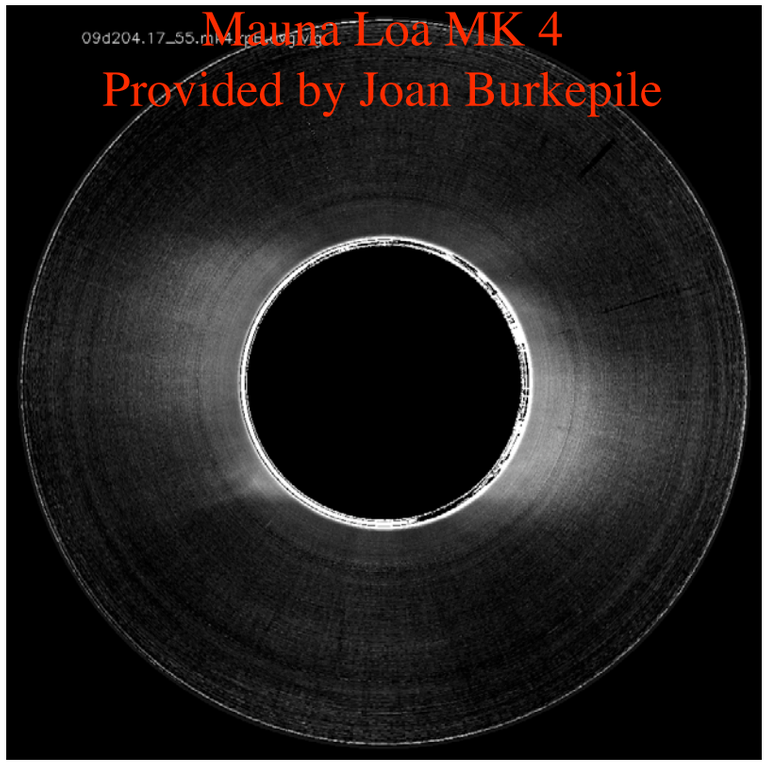


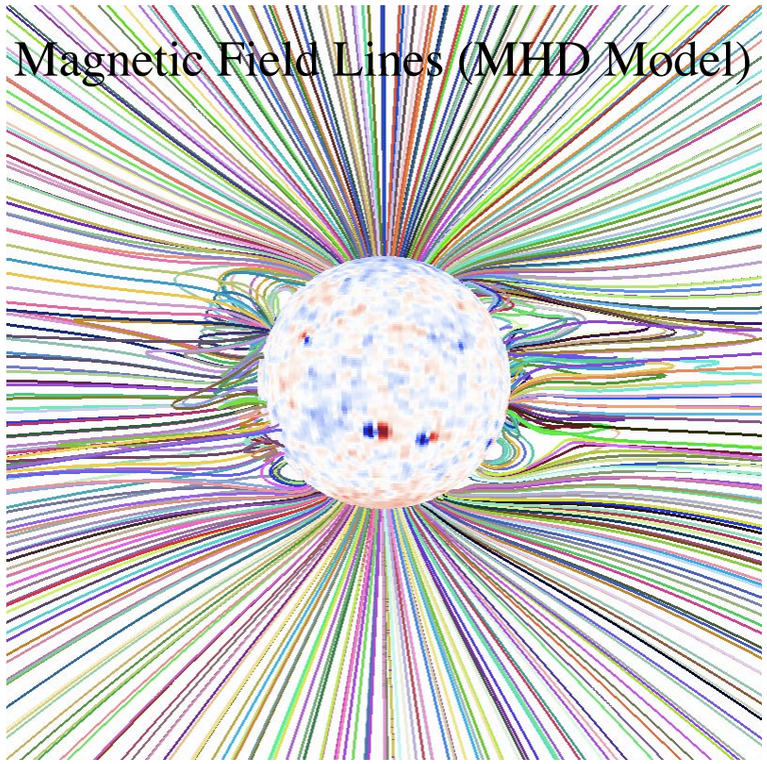


- Fast wind heating is a simple exponential with length scale ~ .7R_S
- Original selection produces coronal holes that are too large

July 22, 2009 Total Solar Eclipse: A Subsequent Model







Summary

- The August 1, 2008 and July 22, 2009 eclipse calculations were much higher resolution than previous calculations. They reveal a great deal of structure in the corona.
- The 2008 simulation reproduced the corona quite well, but the 2009 simulation did not.
  - Are we getting stupider? Hopefully not.
- The difficulty for the models to reproduce the white light corona for July 2009 is at least in part related to this unusual solar minimum:
  - The magnetic field is very weak.
  - The open/closed boundaries and streamer structure are more sensitive to the heating.
  - This is actually good - the sensitivity may teach us about changes in coronal heating/solar wind acceleration during this minimum.
- There are other important effects to consider for obtaining the correct streamer size - e.g., shear in the field.