

# Synoptic Coronal Hole Maps from SDO and STEREO-A

**Synoptic Coronal Hole Maps from SDO and STEREO-A**  
 Ian M. Hewins, Sarah E. Gibson, Barbara A. Emery  
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**Abstract**  
 In support of the Whole Sun Observatory and Helioseismic and Magnetic Imager (HMI) on the Solar Dynamics Observatory (SDO), we have produced synoptic maps of coronal hole locations for the Solar Cycle 25 (SC25) starting in February 2010 and continuing through SC25 (2010-2020). These maps, available for download from the High Altitude Observatory website, are derived from the Synoptic Coronal Hole Maps (SCHM) project, which uses the Synoptic Coronal Hole Maps (SCHM) project to produce synoptic maps of coronal hole locations for the Solar Cycle 25 (SC25) starting in February 2010 and continuing through SC25 (2010-2020). The maps are available for download from the High Altitude Observatory website.

**Description of Products**  
 SC25 and SC25+10 based maps show coronal hole locations for the Solar Cycle 25 (SC25) and the Solar Cycle 26 (SC26). The maps are available for download from the High Altitude Observatory website.

**Coronal Hole Synoptic maps**  
 The figure shows two synoptic maps of the Sun, one for SC25 and one for SC26. The maps show the locations of coronal holes in red and yellow, with a color scale indicating the strength of the magnetic field. The maps are available for download from the High Altitude Observatory website.

**Methodology**  
 These maps were created with the same methodology as the SDO and STEREO-A maps. The maps are available for download from the High Altitude Observatory website.

**Conclusions**  
 By tracking coronal hole locations and size over the entire SC25 period, we are able to get a picture of the location of coronal hole regions over the entire SC25 period. The maps are available for download from the High Altitude Observatory website.

CHAT INFO | ABSTRACT | CONTACT AUTHOR | PRINT | GET POSTER

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## ABSTRACT

In support of the Whole Heliosphere and Planetary Interactions (WHPI) <https://whpi.hao.ucar.edu/> (<https://whpi.hao.ucar.edu/>) effort and to highlight solar structure near solar minimum we are producing solar synoptic maps featuring coronal hole boundaries for the WHPI period (December 2018 – February 2020 or Carrington Rotation's 2212 – 2226). These maps, made in the manner established by Patrick McIntosh and used in the McIntosh Archive of Synoptic maps, enable studies of solar features and their relation to structures in the solar wind and space environment of the earth and other planets. Patrick McIntosh contributed three maps to the initial Whole Sun Months (WSM; 1996), and Robert McFadden, McIntosh's primary cartographer for Solar Cycle 23, similarly contributed three maps to the Whole Heliospheric Interval (WHI; 2008). For the purposes of this study, we focus on coronal hole data using EUV data of 193 Å and 304 Å from the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO). In addition, synoptic maps for CR's 2212 – 2226 are being made from the Solar TERrestrial RELations Observatory (STEREO-A) perspective with EUV 195 Å in order to study coronal hole evolution over time. We hope to compare the positions of coronal holes to stream structure in solar wind data using MAVEN and OMNI data as well as solar wind tracking tools.

The McIntosh Archive of Synoptic maps can be found here.

<https://www2.hao.ucar.edu/mcintosh-archive/four-cycles-solar-synoptic-maps> (<https://www2.hao.ucar.edu/mcintosh-archive/four-cycles-solar-synoptic-maps>)

## DESCRIPTION OF PRODUCTS

SDO and STEREO based maps show positive polarity coronal holes in blue and negative polarity coronal holes in red. As SDO maps use two sets of EUV images, SDO map coronal holes are composites based on two EUV lines: AIA 193 (outlines traced in dark orange) and AIA 304 (outlines traced in burgundy). The colored in (red/blue) coronal hole boundaries represent the largest extent of either of the two lines. The coronal hole polarity is established with SDO magnetograms for SDO maps and is used in STEREO maps for any similarly located coronal holes on STEREO maps. The coronal holes on the STEREO maps that have a gold border and pale interior are ones that did not have a corresponding coronal hole in the same location on the SDO map and therefore we could not establish the polarity. We note that more and/or larger coronal holes are visible from SDO than STEREO presumably due to SDO's higher resolution.

# CORONAL HOLE SYNOPTIC MAPS

McIntosh Archive (WHPI STEREO-A) Synoptic Map

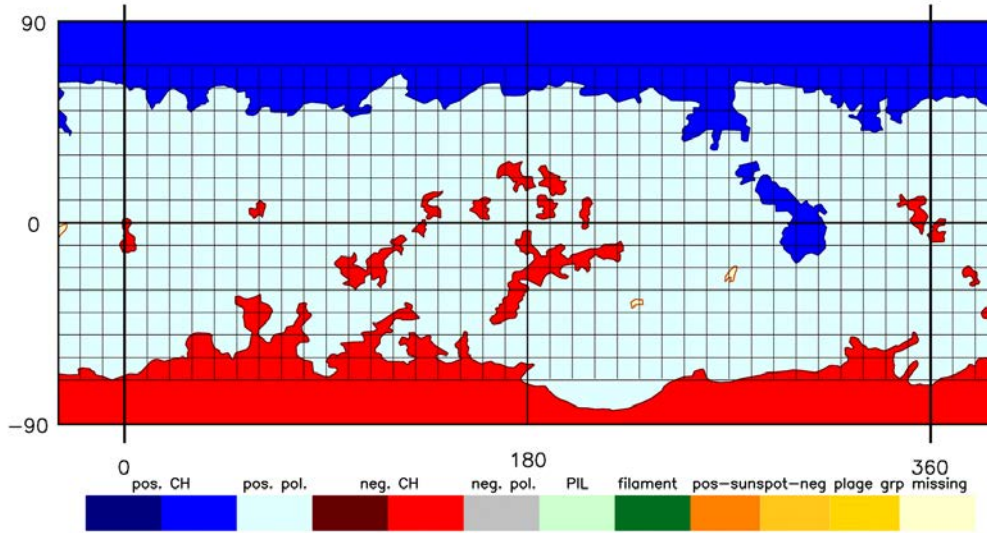
End date (longitude=0): 2019-01-09

Start date (longitude=360): 2018-12-12T19:40:30

B angle end date 6.7

B angle start date 6.7

CR2211wa



McIntosh Archive (WHPI SDO/AIA) Synoptic Map

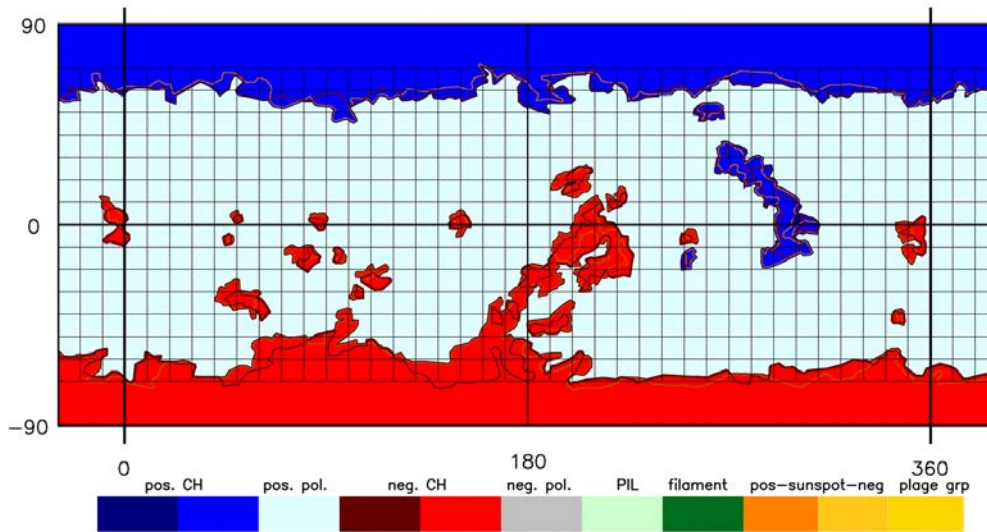
End date (longitude=0): 2018-12-20T11:53:28

Start date (longitude=360): 2018-11-23T04:13:10

B angle end date -1.57

B angle start date 1.900

CR2211we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

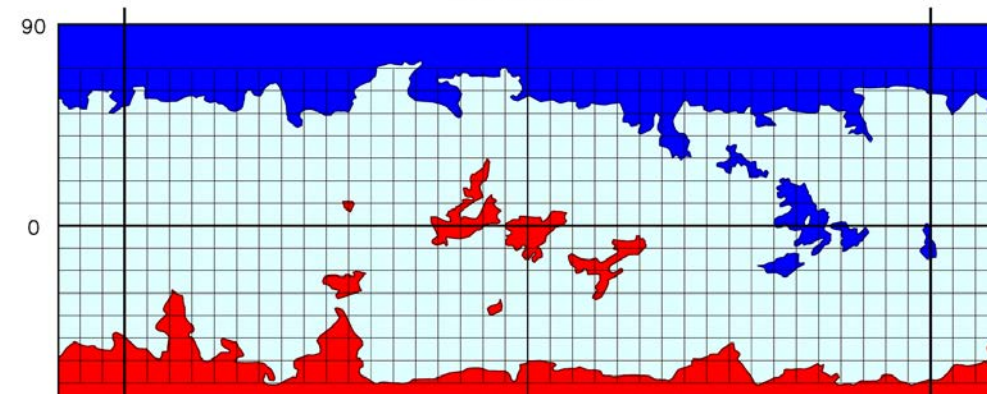
End date (longitude=0): 2019-02-05T15:53:30

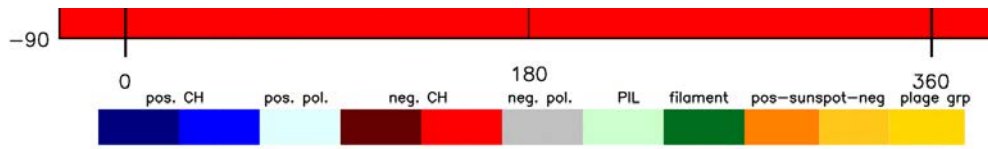
Start date (longitude=360): 2019-01-09T06:05:00

B angle end date 4.5

B angle start date 6.7

CR2212wa





McIntosh Archive (WHPI SDO/AIA) Synoptic Map

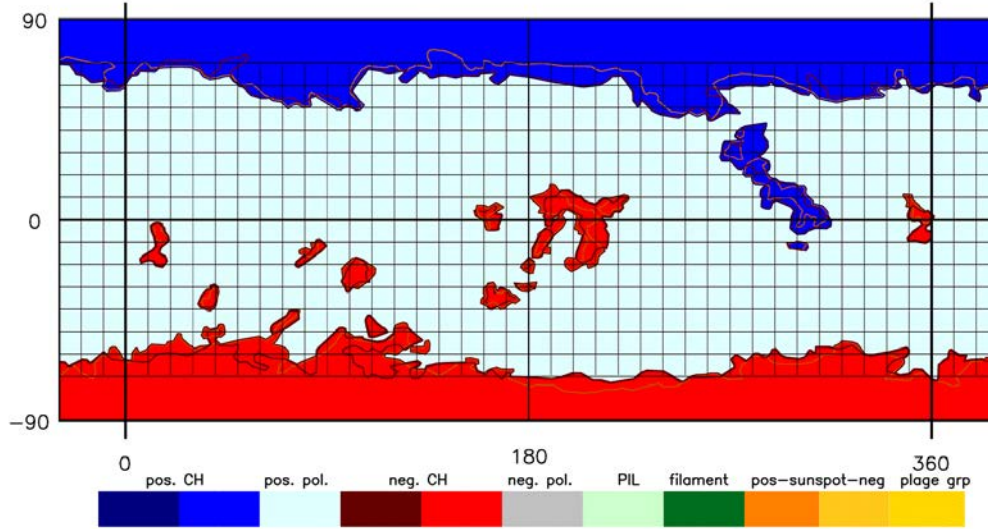
End date (longitude=0):2019-01-16T19:54:55

Start date (longitude=360):2018-12-20T11:53:28

B angle end date -4.69

B angle start date -1.57

CR2212we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

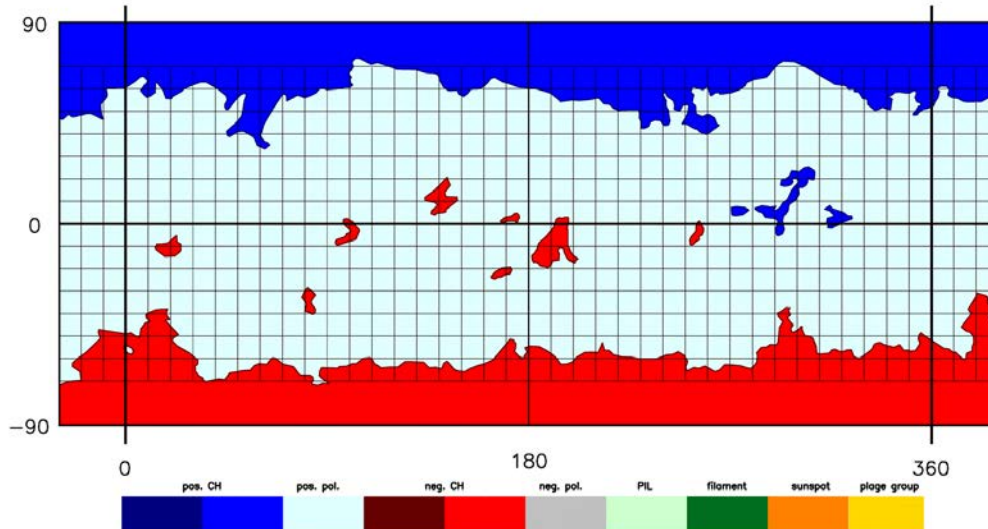
End date (longitude=0): 2019-03-05T01:02:30

Start date (longitude=360): 2019-02-05T15:53:30

B angle end date 1.2

B angle start date 4.5

CR2213wa





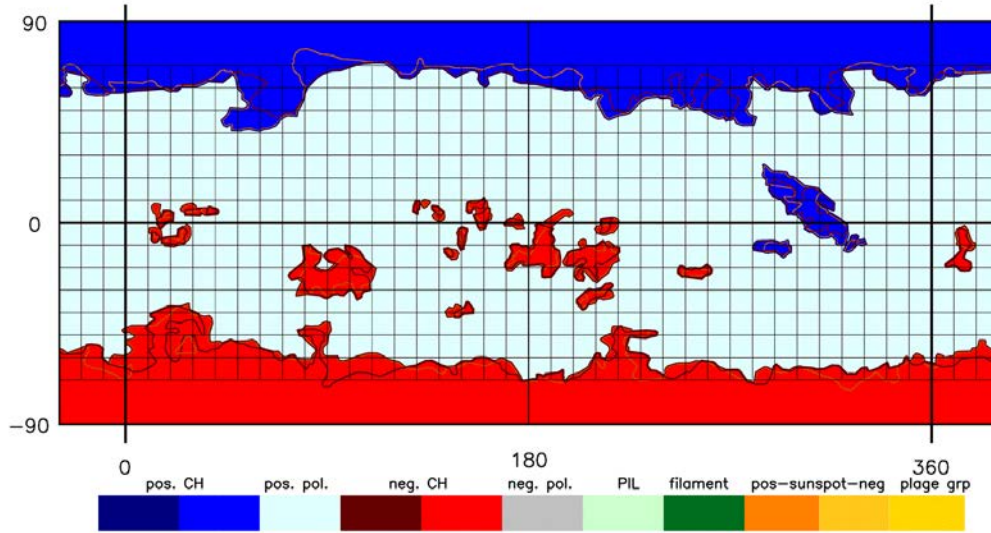
McIntosh Archive (WHPI SDO/AIA) Synoptic Map

End date (longitude=0):2019-02-13T04:07:08 Start date (longitude=360):2019-01-16T19:54:55

B angle end date -6.73

B angle start date -4.69

CR2213we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

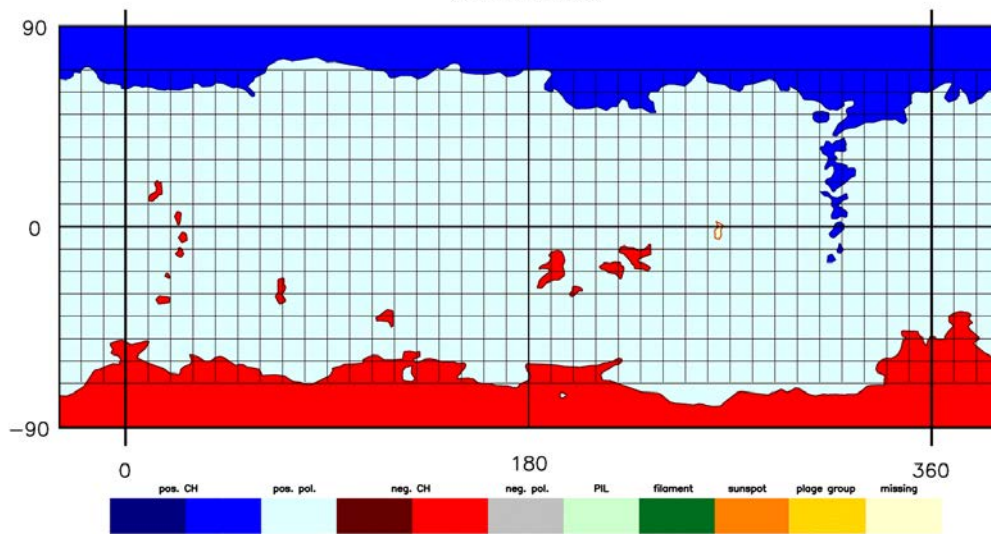
End date (longitude=0): 2019-04-01T09:45:05

Start date (longitude=360): 2019-03-05T01:02:31

B angle end date -2.4

B angle start date 1.2

CR2214wa



McIntosh Archive (WHPI SDO/AIA) Synoptic Map

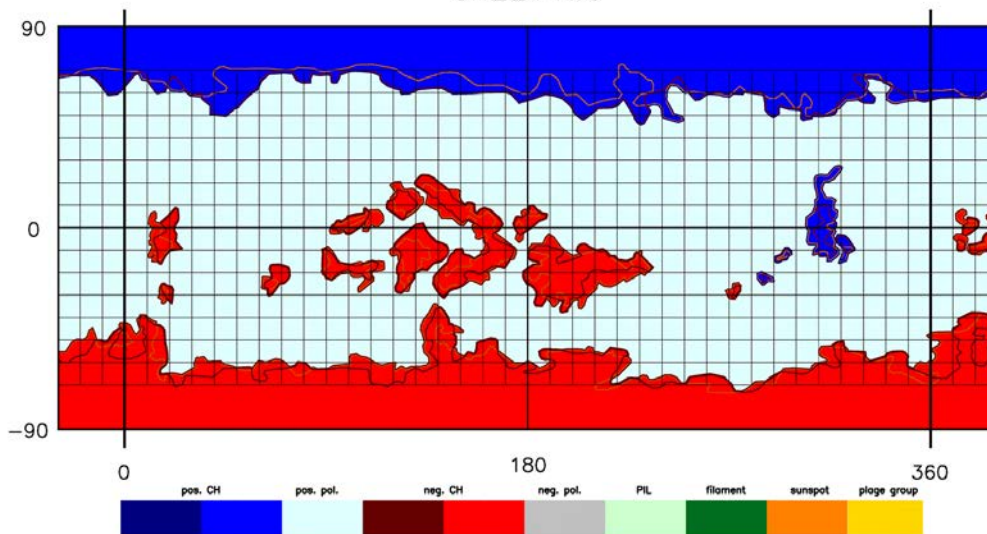
End date (longitude=0):2019-03-12T12:03:32

Start date (longitude=360):2019-02-13T04:07:08

B angle end date -7.22

B angle start date -6.73

CR2214we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

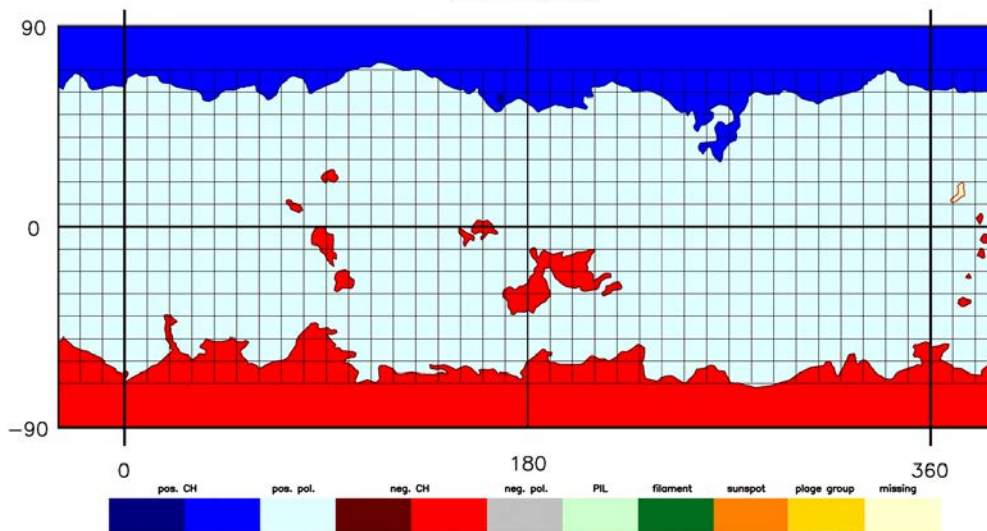
End date (longitude=0): 2019-04-28T18:36:45

Start date (longitude=360): 2019-04-01T09:45:05

B angle end date -5.4

B angle start date -2.4

CR2215wa

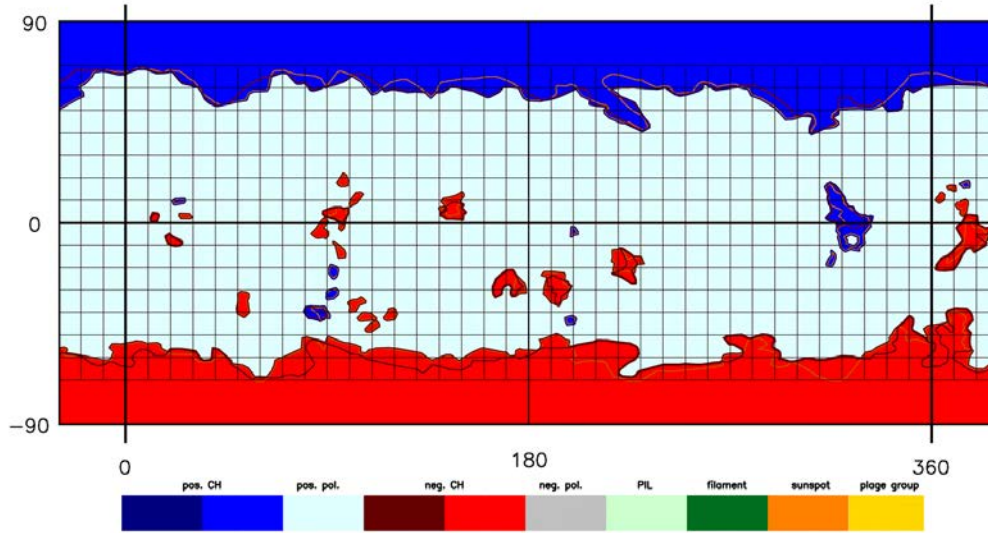




McIntosh Archive (WHPI SDO/AIA) Synoptic Map

End date (longitude=0):2019-04-08T19:12:44 Start date (longitude=360):2019-03-12T12:03:32  
B angle end date -6.10 B angle start date -7.22

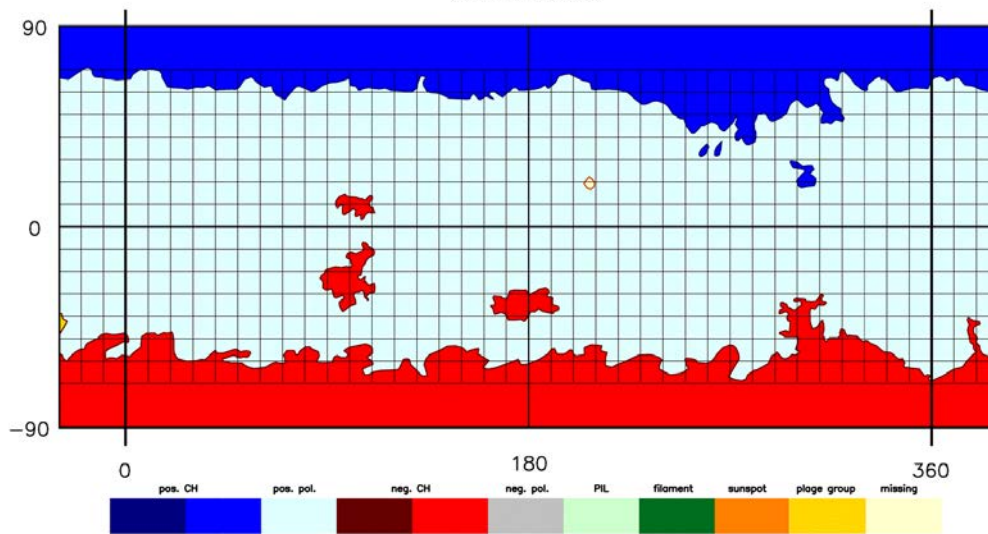
CR2215we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

End date (longitude=0): 2019-05-26T03:46:30 Start date (longitude=360): 2019-04-28T18:36:45  
B angle end date -7.1 B angle start date -5.4

CR2216wa



McIntosh Archive (WHPI SDO/AIA) Synoptic Map

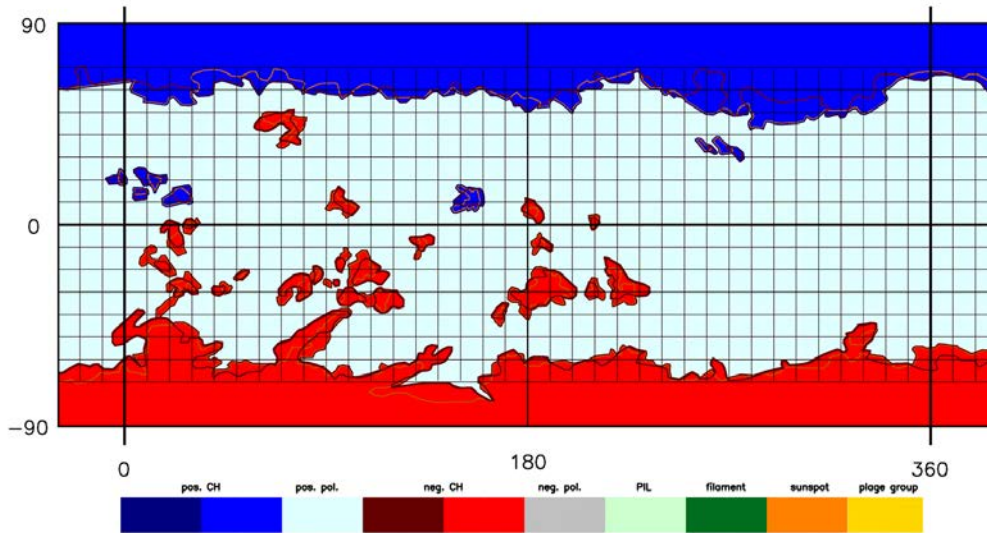
End date (longitude=0):2019-05-06T01:18:25

Start date (longitude=360):2019-04-08T19:12:44

B angle end date -3.70

B angle start date -6.10

CR2216we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

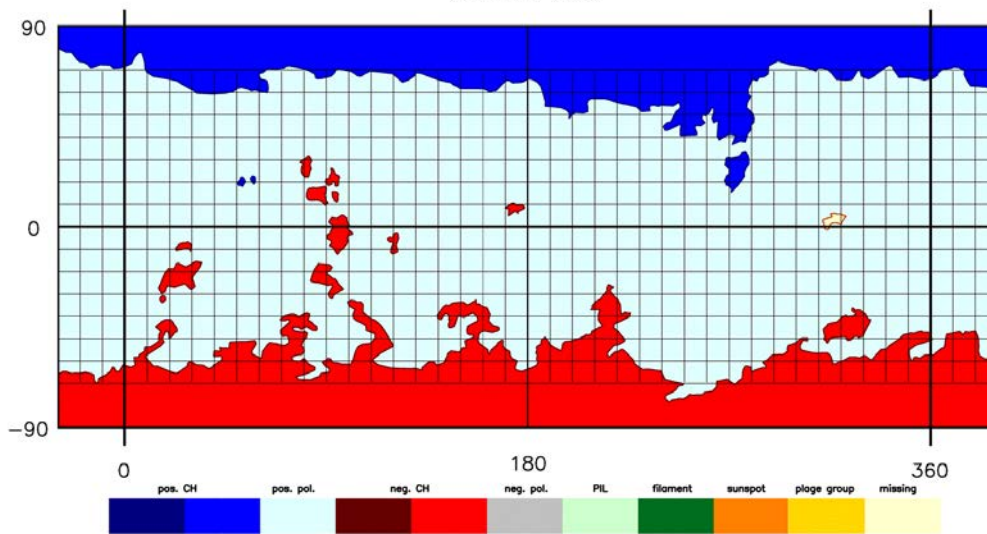
End date (longitude=0): 2019-06-22T13:16:30

Start date (longitude=360): 2019-05-26T03:46:30

B angle end date -7.1

B angle start date -7.1

CR2217wa



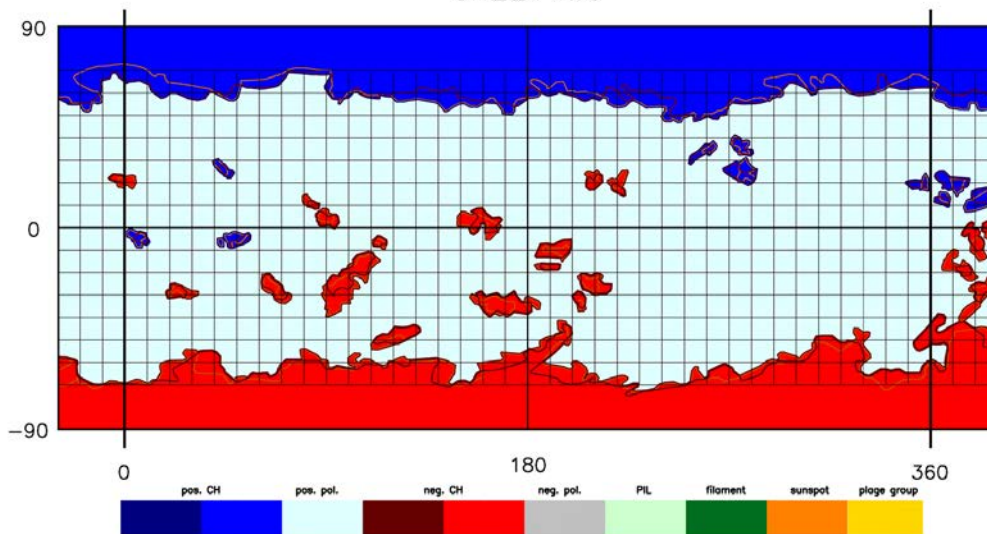
McIntosh Archive (WHPI SDO/AIA) Synoptic Map

End date (longitude=0):2019-06-02T06:29:39 Start date (longitude=360):2019-05-06T01:18:25

B angle end date -0.58

B angle start date -3.70

CR2217we



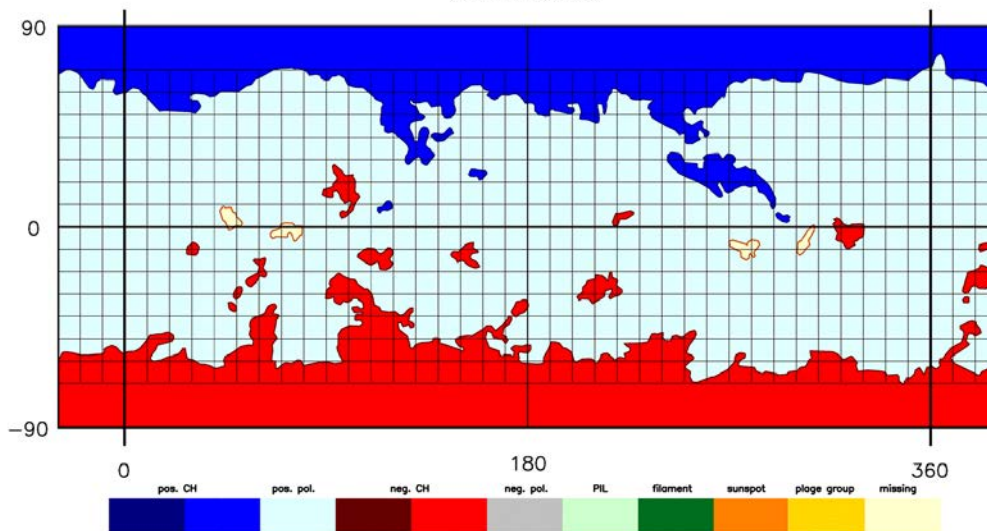
McIntosh Archive (WHPI STEREO-A) Synoptic Map

End date (longitude=0): 2019-07-19T22:48:45 Start date (longitude=360): 2019-06-22T13:16:30

B angle end date -5.4

B angle start date -5.4

CR2218wa





McIntosh Archive (WHPI SDO/AIA) Synoptic Map

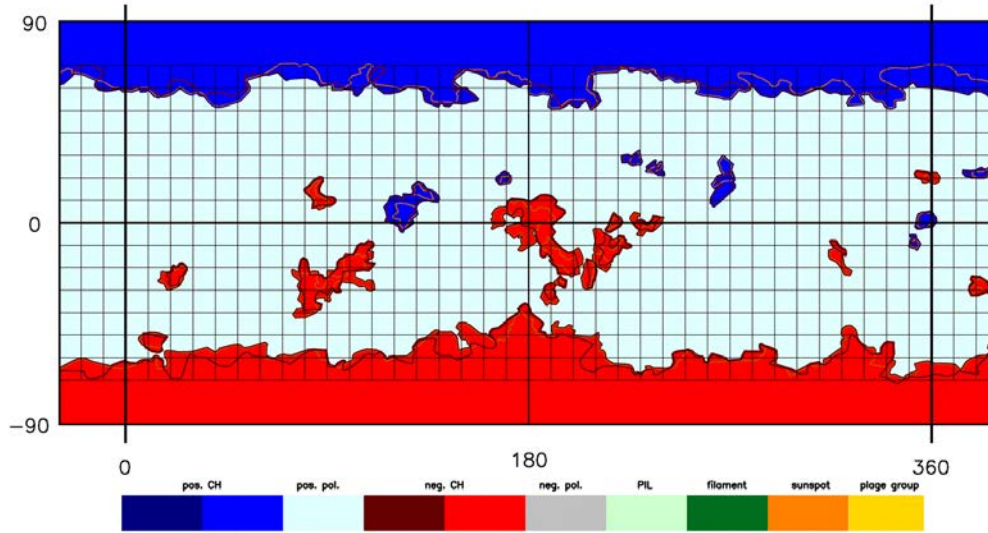
End date (longitude=0):2019-06-29T11:15:14

Start date (longitude=360):2019-06-02T06:29:39

B angle end date 2.640

B angle start date -0.58

CR2218we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

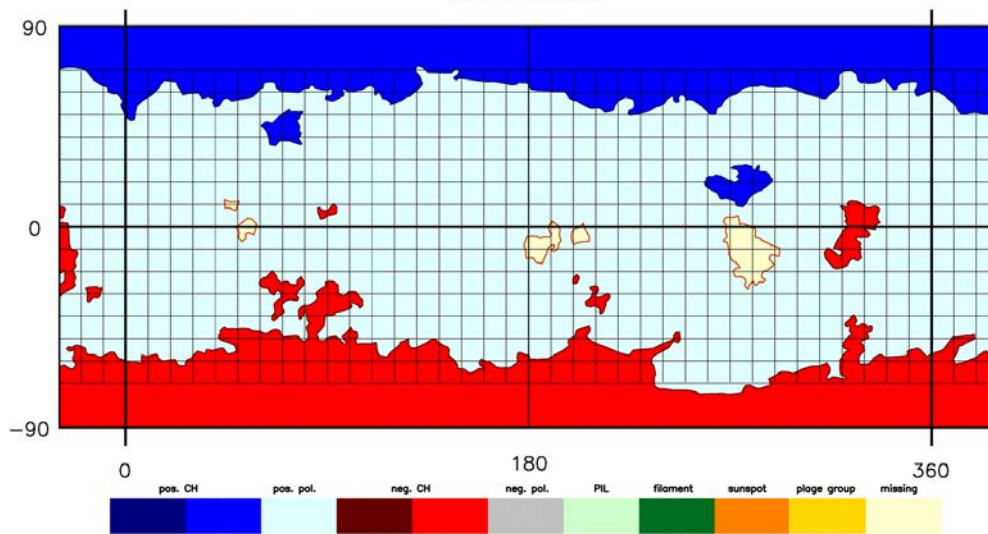
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Start date (longitude=360): 2019-07-19T22:48:45

B angle end date -2.4

B angle start date -5.4

CR2219wa



McIntosh Archive (WHPI SDO/AIA) Synoptic Map

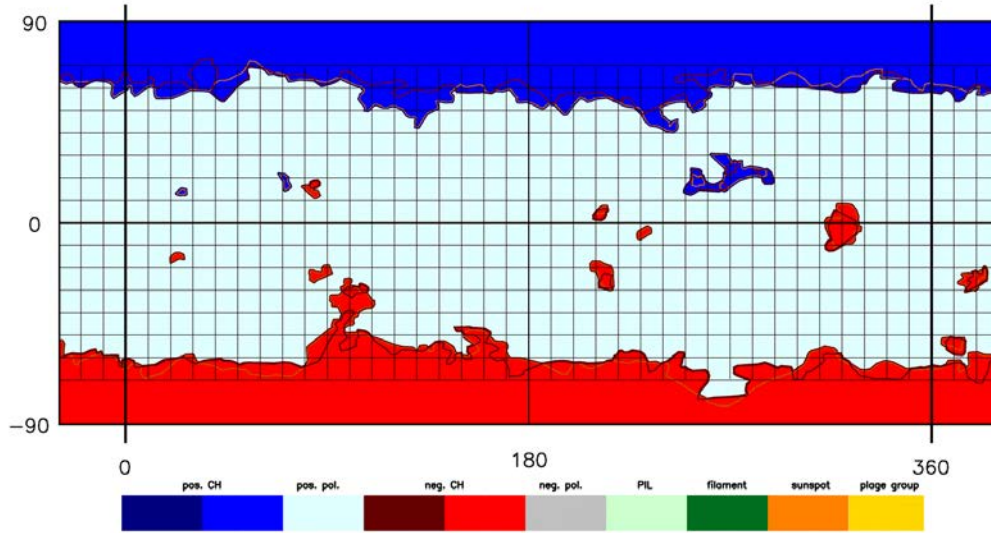
End date (longitude=0):2019-07-26T16:09:25

Start date (longitude=360):2019-06-29T11:15:14

B angle end date 5.330

B angle start date 2.640

CR2219we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

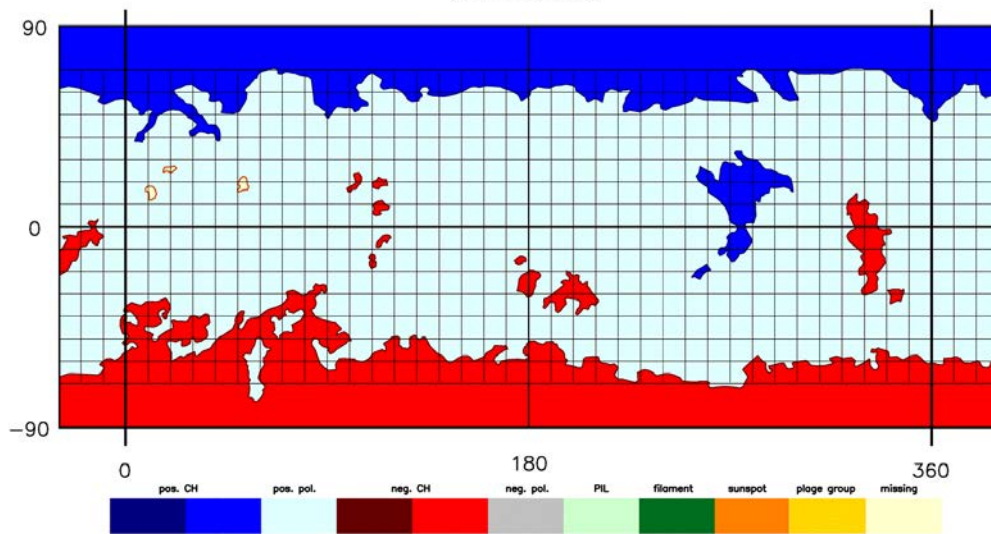
End date (longitude=0): 2019-09-12T17:45:05

Start date (longitude=360): 2019-08-16T08:15:25

B angle end date 1.2

B angle start date -2.4

CR2220wa





McIntosh Archive (WHPI SDO/AIA) Synoptic Map

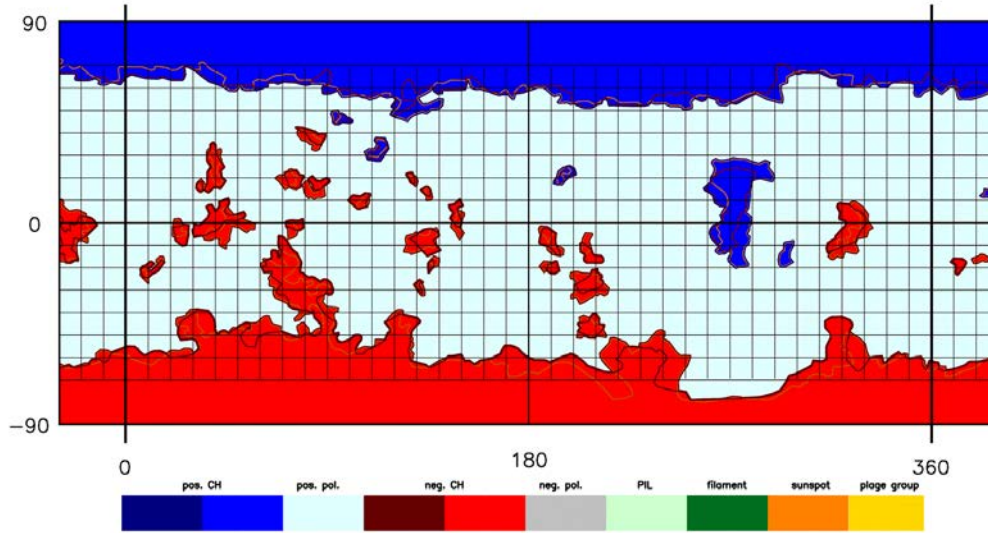
End date (longitude=0):2019-08-22T21:37:38

Start date (longitude=360):2019-07-26T16:09:25

B angle end date 6.950

B angle start date 5.330

CR2220we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

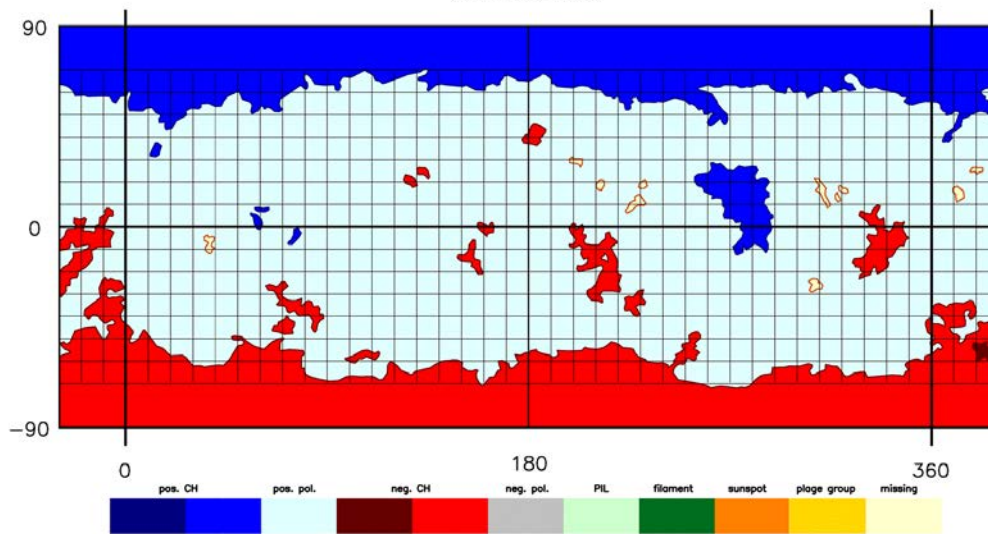
End date (longitude=0): 2019-10-10T03:34:05

Start date (longitude=360): 2019-09-12T17:45:05

B angle end date 4.6

B angle start date 1.2

CR2221wa



McIntosh Archive (WHPI SDO/AIA) Synoptic Map

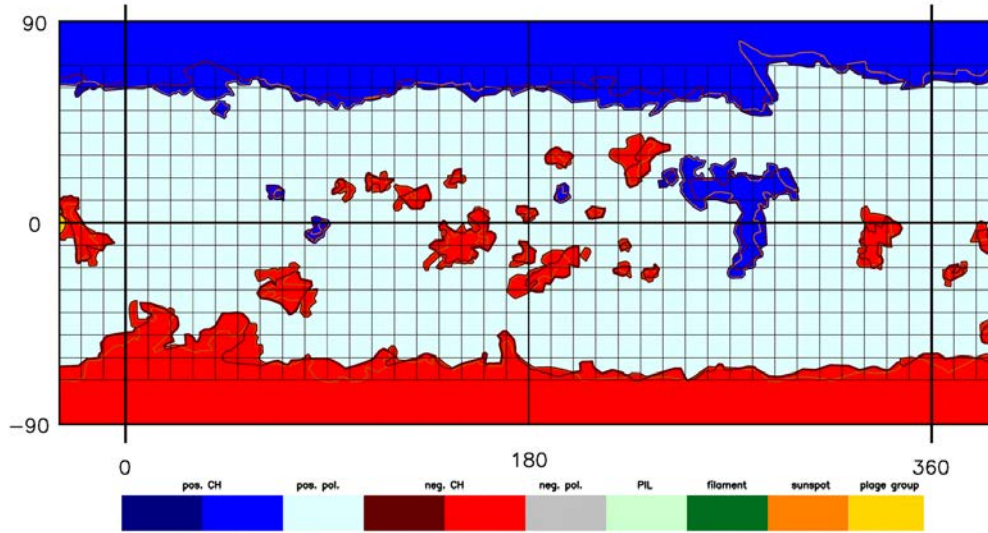
End date (longitude=0):2019-09-19T03:48:17

Start date (longitude=360):2019-08-22T21:37:38

B angle end date 7.140

B angle start date 6.950

CR2221we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

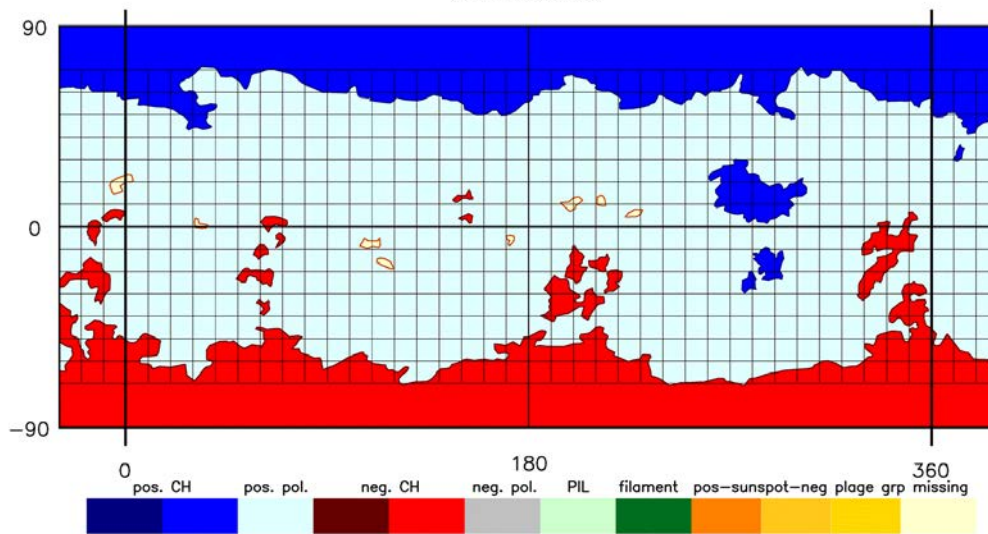
End date (longitude=0): 2019-11-06T13:51:15

Start date (longitude=360): 2019-10-10T03:34:05

B angle end date 6.8

B angle start date 4.6

CR2222wa



McIntosh Archive (WHPI SDO/AIA) Synoptic Map

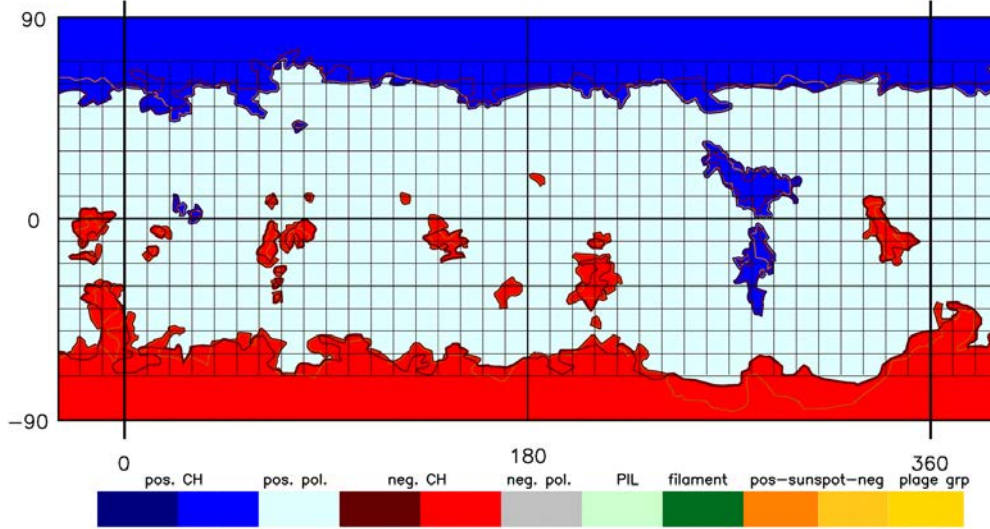
End date (longitude=0):2019-10-16T10:34:43

Start date (longitude=360):2019-09-19T03:48:17

B angle end date 5.800

B angle start date 7.140

CR2222we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

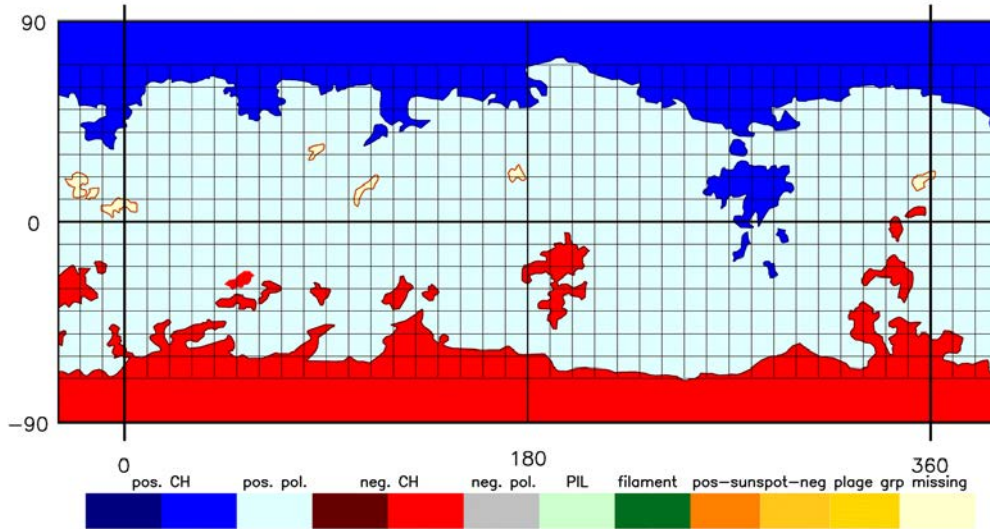
End date (longitude=0): 2019-12-04T00:20:15

Start date (longitude=360): 2019-11-08T13:51:15

B angle end date 7.3

B angle start date 6.8

CR2223wa





McIntosh Archive (WHPI SDO/AIA) Synoptic Map

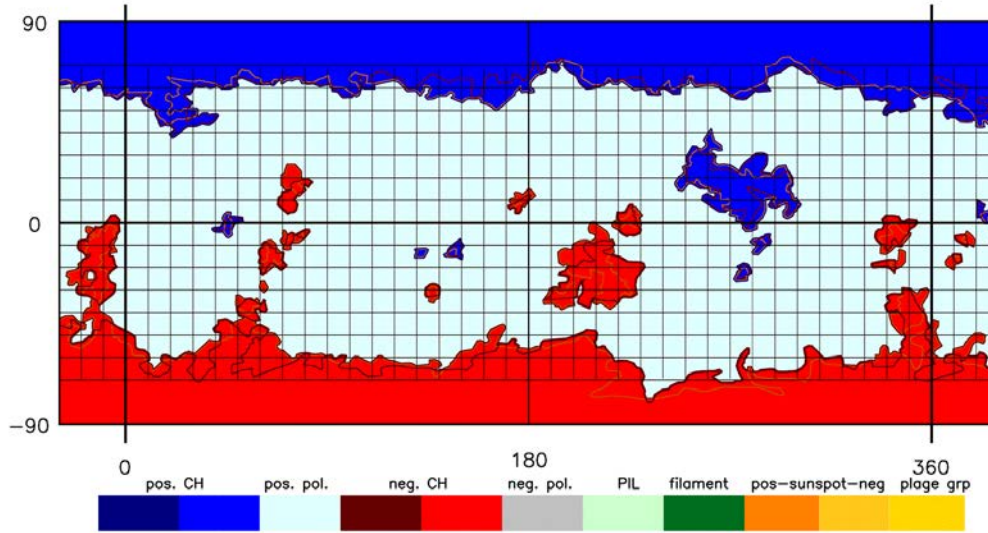
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Start date (longitude=360):2019-10-16T10:34:43

B angle end date 3.170

B angle start date 5.800

CR2223we



McIntosh Archive (WHPI STEREO-A) Synoptic Map

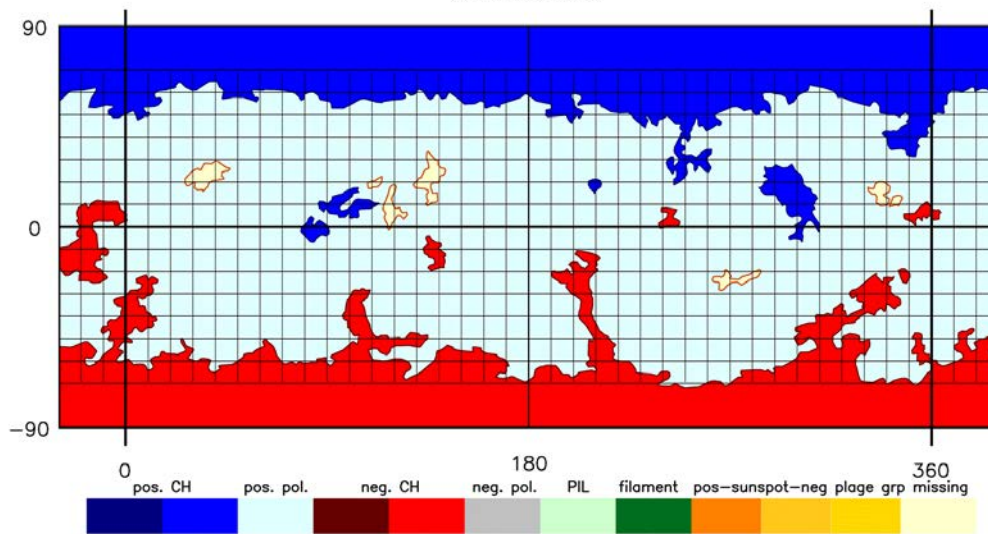
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Start date (longitude=360): 2019-12-04T00:20:15

B angle end date 6.0

B angle start date 7.3

CR2224wa



McIntosh Archive (WHPI SDO/AIA) Synoptic Map

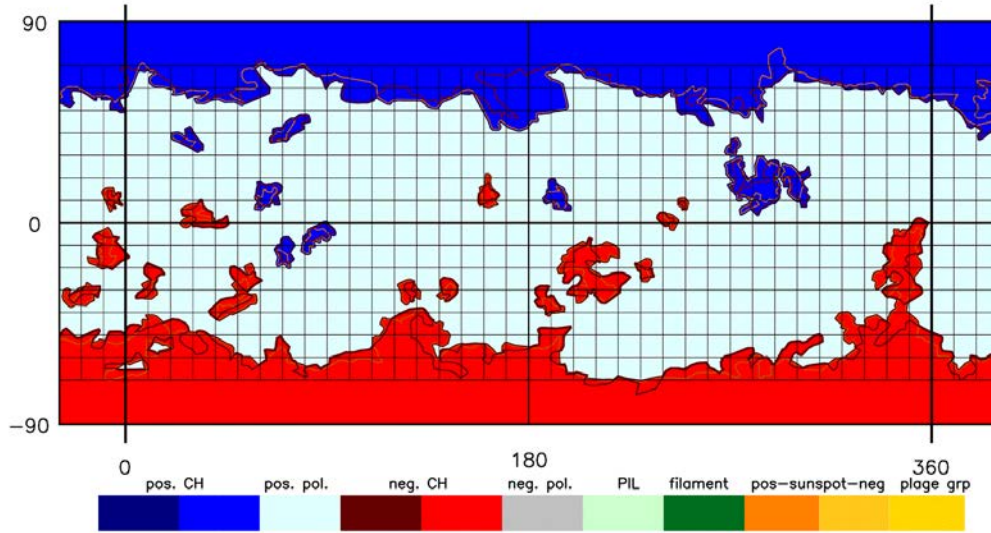
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Start date (longitude=360):2019-11-12T17:46:11

B angle end date -0.21

B angle start date 3.170

CR2224we

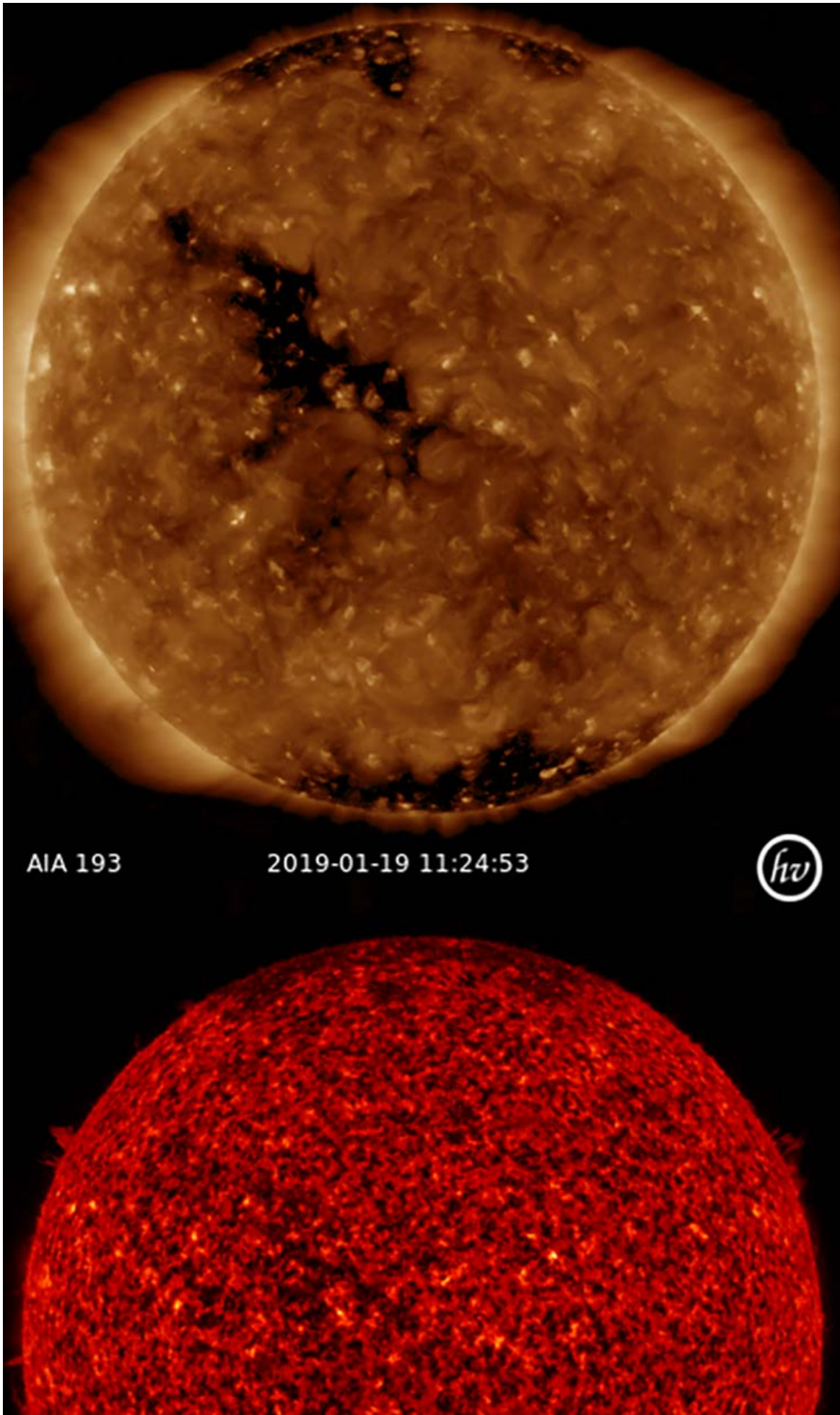


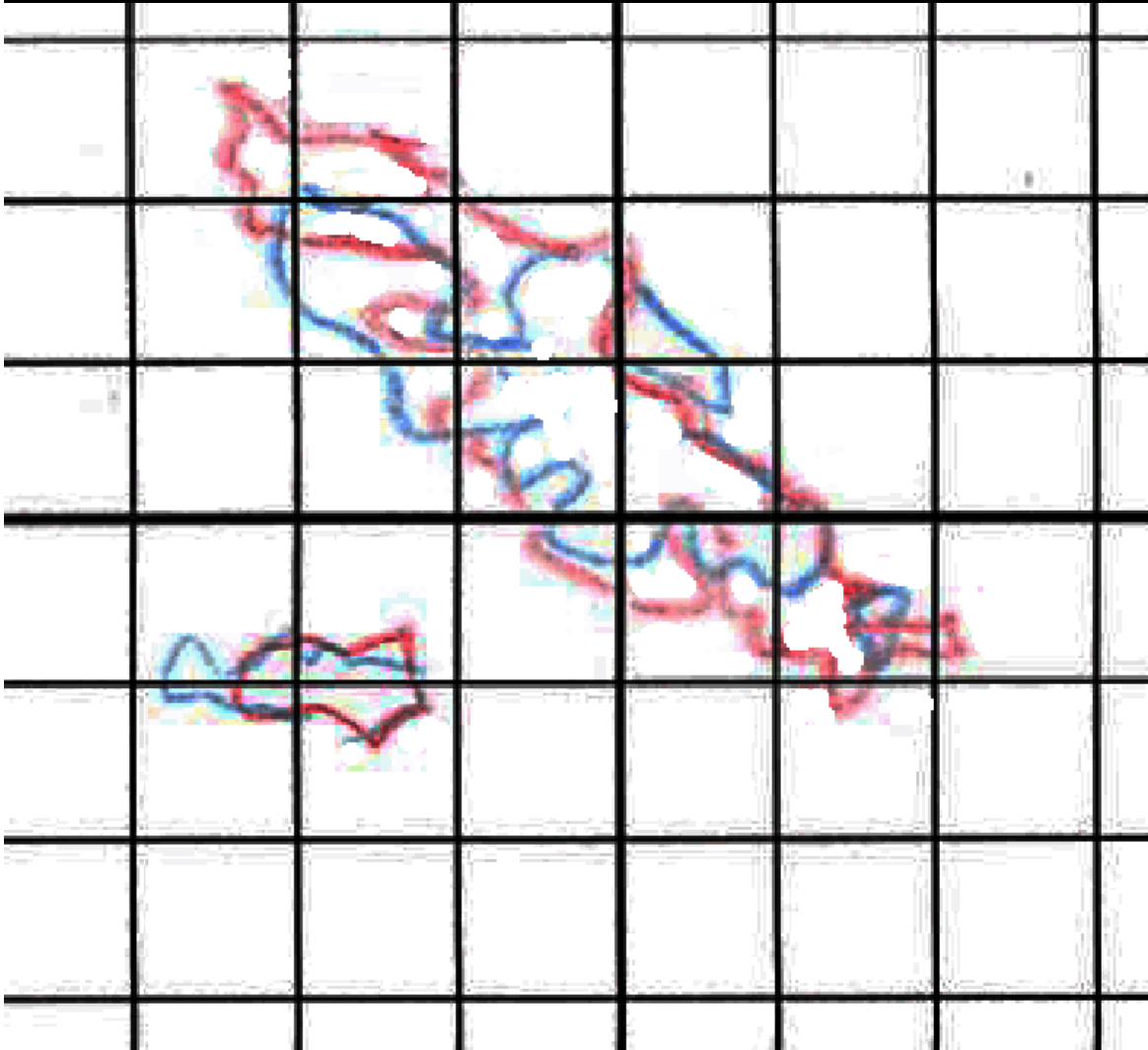
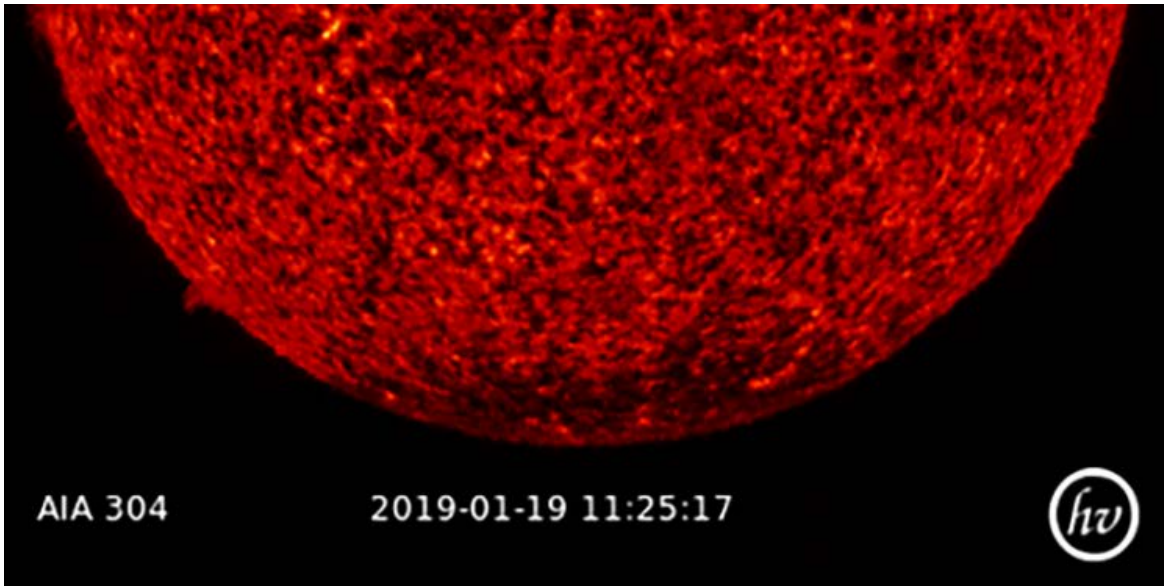


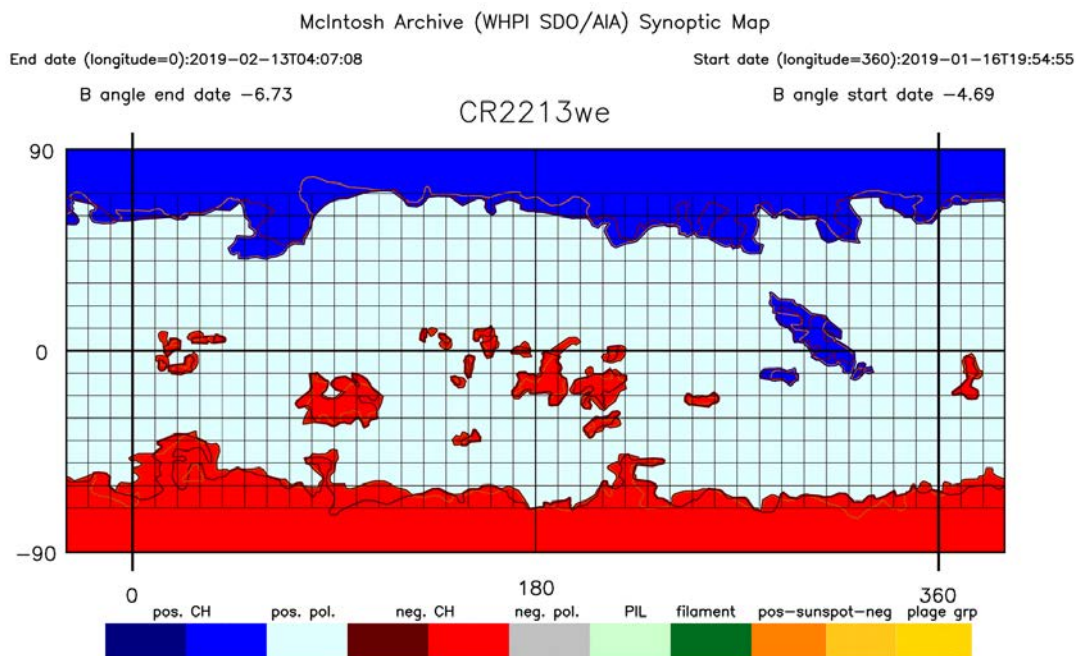
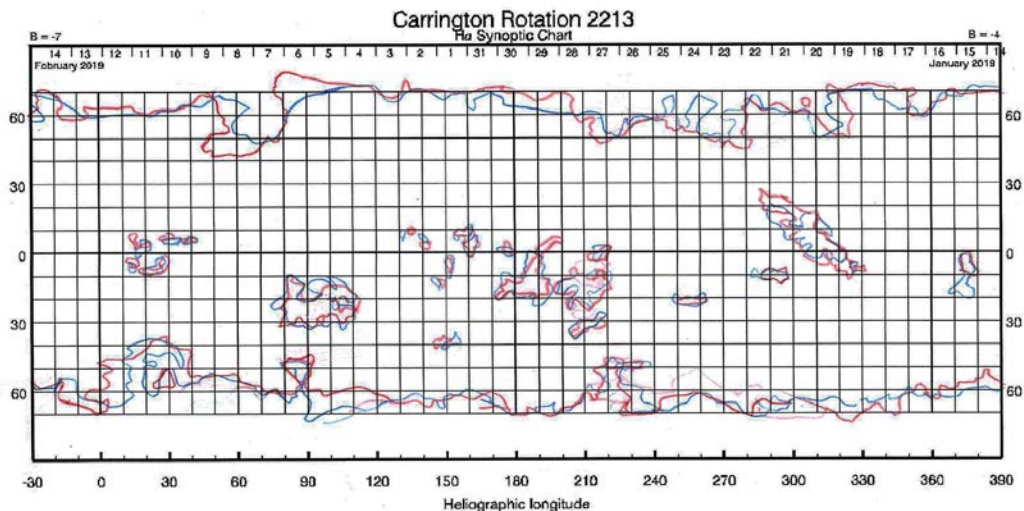
## METHODOLOGY

These maps were made with the same techniques McIntosh developed, and that he and his cartographers used to create the original handmade maps in the McIntosh Archive. However, magnetogram and H alpha images were only used to confirm the polarity of the coronal holes and eliminate filament channels. Unlike the McIntosh Archive, these maps only include coronal hole boundaries and polarities. Daily image coronal hole boundaries were traced and manually transferred to a monthly synoptic map using Stonyhurst disks to adjust for B angle and then converted from spherical coordinates to the rectangular synoptic format. Original handmade maps are then colorized and digitized with Photoshop and IDL.











## CONCLUSIONS

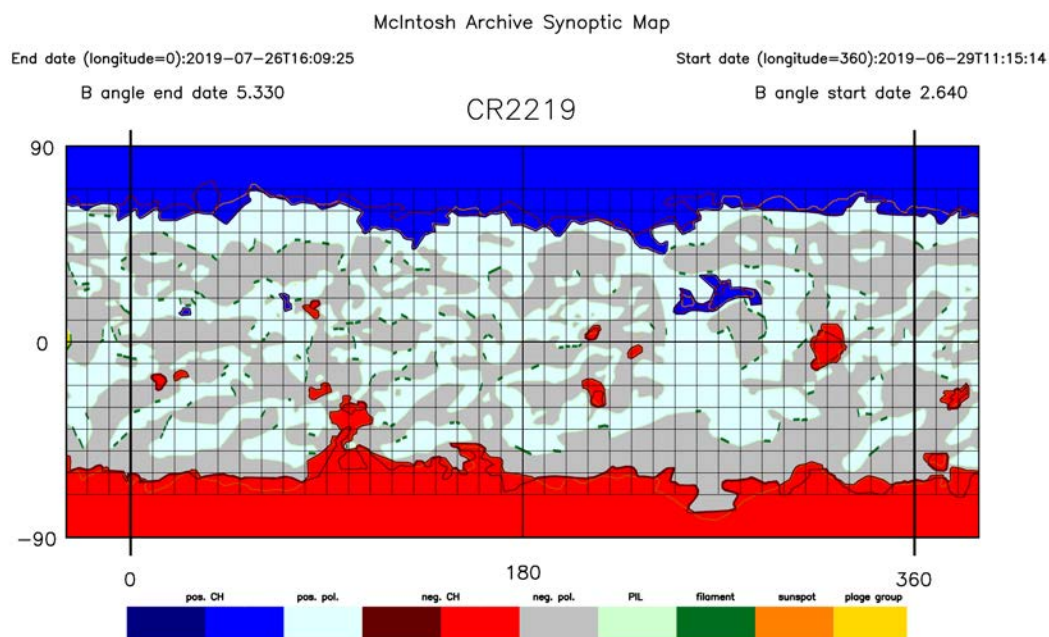
By tracking coronal hole positions and size over the entire WHPI interval we are able to get a picture of the sources of recurrent high speed solar wind streams (HSS) around solar minimum. Several long-lived low-latitude coronal holes are maintained during this time period, leading to periodic forcing of the Earth's space environment by recurring HSS. We expect to find similar periodic forcings in the vicinity of other planets such as Mars, and look forward to a more detailed end-to-end analyses.

# ABSTRACT

Ian Hewins(1), Sarah Gibson (1), Barbara Emery-Geiger (1)

1 = HAO/NCAR

In support of the Whole Heliosphere and Planetary Interactions (WHPI) effort and to highlight solar structure near solar minimum we are producing solar synoptic maps featuring coronal hole boundaries for the WHPI period (December 2018 – February 2020 or CR's 2212 – 2226). These maps, made in the manner established by Patrick McIntosh and used in the McIntosh Archive of Synoptic maps, enable studies of solar features and their relation to structures in the solar wind and space environment of the earth and other planets. Patrick McIntosh contributed three maps to the initial Whole Sun Months (WSM; 1996), and Robert McFadden, McIntosh's primary cartographer for Solar Cycle 23, similarly contributed three maps to the Whole Heliospheric Interval (WHI; 2008). Hewins, who was trained by McIntosh and McFadden will be producing these maps with a focus on coronal hole data using EUV data from SDO (AIA 193 and 304) although some maps will utilize H $\alpha$  and photospheric magnetic field to represent filaments, filament channels, and the large scale distribution of the dominant magnetic polarity, as well. In addition, synoptic maps for CR's 2212 – 2226 are being made from the STEREO perspective with EUVI 195 in order to study coronal hole evolution over time. In some cases, STEREO's alignment is similar to the position of Mars. We hope to compare the positions of coronal holes to stream structure in solar wind data using MAVEN and OMNI data as well as solar wind tracking tools.



([https://agu.confex.com/data/abstract/agu/fm20/0/1/Paper\\_669610\\_abstract\\_641172\\_0.gif](https://agu.confex.com/data/abstract/agu/fm20/0/1/Paper_669610_abstract_641172_0.gif))