McIntosh Synoptic Map Solar Minimum Study

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WHPI Solar Minimum Study

Introduction:

In 1964 (Solar Cycle 20), Patrick McIntosh began creating hand-drawn synoptic maps of solar magnetic features, based on Ha images. These synoptic maps were unique in that they traced magnetic polarity inversion lines (PILs) and connected widely separated filaments, fibril patterns, and plage corridors to reveal the large-scale organization of the solar magnetic field (McIntosh, 1979, NOAA, UAG-70). McIntosh and his cartographer Bob McFadden created and contributed Maps to both WSM (CR1912 and CR1913) and WHI (CR2068, CR2078 and CR2085) (see Fig 1). Hewins, also a cartographer trained by McIntosh, under the guidance of McFadden will make and contribute 13 maps to the WHPI effort (October 2018 - January 2020).

Focus of Study:

Through participation in WHPI (Whole Heliosphere and Planetary Interactions), we hope to contribute to the series of coordinated observing campaigns for this year. As McIntosh style synoptic maps were made for the two previous minima studies, these maps can help us understand how minimum varies from cycle to cycle. In addition, a comparison of He 10830 Ă to EUV for finding coronal hole boundaries was done (see Fig. 3). Hewins and McFadden generally use ground-based He 10830 images for the WHPI time period He 10830 Ă is not available so instead EUV is used.

Figure 1a. WSM

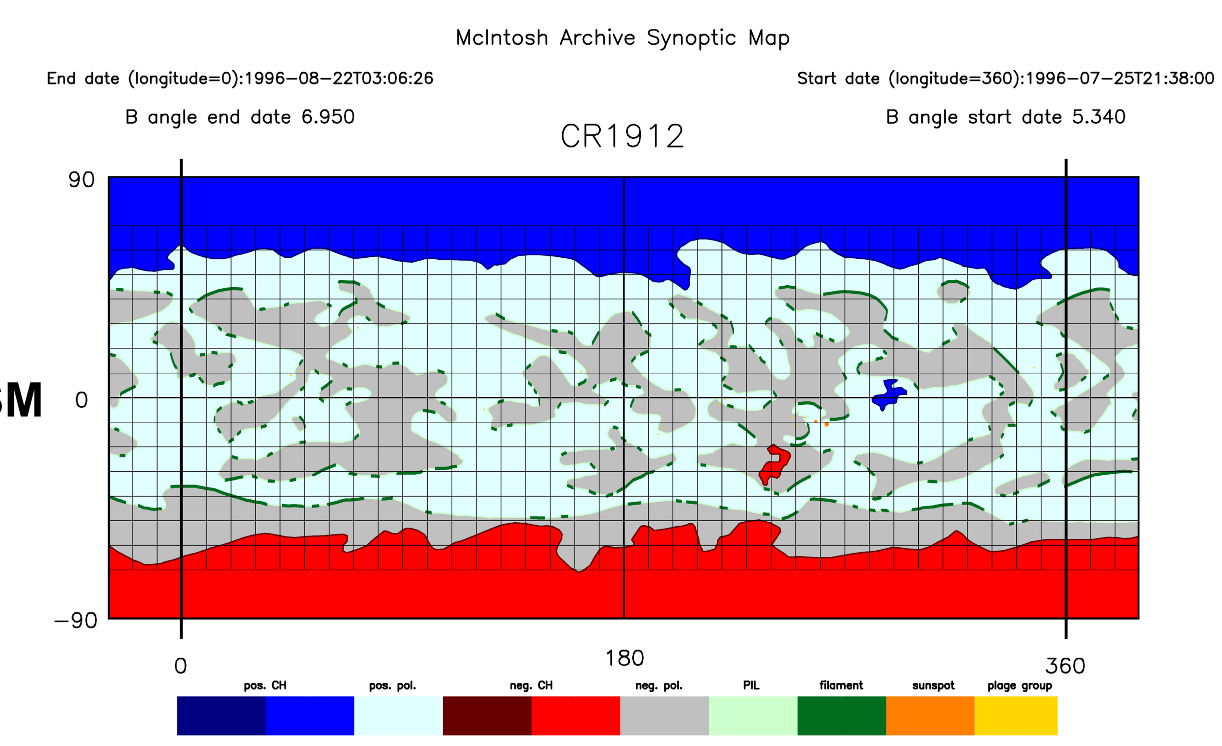

Figure 1b. WHI

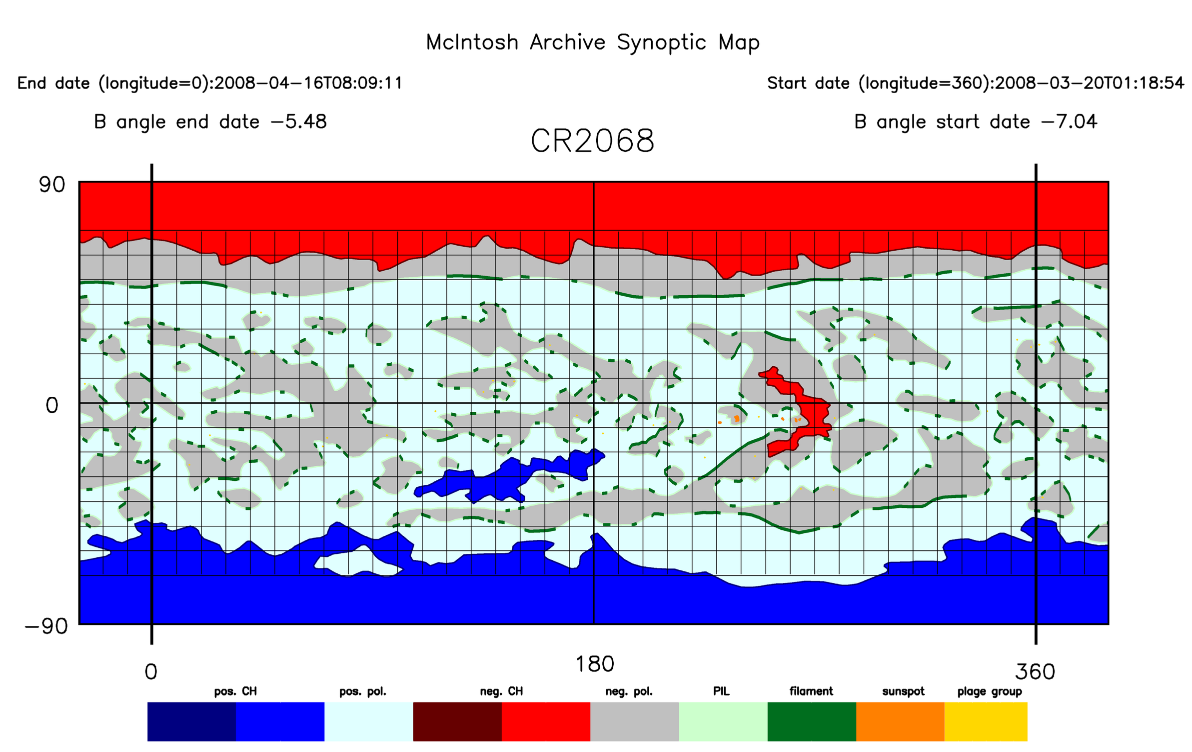

Figure 1: a. WSM and b. WHI McIntosh Maps
In these two maps from previous Minimum studies note the dominant polarity inversion and similarity of low latitude coronal hole positions. Note that the area of the low latitude coronal holes in 2008 or CR 2068 is larger and these coronal holes had longer lifetimes than those of CR1912 (Gibson, et al, Solar Phys (2011)).

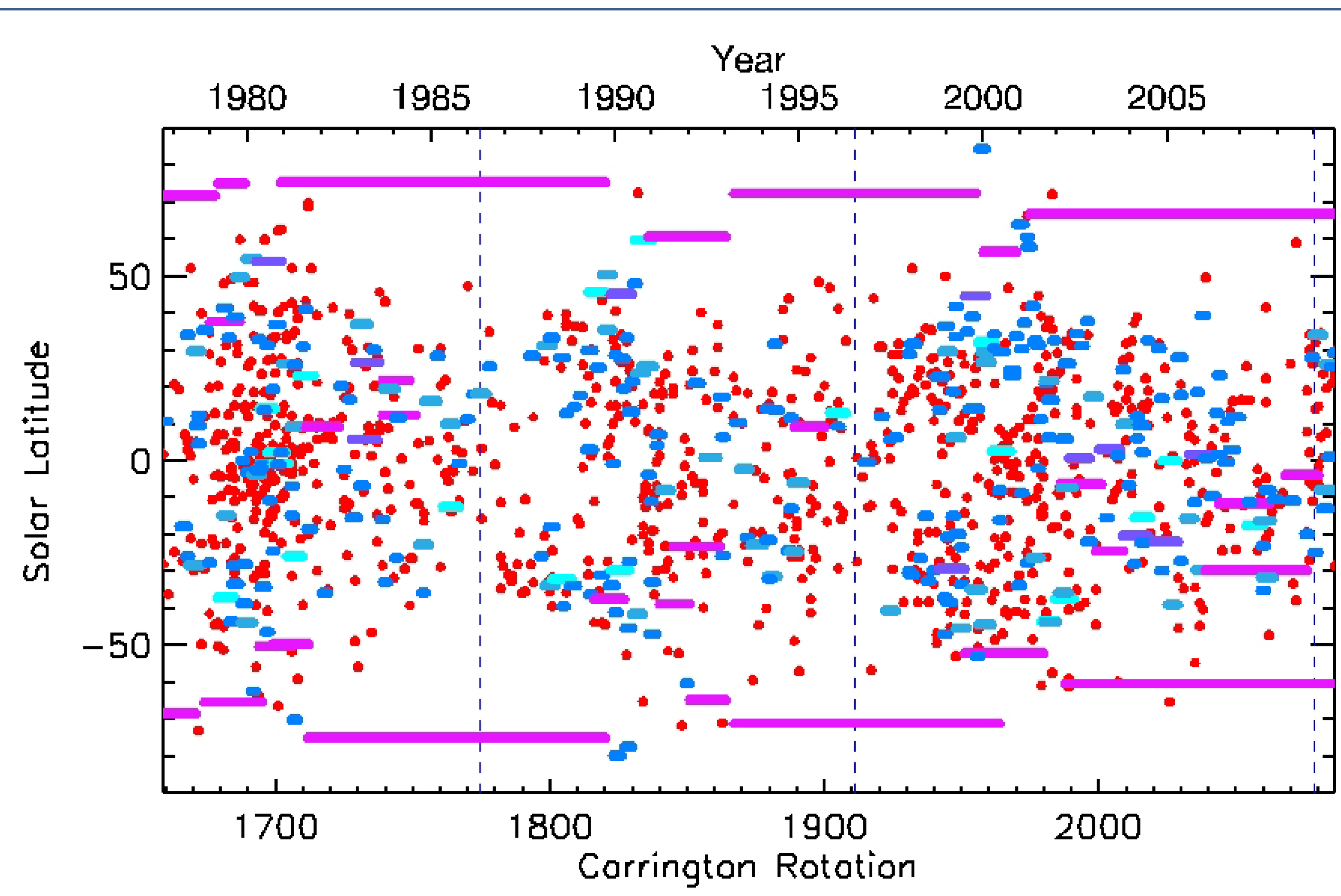

Figure 2:
This plot shows the positions of low latitude coronal holes and their lifespans by initial latitude and time over three solar cycles. Each coronal hole is shown by heliographic longitude and lifespan over the two solar cycles, with color representing lifespan by rotation. Red represents 1 rotational lifetime, Blue 2 – 3 lifetimes, medium blue 4-5, light blue 6-7, cyan 8-9, purple 10-11, magenta 12+. Note there are more long lived low latitude coronal holes from 2004 to 2008 (SC23) than from the last few years of SC22.

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McIntosh, P. S. 1979, NOAA Report UAG-70.
Webb, D.F. et al. 2018, Frontiers, Astronomy Journal, 5, 23.
Gibson, S.E., de Toma, G., Emery, B., et al. Sol Phys (2011) 274: 5. https://doi.org/10.1007/s11207-011-9921-4.

Figure 3a

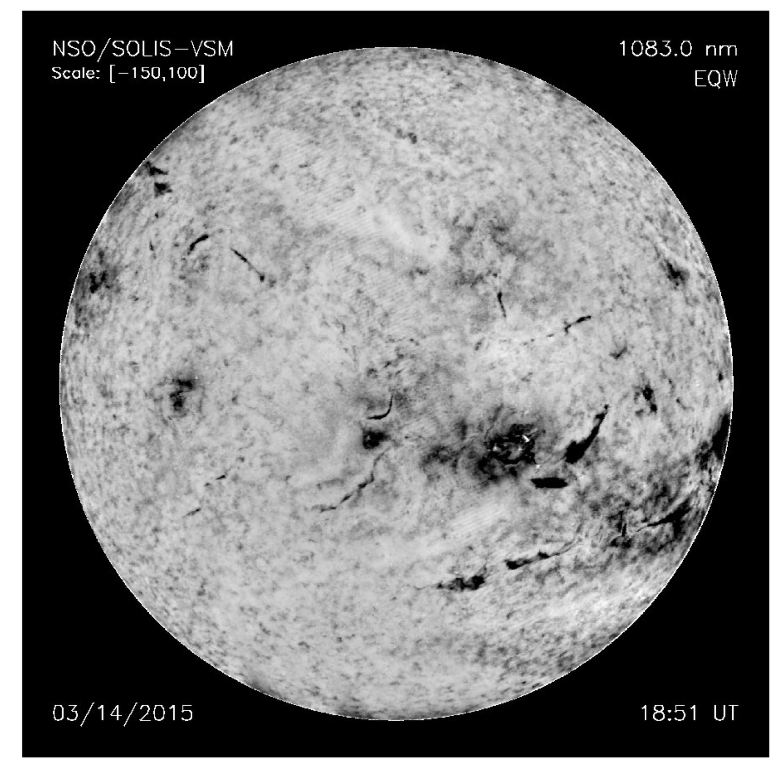

Figure 3b

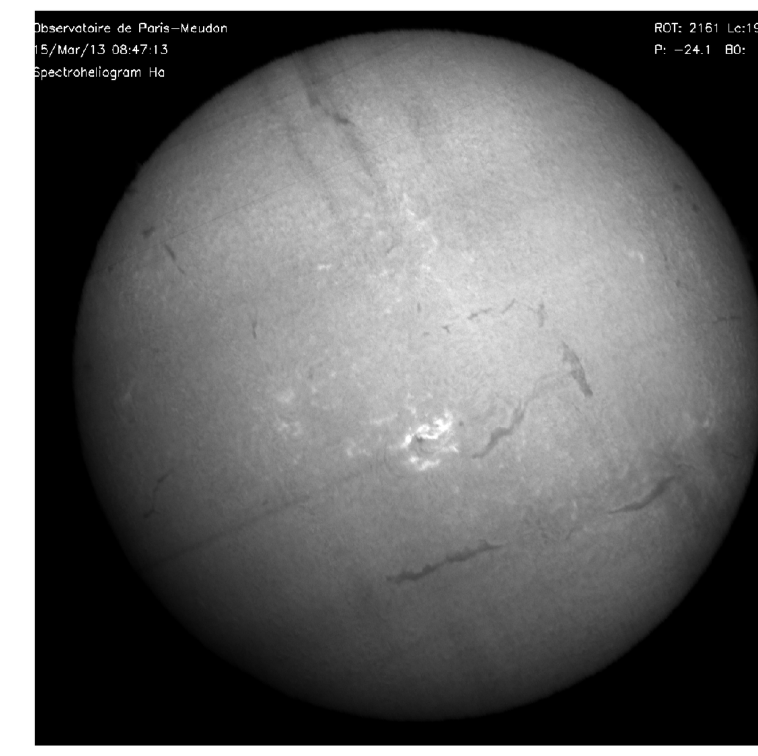

Figure 3c

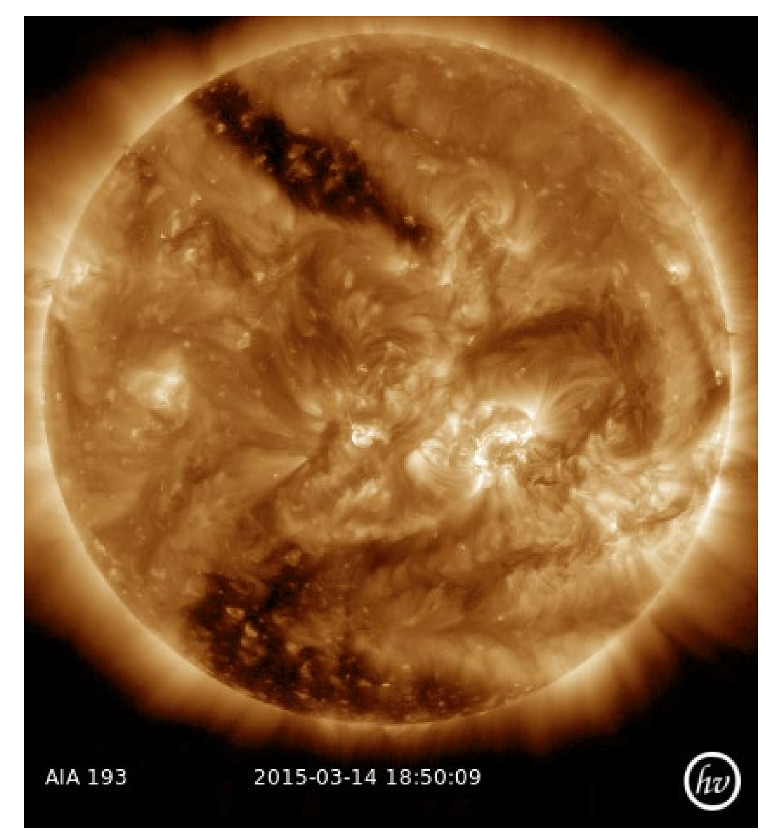

Figure 3d

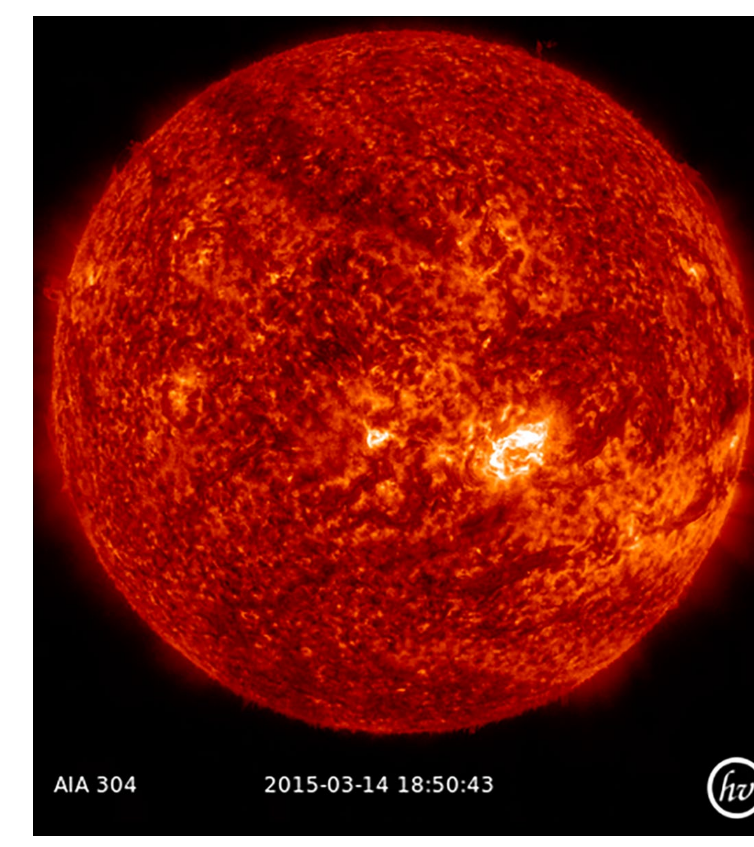

Figure 3: a,b,c,d. Previous McIntosh Maps used He I or Helium 10830 Ă (Fig 3a) to infer coronal hole boundary positions. Due to the lack of quality and consistent He 10830 Ă in 2019 a comparison and scaling to EUV was required. The result is that by using EUV 193 Ă (Fig 3c), 171 Ă (Fig 3d) combined a coronal hole area slightly smaller than seen in He II is visible and therefore all coronal hole areas are expected to be slightly smaller. A comparison to an H α (Fig 3b) image and magnetogram is used to identify filament channels which can appear similar to coronal holes.

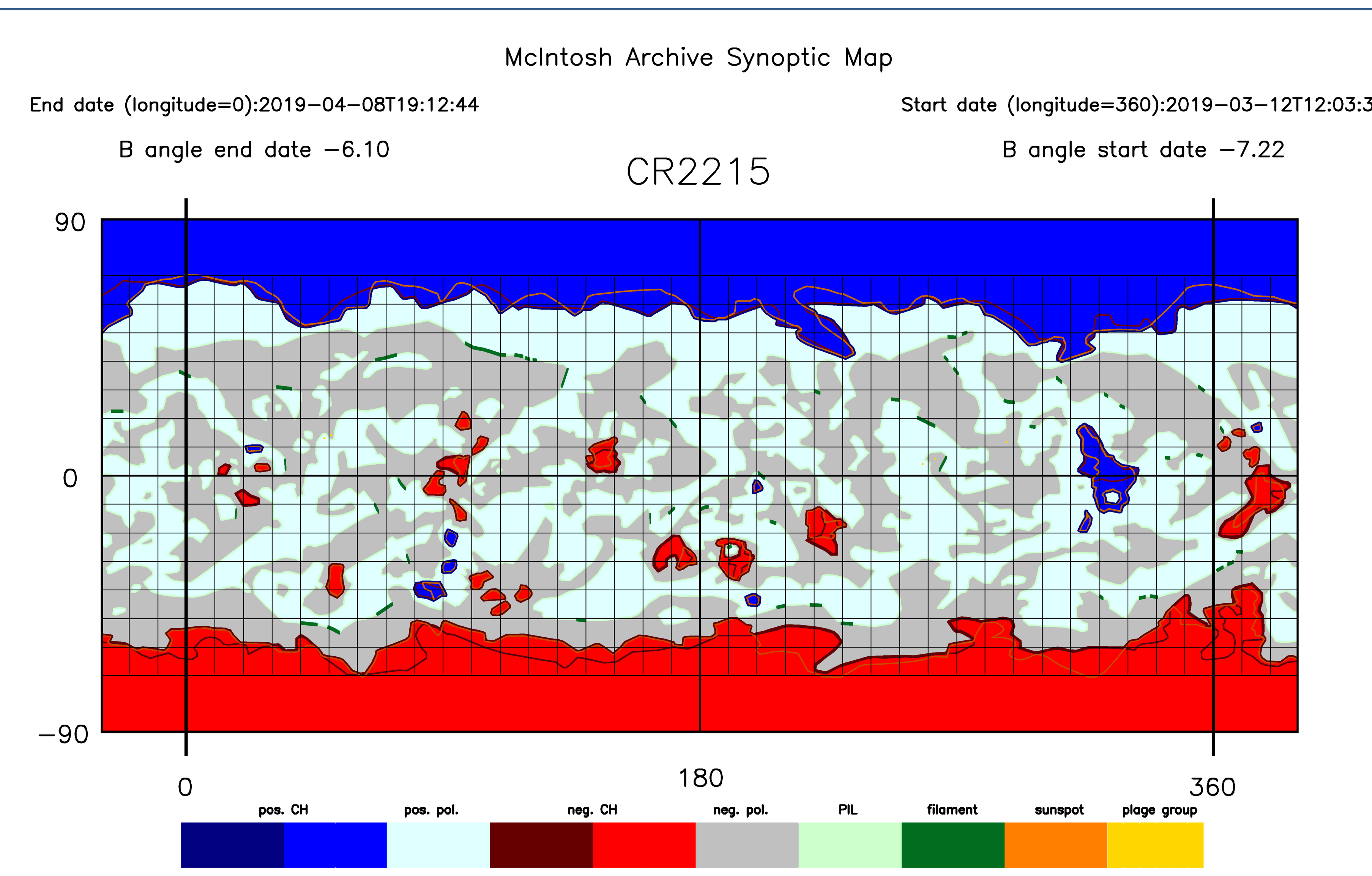

Figure 4:
CR2215 is one solar rotation near the current solar minimum for which a more comprehensive study is being undertaken. This map contains the two recurrent coronal holes which contribute to high speed solar wind periods at Earth that are of interest to WHPI scientists. Many of the coronal holes on this map are observed in both EUV 193 Ă and EUV 304 Ă. Others are seen in just one of the two. We will include the wavelength information to allow scientists to choose how to analyze coronal hole data.

Note: Some coronal holes appeared to exist only in one wavelength. Note that there are significantly more small coronal holes than at previous minima and on most McA maps presumably due to how clear coronal hole boundaries are in EIT 193 Ă.

Conclusions:

From intensive studies of the solar minimum we can learn both what is common between them and what differentiates them from each other. Long term studies show us patterns and irregularities. The current minimum appears to have more low latitude coronal holes than previous and therefore the sun could produce more high speed wind streams than prior minima. We also see how calibrating the data between instruments can affect data.