Feature Story: ALPO Solar Section

A Report on Carrington Rotations 2166 thru 2168

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Overview

In general, solar activity (measured by the provisional International Sunspot Number or "RI") continued to decrease as it has for all of 2015 (Figure 1). If current trends continue, it appears the maximum will have been in mid-2014 with a secondary max happening earlier in Sep. 2011. These peaks are half of what they were in Cycle 22 and around 60-70% of the levels of the last maximum (Cycle 23). Double peaks are not uncommon, so this is not unusual but the overall sunspot activity (the only long-term measure of activity we have) is the lowest since the beginning of the 20th century.

For this reporting period (15Jul.- 4 Oct. 2015), the average sunspot number was 65.8, which is not bad but well below other rotations at this stage. But this number was driven higher mostly from one active region: AR 2422, the largest of these 3 rotations, otherwise it would have been a substantially lower average.

In this report, the ALPO Solar Section will be referred to as "the Section". Carrington Rotations numbered from an arbitrary 0 longitude established on 8 February 1832, will be called "CRs".

How Are Sunspot Measured

Astronomers measure the sizes of sunspots as fractions of the Sun's visible area. Their favorite units are "millionth's." A sunspot that registers 1 millionth has a surface area equal to 0.000001 times the area of the Sun's Earth-facing hemisphere. Typically, a big sunspot measures 300 to 500 millionths. The entire surface area of the Earth is only 169 millionths of the solar disk. Source: *http://www.space-weather.com/sunspots/history.html*

Similarly, Active Regions, designated by the National Oceanic and Atmospheric Administration (NOAA), will be called "ARs" and use only the last 4 digits of the full number. "Groups" will apply to the visible light or "white light" collection of sunspots while "Region" or "Active Region" will apply to all phenomena associated with the particular sunspot group. Statistics used in this report are compiled by the World Data Center – Solar Index and Long Term Solar Observations (WDC-SILSO) at the Royal Observatory of Belgium, which is responsible for the International Sunspot Number used here. All times will be Coordinated Universal Time and dates are reckoned from that. Dates will be expressed numerically, with month/day such as "9/6" or "10/23".

The terms "leader" and "follower" will be used here instead of east or west on the Sun. "W-L" may be used to indicate White Light observations while Hydrogen-Alpha may be "H-a" and Calcium K-line "CaK", abbreviations well-familiar to the experienced solar observer. An important point, "naked

Table of Contributors to This Report

Observer	Location	Telescope (aperture, type)	Camera	Mode	Format
Tony Broxton	Corwall, UK	127mm, SCT	N/A	W-L	dwg
Gabriel Corban	Bucharest, Romania	120mm, RFR	Point Grey, GS3-U3	H-a W-L	d.i.
Howard Eskildsen	Ocala, FL, USA	80mm, RFR	DMK42AF02	Ca-K	d.i.
Rik Hill	Tuscon, AZ, USA	90mm, MCT 120mm, SCT	Skris 445M	W-L	d.i.
David Jackson	Reynoldsburg, OH, USA	124mm, SCT	N/A	W-L	d.i.
Jamey Jenkins	Homer, IL, USA	102mm, RFR 125mm, RFR	N/A	W-L Ca-K	d.i.
Monty Leventhal		250mm, SCT	N/A	W-L, H-a	dwg, d.i.
Theo Ramakers	Oxford, GA, USA	40mm, RFR 40mm, RFR 80mm, RFR	DMK42AU02	H-a Ca-K W-L	d.i.
Randy Tatum	Bon Air, VA, USA	180mm, RFR 180mm, RFR	DFK31AU	W-L, p.p. H-a	d.i.
David Tyler	Buckinghamshire, UK	178mm, RFR 90mm, RFR	ZWO	W-L H-a	d.i.

NOTE: Telescope types: RFR (refractor), SCT (Schmidt-Cassegrain), MCT (Maksutov-Cassegrain)
Mode types: W-L (white light), Ca-K (calcium chloride), H-a (hydrogen alpha), p.p. (pentaprism)
Format types: dwg (drawings), d.i. (digital images)

eye" here means the ability to see a feature on the Sun through a proper and safe solar filter with no other optical aid. You should never look at the Sun, however briefly, without proper filtration. All areas on the disk will be expressed in the standard measurement of millionths of the disk, with a naked-eye spot generally being about 1,000 millionths for the average person. Spot classifications are the ones defined by Patrick McIntosh of NOAA (McIntosh 1981, 1989) and detailed in an article in the JALPO 33 (Hill 1989). This classification system is also detailed by the author on the Section website at *http://www.alpo-astronomy.org/solar/W-Lft.html* in an article on white light flare observation.

Observers contributing to this report and their modes of observing are summarized below. It will be used as a reference throughout this report rather than repeating this information on every image or mention.

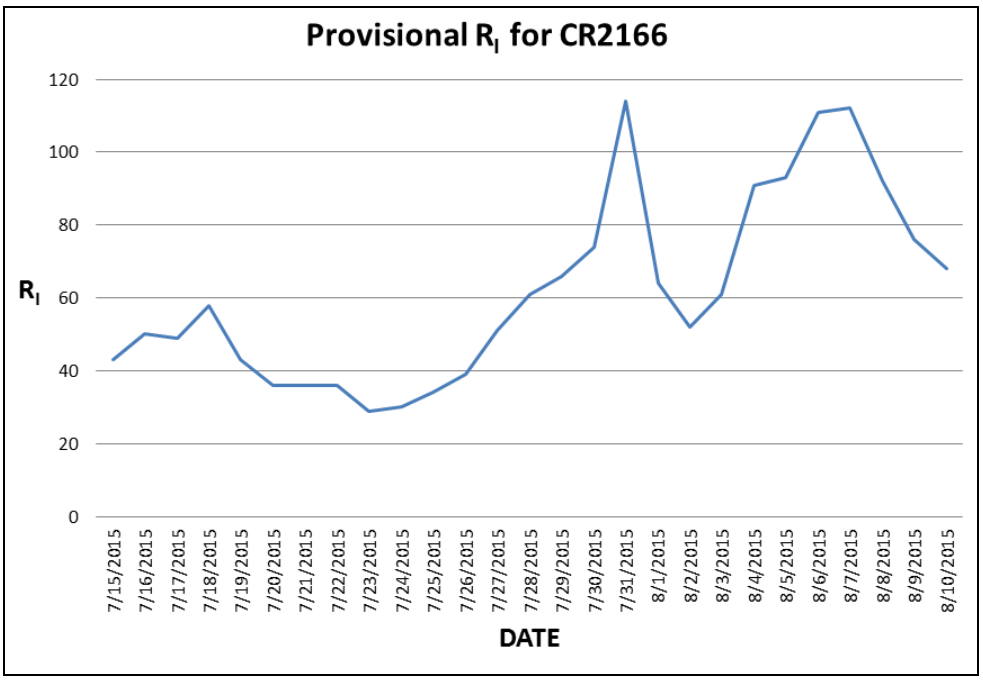
References:

Hill, R.E., (1989), Journal of the Assn of Lunar & Planetary Observers, Vol. 33, p. 10.

Livingston, W., Penn, M.; (2008) "Sunspots may vanish by 2015." *https://wattsupwiththat.files.wordpress.com/2008/06/livingston-penn_sunspots2.pdf*

McIntosh, Patrick S., (1989) "The Classification of Sunspot Groups" Solar Physics, Vol. 125, Feb. 1990, p. 251-267. *http://link.springer.com/article/10.1007/BF00158405*

McIntosh, Patrick S., (1981) The Physics Of Sunspots, Sacramento Peak National Observatory, Sunspot, NM; L.E. Cram and J.H.Thomas (eds.), p. 7. *http://adsabs.harvard.edu/abs/1981phss.conf.....C*



Carrington Rotation 2166

Dates: 2015 07 14.8375 to 2015 08 11.0542

Avg. R_I = 61.8

High R_I = 114(7/31), 112 (8/7)

Low R_I = 29(7/23)

This reporting period opens with pretty low activity, especially for a solar maximum. Little of note took place on the Sun for the first two weeks. The first peak in activity was on the last day of July, when there were four Active Regions in the northern hemisphere ARs 2392, 2391, 2393, 2394 (ARs 2380, 2376, 2373 of the previous rotation) driving the numbers, with lots of little umbral spots.

On 8/3, AR2394 was near the center of the disk but was in the process of dissolution where the follower spots were dissolving and the main leader was becoming more circular and symmetrical. It was well shown in a sketch by Broxton at 8:13UT. [Figure 1] At the same time, the other regions were just umbral spots with no flare production. In the southern hemisphere, AR 2396 was just getting started. It was already the major flare

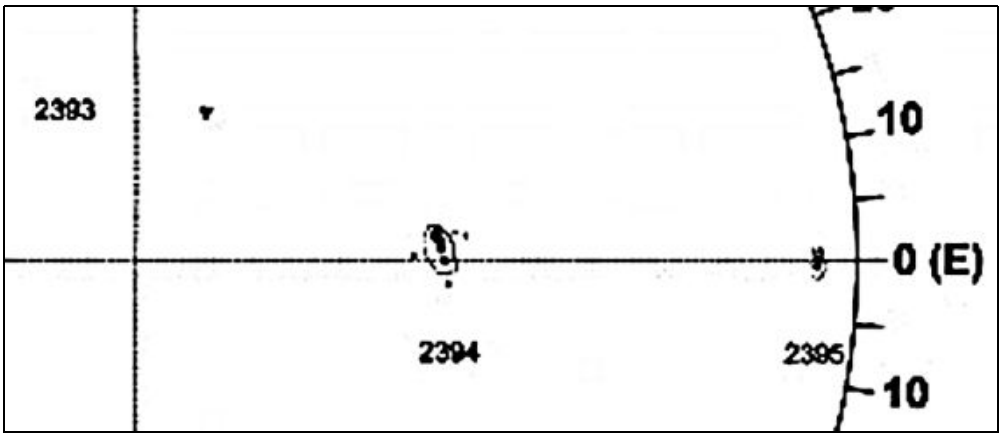


Figure 1. Excerpt from a Broxton whole-disk white light drawing on 2015-08-03-0813 UT showing the first view of AR 2394 by a Section member. See Table 1 for instrument/camera details.

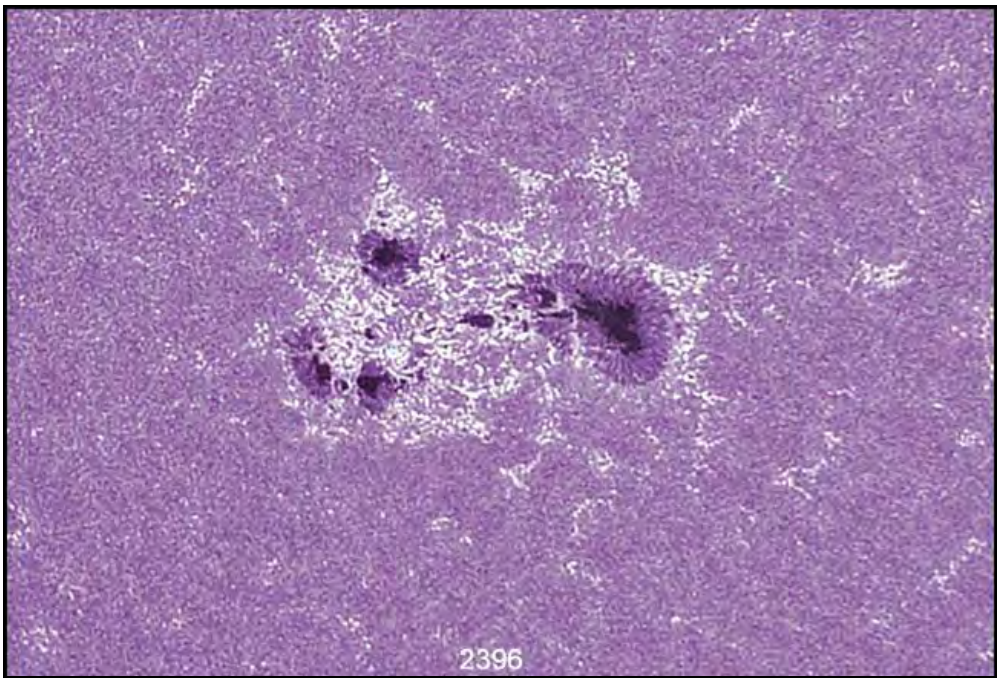


Figure 2. Calcium K-line (Ca-K) filtergram of AR2396, by Eskildsen on 2015-08-06-1244 UT in excellent 1" seeing at an altitude of 22°. See Table 1 for instrument/camera details.

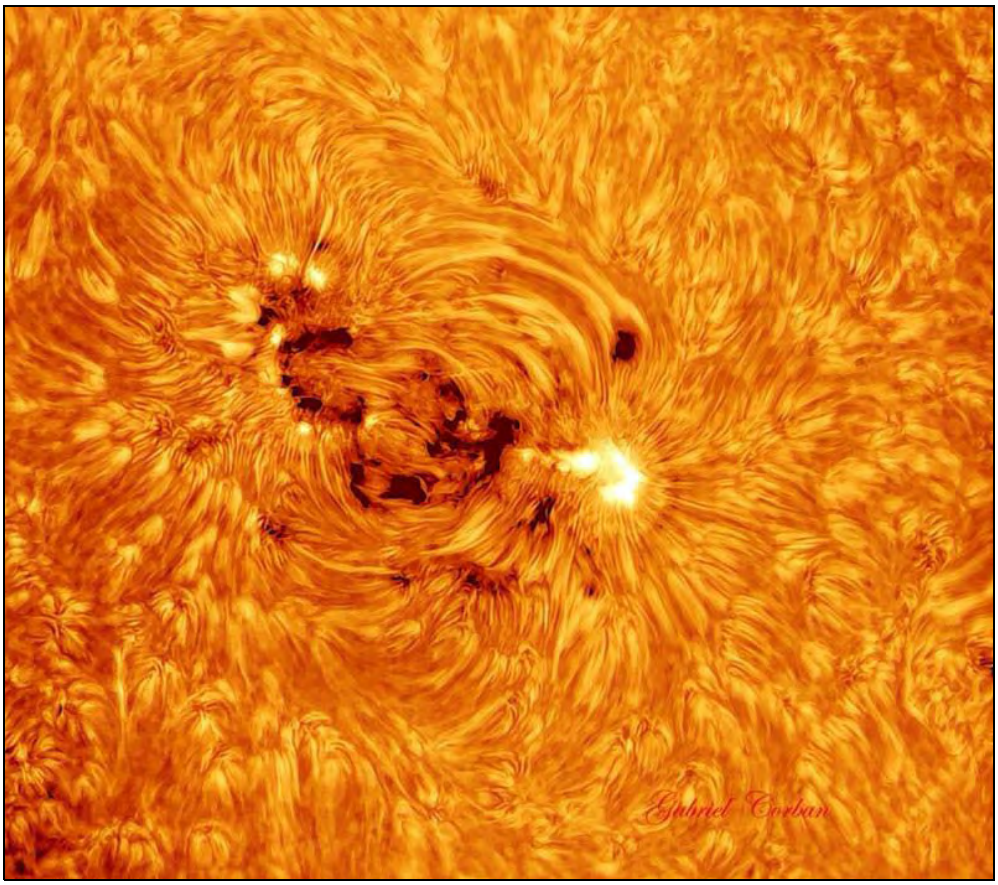
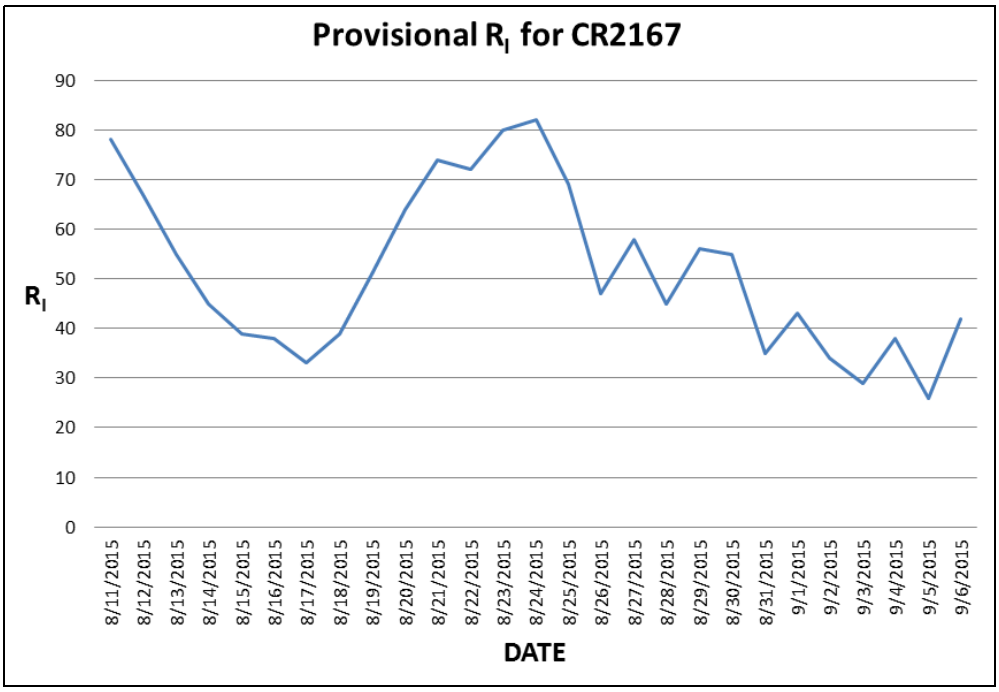


Figure 3. Spectacular H-alpha filtergram of AR 2396 by Corban on 2015-08-09-1056 UT in sub-arc-second seeing. See Table 1 for instrument/camera details.

producer on the disk with 30 flares this day alone. The official class was Hax but it appeared more like a Dai. The first ALPOSS observation for this region was on 8/6 by Eskildsen in a very dramatic CaK image [Figure 2]. He showed it to have a clear leader with an irregularly shaped umbra surrounded by a symmetric penumbra followed by 3 spots with penumbrae and a scattering of small naked umbrae. This all sat in a plage filigree that was quite bright. The next day the leader had merged and was now in an east-west teardrop shape. Two of the following spots had merged and the penumbrae on all the following spots were only on the side away from the group.

Meanwhile, disorganized penumbral material had formed between some of the umbrae from the day before. On the 9th, the teardrop shape of the leader was more pronounced and well-defined, while all the spots following were forming a ring with penumbrae only on the outside rim of each umbra as shown in W-L by Hill, CaK by Eskildsen and H-a by Corban [Figure 3]. While obviously decaying, it still produced over 20 recorded flares. The dissolution of this group continued the next day with less flares, a leader spot that was becoming more circular and follower spots taking less area and losing organization.

The next observations of AR 2396 were not until 8/12, when it was approaching the limb. A W-L observation by Ramakers shows the situation well [Figure 4]. The total area of the group was reduced from 840 to 710 millionths. Only 8 flares were reported in the previous 48 hours. The leader was largely unchanged while the follower spots had reduced in area. This situation was confirmed in a whole disk drawing by Broxton. On 8/13, the region had lost another 200 millionths in area, but even so, Corban captured it in a detailed H-a image [Figure 5]. Very few flares



were now recorded and this was the last of AR 2396.

Carrington Rotation 2167

Dates: 2015 08 11.0542 to 2015 09 07.3000

Avg. R_I = 51.6

High R_I = 82 (8/24)

Low R_I = 26 (9/5)

The numbers for this rotation were largely driven by one large region, AR 2403 (probably a return of AR 2390 from the previous rotation) that was first seen on the disk on 8/18 and lasted until leaving the disk on 8/29. The first observation from the Section was by Broxton in a whole disk W-L drawing on 8/18. His classification of Hrx differed from the official Cso, but this is not uncommon for a group just making its appearance around the limb. The next observation was a W-L montage image by Hill which showed the group to be well-developed with a leader of some 10 umbrae in a well-developed penumbra followed by 15 spots in a more complex penumbra with no less than a dozen smaller spots with umbrae, umbral spots and detached penumbral bits between them. Now listed as a Dkc group (350 millionths in area) it was an active flare producer with over 100 flares in the previous 48 hours! This would have been a rich field for monochromatic observations, but the next day there was only another W-L montage by Hill. It showed that both the leader and follower were coalescing into large penumbrae with many smaller spots with and without penumbrae between and above the two. With an area of only 400 millionths, it was far short of naked eye visibility but still maintained a vigorous flare production with a class advanced to Ekc.

We finally got some monochromatic observations of AR 2403 as it crossed the central meridian on 8/24. The first was an H-a image by Ramakers [Figure 6] showing the interactions of the two main spots with the smaller ones between them. He also caught what appears to be an interesting ejection coming from the follower spots. This H-a image was accompanied by a W-L image by Ramakers of very good resolution that showed the very complex development of string of spots trailing from the leader back to a very complicated follower [Figure 7]. The magnetic class was now beta-gamma-delta, making flares a dead certainty in any given 24-hour period.

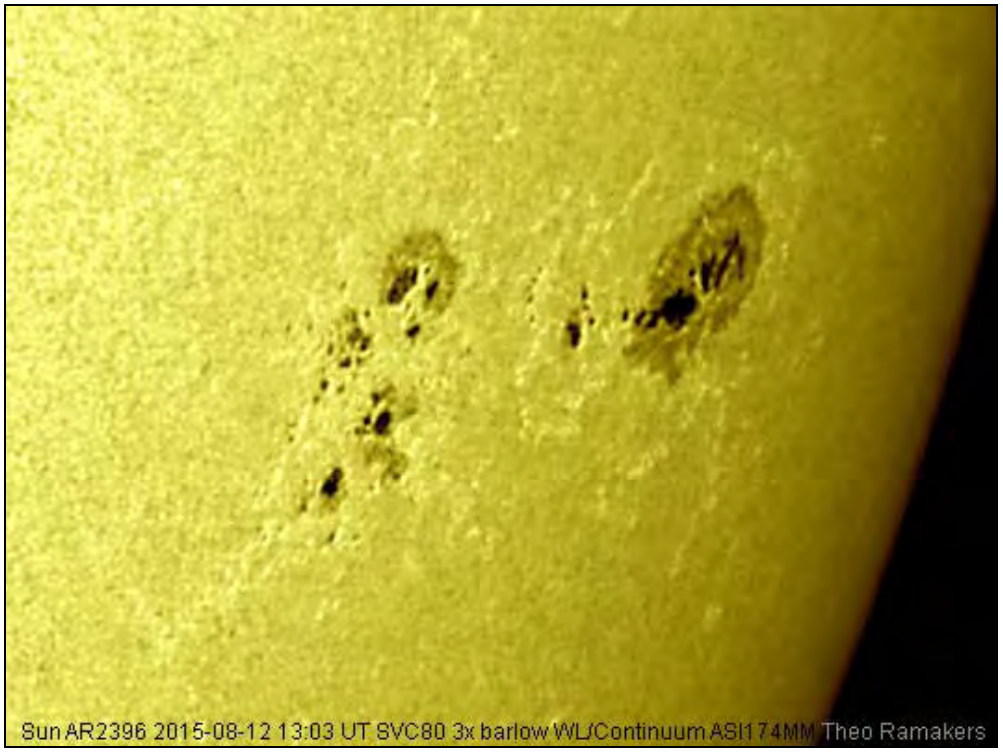


Figure 4. White light image of AR 2396 by Theo Ramakers on 2015-08-12-1303 UT with 3x barlow. See Table 1 for additional instrument and camera details.

When spots take on this kind of appearance, it pays to observe them every hour (or more often), in search for white light flares or sudden movements and changes. Ramakers again caught AR 2403 on 8/25 as it was going through some subflares [Figure 8]. There were many potential sites available for large flares. Large filaments had formed around the leader spot and another zig-zag filament marked the magnetic neutral polarity line between the leader and follower in this beta-gamma-delta magnetic classed region.

Over 80 flares were reported over the previous 48-hour period, the area of the region was now 930 millionths and people were reporting having seen it naked-eye. The area increased further by 8/26 to 1190 millionths and the region was beautifully shown by Hill (W-L) and Ramakers and Corban (H-a). The Corban

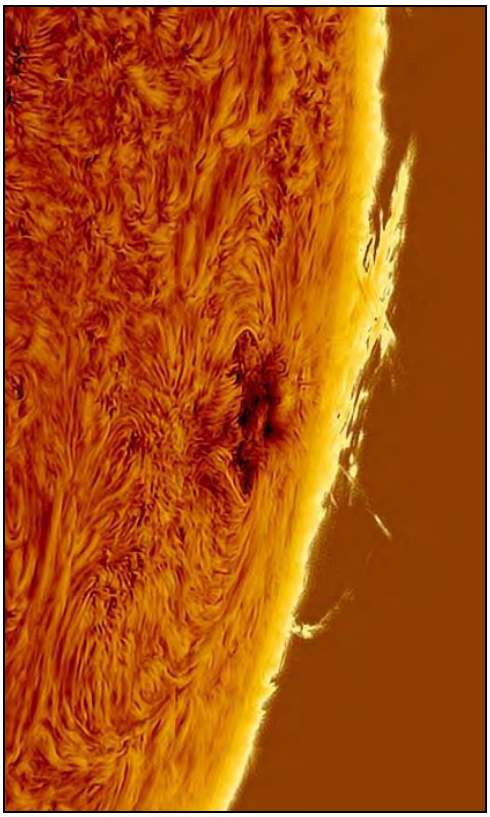
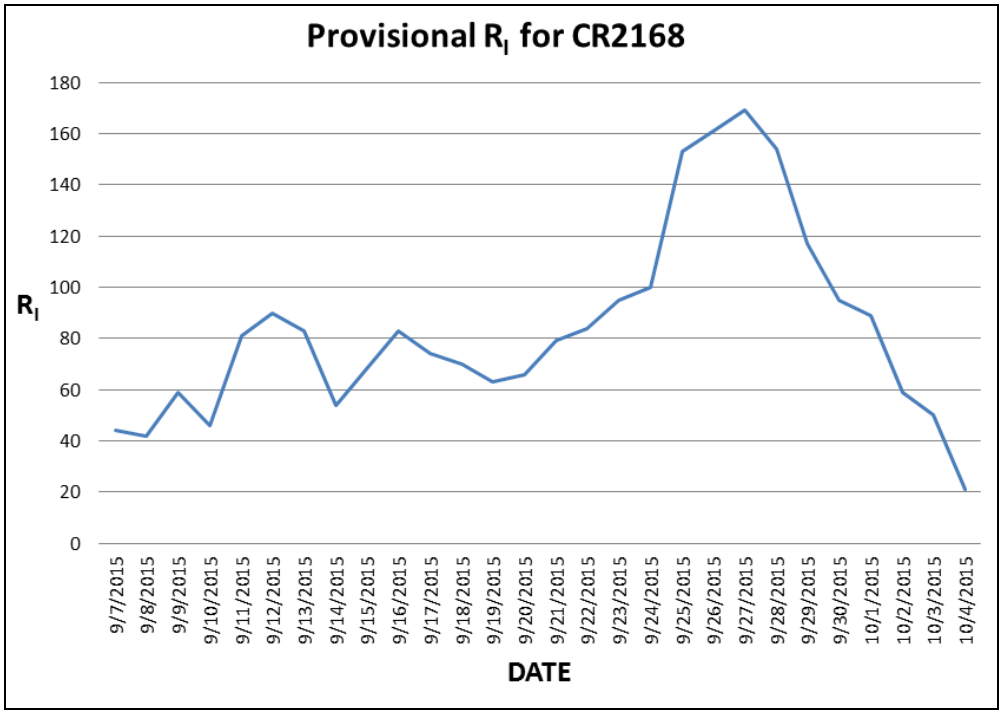


Figure 5. A Corban H-alpha image of AR 2396 near the limb on 2015-08-13-1427 UT again in sub-arc-second seeing. See Table 1 for instrument/camera details.



images in both W-L and H-a are shown here [figures 9 and 10]. The big change was that all the spots and debris in the middle of the group had been swept up by the leader and follower that were now coalescing. The group was listed as Fki and this was to be maximum development. In W-L, the follower consisted of three umbral collections arranged roughly north-south with a bright light-bridge between them, while the leader was a large collection of umbrae in penumbra, open to towards the middle of the group. Flare production was maintained at the high level of the day before and the sites for such flaring were well-shown in Corban's H-a image. The former zig-zag neutral line was one long flare in his image, emanating from the center of the umbra in the leader spot and winding its way to the previously mentioned light-bridge between the two southern spots of the follower.

Both area and flare production began to decline slightly on 8/27 as seen by Hill (W-L) and Corban (H-a). Some of the decrease may have been due to the region nearing the limb. On the 28th, it was seen only by Broxton in a whole-disk W-L image. He showed it to be largely unchanged but foreshortened. Then, on 8/29, Hill saw only the follower spots near the limb, the rest having passed to the other side. Corban showed some nice prominences at the place where the AR 2403 was, but now completely gone from sight. This was the last hint of what had been some enjoyable activity from this region.

Carrington Rotation 2168

Dates: 2015 09 07.3000 to 2015 10 04.5722

Avg. R_I = 83.9

High count = 169 (9/27)

Low count = 21 (10/4)

The peak in this rotation was largely due to AR 2422, the largest region and group of this reporting period. Nevertheless, it was this rotation that had the lowest number of observations contributed and this active region that had the poorest coverage. It was first reported by Broxton (0824UT) on 9/24 in a whole-disk W-L drawing and Jenkins (1500UT) in a W-L whole-disk image, as a Dao class group of only 150 millionths. The next day, 4 more regions formed on

the disk, adding to the overall sunspot number, while AR 2422 jumped to over 300 millionths with a class of Eko making it a major flare producer with around 80 on the first two days alone.

On 9/26, Hill began a 4-day evolutionary montage of the region [Figure 11] covering 5 days (sans 9/28). On the 26th, it showed the leader to be a collection of a dozen umbrae divided into two main groups each with penumbra. To the south of these were 10 or so umbral spots. The follower was the larger of the two spots and consisted of 6-8 umbrae in a well-organized penumbra, all of which was elongated east-west. The magnetic class was beta-gamma-delta and flare production was still at previous levels, though the area of this Eko group still remained around 300 millionths. The leader and follower spots were of comparable size on 9/27 as shown by Hill and Broxton. This was due to a sweeping-up of the stray umbral spots to the south by the leader spot. One of the southern umbrae had pushed north into the larger umbra north of it in the follower spot. This formed a hot light-bridge between them, a very good site for flares. The magnetic and McIntosh classes were unchanged, but the area had increased to 410 millionths.

There were no Section observations for the 28th, but on 9/29, dramatic changes had taken place. The McIntosh class had gone to Fkc with an area of 950 millionths, though the magnetic class remained beta-gamma-delta. The follower had broken into 3 pieces. In the middle of the group, old spots had formed penumbrae and were now two spots with penumbrae arranged north-south. Next to the follower, between these two spots and the main body of the follower, was an umbral spot, probably the one that had collided with the main umbra two days earlier that had now completely separated and formed its own penumbra on the leading side. The

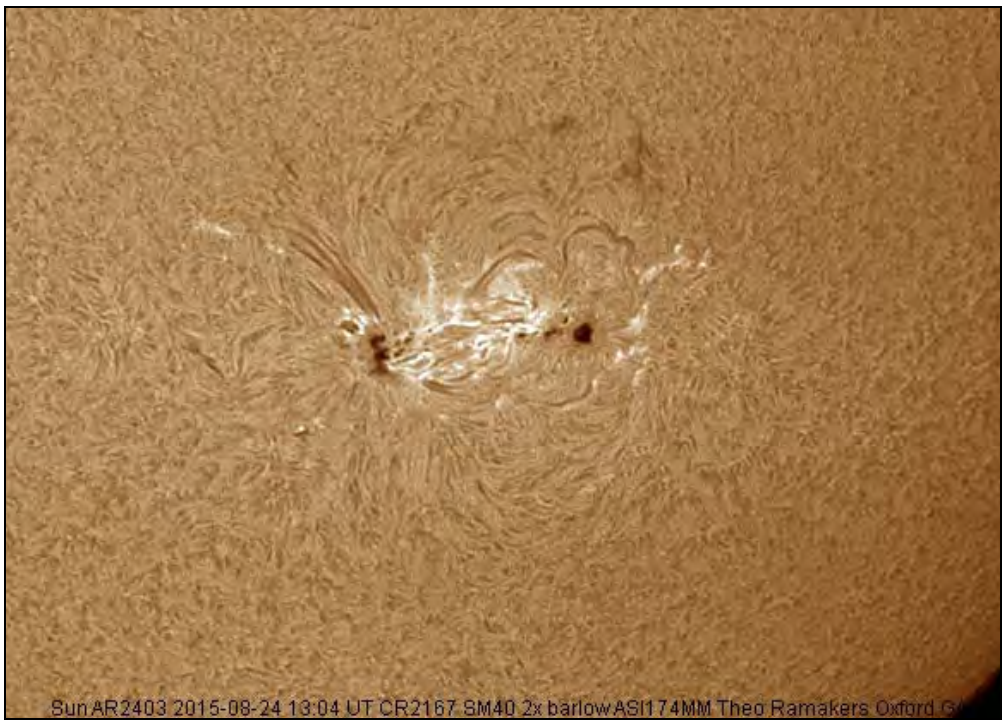


Figure 6. AR 2403 as imaged by Theo Ramakers in an H-alpha filtergram on 2015-08-24-1304 UT with a 2x barlow. See Table 1 for further instrument and camera information.

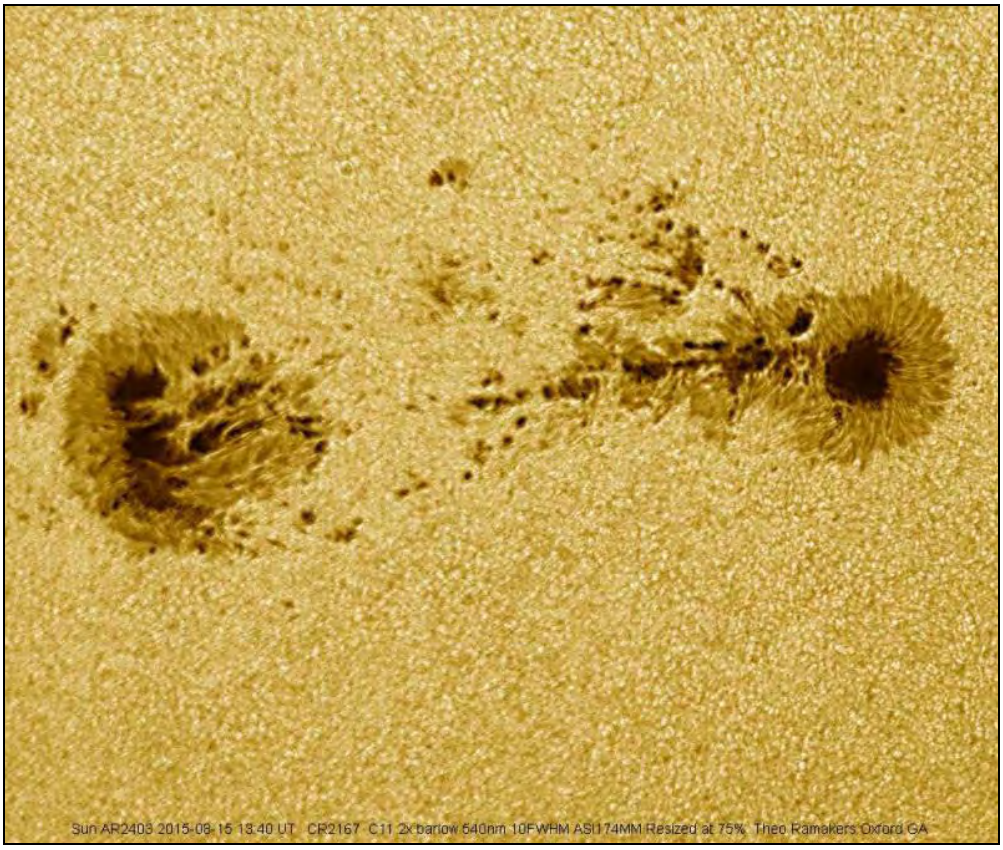


Figure 7. A beautiful white light image of AR 2403 on 2015-08-24-1340 UT by Theo Ramakers using a 2x barlow on the equipment specified in Table 1.

leading spot had formed an interesting collar of just penumbral material that was preceding it. The whole group had spread out more as well, probably accounting for the area increase.

On 9/30 the area had decreased to 860 as AR 2422 neared the limb. The detached spots in the middle of the group were breaking down and the leader had also reduced in size and complexity. It was now only several large umbrae in a penumbra with some smaller spots to the south and following. The follower spot was again the largest spot, consisting of a "v"-shaped umbra, open to the north, in one large penumbra. The last view of the group was by Broxton in a W-L full disk drawing on 10/1. He saw the group as still Fkc and spread over 15° in longitude as it was on the limb. It was now 750 millionths in size, clearly breaking down though the magnetic class was still the same. Flare production was down to half of what it was at the peak. It persisted on the solar farside and came back in the next rotation as AR 2435.

Conclusion

Clearly the activity of this period is well below what a normal solar max would have displayed. Undoubtedly there are still some surprises in store, but the hoped for classical "double max", where the second later, maximum is larger, is not happening. Instead we had a prior "peak" that was weak. So this solar cycle needs close watching!

Several requests that Acting Asst. Coordinator Theo Ramakers has made must be underscored here. Correct time is VERY important, and all image names need to lead with the date/time in the format: YYYY-MM-DD-TTTT, where TTTT is the UT time of the center of observation. Anything after this date/time is fine, especially the initials of the observer. This will ensure that no observations are overlooked in the preparation of these reports when they

Figure 8. Another H-alpha filtergram of AR 2403 by Theo Ramakers on 2015-08-25-1312 UT using a 2x barlow on the equipment listed in Table 1.

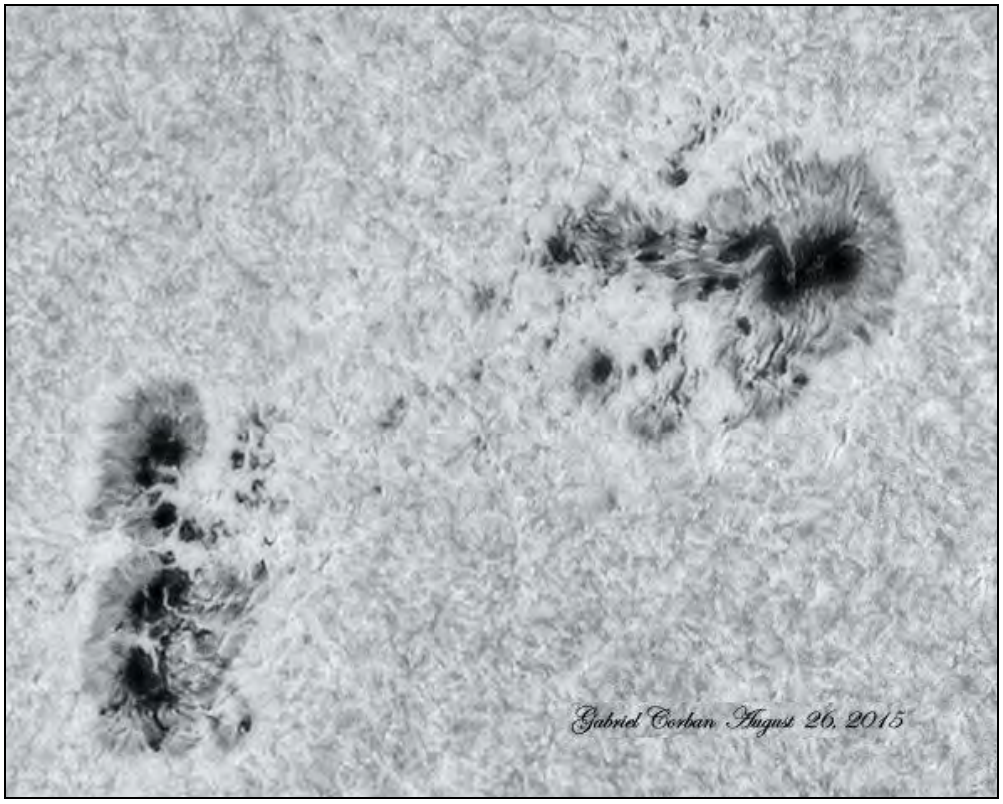


Figure 9. A Corban, off-band H-alpha image of 2015-08-26-1402 UT of AR 2403. See Table 1 for additional instrument and camera details.

have been posted to the ALPOSS Gallery. Also, this helps with sudden events like flares so they can be correctly identified. Further information in the image title is specified in the instructions for Gallery submissions on the Section website. Your cooperation in this matter makes it easier for the staff to give your observations the best exposure and attention.

Additional References

Solar Map of Active Regions
https://www.raben.com/maps/date

SILSO World Data Center
http://sidc.be/silso/home

SILSO Sunspot Number
http://www.sidc.be/silso/datafiles

The Mass Time-of-Flight spectrometer (MTOF) and the solar wind Proton Monitor (PM) Data by Carrington Rotation
http://umtof.umd.edu/pm/crn/

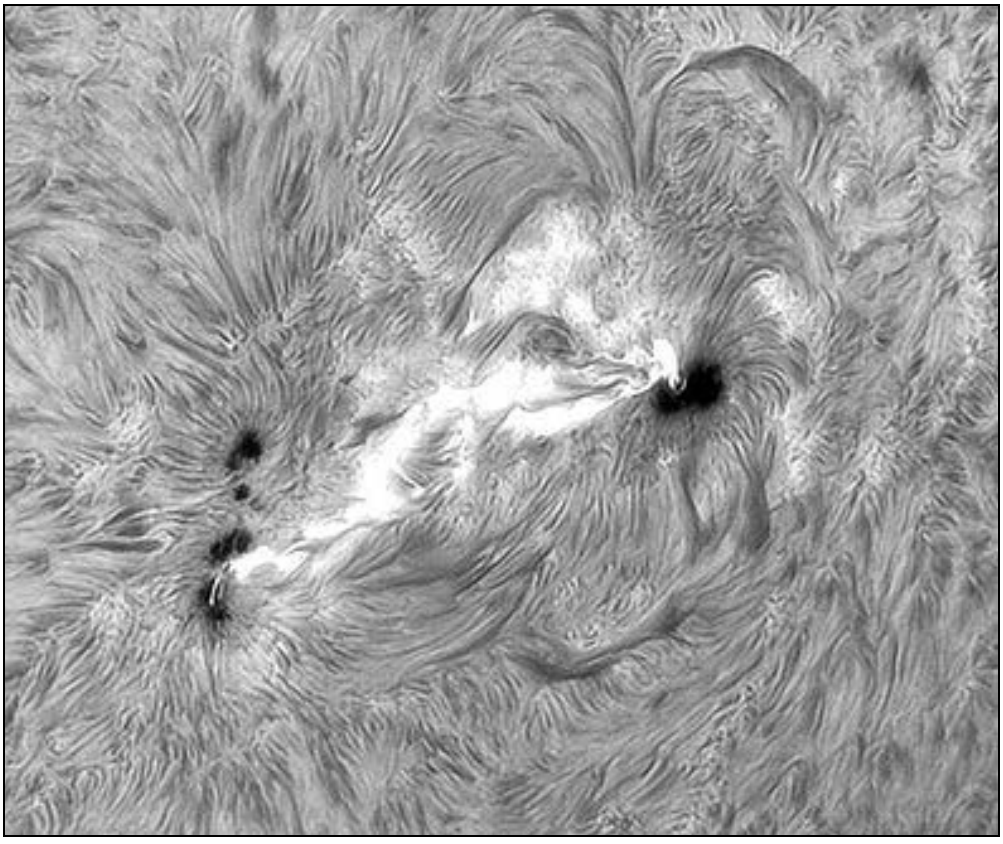


Figure 10.An H-alpha filtergram of AR2403 as taken by Corban on 2015-08-26-1517 UT.

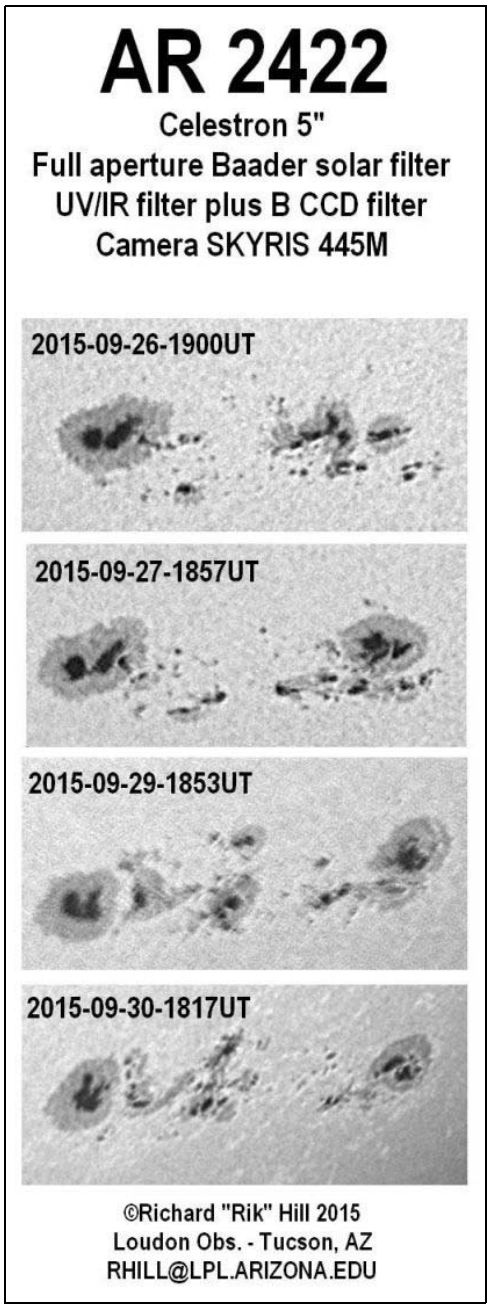


Figure 11. A 4-day image sequence of AR 2422 covering 5 days taken by Hill using a Celestron 5" telescope and other equipment noted in Table 1