

Feature Story: ALPO Solar Section A Report on Carrington Rotations 2178 and 2179 (2016-06-06 to 2016-07-31)

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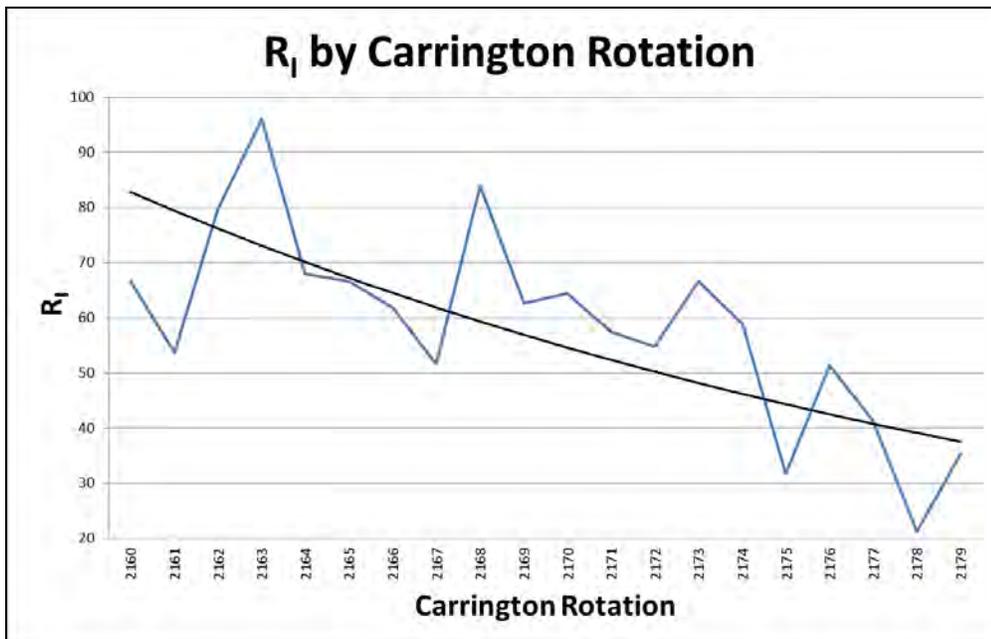
Overview

Solar activity generally continued to decrease and still headed towards minimum (predicted for 2020-21). As Plot 1 shows, with a linear least squares trend-line superimposed, the maximum daily sunspot number (RI) never rose even to 70, with the high for this report being 69 on 7/15. In the two rotations covered in this report, there were 12 spotless days. The average sunspot number for this reporting period was 28.4, a dramatic decrease from the 45.9 of the previous reporting period, or 61.2 in the report before that.

One new observer was added during this period, O'Neal, and the ALPO Solar Section took in over 442 observations on average per rotation. This is remarkable, considering the low level of activity and speaks well to the perseverance and dedication of our observers! However, this amount of data and number of observers makes it difficult to mention all of the observers individually and show all their work. Let it be known that we are grateful to all on the Observers List included in this paper and have the highest regard for their excellent work.

Terms and Abbreviations Used In This Report

As with previous reports, the ALPO Solar Section will be referred to as "the Section". Carrington Rotations will be called "CRs; similarly, Active Regions will



be called "ARs" using only the last 4 digits of the full number. The term "Groups" refers to the visible light or "white light" sunspots, while "Region" or "Active Region" applies to all phenomena, in all wavelengths, 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 daily International Sunspot Number used here. All times are 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" are used here instead of east or west on the Sun to avoid confusion. "W-L" is the abbreviation to indicate White-Light observations while Hydrogen-Alpha is

"H- α " and Calcium K-line is "CaK". An important point here that needs repeating is "naked eye" means the ability to see a feature on the Sun through proper and safe solar filtration, with no other optical aid. You should never look at the Sun, however briefly, without proper filtration even without optical magnification. Orientation of images shown here will be north up and celestial west at the right (northern hemisphere chauvinism).

Areas of regions and groups are expressed in the standard measurement of millionths of the solar disk, with a naked eye spot generally being about 900-1,000 millionths for the average observer. Modified Zurich Sunspot classifications used here 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. Lastly, the magnetic class of regions is as assigned by NOAA and will be abbreviated “mag-class”.

Observers contributing to this report and their modes of observing are summarized in Table 1. It will be used as a reference throughout this report rather than repeating this information on every image or mention.

Table 1. Contributors to This Report

Observer	Location	Telescope (aperture, type)	Camera	Mode	Format
Michael Borman	Evansville, IN	102mm, RFR 90mm, RFR 102mm, RFR	Point Grey GS3	W-L H-a CaK	digital images
Richard Bosman	Enschede, Netherlands	110mm, RFR 355mm, SCT	Basler Ace 1280	H-a W-L	digital images
Tony Broxton	Cornwall, UK	127mm, SCT	N/A	W-L	drawings
Gabriel Corban	Bucharest, Romania	120mm, RFL-N	Point Grey GS3-U3	H-a W-L	digital images
Franky Dubois	West-Vlaanderen, Belgium	125mm, RFR	N/A	visual sunspot reports	—
Howard Eskildsen	Ocala, FL	80mm, RFR	DMK41AF02	W-L wedge CaK	digital images
Joe Gianninoto	Tucson, AZ	115mm, RFR 80mm, RFR	N/A	W-L H-a	drawings
Guilherme Grassmann	Curitiba, Brazil	60mm, RFR	Lumenera Skynyx 2.0	H-a	digital images
Richard Hill	Tucson, AZ	90mm, MCT 120mm, SCT	Skyris 445m	W-L	digital images
Bill Hrudey	Grand Cayman	200mm, RFL-N 60mm, RFR	ASI174MM	W-L H-a	digital images
David Jackson	Reynoldsburg, OH	124mm, SCT	N/A	W-L	digital images
Jamey Jenkins	Homer, IL	102mm, RFR 125mm, RFR	DMK41AF02	W-L CaK	digital images
Pete Lawrence	Selsey, UK	102.5mm, RFR	ZWO ASI174MM	H-a	digital images
Monty Leventhal	Sydney, Australia	250mm, SCT	N/A Canon-Rebel	W-L/H-a H-a	drawings digital images
Efrain Morales	Aguadilla, Puerto Rico	50mm, RFR	Point Grey Flea 3	H-a	digital images
German Morales C.	Bolivia	200mm, SCT	N/A	visual sunspot reports	—
John O'Neal	Statesville, NC	102mm, RFR	ZWO ASI174MM	H-a, CaK, CaH, Na	digital images
Theo Ramakers	Oxford, GA	80mm, RFR 11" SCT 40mm, H-a PST 40mm, CaK PST	ZWO ASI174MM DMK41AU02AS DMK21AU03AS DMK21AU03AS	H-a W-L H-a CaK	digital images
Ryc Rienks	Baker City, OR	203mm, SCT 40mm, H-a PST	N/A	W-L H-a	drawings
Chris Schur	Payson, AZ	152mm, RFR 100mm, RFR	DMK51	CaK W-L (CaK-off-band continuum) H-a	digital images
Avani Soares	Canoas, Brazil	120mm, RFR	ZWO-ASI 224	W-L	digital images
Randy Tatum	Bon Air, VA	180mm, RFR	DFK31AU	W-L-pentaprism	digital images
David Teske	Starkville, MS	60mm, RFR	N/A Malincam	W-L, H-a W-L	digital images
David Tyler	Buckinghamshire, UK	178mm, RFR 90mm, RFR	ZWO	W-L H-a	digital images

NOTE: Telescope types: Refractor (RFR), Newtonian Reflector (RFN), Schmidt Cassegrain (SCT), Maksutov-Cassegrain (MCT), Cassegrain (Cass)

References:

Hill, R.E., (1989) “A Three-Dimensional Sunspot Classification System” Journal of the Assn of Lunar & Planetary Observers, Vol. 33, p. 10. http://articles.adsabs.harvard.edu/cgi-bin/nph-iarticle_query?1989JALPO..33...10H&data_type=PDF_HIGH&whole_paper=YES&type=PRINTER&filetype=.pdf

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, pp. 251-267.

McIntosh, Patrick S., (1981) The Physics Of Sunspots Sacramento Peak National Observatory, Sunspot, NM; L.E. Cram and J.H.Thomas (eds.), p.7.

Further references used in the preparation of this report:

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/>

Carrington Rotation 2178

**Dates: 2016 06 06.2479 to
2016 07 03.4444**

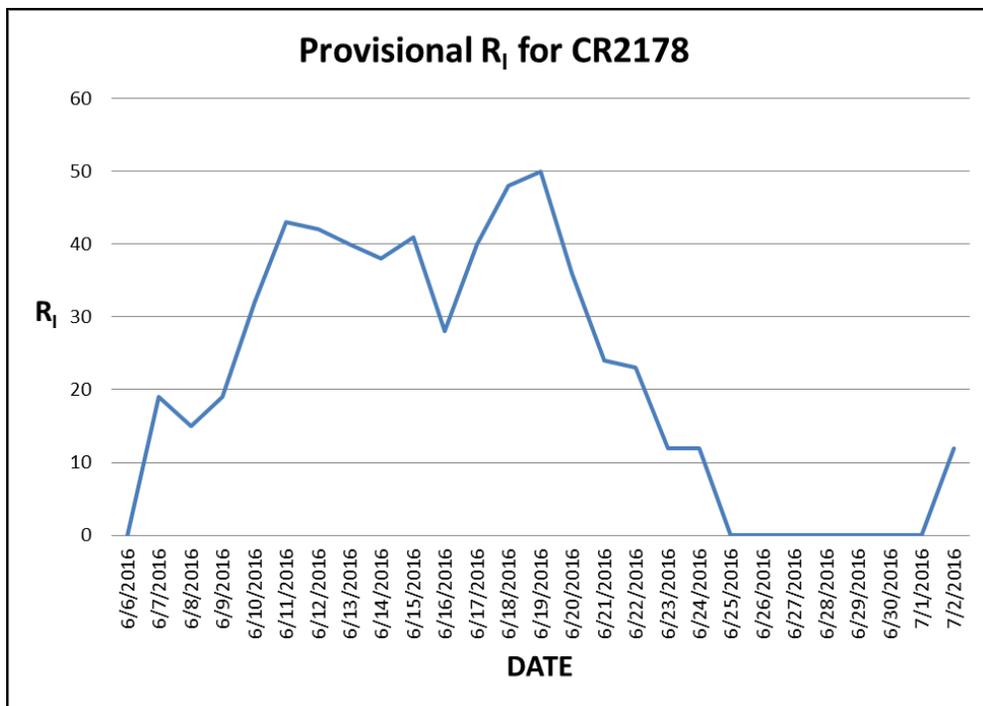
Avg. $R_1 = 21.3$

High $R_1 = 50$ (6/19)

Low $R_1 = 0$ (eight days)

This rotation was characterized by low activity with no naked eye spots. There were eight days of zero sunspot count. The highlighted region, AR2552, was not numerically the largest; instead, that was AR2553, which was Hsx (1 spot) when it came on the disk and Hhx when it left (still 1 spot) and rose to a maximum of 330 millionths of the disk.

This may well have been the second reappearance of AR2533 as demonstrated by Tyler in his three-pane image showing this spot (Fig. 1) This would not be unusual for H-class spots, as they can often persist for multiple rotations. The former region formed on the disk past the central meridian was smaller (around 150 millionths at best), getting to a D-class group, but had many small spots and was the major flare producer for this rotation.



Gianninoto, Leventhal and Ramakers were the first to report this region on 6/7. Ramakers shows a disturbance with one or two spots in both H-a and CaK while drawings of the other two observers show several small spots, with Leventhal classing the region as Axx in contrast to the published class of Bxo with an area of 10 millionths and mag-class of beta. Already it was producing

roughly one flare every two hours! Ramakers did two fine images in w-l (12:42 UT) and H-a (12:48 UT) on 6/8 that show unusual structure to the group. The leader was a triangular spot of three or four umbrae in a rather chaotic penumbra. It was followed a little to the south by a ring of tiny umbrae and pores with a larger umbra contained. The whole region was hot in H-a, but the



Figure 1. White-light images of AR2533, AR2546, AR2553 illustrating the possibility that these may all be different passages of the same region renumbered in each rotation. Images by Dave Tyler using equipment specified in Table 1.

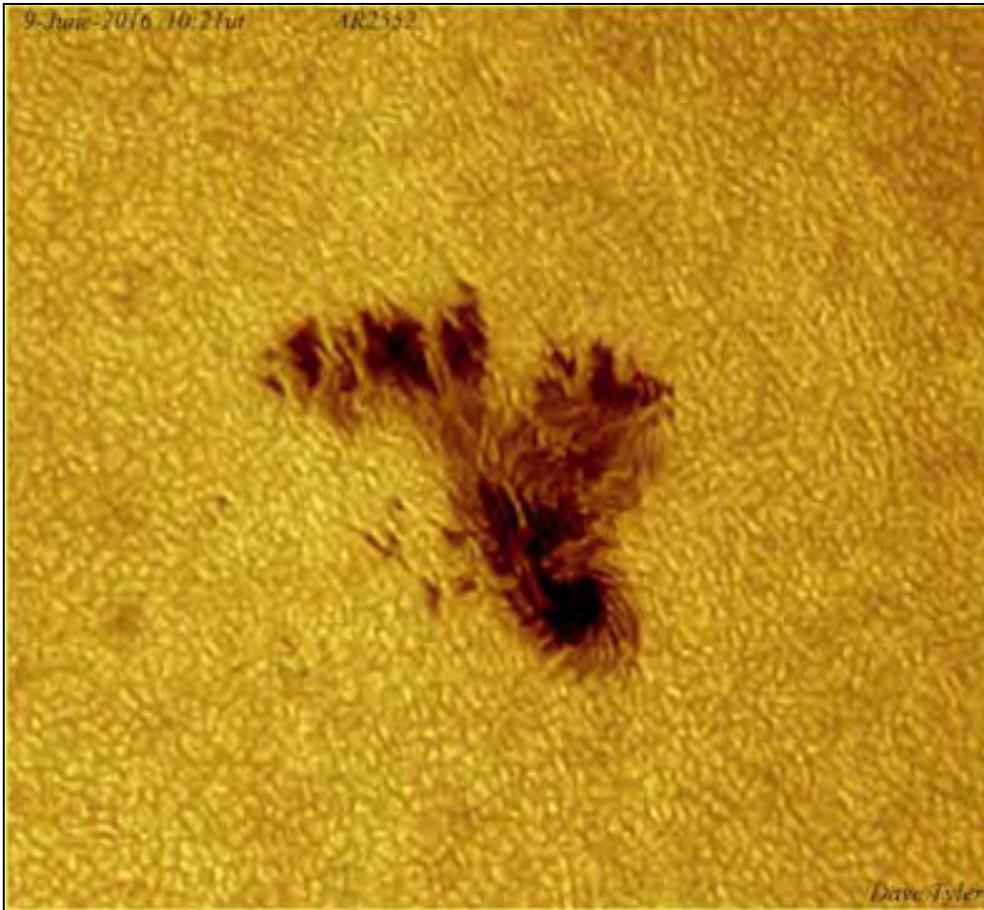


Figure 2. White-Light image of AR2552 by Tyler on 6/9 at 10:21 UT using his w-l equipment noted in Table 1.

flare production was probably in the follower. The area, mag-class and rate of flare production were unchanged.

To the north of the group were a few more pores. The next day, 6/9, we have a spectacular w-l image by Tyler that shows this sunspot group in great detail (Fig. 2). The follower spots were either had merged with the leader spot into a single complicated spot. The main umbral mass was enclosed within disorganized penumbra. To the north end of this mass, three umbrae, oriented east-west, perpendicular to the southern portion, were in fragmentary penumbra. The two hours between a Tyler w-l image (10:12 UT) and a Ramakers image show rapid internal movements and a change taking place in this small group. A

Ramakers H-a image, just after a flare ended at 12:15 UT shows the site for flaring was in the north portion of the spot. On 6/10, the area shot up to 140 millionths as the region spread out to the north as well-shown in another Tyler w-l image at 11:49 UT and a Ramakers w-l image at 13:55 UT. The mag-class was now listed as beta-delta and flare production was slightly increased. Leventhal classed it as McIntoshclass Csi in contrast to the NOAA class of Dao. This could simply be due to the time difference between the observations. The next day, 6/11, observations by Grassmann and Ramakers showed AR2552 to be reduced in area with several umbrae separated and following (Fig. 3). Officially the area was now 60 millionths, but the mag-class was the

same. Flare production had decreased by about a third. Gianninoto got the last close-up look at this region as it was on the limb. He counted seven spots in the w-l group with a class of Dai, and was the only observer to show the prominences associated with this region (Fig. 4).

Carrington Rotation 2179

Dates: 2016 07 03.4444 to 2016 07 30.6521

Avg. $R_I = 35.53$

High $R_I = 69$ (7/15)

Low $R_I = 0$ (four days)

This rotation showed a slight increase in activity over the previous rotation, mostly due to the regions AR2565, 2566 and 2567, which are the highlights of this rotation.

AR2565 was first observed on the limb by ALPOSS observers on 7/11. There were three other small regions on the Sun at the time and its appearance went largely unnoticed. At that time, it looked to be a single large spot with a small associated prominence as noted in drawings by Gianninoto, Grassmann and Rienks. Observers classed it as Hhx or Hsx -- in agreement with the NOAA classification of Hsx and area of 120 millionths. But an indication of a more complex region were the dozen flares that it had already produced. In H-a images, Ramakers captured a bright but small plage following the large sunspot. On 7/12, this was seen in better detail in a Ramakers image (Fig. 5) and confirmed in a Gianninoto drawing as a hot spot that was likely the site of solar flaring. Flare production had fallen off to about half of what it was previously, but it was still the strongest on the solar disk. In CaK (Ramakers), the following plage was much larger with another extensive plage region to the north of AR2565. The w-l appearance (Grassmann, Teske & Ramakers) showed the one large spot

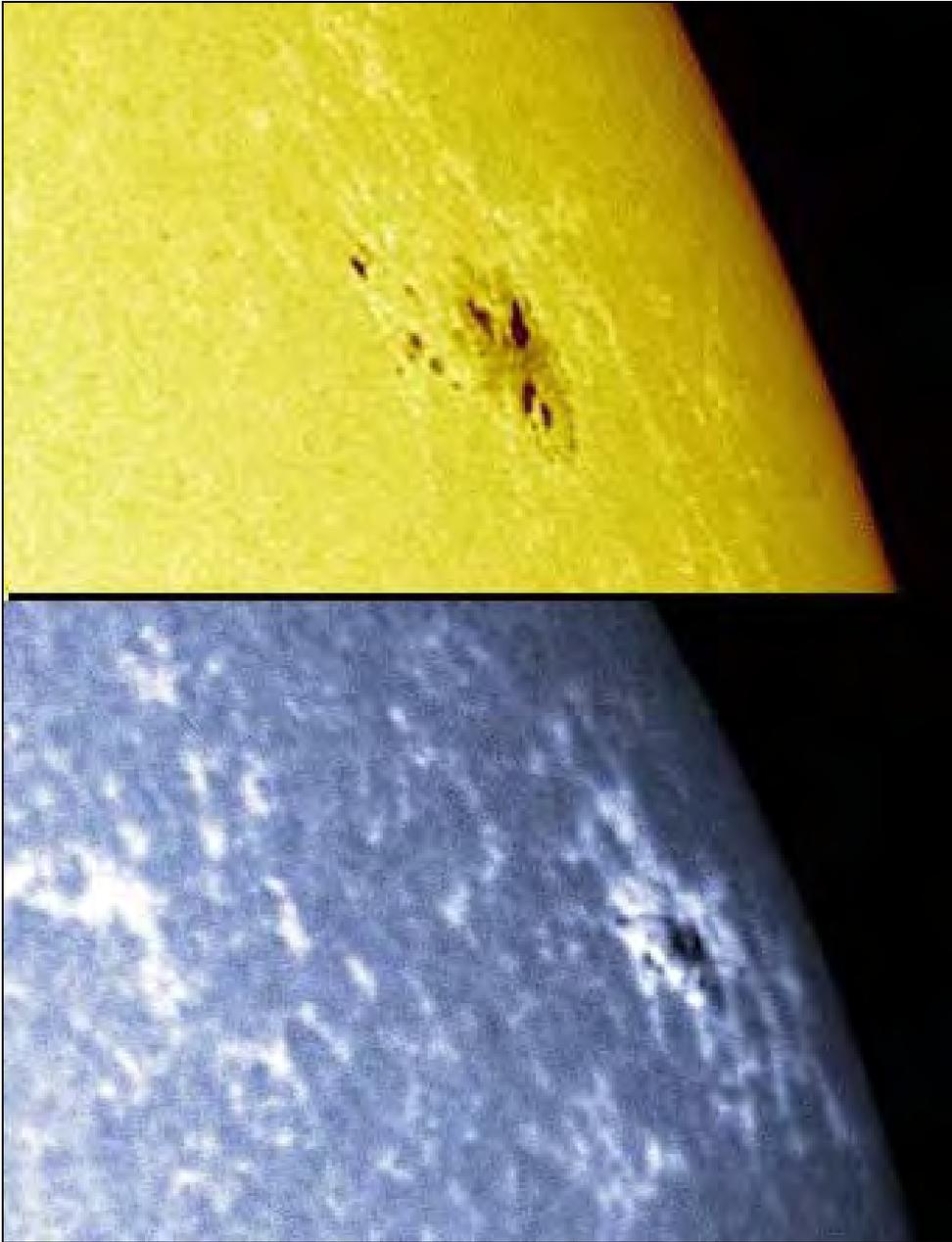
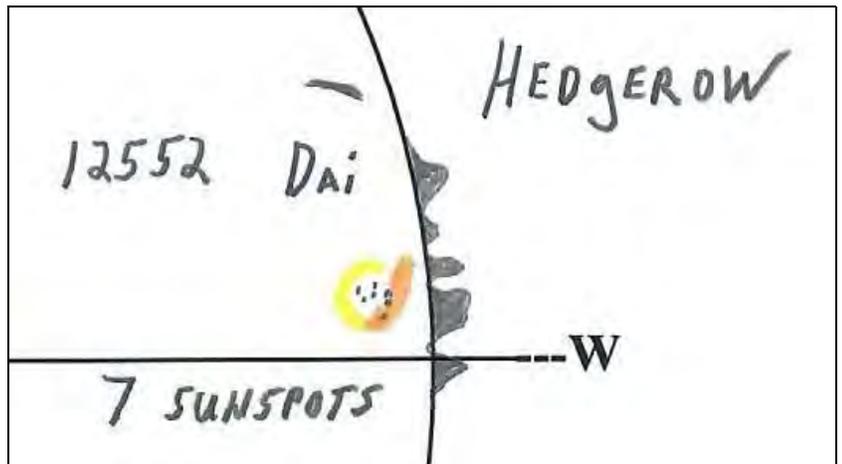


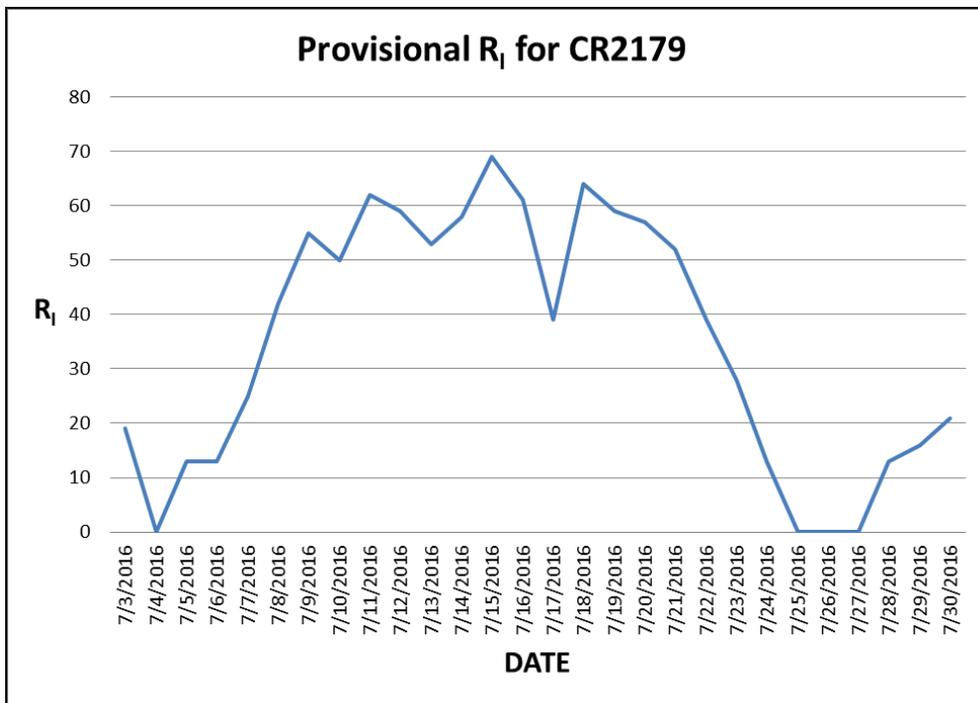
Figure 3. Two views of AR2552 on 6/11. The upper is a white-light (540nm) image by Ramakers at 12:57 UT. Below is a CaK image by Grassmann at 10:47 UT. Instrumental details can be found Table 1.

Figure 4. A combined white-light and H-alpha drawing of AR2552 by Ginninoto at 14:10 UT on 6/11. Note the limb prominences. Details on his equipment can be found in Table 1.



with symmetrical penumbra containing four umbrae and a few tiny umbrae around and following with the area unchanged. The site of the following plage was seen as bright faculae. Giannino put a class estimate for the group at Hsx and Rienks as Hax, which agreed well with the NOAA estimate of Hsx. Things were remarkably unchanged on 7/13 and we got a nice sub-arc-second look at the large spot in a Tyler image (Fig. 6). One thing just barely shown in the Tyler image but much better seen in a Ramakers image a few hours later is the small cluster of umbrae that had formed following the big spot and a little south. By 7/14, several of the larger spots in this cluster had begun to develop their own penumbra. This had earned the group a new classification of Cao, though the mag-class remained “beta” with similar flare production (about 1 every 4 hours). This cluster of spots had almost doubled the area of the group to 220 millionths.

Early on 7/15, the cluster rapidly broke down while another, larger cluster very rapidly formed about three times farther out from the large spot, still following. This was a new group designated AR2567 late on this date which was classed as Dac with a mag-class of beta-gamma-delta, a very exclusive fraternity! No one showed any transition of the following spots into this new region, so it must be assumed that one broke down and the other, with a distinctly separate magnetic identity, rapidly formed between 22:30 UT on 7/14 and 12:29 UT on 7/15. On this latter date, Ramakers began a seven-day sequence that documented the life of this region very well (Fig. 7). In the Ramakers image at 13:40 UT on 7/15, AR2567 shows a lot of signs of violent activity (shattered penumbrae, etc.) with around 75-80 flares on its first full day! This eclipsed AR2565 by about a factor of 10, which



was still just a fairly round spot of H-class. Above AR2565 was a lone

sunspot. This was designated AR2566 and was destined to be utterly

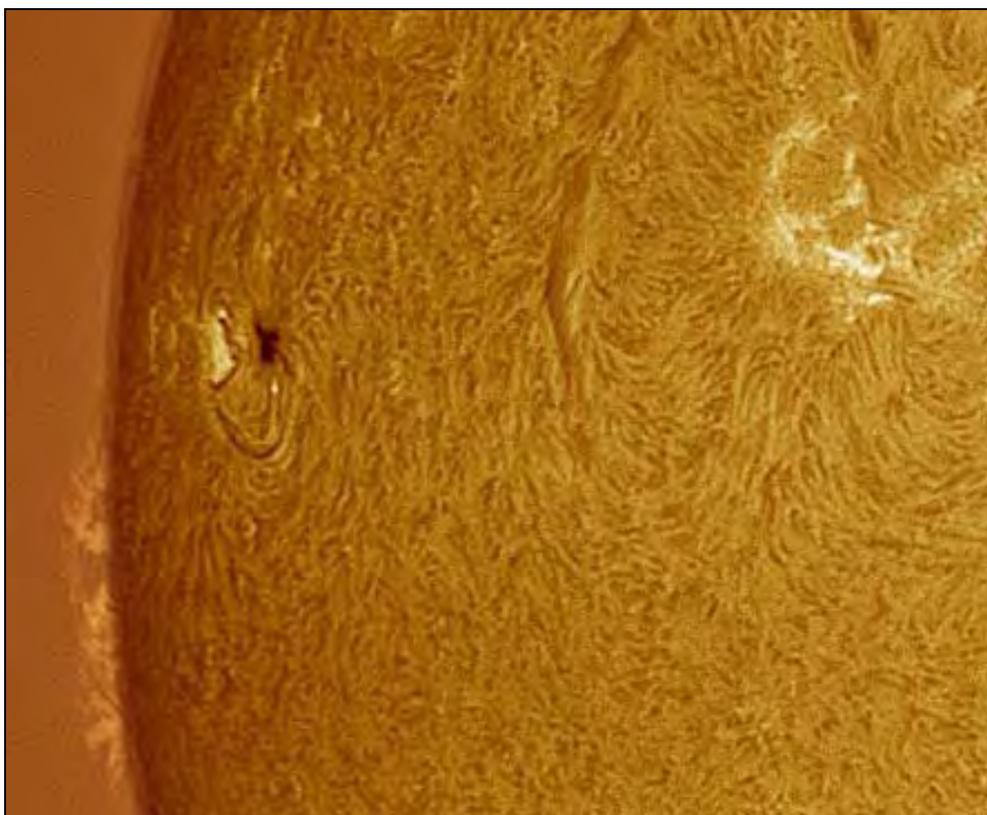


Figure 5. An H-alpha image of AR2562 by Ramakers at 14:07 UT on 7/12 as it comes on the disk. Prominences on the limb are from AR2565 just starting to make an appearance. Instrumental information is found on Table 1.

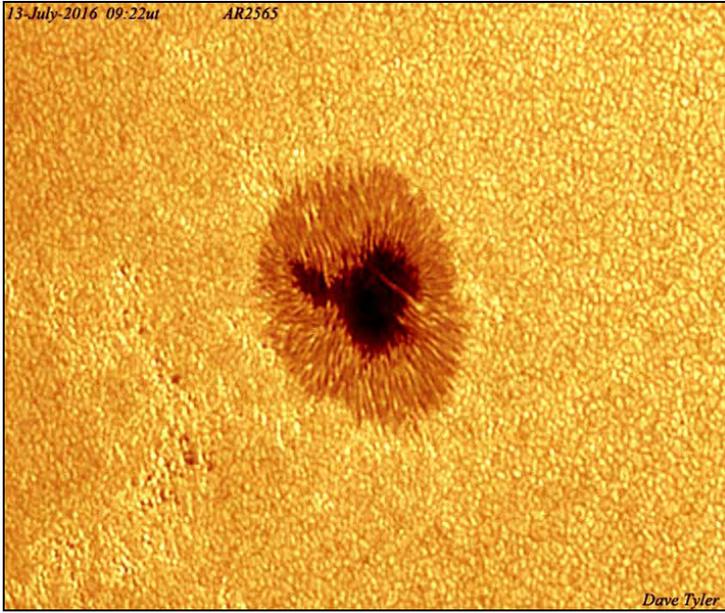
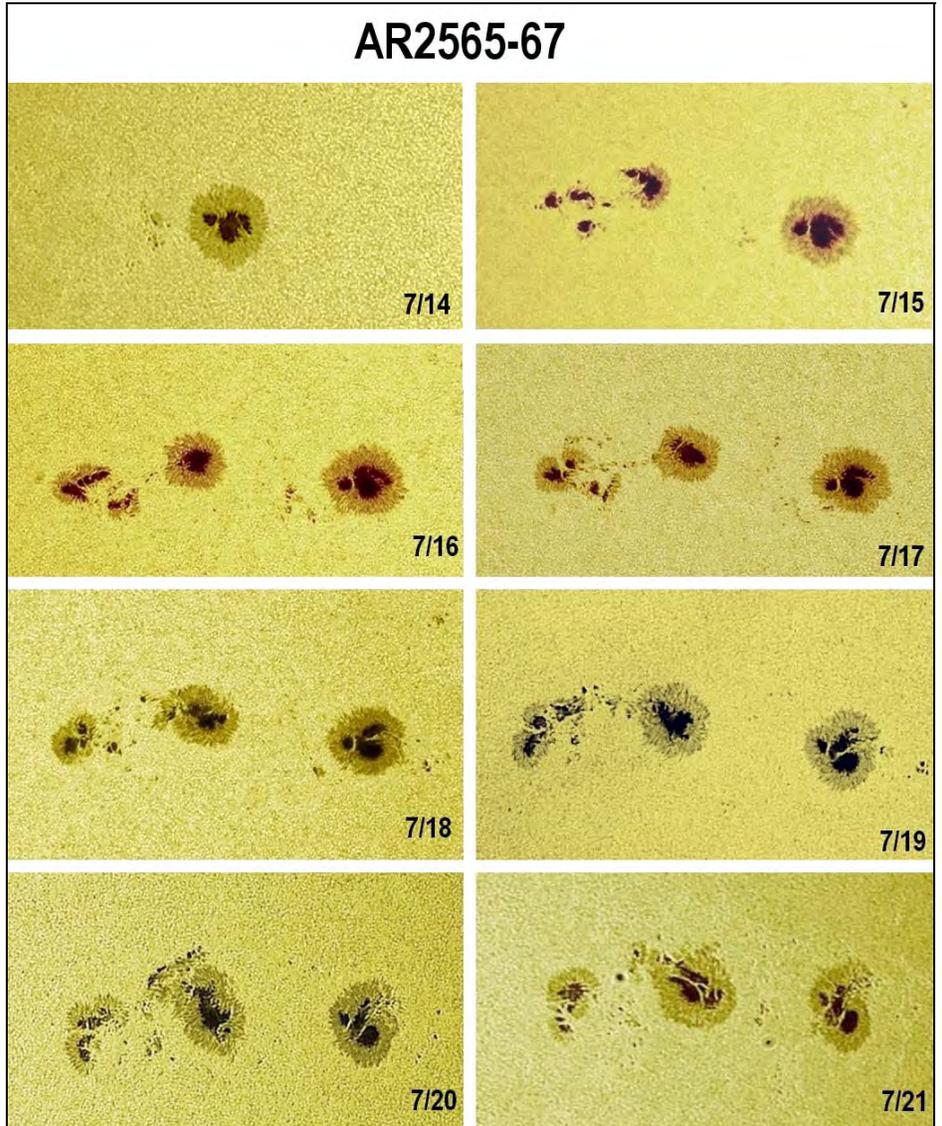


Figure 6. An excellent view of AR2565 on 7/13 by Tyler at 09:22 UT. Equipment used are in Table 1.

Figure 7. An eight-day, white-light montage by Ramakers showing the development of AR2565 and AR2567. Image times are: 7/14 13:10 UT, 7/15 13:40 UT, 7/16 14:08 UT, 7/17 12:22 UT, 7/18 12:41 UT, 7/19 15:11 UT, 7/20 14:29 UT and 7/21 14:07 UT. His telescope/camera information can be found in Table 1.



unremarkable. These events were corroborated by numerous observers on this date (Grassmann, Gianninoto, Levinthal, Reinks, Teske, Tyler). AR2567 developed further by 7/16 to Dsc class with 200 millionths area. All

follower spots now had penumbrae on the outer edges from the center of the group, indicative of flare production in the middle, and a leader spot that had become even more circular than AR2565! This latter group had a

collection of sizable umbrae contained in a round, radially symmetric penumbra. Between the larger collection of umbrae and one that had become separated was a hot light bridge, a good site for flares. The following collection of tiny umbrae and pores had once again reformed, following the leader closely. The area was still 320 millionths and the class was back up to Dho. In addition to the Ramakers montage, Tyler did an exquisite H-a and w-l pair of images that the author has put together here to show just where some of the flare activity is occurring. Tyler shows excellent sub-arc-second detail in w-l at 11:03 UT with a corresponding H-a image at 11:28 UT, which also includes an inset of a drawing by Teske on the same day at 15:48 UT (Fig. 8).

The next day, 7/17, flare production decreased a bit in AR2567 which was now a mag-class of beta-gamma and a McIntosh class of Dhi with an area of 330 millionths. The follower spots moved away from the leader and were coalescing. An interesting trail of small umbrae and pores connected the leader and follower. AR2565 was now Cko, with an area of 350 millionths with the small follower spots mostly just pores again. It's odd that the area should be slightly larger because the follower spots were gone and the main spot looked about 10% smaller than the day before. The follower spots in AR2567 had largely coalesced by 7/18 with a few naked umbrae and penumbral bits between the leader and follower. The leader spot was showing signs of disruption on the following side. These things indicated that flares were probably in this area. A Schur h-a image on 7/18 shows not only this hot spot, but another between the two ARs. Other parameters of these two regions were largely unchanged from the previous day (Fig. 9).

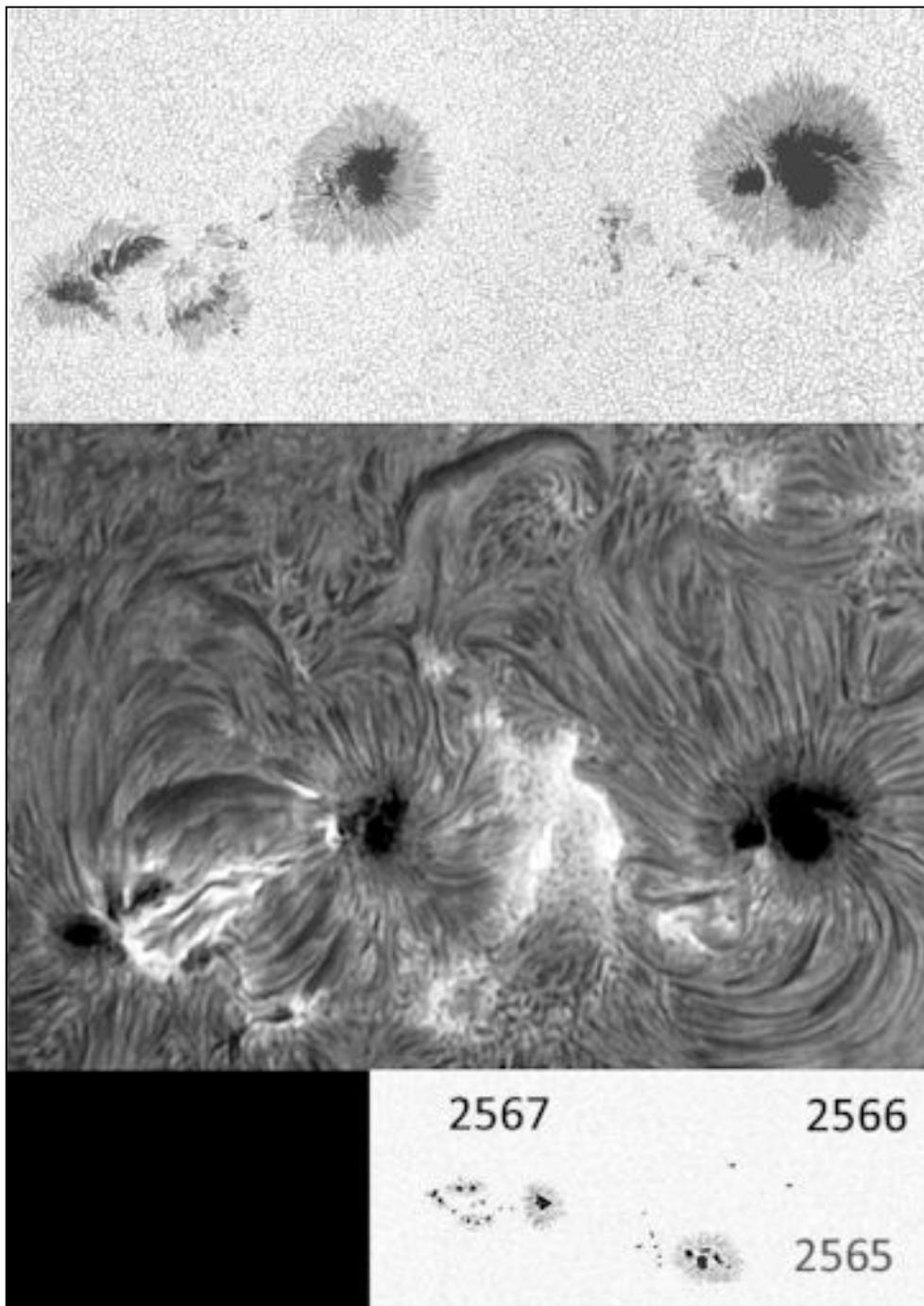


Figure 8. Three views of AR2565 and 2567 on 7/16. The upper one is a white light image by Tyler at 11:03 UT. The middle image is an H-alpha image by Tyler at 11:28 UT and the bottom inset is a drawing by Teske at 14:35 UT. Further instrumental information is in Table1.

The Strolling Astronomer

In AR2567 on 7/19, things were more active, as the leader was now larger and the follower had increased in area with light bridges cutting the larger spot into three pieces with a scattering of umbrae and detached penumbra between the leader and follower. The class was listed

as Dki with the mag-class being beta-gamma, down from previous days. Flare production had dropped by another 20% to about 50 in the previous 48 hours, but still an impressive average of 1 per hour. A blue-shifted H- α image by O'Neil (Fig. 10) shows very interesting fibril structures

stretching across the region from the leading side of the leader spot to the leading edge of the follower. It also shows some interesting bright spots around AR2565.

The next day, 7/20, saw AR2565 continuing a process of decay, where the former umbra was divided into three pieces by thin light bridges and the leading penumbra was quite disturbed. AR2567 had a leader spot with a large north-south elongated umbra surrounded by penumbra that was disturbed on the north and south ends. The follower spot of this group consisted of between six and eight umbrae, in two separate masses arranged north-south, with penumbra only on the following sides. Again the classes and area for the former region were unchanged, but the latter had increased in area to 510 millionths with a w-l class of Dki and a mag-class reduced to just beta. This would be maximum development for this region. Grassmann got a good CaK image at 08:53 UT of these regions showing hot spots between the leader and follower in AR2567 and another north-south elongated hotspot between the two regions (Fig. 11). Things showed dissolution in both regions on 7/21. In AR2565, the northern end of the group was now broken penumbra with a scattering of tiny umbrae and pores mixed in. The two northern umbrae were smaller and the middle one crossed by several small light bridges. The class was Hkx with an area of 250 millionths and mag-class was listed as alpha with only one flare in 48 hours. Similarly, AR2567 displayed the signs of break up. The leader spot umbra was crossed by no less than four light bridges and its northern end was broken up similar to the previous group. The follower spot had one larger spot (the northern one) while the southern one that was formerly the larger was now much reduced in size as seen in a Tyler



Figure 9. A Ramakers H- α image of AR2565-67 on 7/17 at 15:16 UT. See Table 1 for additional instrumental details.

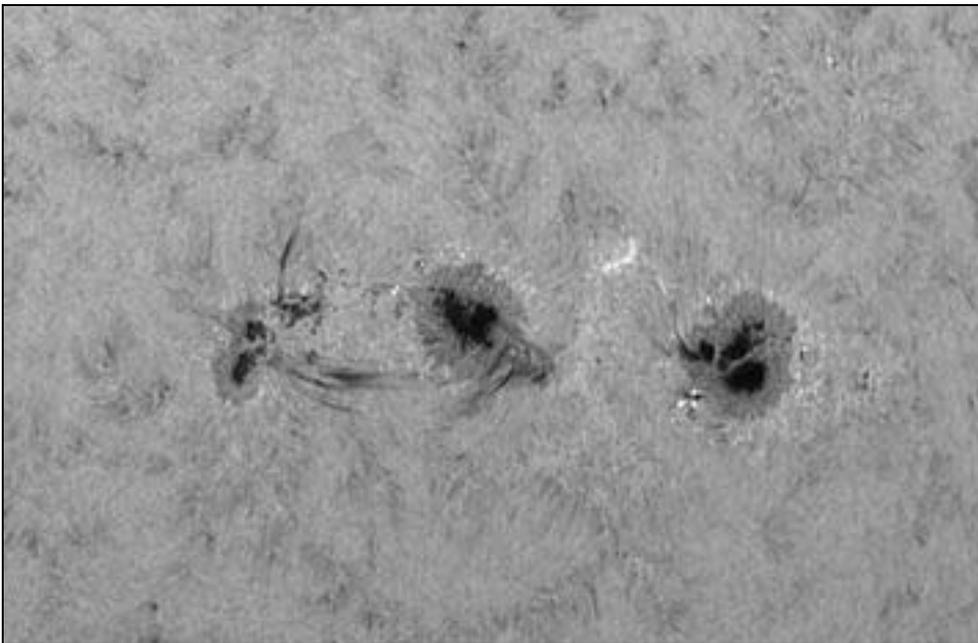


Figure 10. A blue-shifted H- α image of AR2565-67 on 7/19 at 13:48 UT. Note the filaments that reach completely across AR2567 and the interesting bright points around AR2565. More instrument and camera details are on Table 1.

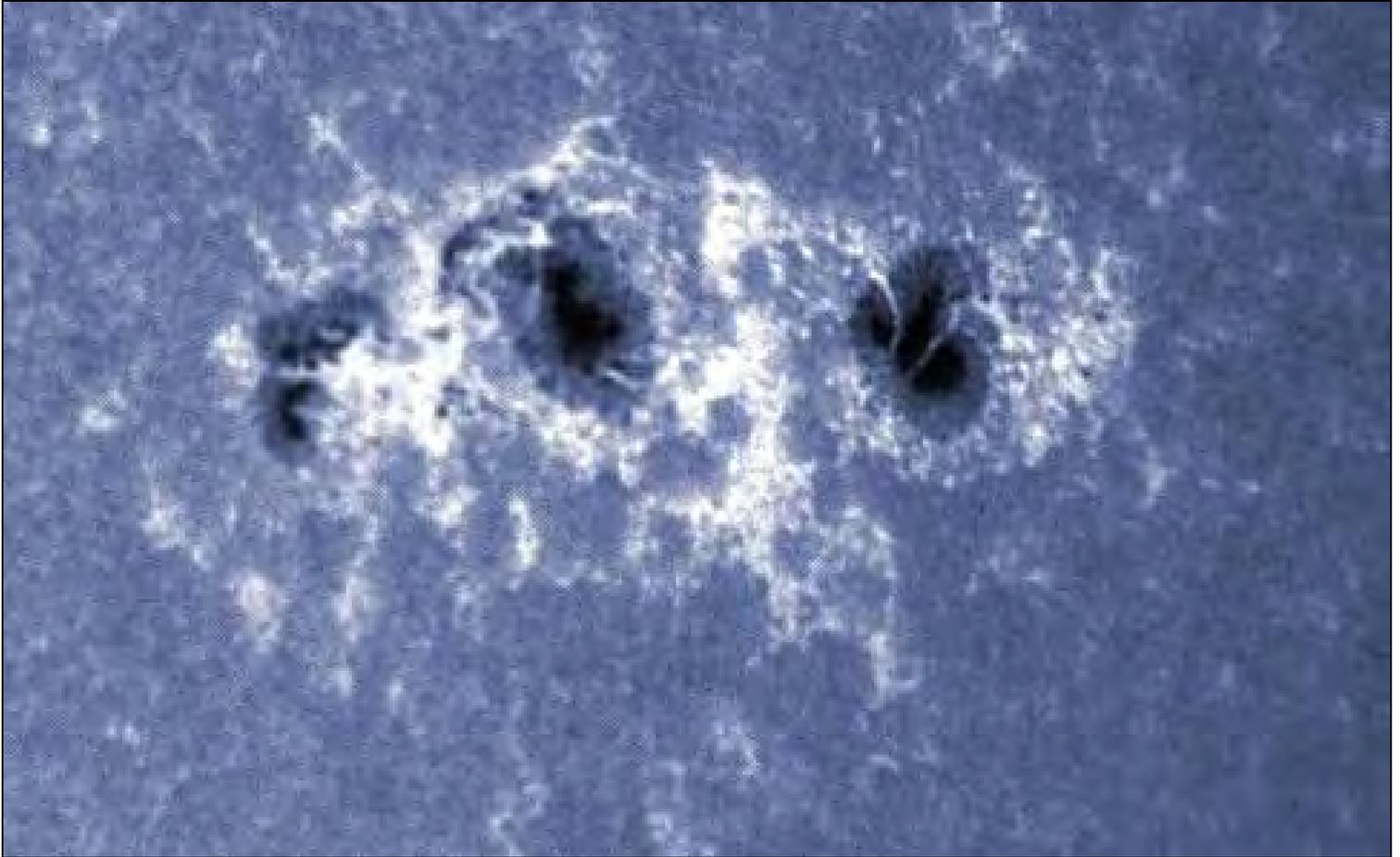


Figure 11. An excellent CaK image of AR2565-67 by Grassmann on 7/20 at 08:53 UT. Instrumental details are in Table 1.



Figure 12. Another arc-second image of AR2565-67 by Tyler on 7/21 at 09:51 UT. Equipment used is listed in Table 1.

w-l image taken at 09:31 UT (Fig. 12). The area and classes were reduced to Dki and beta-gamma again with an area of 380 millionths. This region was still producing an average of one flare per hour.

Things remained much the same as these regions approached the limb. AR2565 stayed at Hkx with an area of 250 millionths for the rest of its time on the disk. AR2567 kept breaking down until it was Dao at 210 millionths as it left the disk on 7/24. One beautiful high resolution CaK view of these regions on 7/23 (the last day they were both on the disk) was had by Eskildsen at 12:38 UT (Fig. 13); it shows the regions much reduced in area with one small flare in progress. Tyler the regions on the limb

just a few hours earlier in w-l (Fig. 14). Note the extensive faculae and the Wilson Effect nicely demonstrated in this last w-l view.

Conclusion

As can be seen, activity is still decreasing though there is still the occasional interesting region. AR2567 at its peak was less than half the area of the best regions only a year ago. But it demonstrates that it is nevertheless important for vigilant monitoring of solar activity on this most dynamic of bodies. Use what equipment you have and observe in whatever mode is convenient for you. We have four observers who, as seen in this report, do drawings. All observations are useful and helpful. Further, observers are encouraged to consider doing as was done for the Ramakers observations by compiling, in one image, a time sequence of one or two regions. It makes it much easier to note changes and see predictive behavior that might have otherwise been missed.

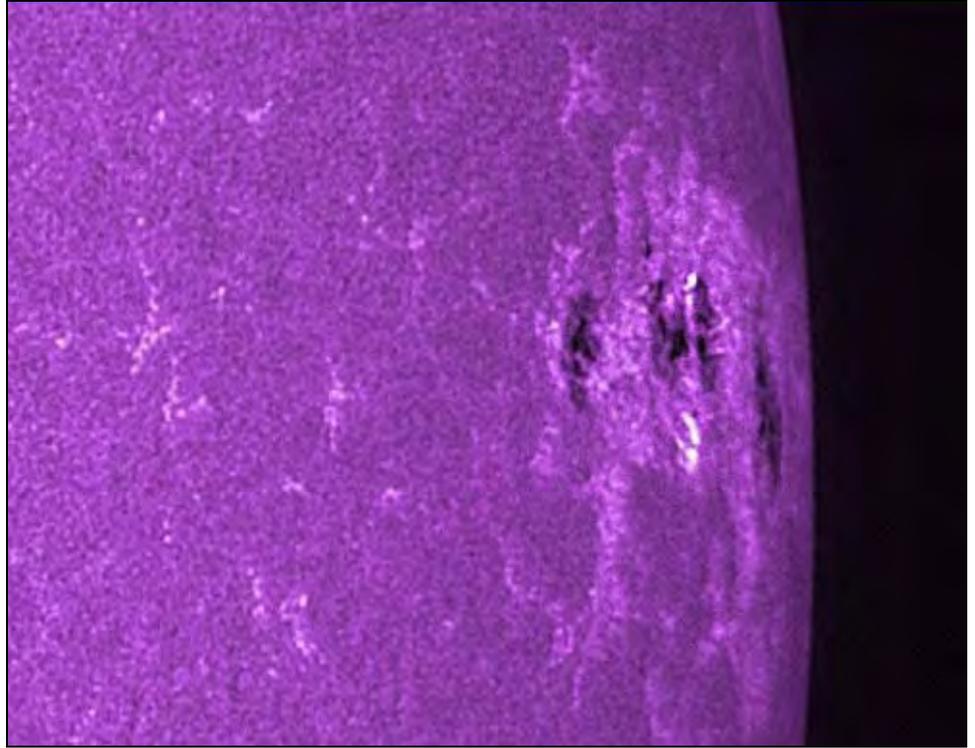


Figure 13. A breathtaking last look at AR2565-67 in a CaK image by Eskildsen on 7/23 at 12:38UT. See Table 1 for his instrumentation.

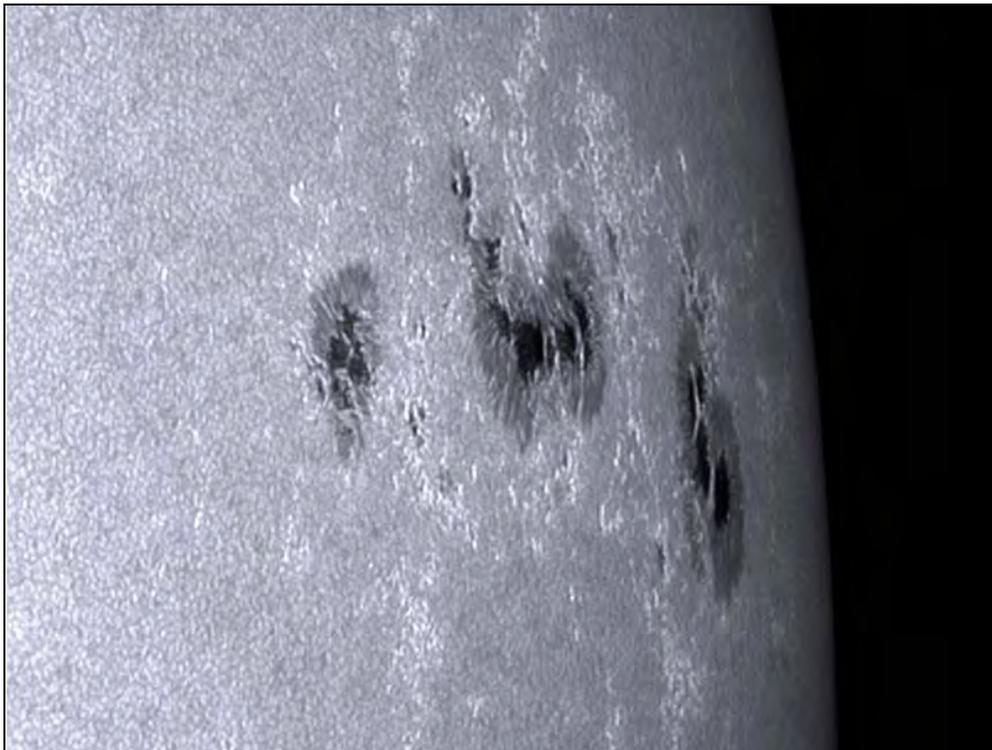


Figure 14. A last white-light look at AR2565-67 on the limb by Tyler on 7/23 at 09:01 UT.