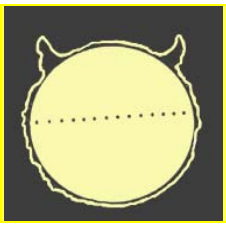

Papers & Presentations:

Are We There Yet? When Will Solar Cycle 25 Arrive?

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To our hard-copy readers: This paper can be viewed in full-color in the online (pdf) version of this Journal.

Abstract

Questions arise about where we are in the current solar cycle and what is happening in the transition to the new Cycle on a day to day basis. This paper is a limited review of the amateur and scientific data associated with the transition from Solar Cycle 24 to Solar Cycle 25.

Discussion

We know that we are somewhere between solar maximum and solar minimum but we also wonder exactly when we will be at solar minimum? We know that all of the nice spots and flares of a few years ago are gone. The last real activity was in the beginning of September 2017, when out of nowhere, AR2673 popped up and then increased in size to over a whopping 1,000 millionths of the solar hemisphere. While AR2673 was growing rapidly on September 6, it produced an X9.3 flare, the largest X flare of Cycle 24. But that was not all. A few days following that event on September 10, a new short-lived and unnamed active region became visible in the northern solar hemisphere (North 36°). However, the odd thing about this area was that the magnetogram showed that the polarity of this region did not line up with the other Cycle 24 areas. Its poles were reversed, suggesting that some Cycle 25 activity below the surface might have been

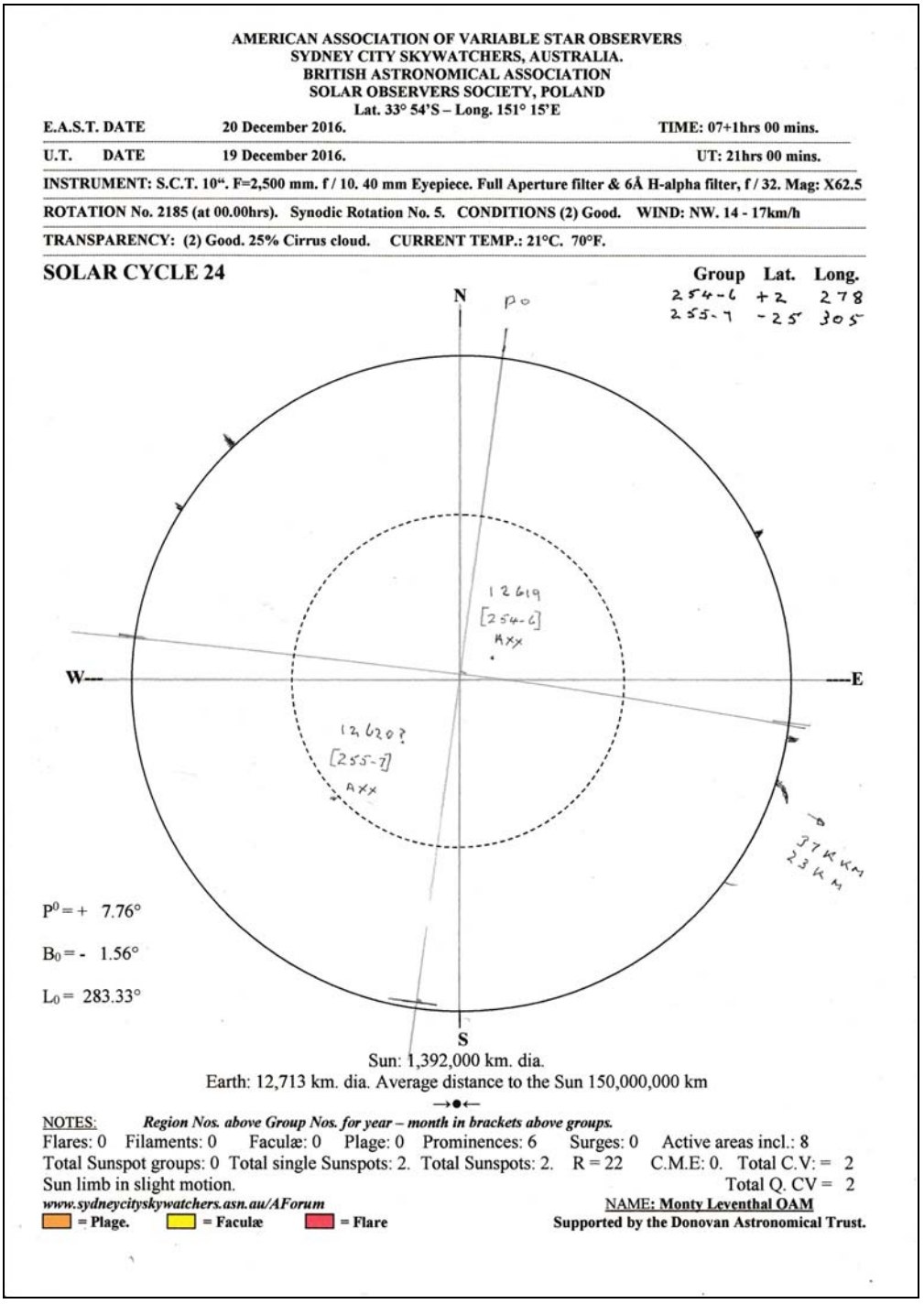

Figure 1. AR2620, a reversed polarized area on 2016-12-19 by Leventhal, South 25°.

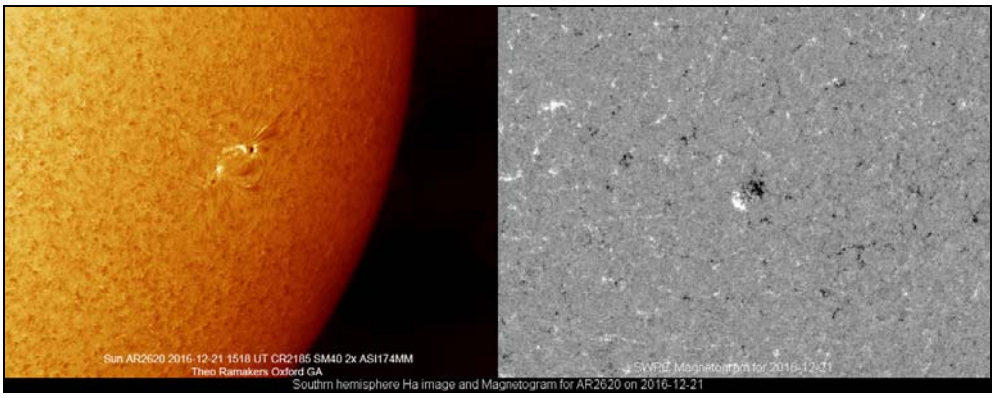

Figure 2. AR2620, a reversed polarized area on 2016-12-21 by Ramakers, South 23°.

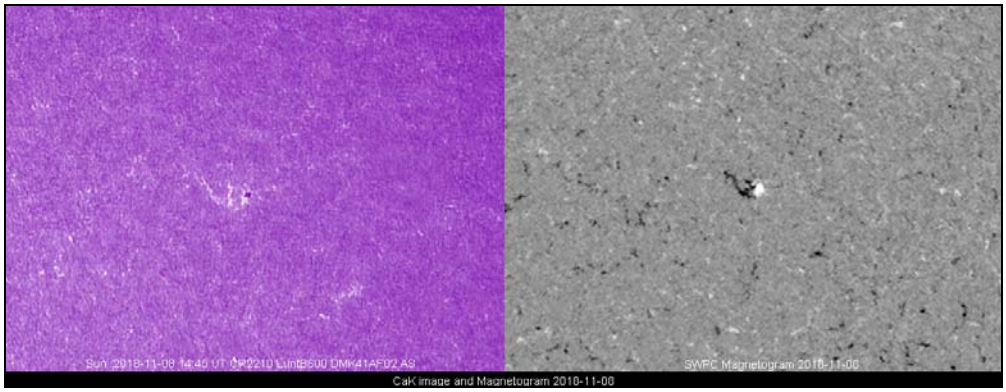

Figure 3. Small Cycle 25 polarized area on 2018-11-08 by Eskildsen, North 26°.

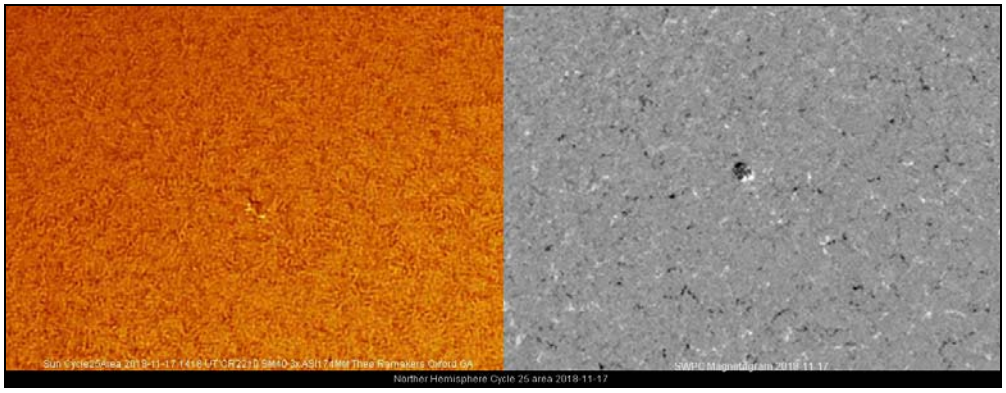

Figure 4. A small Cycle 25 polarized area on 2018-11-17 by Ramakers, North 27°.

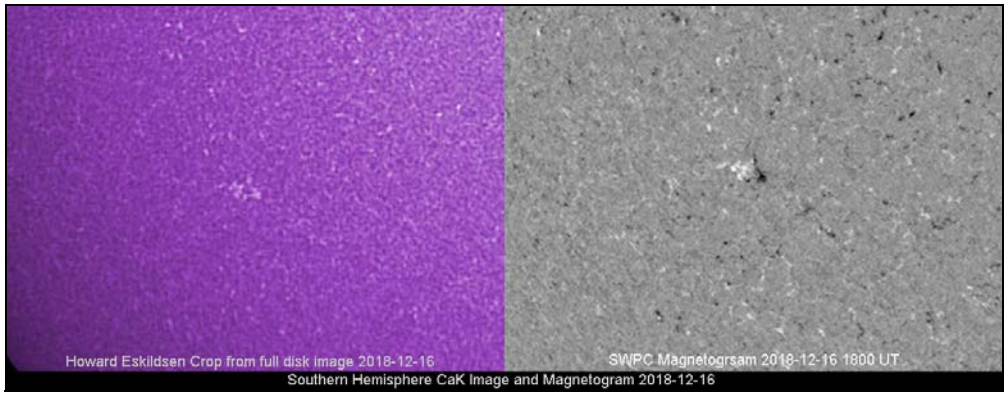

Figure 5. Small Cycle 25 polarized area on 2018-12-16 by Eskildsen, South 20°.

NOTE: The magnetogram images shown with figures 2 through 7 were extracted from the magnetogram images provided by NASA's SDO HMIB archive.

struggling with the prevailing Cycle 24 activities. The appearance of this region might support claims that this disruption might have contributed to the immense X9.6 solar flare of September 6.

We have known for a long time that the Sun's activities go through cycles. Approximately every 11 years or so, the Sun goes through a period of high solar activity and then low activity. In addition, the magnetic fields of the Sun reverse every 11 years; so after approximately 22 years (two solar cycles), the magnetic field is restored to what as it was at the beginning. This can be seen by observing the polarity of the dipoles associated with active regions which are shown in magnetograms. Dark and light areas depict the difference in polarity indicating which way the plasma moves that follows the magnetic field. In addition, it should be noted that the normal polarity of the regions in the northern and southern hemispheres of the Sun, regardless of the cycle, are reversed from each other.

The appearance of the reversed polarized region described in the event above, showed that Cycle 25 was already on its way in the fall of 2017. However, this was not the first time we had seen Cycle 25 areas. To our knowledge, the first Cycle 25 polarized area in our archive is AR2620, which appeared at the solar latitude South 23°, and whose observation was submitted in a drawing by Leventhal on December 19, 2016 (Figure 1), as well as an image captured on December 21, 2016 by Ramakers (Figure 2). On these days, the magnetogram showed again a polarization of the region conforming with Cycle 25. Occurrences of the Cycle 25 polarized areas have been long and far, but between October and December 2018, their frequency has increased. Two small Cycle 25 areas were observed on October 9, both in the southern solar

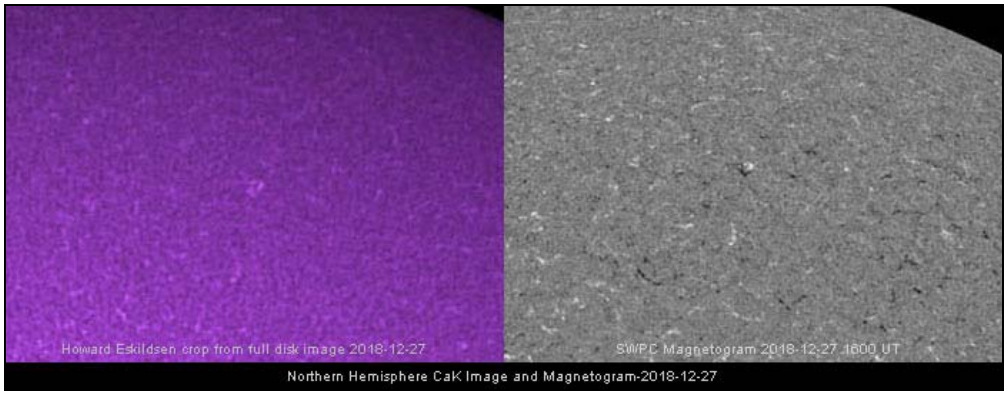

Figure 6. Cycle 25 polarized area on 2018-12-27 by Eskildsen, North 48°.

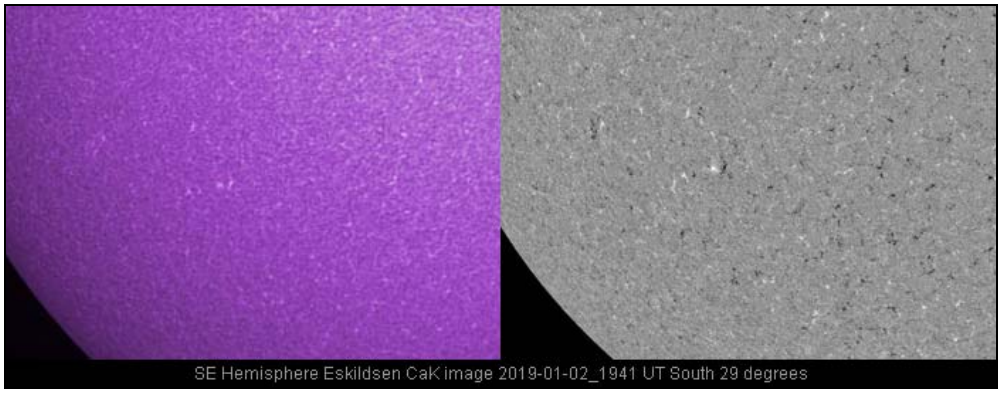

Figure 7. SE hemisphere Cycle 25 polarized area on 2019-01-02 by Eskildsen South 29°.

hemisphere (South 29° and 49°). A small Cycle 25 area started developing in the northern solar hemisphere on November 8 (North 26°), and was imaged the same day by Eskildsen (Figure 3), but it disappeared after a few days. Nine days later on November 17, another Cycle 25 polarized area was imaged by Ramakers (Figure 4), this time, in Ha in the solar northern hemisphere, at a latitude of approximately North 27°. The last two Cycle 25 polarized areas of 2018 can be seen in two full-disk CaK images captured by Eskildsen — the first one on December 16 at a latitude North South 18° (Figure 5), and the second one on December 27 (Figure 6) at a latitude of North 48°. And finally the first occurrence of a reversed polarized area in the new year happened on January 2, 2019 which can be seen in Eskildsen's image (Figure7) from the same date.In addition to the areas mentioned here, reports show a number of additional Cycle 25 polarized areas (or "pores"). And even though we might not see sunspots, we notice plages in CaK and Ha in higher latitudes as well as many associated filaments and prominences. These are all indications of the solar activity in areas where we expect the next Cycle 25 sunspots to start to occur.

The observation of areas on the Sun and determining when an area is a spot or pore can be very subjective, and reports of the observed sunspot number, or "Wolf number", varies widely and depends on the observer, their eyesight and equipment, as well as seeing conditions. There is also the question of when does a pore become a spot. Many observers ask why the region they saw did not get assigned an Active Region number by the SWPC (Space Weather Prediction Center) in Boulder, which is the authority to assign these numbers.

It is, therefore, important to know the guidelines SWPC follows in assigning Active Region numbers which can be found in "Region Summary" on page 6 of its *Users Guide to The Preliminary Report and Forecast of Solar Geophysical Data*. Regions are assigned SWPC region, or "AR numbers", if any of the following conditions exist:

(1) The region has a sunspot group with a first digit spot class of C, D, E, F or H,

(2) Two or more reports confirm the presence of class A or B spot group,

(3) The region produces a solar flare, or

(4) The region is "bright" in Ha and exceeds 5 heliographic degrees in either latitude or longitude."

In this context, one should also review the observing sites which submit reports to the SWPC which can be found on page 11 of the guide.

So we can see many areas with polarities that are consistent with Cycle 25, but if they do not meet the Active Region naming requirements, they might be recorded but not named by SWPC. In addition, new cycles' activities start at higher latitude locations on the Sun and move to the lower latitudes (equator) in a butterfly pattern as the cycle progresses (see Figure 8).

So it should not be a surprise if active regions with new polarity are not deemed members of the new cycle if their location is not consistent with this but appear at the lower latitudes. Lastly, don't despair if your sunspot number is different from the official sunspot number. Different organizations report different results for the sunspot number simply because the observing sites for the organizations are different and observers might use different interpretations.

For the record, we want to point out that the organization responsible for assigning the AR (active region) numbers is NOAA and its SWPC, while the organization responsible for the International Sunspot Number (Ri) is the World Data Center for the production, preservation and dissemination of the International Sunspot Number of SILSO (Sunspot Index and Long-Term Solar Observations), which is associated with the Royal Observatory of Belgium.

Conclusion

So to come back to the question we started with: Are we there yet? The answer is: We don't know. And with it, the questions raised by predictions of different scientists predicting "the most active cycle" or the "Maunder Minimum" will not be answered until we have proof of being on the way to solar maximum again, and we have not seen any proof of that yet.

The Sun not only goes through the 11-year solar cycle, but other cycles are also at work, which cause subsequent cycles to go up or down in solar activity. One might refer to *The Gleissberg Cycle of Solar Activity* by Frederick Colbourn (see References at the end of this paper). The solar minimum happens when the smoothened Ri is lowest, and we won't know until it starts rising again.

To refresh our memory, one might remember that we had two peaks in Cycle 24 of which the second produced the solar maximum; also, the longest spotless streak of the last solar minimum was 52 days and so far, we have seen a streak of only 25 days. But in addition to the lowest Ri, we should also see an increase in Cycle 25 areas at higher latitudes, indicating that we have left Cycle 24 and have entered Cycle 25.

References

Colbourn, Frederick S. (2015). "The Gleissberg Cycle of Solar Activity." *https://geoscienceenvironment.wordpress.com/2015/10/23/the-gleissberg-cycle-of-solar-activity/*

Hathaway, Dr. David. (revised, 2017), "The Sunspot Cycle." *https://solarscience.msfc.nasa.gov/SunspotCycle.shtml* including butterfly diagram shown in this paper *https://solarscience.msfc.nasa.gov/images/bfly.gif*

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

Space Weather Prediction Center. "Users Guide to The Preliminary Report and Forecast of Solar Geophysical Data." *https://www.swpc.noaa.gov/sites/default/files/images/u2/Usr_guide.pdf*

For information on solar observing – including the various observing forms and information on completing them – go to *www.alpo-astronomy.org/solar*

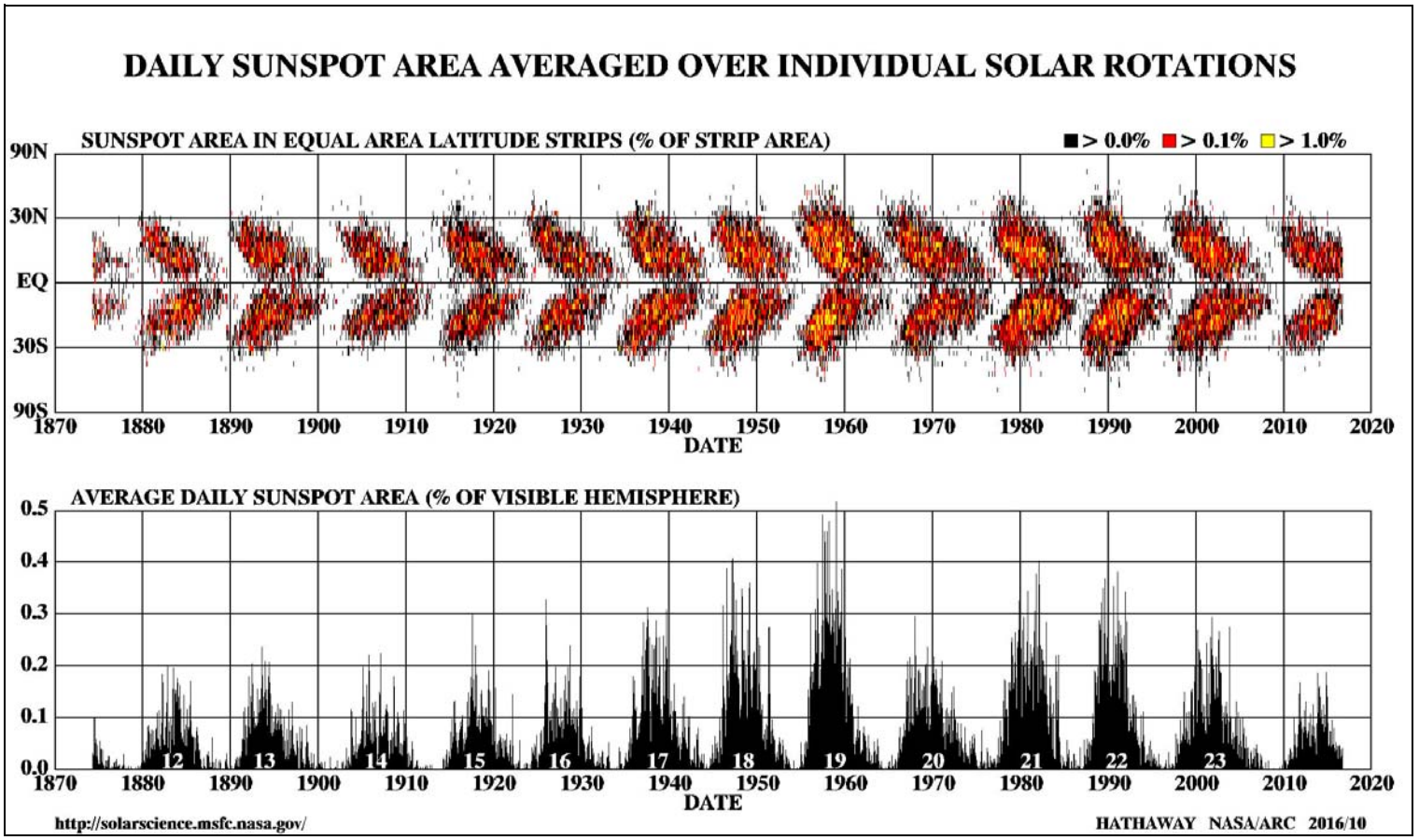

Figure 8. Sunspot location butterfly diagram. Source: Dr. David Hathaway, *NASA SolarScience*.