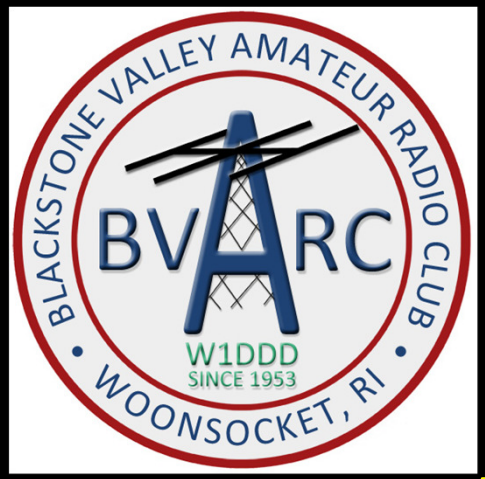
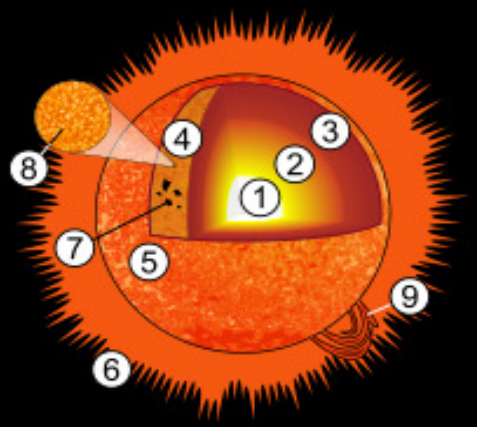


Sunspots

What are they?
What is a Sunspot cycle?
What are the effects on Amateur Radio?

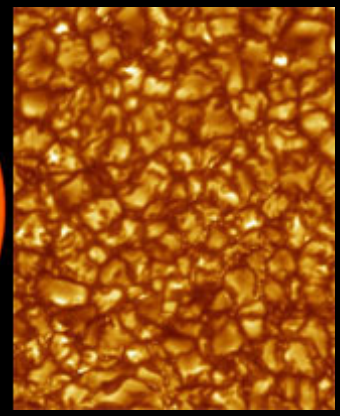
What are Sun Spots?

- Sunspots are a temporary phenomena on the Sun's *photosphere* that appear as spots darker than the surrounding areas.
- The *photosphere* is a star's outer shell from which light is radiated.
- Sun Spots are regions of reduced surface temperature caused by concentrations of magnetic field flux that inhibit convection.
- Sunspots usually appear in pairs of *opposite* magnetic polarity.
- Individual Sunspots can be very large, up to 50,000 kilometers in diameter. In feet, that's 1.64042e+8 or 164,042,000 feet in diameter.
- They are caused by interactions with the Sun's magnetic field which are not fully understood.



The structure of our Sun, a G-type main-sequence star.

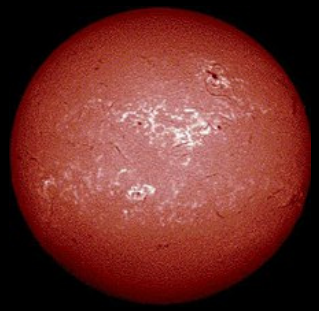
1. Core
2. Radiation zone
3. Convection zone
4. **Photosphere**
5. Chromosphere
6. Corona
7. Sunspot
8. Granules
9. Prominence



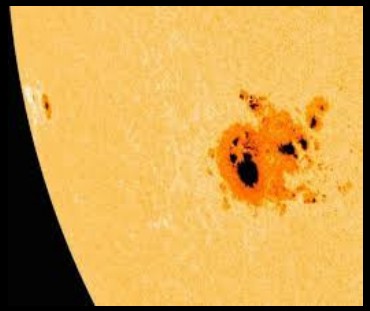
Just in Case You Wanted To Know More…

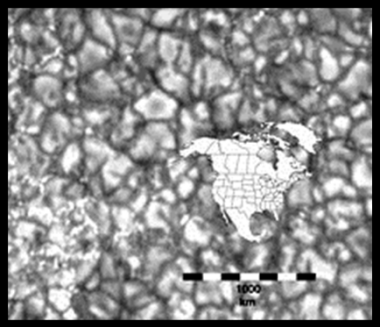
- The structure of our Sun, a G-type main-sequence star.

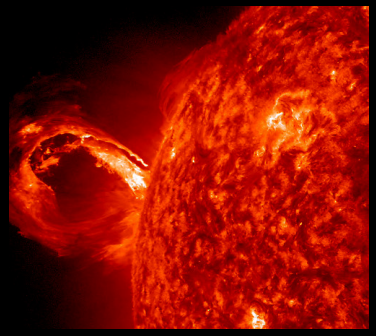
1. Core - It is the hottest part of the Sun and of the Solar System. It has a density of 150 g/cm^3 at the center, and a temperature of 15 million kelvins or 26,999,540.33 degrees Fahrenheit.
2. Radiation zone - Energy travels through the radiation zone in the form of electromagnetic radiation as photons.
3. Convection zone - Convection is the heat transfer due to the bulk movement of molecules within fluids such as gases and liquids, including molten rock.
4. Photosphere - The photosphere is a star's outer shell from which light is radiated.
5. Chromosphere - The chromosphere's rosy red color is only apparent during eclipses. The chromosphere sits just above the photosphere.
6. Corona - A corona is an aura of plasma that surrounds the Sun and other stars. The Sun's corona extends millions of kilometers into outer space and is most easily seen during a total solar eclipse.
7. Sunspot - Individual sunspots or groups of sunspots may last anywhere from a few days to a few months, but eventually decay. Indicating intense magnetic activity, sunspots accompany secondary phenomena such as coronal loops, prominences, and reconnection events.
8. Granules - Granules on the photosphere of the Sun are caused by convection currents of plasma within the Sun's convection zone.
9. Prominence - A prominence is a large, bright, gaseous feature extending outward from the Sun's surface, often in a loop shape.


Chromosphere


Corona


Sunspot


Granules


Prominence

Video – How The Universe Works

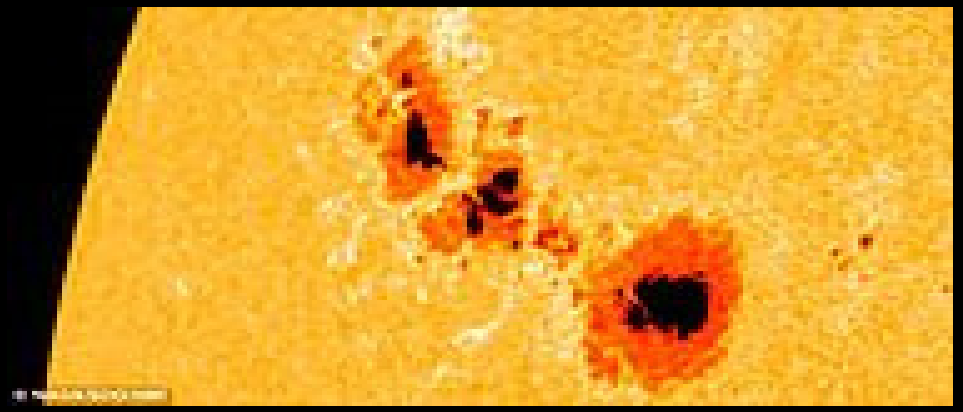
- Key Points to take away from this Video
  - Photons of light are trapped
  - Photosphere
  - Blocking convection flows resulting in a cooler region on the surface of the sun
  - Magnetism from deep in the sun stops convective motion of the sun

What are Sunspots?

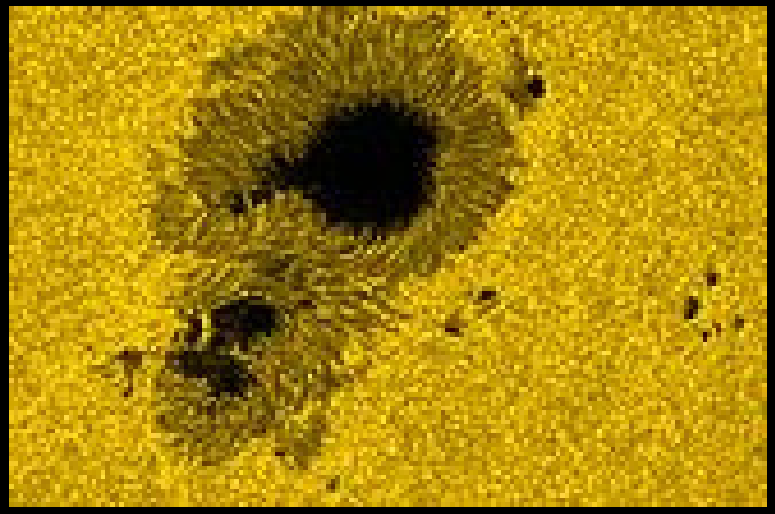
Watch video:

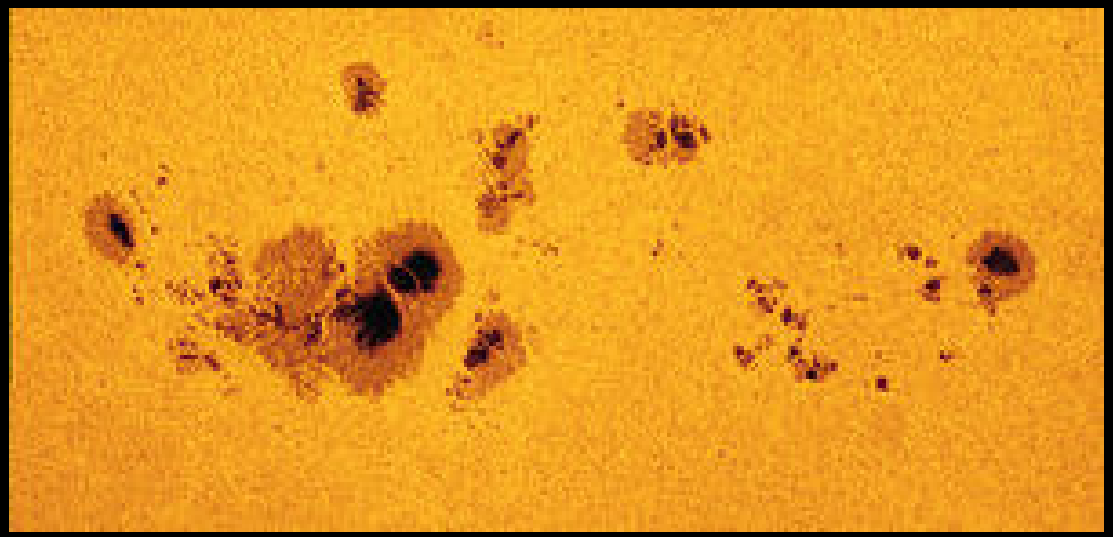
- https://www.youtube.com/watch?v=ZC2dfDS8g0Q
- Click on back-arrow to return to PDF after video

Sunspots



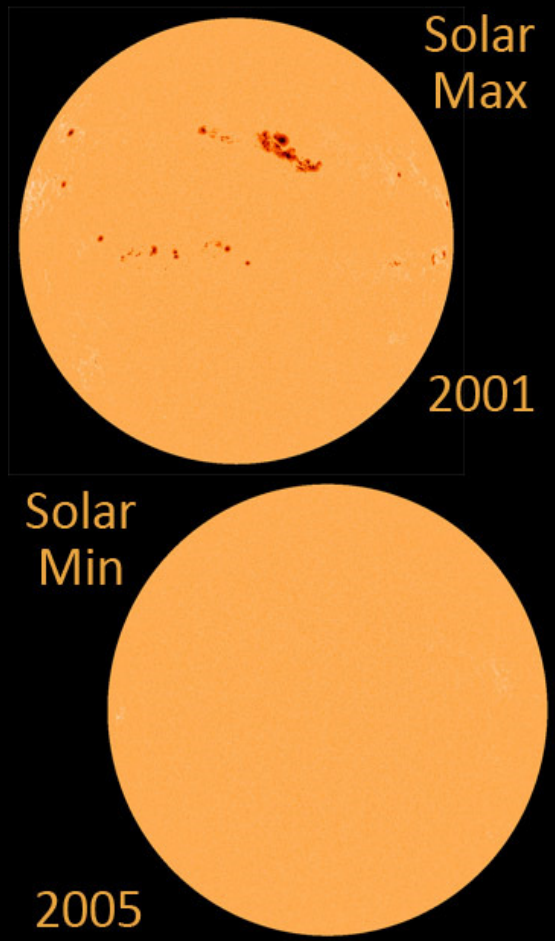
Sunspot region 1302 in September 2011.





Sunspots stretching about 320,000 km (200,000 mi) across.

Sunspots – Max and Min



These two images of the Sun show how the number of sunspots varies over the course of a sunspot cycle.

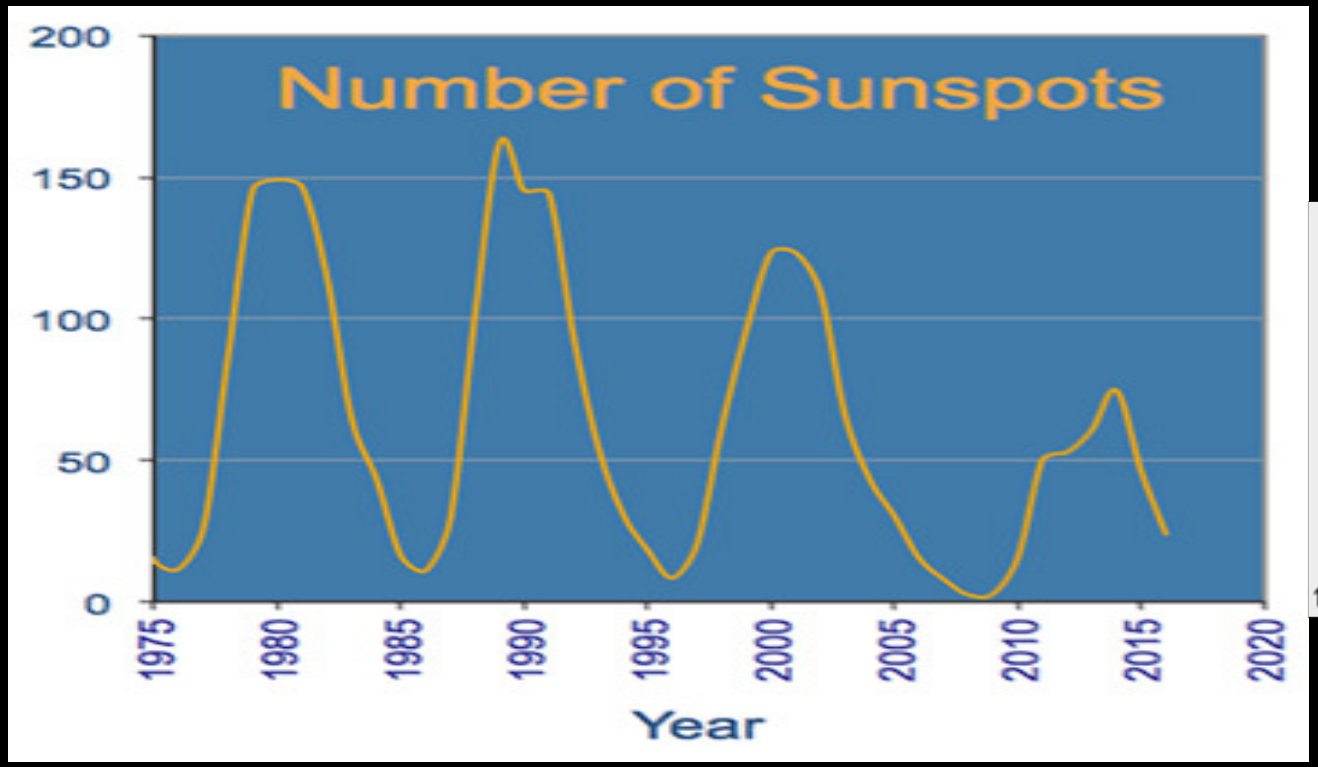
The image on the top, with many sunspots, was taken near solar max in March 2001.

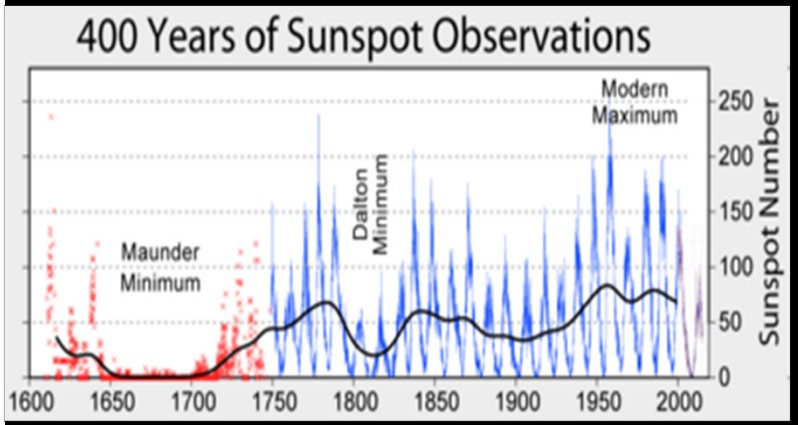
The lower image, in which no spots are evident, was taken near solar min in January 2005.

Credit: SOHO (ESA & NASA)

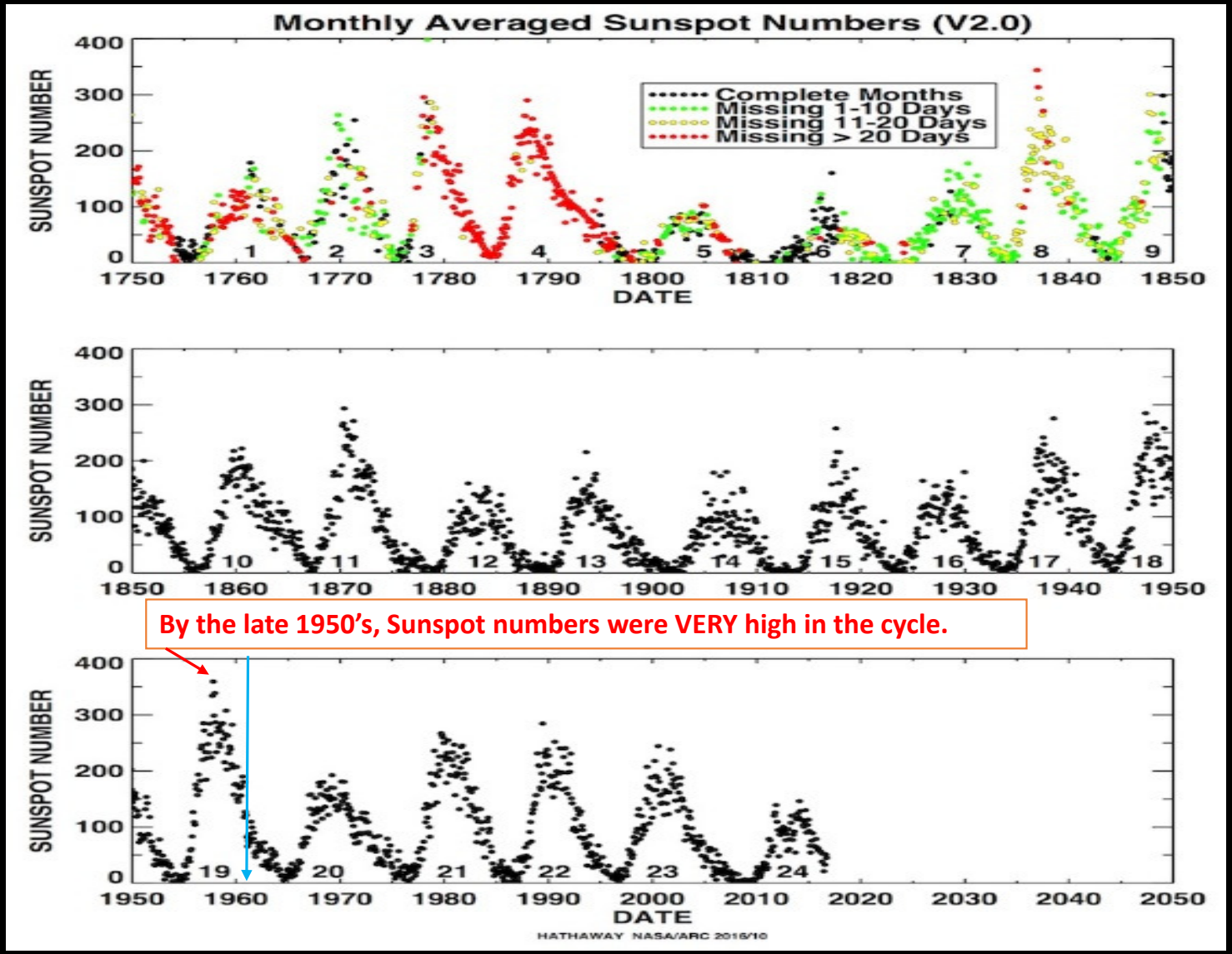
The "Good" Old Days...

- The number of sunspots increases and decreases over time in an approximate 8-14 year cycle, called the sunspot cycle.
- The exact length of the cycle can vary.
- It has been as short as eight years and as long as fourteen years, but the number of sunspots always increases over time and then returns to low number again.
- Previous years of maximum - the period when the Sun is most active and radio signal propagation was highest.
  - Solar Cycle 24 reached its maximum in April 2014 with a peak average of 82 sunspots.
  - Solar Cycle 23 reached its maximum in 2001
  - Solar Cycle 22 reached its maximum in 1989
  - Solar Cycle 21 reached its maximum in 1979
  - Solar Cycle 20 reached its maximum in 1968





This graph shows the number of sunspots counted each year for several decades. Notice how the sunspot count rises and falls in approximately an average 11-year cycle.



My first solar cycle peak in the late 50s

I was first licensed in 1953.

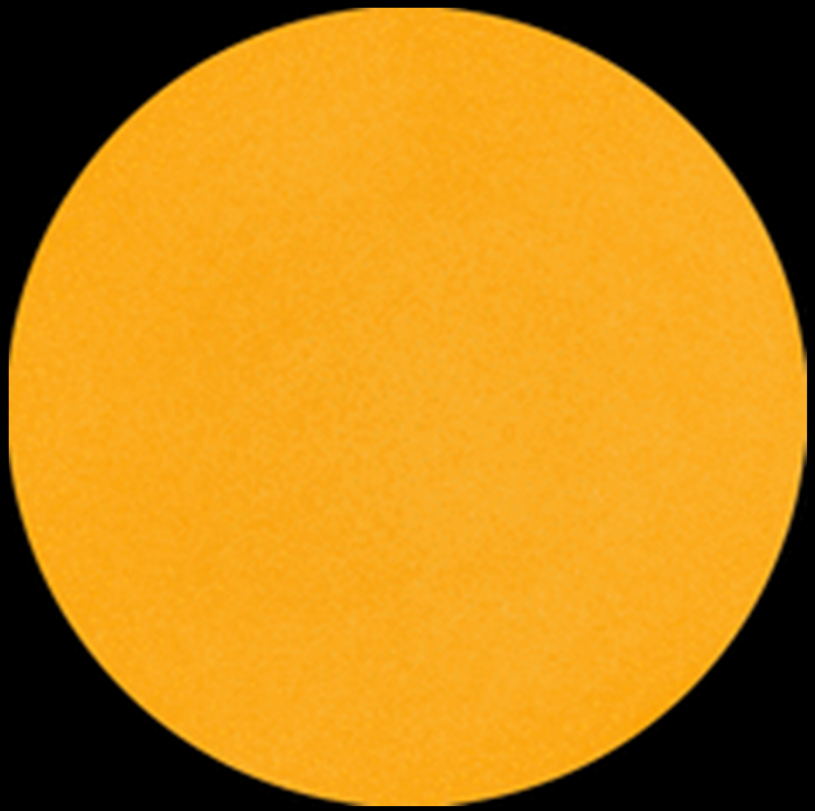
By the late 1950s, I had a General ticket, a Viking II and a 10 meter beam on top of my parent's house, about 40 feet above ground.

I could work the world on 10 meters.

Bob W1YRC

IMPORTANT: NOTE THE SUNSPOT NUMBER IN 1959…

What's Happening Now… The "Ugly" ….



Daily Sun: 30 Dec 2019

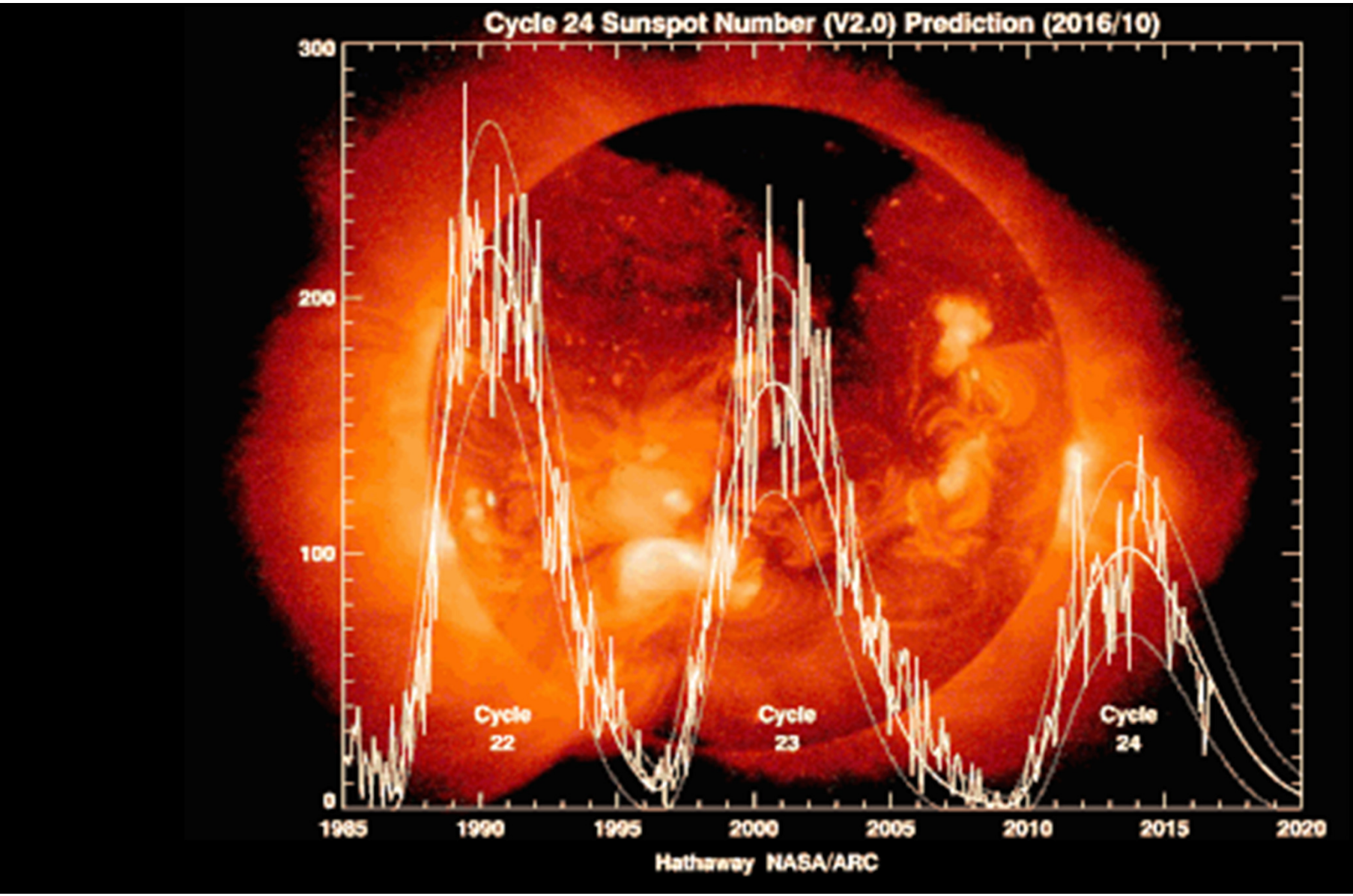
SUNSPOTS BREAK A SPACE AGE RECORD:

Solar Minimum is becoming very deep indeed. Recently, the sun set a Space Age record for spotlessness. So far in 2019, the sun has been without sunspots for more than 280 days, including the last 33 days in a row.

Since the Space Age began, no other year has had this many blank suns.

The sun is blank--no sunspots.
Credit: SDO/HMI

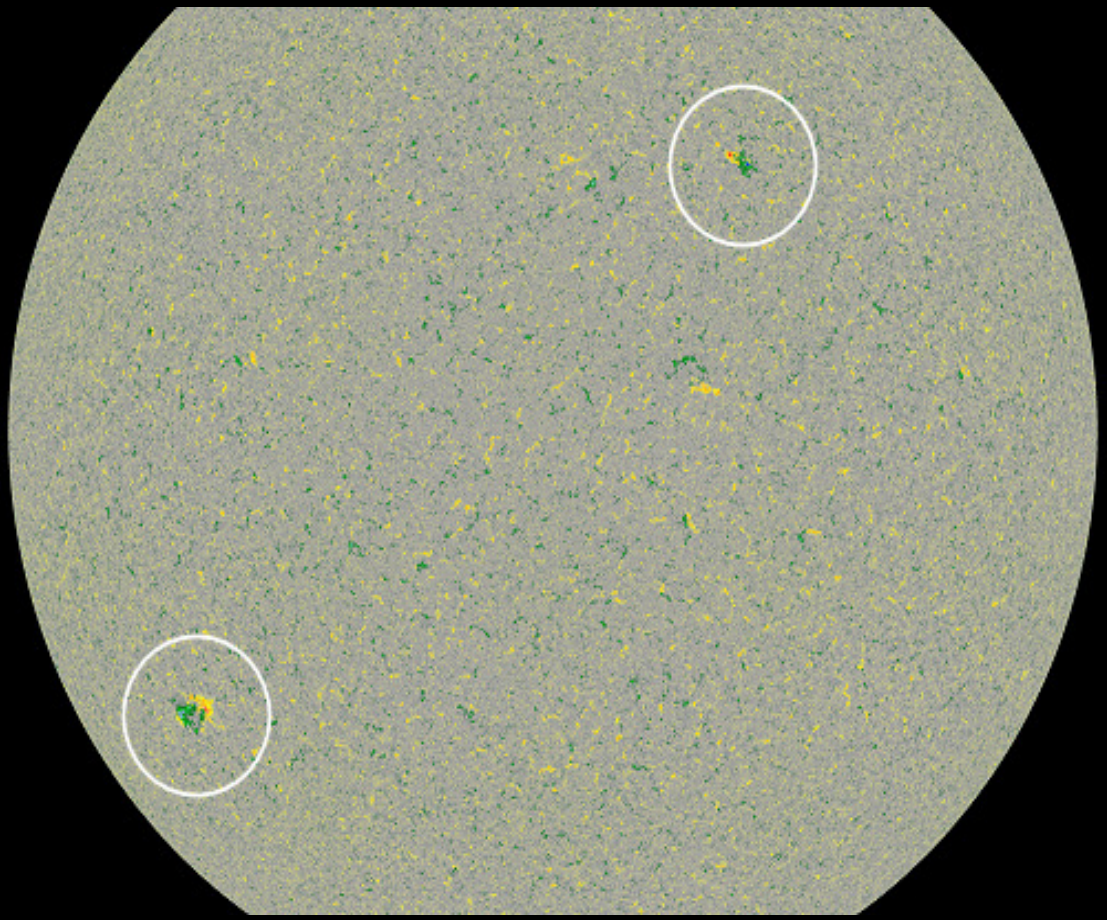
Sun Spotless Days – aka NO SUN SPOTS
2019 total: 280 days (77%) ← ← ← ←
2018 total: 221 days (61%) ← ← ← ←
2017 total: 104 days (28%) ← ← ← ←
2016 total: 32 days (9%)
2015 total: 0 days (0%) ← ← ← ←
2014 total: 1 day (<1%) ← ← ← ←
2013 total: 0 days (0%) ← ← ← ←
2012 total: 0 days (0%) ← ← ← ←
2011 total: 2 days (<1%) ← ← ← ←
2010 total: 51 days (14%)
2009 total: 260 days (71%) ← ← ← ←
2008 total: 268 days (73%) ← ← ← ←
2007 total: 152 days (42%) ← ← ← ←
2006 total: 70 days (19%) ← ← ← ←
Updated as of 30 Dec 2019


Cycle 24 Sunspot Number (V2.0) Prediction (2016/10)
300
200
100
0
Cycle 22
Cycle 23
Cycle 24
1985
1990
1995
2000
2005
2010
2015
2020
Hathaway NASA/ARC

Goddard Space Flight Center – Video

- Solar Cycle – Made Oct 27, 2011
  - Although this video is a few years old, its perfect in that it has predictions of what will occur up to and including 2020.
  - See if you can pick out any abnormalities in their predictions or were their predictions reasonably accurate?
  - Also, listen for the following:
    - 11 Year Sunspot Cycle
    - 22 Year Solar Cycle or Hale Cycle
    - Every 11 years the Magnetic Poles of the sun flip
    - Watch Video: https://www.youtube.com/watch?v=sASbVkK-p0w
    - Click on back-arrow to return to PDF after the video

But… Solar Cycle 25 really is coming! SLOWLY

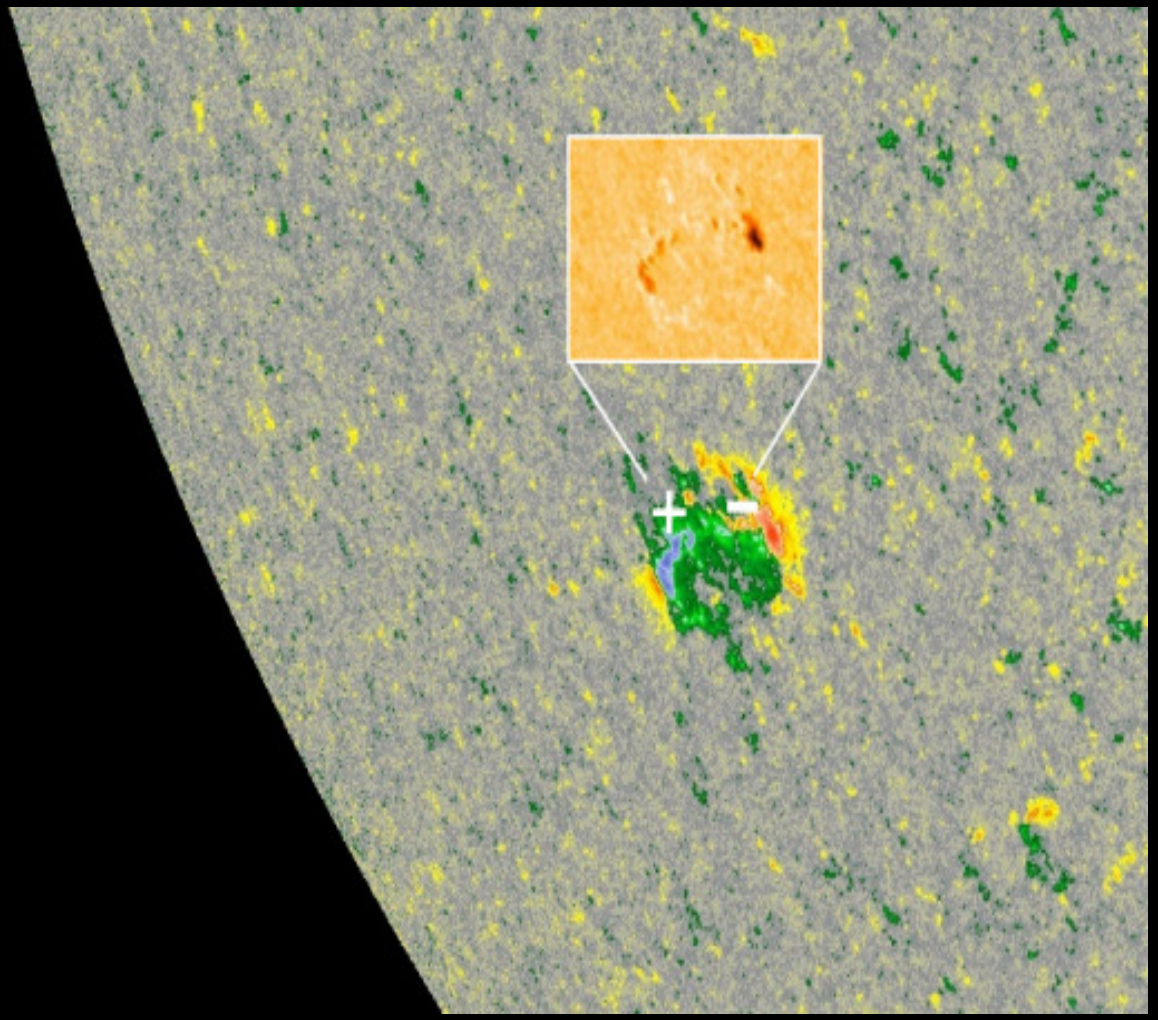


We know these sunspots belong to the next solar cycle because of their magnetic polarity. Simply put, they are backwards or flipped.

According to Hale's Law, sunspot polarities flip-flop from one solar cycle to the next. (George Hale, American Solar Astronomer 1868-1938)

During old Solar Cycle 24, we grew accustomed to sunspots in the sun's southern hemisphere having a -/+ pattern.

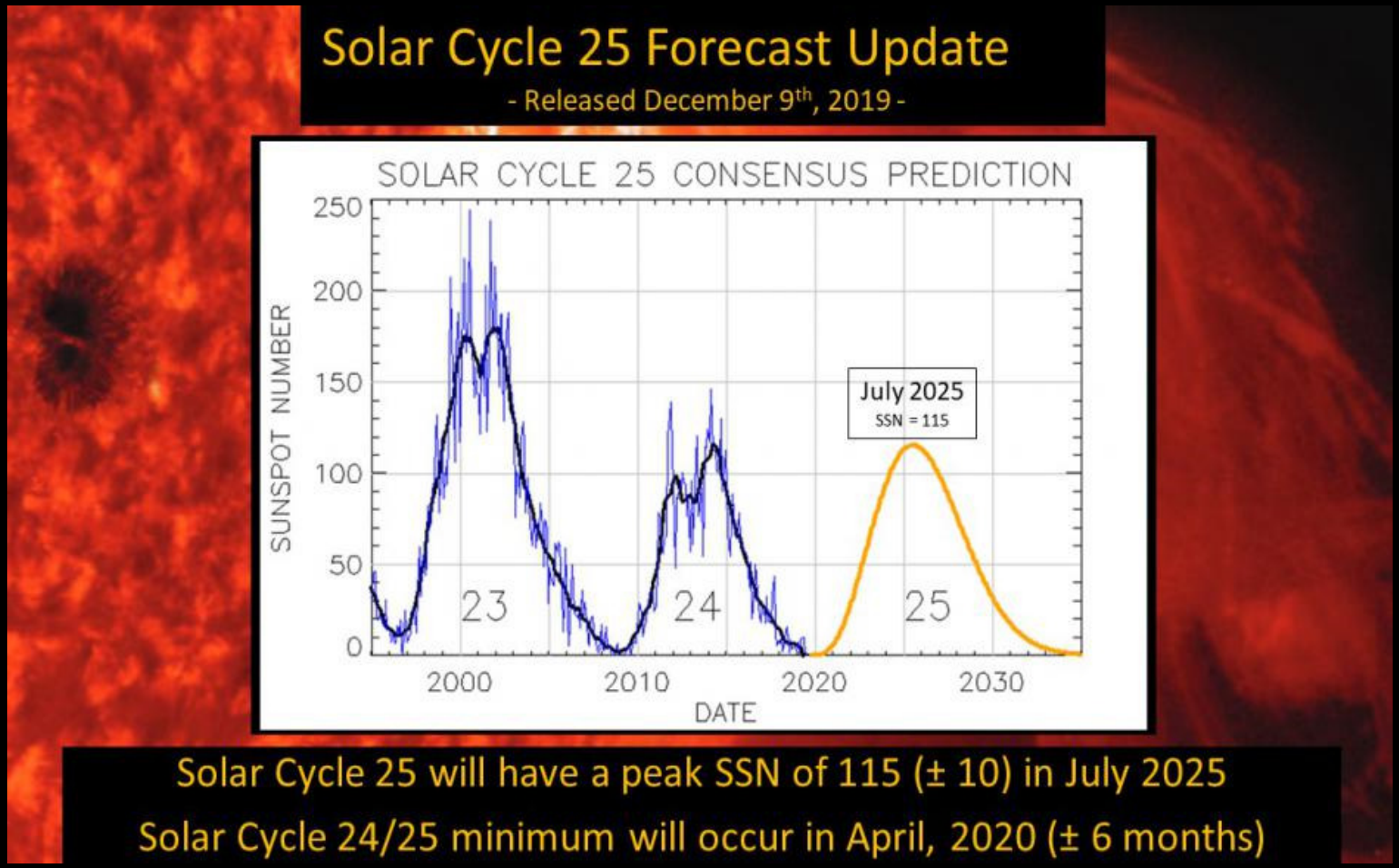
The Beginnings of Solar Cycle 25



It is the opposite: +/-. This identifies it as a member of new Solar Cycle 25.

Today's new-cycle sunspots (along with isolated new-cycle spots earlier in 2019) suggest that solar cycle 25 is, in fact, unfolding normally.

Prediction of Solar Cycle 25



Predictions of Solar Cycle 24 & 25

- The NOAA/NASA co-chaired an international panel to forecast Solar Cycle 25. The panel concurred that solar minimum between Cycles 24 and 25 will occur in April, 2020 (+/- 6 months).

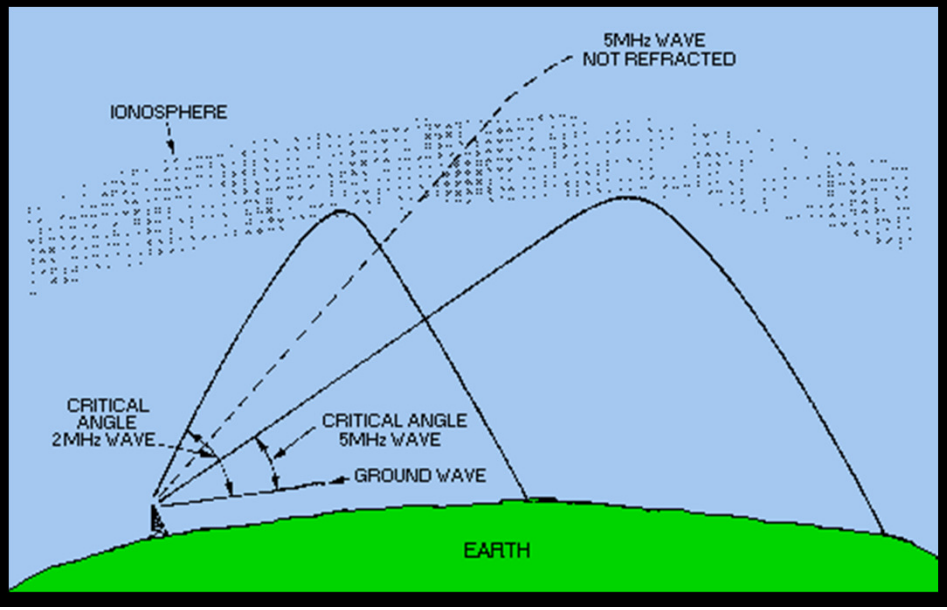
- If the solar minimum prediction is correct, this would make Solar Cycle 24 the 7th longest on record (11.4 years).

- Solar Cycle 25 Prediction Panel experts said Solar Cycle 25 may have a slow start, but is anticipated to peak with solar maximum occurring between 2023 and 2026, and a sunspot range of 95 to 130. This is well below the average number of sunspots, which typically ranges from 140 to 220 sunspots per solar cycle.

- The panel has high confidence that the coming cycle should break the trend of weakening solar activity seen over the past four cycles.

How and why sunspots affect propagation on HF bands.

- Charged particles from the sun streaming past Earth affect the ability of the ionosphere to refract radio signals back to Earth.
- Sometimes, hams use the word reflection to describe what happens at the ionosphere where signals below the MUF, or Maximum Usable Frequency, return to Earth. This is a simplification. The ionosphere is not a mirror, where there is a sudden pronounced change of materials, but rather varies in density bending the signal. This bending is called refraction.



How and why sunspots affect propagation in HF bands.

- HF propagation occurs by way of the ionosphere. The signal from the transmitting antenna travels up to the ionosphere, is bent (or refracted) back to Earth and is then audible hundreds or thousands of miles away.

- The ionosphere consists of several layers, and the distance traveled by the radio signal in one hop depends on the height of the layer of the ionosphere that is involved.

- Roughly, the effect of increased solar activity is to increase the usability of the bands from 14-28 Mhz (20 – 10 Meters) and sometimes 50 Mhz (6-Meters).

- However, solar "storms" can cause other effects, such as seeing an aurora at lower latitudes, causing the ionosphere to absorb rather than refract signals (making bands unusable), or cause unusual phenomena such as 50 Mhz or even 144Mhz (6-2 Meters) to be temporarily useful for long distance contacts.

How and why sunspots affect propagation in HF bands.

- Sun spots affect radio propagation by affecting the layer of the atmosphere called the ionosphere. The ionosphere contains electrified layers of ions. The layers are formed by the sun bombarding them with ultraviolet light.

- The intensity of the sun's bombardment of these layers with ultraviolet radiation varies depending on the hour of the day, the season of the year, and year to year resulting in great variations in the amount of energy in these layers. Enter sunspots, they also add to ionization.

The Bottom Line…

- Why do Sun Spots add to ionization?
  - Because they create ultraviolet radiation which “hardens or adds to” the ionosphere. This increases the ability for radio signals to reflect back to earth.
- The more sun spots, the greater the level of ultraviolet radiation emitted by the sun.
- Greater levels of ultraviolet radiation means more ultraviolet energy pumped into the ionosphere.
- Higher levels of ionization in the electrified layers encircling the earth increases its ability to bend HF radio waves and return them to the earth at great distances from their source. That's why when the sun surface is covered with a great number of sun spots that communications has a positive effect on propagation in HF bands.

Additional Information – Website

- https://www.dxzone.com/dx19432/solar-ham.html
- https://www.solarham.net This for Solar Ham Webpage!

73, N1RGK