Welcome to The Radio JOVE Project Citizen Science Training Modules.

Partnerships and Acknowledgements

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Acknowledgements: SunRISE and SunRISE GRL were sponsored by NASA grant #AWD006989, and hosted at the Climate and Space Sciences and Engineering (CLaSP), University of Michigan College of Engineering, Ann Arbor, MI. Radio JOVE receives funding from NASA Citizen Science Seed funding program (NNH21ZDA001N-CSSFP), Grant# 80NSSC23K0.

These training modules are a partnership between the SunRISE mission team and The Radio JOVE Project. We acknowledge contributors to these modules as well as our funding sources of support.

This is Training Module 0.3 – Solar Activity

Prerequisites for Training Modules

1. High School Reading Comprehension and General Science
2. Electromagnetic Spectrum
3. Speed, Wavelength, Frequency, and Energy of Waves
4. Graphical Interpretation of Data
5. Training Modules 0.0, 0.1, 0.2

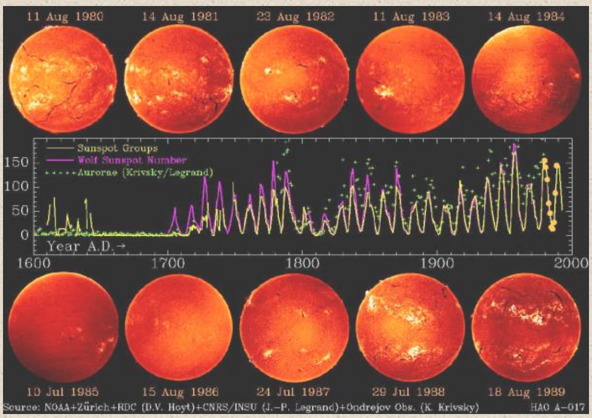
This is a list of prerequisites needed to be able to understand the material in this module.

Learning Objectives

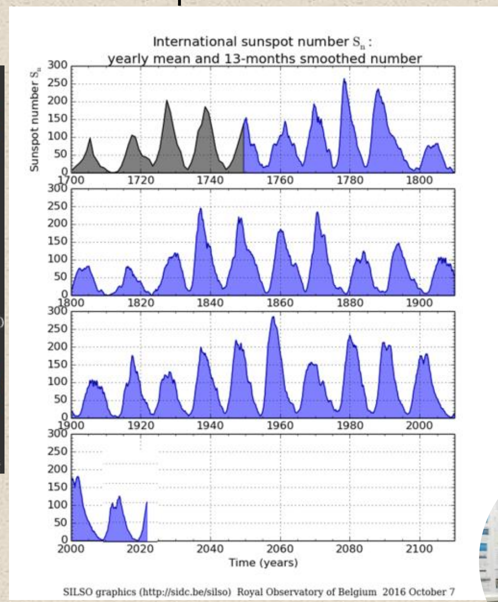
1. Understand the Solar Cycle
2. Learn the types of Solar Activity

This is a brief summary of the learning objectives for this presentation.
We overview the solar cycle and then discuss solar activity and the types of solar activity.

Sunspot cycle



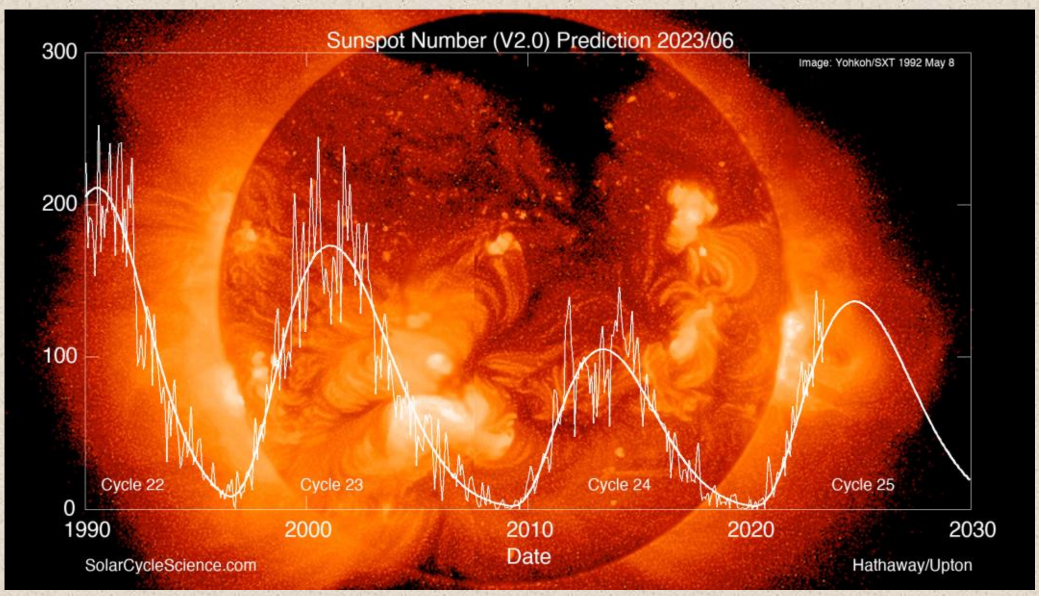
Sunspot Numbers



Royal Observatory of Belgium, Sunspot Index
https://www.sidc.be/SILSO/home

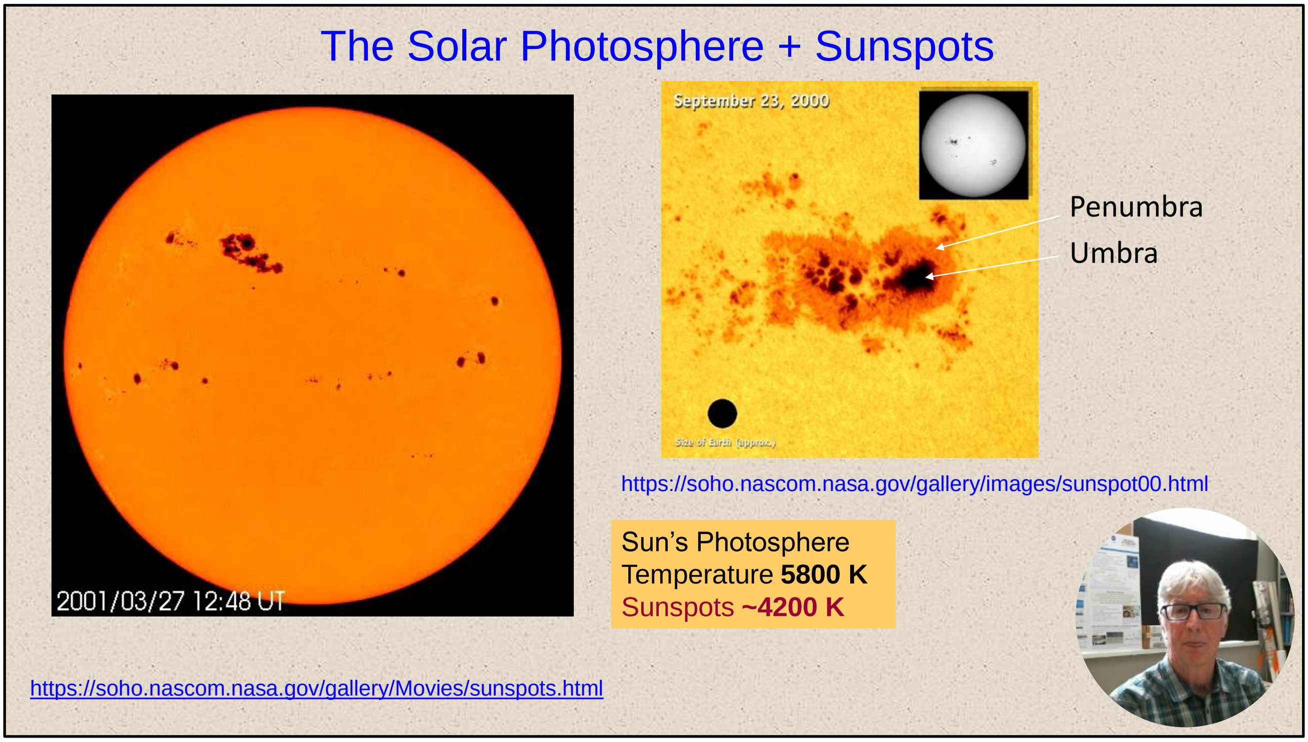
A well-known sunspot cycle occurs on the Sun, averaging about 11 years. The images on the left show the progression of the Sun from 1980-1989 from active times near solar maximum through "quiet" times at solar minimum and almost back to solar maximum. Also shown is a graph showing that sunspot data go back to the 18th century. (https://www.sidc.be/SILSO/)

Sunspot Number Prediction

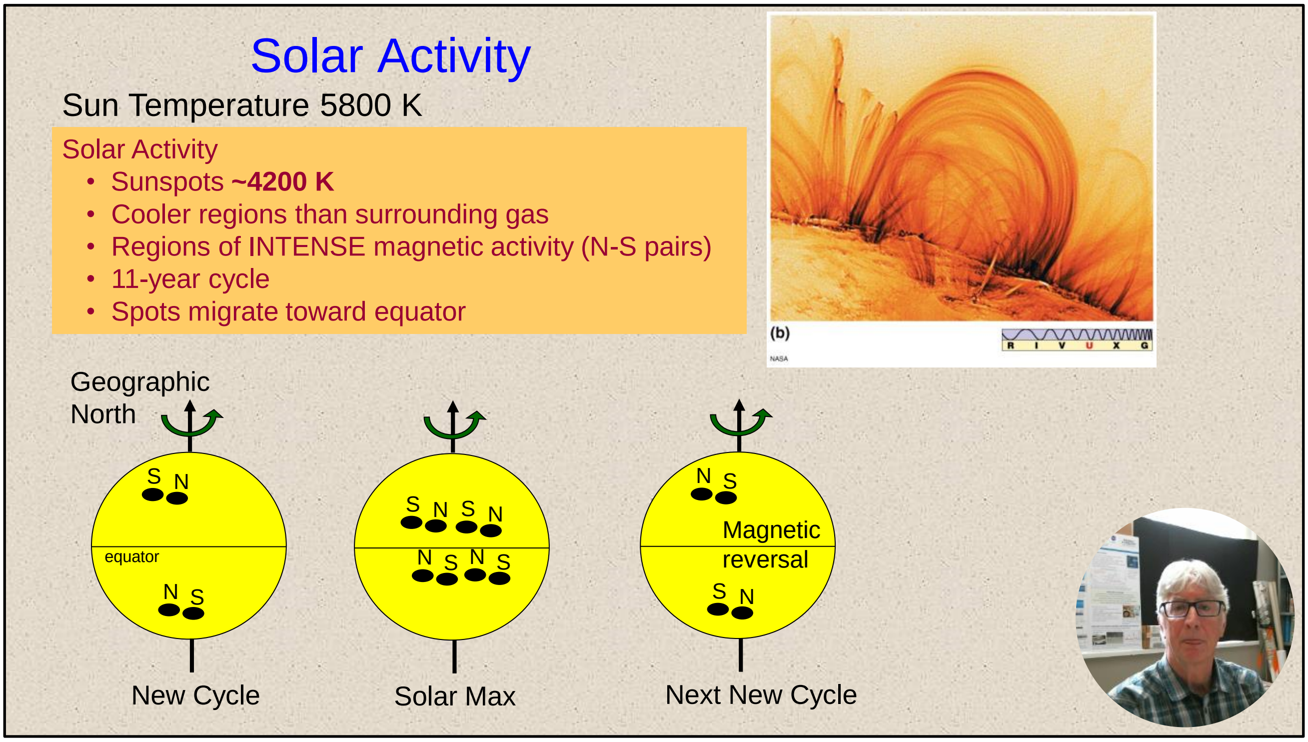


http://solarcyclescience.com/forecasts.html#Cycle24Prediction

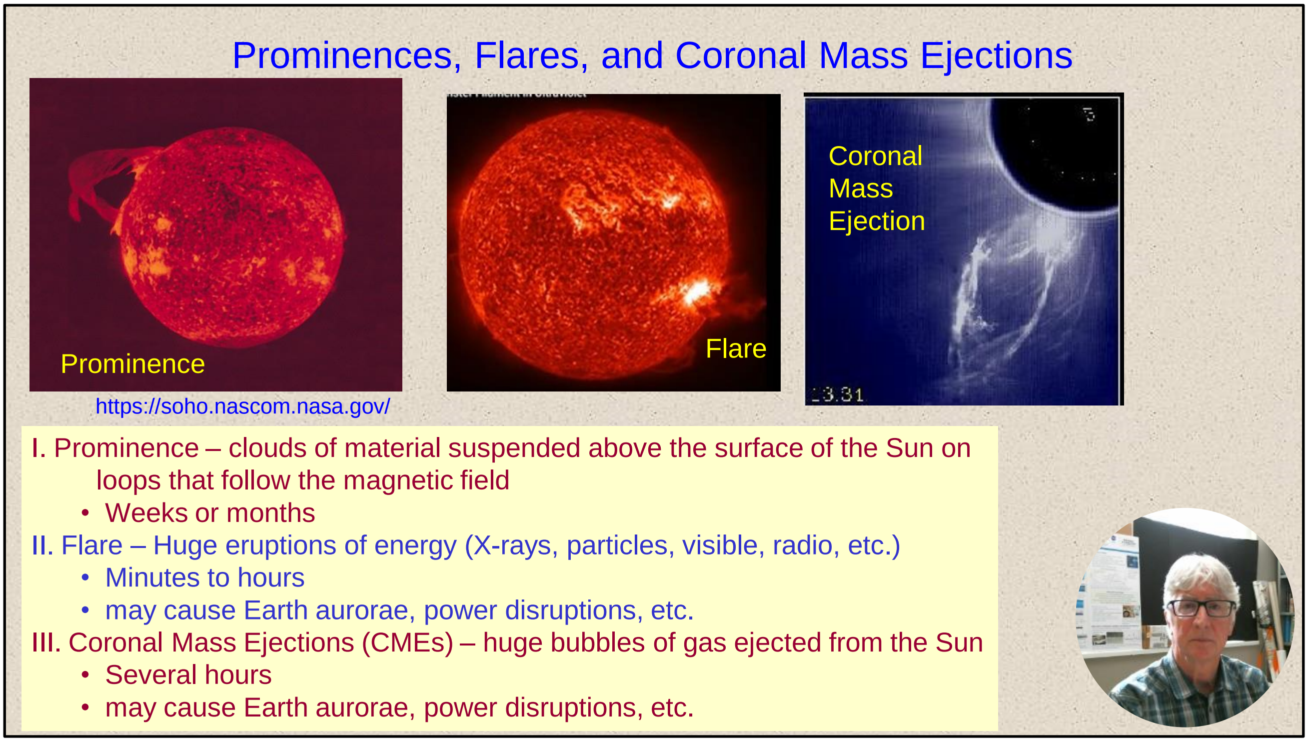
The most recent sunspot cycle data and predictions for Cycle 25 from Hathaway/Upton, http://solarcyclescience.com/forecasts.html#Cycle24Prediction. The monthly average sunspot number varies greatly. Notice the amplitude of the sunspot cycle changes.



Many sunspots observed on the Sun in 2001 at a time when the Sun was active. The image on the right shows sunspots under high magnification illustrating a darker central region called the umbra and a lighter region called the penumbra. The sunspots are associated with regions of intense magnetic activity near the surface of the Sun. Sunspots appear darker on the surface because they are cooler than the surrounding gas: the Sun's average photosphere temperature is 5800 K, but the sunspots are about 4200 K.



The Sun cycles through activity on an average 11-year cycle called the sunspot cycle. Sunspots almost always occur in magnetic pairs in the photosphere, and the intense magnetic field lines are beautifully outlined by loops of hot gas above the photosphere in this high-resolution ultraviolet image by NASA. These pairs begin forming at the start of a solar cycle, increase in number and migrate toward the equator reaching a solar maximum. The migration towards the equator is caused by the differential rotation of the Sun, that is, faster rotation at the equator. After solar maximum, the Sun's magnetic field undergoes about a yearlong reconfiguration with no sunspots. The appearance of the next sunspots starts a new solar cycle with a magnetic reversal demonstrated by pairs of sunspots with reverse polarity.
Note that there are many single spots (not in pairs) that cannot be explained by current understanding of pair formation which involve magnetic flux tubes emanating from below the photosphere.



There are three main types of solar activity, prominences, flares, and coronal mass ejections (CME). Large clouds of material suspended above the surface of the Sun on loops that follow the magnetic field lasting days, weeks, or even months, are called prominences. Solar flares are huge eruptions of energy and particles released across all parts of the spectrum from x-rays to radio waves. They result from magnetic energy released during reconnection events near sunspots. These energy releases can impact the Earth in many ways, causing aurora, satellite and communication problems, and possibly power disruptions. Coronal mass ejections (CMEs) are huge blobs of plasma released into the solar wind as a result of a flare or other energetic event on the Sun. These blobs of plasma typically move harmlessly out into the solar wind, but occasionally they are directed toward the Earth causing similar disruptions as flares.

Magnetic Energy

An illustration of magnetic reconnection

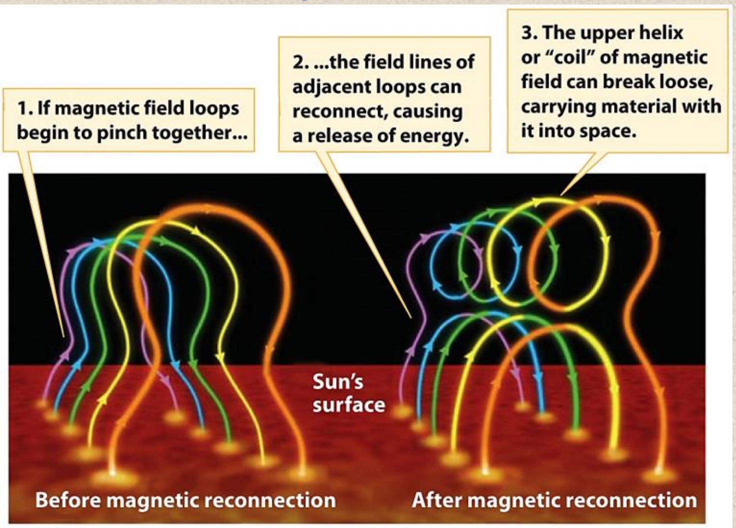


Figure 16-26b
Universe, Tenth Edition

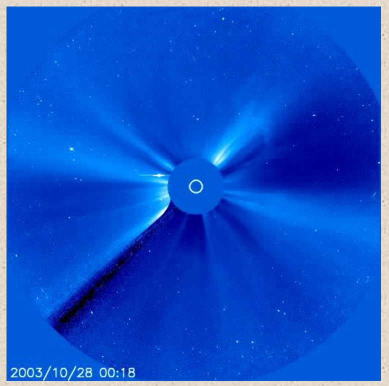
This illustration shows how magnetic reconnection happens. The magnetic fields can pinch together off the surface of the Sun. If the magnetic loops reconnect with each other, they release tremendous amounts of energy in the form of electromagnetic waves and plasma particles.

An example of a prominence is shown here. An impressive movie of a long-lasting prominence called coronal rain can be found on these websites.

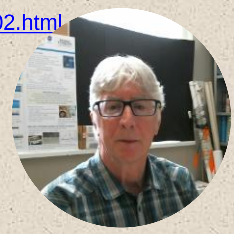
Coronal Rain http://apod.nasa.gov/apod/ap130226.html

Solar Flares

Monster filament in UV
https://apod.nasa.gov/apod/ap180409.html



Powerful solar flare with cosmic rays
https://apod.nasa.gov/apod/ap180902.html



Some impressive movies of flares can be found here
Monster filament in UV, https://apod.nasa.gov/apod/ap180409.html
Powerful solar flare with cosmic rays,
https://apod.nasa.gov/apod/ap180902.html

Sun – Coronal Mass Ejection (CME)

A movie from the SOHO spacecraft shows several CMEs. Note the steady stream of the solar wind

A movie from the SOHO spacecraft shows several CMEs over 20 days. Note the steady stream of the solar wind. That is the planet Jupiter moving relative to the Sun.

Excellent movies of flares and CMEs are found on the NASA Solar and Heliospheric Observatory (SOHO) site: https://soho.nascom.nasa.gov/gallery/Movies/flares.html

Resources

NASA Marshall Space Flight Center Solar Physics https://solarscience.msfc.nasa.gov/

NASA Solar and Heliospheric Observatory (SOHO) https://soho.nascom.nasa.gov/home.html

National Solar Observatory: https://nso.edu/

NOAA Space Weather Prediction Center: https://www.swpc.noaa.gov/
Australian Space Weather Forecasting Center https://www.sws.bom.gov.au/Educational/2/1

Current views of space weather:
https://spaceweather.com/
https://swe.ssa.esa.int/current-space-weather
https://www.swpc.noaa.gov/

This is a short list of good resources on the Sun.

Thank you for your attention!

Next, you will learn about Space Weather …

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