Space Weather Workshop

PART 1

Australian Space Discovery Centre

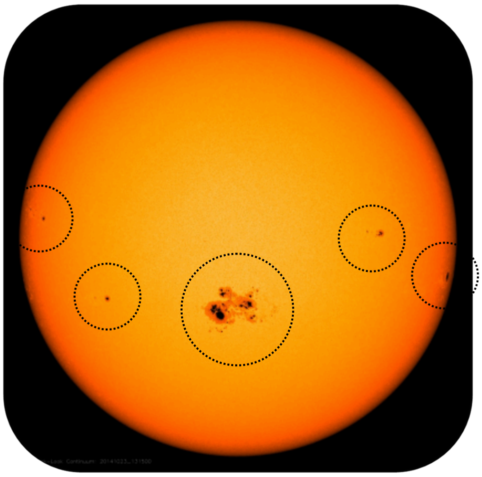
Every second of every day, energy from the Sun makes its way towards our planet. Sometimes it is stronger, sometimes weaker; these changes are known as 'space weather'. We work hard to monitor and predict space weather patterns because they can have massive effects on life here on Earth.

Your Mission

In this activity, you'll use your scientific skills to observe some space weather. We'll show you how to analyse real space data and 'spot' the sunspot patterns! In order to do this, you first need to know **what you're looking for**.

A **sunspot** is a region on the Sun's surface where the magnetic field is extremely strong, causing the area to be cooler than the surrounding surface. This makes it appear darker.

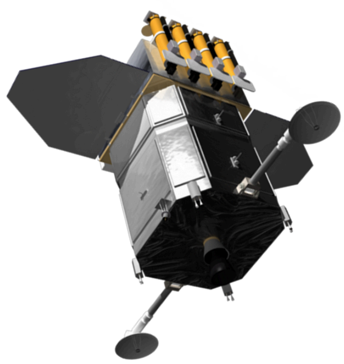
The average sunspot is roughly the size of the Earth. However, much larger, Jupiter-sized sunspots have also been observed! They last anywhere from a few hours to several weeks, and happen much more frequently during periods of busy **solar activity**.



There are many different ways of imaging the Sun, and each one can tell us about different features. While they all provide useful information, some are better than others for counting sunspots! The below images were taken at the same time using different types of equipment.

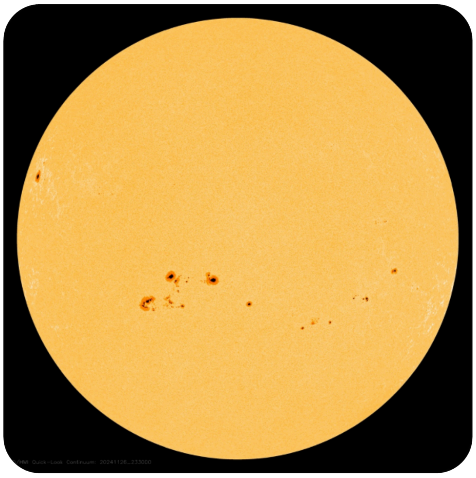
THESE IMAGES WERE TAKEN USING SPECIALISED CAMERAS. IT IS NEVER SAFE TO LOOK DIRECTLY AT THE SUN.

The Solar Dynamics Observatory (SDO) records detailed data about the activity of our Sun.



Images: NASA/SDO

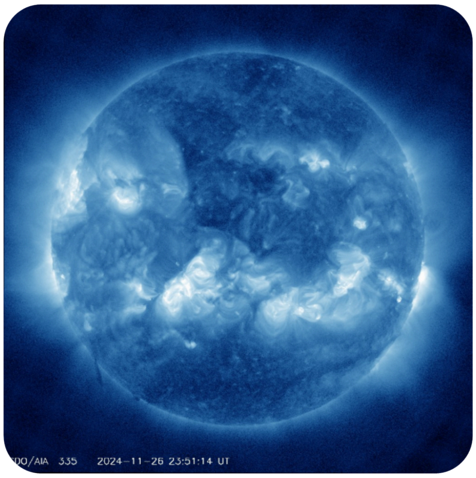
Seeing the surface...



The Helioseismic Magnetic Imager (HMI) aboard the Solar Dynamics Observatory takes a series of images every 45 seconds in the visible light band.

Dark regions represent sunspots.

...and beyond!



The Solar Dynamics Observatory can also image in extreme ultraviolet. We can't see it with our eyes, but special instruments pick up this high-energy light.

Bright regions indicate higher levels of magnetic activity.

Australian Government
Australian Space Agency
Australian Space Discovery Centre
Australian Government Bureau of Meteorology

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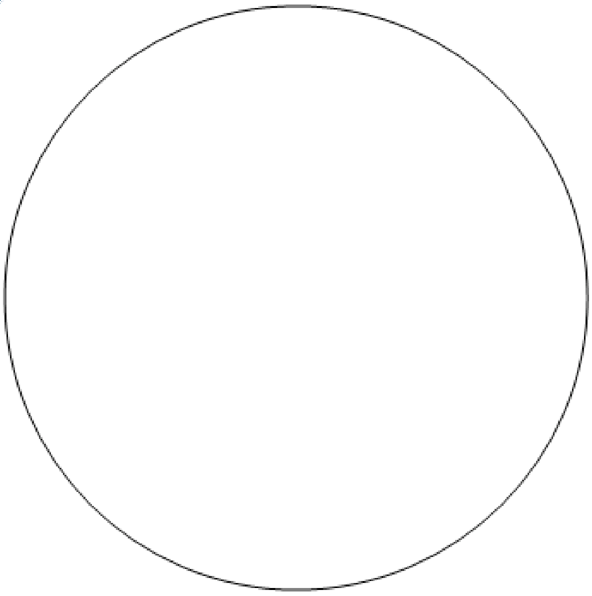
PART 2

Australian Space Discovery Centre

For this activity you'll be looking out for sunspots using real solar observatory data! Use the below templates to sketch and group your observations and record your totals.

Counting sunspots and sunspot groups this way is known as the Wolf Method, and has been used since the 1800s! Record the location of the sunspots you observe in the solar data.



LEGEND

X = Sunspot

--- = Sunspot Group
(circle each group)

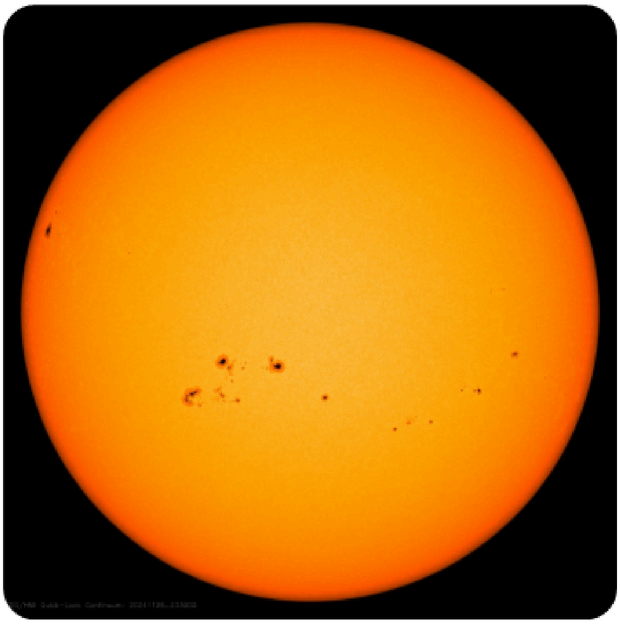
RESULTS

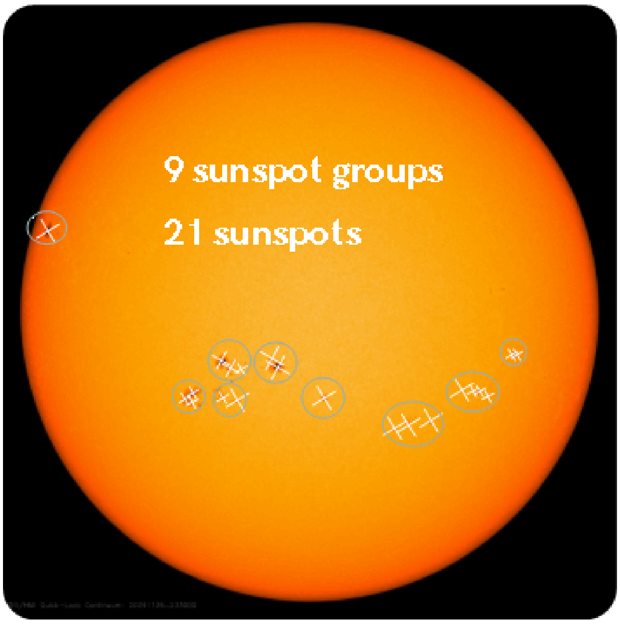
☐ SUNSPOT GROUPS

☐ SUNSPOTS

EXAMPLE

Remember, it's okay if your count is different to others by a few sunspots.





To access up-to-date daily Solar Weather Images, visit **sdo.gsfc.nasa.gov/data/**
Look for the HMI Intensitygram Image Channel!

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PART 3

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Calculating the Sunspot Number

Now that you have gathered your data, it's time to use it! Some simple calculations with your data can be used to generate a space weather report.

To calculate the Sunspot Number, also written as R, we use the below formula:

$$R = 0.6 \times [(10 \times g) + s]$$

In this formula, g represents the number of sunspot groups and s represents the total number of distinct sunspots. Since we collected this data in Part 2, we can find R!

Today's solar data [/ /] produced an **R** value of:

Calculating the Sunspot Number

Come back a few days (or weeks) later and count the sunspots to find **g**, **s** and **R**.
Has **R** changed, or is it the same as before??

The data from [/ /] produced an **R** value of:

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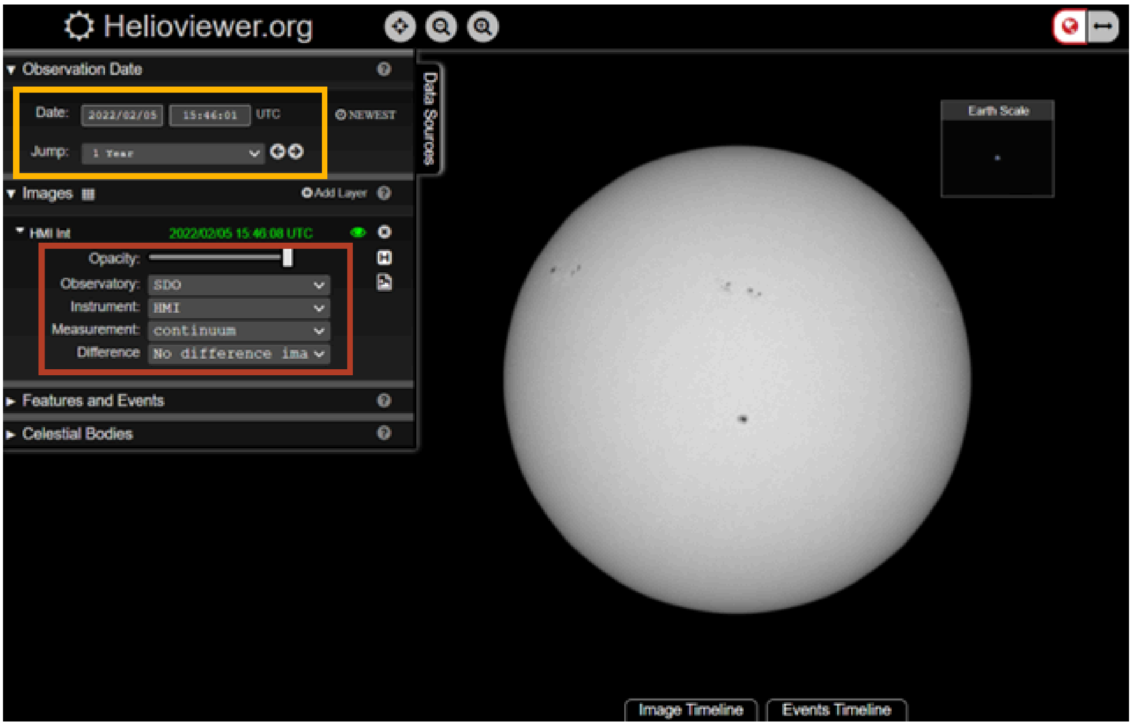
PART 3

Calculating Solar Cycle

Over long periods of time, the relative number of sunspots can change quite a lot! Cyclical (repeating) patterns have been tracked across many years of observation, and this is known as the **Solar Cycle**. Within each cycle there are alternating periods of **solar maximum** and **solar minimum**, when the Sun is most or least 'active'.

Your job is to track the relative sunspot number over a 15-year period. From this you will be able to calculate the length of a typical solar cycle, and determine whether we are in a **maximum** or **minimum.**

1. Open up **Helioviewer.org** in your browser. Using the formula for **R** given in Part 3, you will need to calculate the relative sunspot number for a range of different dates.
Ensure your settings match the **YELLOW** and **RED** boxes below. This will help you find the right data!



2. Use the viewer to look back through 15 years of solar data. Make sure to calculate and record a value for **R** <u>at least</u> once every 6 months.

Date	Time (nearest hour)	Sunspot Groups (**g**)	Distinct Spots (**s**)	Relative Sunspot Number (**R**)
2022/02/05	16:00	4	12	31.2
...	...	...	...	...
...	...	...	...	...

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PART 4

Calculating Solar Cycle (continued)

3. Use some graph paper or a digital tool to create a line graph of your measurements. Plot the **date** on the x axis, and **R value** on the y axis, and don't forget to include:

- ☐ Title
- ☐ Axis Labels
- ☐ Legend
- ☐ Units (note that **R** does not have a unit—it is a 'dimensionless' value.)

Note: The exact time of day associated with each measurement does not need to be included on your graph. The purpose of recording the time (in hours) is to remember when the snapshot was taken in case you need to look at it again!

Discuss the following questions:

- What do you notice about the behaviour of R, the relative sunspot number, over time?
- Do you notice any peaks or troughs in the data? If so, what years do they appear around?
- Compare your graph with a classmate who has used a different set of data points. Are there any similarities?

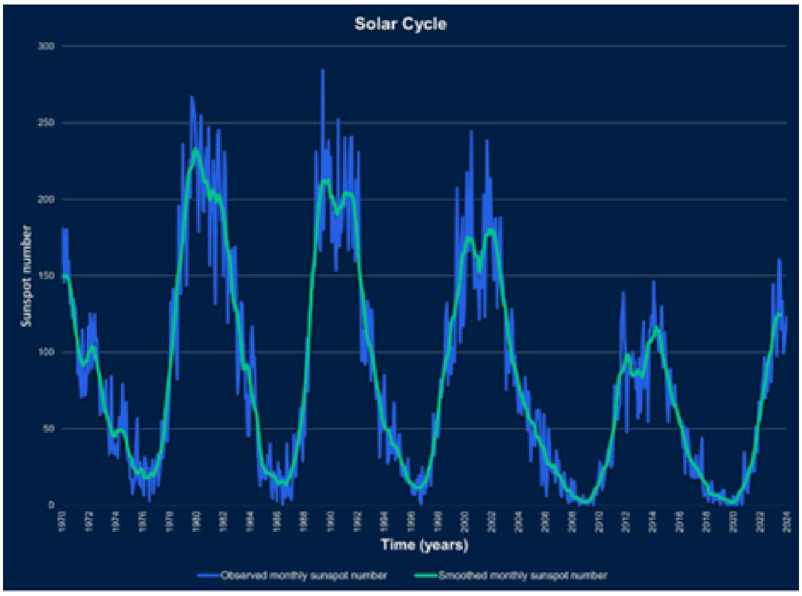
Solar Maximum and Minimum

The sun goes through periods of activity called solar cycles.

These cycles are like seasons. One cycle lasts approximately 11 years.

During 'solar maximum', the peak of a cycle, the sun is at its most magnetically active. During 'solar minimum', the sun is least magnetically active.

Sunspots and space weather events occur more frequently and with increased intensity around the solar maximum, however, significant space weather events have been observed at other times too.



Sunspot data from 1970 - 2024. Credit: Bureau of Meteorology

Based on your observations, can you predict whether we are in a period of solar maximum, minimum, or somewhere in between?

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PART 5

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The Effects of Space Weather

Coronal Mass Ejections (CME) are space weather events that send large bursts of energy out into the solar system.

During a CME, billions of tonnes of magnetised solar plasma erupt into space at up to 3,000 km/s, with increased solar wind particles and magnetic field strength typically reaching Earth within half a day to 3 days.

If the material is directed towards the Earth, geomagnetic, ionospheric, and radiation storms can occur. Severe space weather can significantly impact the technologies we rely on here on Earth.


Coronal Mass Ejection. Credit: Bureau of Meteorology

The sun's activity is carefully monitored at facilities such as the **Australian Space Weather Forecasting Centre**. Based in Adelaide, SA, forecasters from the Bureau of Meteorology **provide daily space weather reports; these include emergency alerts** in the case of extreme space weather events.

Want to Learn More?

Explore these resources to learn even more about how space weather impacts us on Earth.


Ask the Bureau: What is an Aurora?


Look inside the Australian Space Weather Forecasting Centre

Australian Space Weather Alert System

Challenge Task

You run a power supply company with several thousand people relying on your grid for electricity. You receive a report that a G5 (extreme) geomagnetic storm is approaching Earth; this may interfere with power supply for up to 24 hours. Your three biggest clients are:

1 Major Hospital

5 Medium Suburbs (Total population 5,000)

16 Grocery Stores

Write an emergency response plan for your business in the event of an extreme geomagnetic storm.
- **How will the increased solar activity impact your clients, and how will you notify them of these hazards?**
- **Who will you supply power to if your grid capacity goes down and can only serve one client group?**

Learning Intentions & Curriculum Links

Learning Intentions

Students will...

- Learn about the Sun's magnetic activity and how it is monitored using space technology.
- Identify sunspot groups and use them to calculate the relative sunspot number (R).
- Collect, analyse, and represent sunspot data using a number of digital and analogue tools.
- Interpret long-term patterns in the Sun's magnetic activity, understanding that the Sun goes through periods of Solar Maximum and Solar Minimum.
- Discuss the potential impacts of a geomagnetic storm on different areas of society.

Australian Curriculum V9 | Years 7-10

Note: this workshop has been designed to align with the Australian Curriculum Version 9.

Connections to a range of Learning Areas and General Capabilities are included to highlight content relevance and possible learning applications in the classroom.

Science

Science Understanding: Physical sciences; Earth and Space Sciences

Science as a Human Endeavour: Nature and development of science; Use and influence of science

Science Inquiry: Questioning and predicting; Planning and conducting; Processing, modelling, and analysing; Evaluating; Communicating

Mathematics

Number and Algebra: Patterns and algebra; Linear and non-linear relationships; Mathematical modelling; Recognising and using mathematical formulas

Measurement and Geometry: Using units of measurement

Statistics and Probability: Data representation, interpretation, and visualisation

Geography

Knowledge and Understanding: Place and liveability

Skills: Questioning and researching using geographical methods; Concluding and decision-making; Communicating

Digital Technologies

Processes and Production Skills: Acquiring, managing, and analysing data

Learning Intentions & Curriculum Links

General Capabilities — Years 7-10

Capabilities: Critical and Creative Thinking (v9)
Inquiring: Develop questions; Identify, process, and even evaluate information
Generating: Create possibilities; Consider alternatives
Analysing: Interpret concepts and problems; Draw conclusions and provide reasons; Evaluate actions and outcomes
Capabilities: Literacy (v9)
Speaking and listening: Listening; Interacting; Speaking
Reading and viewing: Understanding texts
Writing: Creating texts
Capabilities: Numeracy (v9)
Measurement and geometry: Understanding units of measurement
Statistics and probability: Interpreting and representing data
Capabilities: Digital Literacy (v9)
Investigating: Locate information; Acquire and collate data; Interpret data
Creating and exchanging: Plan; Create, communicate, and collaborate; Respect intellectual property
Managing and Operating: Select and operate tools
Capabilities: Ethical Understanding (v9)
Understanding ethical concepts and perspectives: Explore ethical concepts; Recognise influences on ethical behaviour and perspectives
Responding to ethical issues: Explore ethical issues; Make and reflect on ethical decisions
Capabilities: Personal and Social Capability (v9)
Social Awareness: Community awareness
Social Management: Communication; Collaboration; Decision-making