

National Aeronautics and Space Administration



The Heliophysics Big Year

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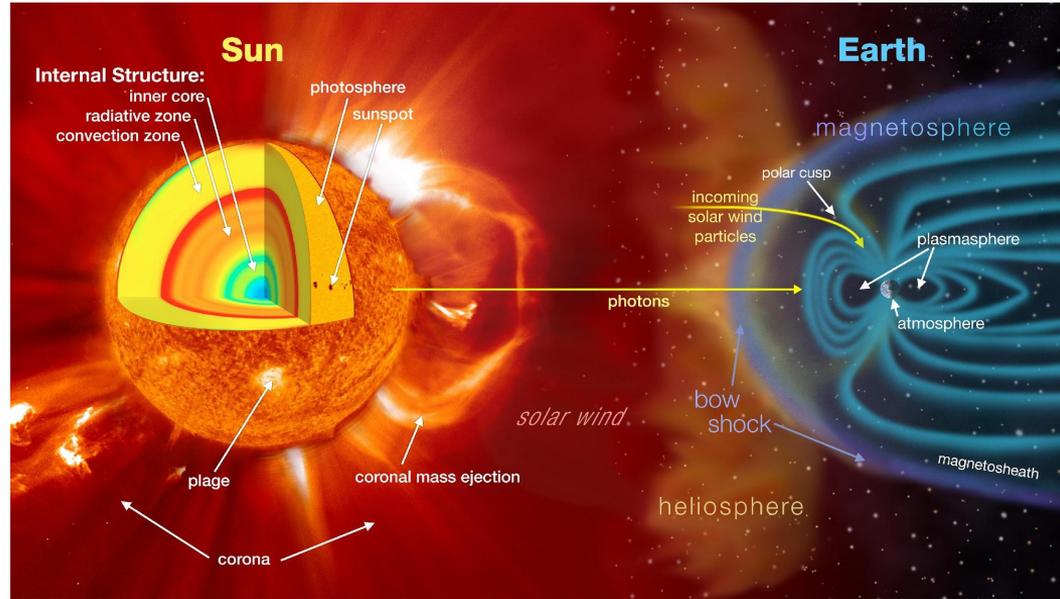
NASA Heliophysics Education Activation Team



September 2024: What is Heliophysics?

Heliophysics is the discipline in space science that deals with the matter and energy of our Sun and its effects on the solar system.

It also studies how the Sun varies over time and how those changes can sometimes pose a hazard to humans on Earth and in space.



Heliophysics Big Year Timeline

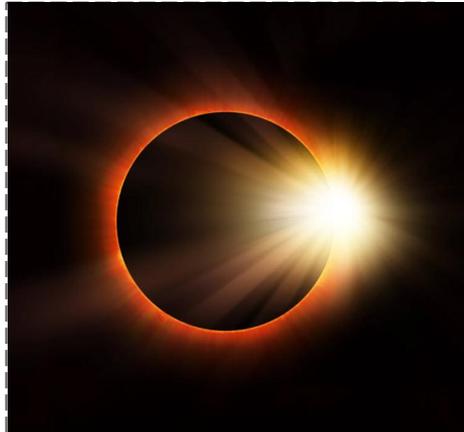
Annular Eclipse

October 14, 2023



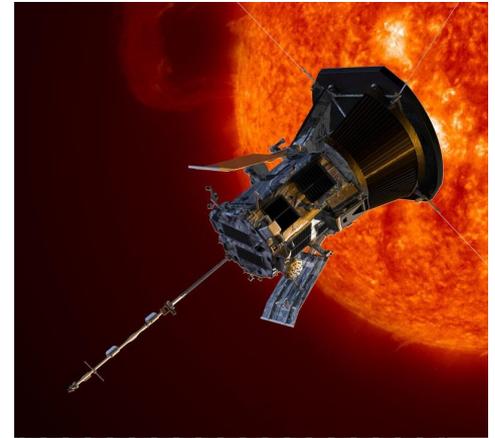
Total Eclipse

April 8, 2024



Solar Parker
Probe Perihelion

December 24, 2024



Heliophysics Big Year Themes

2023

- ✓ **October**- Annular Solar Eclipse
- ✓ **November**- Mission Fleet
- ✓ **December**- Citizen Science

2024

- ✓ **January**- The Sun Touches Everything
- ✓ **February**- Fashion
- ✓ **March**- Experiencing the Sun
- ✓ **April**- Total Solar Eclipse
- ✓ **May**- Visual Art
- ✓ **June**- Performance Art
- ✓ **July**- Physical and Mental Health
- ✓ **August**- Back to School
- September**- Environment / Sustainability
- November**- Bonus Science
- December**- Parker's Perihelion

<https://www.nasa.gov/science-research/heliophysics/nasa-announces-monthly-themes-to-celebrate-the-heliophysics-big-year/>



September 2024 : NASA's Big Questions

1. What causes the Sun to vary?
2. How do the Earth and the heliosphere respond?
3. What are the impacts on humanity?

These Big Questions form the basis for the

Framework for Heliophysics Education

<https://science.nasa.gov/learn/heat/big-ideas/>



How to Teach Heliophysics

Framework for Heliophysics Education

3 Heliophysics
Investigatory Questions



3 NGSS-aligned
Big Ideas per Question



3 Guiding Questions per
Idea
-1 Question per Level-



Heliophysics
Resource Database

1. What causes the Sun to vary?

- 1.1 The Sun is really big and its gravity influences all objects in the solar system. (PS2, ESS1)
- 1.2 The Sun is active and can impact technology on Earth via space weather. (PS1, PS2, PS4, ESS2, ESS3)
- 1.3 The Sun's energy drives Earth's climate, but the climate is in a delicate balance and is changing due to human activity. (PS1, PS2, PS3, LS4, ESS2, ESS3)

1. How do Earth, the solar system, and the heliosphere respond to changes on the Sun?

- 2.1 Life on Earth has evolved with complex diversity because of our location near the Sun. It is just right! (PS3, PS4, LS1, LS2, ESS2)
- 2.2 The Sun defines the space around it, which is different from interstellar space. (PS2, ESS1, ESS2)
- 2.3 The Sun is the primary source of light in the solar system. (PS1, PS2, PS3, PS4, ESS1)**

1. What are the impacts of changes on the Sun on humans?

- 3.1 The Sun is made of churning plasma, causing the surface to be made of complex, tangled magnetic fields. (PS1, PS2, ESS1, ESS2)
- 3.2 Energy from the Sun is created in the core and travels outward through the Sun and into the heliosphere. (PS1, PS3, PS4, ESS1, ESS2, ESS3)
- 3.3 Our Sun, like all stars, has a life cycle. (PS1, LS1, ESS1)



September 2024: Environment / Sustainability

The Sun is a powerful source of energy. In modern times, we rely on the Sun to help produce the electricity we use every day.

To make this work, we use solar panels to convert sunlight into electricity.



<https://sciencephotogallery.com/featured/life-cycle-of-the-sun-mark-garlickscience-photo-library.html>

September 2024: Environment / Sustainability

The Sun is a powerful source of energy. In modern times, we now rely on the Sun to produce electricity.

Spacecraft also use solar panels to generate the power they need to operate millions of miles from Earth.



NASA / Juno Spacecraft

September 2024 – Beginning – Power Math

A typical home needs about 30,000 watt-hours (30 kWh) or 1,200 watts to operate each day.

The average cost of electricity is \$0.16 per kWh.

The average CO₂ emission per kWh is about 1 kg/kWh for coal and petroleum.

How much does it cost to run this house for one year and how much CO₂ is produced?



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$$\text{House} = 30 \text{ kWh}$$

$$\begin{aligned} \text{Cost} &= \$0.16/\text{kWh} \times 30 \text{ kWh} \\ &= \$4.80/\text{day} \\ &= \mathbf{\$1,752/\text{year}} \end{aligned}$$

$$\begin{aligned} \text{CO}_2 &= 1\text{kg}/\text{kWh} \times 30 \text{ kWh}/\text{day} \\ &= 30 \text{ kg}/\text{day} \\ &= \mathbf{12 \text{ tons}/\text{year}.} \end{aligned}$$

September 2024 – Beginning – Solar Electricity

A typical solar panel for homes generates about 400 watts. But there are only about 5 sunny hours every day to generate electricity.

How many panels do you need to generate the 30 kWh to run your home?



September 2024 – Beginning – Solar Electricity

A typical solar panel for homes generates about 400 watts. But there are only 5 sunny hours every day to generate electricity.

How many panels do you need to generate 30 kWh to run your home?

If it costs \$9 per watt including installation, how much will your system cost?

$$400 \text{ watts} \times 5 \text{ hours} = 2000 \text{ Wh or } 2 \text{ kWh.}$$

But you need 30 kWh to run your home, so

$$\text{Number} = 30 \text{ kWh} / (2 \text{ kWh per panel})$$

You need 15 panels.

$$\text{Home} = 30,000 \text{ Wh}/24\text{h} = 1200 \text{ watts}$$

$$\text{Cost} = \$9/\text{ watt} \times 1200 \text{ watts} = \textbf{\$10,800.}$$

For more about costs: <https://evergreensolar.com/cost-savings/>



September 2024 – Intermediate – Carbon reduction

If you install solar panels and become 100% 'green' you save about 6 tons of CO₂ production every year, and over the 30-year life of solar panels that's about 180 tons.



Coal plant smoke: Getty Images
Stock photo ID:167231386

September 2024 – Intermediate – Carbon reduction

Solar panels have to be manufactured. This process produces pollution. The mining and melting of silicon releases about 50 grams/kWh.

For your home, this is a one-time cost once you install your panels.

How many kg of CO₂ was released in creating a 30 kWh home system?



September 2024 – Intermediate – Carbon reduction

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For your home, this is a one-time cost once you install your panels.

How many kg of CO₂ was released in creating a 30 kWh home system?

How does this compare with a 30-year use of fossil fuels?

$$\text{CO}_2 = 0.05 \text{ kg/kWh} \times 30 \text{ kWh} = 1.5 \text{ kg.}$$

We just calculated that our 30 kWh electricity from fossil fuels produces 180 tons of CO₂.

Clearly, solar panels are a green source of energy even when you include manufacturing.

**180,000 kg saved versus
1.5 kg expended
over 30 years.**

September 2024 – Advanced- EV and Solar Power

A typical car burns fossil fuels and produces about 44 tons every 10 years. An electric vehicle (EV) runs on battery electricity, and for typical driving, this saves about 44 tons of CO₂ every 10 years because gasoline is not burned.

Charging: An electric car uses 20 kWh of energy per 62 miles (100 km) on average. You'll produce 1.8 lbs of CO₂ each 60 miles if you fill it up using solar power and 44 lbs (20 kg) if you use coal-powered electricity. **So over the course of 10 years,**

Coal-powered charging (12,000 miles/year) = $10 \times (12000/60) \times 44 \text{ lbs} = 44 \text{ tons}$

Solar-powered charging (12,000 miles/year) = $10 \times (12000/60) \times 1.8 \text{ lbs} = 1.8 \text{ tons}$.

Your best bet is to convert your house to solar, buy an EV and charge it at home.

Net savings in 10 years = 44 tons – 1.8 tons = **42 tons of CO₂**



September 2024 - Advanced

The annual US CO₂ savings in megatons from solar homes can be modeled by

$$H = 0.06x^2 + 1.4x + 23$$

The annual US CO₂ savings from EVs in megatons can be modeled by

$$EV = 0.3x^2 + 1.4x + 15$$

where x = current year - 2025

For what year will the EV and Home CO₂ savings be equal in the US?



September 2024 – Advanced

H=EV

$$0.06x^2 + 1.4x + 23 = 0.3x^2 + 1.4x + 15$$

$$0 = 0.24x^2 - 8$$

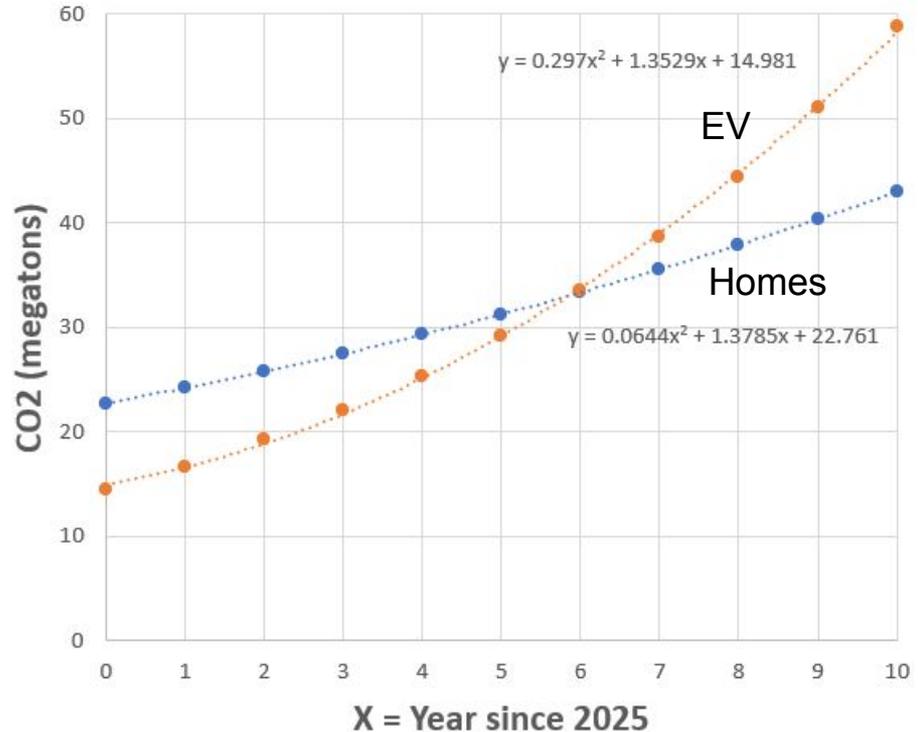
$$X^2 = 8/0.24$$

$$X = +/- 5.8$$

So $X = +5.8 = \text{current year} - 2025$

Year = 2031

CO2 Savings



September 2024 – ChatGPT

ChatGPT query: $H=0.06x^2+1.4x + 23$ and $EV = 0.3x^2 + 1.4x + 15$. For what value of X will EV and H intersect? Show your work. Evaluate to one significant figure.

Abbreviated ChatGPT response:

Set $H = EV$

Simplify to $8 = 0.24x^2$

Then $x^2 = 8/0.24$

Take the square-root $x = +/- 10/\sqrt{3}$

so $x = + 5.77$, and to one SF $X = +5.8$



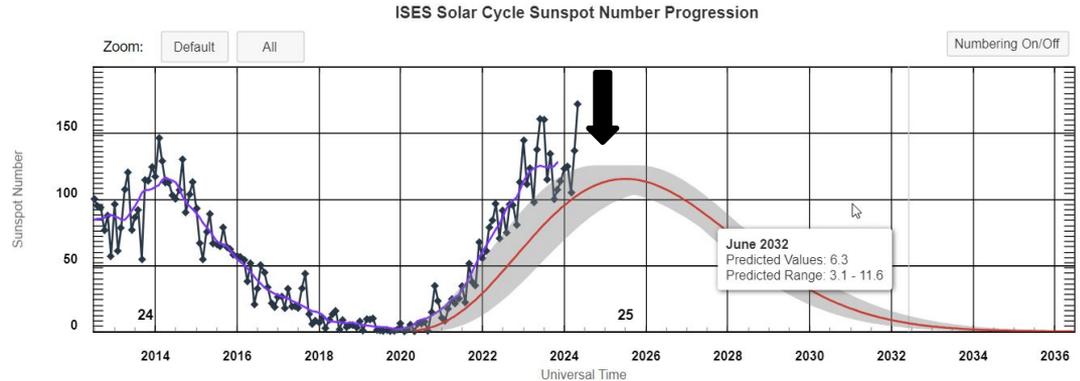
October 2024 – Solar Cycle and Solar Max

Next Time!

The Sun's 11-year activity cycle will be nearing its maximum point during this month, which will include activities to explore the solar cycle.

Solar flares, cosmic rays and astronaut hazards.

When will the next few sunspot cycles occur and when would be the best times for astronauts to travel to Mars?



From NOAA/SWPC:

<https://www.swpc.noaa.gov/products/solar-cycle-progression>