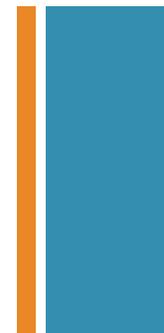
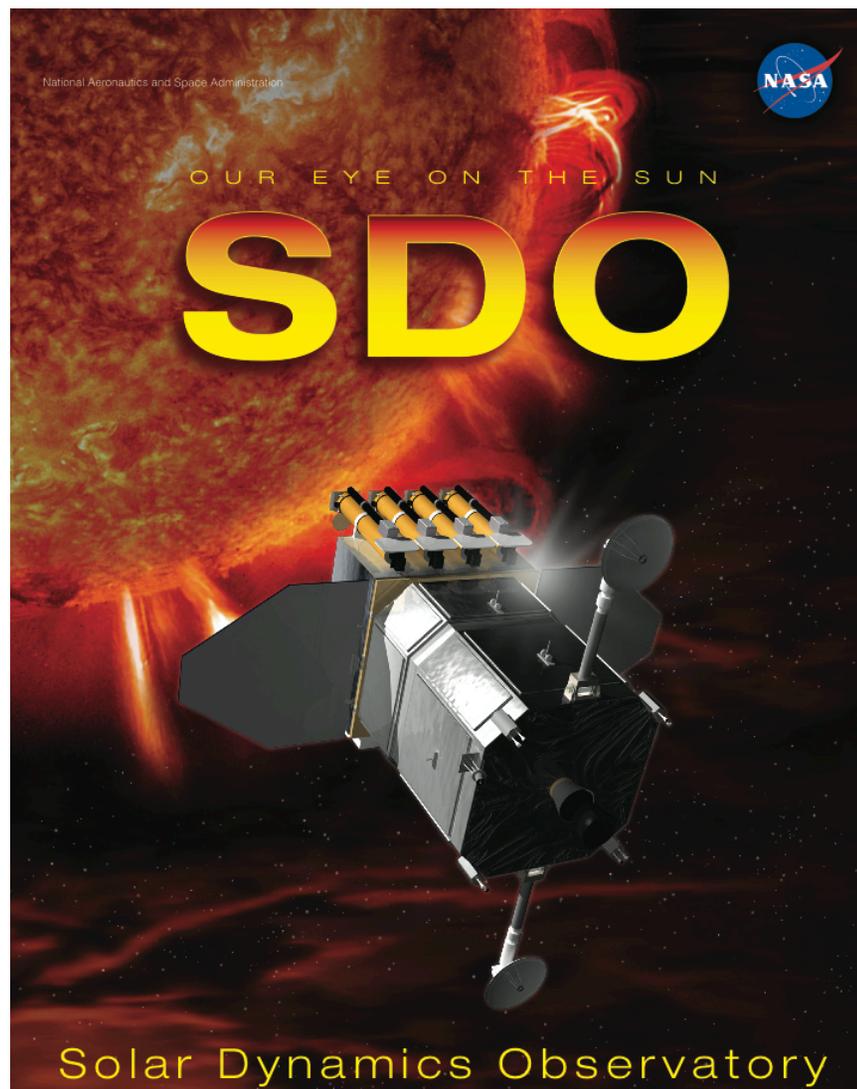


The Solar Dynamics Observatory SDO

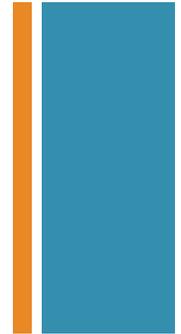
Emily Kellagher
CIRES at CU Boulder

+ Overview

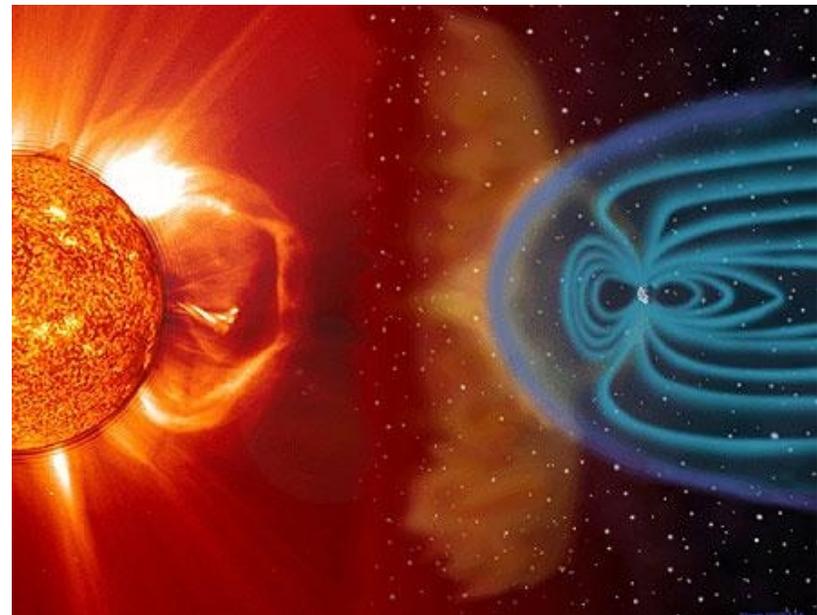
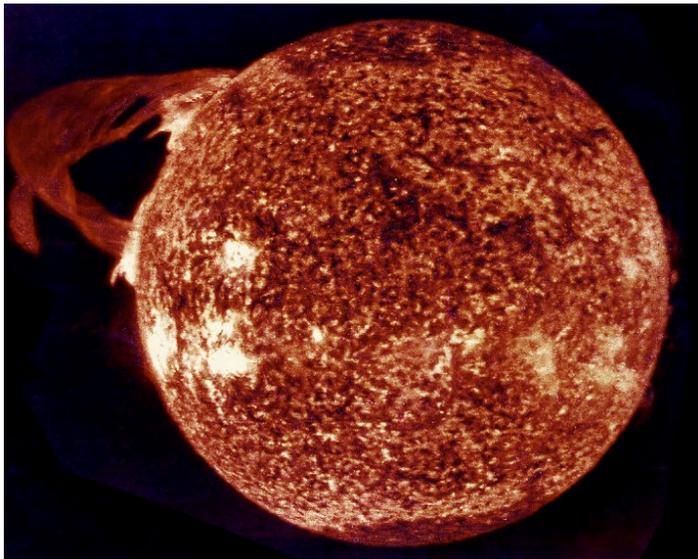
- The Mission
- The Science
- Educational Resources
- Space Weather (short and sweet)



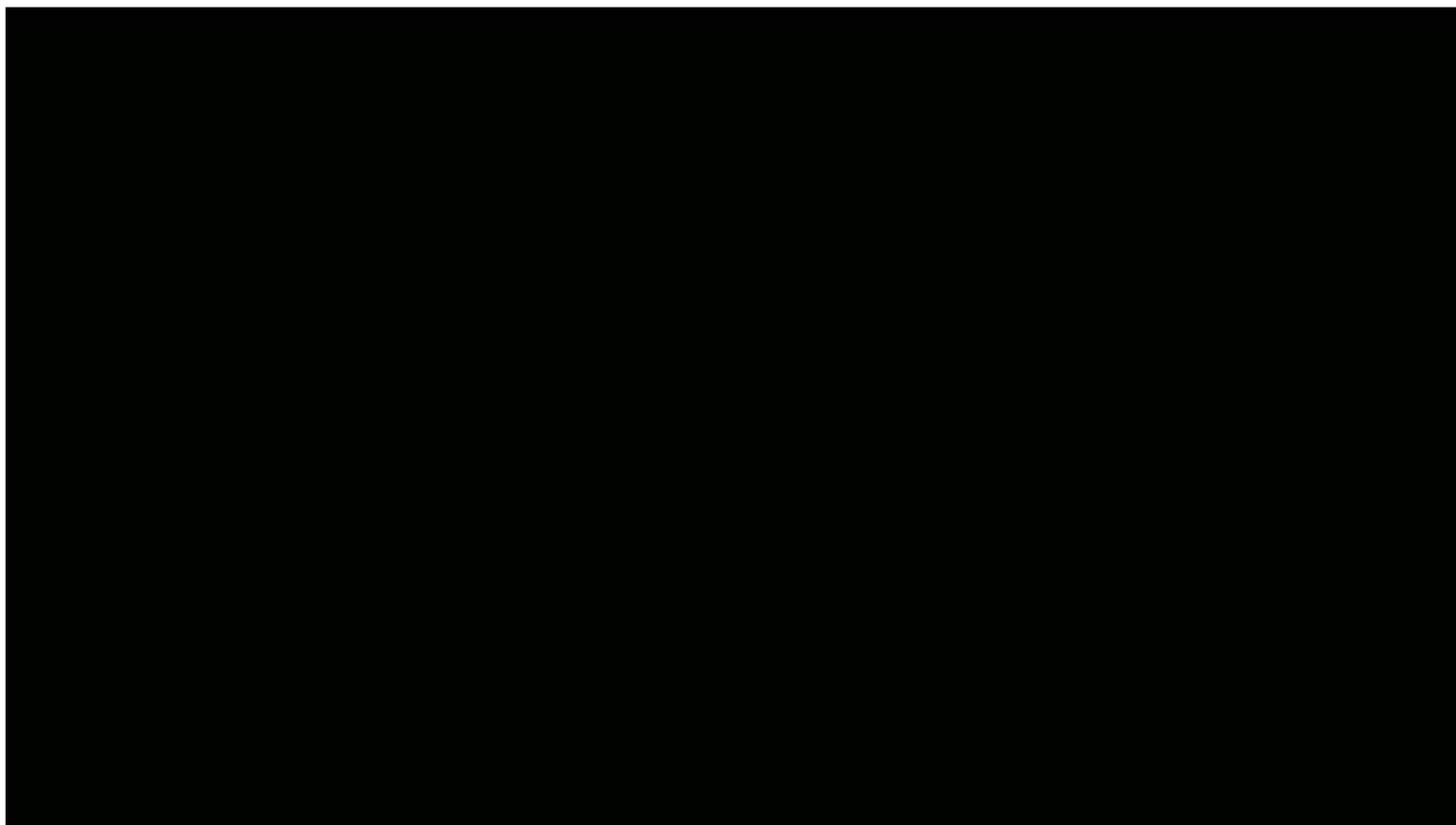
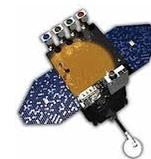
+ SDO: The Mission



- Launched in 2010, First Living with a Star Mission
Journey To the Stars video link <http://vimeo.com/8679190>
- Designed to understand the causes of solar variability and its impacts on Earth



+ SDO Video

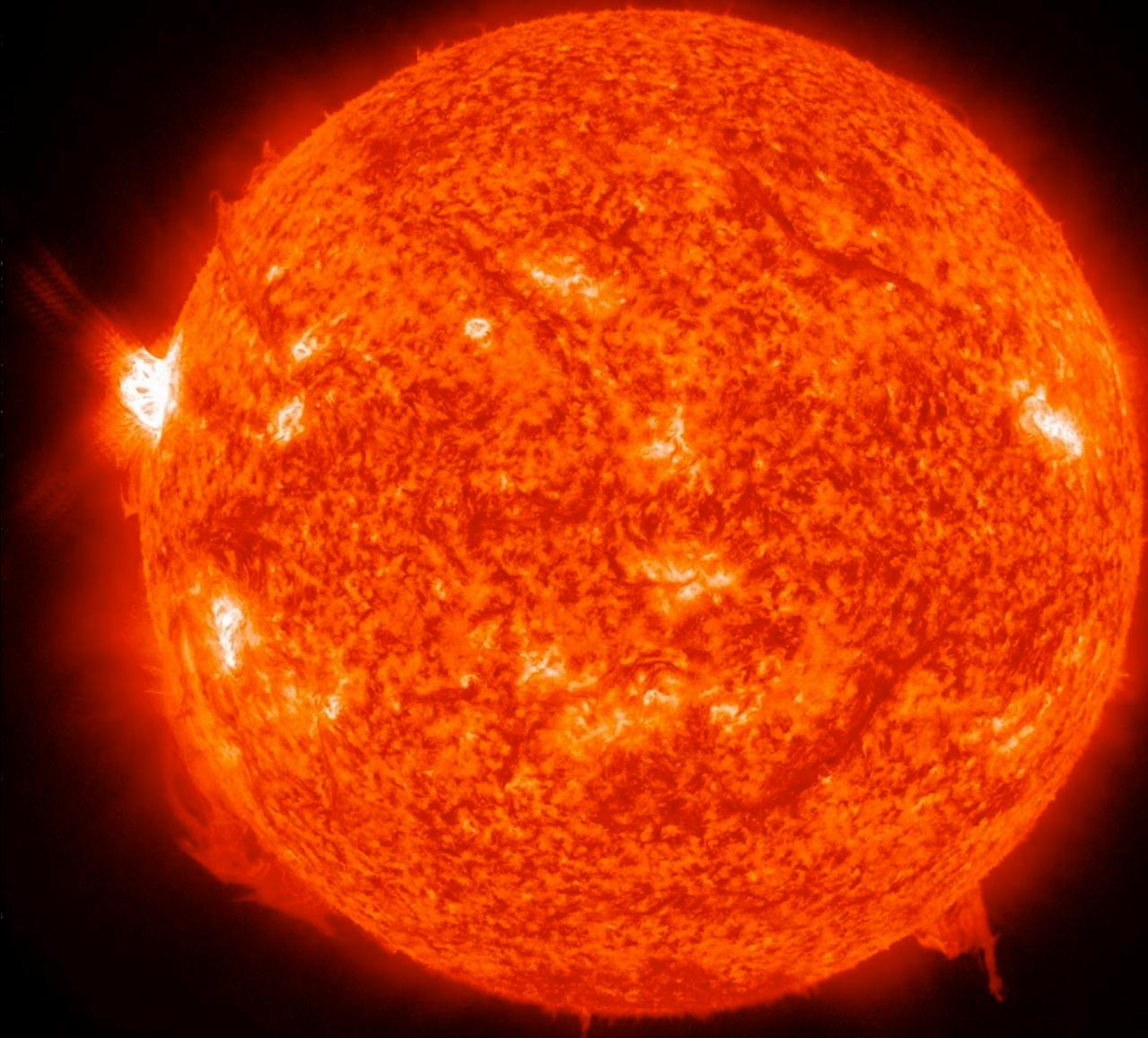


+ SDO: The Science



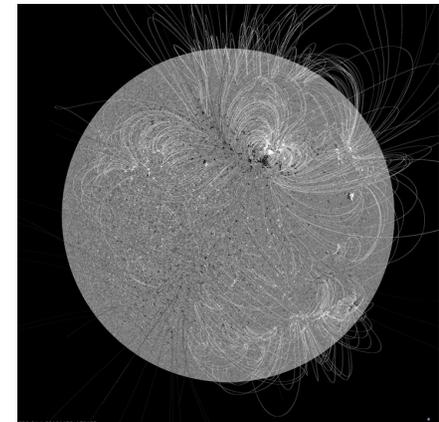
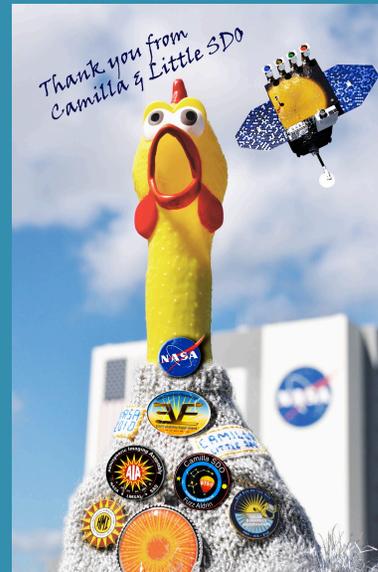
- Instruments to study the Sun's interior, atmosphere, and solar wind all day every day
- Atmospheric Imaging Assembly (AIA)
- EUV Variability Experiment (EVE)
- Helioseismic and Magnetic Imager (HMI)

Activity	Prediction Type	Prediction Time
Flares	Probability of occurrence, location	Today, tomorrow, next week
CMEs	Probability of occurrence, location, geoeffectiveness	Today, tomorrow, next week
Active region emergence and growth	Location of emergence, rate of growth	Today, next month



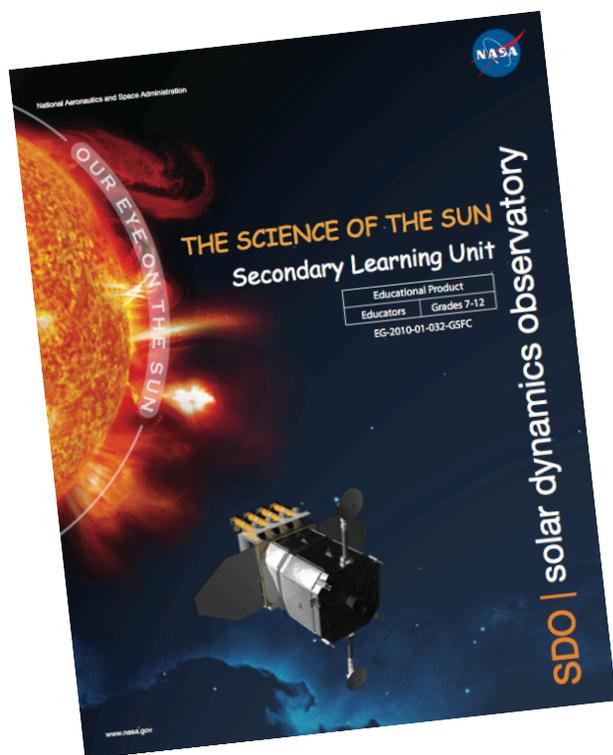


SDO Education Outreach

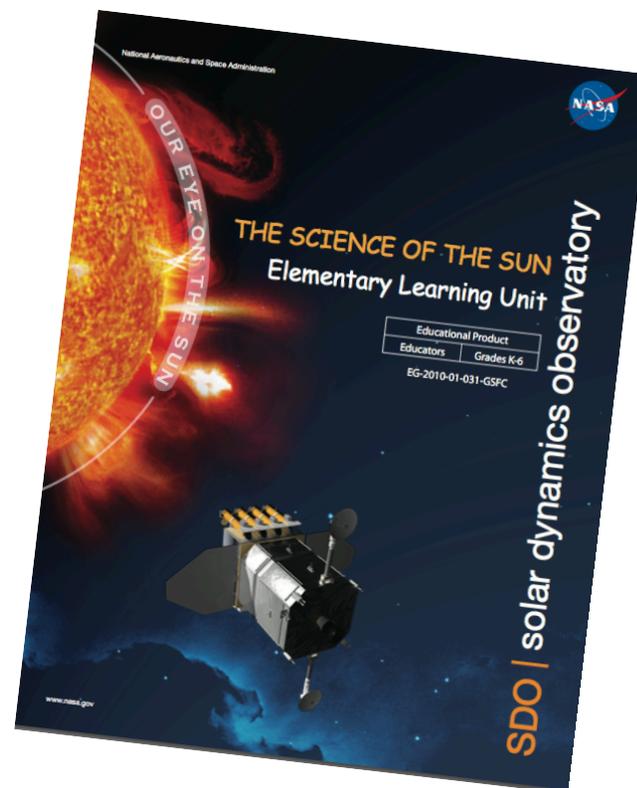


+ SDO Curriculum

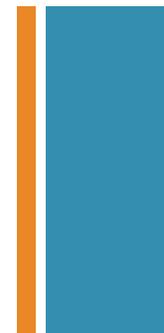
SDO Elementary K-6 Lessons



SDO Secondary 7-12 Lessons



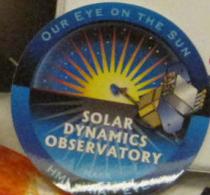
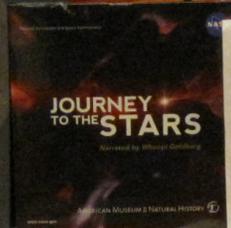
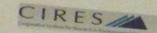
<http://sdo.gsfc.nasa.gov/eпо/educators/>



OUR EYE ON THE SUN

SDO

Introduction to Solar Science
Learning Kit



Build a Spectrometer

1 Cut out the pieces of the spectrometer. Glue all of the colored paper to the back of the cardboard. Use the pattern to cut out the pieces of the spectrometer. The pieces are:

- Spectrometer Body: All the pieces on the pattern.
- Slit: Cut out the slit.
- Slit Cover: Cut out the slit cover.
- Slit Cover Glue: Cut out the slit cover glue.
- Slit Cover Glue: Cut out the slit cover glue.
- Slit Cover Glue: Cut out the slit cover glue.

2 Assemble the Spectrometer Body. Glue the pieces of the spectrometer body together. Use the pattern to cut out the pieces of the spectrometer body. The pieces are:

- Spectrometer Body: All the pieces on the pattern.
- Slit: Cut out the slit.
- Slit Cover: Cut out the slit cover.
- Slit Cover Glue: Cut out the slit cover glue.
- Slit Cover Glue: Cut out the slit cover glue.

3 Glue the slit cover to the spectrometer. Use the pattern to cut out the pieces of the spectrometer. The pieces are:

- Slit Cover: Cut out the slit cover.
- Slit Cover Glue: Cut out the slit cover glue.
- Slit Cover Glue: Cut out the slit cover glue.

4 Finish with the Spectrometer. Glue the slit cover to the spectrometer. Use the pattern to cut out the pieces of the spectrometer. The pieces are:

- Slit Cover: Cut out the slit cover.
- Slit Cover Glue: Cut out the slit cover glue.
- Slit Cover Glue: Cut out the slit cover glue.

5 Make Entrance Slit. Use the pattern to cut out the pieces of the spectrometer. The pieces are:

- Entrance Slit: Cut out the entrance slit.
- Entrance Slit Glue: Cut out the entrance slit glue.
- Entrance Slit Glue: Cut out the entrance slit glue.

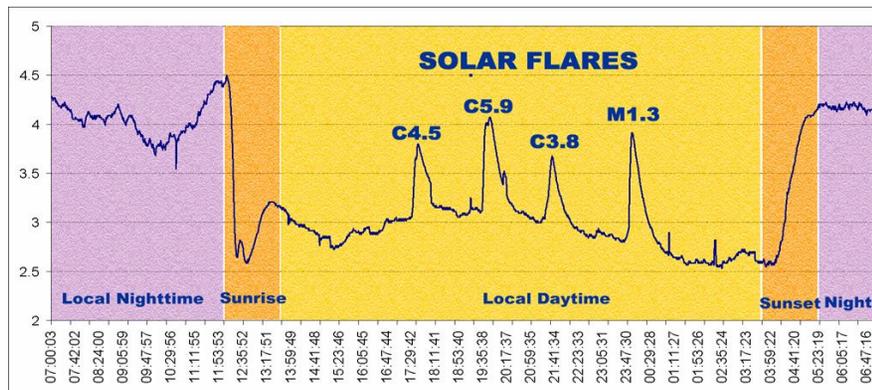


+ SID Monitors

- Help teachers and students participate in this citizen science program
- Measure ionosphere disturbances
- Help scientists better understand the influence of charged particles on radio communications and satellite surveillance systems.



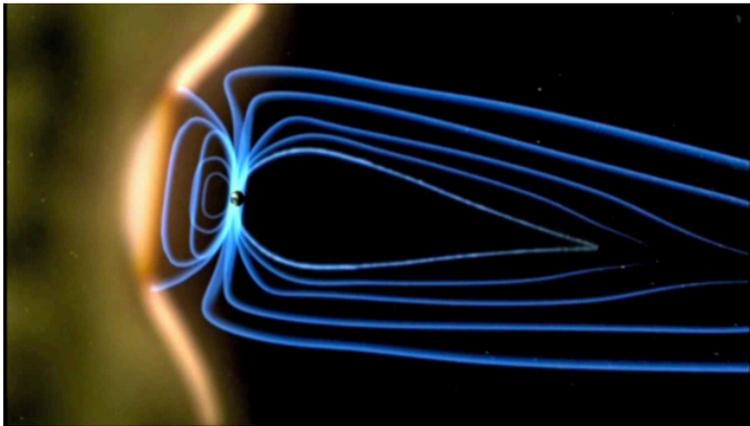
STANFORD
S O L A R
C E N T E R



+ VIDEOS and DVDs



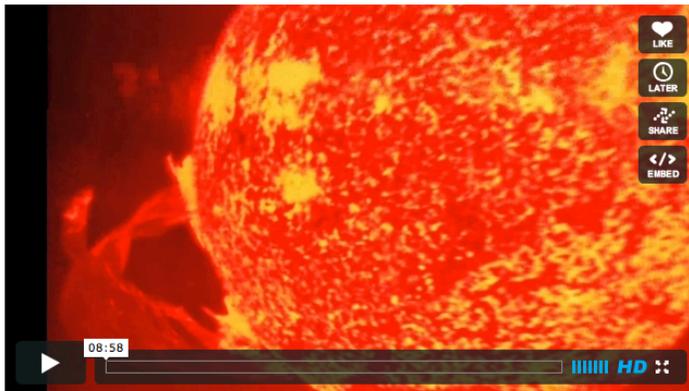
 **All About EVE**
by CIRES Education & Outreach PLUS
2 years ago



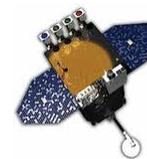
 **All About EVE**
by CIRES Education & Outreach PLUS
2 years ago



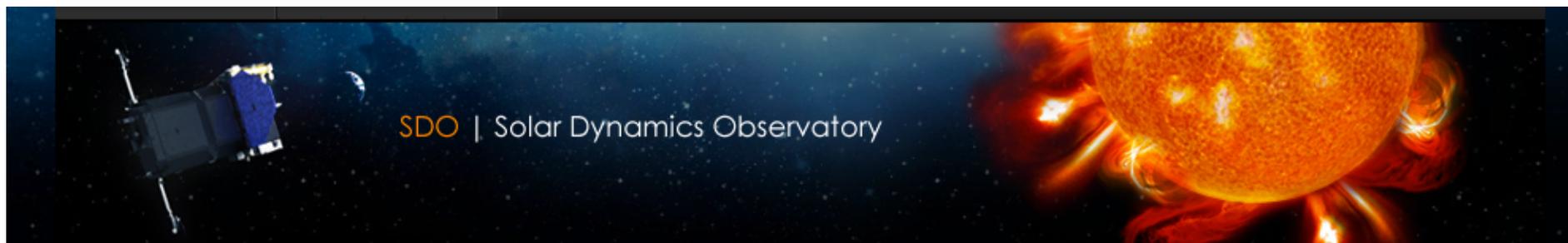
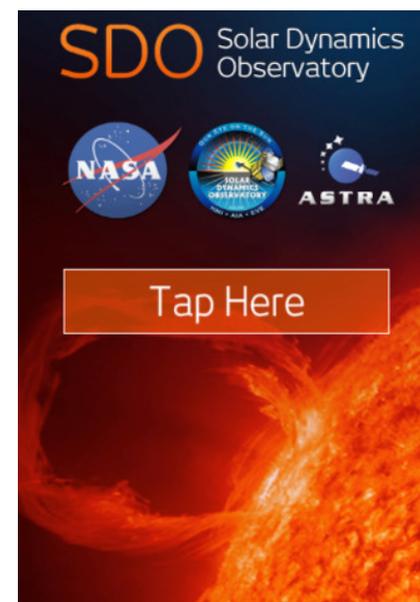
 **All About EVE**
by CIRES Education & Outreach PLUS
2 years ago



+ SDO Resources



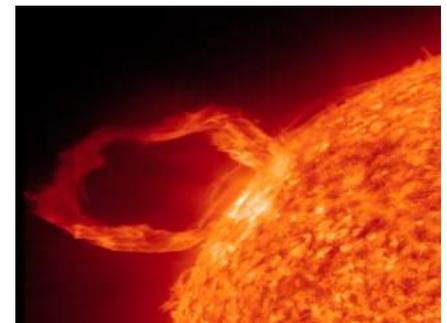
- NASA Goddard <http://sdo.gsfc.nasa.gov/>
- NASA http://www.nasa.gov/mission_pages/sdo/main/index.html
- SDO App <http://itunes.apple.com/us/app/sdo-iphone-version/id455184323?mt=8>
- Helioviewer <http://www.helioviewer.org/>





Solar Storms and Space Weather

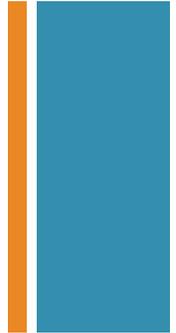
Short and Sweet



+ So why do we care about Space Weather?

Energy and radiation from the Sun can:

- Create blackouts on Earth when they cause surges in power grids.
- Disrupt our navigation systems (i.e. aircraft, GPS).
- Interfere with communication systems on Earth.
- Cause colorful auroras, often seen in the higher latitudes.
- Harm astronauts in space.
- Damage sensitive electronics on orbiting spacecraft, like SDO.



+ Aurora: Points of View



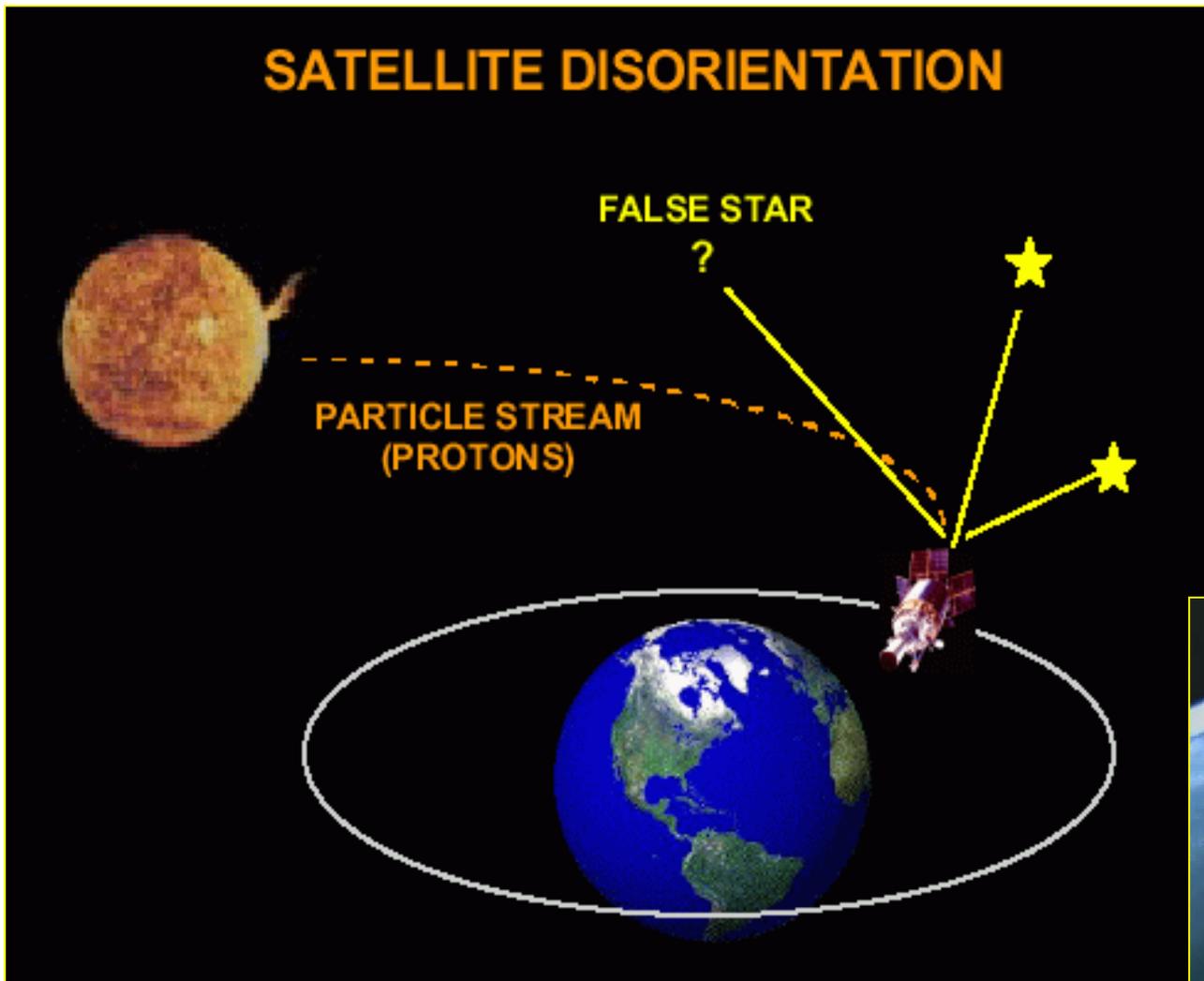
View From Earth



View From Space



+ Space Weather: Effects on Orbiting Spacecraft



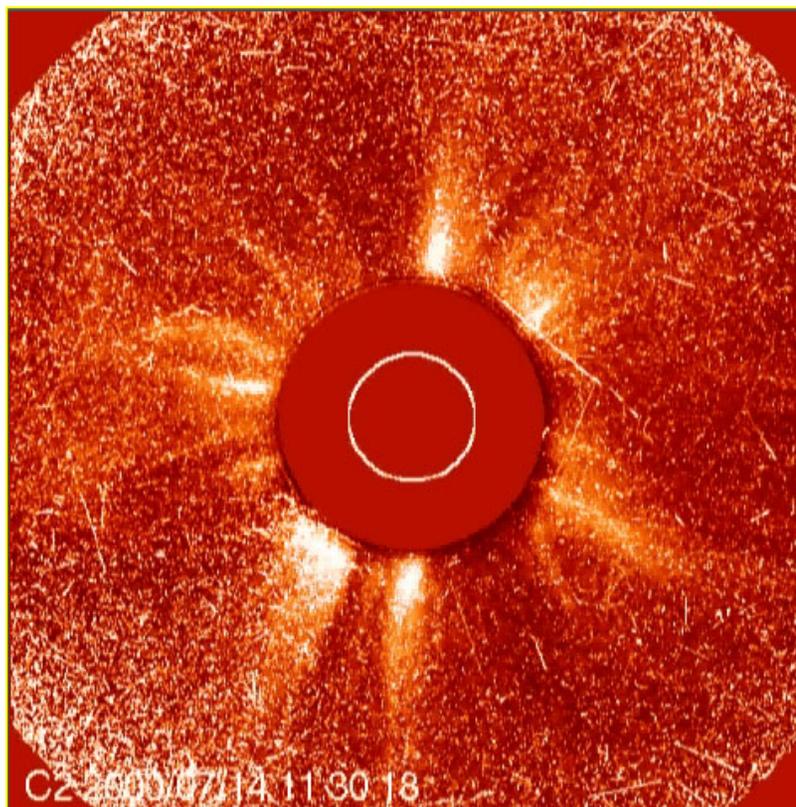
- In 16 yr time span 13 satellites lost due to Space Weather Effects
- 1998-2004 space losses may have exceeded \$500 million



+ Space Weather: Effects on Satellite Sensors

When particles hit the CCD they generate electrons which charge up the pixels just like the regular photons, producing images similar to a star.

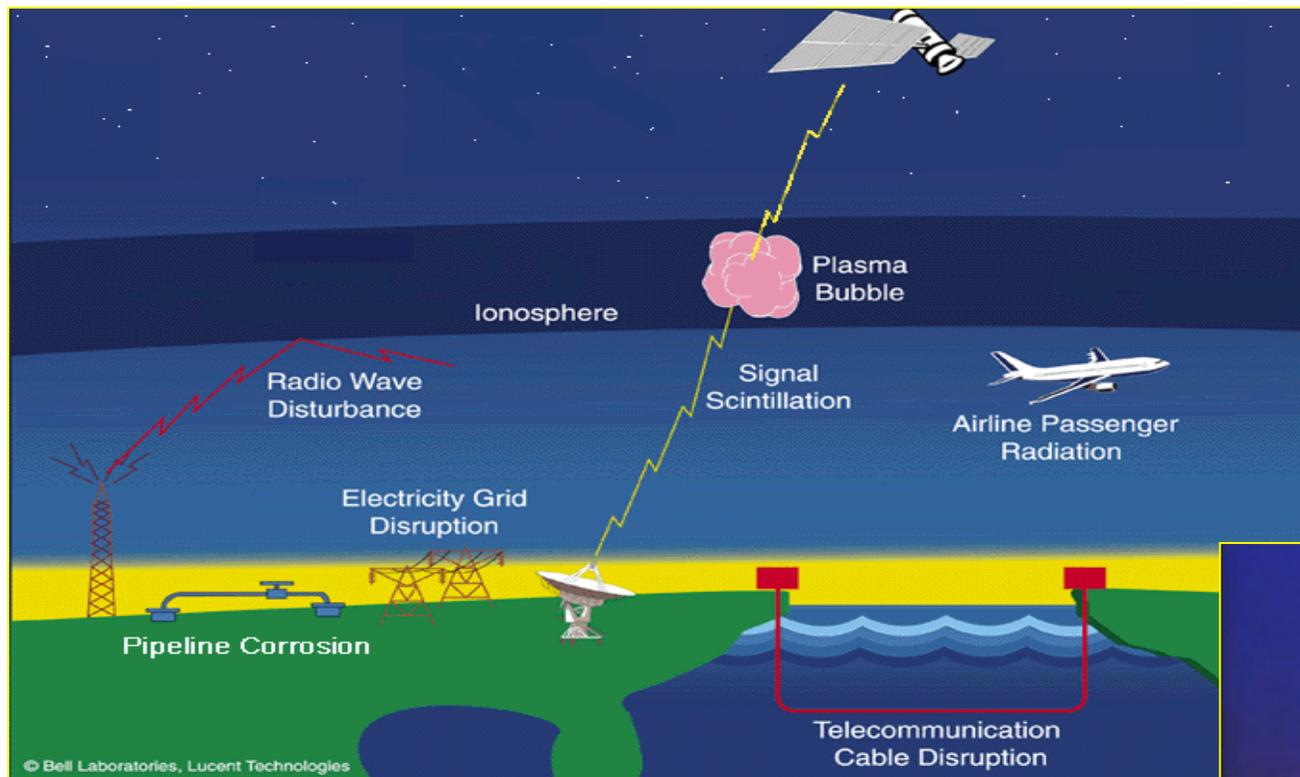
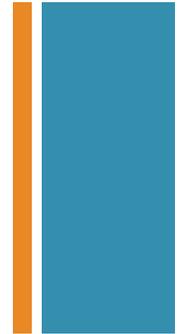
Confuses the attitude control unit and can lead to tumbling.



+ Space Weather: Effects on Humans in Space



+ Solar Storms: Effects on Societal Systems



+ Help Camilla Predict Space Weather!



- Students use Space Weather Forecast Submission Form
- Answer questions
- Instructional videos

Part A
Use the HMI Intensitygram to answer questions 1 - 5
» See instructional video for part A

1. Are there any sunspots? ⓘ
Yes:
No:

2. How many sunspots are there? ⓘ

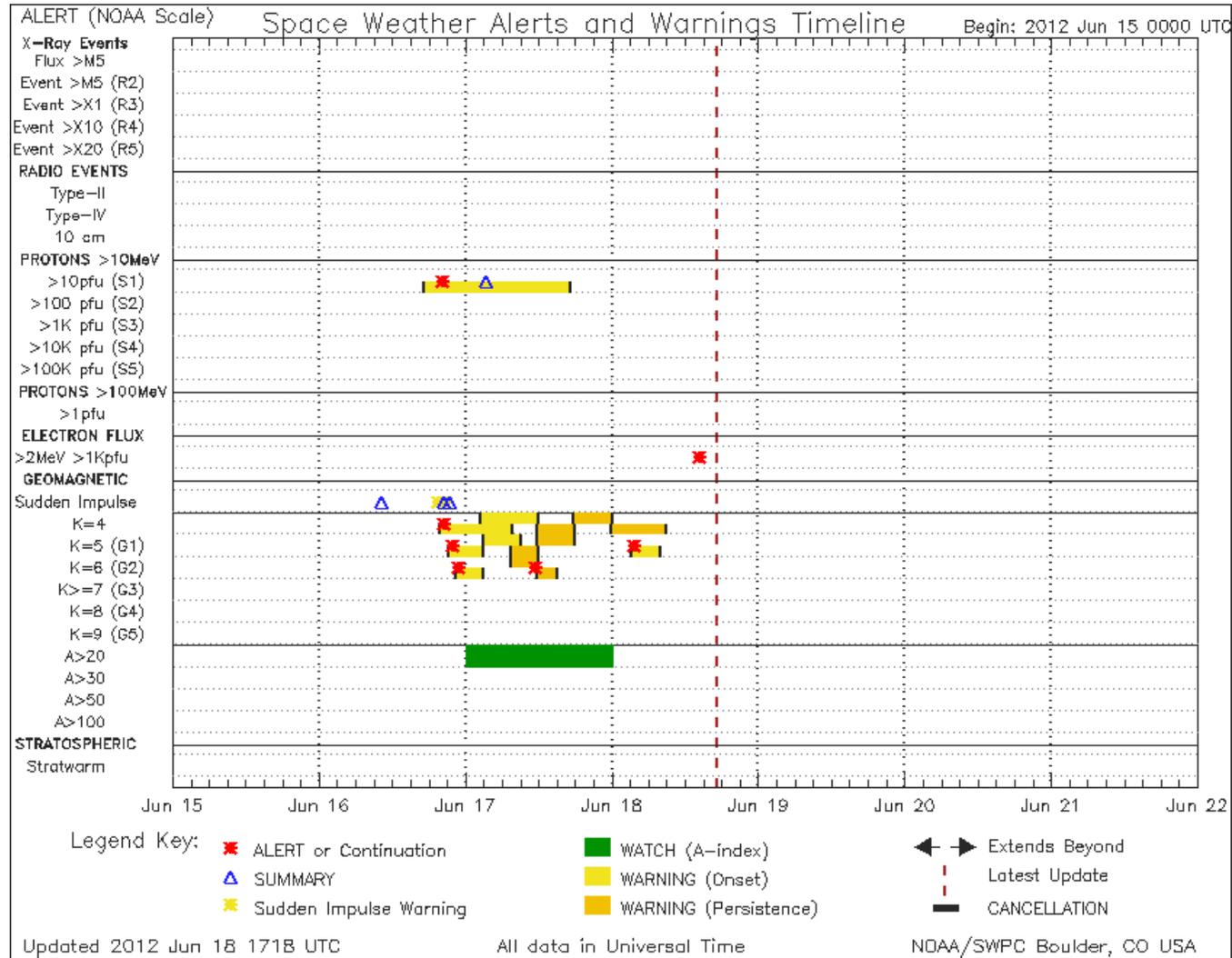
3. Are the sunspots grouped in clusters? ⓘ
Yes:
No:

4. Where are the sunspots located compared to the sun's equator? Use the hands of a clock and North/South to describe position (i.e. 10 o'clock north) ⓘ



<http://sdo.gsfc.nasa.gov/swx/>

+ Today

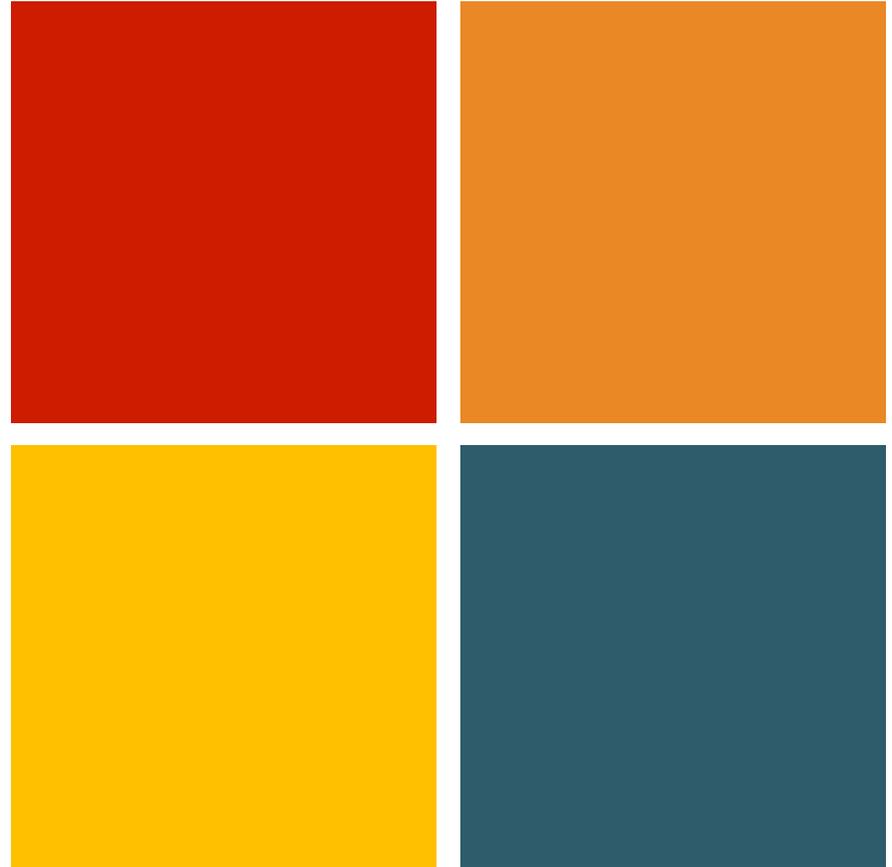
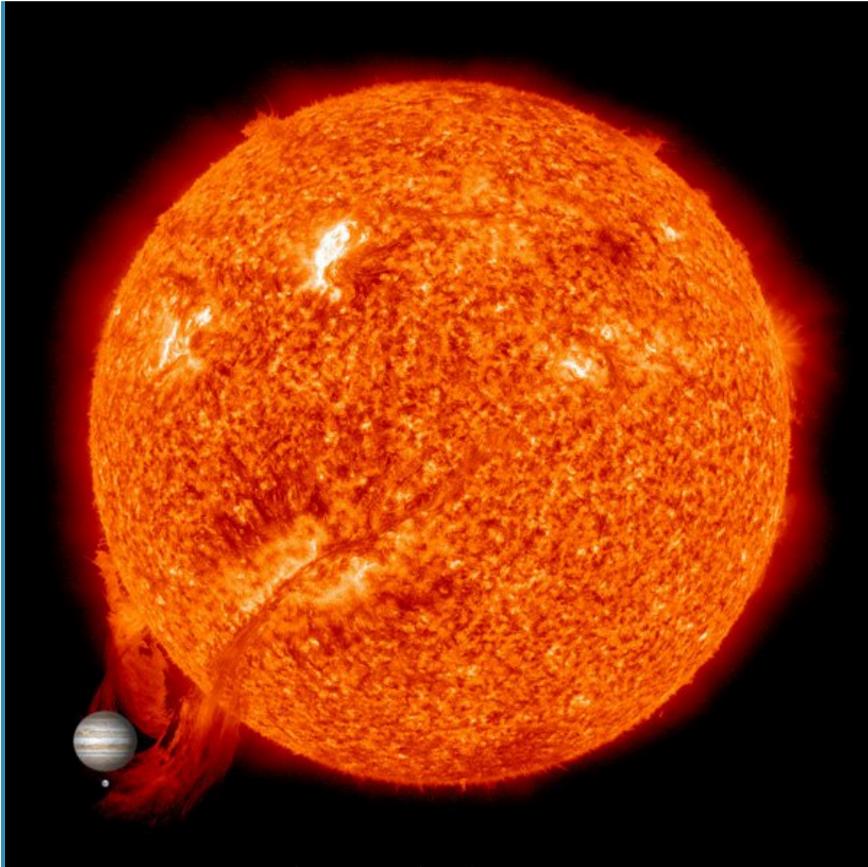


■ <http://www.swpc.noaa.gov/alerts/k-index.html>

+ Reports from this weekend

- **The impact of the double Coronal Mass Ejection (CME) provided visible aurorae as far south as Utah, Michigan, Maryland and Washington.**



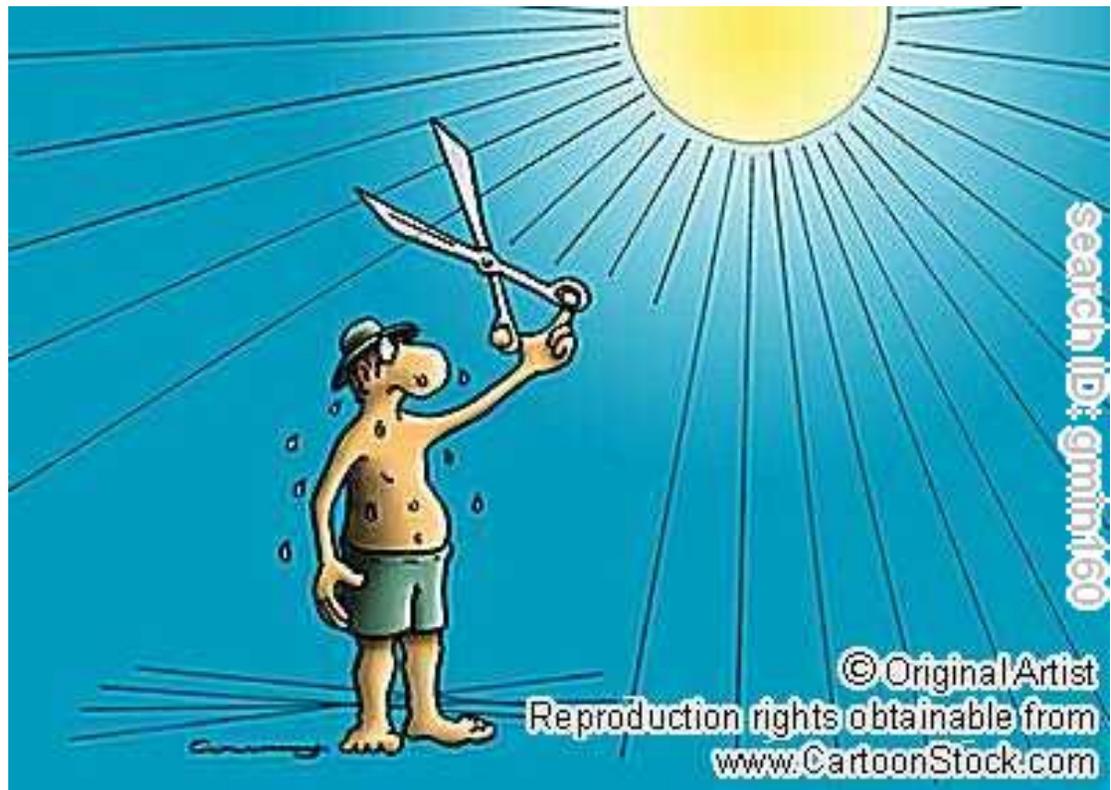


The Sun Earth Connection Climate Change

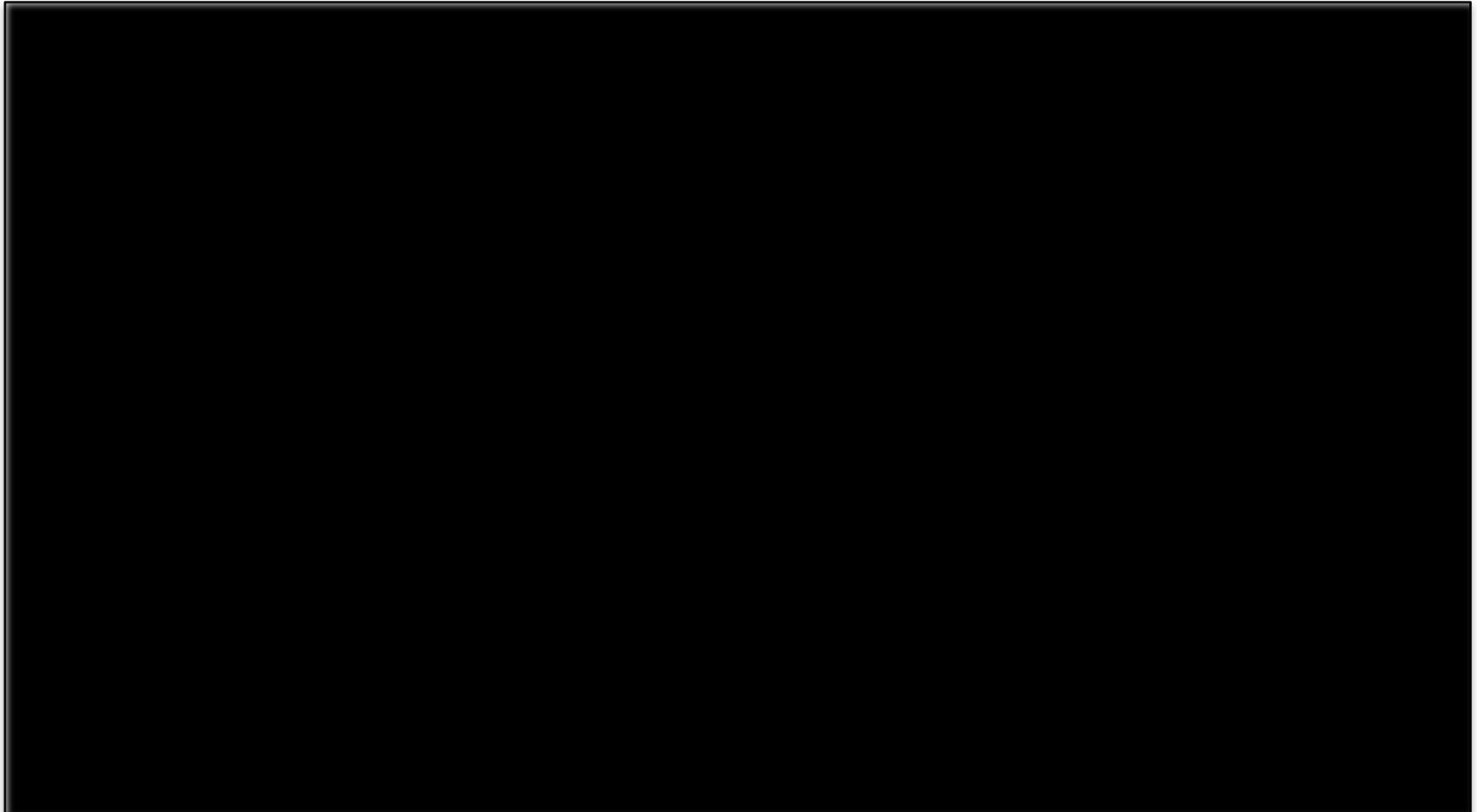
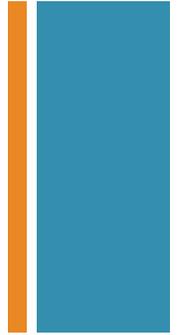
Emily Kellagher
CIRES at CU Boulder

+ Overview

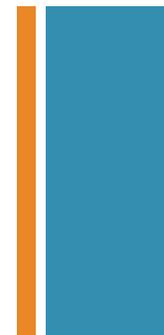
- Sun Earth Connection
- Solar Misconceptions related to Climate Change
- Measuring the Solar Constant
- UV activities



+ What Comes from the Sun?

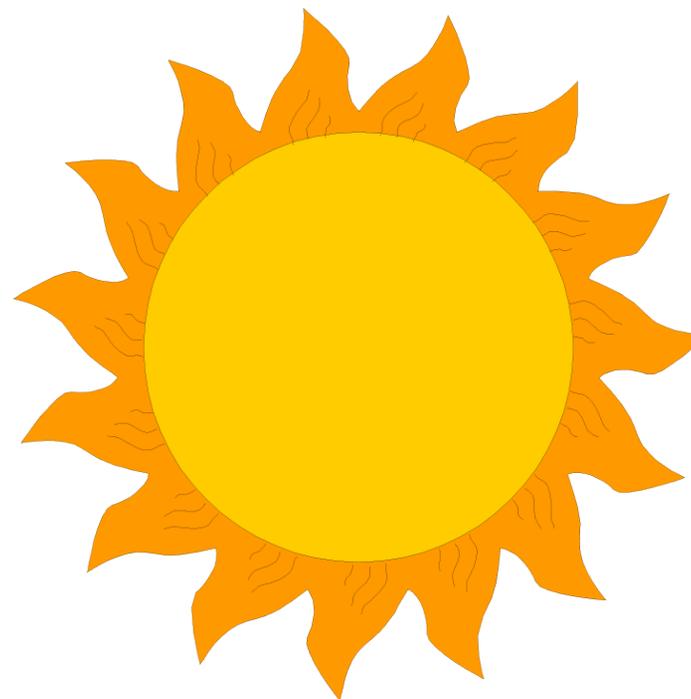


+ What Comes from the Sun?

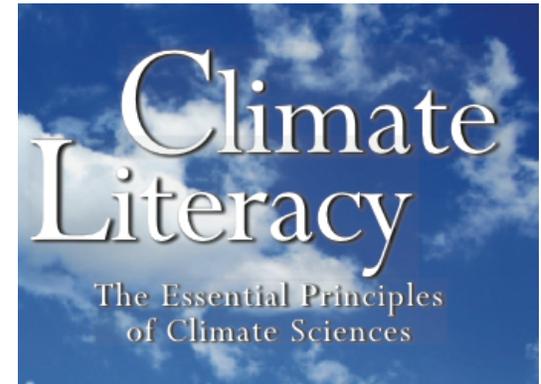


We know that the Sun is very important for life on Earth. What do we get from the Sun? Place an X next to each correct answer.

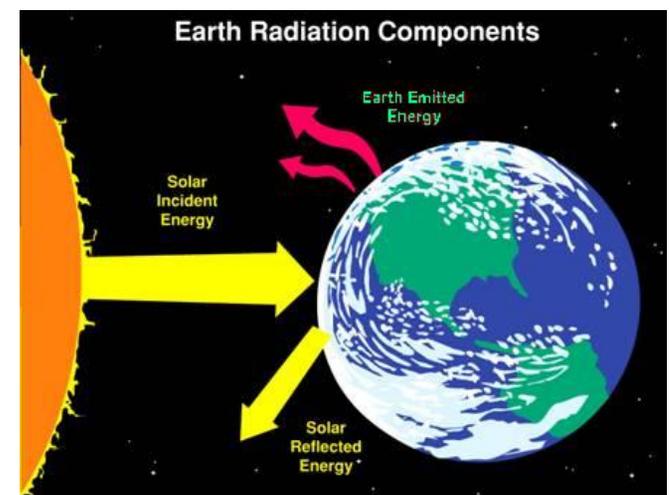
- Visible light
- Heat
- Ultraviolet (UV) radiation
- Infrared radiation



+ Climate Literacy: Essential Principle 1

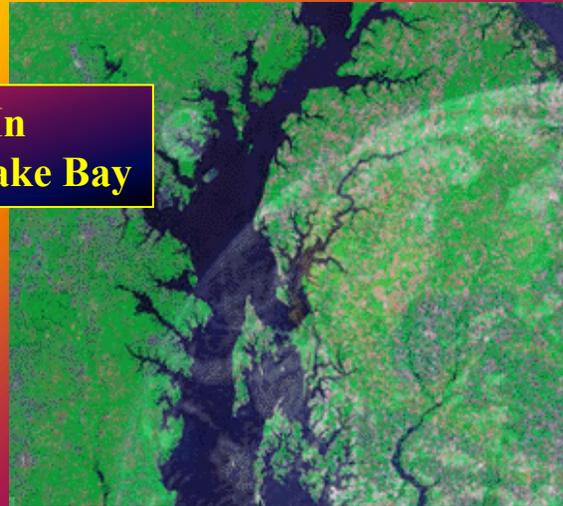


- The Sun is the primary source of energy for Earth's climate system
- Sunlight energizes the Earth's climate system, seasonal cycles, orbital cycles and other variables affect the energy balance on the Earth's surface.
- Earth's Energy Balance



+ The Sun's Energy: Driver of Earth Weather

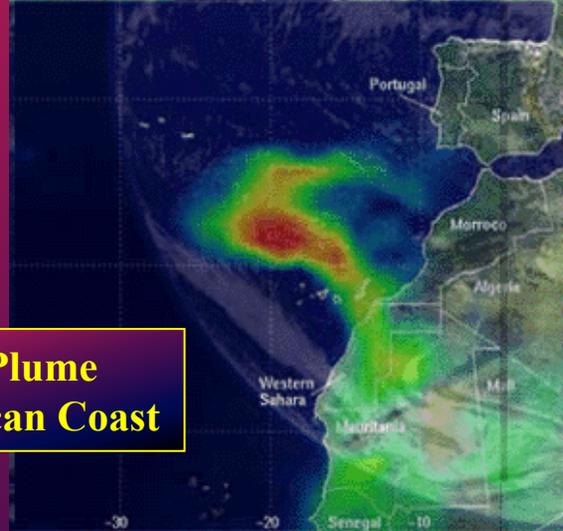
Water Level In
The Chesapeake Bay



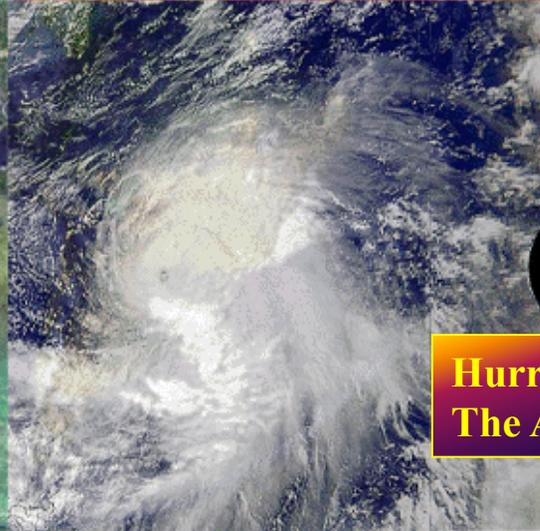
Infrared Image Of
Atlanta, Georgia



Sahara Dust Plume
Off The African Coast

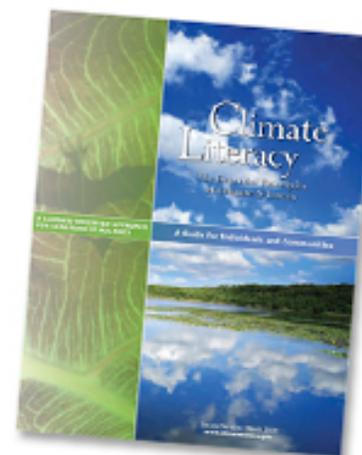


Hurricane In
The Atlantic Ocean



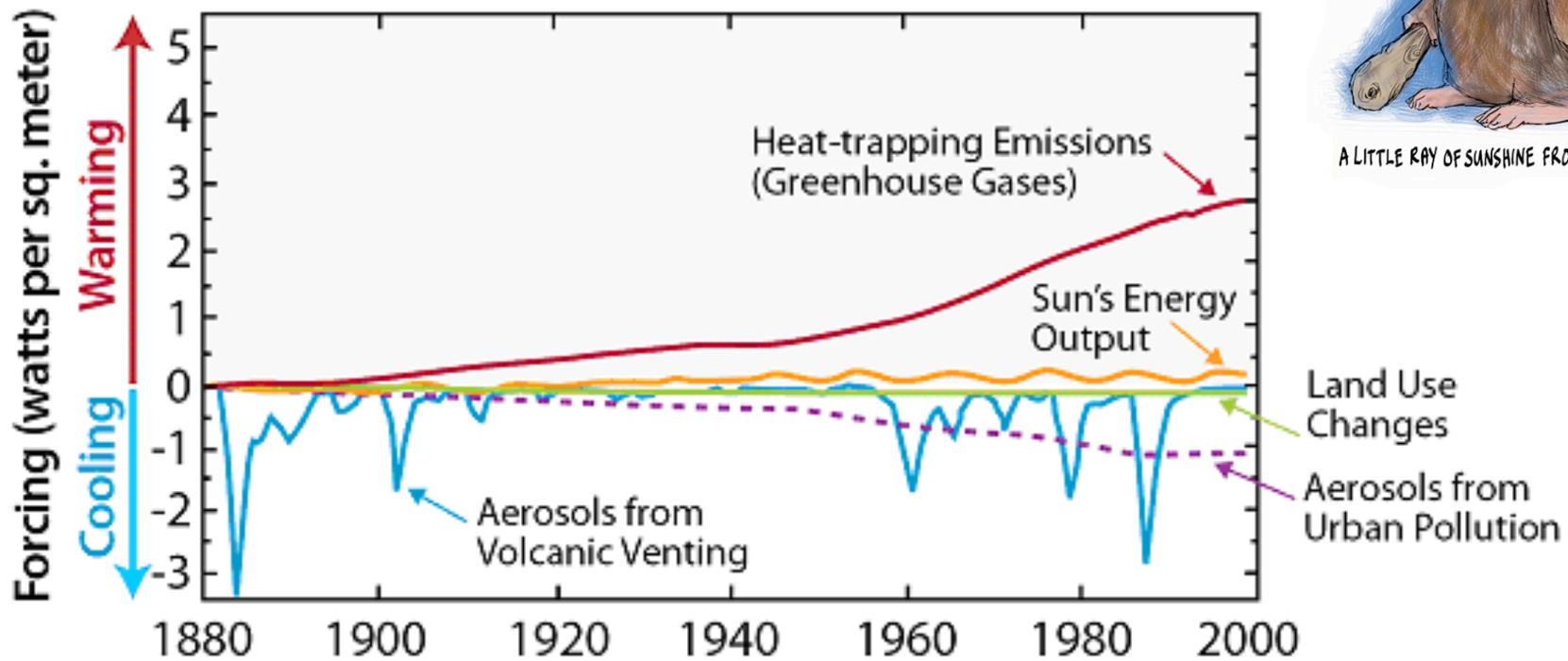
+ Teaching this principle is supported by five key concepts:

- ① Solar Energy and Earth's Albedo
- ② Energy Budget
- ③ Annual cycle of seasons
- ④ Earth's rotation and orbit around the sun
- ⑤ Satellite measurements of sun's energy output

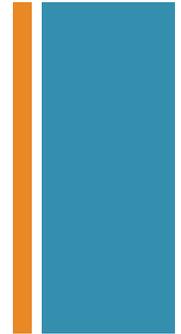


+ Why start with the Sun?

Global Climate Drivers

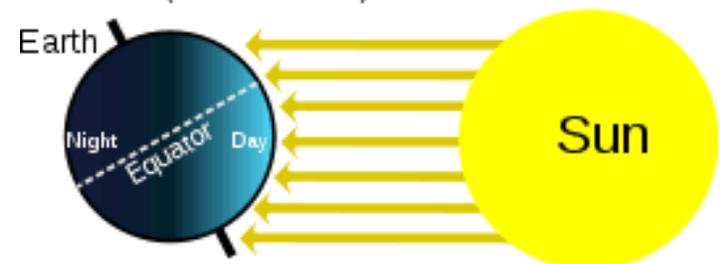


+ **What makes this principle
challenging to teach?**



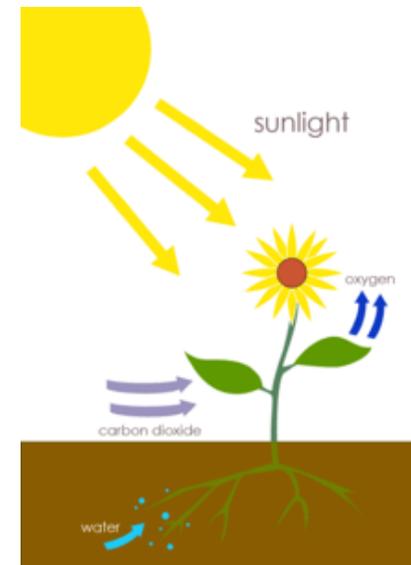
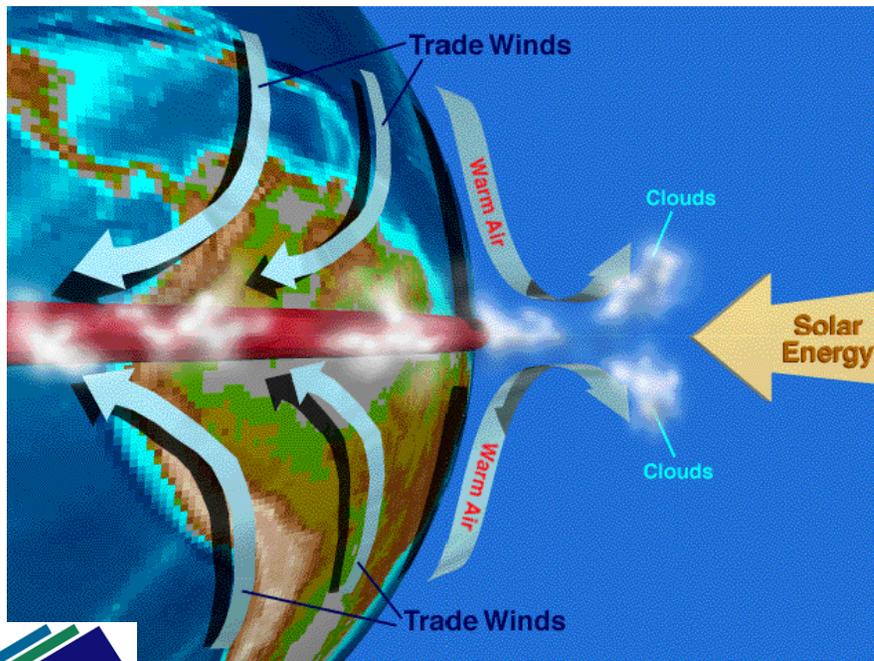
+ Understanding the role of solar radiation in the Earth's climate system can help us grasp important concepts such as:

- The causes of the seasons.
- The reasons ice ages occur.
- How the amount of energy emitted from the sun (sun's luminosity) changes over time.
- Why recent climate warming has not been caused by increases in the sun's energy output.
- Most forms of energy that humans use are derived from solar energy.

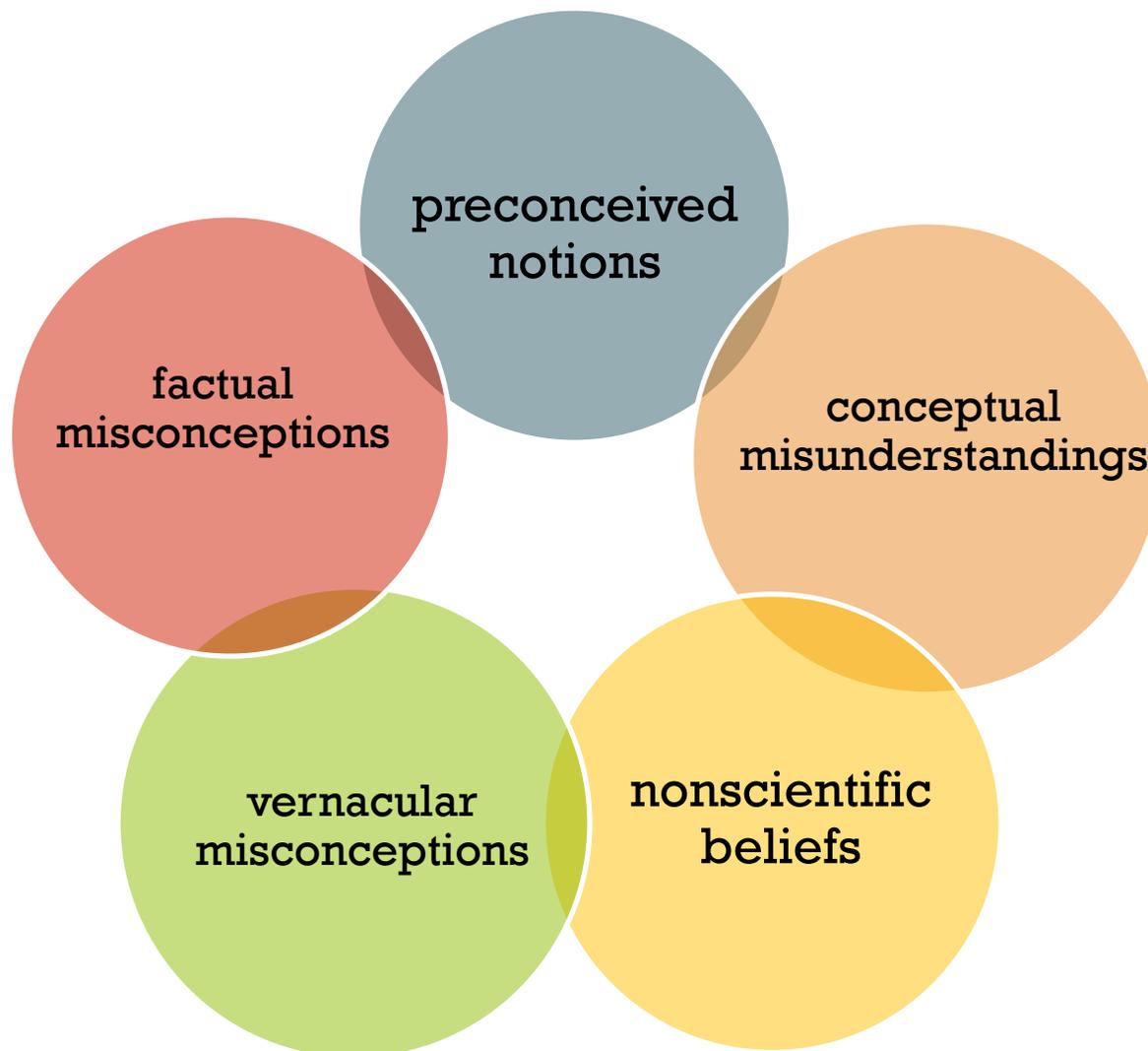


+ How can I use this principle in my teaching?

- Connections Connections Connections
- Integrated approach to science concepts



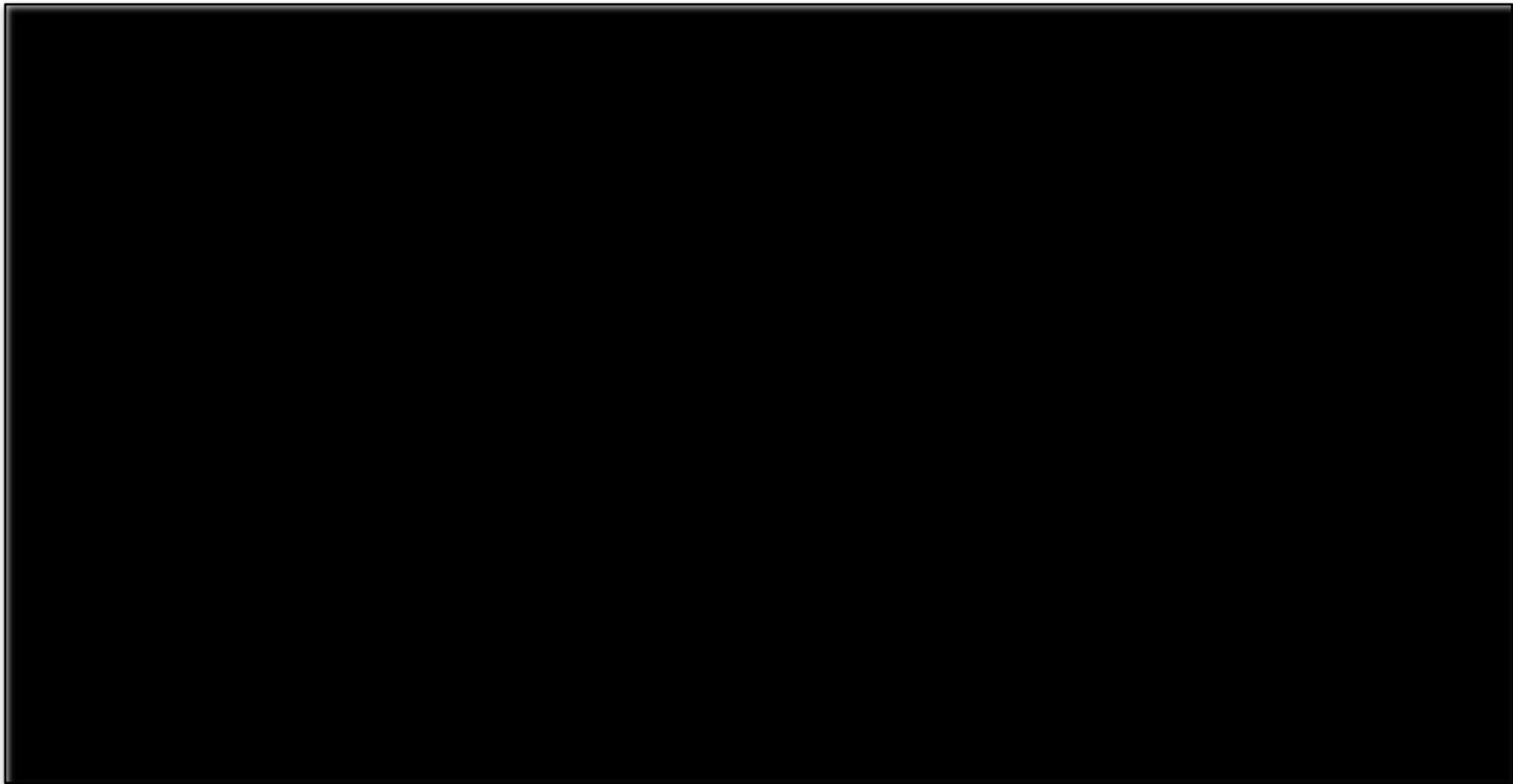
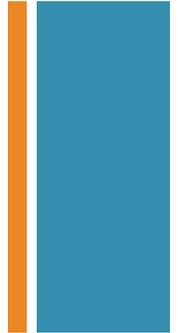
+Types of misconceptions



+ It's the Sun, stupid!

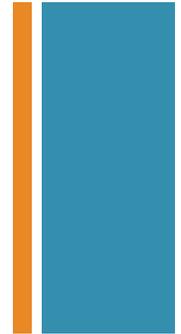
- Increased radiation causes recent climate change
- Increased sun spots cause recent climate change
- Changes in Earth's orbit causes recent climate change
- Warming is due directly to sunlight.

+ Uncovering misconceptions

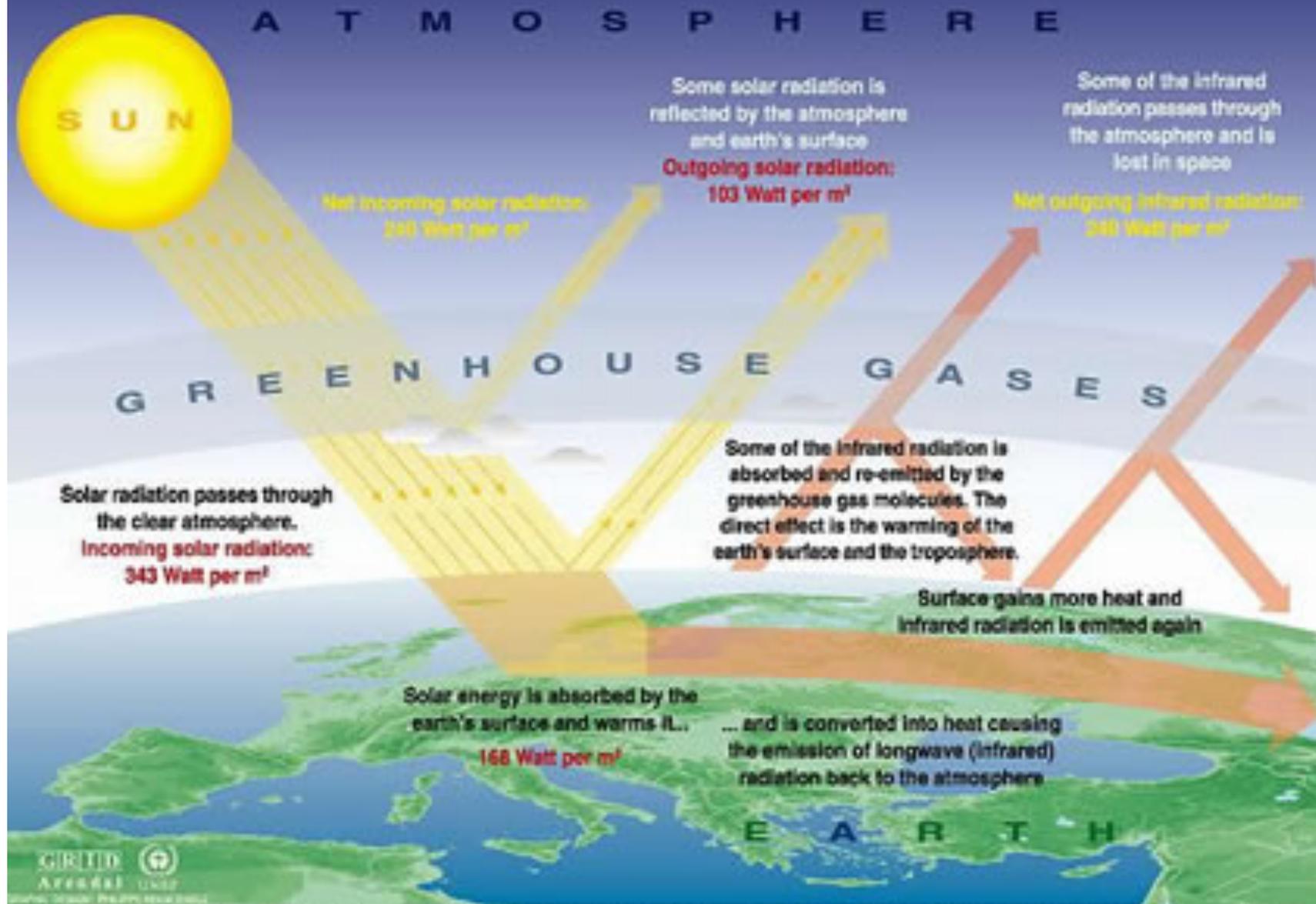


+ Solar Radiation

- *Misconception:* The sun's energy is reflected or bounced off the surface of Earth.
- *Correct concept:* Incoming UV radiation is absorbed by the surface of Earth and transformed into outgoing infrared energy.

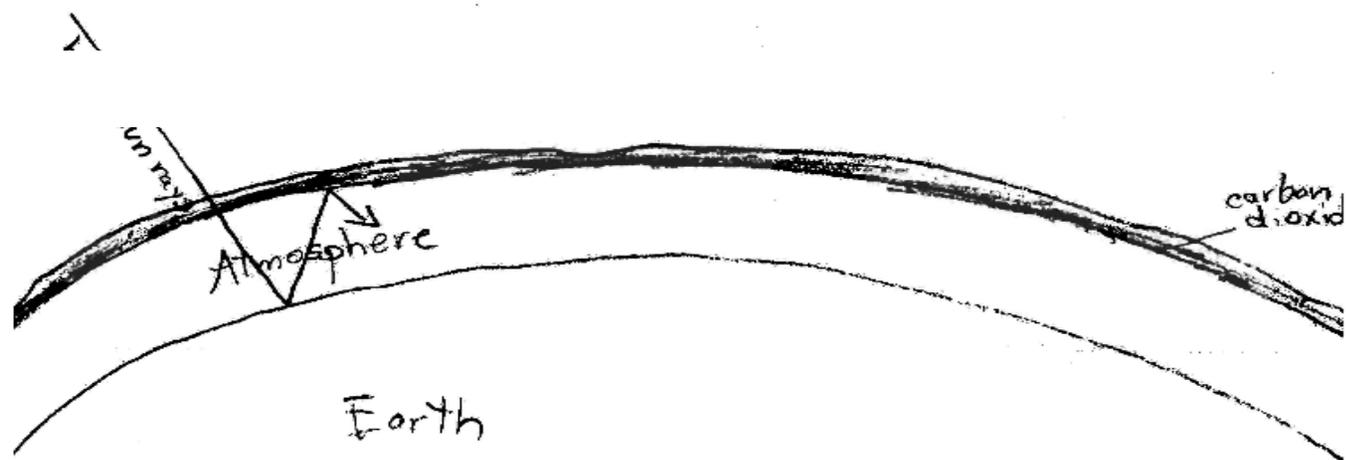


The Greenhouse effect



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

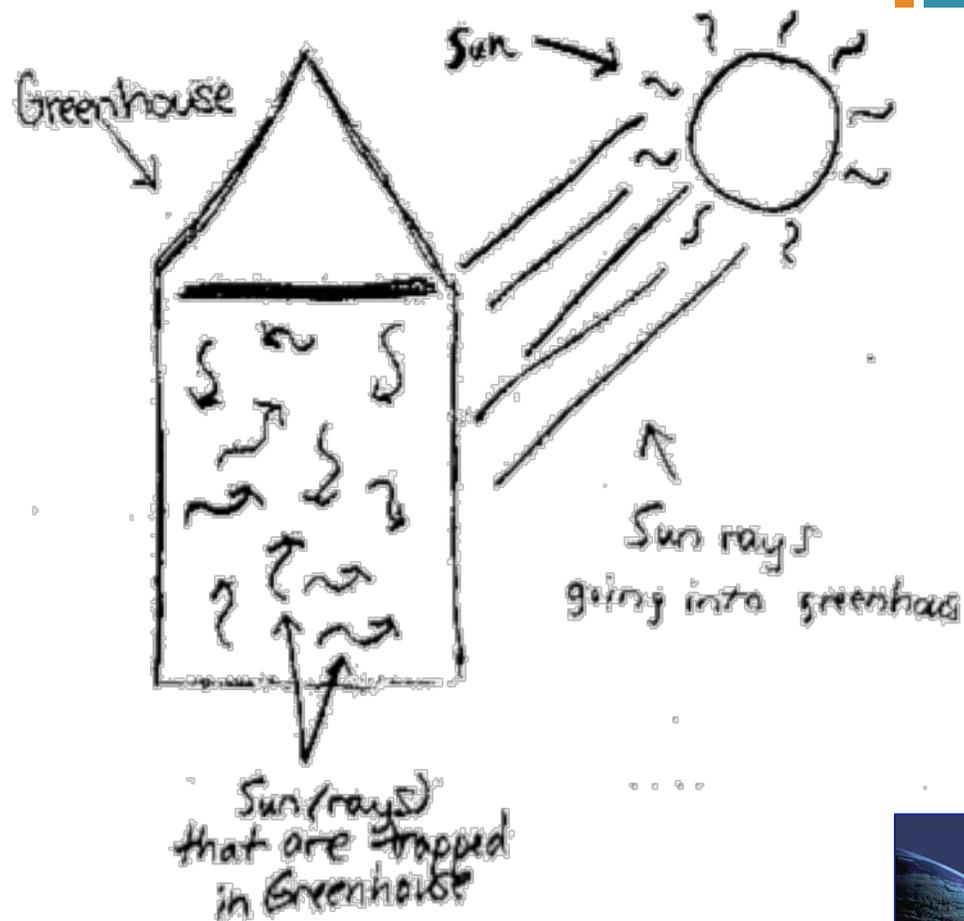
+ Greenhouse effect: Prior concepts



Shepardson, et. al., 2010

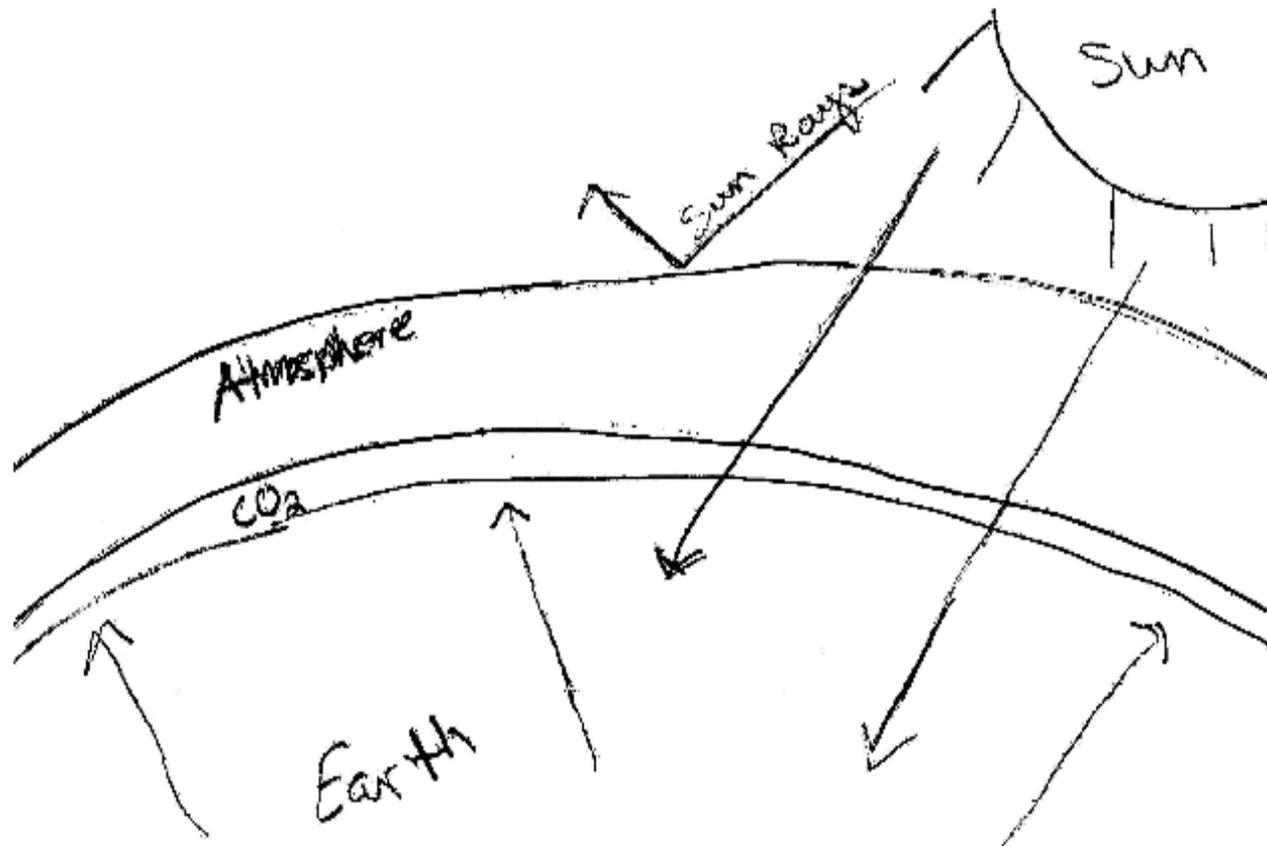
+ Greenhouse effect: Prior Concepts

- Like a physical greenhouse

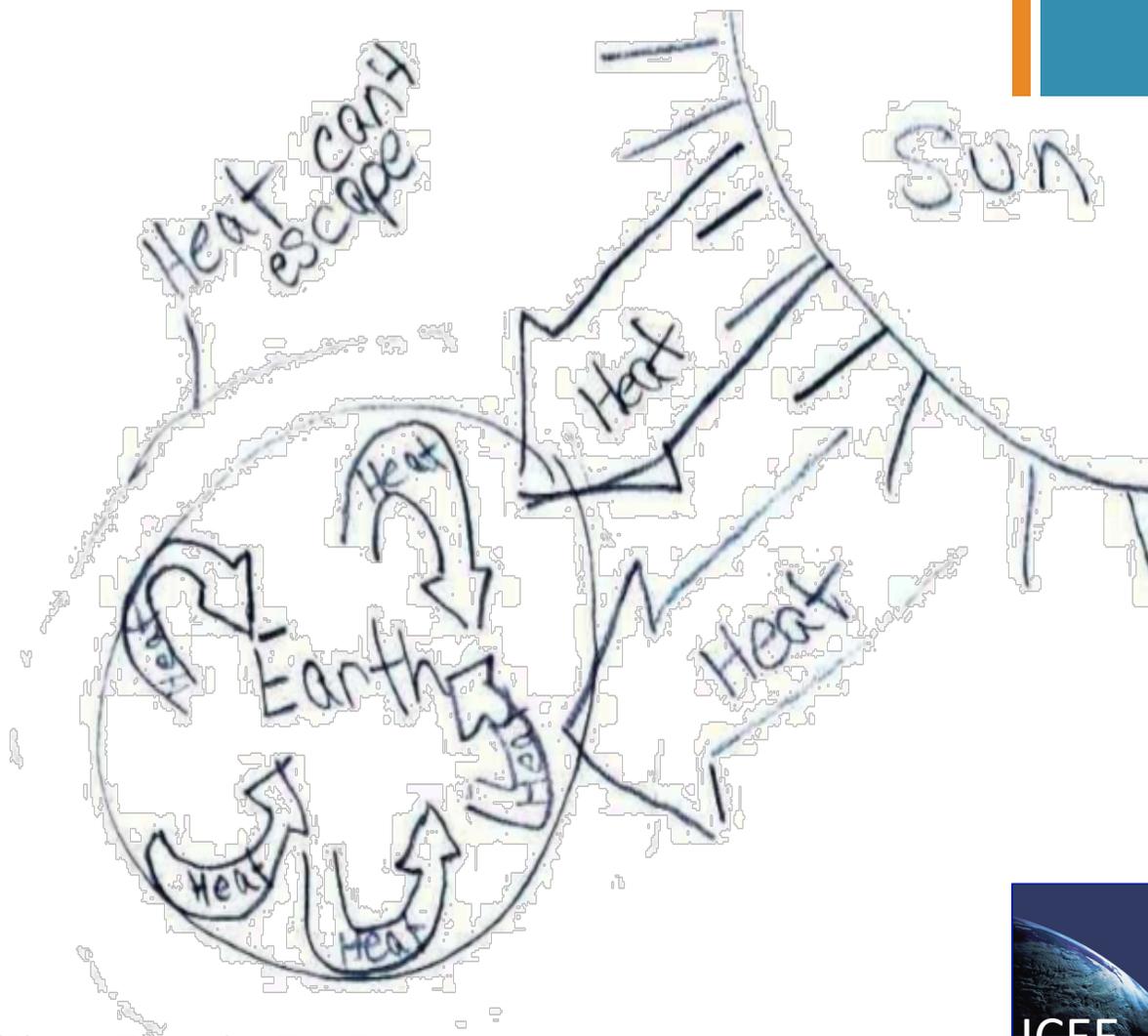


Shepardson, et. al., 2010

+ Draw the greenhouse effect



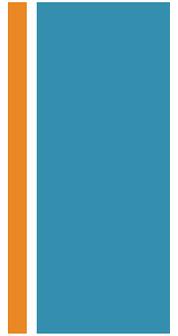
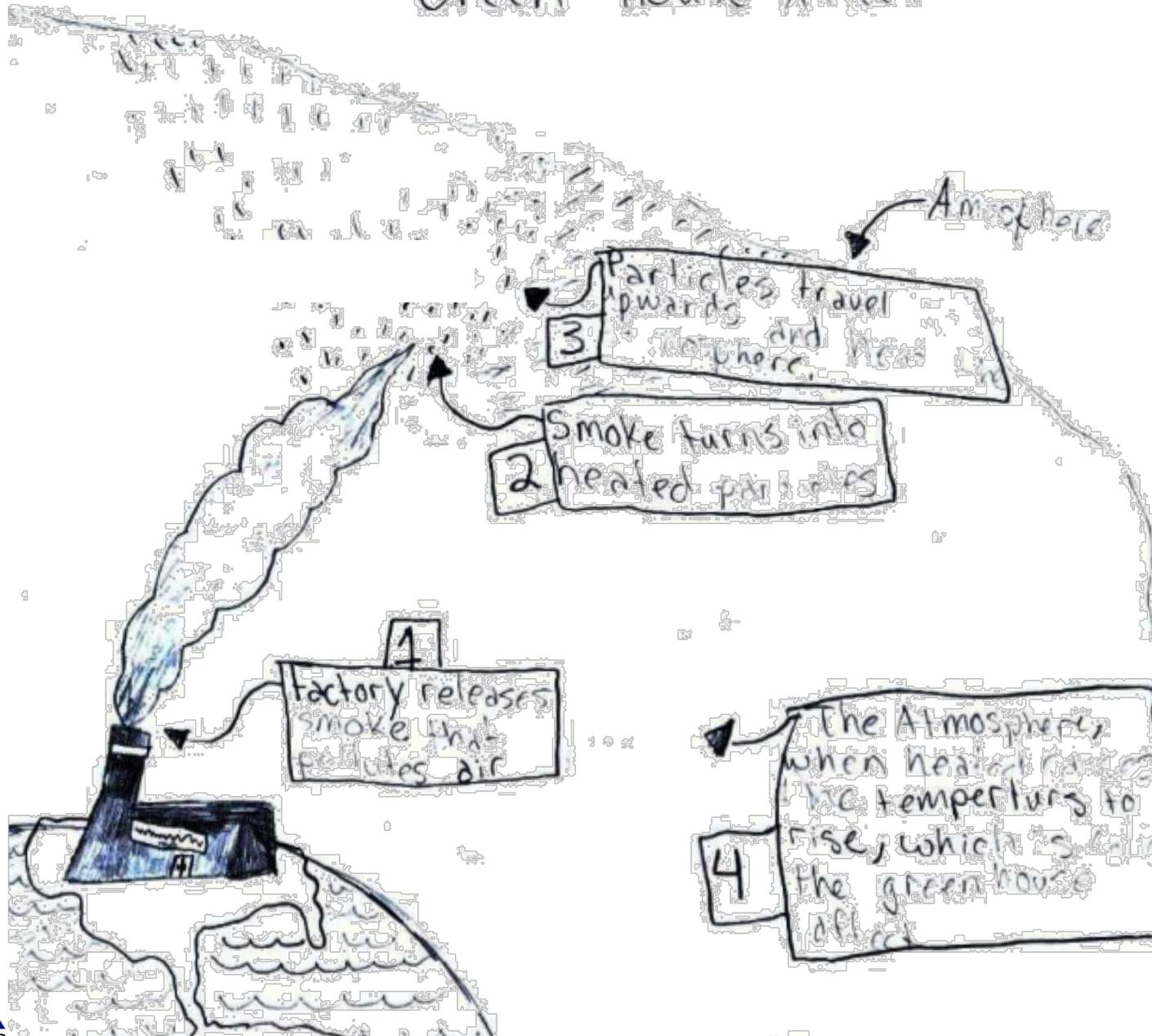
+ What is the missing concept?



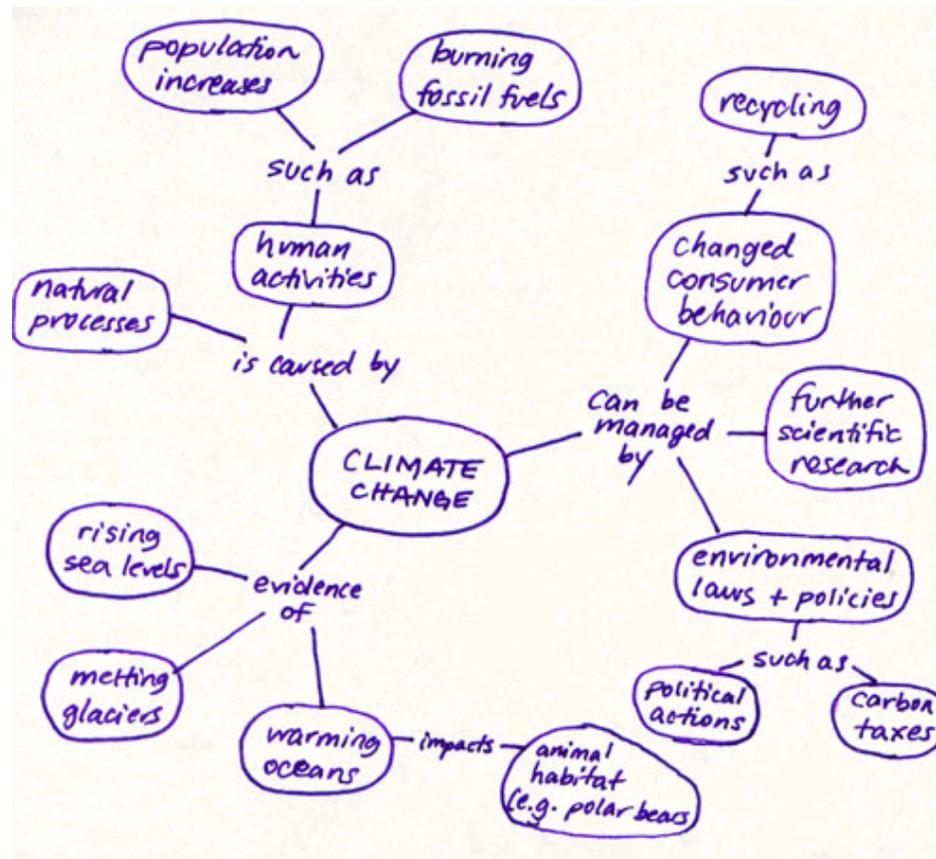
Shepardson, et. al., 2010



Green House Affect



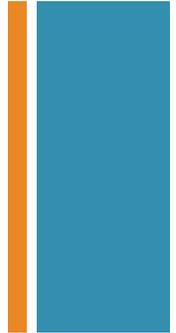
+ How does climate change impact polar bear habitat?



Example from U. of Victoria

+ Common Solar Misconceptions

- Look for the *subtleties* in the statements
- How would you address this misconception with your students
- What resources do you know of – that would help a student correct his/her concept



+ Strategies that lead to change

- Raise student metacognition
- Cause cognitive conflict
- Understand nature of science, quality of research
- Help student “self-repair” misconceptions
- Engage students in argumentation to strengthen new knowledge



+ Sources for target concepts

CLEAN
CLIMATE LITERACY & ENERGY AWARENESS NETWORK

CLEAN > Teaching Climate & Energy > Maps of Climate & Energy Concepts > Concept Map 4B-H4

Concept Map Centered on The Earth-4 (High 9-12)

Click on each box to view resources for teaching this benchmark as well as the National Science Education Standards that are aligned with the benchmark. This map helps you explore the connection between different learning objectives, which in turn link to CLEAN resources. (Benchmark 4B-H4)

Greenhouse gases in the atmosphere, such as carbon dioxide and water vapor, are transparent to much of the incoming sunlight but not to the infrared light from the warmed surface of the earth. When greenhouse gases increase, more thermal energy is

Thermal energy is transferred through a material by the collisions of atoms within the material. Over time, the thermal energy tends to spread out through a material and from one material to another if they are in contact. Thermal energy

Materials vary in how they respond to electric currents, magnetic forces, and visible light or other electromagnetic waves.

The atmosphere is a mixture of nitrogen, oxygen, and trace amounts of water vapor, carbon dioxide, and other gases.

Because the earth turns daily on an axis that is tilted relative to the plane of the earth's yearly orbit around the sun, sunlight falls more intensely on different parts of the earth during the year. The difference in intensity of sunlight and the

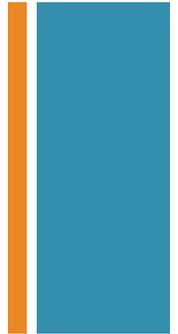
There are a great variety of electromagnetic radio waves, microwaves, infrared waves, light, ultraviolet, X-rays, and gamma rays. These wavelengths range from the longest, to gamma rays, to the shortest.

Navigation sidebar:

- Teaching Climate & Energy
- Principle 1
- Principle 2
- Principle 3
- Principle 4
- Principle 5
- Principle 6
- Principle 7
- Guiding Principle
- Energy Awareness
- Energy Awareness Quiz
- Maps of Climate & Energy Concepts
- Educational Resources
- Community
- About CLEAN

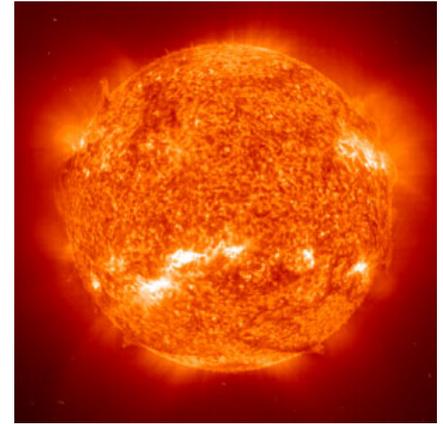
+ Conclusions

- As many misconceptions as stars in the sky
- But, we may become familiar with major themes
- Uncovering misconceptions is easy
- “Repairing” takes time and thought
- Being a positive, reliable source is important.



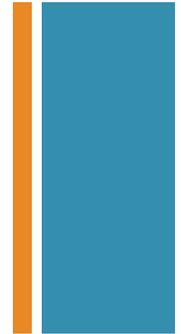
+ Resources

- CLEAN: Climate Literacy Essential Principle 1
<http://www.cleantech.org/clean/literacy/index.html>
- A list of common and uncommon about the sun
<http://pwg.gsfc.nasa.gov/istp/outreach/sunearthmiscons.html>
- Solar Matters II: Sun Misconceptions
www.fsec.ucf.edu/en/education/k.../SM2_sun-misconceptions.pdf
- *Common Student Alternative Conceptions*
<http://www.apa.org/education/k12/alternative-conceptions.aspx>
- Skeptical Science: Is the sun causing global warming?
<http://www.skepticalscience.com/solar-activity-sunspots-global-warming.htm>



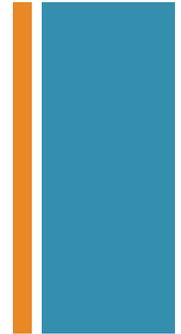
+ More advanced:

Check all the statements that are True about Greenhouse gases. (GHG)



- N₂ is a GHG
- Most GHG do not trap heat
- Methane is a GHG that does trap heat
- Water is a GHG
- CO₂ lags, not leads temperature rise

+ Misunderstanding variability

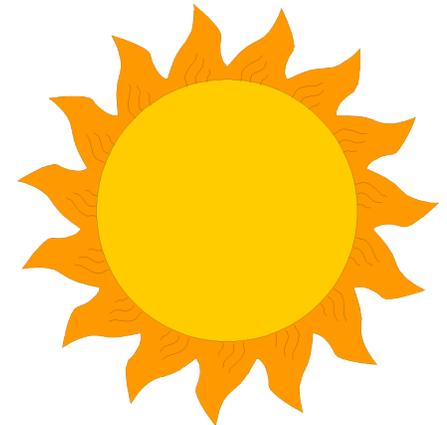


- Seasonal: The Equator is warmer because it is closer to the Sun
- Seasonal: Summer is warmer because the Earth is closer to the Sun.
- Weather is the same as climate-if we have a blizzard, so much for global warming
- Sea ice is recovering so climate change isn't happening



UV Lesson

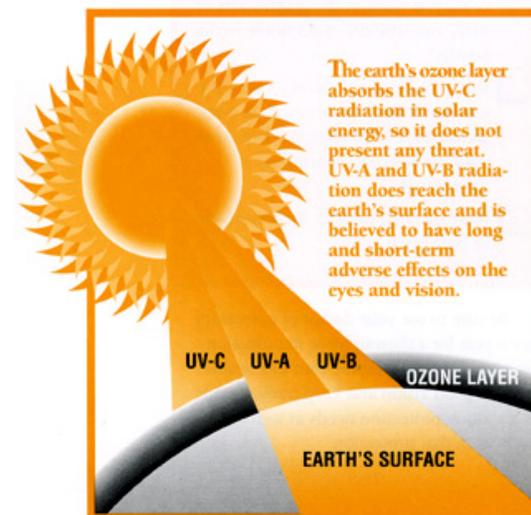
Exploring possible lessons and activities!



+ UV Lesson: Why study UV?

- Effect on humans –
positive: help regulate and synthesize Vitamin D within the body
negative: sunburn, premature aging, cancer, eye damage,
- Effect on animals –
negative: can harm phytoplankton in the oceans
- Effect on plants –
negative: decrease in production rates

Pedagogical Reasons:
Student Engagement
Concept Scaffolding



+ New FDA Sunscreen labeling

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FDA Sheds Light on Sunscreens

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En Español



Drug Facts	
Active Ingredients	Purpose
Avoberzone 3% Homosalate 10% Octyl methoxycinnamate 7.5%	Sunscreen
Uses	
<ul style="list-style-type: none"> • helps prevent sunburn • if used as directed with other sun protection measures (see Directions), decreases the risk of skin cancer and early skin aging caused by the sun 	
Warnings	
For external use only Do not use on damaged or broken skin. When using this product keep out of eyes. Rinse with water to remove. Stop use and ask a doctor if rash occurs. Keep out of reach of children. If product is swallowed, get medical help or contact a Poison Control Center right away.	
Directions	
<ul style="list-style-type: none"> • apply liberally 15 minutes before sun exposure • reapply: <ul style="list-style-type: none"> • after 40 minutes of swimming or sweating • immediately after towel drying • at least every 2 hours • Sun Protection Measures. Spending time in the sun increases your risk of skin cancer and early skin aging. To decrease this risk, regularly use a sunscreen with a broad spectrum SPF of 15 or higher and other sun protection measures including: <ul style="list-style-type: none"> • limit time in the sun, especially from 10 a.m. – 2 p.m. • wear long-sleeve shirts, pants, hats, and sunglasses • children under 6 months: Ask a doctor 	
Inactive ingredients	
aloe extract, butyl stearate, benzyl alcohol, carbomer, dimethicone, disodium EDTA, jojoba oil, methylparaben, octadecane/MA copolymer, polyglyceryl-3 distearate, phenethyl alcohol, propylparaben, sorbitan isostearate, sorbitol, stearic acid, tocophenol (vitamin E), triethanolamine, water	
Other information	
<ul style="list-style-type: none"> • protect this product from excessive heat and direct sun 	
Questions or comments?	
Call toll free 1-800-XXX-XXXX	

How Sunscreen Works



Not all sunscreens are created equal. Listen to the reasons why some work—and others don't.

Sunscreen: Stronger Rules, Better Protection

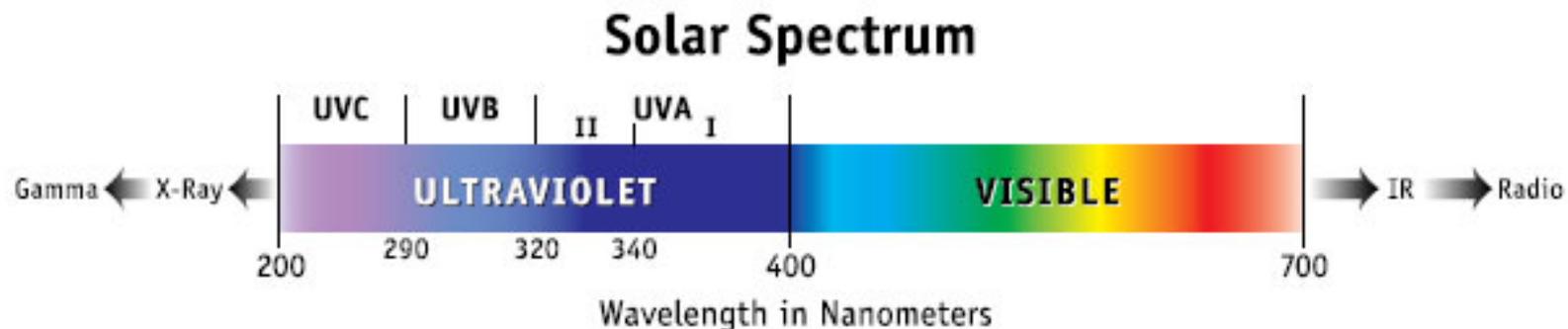


This video outlines the new steps FDA is taking to protect consumers from sun damage to the skin.

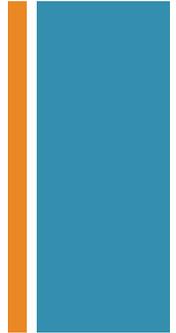
A sunscreen with broad spectrum UV protection and SPF 15 or higher is one skin-protecting tool. High-res versions of this graphic—and another on products with less protection—are available via [PDF](#) or [Flickr](#).

+ UV Radiation

- There are three types of UV radiation identified within the 100 to 400 nm range. They are:
- **UV A** - 330-400 NM - causes aging, wrinkling, and loss of elasticity of skin
- **UV B** - 290-330 NM - causes the greatest risk of skin cancer
- **UV C** - 100-290 NM - very destructive to tissues, however most is absorbed by the Earth's atmosphere before reaching ground level



+ UV Probe



Place a Check by all the true statements.

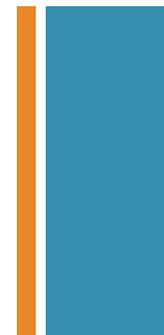
- A) The sun's rays are less intense at high altitudes.
- B) The thickness of the Ozone layer also plays its part in determining the UV strength at any given location.
- C) UV radiation is reflected or scattered to varying extents by different surfaces and is therefore less harmful than direct rays.
- D) In the USA, UV intensity is not very high in the northern states, only in the southern states.

KEY:

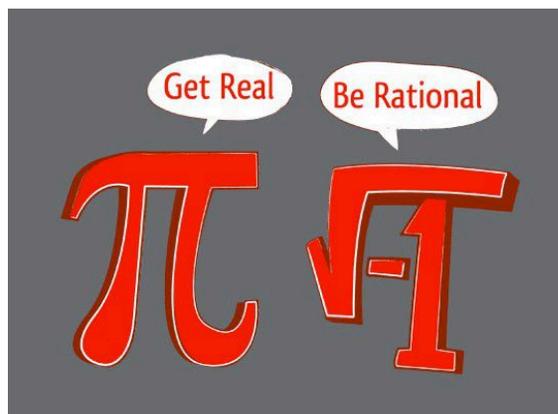
Sticky Note Graph

+ Lesson Expectations

- Test three materials with UV beads
- Explore the UV meters
- Consider how you might use this activity or modify it for your students
- Be open minded and creative
- Consider other questions to test



UV Color Changing Nail

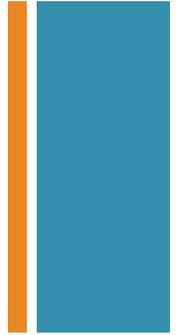


+ Predictions and Procedure

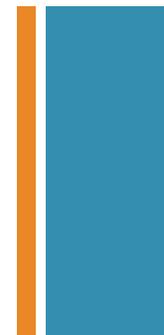
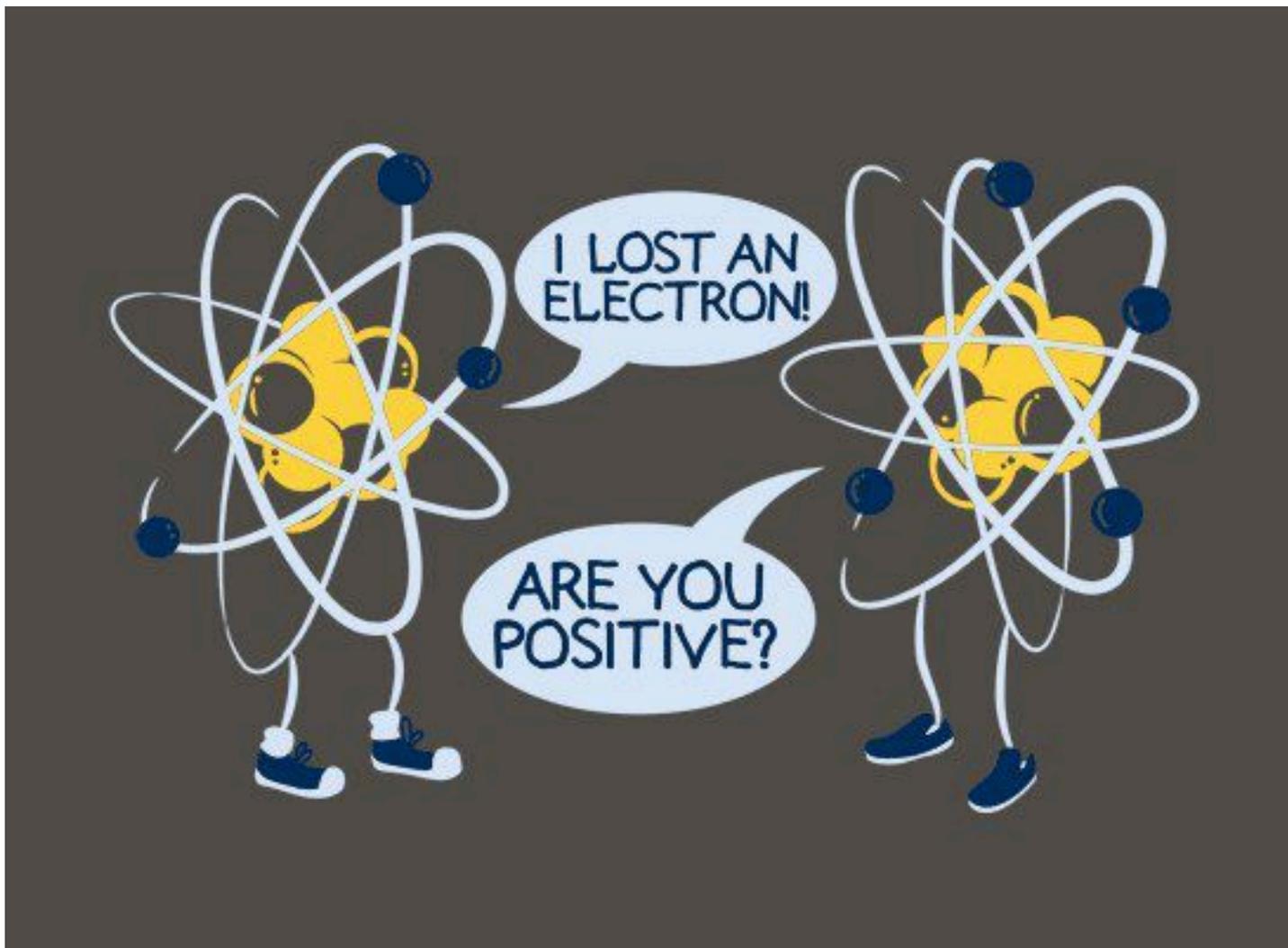
- What do you think will happen?



+ Reflection and Sharing



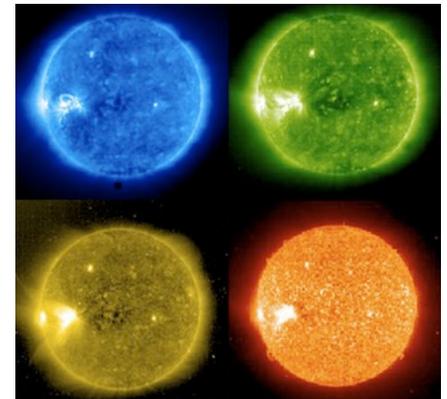
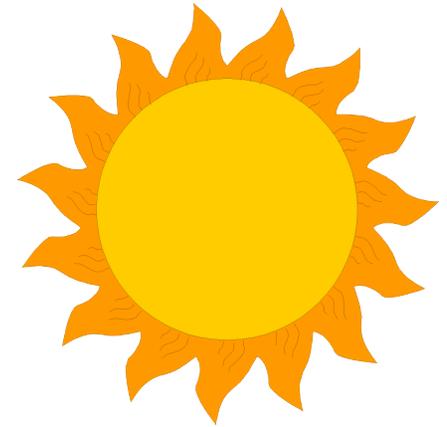
+ Extra!





The Solar Constant

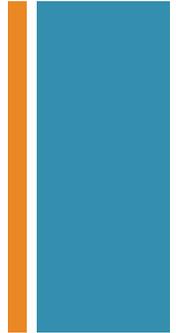
A Sun Earth Connection Lesson



+ What is the Solar Constant?

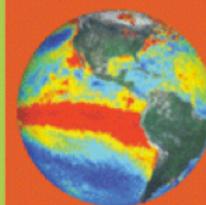
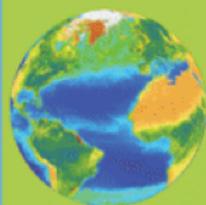
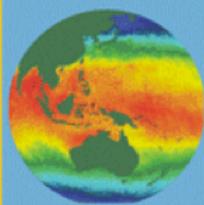
- The luminosity of the Sun is about 3.86×10^{26} watts. This is the total power radiated out into space by the Sun.
- Most of this radiation is in the visible and infrared part of the electromagnetic spectrum, with less than 1 % emitted in the radio, UV and X-ray spectral bands.
- The sun's energy is radiated uniformly in all directions.

Does the sun's out put ever change?



+ from the CLEAN collection

CLEAN



CLIMATE LITERACY & ENERGY AWARENESS NETWORK

Star Power!

<http://www.challenger.org/lessons/59.pdf>

NASA Discovery Program, Carnegie Institution of Washington and Johns Hopkins University Applied Physics Laboratory.



In this extensive activity students estimate the energy output of the Sun by doing a simple experiment and discover how much energy sunlight provides to Earth and the role of the Sun in the Earth System. Students also evaluate the power of sunlight closer to the Sun, at the distance of Mercury, since the activity was developed in support of the NASA Mercury Messenger program.

Activity takes two to three 45-minute lesson periods. Additional materials needed.

[Discuss this Resource»](#)

[Learn more about Teaching Climate Literacy and Energy Awareness»](#)

Notes From Our Reviewers

The CLEAN collection is hand-picked and rigorously reviewed for scientific accuracy and classroom effectiveness. Read what our review team had to say about this resource below or learn more about how

[CLEAN reviews teaching materials](#)

[Teaching Tips](#) | [Science](#) | [Pedagogy](#) | [Technical Details](#)

Teaching Tips

- Before introducing this activity, it is suggested to read the extensive background materials.
- While the guide states that this activity takes 2 hours, with the extensive equation-based investigations, this activity could take much longer and requires a knowledge of physics.
- Because there are many variables that would affect this experiment, try this experiment before using.

Topics

Global Energy Balance

See more on this topic.

Solar Radiation

See more on this topic.

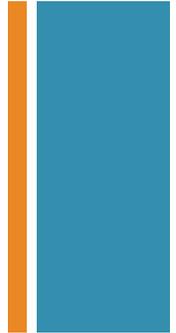
Grade Level

High School (9–12)

See more at this grade level.

+ Lesson Expectations

- Complete the activity procedure and calculations
- Brainstorm variations and lesson adaptations
- Understand why and when you might include this lesson in your curriculum



+ Calculate the solar constant

Calculate the solar constant for two cases: the values from your own group, and the class average.

Your group's $\Delta T/s =$
Average $\Delta T/s =$

The specific heat of a substance or object is defined as the amount of energy needed to raise the temperature of one kilogram of the substance one degree Celsius. The specific heat of water is $4186 \text{ J}/(\text{kg} \times ^\circ\text{C})$. Therefore the energy absorbed by your water per second is:

$\text{Energy}/s = 4186 \text{ J}/(\text{kg} \times ^\circ\text{C}) \times \text{water's mass}(\text{kg}) \times \Delta T (^\circ\text{C})/\text{sec}$
 $\text{Energy}/s = \text{J}/s$ (your group)
 $\text{Energy}/s = \text{J}/s$ (class average)

Energy collected per unit of surface area is:

$(\text{Energy}/s) / (\text{exposed surface area } (m^2)) = \text{J}/s/m^2$ (your group)
 $(\text{Energy}/s) / (\text{exposed surface area } (m^2)) = \text{J}/s/m^2$ (class average)

+ Calculate the solar constant

Multiply your uncorrected solar irradiation by 2 to correct for the glass (determined experimentally) and also by a factor (F_c) to correct for the atmosphere (to determine which factor you should use, look on the Condition Correction Table on Page 6):

$$\begin{aligned} \text{solar constant} &= \text{irradiation} \times 2 \times F_c \\ &= \text{J/s/m}^2 \text{ (your group)} \end{aligned}$$

$$= \text{J/s/m}^2 \text{ (class average)}$$

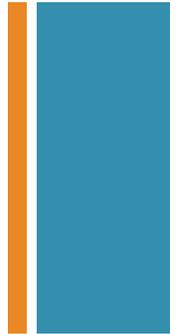
You have now calculated how much energy the Earth is receiving per second per square meter from the

Sun. This value is called the solar constant. The accepted value of the solar constant is about 1370 J/s/m².

Then your % error is:

$$(\text{your solar constant} - 1370) / 1370 \times 100$$

$$= \% \text{ (include the sign) (your group)} = \% \text{ (include the sign) (class average)}$$



+ **Take away ideas and understandings:**

