

CLEAN

CLIMATE LITERACY & ENERGY AWARENESS NETWORK

CLEAN & NGSS: Climate and Energy Resources Supporting Three Dimensional Learning

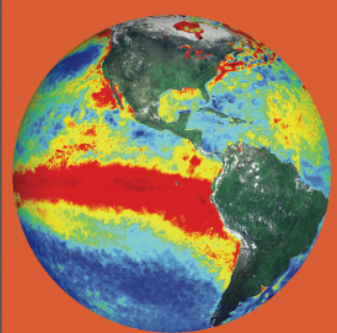
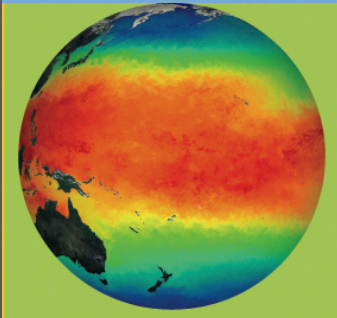
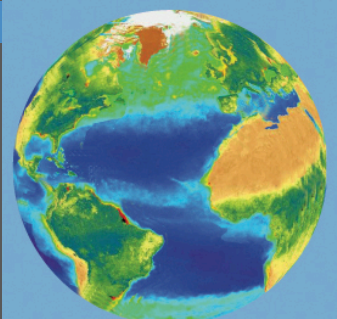
*Kathryn Boyd and Anne Gold
Geological Society of America Annual Meeting
September 24, 2019*

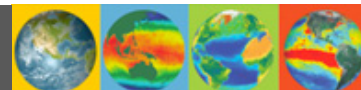
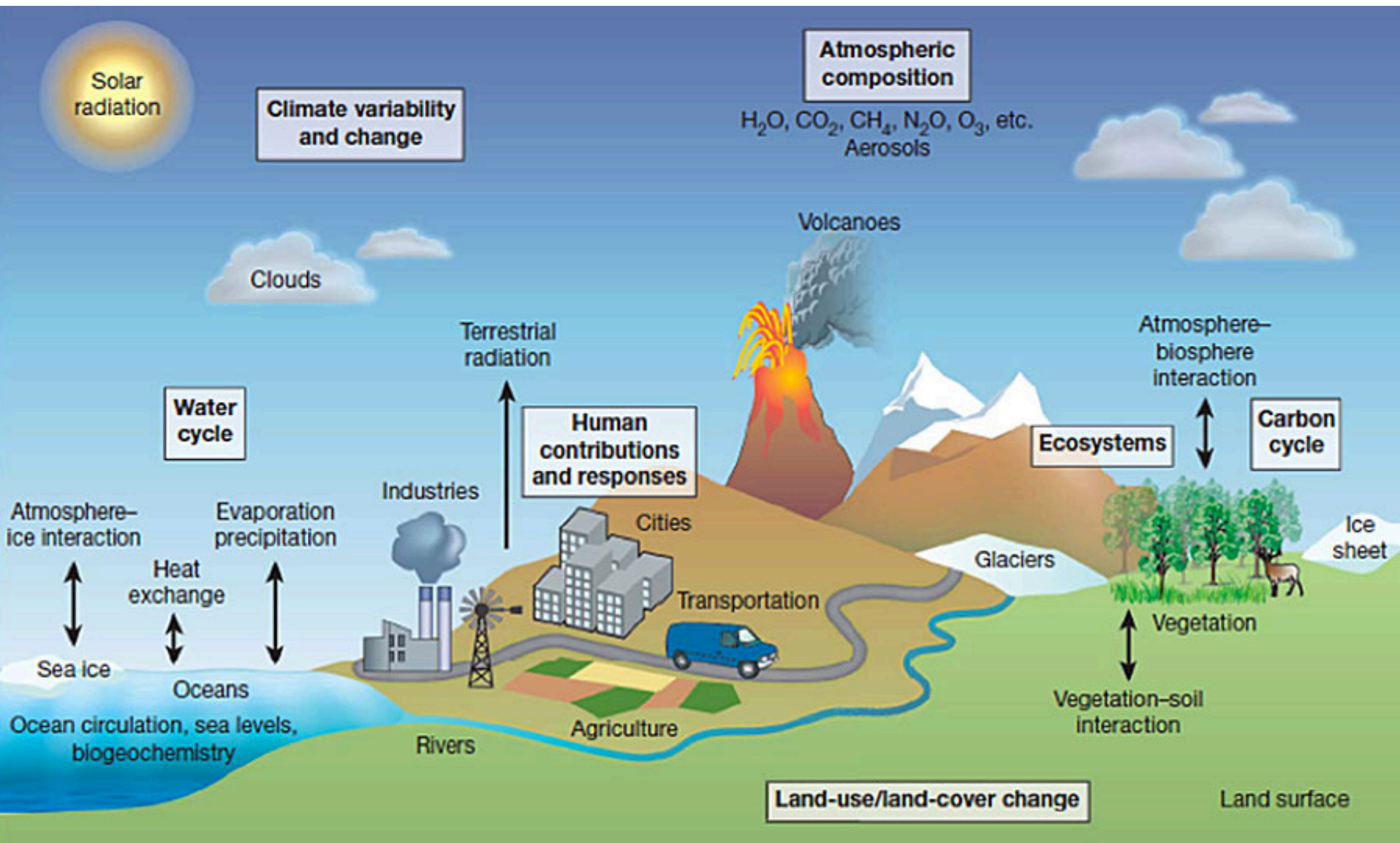


SERC the Science Education Resource Center at Carleton College

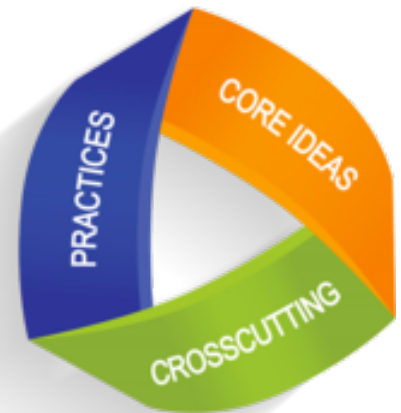
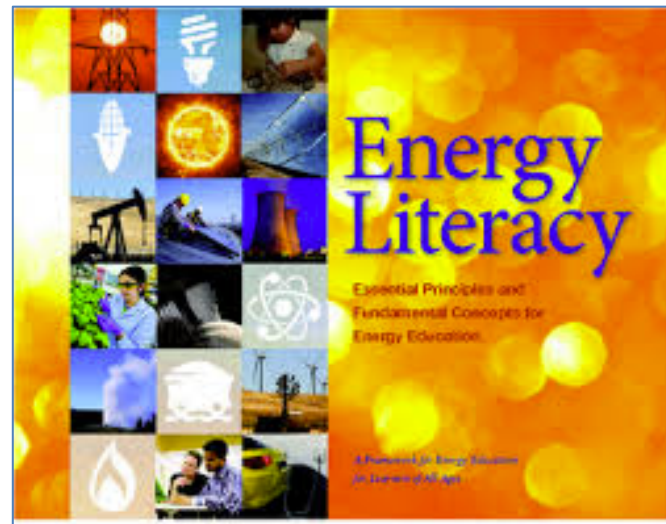


U.S. DEPARTMENT OF ENERGY

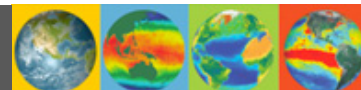




Frameworks for Teaching about Climate and Energy System



A perspective and approach for solving problems centered on the whole system, including system elements and their inter-relationships.



CLEAN Portal

CLEAN Collection

Guidance for Teaching
Climate and Energy

CLEAN Network



The screenshot shows the CLEAN Portal homepage. At the top, the logo reads "CLEAN CLIMATE LITERACY & ENERGY AWARENESS NETWORK" with four globe icons. Below the header, a large blue banner features the text "Collection of Climate and Energy Educational Resources" and "A collection of ~700 free, ready-to-use resources rigorously reviewed by educators and scientists. Suitable for secondary through higher education classrooms." Two buttons, "Search the Collection" and "Browse by NGSS", are present. To the right is a video player showing a classroom scene. On the left sidebar, a "News" section lists several items: "Register for one or more webinars in the CLEAN Webinar Series!", "Teachers, check out the create-your-own CLEAN-NGSS unit resources!", "CLEAN was awarded the 2017 Friend of the Planet award by the NCSE!", "The CLEAN Collection is now aligned with NGSS!", and "CLEAN STEM Flashes: View and sign up for this topical newsletter". Three arrows originate from the left: a blue arrow from "CLEAN Collection" points to the main banner; a green arrow from "Guidance for Teaching Climate and Energy" points to the "Guidance in Teaching Climate and Energy Science" box; and an orange arrow from "CLEAN Network" points to the "CLEAN Network" box.

Collection of Climate and Energy Educational Resources
A collection of ~700 free, ready-to-use resources rigorously reviewed by educators and scientists.
Suitable for secondary through higher education classrooms.

Search the Collection » Browse by NGSS »

Guidance in Teaching Climate and Energy Science
Background information, pedagogic approaches, links to relevant educational resources in the CLEAN collection.

CLEAN Network
A community of professionals committed to improving climate and energy literacy.

News

- Register for one or more webinars in the [CLEAN Webinar Series!](#)
- Teachers, check out the create-your-own [CLEAN-NGSS unit resources!](#)
- CLEAN was awarded the [2017 Friend of the Planet award](#) by the NCSE!
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About the CLEAN Project

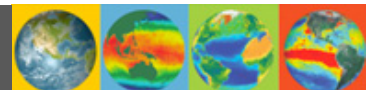
CLEAN Review Process



<http://cleanet.org>

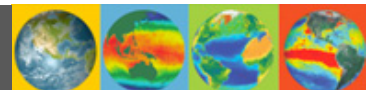
<https://www.climate.gov/teaching>

cleanet.org



CLEAN Collection

- 700+ online, free resources
- Activities, videos, visualizations
- Classroom ready
- Community & Expert scientist reviewed, Curated
- Aligned with NGSS, Literacy Frameworks
- Grades 6-16
- Pointer collection – resources developed by others



Google

All Images Videos News Shopping More Settings Tools

About 1,510,000 results (0.60 seconds)

Greenhouse Effect Teaching Box | UCAR Center for Science Education
<https://scied.ucar.edu/teaching-box/greenhouse-effect> ▼
 Click the "Remove CO₂" button a bunch of times to remove most or all of the carbon dioxide from the atmosphere. Observe the effect on temperature. Use the "Follow energy packet" and "Follow CO₂" buttons to focus in on individual photons and gas molecules to better understand their behaviors.

Greenhouse Effect Lab - SERC-Carleton - Carleton College
<https://serc.carleton.edu/teachearth/activities/50193.html> ▼
 In this lab, students measure temperature changes inside soda bottles (one with CO₂ added, the other with only air inside) as incandescent light is shined on them to model the Greenhouse Effect.

3. Greenhouse Gases and Energy Balance | Climate Change ...
<https://pangea.stanford.edu/programs/.../3-greenhouse-gases-and-energy-balance> ▼
 High School Version 2011. Students will be able to identify greenhouse gases and their sources and apply the properties of these gases and radiative forcing to model Earth's energy budget. Lesson Guide. 3.1.2 Quiz LP1 & LP2 3.1.3 Greenhouse Gases Slides 3.1.4 Student Notes Handout (for use during slides and ...

[PDF] Lab: Greenhouse Gas Simulation
<https://www.acs.org/content/dam/AACT/middle-school/gases/.../lab-greenhousegas.pdf> ▼
 an increased presence of carbon dioxide gas in order to analyze how this effects temperature. They will also complete research in order to learn more about the makeup of the Earth's atmosphere. Grade Level. Middle or High School. Objectives. By the end of this lab, students should be able to. • Identify the types and ...

[PDF] Modeling the Greenhouse Effect
<https://www.esrl.noaa.gov/.../lesson.../Modeling%20the%20Greenhouse%20Effect.pdf> ▼
 Students should begin measuring and recording the temperature in each bottle every minute for 15 minutes. ... • Students should record their measurements in the Data Table. . At the end of the investigation, students should complete the activities in the. Collecting and Analyzing Data and the Drawing Conclusions sections.

Observe the Greenhouse Effect in a Jar | Activity | Education.com
<https://www.education.com> > ... > Observe the Greenhouse Effect in a Jar ▼
 This simple experiment serves as an introduction to the greenhouse effect.

Go to dev page Full Editor Account

CLEAN CLIMATE LITERACY & ENERGY AWARENESS NETWORK

Educational Resources

Collection of Climate and Energy Educational Resources

The CLEAN Collection is a hand-picked and rigorously reviewed collection of educational resources aligned with the [Climate Literacy](#) and the [Energy Literacy](#) frameworks, and the Next Generation Science Standards.

The review process engages scientists and educators in vetting each resource for scientific accuracy, pedagogic effectiveness and useability.

Explore the Collection

[Help](#)

Current Search Limits: **Text Search** Greenhouse effect **Resource Type** Activity **Grade Level** Middle (6-8)

Results 1 - 10 of 57 matches

Automotive Emissions and the Greenhouse Effect
<https://www.teachmeanthepoint.org/wp-content/uploads/2015/04/A...>
 This is a laboratory activity in which students will compare the amount of carbon dioxide in four different sources of gas and determine the carbon dioxide contribution from automobiles. They test ... [Reviewed Collection](#)

Heating it Up: The Chemistry of the Greenhouse Effect
<http://www.explainingclimatechange.org/Climate%20Change/L...>
 This lesson explores the chemistry of some of the greenhouse gases that affect Earth's climate. Third in a series of 9 lessons from an online module entitled 'Visualizing and Understanding ... [Reviewed Collection](#)

Investigating Climate Change at a Macroscopic and Microscopic Level
<http://phet.colorado.edu/en/contributions/view/4038>
 This activity uses two interactive simulations to illustrate climate change, 1) at the micro/molecular level - modeling the impact of increasing concentrations of greenhouse gases in the atmosphere ... [Reviewed Collection](#)

Why Do Some Molecules Absorb Infrared Energy?
<http://www.globalsystemscience.org/studentbooks/cc/ch2...>
 In this short, hands-on activity, students build simple molecular models of 4 atmospheric gases (O₂, N₂, CO₂, and methane), compare their resonant frequencies, and make the connection between ... [Reviewed Collection](#)

Air: Fuel for Thought
http://www.pbs.org/pov/borders/2004/educators/edu_air1.html
 This lesson plan engages students in a real-life exploration of climate change as it is affected by greenhouse emissions from vehicles. The aim of this activity is for students to realize the impact ... [Reviewed Collection](#)

The Findings From Mauna Loa
<http://www.globalsystemscience.org/studentbooks/cc/ch6/>
 This activity involves plotting and comparing monthly data on atmospheric CO₂ concentrations over two years, as recorded in Mauna Loa and the South Pole, and postulating reasons for differences in ...

Refine the Results

Resource Type [Show all](#)

Activity [57 matches](#)

Grade Level [Show all](#)

Middle (6-8) [56 matches](#) General/Other Middle - 7 [1 match](#) Middle - 8 [1 match](#)

NGSS Performance Expectations

Middle School [33 matches](#) **High School** [30 matches](#)

NGSS Disciplinary Core Ideas

Middle School [50 matches](#) **High School** [42 matches](#)

NGSS Cross-Cutting Concepts

Middle School [54 matches](#) **High School** [42 matches](#)

NGSS Science and Engineering Practices

Middle School [56 matches](#) **High School** [43 matches](#)

Regional Focus

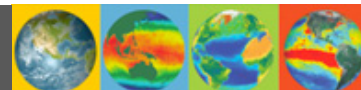
Islands, Oceans (Global) [3 matches](#) **No Regional Focus** [28 matches](#) **North America** [6 matches](#) **Polar Regions** [2 matches](#)

Dataset Use

Students Use Scientific Dataset [15 matches](#)

Other Categories

Climate and Energy Topics [add this category](#)



http://www.damocles-eu.org/education/Animation_about_the_greenhouse_effect_182.shtml

[Jump to this Animation »](#)



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



High School: 2 Disciplinary Core Ideas, 1 Cross Cutting Concept

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](#)

- Educators will need to scaffold this animation to ensure that the information presented is well understood by learners.
- When teaching about the greenhouse effect, using the term "heat," as this animation does, may confuse students, especially if they think of heat as a verb. The more accurate technical term "outgoing long wave IR radiation" may prove more difficult to convey, but ultimately is a clearer depiction of Earth's energy balance.

- The animation is an accurate general overview of Earth's energy balance, but educators should recognize some of the sun/Earth dynamics have been oversimplified.
- For example, the atmosphere does filter out some short wave energy from the sun, such as extreme ultraviolet and X-rays.
- In general, the animation provides a good overview of the incoming shortwave radiation from the sun, and Earth radiating long wave Infrared Radiation (IR) once it has been warmed by the short wave visible and IR.

Greenhouse Effect
See more on this topic.

Carbon Cycle
See more on this topic.

Middle (6–8)
See more at this grade level.

High School (9–12)
See more at this grade level.

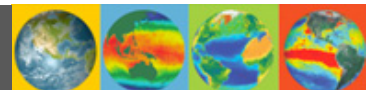
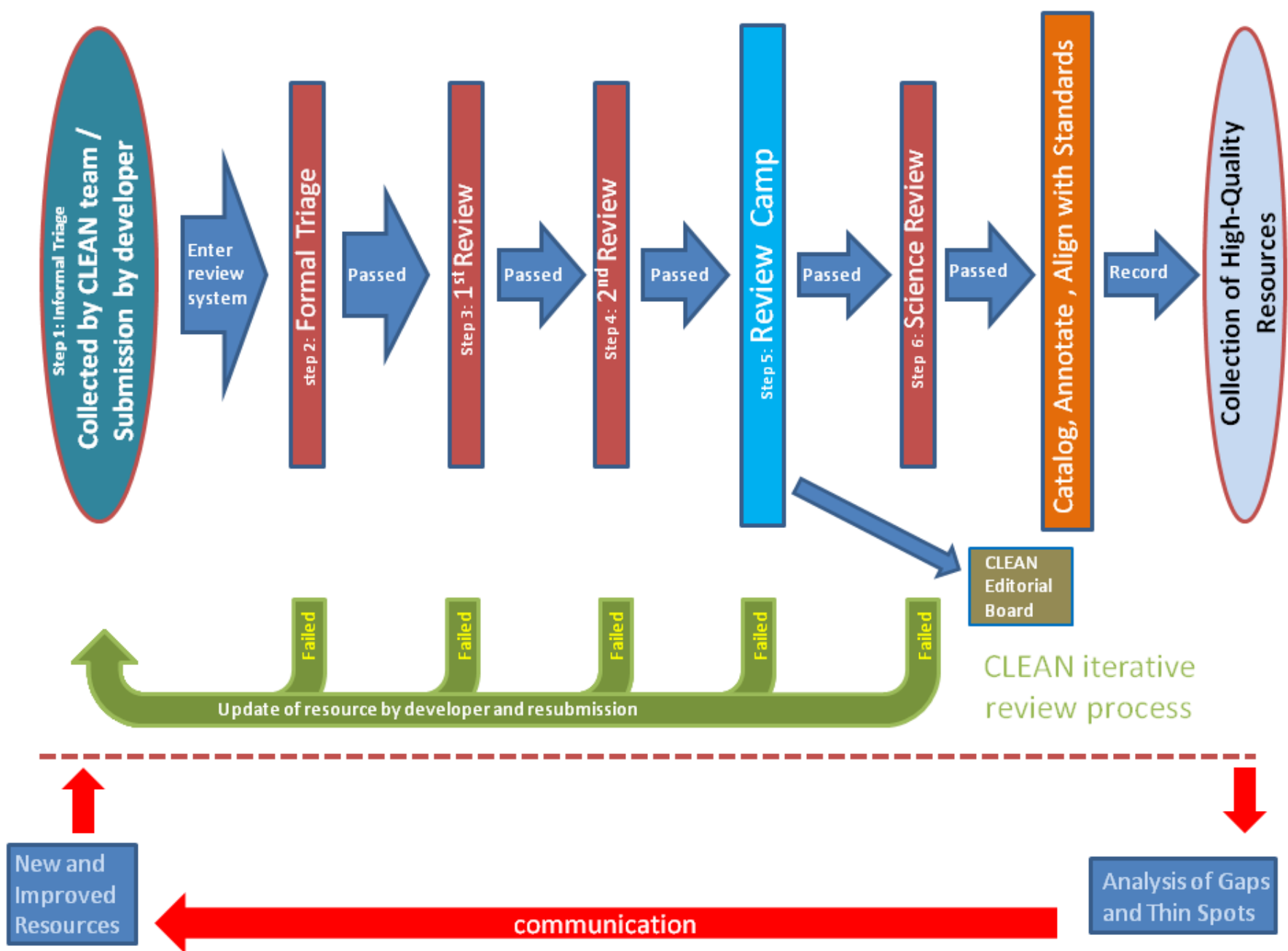
College Lower (13–14)
See more at this grade level.

Informal
See more at this grade level.

About Teaching Climate Literacy

- 2c (see details)

► 2d (see details)
About Teaching Principle 2



Search the Collection

- Resource Type
- Grade Level
- Next Generation Science Standards (NGSS)
- Regional Focus / Dataset Use
- Climate & Energy Topics / Principles, etc.

Refine the Results ↓

Resource Type

Activity [101 matches](#)
Short Demonstration/Experiment [5 matches](#)
Teaching Guidance [10 matches](#)
Video [49 matches](#)
Visualization [67 matches](#)

Grade Level

Intermediate (3–5) [6 matches](#)
Middle (6–8) [151 matches](#)
High School (9–12) [197 matches](#)
College Lower (13–14) [130 matches](#)
College Upper (15–16) [56 matches](#)
Graduate/Professional [10 matches](#)
Informal [30 matches](#)
General Public [1 match](#)

NGSS Performance Expectations

Middle School [37 matches](#)
High School [78 matches](#)

NGSS Disciplinary Core Ideas

Middle School [146 matches](#)
High School [199 matches](#)

NGSS Cross-Cutting Concepts

Middle School [114 matches](#)
High School [157 matches](#)

NGSS Science and Engineering Practices

Middle School [89 matches](#)
High School [130 matches](#)

Regional Focus

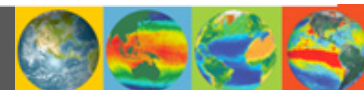
Africa [1 match](#)
Asia [1 match](#)
Europe [1 match](#)
Islands, Oceans (Global) [10 matches](#)
No Regional Focus [93 matches](#)
North America [27 matches](#)
Polar Regions [11 matches](#)
South and Central America [1 match](#)

Dataset Use

Students Use Scientific Dataset [53 matches](#)

Other Categories

[Climate and Energy Topics](#) (add this category)
[Energy Literacy Principles](#) (add this category)
[Environmental Education Guidelines](#) (add this category)
[Climate Systems and Solutions](#) (add this category)



CLEAN Portal

Guidance for Teaching Climate and Energy

The screenshot displays the CLEAN Portal homepage. At the top, the logo reads "CLEAN CLIMATE LITERACY & ENERGY AWARENESS NETWORK" with four globe icons. The main banner features a wind turbine background and the text: "Collection of Climate and Energy Educational Resources. A collection of ~700 free, ready-to-use resources rigorously reviewed by educators and scientists. Suitable for secondary through higher education classrooms." Below this are buttons for "Search the Collection" and "Browse by NGSS". On the right, a video thumbnail shows students in a classroom. A green arrow points from the "Guidance for Teaching Climate and Energy" text to the "Guidance in Teaching Climate and Energy Science" section. The left sidebar contains a "News" section with updates on webinars, unit resources, awards, and alignment with NGSS, along with a "CLEAN STEM Flashes" newsletter sign-up. The bottom right features links for "About the CLEAN Project" and "CLEAN Review Process".

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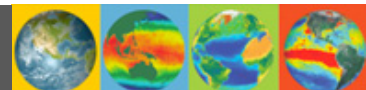
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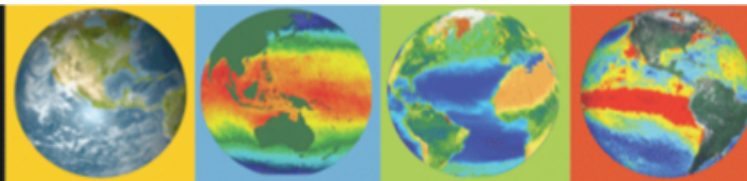
News
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Teachers, check out the create-your-own [CLEAN-NGSS unit resources!](#)
CLEAN was awarded the [2017 Friend of the Planet award](#) by the NCSE!
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CLEAN STEM Flashes: View and sign up for this topical newsletter »

About the CLEAN Project CLEAN Review Process



<http://cleanet.org>
<https://www.climate.gov/teaching>



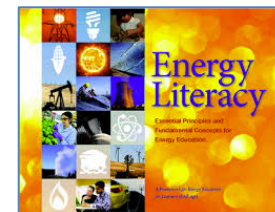


Guidance in Teaching Climate and Energy

Climate and energy are complex topics, with rapidly developing science and technology and the potential for controversy.

See the following pages for:

- a summary of each of the climate and energy science principles and concepts
- possible challenges for educators
- suggested pedagogic approaches to teaching these topics, for each grade level
- relevant teaching materials from the CLEAN reviewed collection



Teaching Climate

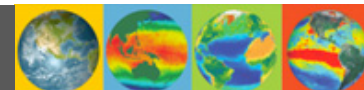
One of CLEAN's goals is to help teachers be as effective as possible when teaching climate science. This series of web pages introduces climate science in a sequence that illustrates different aspects of the climate system.



Teaching Energy

Energy Literacy is an understanding of the nature and role of energy in the universe and in our lives and the ability to apply this understanding to answer questions and solve problems. Explore the Energy Literacy Framework along with scaffolding for teaching the energy science.

[Next Page »](#)



CLEAN Portal

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Guidance in Teaching Climate and Energy Science
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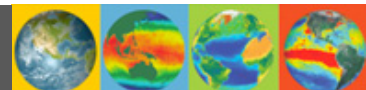
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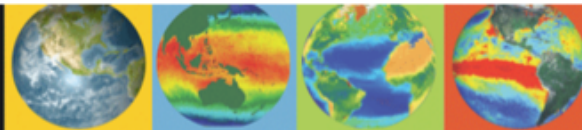
About the CLEAN Project

CLEAN Review Process

CLEAN Network



CLEAN



CLIMATE LITERACY & ENERGY AWARENESS NETWORK



CLEAN Network

The CLEAN Network is a professionally diverse community of over 570 members committed to improving climate and energy literacy locally, regionally, nationally, and globally, to enable responsible decisions and actions. The CLEAN Network has been a dynamic group since 2008 and is now led by the [CLEAN Leadership Board](#) established in 2016.

[Join the CLEAN Network »](#)

[Email list archive »](#)

Tuesdays at 1pm Eastern time CLEAN Network members meet in a teleconference to collaborate and share information about their literacy work, upcoming events, opportunities for collaboration or funding. Frequently guest speakers present on the topic of climate and energy literacy.

[Recent and upcoming telecon topics and speakers »](#)



[Educators](#)

Search or browse the Collection of Climate and Energy Educational Resources and learn more about teaching climate and energy science.

[CLEAN Collection »](#)



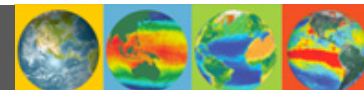
[Resource Developers](#)

See the multiple ways in which developers can participate in strengthening the collection of educational resources.

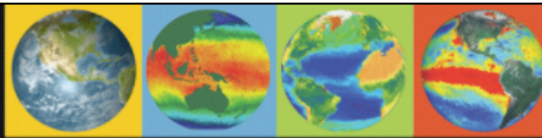


[Partners](#)

Learn about the variety of organizations that partner with CLEAN.



CLEAN



CLIMATE LITERACY & ENERGY AWARENESS NETWORK

Share f t e m Like 70

Collection of Climate and Energy Educational Resources

A collection of 650+ free, ready-to-use resources rigorously reviewed by educators and scientists.

Suitable for secondary through higher education classrooms.

[Search the Collection »](#)

[Browse by NGSS »](#)



CLEAN

Collection of Educational Resources

Guidance in Teaching Climate and Energy

CLEAN Network

About CLEAN

News



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NGSS! The CLEAN Collection is now aligned with NGSS!

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Guidance in Teaching Climate and Energy Science

Background information, pedagogic approaches, links to relevant educational resources in the CLEAN collection.

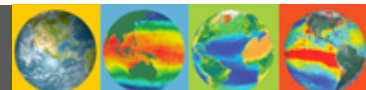


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About the CLEAN Project

CLEAN Review Process



Three Ways to Search CLEAN for NGSS

1. NGSS and CLEAN At-a-Glance Tables

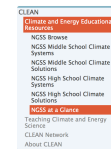
- Search by specific standards related to climate & energy

2. Browse by NGSS

- Allows you to consider where in the NGSS are climate & energy addressed and then search the collection using this knowledge

3. Search the entire Collection

- Use larger search feature and NGSS tags to narrow search
- Allows one to search NGSS related to specific topic

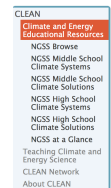


NGSS and CLEAN at a Glance

Clicking the blue text below will display tables with the NGSS Performance Expectations (PE) and Disciplinary Core Ideas (DCI) that address climate and energy topics. The table includes links to relevant CLEAN resources. Hovering on the green DCI concept bullet will display the full text.

| Middle School | | |
|---|--|--|
| <ul style="list-style-type: none"> Show Middle School - Life Science in CLEAN Show Middle School - Physical Science in CLEAN Show Middle School - Earth and Space Science in CLEAN Show Middle School - Engineering, Technology, and Applications of Science in CLEAN | | |
| High School | | |
| <ul style="list-style-type: none"> Show High School - Life Science in CLEAN Show High School - Physical Science in CLEAN Show High School - Earth and Space Science in CLEAN | | |
| High School - Engineering, Technology, and Applications of Science in CLEAN | | |
| Performance Expectation (PE) | Disciplinary Core Idea (DCI) | DCI Concept Bullet |
| HS-ETS1: Engineering Design (see CLEAN Resource) | HS-ETS1.A: Defining and Delimiting Engineering Problems (see CLEAN Resource) | HS-ETS1.A: Criteria and constraints also include... (see CLEAN Resource) |
| | HS-ETS1.B: Developing Possible Solutions (see CLEAN Resource) | HS-ETS1.B: When evaluating solutions... (see CLEAN Resource) |
| | HS-ETS1.C: Optimizing the Design Solution (see CLEAN Resource) | HS-ETS1.C: Criteria may need to be... (see CLEAN Resource) |

Note: Limited to standards that are relevant to climate and energy science.



Collection of Climate and Energy Educational Resources

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Explore the Collection

Ocean Acidification search

Current Search Limits: [Text Search](#) Ocean Acidification

Results 1 - 10 of 42 matches

Ocean Acidification
This simulation allows students to explore the change in sea surface pH levels with increasing CO2 levels.

What Is Ocean Acidification?
This static image from NOAA's Pacific Marine Environmental Laboratory Carbon Program offers a visually compelling and scientifically sound image of the seawater carbonate chemistry process that...

Graphing Ocean Acidification
This is a static image from NOAA's Pacific Marine Environmental Laboratory Carbon Program that allows user to plot change in atmospheric CO2 against ocean pH, from 1982 to 2009, in the central North Pacific.

Changing Planet: Ocean Acidification

Refine the Results

Resource Type
Activity 14 matches
Short Demonstration/Experiment 2 matches
Teaching Guidance 2 matches
Video 18 matches
Visualization 8 matches

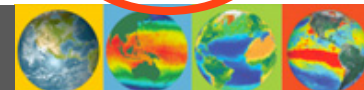
Grade Level
Middle 66-80 matches
High School 9-12 38 matches
College Lower (13-14) 18 matches
College Upper (15-16) 2 matches
Graduate/Professional 1 match
Informal 4

NGSS Performance Expectations
Middle School 6 matches
High School 10 matches

NGSS Disciplinary Core Ideas
Middle School 28 matches
High School 36 matches

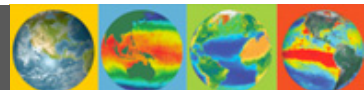
NGSS Cross-Cutting Concepts
Middle School 14 matches
High School 21 matches

NGSS Science and Engineering Practices



CLEAN & NGSS-3D Instruction

- NGSS and 3 dimensional instruction might seem a bit daunting
- Teaching climate science and energy solutions might be a bit challenging
- CLEAN makes teaching NGSS & 3 dimensional style climate and energy science and engineering easier
- We have webinars on how to develop your own 3-dimensional learning units with CLEAN resources



CLEAN Get Started Guide Homepage

Create Your Own CLEAN-NGSS Unit Overview

How to Get Started

Phenology Unit

History of Oceans and Atmosphere Unit

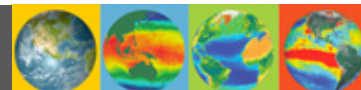
Debating the Grid Unit

1. Get Started guide, resources, and [video](#) to create climate & energy units
2. Three ready-to-use unit exemplars

Using CLEAN to Build NGSS Units



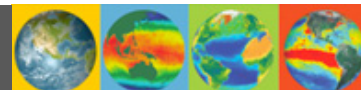
To access the *Get Started Guide*: Click the “CLEAN-NGSS unit resources” tab in the left sidebar of the CLEAN homepage



Unit Exemplars

Classroom-ready units are available to download and use:

Explore Examples of CLEAN-NGSS Units



Become involved!

- Use CLEAN resources & teaching guidance
- Sign up for CLEAN STEM Flash
- Watch the CLEAN webinars
- Submit a resource to CLEAN
- Join CLEAN Network

cleanet.org

CLEAN STEM Flash Wildfires and Climate Change

First in a series of timely climate & energy e-blasts to use and share. Sign-up [here](#) to be sure you're on the list. Browse the [CLEAN Collection](#) for NGSS-aligned resources.

CLEAN supports teaching and learning about climate and energy with 600+ free peer-reviewed, scientifically accurate, and classroom-ready resources.

CLEAN Resource Spotlight:

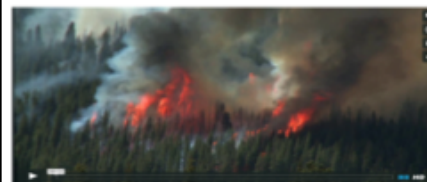
Wildfires Out West video

Watch this video for a quick overview about the causes and effects of wildfires.

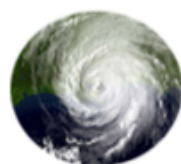
Audience: Middle and high school classes

Video length: 3:13 min

Find more resources on [wildfires](#) in the CLEAN Collection.



This video from Climate Central looks at the way climate conditions can affect vegetation in the West and what influence this has on wildfires.



Hurricanes

Howling Hurricanes! V



Wildfires

Wildfires and the C



Drought and Crops

Crop Challenges in a Changi



Stronger Storms

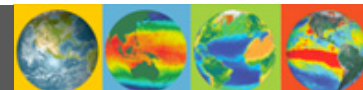
Climate Change and Stronger storms.



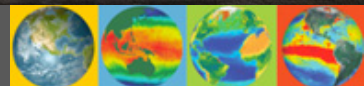
Arctic Change

Sea Change for Arctic Ice and Polar arctic ice and ecosystems.

CLEAN STEM Flashes:
View and sign up for this topical newsletter »



Questions?



Thank you!

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