BUILDING CLIMATE UNDERSTANDING: TOOLS AND STRATEGIES
WEB TOOLS
Paleoclimate Data
Climate is the long-term prevailing pattern of temperature and other weather variables at a given location, described in terms of means and extremes. The climate includes atmosphere and oceans, and it is often described in terms of frequency, duration of severe and non-severe weather. Earth's history indicates that climate change has been both gradual and abrupt, and that extreme and extensive glaciation at high latitudes and drought at one extreme and more extended glaciation at the other. NASA data show that Earth's global surface temperature has increased by about 1.4°F (0.8°C) over the past century. Understanding the effect of a changing climate is important and is affected. The consequences under this theme are developed to improve access to scientific information, which can inform actions that influence a climate.

Changing Seasons

This collection provides educational resources that can help students learn about the impacts of the seasons. The majority of the resources are related to energy by the annual seasonal cycle. These resources include those that are related to climate impacts on ecosystems and organisms.

Quick Links

- For Seal Migration Video
- The Mystery of the Missing Humpback Whales
- Sea-Watch: Measuring Life (L, M, H)
- Seasonal Changes: Green-Up and Glow-Down (L, M, H)
- Seasonal Changes: Snow-Melt (L, M, H)
- For Sea Ice Data

Background Information

- Why Do We Have Seasons?
- The Annual Cycle

Resources

- Multimedia
- Lessons and Activities
- Real World Data
- For Background Information

You may adapt your wardrobe and activities to the seasons, grabbing a heavy coat and skiis in winter or instead, a swimsuit and snorkel in summer. However, ecosystems, plants, and animals cannot adjust their wardrobe quite so easily but they do make changes that help them survive seasonal conditions caused by the annual dance of the sun and Earth.

Birds migrate from the North Atlantic to the southern tip of South America. Whales and other marine mammals travel thousands of miles across the ocean. Seasonal changes in precipitation and temperature affect soil moisture, evaporation rates, river flows, lake levels, and snow cover. Leaves fall and plants wither as cold and dry seasons approach. These changes in evapotranspiration affect the type and amount of food available to humans and other organisms. Only with the recent advent of rapid transportation are fruits and vegetables available in grocery stores during the winter in cold regions. Animals do not stop where gardens are, for example, instead of being stored, they must follow alternative food sources, move to warmer locations, or hibernate.

It may be surprising that all these changes are the result of the Earth's $90^\circ$ tilt around the sun.

As we go about our daily activities, it is not obvious that the Earth is tilted 23.5 degrees on its axis and that we orbit the sun. Nevertheless, these factors result in changes to the distribution of the sun's energy across the surface of the Earth causing the seasons. As the Earth tilts, the sun's rays strike the northern hemisphere for 186 days, the winter months, and the southern hemisphere for 186 days, the summer months, and the Earth is pointing in the same direction into space with...
Teaching Climate Literacy and Energy Awareness

How do we develop climate literacy and energy awareness in our students? A set of essential principles frame the key science and teaching strategies. Learn more about these principles and how they can inform your teaching.

Browse the Reviewed Educational Resources

This hand-picked collection of teaching activities includes materials for middle and high school students as well as undergraduate classrooms. Learn more about the materials that are both scientifically sound and pedagogically effective.

Join the CLEAN Community

Meet your colleagues, join discussions, comment on educational resources, become a CLEAN reviewer, join the CLEAN announcement email list, or join the active Climate Literacy Network.

Feature Signs of Studying

In this hand-picked collection of teaching activities, teachers can find lessons on climate literacy and energy awareness. Learn more about the materials that are both scientifically sound and pedagogically effective.

CLEAN Teaching Climate & Energy

Educational Resources

CLEAN Climate Literacy & Energy Awareness Network

Notes From Our Reviewers

In this activity, students examine pictures of pollen grains representing several species that show the structural differences that scientists use for identification. Students analyze model soil samples with material mixed in to represent pollen grains. They determine the type and amount of pollen in the samples and, using information provided to them, determine the type of vegetation and age of their samples. Finally, they make some conclusions about the likely climate at the time the pollen was shed.

Activity takes one to two 45-minute class periods. Materials that are needed are tweezers, pie pans, cornstarch/paper dots and soil.

Teaching Tips

- Questions like “Why does climate change over time?” need to be addressed after stimulating the students with this activity.
- Educators should show an image of a real soil core so students can differentiate between the model and reality.
- Educators should note that all soil layers do not have unique pollen, and that pollen is not often well preserved in sediments.
- Educators need to be explicit about what is modeled and what is real. E.g., petting soil is very different than a real soil sample from a lake from a certain period.
- Educators should include a discussion on the difficulty of deciding on boundaries between sedimentation layers and touch on dating techniques of these layers. In the activity, dates are given but no explanation is provided.
- Keys to types of pollen and climate are found in tables and student answer sheets.
Coming Soon: Interactive Earth
http://csc.noaa.gov/psc/dataviewer

This dataset shows the intricate topography and bathymetry of the Earth. The Himalayas in Asia, are home to Mount Everest, the tallest point on Earth at 29,035 feet. The longest mountain range in the world, the global mid-oceanic ridge system, can be found on the ocean floors and runs for approximately 37,000 miles.

Please select a data set from the HAZARDS, OCEANS, and CLIMATE icons above. Manipulate the globe by clicking and dragging it. Click on the tabs (Narrative, More Info, FAQ, References, and Standards) for additional information and resources.

Look/play with the globe to see if you can answer the question posed in the Narrative section.
This is an animation of the daily distribution of carbon dioxide (CO2) in the atmosphere in 2004. The colors represent different CO2 concentrations. The black and white dots show where NOAA Earth Systems Research Lab and its collaborators collect samples of air, to analyze the contents for CO2 and other gases.

CO2 tracking equipment can distinguish between changes in the natural carbon cycle and those occurring in human-produced fossil fuel emissions. This accurate information helps NOAA scientists project future climate change.

Where are there major sources of carbon dioxide? How does the carbon dioxide distribution change with the seasons?
Stand where you would expect the greatest impact of sea level rise? Type potential impacts in the chat box.
Coral Reefs and Ocean Acidification

This animation shows computer model simulations of the ocean’s carbonate chemistry from January 1895 through July 2094. Dark gray dots show cold-water coral reefs. Medium gray dots show warm-water coral reefs. Ocean acidification describes the process of ocean water becoming corrosive and harmful to corals.

The colors show aragonite saturation levels, which represent the amount of material available for corals and shellfish to build their skeletons and shells. The blue areas are the most favorable conditions for corals and shellfish. Green and yellow areas have fewer present. In areas that are orange or gray, they may be rare, injured, or gone. White indicates no data.

Which areas (shown in gray) are predicted to have the least favorable conditions for coral and shellfish?

Stand where you would expect high ocean acidification by 2100? Type potential impacts in the chat box.
NASA’s Global Climate Change Website

http://climate.nasa.gov

NASA’s one-stop shop for news, current data, multimedia, and teaching tools

- Key Indicators of climate change
- Interactives
- Images of Change
- Climate Reel: videos and animations
- Tips n’ Tricks for Teachers

Continuously updated

Near real time satellite data in 3D
Interactive Visualizations

http://climate.nasa.gov/interactives/

Climate Time Machine
Go backward and forward in time with this interactive visualization that illustrates how the Earth's climate has changed in recent history.
Click here to launch

Sea Level Viewer
Explore the world of ocean topography from space with this 3D interactive viewer.
Click here to launch

Global Ice Viewer
Explore the sentinels of climate change with this 3D interactive global ice viewer.
Click here to launch

Quizzes
Explore and test your knowledge with these interactive quizzes.
Click here to view

How Hot is the Earth?
Take a look at the latest worldwide temperature trends and what they mean.
Click here to launch

- Create immersive experience
- Help viewers visualize complicated scientific concepts
- Students have fun and forget they are being educated
Key Indicators
http://climate.nasa.gov/keyIndicators/

Vital signs of the planet:
• 5 Key indicators
• Scroll over from mainpage
• Current satellite datapoints
• Interactive slider bars

Global Surface Temperature

Arctic Sea Ice

Land Ice

Carbon Dioxide Concentration

What does this mean?
- Sea level rise is caused by the thermal expansion of seawater due to climate warming and widespread melting of glaciers.
- The chart on the left shows historical sea level data derived from tide gauges, and the chart on the right shows the average sea level since 1960 derived from global satellite data.
- The time series on the right shows average annual sea level anomalies. Red and yellow indicate where sea levels are higher; black-purple indicates sea level is lower.

NASA measure the ocean level:
Janet E. Jenkins

What does this mean?
- Carbon dioxide (CO2) is an important greenhouse gas released through natural processes such as respiration and decay and through human activities such as deforestation and burning fossil fuels. The chart on the left shows the CO2 levels in the Earth’s atmosphere during the last three glacial cycles, as reconstructed from ice cores. The chart on the right shows CO2 levels in recent years, corrected for average seasonal cycles.
- The time series on the right shows global distribution and variation of the concentration of atmospheric CO2 in parts per million (ppm) at an altitude range of 2-10 km (0-3.2 miles).

NASA measure the forest CO2:
CERES - Climate Energy Research and Remote Sensing

What does this mean?
- Sea level rise is caused by the thermal expansion of seawater due to climate warming and widespread melting of glaciers.
- The chart on the left shows historical sea level data derived from tide gauges, and the chart on the right shows the average sea level since 1960 derived from global satellite data.
- The time series on the right shows average annual sea level anomalies. Red and yellow indicate where sea levels are higher; black-purple indicates sea level is lower.

NASA measure the ocean level:
Janet E. Jenkins

What does this mean?
- Sea level rise is caused by the thermal expansion of seawater due to climate warming and widespread melting of glaciers.
- The chart on the left shows historical sea level data derived from tide gauges, and the chart on the right shows the average sea level since 1960 derived from global satellite data.
- The time series on the right shows average annual sea level anomalies. Red and yellow indicate where sea levels are higher; black-purple indicates sea level is lower.

NASA measure the ocean level:
Janet E. Jenkins

What does this mean?
- Sea level rise is caused by the thermal expansion of seawater due to climate warming and widespread melting of glaciers.
- The chart on the left shows historical sea level data derived from tide gauges, and the chart on the right shows the average sea level since 1960 derived from global satellite data.
- The time series on the right shows average annual sea level anomalies. Red and yellow indicate where sea levels are higher; black-purple indicates sea level is lower.

NASA measure the ocean level:
Janet E. Jenkins

What does this mean?
- Sea level rise is caused by the thermal expansion of seawater due to climate warming and widespread melting of glaciers.
- The chart on the left shows historical sea level data derived from tide gauges, and the chart on the right shows the average sea level since 1960 derived from global satellite data.
- The time series on the right shows average annual sea level anomalies. Red and yellow indicate where sea levels are higher; black-purple indicates sea level is lower.

NASA measure the ocean level:
Janet E. Jenkins

What does this mean?
- Sea level rise is caused by the thermal expansion of seawater due to climate warming and widespread melting of glaciers.
- The chart on the left shows historical sea level data derived from tide gauges, and the chart on the right shows the average sea level since 1960 derived from global satellite data.
- The time series on the right shows average annual sea level anomalies. Red and yellow indicate where sea levels are higher; black-purple indicates sea level is lower.

NASA measure the ocean level:
Janet E. Jenkins

What does this mean?
- Sea level rise is caused by the thermal expansion of seawater due to climate warming and widespread melting of glaciers.
- The chart on the left shows historical sea level data derived from tide gauges, and the chart on the right shows the average sea level since 1960 derived from global satellite data.
- The time series on the right shows average annual sea level anomalies. Red and yellow indicate where sea levels are higher; black-purple indicates sea level is lower.

NASA measure the ocean level:
Janet E. Jenkins
Before and after glacier pairs at seven locations around the world

McCarty Glacier 1909 and 2004
ACTIVITIES THAT USE DATA
Investigate Earth processes using real data:

- El Niño
- Sea Level
- Water Quality (in development)

Sign up

Step 1
Teachers, if you are interested in helping us test the new curriculum modules for this project, please take a moment to register and sign up.

Step 2
Once you've registered, feel free to try any of the curriculum modules shown above. The El Niño and Sea Level modules are available now.

Step 3
After using the curriculum, be sure to fill out an evaluation survey. You can earn continuing education credits through the University of Wisconsin.
Activity Levels:
1. **Entry** – look for patterns and relationships
2. **Adoption** – use data graphs
3. **Adaptation** – recreate climate change models
4. **Interactivity** – use data to support or disprove a simple hypothesis
5. **Invention** – design an investigation using real data
Professional Development

Teachers need accurate information and resources to integrate ocean, coastal, and climate science into local and state curricula. These resources provide a variety of lesson plans, background information, resource links, tutorials, archived professional development seminars, media galleries, and interactive tools that can be used in a variety of ways in grades 5-12. Many of the resources provided here were created in partnership with the National Science Teachers Association. Teachers can access resources in additional topics at the NSTA Learning Center site, http://learningcenter.nsta.org.
The Ocean’s Role in Weather and Climate

The ocean covers more than 70 percent of the Earth’s surface. The ocean plays a major role in regulating the weather and climate of the planet. These materials will help you understand the factors that impact the Earth’s weather and climate, and how changes in temperature or air circulation are part of complex, long-term cycles. Understanding the influence of ocean conditions on the Earth’s climate and monitoring changes in ocean conditions are key to predicting climate change.

Classroom Resources

- Ocean Basics
- Weather and Climate Basics
- Energy in the Ocean and Atmosphere

This professional development section provides an understanding of the complex interactions between the ocean, weather, and climate. These resources present information on the water cycle, including real-time and animated data of surface and deep ocean currents. Activities and lesson plans explain the causes of ocean currents, and the interaction of ocean density, atmospheric winds, and Earth’s rotation. Real-time weather and climate data show how meteorologists record and forecast the weather. Satellite and radar imagery provide a visual understanding of convection in the ocean, the atmosphere, and their interrelatedness.

Teacher Tutorials

The tutorials, cooperatively developed by NOAA scientists and National Science Teachers Association (NSTA) pedagogy experts, are designed to help teachers understand ocean, climate, and weather connections based on the science literacy goals in the National Standards. Each tutorial focuses on a key content idea, contains interactive simulations and embedded questions.
Interactive simulations*
  • Coral reef
  • Climate
  • Ocean Circulation

Developed in partnership with the National Science Teachers Association.
The Question:
Has the climate changed over the last 600 years?
Climate Change in Wisconsin and the Great Lakes Region

CIMSS EPO manager, Margaret Mooney, collaborated with NOAA’s National Weather Service on a climate stewards project in May 2011. Mooney invited local storm spotters to a webinar on climate change, climate mitigation and mobile devices to monitor weather and climate.

Nineteen storm spotters participated and eleven provided feedback via a follow-up survey. A third of the respondents indicated that they took action to minimize their carbon footprint, a large majority (90%) indicated their likelihood to take action in the near future!

The webinar is available for viewing at http://vimeo.com/23571211.
NSTA Learning Center

• Educators are provided with a subscription to all materials in the NSTA library

• Library has been built with funding from agencies

• Allows educators to maintain a professional development portfolio

• Individual collections of resources can be customized for the needs of the educator
## NSTA Web Seminars

<table>
<thead>
<tr>
<th>Title</th>
<th>Featured Scientist(s)</th>
</tr>
</thead>
</table>
| “Climate Change, Here and Now: Western Regional Climate Impacts”    | Katharine Hayhoe  
Texas Tech University                                    |
| “Climate Change, Here and Now: Eastern Regional Climate Impacts”    | Tim Owen  
NOAA NCDC                                                |
| “Monitoring the Impacts of Climate Change on Corals”                 | Mark Eakin  
NOAA Coral Reef Watch                                      |
| “Higher Than a Sea-Bird’s Eye View: Coral Reef Remote Sensing Using Satellites” | Margaret Mooney  
Steve Ackerman  
CIMSS, U.W, Madison                                        |
| “Impact of Climate Change on West Coast Marine Mammals”              | Siri Hakala, NMFS                                          |
| “Impact of Climate Change on East Coast Fisheries”                   | NMFS TBD                                                  |
| “Climate Change and Ocean Acidification”                             | CRCP TBD                                                  |
| “Climate Change and Sea Level Rise”                                  | William Sweet  
NOS CO-OPS                                                |
| “Climate Change and Coastal Communities”                             | Chris Bowser and NERRS Climate Education Working Group    |
Climate Stewards Project - Overview

- Nation-wide program led by NOAA Ed. Community
- Formal and informal educators, citizen scientists
- Distribution of climate science data, professional development, place-based field opportunities and teaching tools
- Implement of action plans for local environmental stewardship projects
Stewardship in Action!
Half-day Symposia at Education Conferences

e.g. Climate Change Impacts on Western Coasts, the Ocean and Atmosphere