

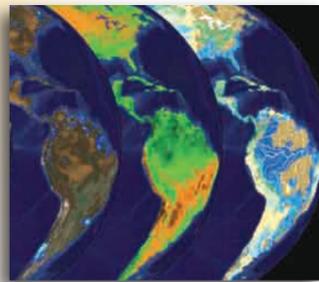
VISUALIZING EARTH SYSTEMS

Connect Learning to Real World Science

Atmosphere ■ Climate ■ Ecosystems ■ Ocean, Water & Ice ■ Natural Hazards ■ Weather

CAUSE & EFFECT • Cause and effect relationships may be used to predict phenomena in natural systems.

Aquarius Sea Surface Salinity: 2011–2014 (left image). Heavy rain, river outflows, ice melt and evaporation can all alter sea surface salinity (concentration of dissolved salt), providing a fingerprint of Earth's freshwater cycle. In this visualization, higher salinity is shown in red—regions of high evaporation sometimes called "ocean deserts." Blue colors show lower salinities resulting from freshwater inputs into the ocean, e.g., Amazon River outflow appearing as a ribbon-like feature in the tropical Atlantic; a zone of persistent rainfall that spans the tropical Pacific; and melting ice near the poles.



ENERGY & MATTER •

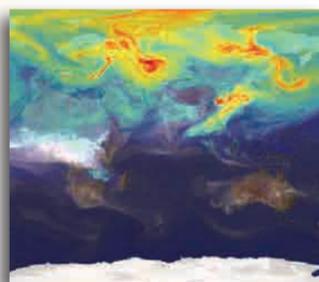
Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Water Cycle Series. Follow water cycling through the atmosphere, ocean and land in this 4-part video series. The movement of water is evaluated using ground and satellite measurements along with computer models.

SYSTEMS & SYSTEM MODELS •

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions within and between systems at different scales.

Atmospheric CO₂ Model. This NASA computer model has given scientists a stunning new look at how carbon dioxide in the atmosphere travels around the globe.



PATTERNS, SIMILARITIES & DIFFERENCES •

Patterns can provide information about natural systems and evidence for causality in explanations of phenomena.

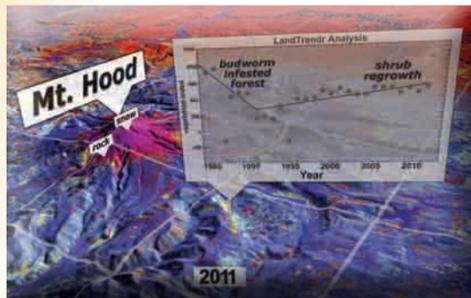
27 Storms: Arlene to Zeta. The 2005 Atlantic tropical storm season was a record-breaker. The unusually high frequency and strength of these tropical storms were linked to favorable development conditions observed in the ocean and atmosphere. Ideal open ocean wind patterns and warmer ocean surface waters permitted storm clouds to easily mature into vigorous convective cells—the building blocks of hurricanes.



STABILITY & CHANGE •

Change and rates of change can be quantified and modeled over very short or very long periods of time.

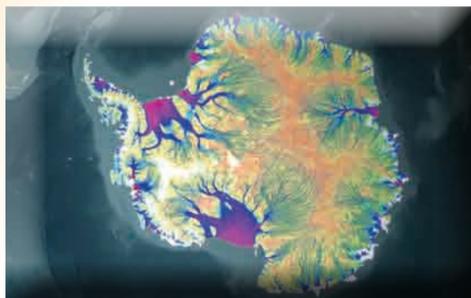
The Secret Life of Forests. This visualization of the Pacific Northwest from 1984 to 2011 uses false color images from Landsat to reveal different stories about the forest, from the obvious patchworks of logged land to the subtle changes from bark beetle infestations.



SCALE, PROPORTION & QUANTITY •

Phenomena that can be observed at one scale may not be observable at another scale.

Antarctic Ice Flow Charted from Space. Three animations are presented: 1) Slower processes—interior flow of ice—are sped up so they are visible; 2) Processes are shown at the same scale—only fastest ice movement is visible; and 3) Color is removed which allows the direction of ice flow to stand out.



Credit, all above images: NASA Scientific Visualization Studio.

NASA Earth science visualizations can demonstrate these crosscutting concepts commonly found in middle and high school curricula.

More visualizations for each of these concepts are included on the DVD.

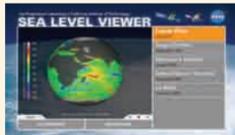
Additional sources of NASA Earth visualizations and tools:

NASA Earth Observatory
earthobservatory.nasa.gov



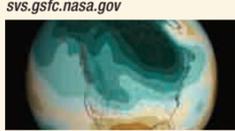
- Explore images, stories and discoveries from NASA Earth science research.
- View global maps of NASA data; check out the **Image of the Day**, images of current events and special collections.

NASA Global Climate Change: Vital Signs of the Planet
climate.nasa.gov

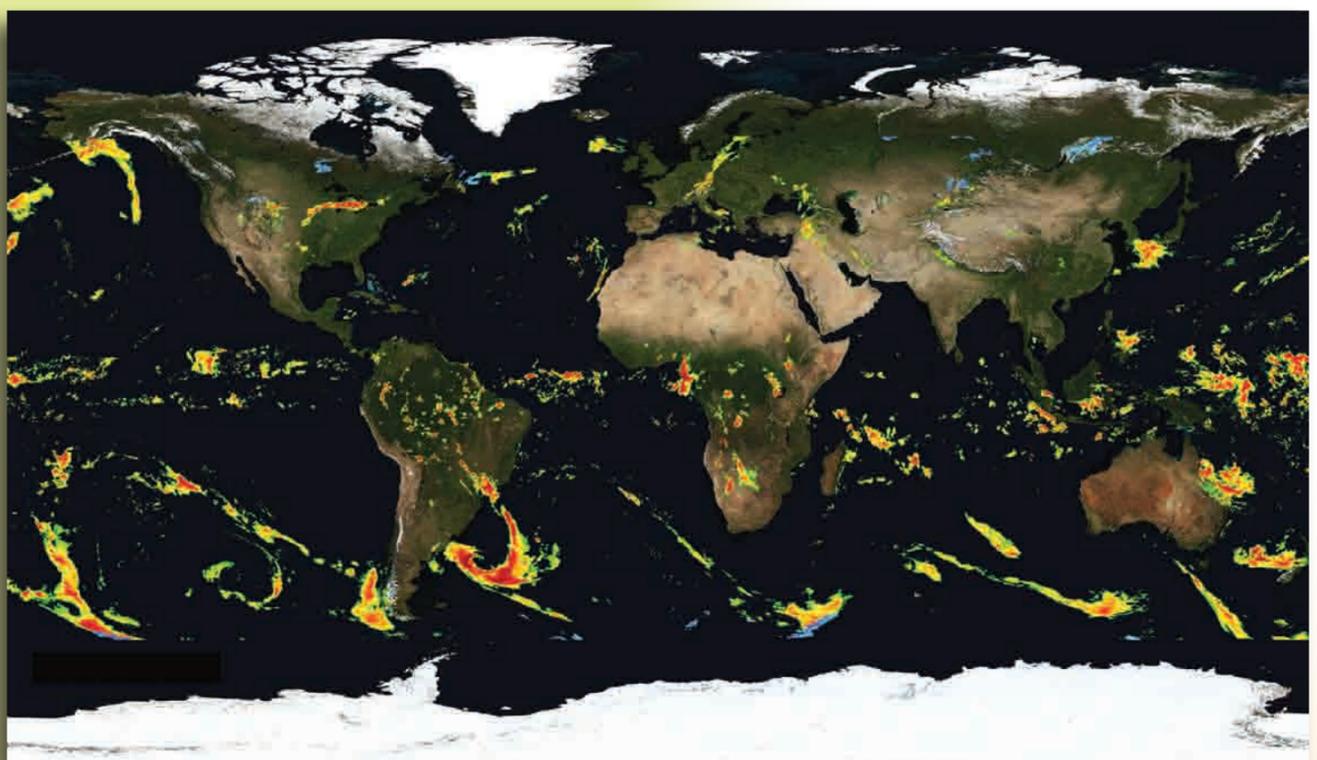


- Collection of climate news, visualizations, interactives and resources related to the changing climate and NASA's role in studying climate change.

NASA Scientific Visualization Studio (SVS)
svs.gsfc.nasa.gov



- **Climate Essentials Multimedia Gallery:** Brings together the latest and most popular climate-related images, data visualizations, and video features on one web page. • svs.gsfc.nasa.gov/Gallery/ClimateEssentials.html
- **Visualization Explorer App:** Delivers the latest multimedia stories to your iPad. • svs.gsfc.nasa.gov/nasaviz



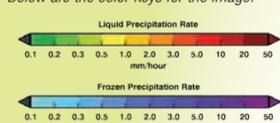
INQUIRY-BASED TEACHING with Visualizations

Learners will use their prior knowledge, observations, and inferences to interpret this unlabeled image.

IMAGE DESCRIPTION:

IMERG Global Precipitation Rates (Rainfall and Snowfall). The Global Precipitation Measurement (GPM) Core Observatory was launched Feb. 27, 2014 and is a U.S.-Japan collaboration. It acts as the standard to unify precipitation measurements from a network of 12 satellites. The result is NASA's Integrated Multi-satellite Retrievals for GPM (IMERG) data product, which combines data from all 12 satellites into a single, seamless map. The map provides the most detailed information on precipitation—from light rain to heavy rain and snow—and is updated every half hour, allowing scientists to see how rain and snowstorms move around nearly the entire planet. As scientists work to understand all the elements of Earth's climate and weather systems, and how they could change in the future, GPM provides a major step forward in providing comprehensive and consistent measurements of precipitation.

The still image shown above is one frame from an animation (included on the DVD) covering April 1 to August 26, 2014; this frame is from April 13. Below are the color keys for the image.



Credit: NASA Scientific Visualization Studio.

INTRODUCTORY APPROACH

Providing guidance to interpretation involves a process of scaffolding, using observations and prior knowledge at first, and allowing questions to emerge from what cannot be interpreted easily. The goal is for learners to start making the link between observations (data), evidence, and conclusions.

Describe what you see. What do you recognize?

Responses will generally focus on common elements that are recognizable (e.g., outlines of continents). There is a tendency to name specific features that are recognized (e.g., South America, Pacific Ocean). Accepting responses at this point without acknowledging their accuracy will encourage learners to validate or correct each other, which supports critical thinking.

What are some things you notice?

What features stand out to you?

More vivid features tend to stand out, attracting more attention (e.g., patches of bright color) at the expense of other features (e.g., the even coloring of the ocean). As the "stand out" features are discussed, learners can be encouraged to also consider less vivid features.

Often very early in the process of interpretation, learners may begin to speculate as to what the images are intended to show. When speculations do come up, it can be useful to ask the learners to explain what

observations support their ideas. This can refocus attention onto observations, and start making the link between observations, evidence, and conclusions.

What are some features that seem realistic?

What features seem not as real? Why not?

(e.g., continent shape and relative size might seem accurate, while clouds may be missing or the Earth is stretched at the poles)

The distinction between "real" and "unreal" is a bit challenging with visualizations, since even realistic elements (e.g., desert color) are often contrived through the imaging process. This is why "seem realistic" is used in the question.

Responses will often refer to color (e.g., green in some continental areas), shapes (e.g., coastlines), and sizes (e.g., continents being exaggerated at the poles). It is often the case that there will be some debate about what is real and what is unreal or exaggerated (e.g., questions of scale may come up here, and questions of coloring that mimic reality but are actually computer generated).

What questions do you have about the image?

These questions, based on close observations, can become the focus of student investigations.

VISUALIZING EARTH SYSTEMS

A NASA Quick Start Guide for Educators

Everything on the DVD and more are also at:
svs.gsfc.nasa.gov/forEducators

VISUALIZATIONS

A select collection of stunning images, videos and animations, organized by crosscutting topics.

VIDEO INTERVIEW

Take a guided tour with a NASA visualization expert.

K-12 LESSONS

Bring NASA visualizations and data into your classroom.
Requires Internet Connection.

GO FURTHER AT
svs.gsfc.nasa.gov/forEducators

To use this DVD you will need a computer with a DVD drive and an up-to-date Internet browser (Chrome, FireFox, Safari, IE).

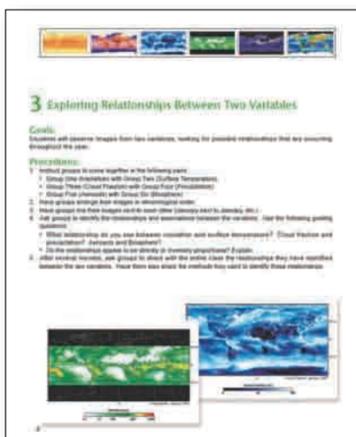
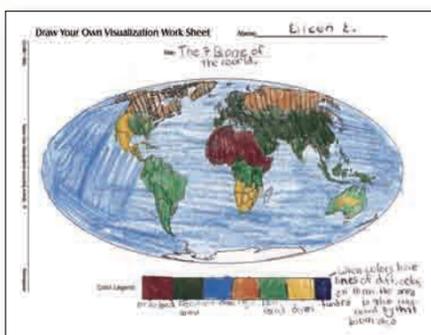
1. Insert DVD
2. Launch .HTML file
3. Enjoy!

VISUALIZATIONS FOR THE CLASSROOM

- Students of all ages can use visualizations to explore the Earth system.
- These activities draw on diverse sources of NASA data and have been organized by grade level.
- Classroom activities and lessons are provided that will enable students to become familiar with visualization tools and data, and to conduct their own research and analyses.

Find these and additional standards-aligned lessons and activities on the DVD or online at: nasawavelength.org

- Elementary School:**
 - MY NASA DATA: *Rock Star Precipitation*
 - Draw Your Own Visualization* (top center)
- Middle School:**
 - Exploring Relationships Between Two Variables* (bottom center)
 - MY NASA DATA: *Using Vegetation, Precipitation and Surface Temperature to Study Climate Zones* (top right)
- High School:**
 - Hurricane Katrina: A Problem-Based Learning Module*
 - Monitoring the Global Environment*



SOURCES ■ Above: *Using Vegetation, Precipitation and Surface Temperature to Study Climate Zones* from MY NASA DATA • mynasadata.larc.nasa.gov; Top center: *Draw Your Own Visualization* from The GLOBE Program • www.globe.gov; Bottom center: *Exploring Relationships Between Two Variables* from The GLOBE Program • www.globe.gov

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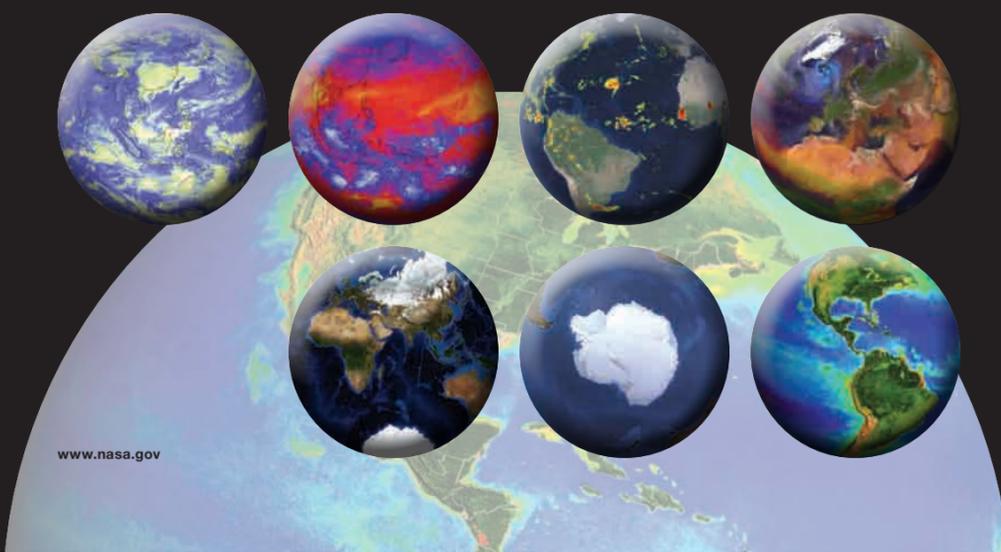
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National Aeronautics and Space Administration



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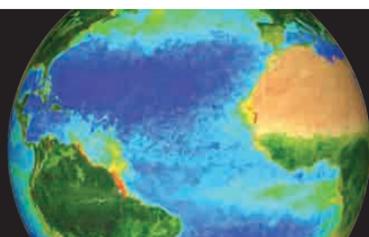
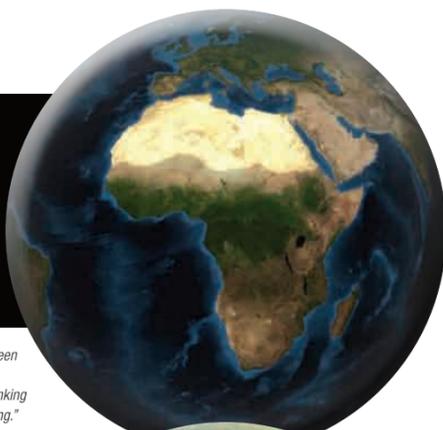
A NASA Quick Start Guide for Educators



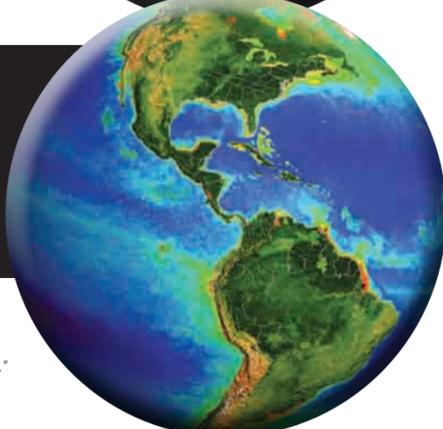
SCIENTIFIC Visualization



CAUSE & EFFECT: Satellite observations have confirmed the relationship between the transport of Saharan dust by wind and the fertilization of the Amazon basin. This stunning animation visualizes dust transport and provides a context for thinking about cause and effect relationships in the Earth system. Source: "Dust Crossing." Credit: NASA Scientific Visualization Studio and Goddard Space Flight Center.



ENERGY & MATTER: This animation represents nearly a decade's worth of data showing the abundance of life in the sea. By monitoring the color of reflected light via satellite, scientists can determine how successfully plant life is photosynthesizing. Source: "SeaWiFS Biosphere Data over the North Atlantic." Credit: NASA Scientific Visualization Studio, The SeaWiFS Project, and GeoEye.



At the core of scientific visualization is the representation of data graphically—through images, animations and videos—to improve understanding and develop insight. Visualizations allow us to explore data, phenomena and behavior; they are particularly effective for showing large scales of time and space, and "invisible" processes (e.g., flows of energy and matter) as integral parts of the models.

This booklet and DVD provide a selected collection of NASA visualizations that demonstrate the complexity and interconnectedness of our Earth system. They are a great jumping off point for discussion, to illustrate an abstract concept, and to engage students in inquiry.

Visualizations in this package are organized by crosscutting topics that are commonly found in middle and high school curricula, including:

- Systems and system models
- Cause and effect
- Scale, proportion and quantity
- Patterns, similarities and differences
- Stability and change
- Energy and matter

Cover credits: Images are from the NASA Scientific Visualization Studio. Top row, left to right: NPP Ceres Shortwave Radiation, NPP Ceres Longwave Radiation, Painting the World with Water, Planet on Fire. Bottom row, left to right: Blue Marble Next Generation, Pulse of Snow and Sea Ice, SeaWiFS Biosphere Data over the North Atlantic (also the background image).