Robert Simmon

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Image of the Day for February 27, 2013

Swirling Sediment Reveals Erosive Power of New England Storm

Winds and waves from a February 2013 nor'easter churned up the seafloor and beaches around coastal Massachusetts.
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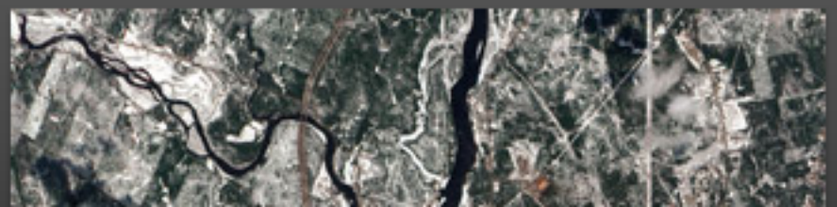
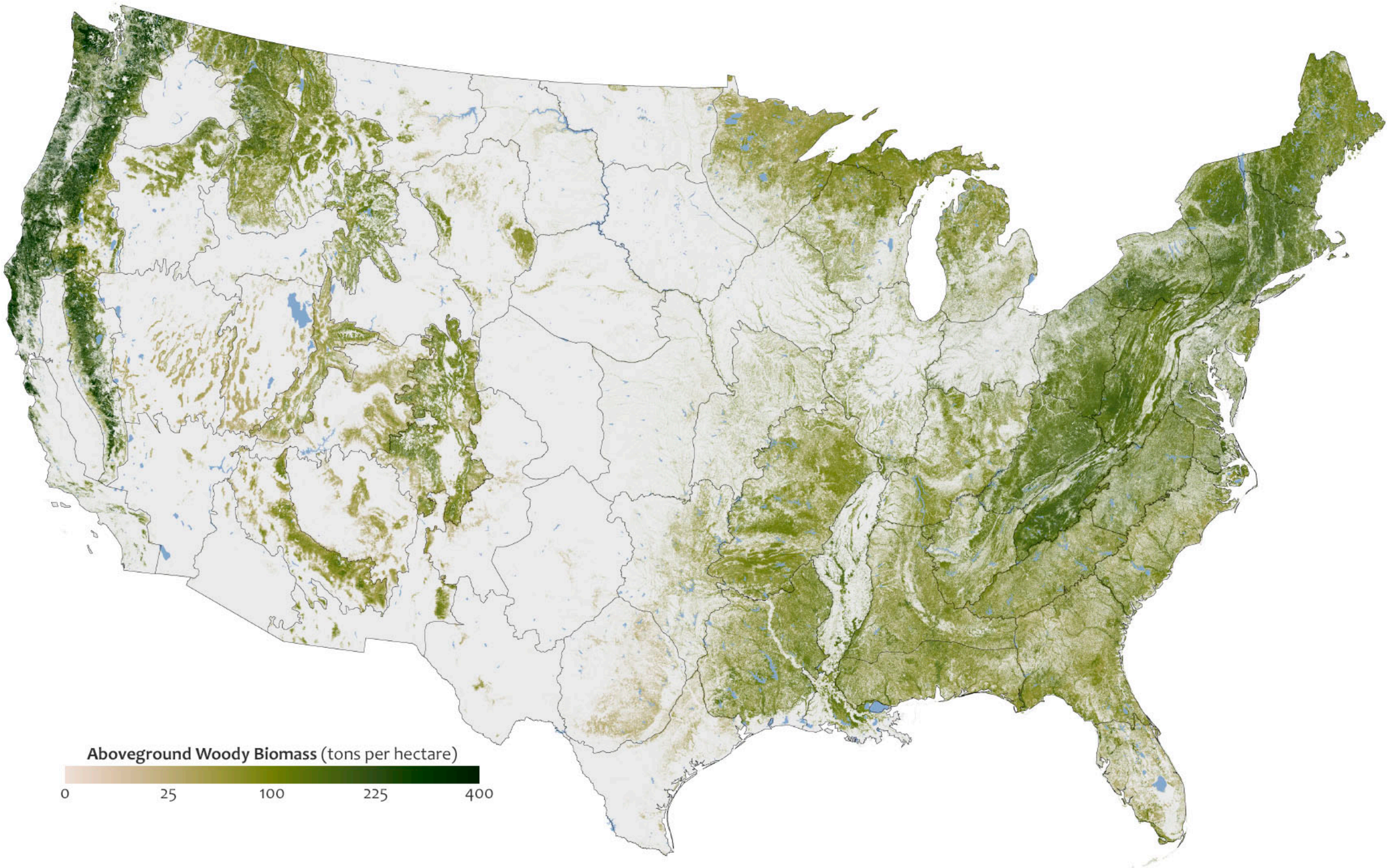


World of Change: Green Seasons of Maine

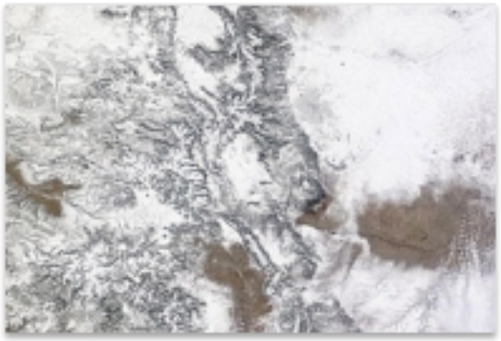
February 8, 2013

CLIMATE 365

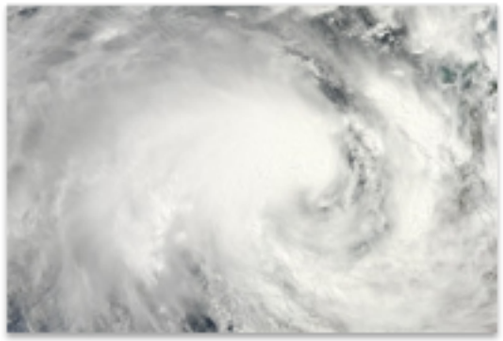

Aboveground Woody Biomass (tons per hectare)
0
25
100
225
400

February 2013

January | March



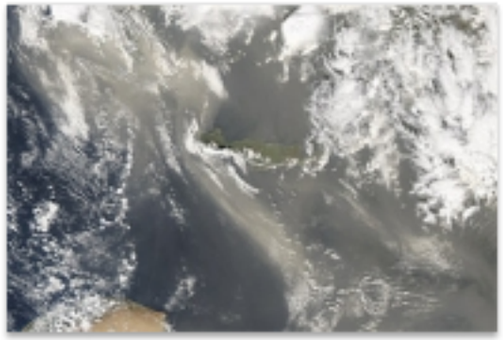
February 25, 2013
Another Snowstorm Strikes Western States



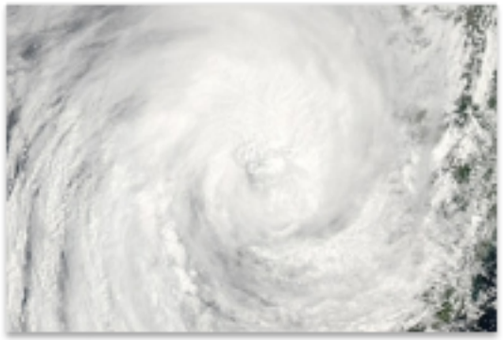
February 25, 2013
Tropical Cyclone Rusty

February 23, 2013
Winter Storm across Central United States

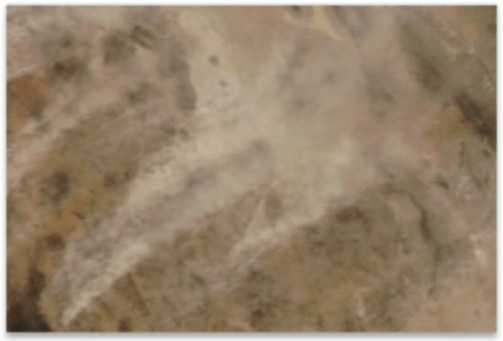
February 22, 2013
Nighttime View of Snow across the United States



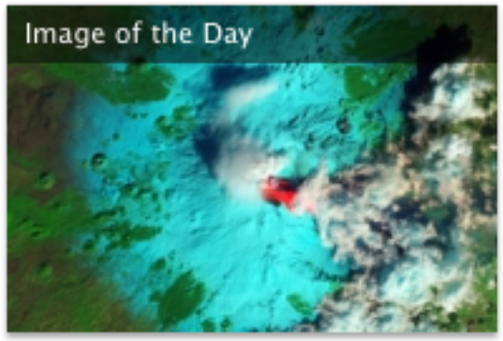
February 22, 2013
Saharan Dust over the Mediterranean Sea



February 22, 2013
Tropical Cyclone Haruna

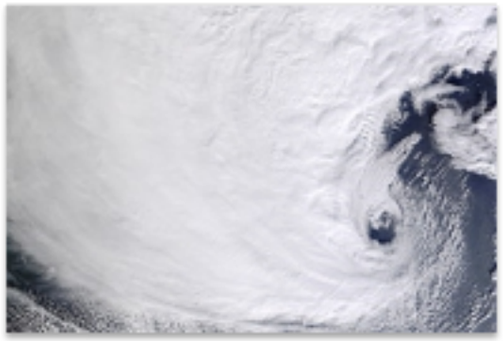


February 20, 2013
Dust Storm in Mexico and New Mexico

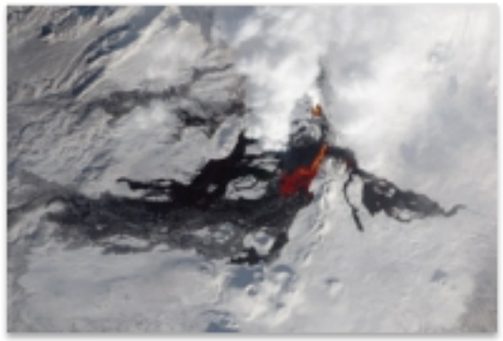


February 20, 2013
Mount Etna Boils Over

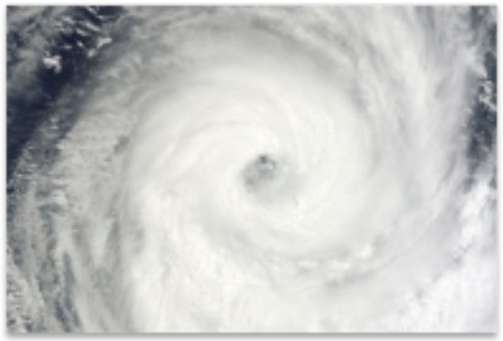
February 18, 2013
Fires in Southeastern Australia



February 17, 2013
Storm over Eastern New England



February 14, 2013
Lava Flows on Tolbachik Volcano



February 13, 2013
Tropical Cyclone Gino

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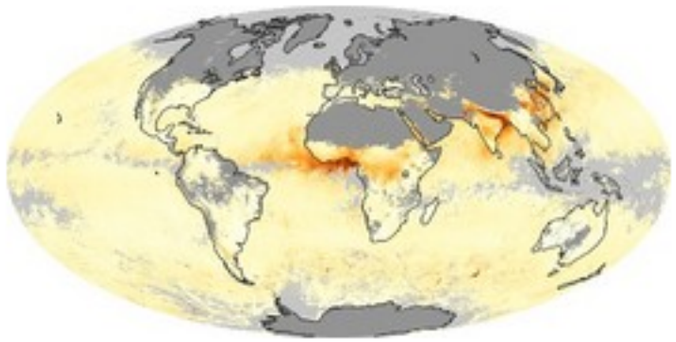
Apr	May	Jun
Jul	Aug	Sep
Oct	Nov	Dec

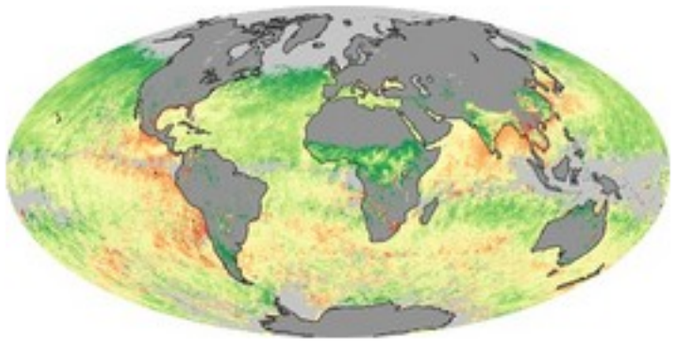
Global Maps

NASA satellites give us a global view of what's happening on our planet. To explore how key parts of Earth's climate system change from month to month, click on one of the maps below.

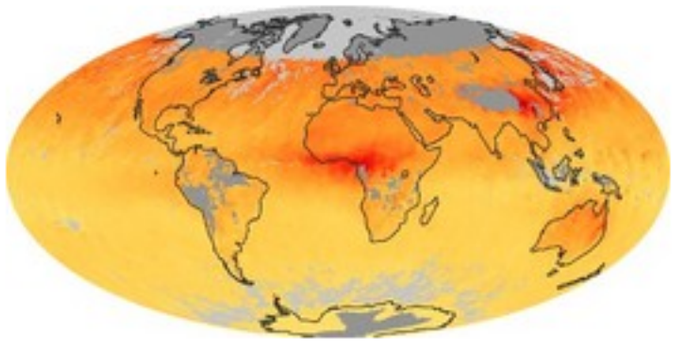
Aerosol Optical Depth



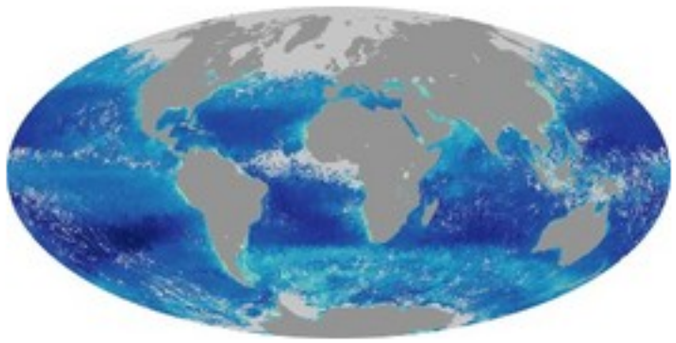
Aerosol Size



Carbon Monoxide

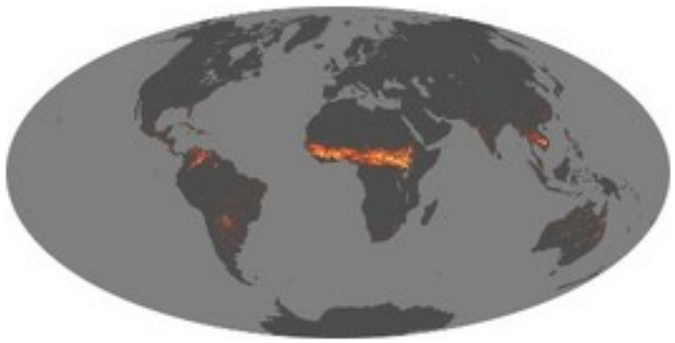


Chlorophyll

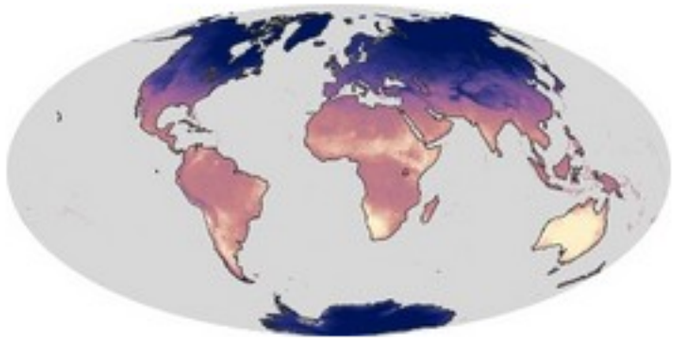


Cloud Fraction

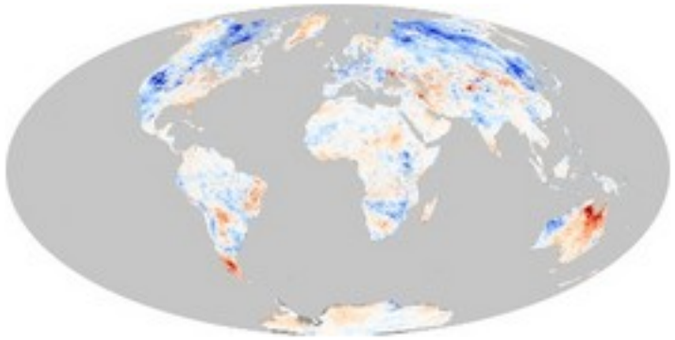
Fire



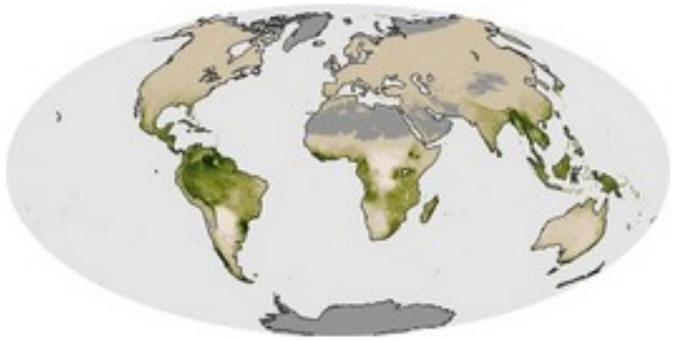
Land Surface Temperature



Land Surface Temperature Anomaly



Net Primary Productivity



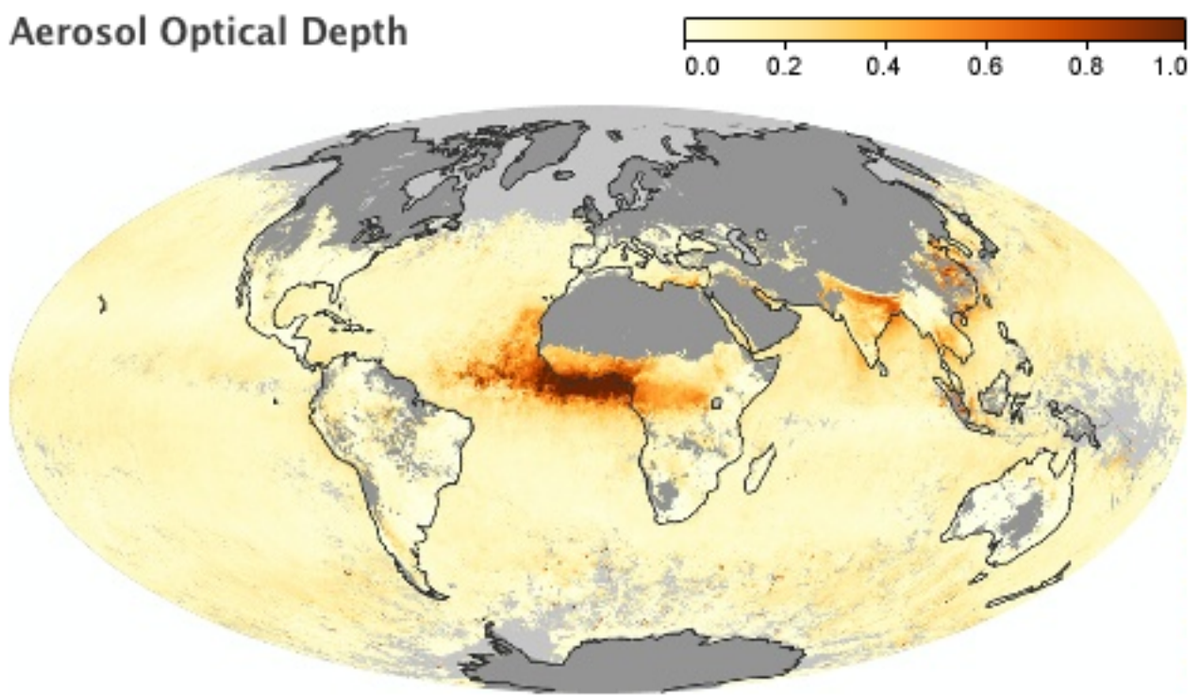
Net Radiation

Sea Surface Temperature

Sea Surface Temperature Anomaly

Global Maps

January 2005



January 2005

January 2013

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Tiny solid and liquid particles suspended in the atmosphere are called aerosols. Windblown dust, sea salts, volcanic ash, smoke from wildfires, and pollution from factories are all examples of aerosols. Depending upon their size, type, and location, aerosols can either cool the surface, or warm it. They can help clouds to form, or they can inhibit cloud formation. And if inhaled, some aerosols can be harmful to people's health.

These maps show average monthly aerosol amounts around the world based on observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite. Satellite measurements of aerosols, called aerosol optical thickness, are based on the fact that the particles change the way the atmosphere reflects and absorbs visible and infrared light. An optical thickness of less than 0.1 (palest yellow) indicates a crystal clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions.

High aerosol amounts are linked to different process in different places and times of year. High aerosol amounts occur over South America from July through September. This pattern is due to land clearing and agricultural fires that are widespread across the Amazon Basin and Cerrado regions during the dry season. Aerosols have a similar seasonal pattern in Central America (March–May), central and southern Africa (June–September, and Southeast Asia (January–April).

Aerosol Optical Depth

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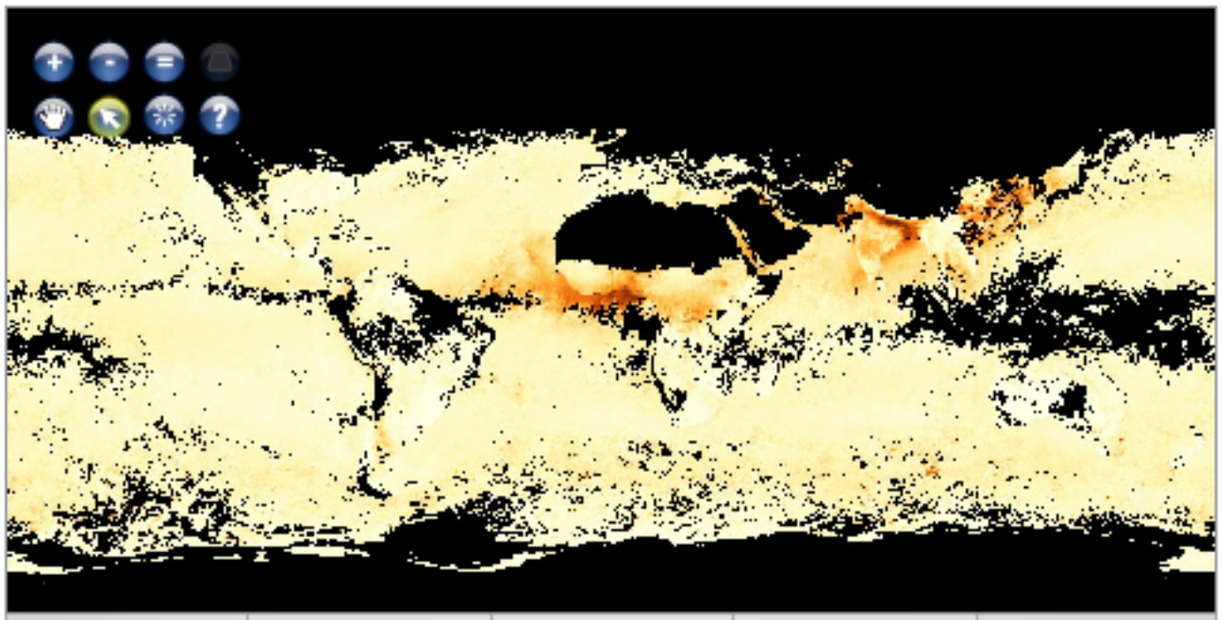

Ocean | Atmosphere | Energy | Land | Life

Aerosol Optical Thickness (1 month - Terra/MODIS)
January 1, 2013 00:00-February 1, 2013 00:00
About this dataset

0.0 0.2 0.4 0.6 0.8 1.0
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- **November 1, 2012 00:00** to **December 1, 2012 00:00**
- **October 1, 2012 00:00** to **November 1, 2012 00:00**
- **September 1, 2012 00:00** to **October 1, 2012 00:00**
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World of Change: Green Seasons of Maine

February 8, 2013

Not many places on Earth have year-round greenery *and* four distinct seasons. The images in this series show the four seasons of Maine, the most forest-covered state in the U.S.A. Read more

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December 5, 2012

The night is nowhere near as dark as most of us think. In fact, the Earth is never really dark; it twinkles with lights from humans and nature. Read more

Earth at Night 2012

December 5, 2012

Scientists are using new images of Earth's dark side to gain insight on human activity and poorly understood natural events. Read more

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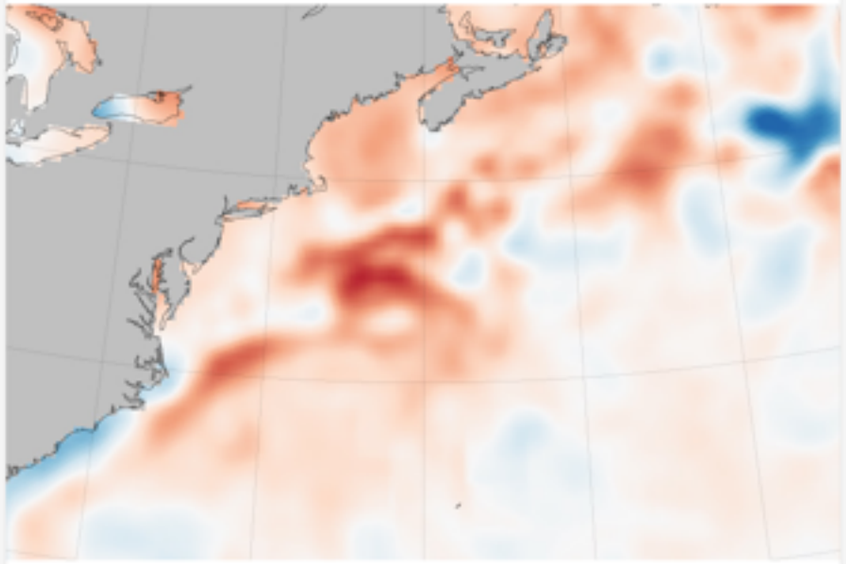
World of Change

Satellite images showing how our world

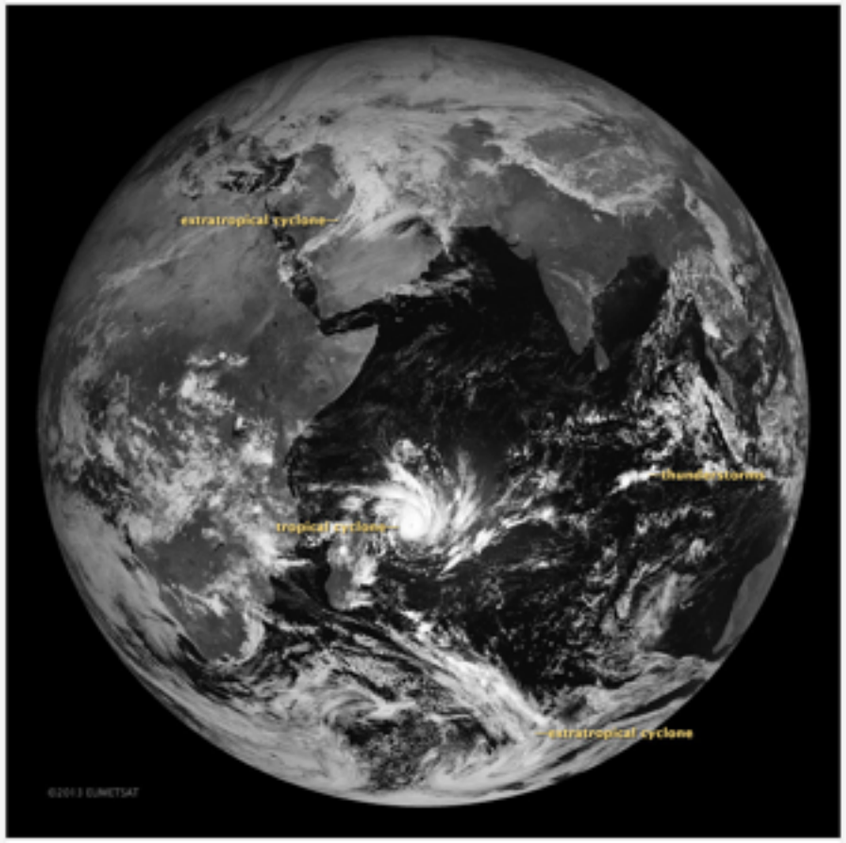
Rising sea levels exacerbated Sandy's storm surge, for example, a direct link between global warming and storm damage. And abnormally high sea surface temperatures in the Atlantic probably intensified the storm. But pinning all of Sandy's fury—its hybrid nature, the scale of its winds, its unusual track—squarely on global warming is premature, says Shepherd, the current president of the American Meteorological Society.



As Sandy was moving up the U.S. East Coast, unusually warm ocean temperatures allowed the storm to stay strong after it left tropcial waters. (Map by Robert Simmon, using data from the NOAA Earth System Research Laboratory.)

Weather forecasters use terms like snowstorms, derechos, hailstorms, rainstorms, blizzards, low-pressure systems, lightning storms, hurricanes, typhoons, nor'easters, and twisters. Research meteorologists and climatologists, have a simpler way of dividing up the world's storms: thunderstorms, tropical cyclones, and extra-tropical cyclones. All are atmospheric disturbances that redistribute heat and produce some combination of clouds, precipitation, and wind.

Thunderstorms are the smallest type, and they are often part of the larger storm systems (tropical and extra-tropical cyclones). All storms require moisture, energy, and certain wind conditions to develop, but the combination of ingredients varies depending on the type of storm and local meteorological conditions.



For example, thunderstorms form when a trigger—a cold front, converging near-surface winds, or rugged topography—destabilizes a mass of warm, humid air and causes it to rise. The air expands and cools as it ascends, increasing the humidity until the water vapor condenses into liquid droplets or ice crystals, forming precipitation-making clouds. The process of converting water vapor into liquid water or ice releases latent heat into the atmosphere. (If this doesn't make sense, remember that the reverse—turning liquid water into water vapor by boiling it—requires heat).

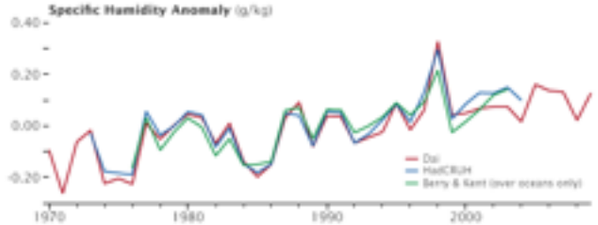
Storms feed off of latent heat, which is why scientists think global warming is strengthening storms. Extra heat in the atmosphere or ocean nourishes storms; the more heat energy that goes in, the more vigorously a weather system can churn.

Tropical cyclones, extra-tropical cyclones, and thunderstorms are the three fundamental types of storms studied by the climate change community. (Image ©2013 EUMETSAT.)

Thunderstorms derive their energy from the heat released by the condensation of water vapor. This "latent heat" energy drives thunderstorm clouds high into the atmosphere. (Astronaut photograph ISS022-E-006510.)

Already, there is evidence that the winds of some storms may be changing. A study based on more than two decades of satellite altimeter data (measuring sea surface height) showed that hurricanes intensify significantly faster now than they did 25 years ago. Specifically, researchers found that storms attain Category 3 wind speeds nearly nine hours faster than they did in the 1980s. Another satellite-based study found that global wind speeds had increased by an average of 5 percent over the past two decades.

There is also evidence that extra water vapor in the atmosphere is making storms wetter. During the past 25 years, satellites have measured a 4 percent average rise in water vapor in the air column. Using ground-based records, about 76 percent of weather stations in the United States have seen increases in extreme precipitation since 1948. One analysis found that extreme downpours are happening 30 percent more often in the contiguous United States than they did in 1948.



Increases in global temperature have raised atmospheric humidity. Satellite, ground-based, and balloon-borne instruments have measured an increase of about 5 percent since 1970. (Graph by Robert Simmon, based on data from the NOAA National Climatic Data Center.)

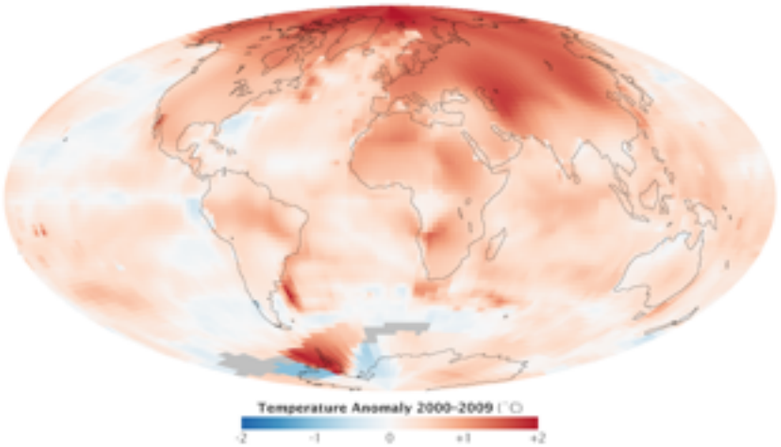
Another found that the largest storms now produce 10 percent more precipitation than they did in 1948. William Lau, a scientist at NASA's Goddard Space Flight Center, concluded in a 2012 paper that rainfall totals from tropical cyclones have risen at a rate of 24 percent per decade since 1988. The increase in precipitation doesn't just apply to rain. NOAA scientists have examined 120 years of data and found that there were twice as many extreme regional snowstorms between 1961 and 2010 as there were from 1900 to 1960.

But measuring a storm's maximum size, heaviest rains, or top winds does not capture the full scope of its power. Kerry Emanuel, a hurricane expert at the Massachusetts Institute of Technology, developed a method to measure the total energy expended by tropical cyclones over their lifetimes. In 2005, he showed that Atlantic hurricanes are about 60 percent more powerful than they were in the 1970s. Storms lasted longer and their top wind speeds had increased by 25 percent. (Subsequent research has shown that the intensification may be related to differences between the temperature of the Atlantic and Pacific oceans.)

Effects of the Temperature See-Saw

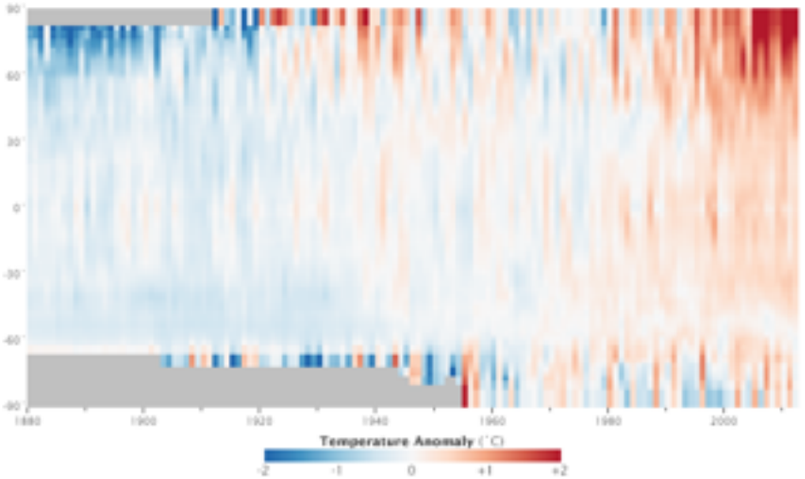
If understanding the impact of global warming on storms were simply a matter of tallying up extra moisture, the answer would be pretty straightforward. However, reality is more complicated. Putting extra water vapor into the atmosphere is just one of the ways global warming is changing the planet. Another important factor is how the heat in the atmosphere is distributed.

Since 1880, average global temperatures have warmed about 0.8°C (1.4°F), but the warming has not occurred equally everywhere. Temperatures have increased about twice as fast in the Arctic as in the mid-latitudes. The loss of sea ice is a key reason why. Bright and reflective ice is giving way to darker, open ocean—amplifying the warming trend by absorbing more heat from the Sun. On the other hand, the abundance of convection and thunderstorms in the tropics contributes to a slower rate of warming by transporting heat away from the surface.



Global temperatures from 2000-2009 were on average about 0.6°C higher than they were from 1951-1980. The Arctic, however, was about 2°C warmer. (NASA image by Robert Simmon, with GISS Surface Temperature Analysis (GISTEMP) data.)

Climatologists think the differing rates of warming from the equator to the Poles could have a significant impact on some types of storms. Extra-tropical cyclones, for example, harvest energy from the atmosphere when masses of warm and cold air interact along the polar front—the boundary between cooler polar air and warmer subtropical air. As the difference between the temperature at the poles and the tropics decreases, there could be less energy for these storms to absorb, a change that could weaken them or make them less frequent.



Temperatures are warming more near the poles than near the equator. This plot shows the change in temperature from 1880 to 2012 versus latitude. The reduced temperature contrast between high latitudes and the tropics likely weakens extra tropical cyclones. (NASA image by Robert Simmon, with GISS Surface Temperature Analysis (GISTEMP) data.)

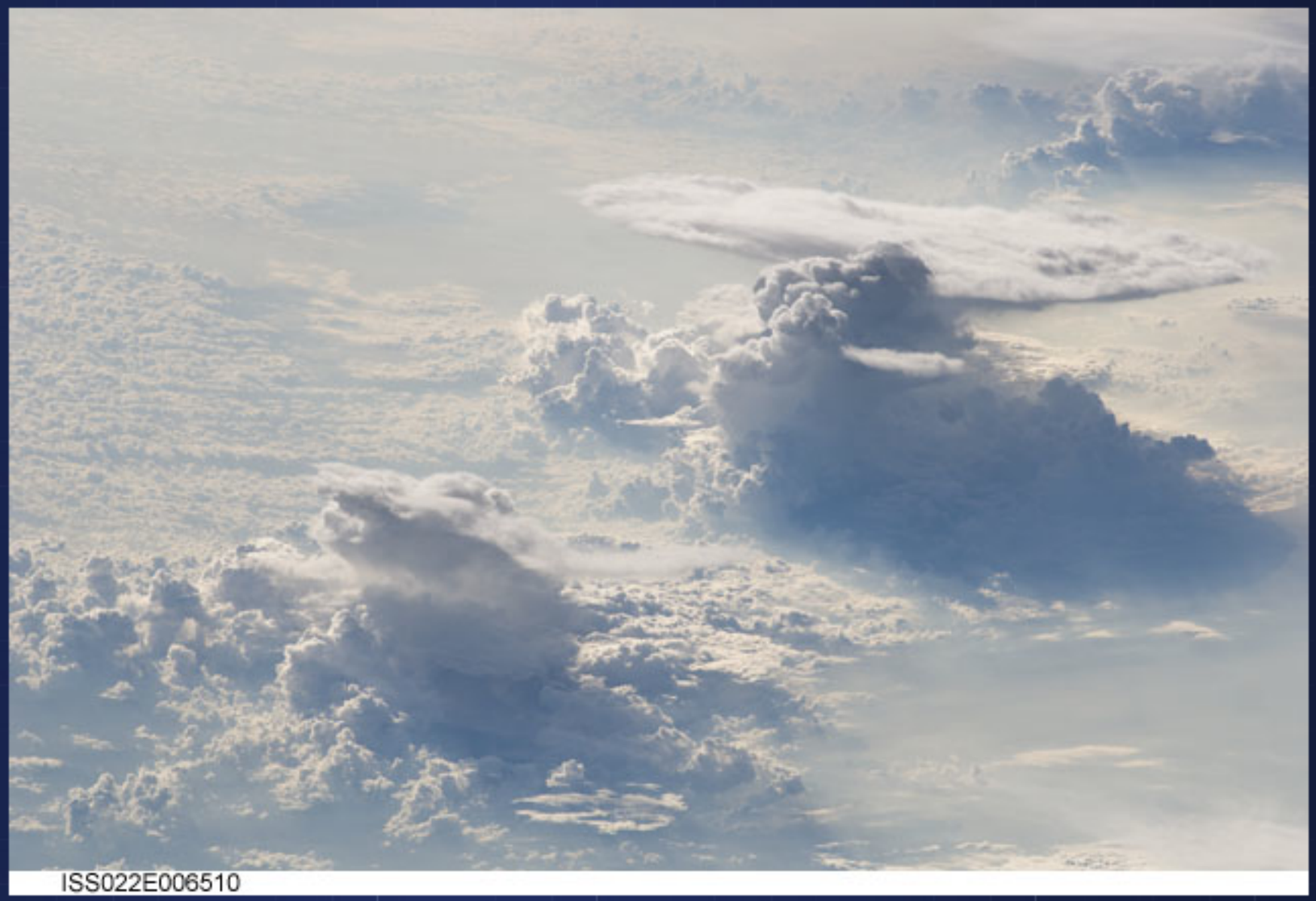
"Sorting out opposing factors is what makes this such a challenging problem," Del Genio says. "And keep in mind that this is a simplification. These aren't the only two factors involved."

Wind shear— a measure of how the speed and direction of winds differ at different levels of the atmosphere—complicates the picture because it can affect storms in a variety of ways. Tropical cyclones require weak wind shear to form; in other words, they need minimal differences in wind speeds at adjacent levels of the atmosphere. Strong wind shear tears tropical cyclones apart, preventing heat and moisture from organizing into a storm core.

Research suggests that Atlantic wind shear could increase by 1 to 2 miles (0.6 to 1.2 kilometers) per hour for each degree that global temperatures increase. It's this potential increase that explains why many climate simulators conclude that the number of tropical cyclones will stay the same or decrease even as the strongest storms get stronger. An article published in 2010 by a group of the world's leading storm experts concluded that the average intensity of tropical cyclones will likely increase by 2 to 11 percent by 2100, but the overall frequency of storms

Astronaut Photography of Earth - Display Record

ISS022-E-006510



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Data Sources

Earth Observatory	earthobservatory.nasa.gov
JSC Earth Observation Lab	eol.jsc.nasa.gov
NASA Earth Observations	neo.sci.gsfc.nasa.gov
NOAA CLASS	www.class.ncdc.noaa.gov
Global Visualization Viewer	glovis.usgs.gov
Physical Oceanography DAAC	podaac.jpl.nasa.gov
Goddard Earth Sciences DISC	disc.sci.gsfc.nasa.gov
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