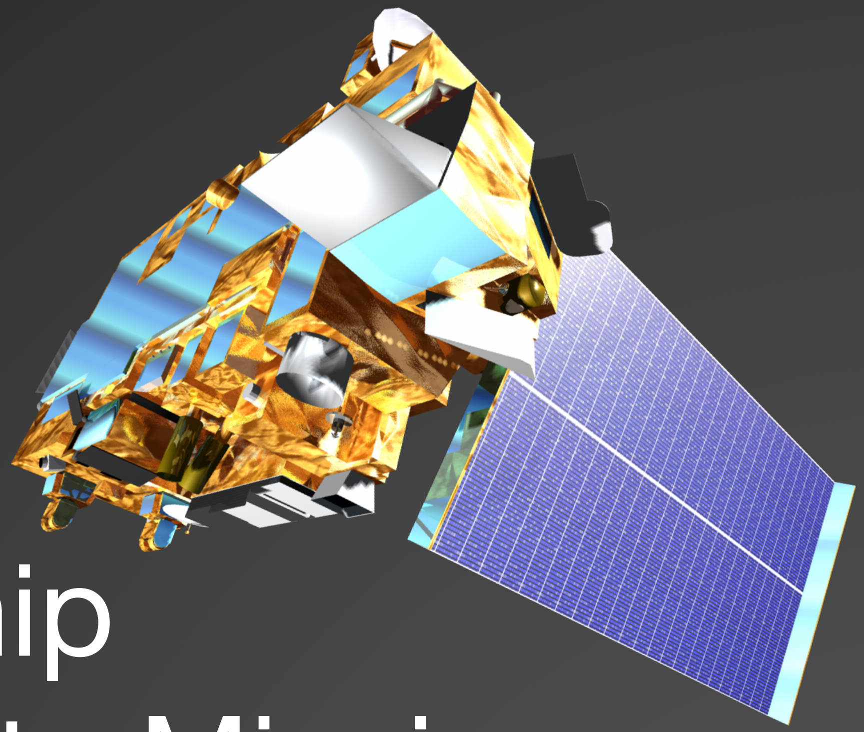
TERRA



NASA’s Flagship
Earth Observing Satellite Mission

TERRA @ 20

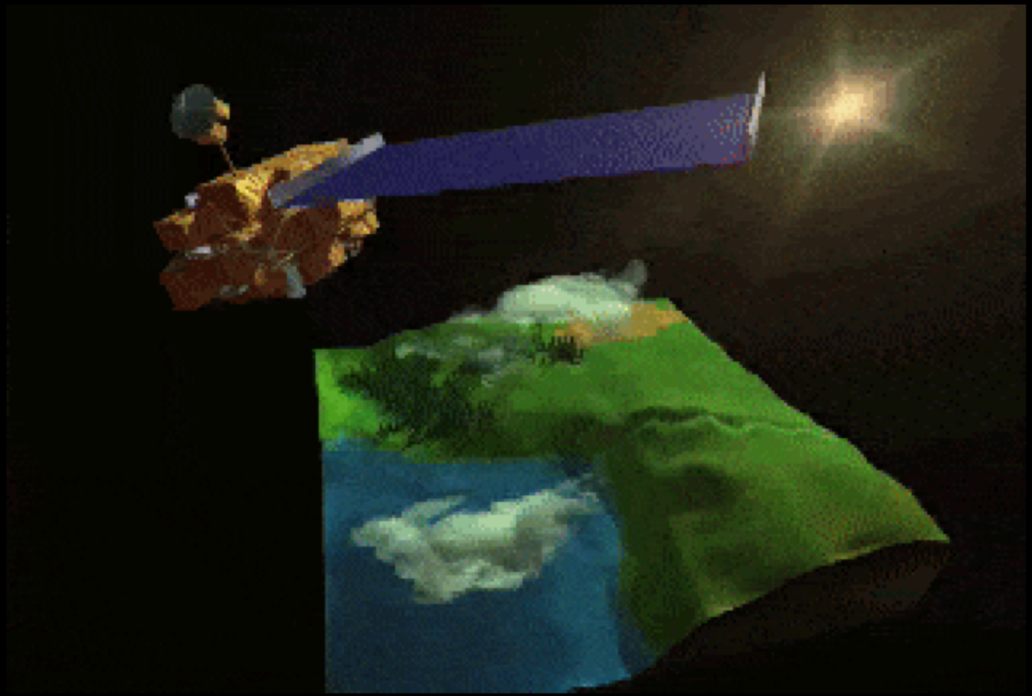
Terra, the flagship Earth observing satellite launched December 18, 1999. Having exceeded its expected design life of six years, Terra is an amazing feat of engineering. Terra is the longest continuously operating satellite to capture simultaneous measurements of Earth from five different sensors. Many of the climate data records produced by Terra's instruments are the longest ever produced by a single satellite mission. Terra's five sensors ASTER, CERES, MISR, MODIS, and MOPITT record data about land surface, water, atmosphere, snow and ice, and Earth's energy budget.


TERRA
NASA
20 YEARS
5 INSTRUMENTS
ASTER • CERES • MISR
MODIS • MOPITT
OVER 100,000 ORBITS
20,000 PUBLICATIONS
350,000 CITATIONS
4.6 MILLION USERS
83 DATA PRODUCTS

ASTER

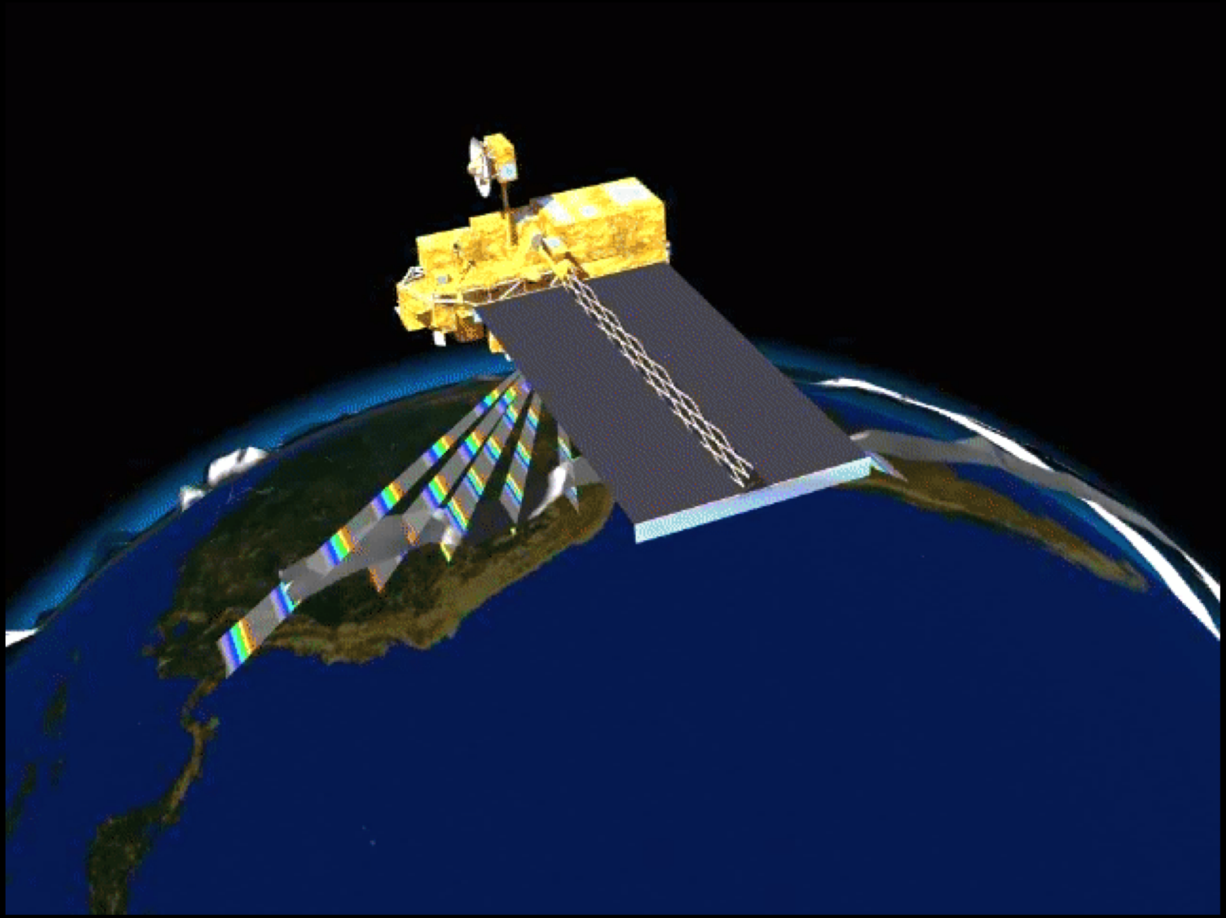
The Advanced Spaceborne Thermal Emission and Reflection Radiometer's high-resolution images are used to create detailed maps of Earth’s land surface temperature, emissivity, reflectance, and elevation, while aiding in natural disaster recovery efforts.

CERES



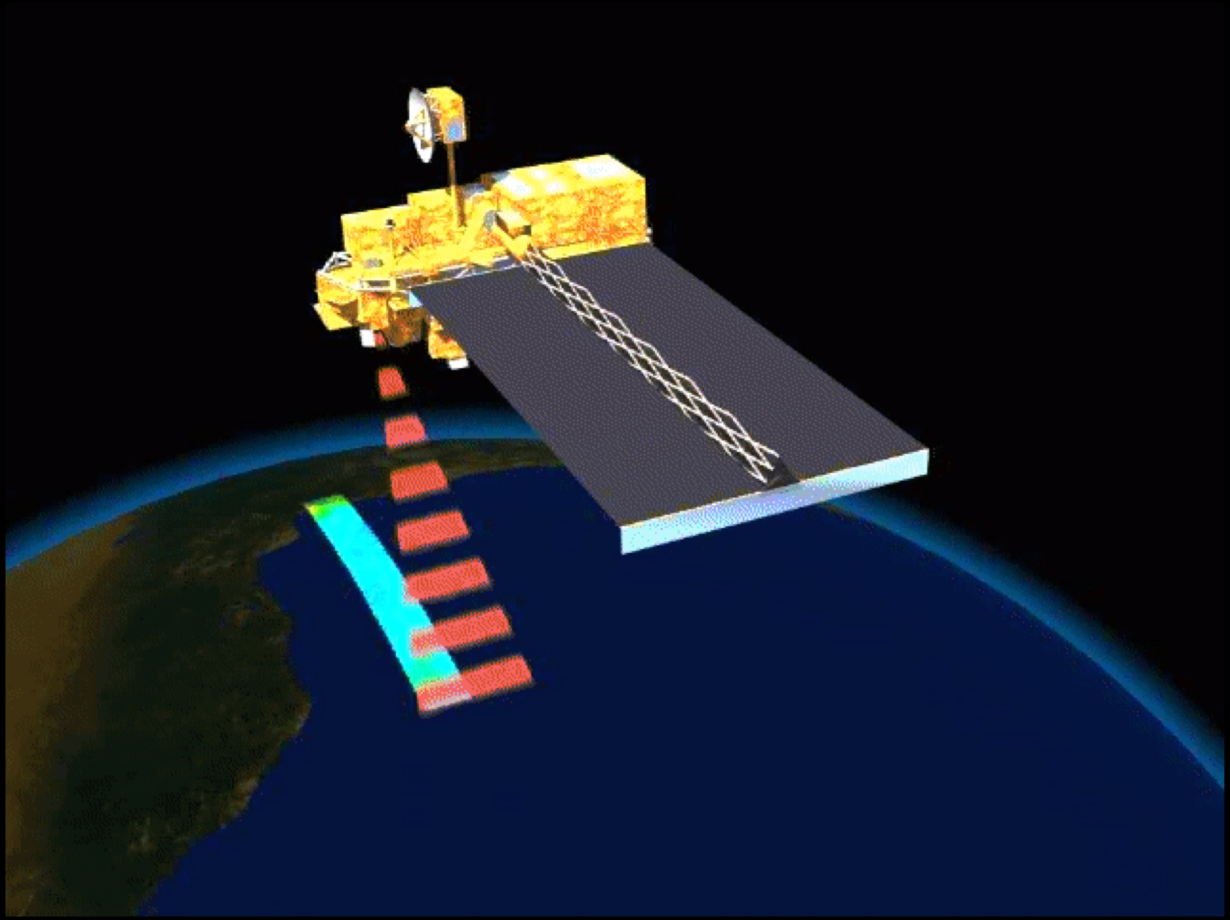
The Clouds and the Earth's Radiant Energy System instrument measures reflected sunlight and thermal radiation emitted by the Earth, providing data to better understand how the Sun’s energy drives Earth’s climate system and how our climate is changing.

MISR



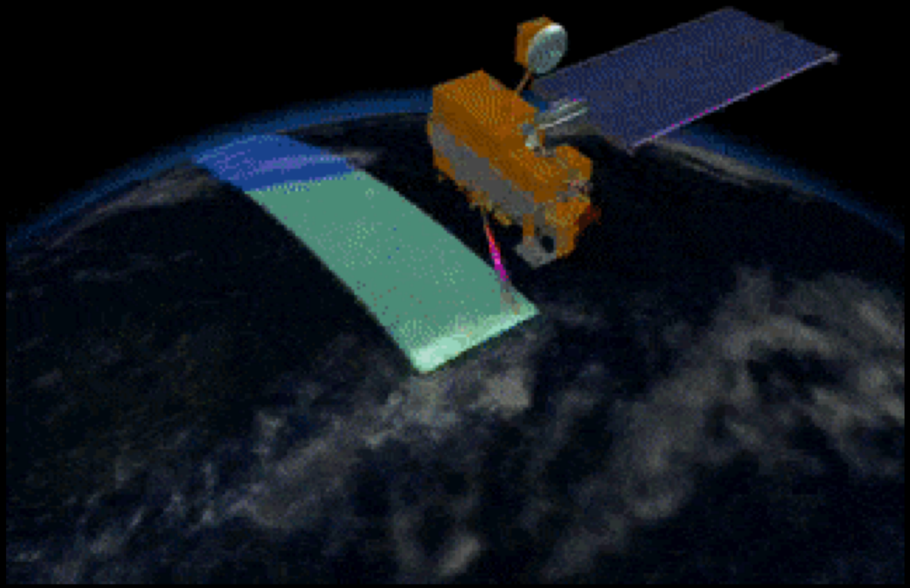
The Multi-angle Imaging SpectroRadiometer provides detailed, global coverage of Earth's atmosphere and surface. Its unique 9-angle views of reflected sunlight distinguish different types of atmospheric particles, clouds, and surface cover for use in climate and environmental research.

MODIS



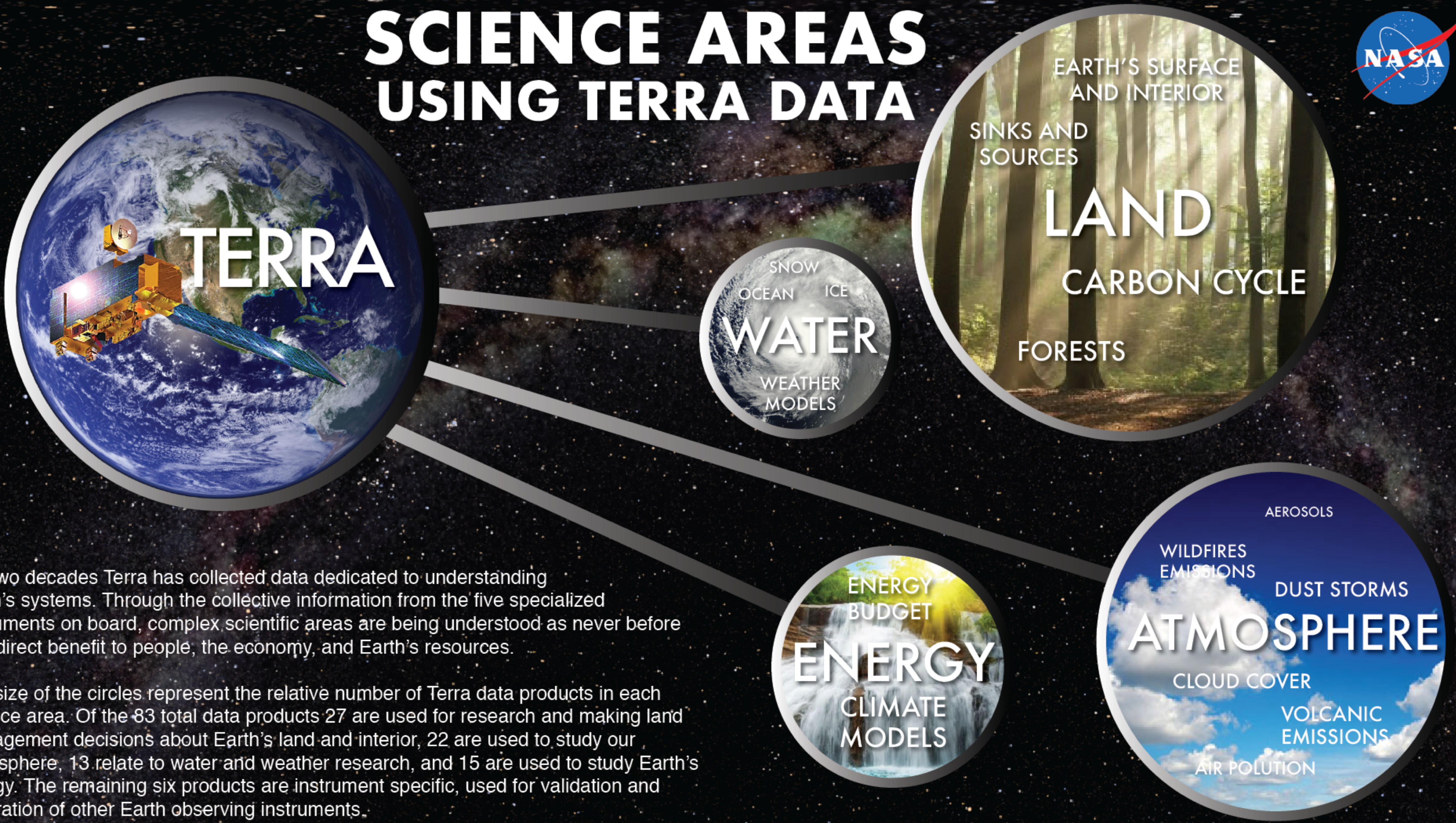
The Moderate Resolution Imaging Spectroradiometer views the whole Earth every 1 – 2 days, collecting valuable data about Earth’s atmosphere, hydrosphere, biosphere, and cryosphere. MODIS data help protect people and property during natural disasters.

MOPITT



Measurement of Pollution in the Troposphere gathers data on the distribution, transport, sources, and sinks of carbon monoxide in the troposphere. Carbon monoxide – from factories, cars, and forest fires – hinders the atmosphere’s ability to rid itself of harmful pollutants.

SCIENCE AREAS USING TERRA DATA

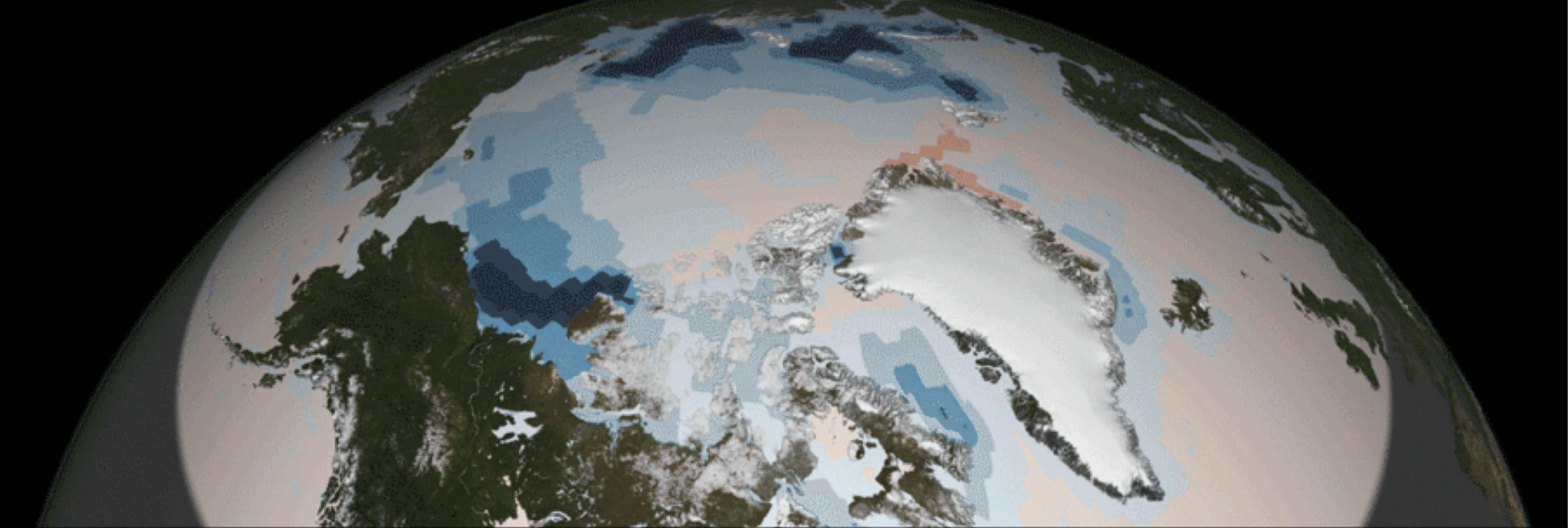


For two decades Terra has collected data dedicated to understanding Earth's systems. Through the collective information from the five specialized instruments on board, complex scientific areas are being understood as never before with direct benefit to people, the economy, and Earth's resources.

The size of the circles represent the relative number of Terra data products in each science area. Of the 83 total data products 27 are used for research and making land management decisions about Earth's land and interior, 22 are used to study our atmosphere, 13 relate to water and weather research, and 15 are used to study Earth's energy. The remaining six products are instrument specific, used for validation and calibration of other Earth observing instruments.

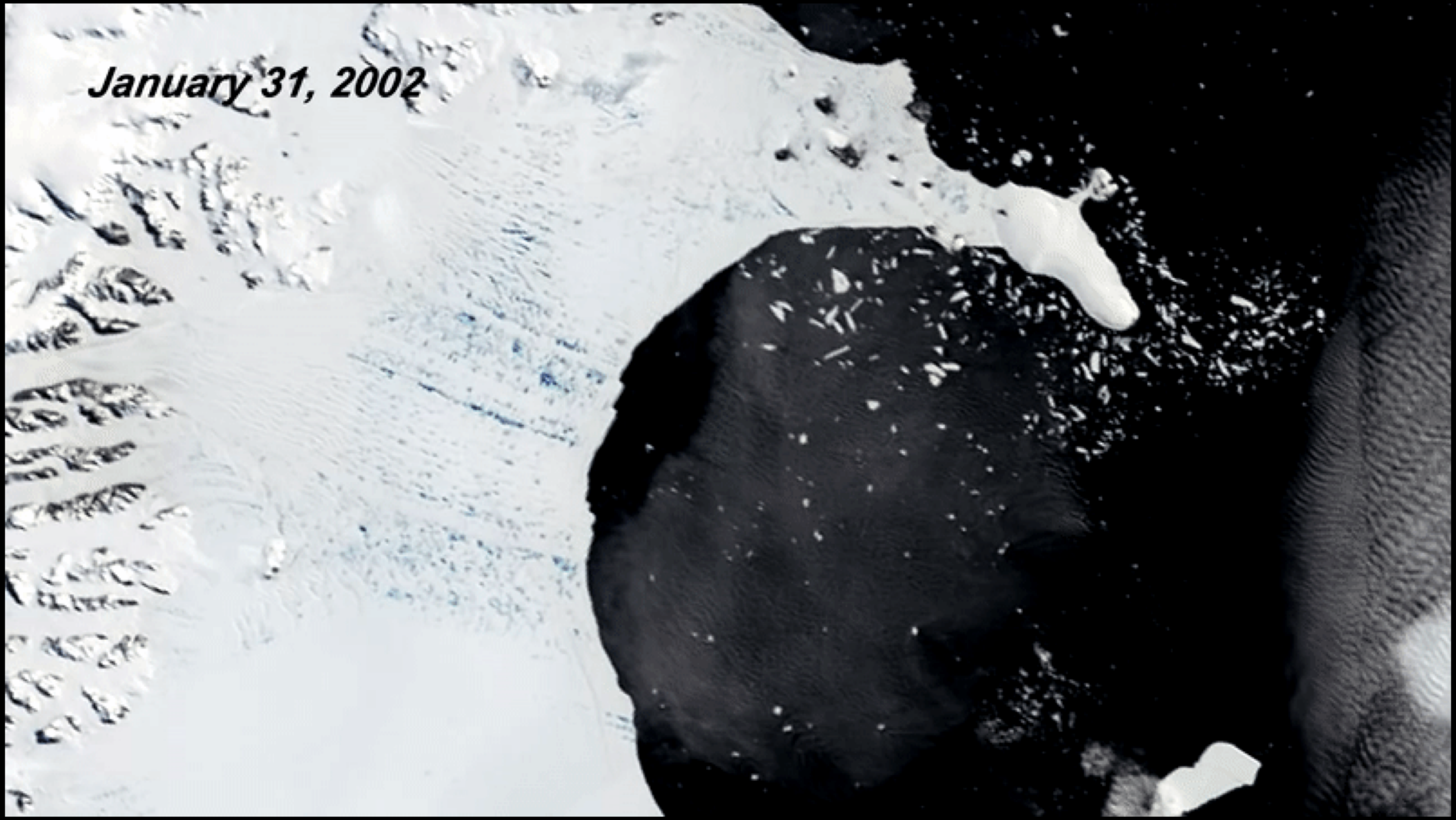
Blue Marble 2002

In 2002, NASA scientists and visualizers stitched together strips of brand new data, in natural color, collected over four months from the Moderate Resolution Imaging Spectroradiometer, or MODIS, instrument aboard Terra. This composite Blue Marble became one of the most iconic Earth images of the new century when Apple selected it as their default background for the iPhone in 2007.



Arctic Heating

As ice melts in the Arctic, Earth loses much of its white, reflective surface that repels the sun’s energy back to space. Darker ocean waters are exposed, which absorb the sun’s energy, This may enhance the warming pattern in the Arctic. The Clouds and the Earth’s Radiant Energy Systems, or CERES, instruments on Terra and Aqua have measured how much solar radiation is absorbed by the Earth since the year 2000.

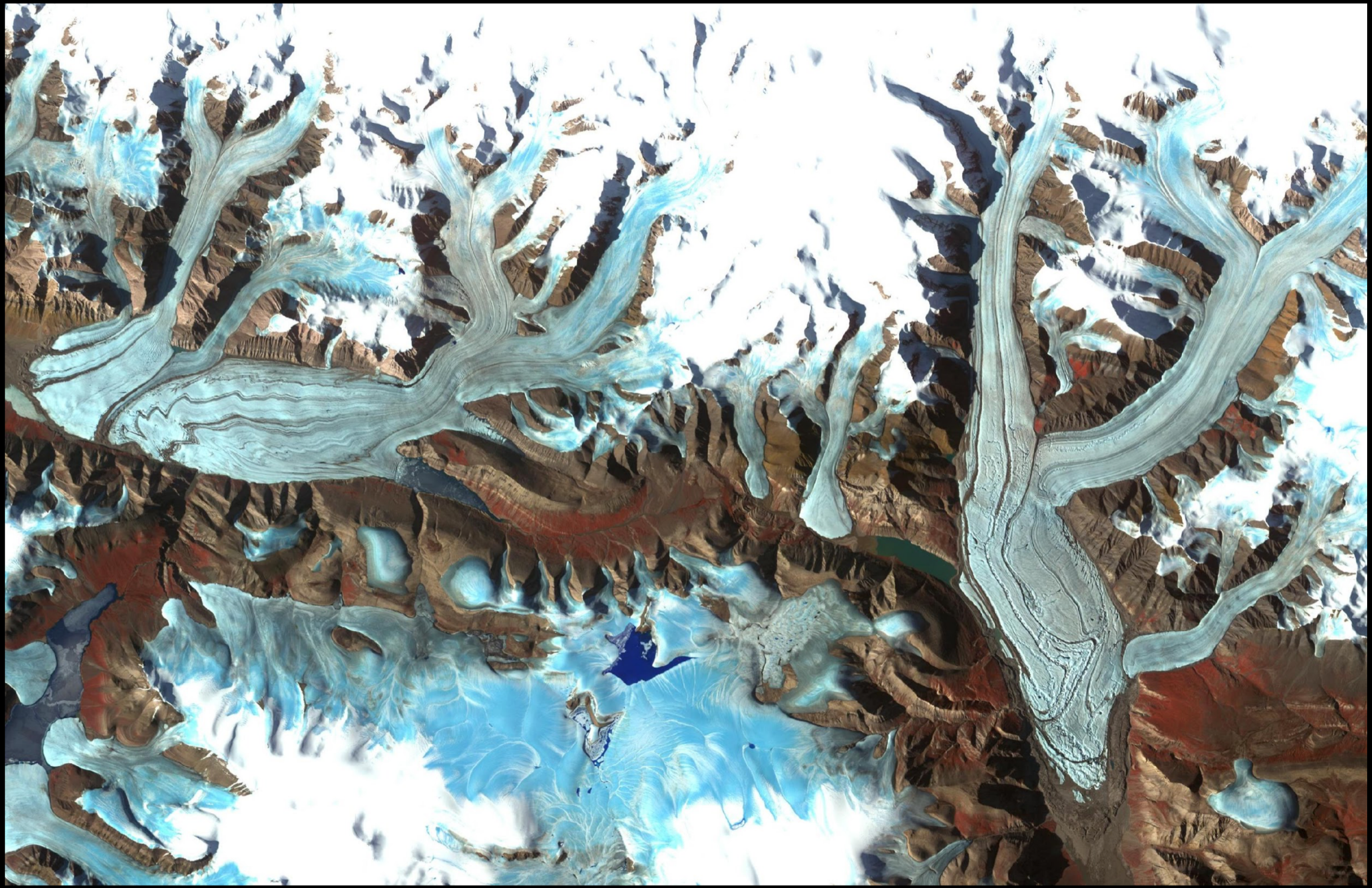


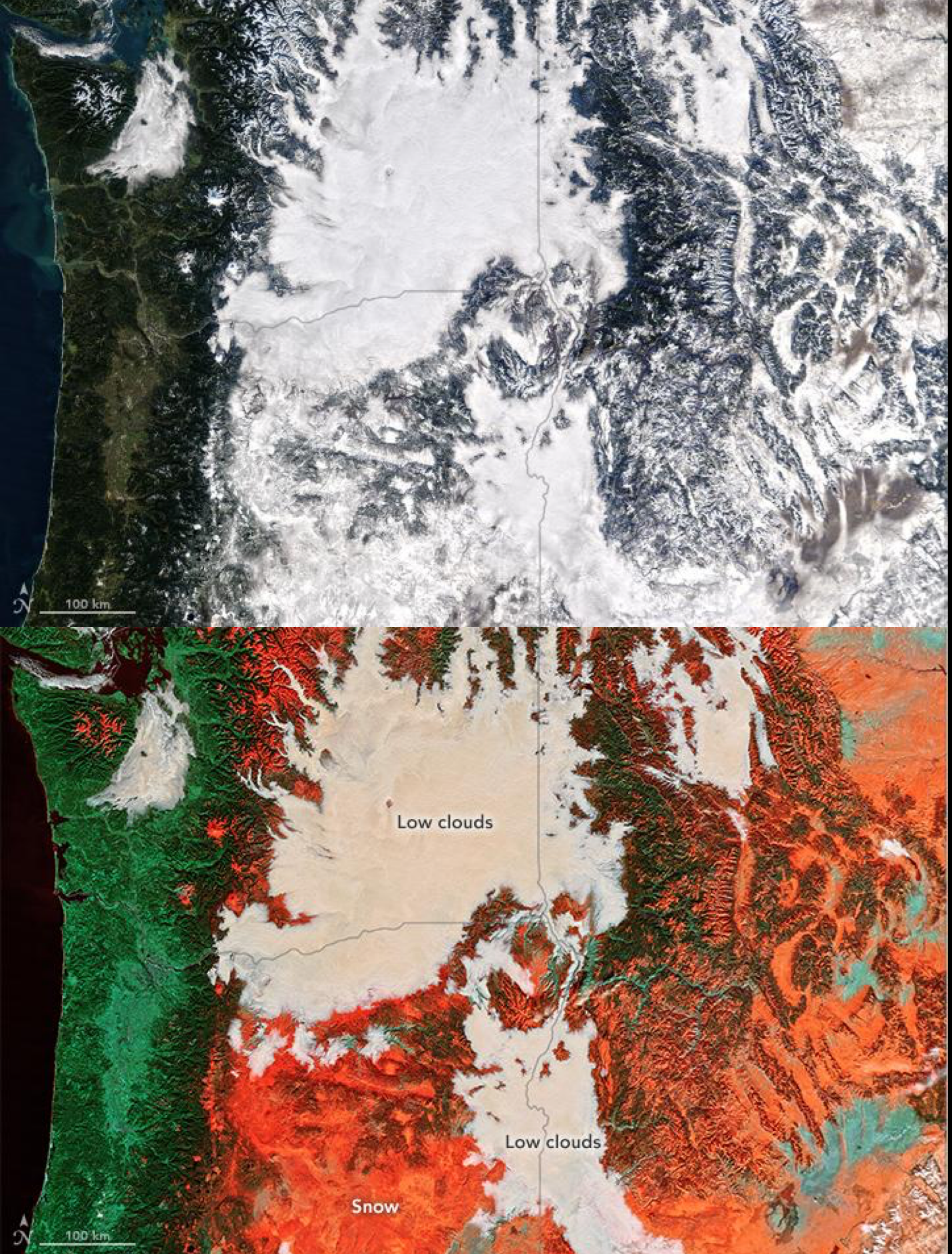
Collapse of An Ice Shelf

Over a period of several months in early 2002, the MODIS instrument on Terra observed the Larsen B Ice Shelf in Antarctica collapse and disappear, giving scientists and the world a birds-eye view to of this dramatic event.

Changing Glaciers

A lot can change in 20 years, even for things moving at a glacial pace. Terra's 20 years of data on global glacial changes are used to monitor the extent and volume of glaciers as the climate warms. In collaboration with the Global Land Ice Measurement from Space Project, over 18,000 glacier scenes are available in several specialized archives.



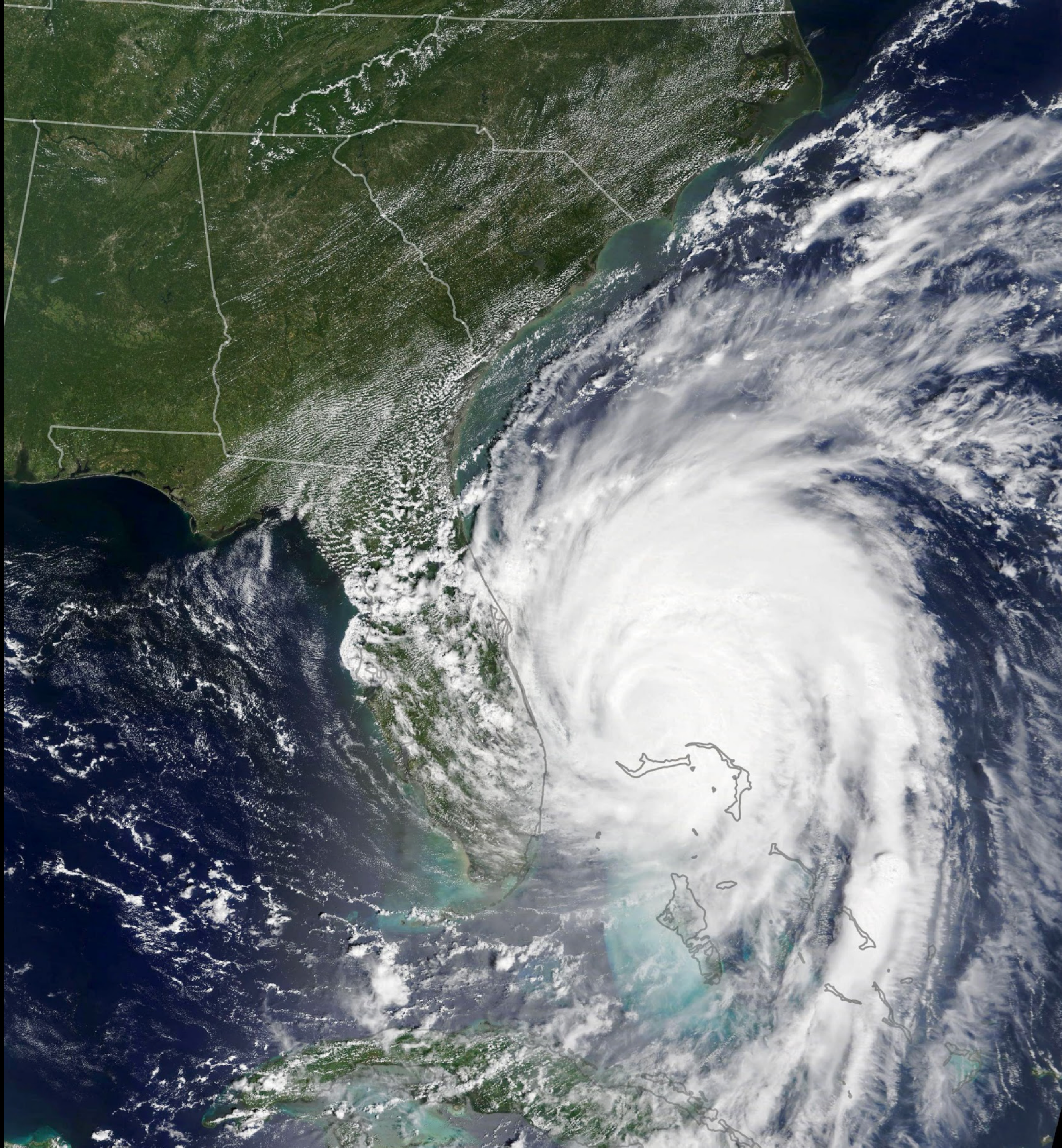


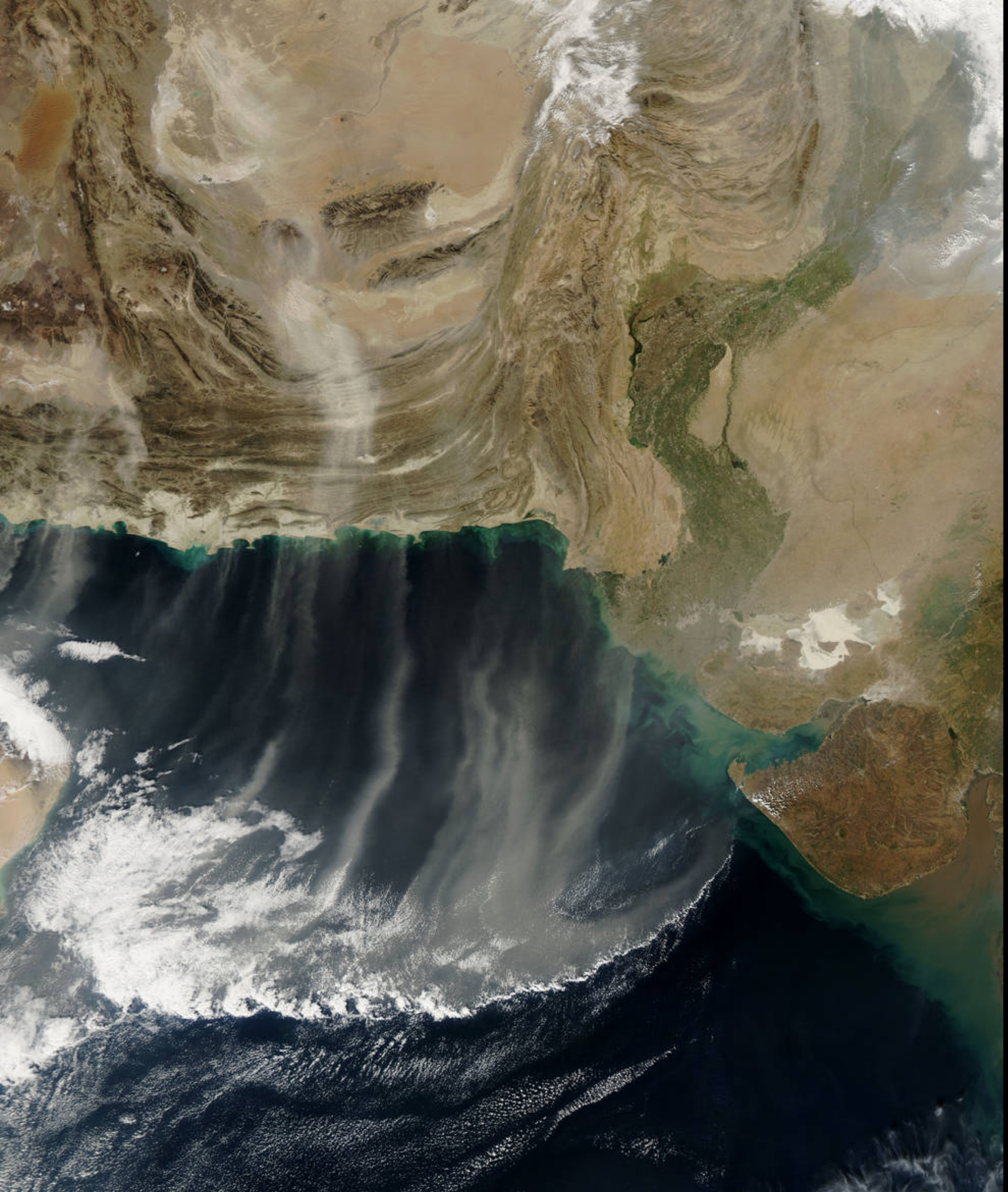
Not Everything White is a Cloud

Clouds and snow are the same color, are made of water, and both develop at cool temperatures. Although similar, snow and clouds are not the same. MODIS on Terra measures different wavelengths of reflected light from Earth. Snow absorbs and reflects different wavelengths of light than clouds, even if they both look white to us. The top natural color shows how the human eye would see it, just a lot of white. The second, false-color image was composed from blue and shortwave infrared light, measured by MODIS. Scientists use these wavelengths to reveal what the human eye cannot.

Weather Forecasting

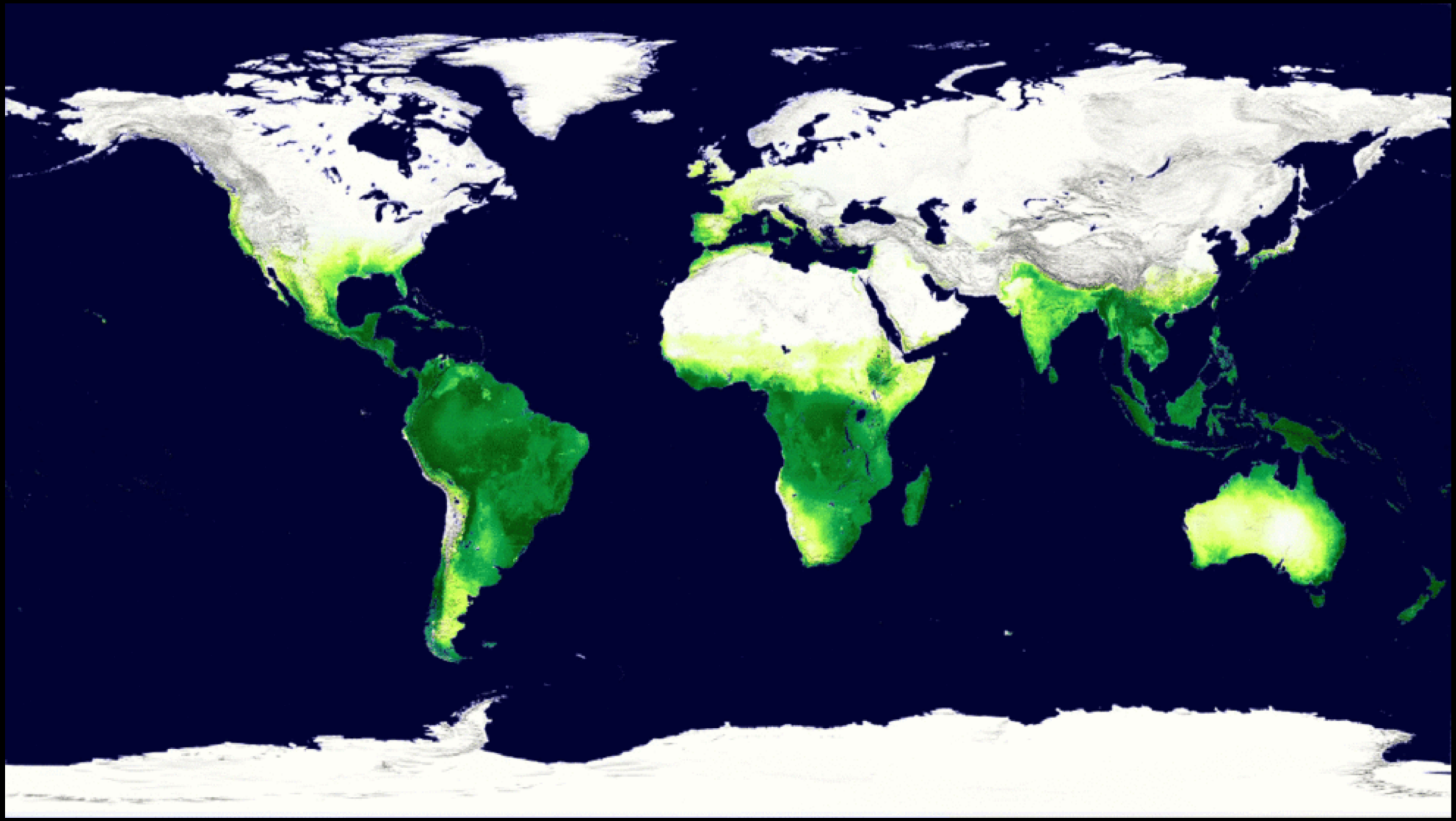
MODIS and MISR provide observations of water vapor, winds, and cloud movement that are used to track motion in the atmosphere and improve weather forecasts and understand how wind speeds vary within hurricanes.





Clouds, Aerosols, and Climate

Clouds and tiny particles called aerosols create uncertainty about how climate changes will unfold. Clouds can reflect the Sun’s rays or trap outgoing heat. Aerosols, can scatter light – causing cooling – or absorb light – causing heating. Scientists use data from MODIS, MISR, MOPITT and CERES on Terra to keep a continuous, long-term record of clouds and aerosols that help the science community better understand how clouds influence Earth’s energy balance and climate.



Global Vegetation

Are you seeing green? MODIS on Terra and Aqua show where plants and trees grow. This helps scientists understand how much carbon dioxide plants are absorbing from the atmosphere during photosynthesis. For 20 years, scientists have compared plant productivity around the world, helping us understand how climate change and seasons affect vegetation.

Burning Planet

One-third of Earth’s land surface is touched by fire every year. The MODIS instruments aboard Terra and Aqua scan Earth four times a day to pinpoint active fires on the planet. The real-time fire map is one of the most in-demand products for fighting wildfires in the United States and across the globe. It revolutionized our understanding of wildfires and helps protect people and their property.

Apr 2006

Smokey Skies

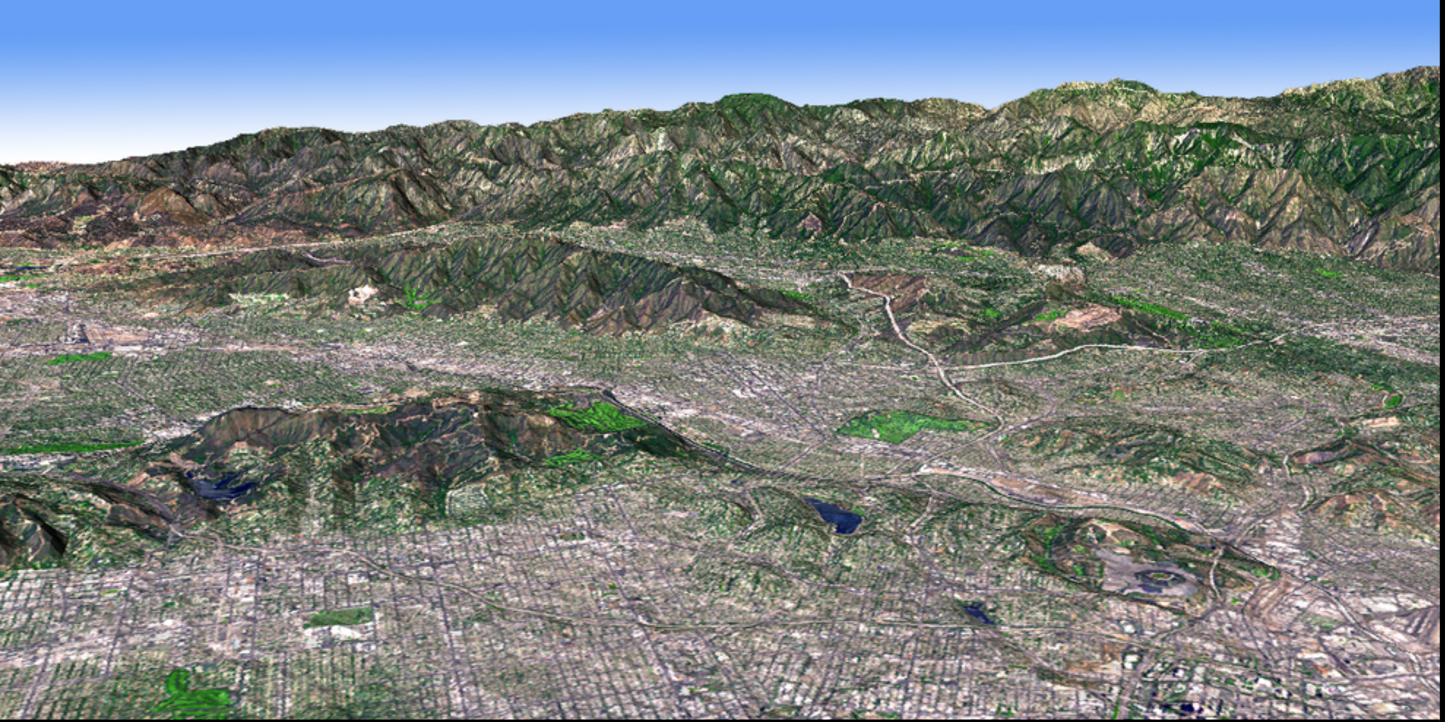
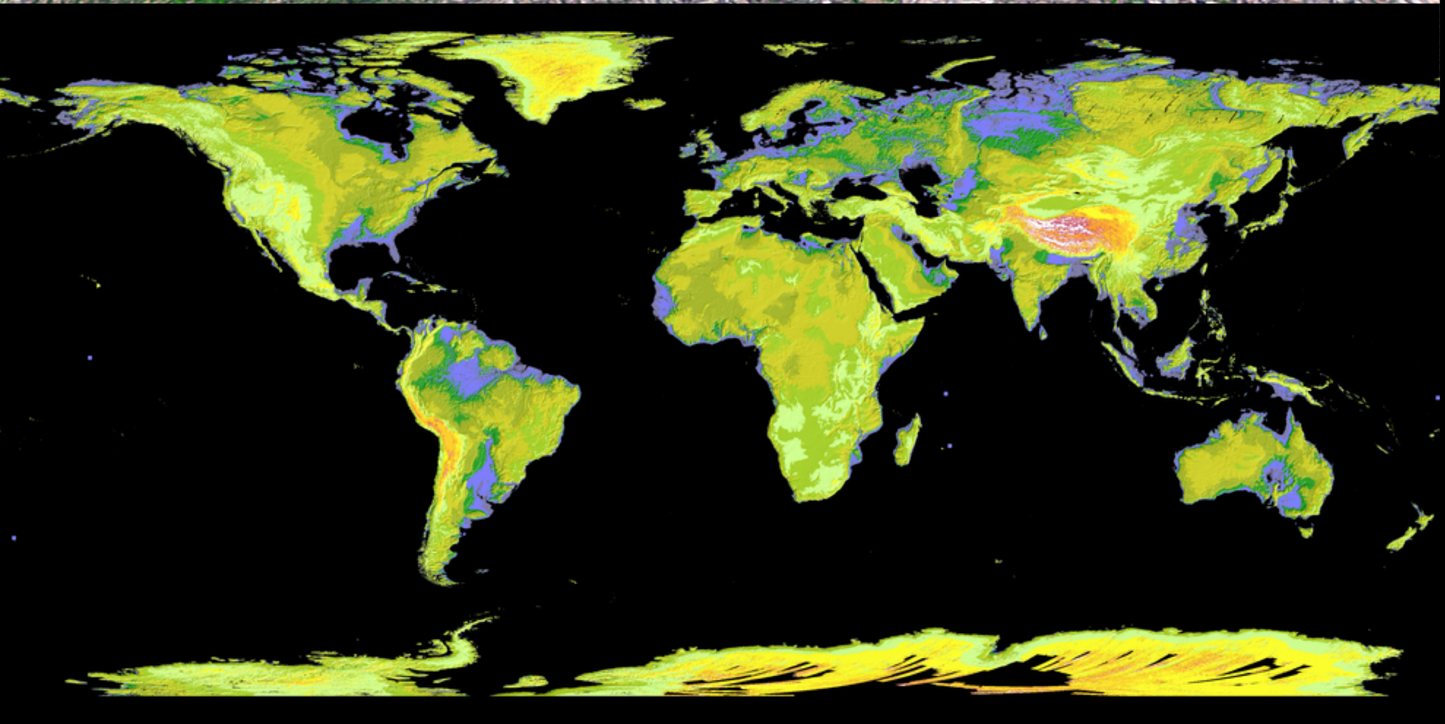
Terra’s instruments not only detect heat from wildfires and “count” active fires around the globe, Terra also collects imagery of active fires and measurements of their smoke and aerosols. The Multi-angle Imaging Spectroradiometer, or MISR, on Terra is instrumental in learning more about how wildfire smoke plumes get “injected” high into the atmosphere and how the plumes mix with clouds and travel through the sky.

Air Quality and Health

Every year nearly 4 million people die prematurely from air quality related deaths. Air quality data from MISR, MOPITT, and MODIS are being used to improve forecasting models and identify sources of pollution. This data helps people better understand where air quality may be hazardous, so they can take steps to protect themselves.

Plankton Paints the Ocean

Phytoplankton bloom for hundreds of miles. Globally, these blooms account for about half of the net photosynthesis on Earth and are important in taking carbon out of the atmosphere and transferring it to the ocean. Daily ocean color measurements from MODIS aboard the Terra and Aqua satellites have dramatically changed scientists' understanding of the complex biological and physical relationships between phytoplankton, marine ecosystems, and the global carbon budget.

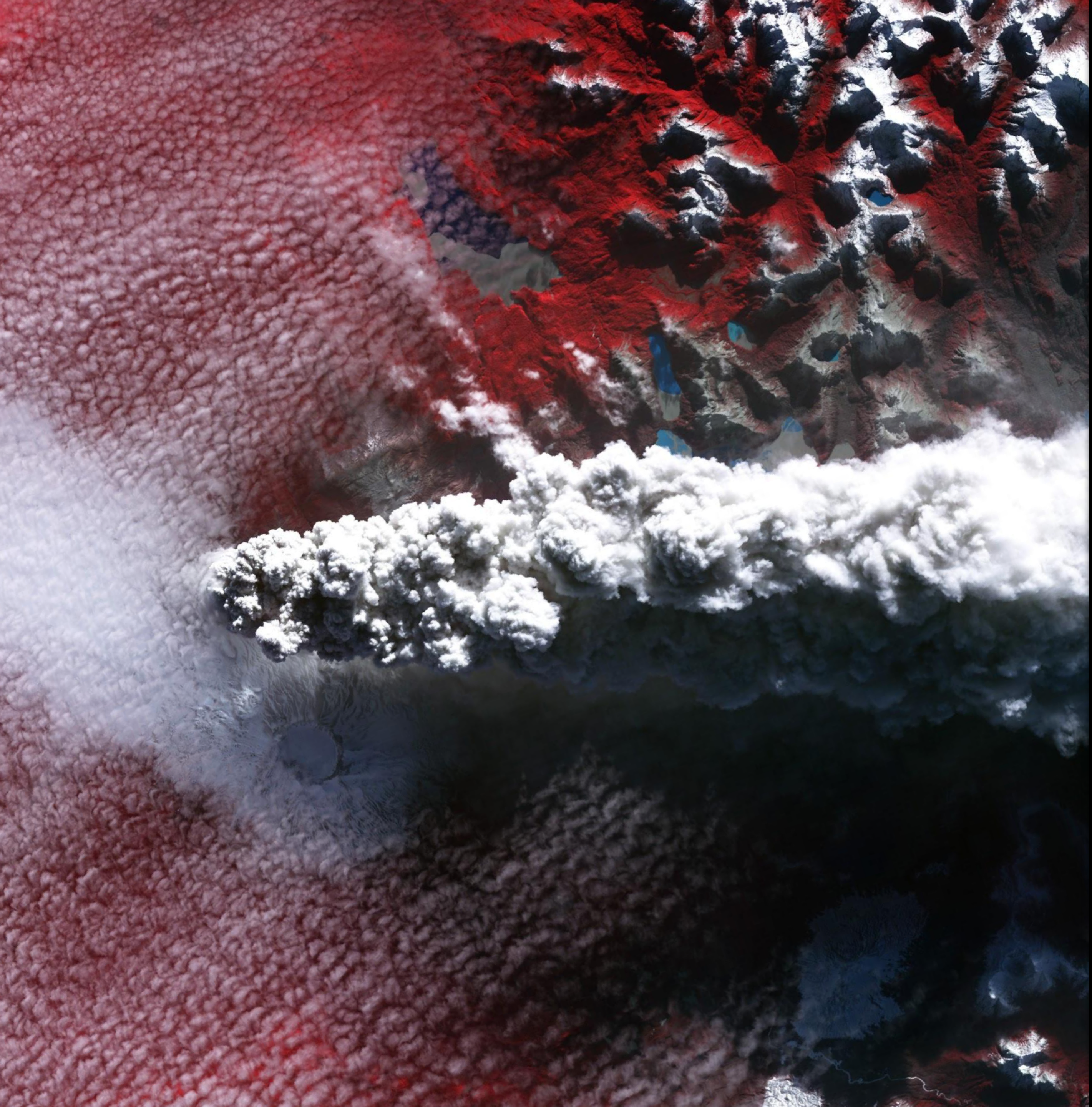



Topping Topo Maps

Terra’s Advanced Spaceborne Thermal Emission and Reflection Radiometer, or ASTER, collected data to create the the highest resolution global digital elevation model, covering 90% of Earth's surface from nearly pole to pole, including rivers, lakes and oceans as of 2019. Scientists use elevation data to understand how the land changes over time and as an important factor in identifying landslide risk.

Volcanoes and Flight

MODIS daily images are used to track volcanic ash, which can damage jet engines. MISR has also been used to estimate volcanic plume height to provide a better estimate of where ash is in the atmosphere. Both MODIS and MISR measurements help decision makers divert air traffic away from ash plumes.

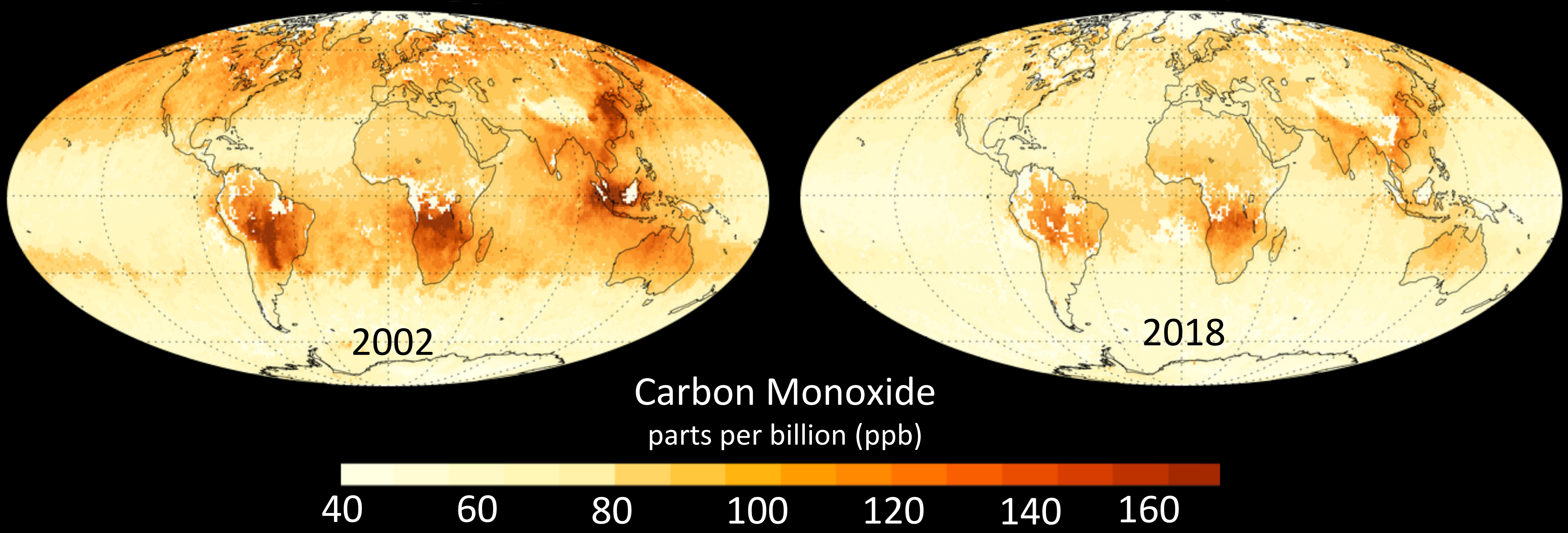


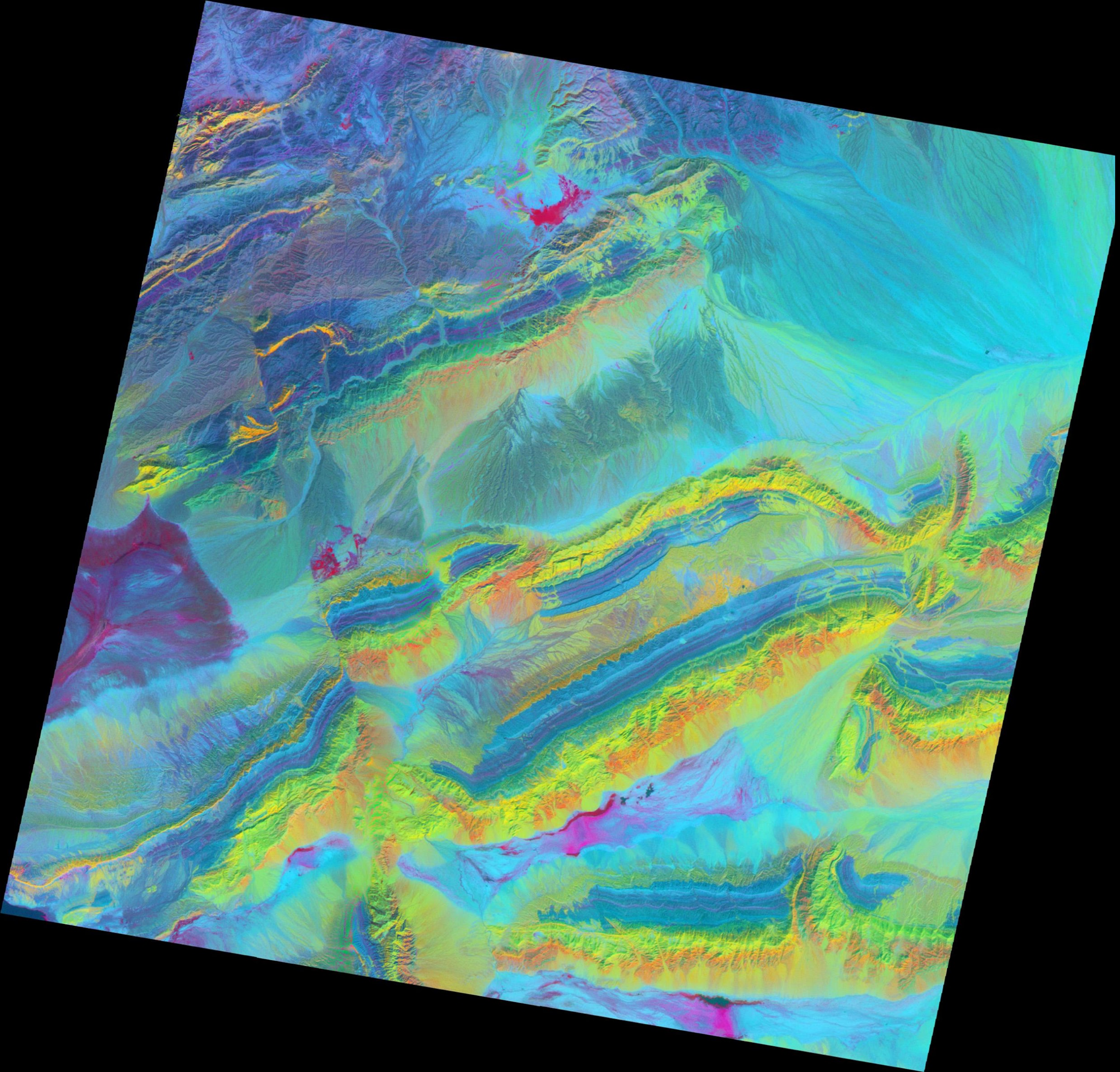
Monitoring Active Volcanoes

MODIS and ASTER also work together to monitor volcanic activity, particularly in remote regions. When MODIS detects an abnormal hot spot over a volcano, a request for a high-resolution ASTER image of the volcano is automatically scheduled. ASTER’s high resolution visible, infrared, and thermal infrared measurements provide unprecedented information about erupting volcanoes, helping people better anticipate when one may erupt.

Mapping Carbon Monoxide

Measurements of Pollution in the Troposphere, or MOPITT, was the first long-term satellite instrument dedicated to tracking sources of carbon monoxide, an air pollutant from incomplete combustion from fires, factories, and cars. MOPITT tracks the gas across the globe, improving climate models and air quality forecasts. MOPITT data shows that levels of carbon monoxide have decreased globally over the past two decades.



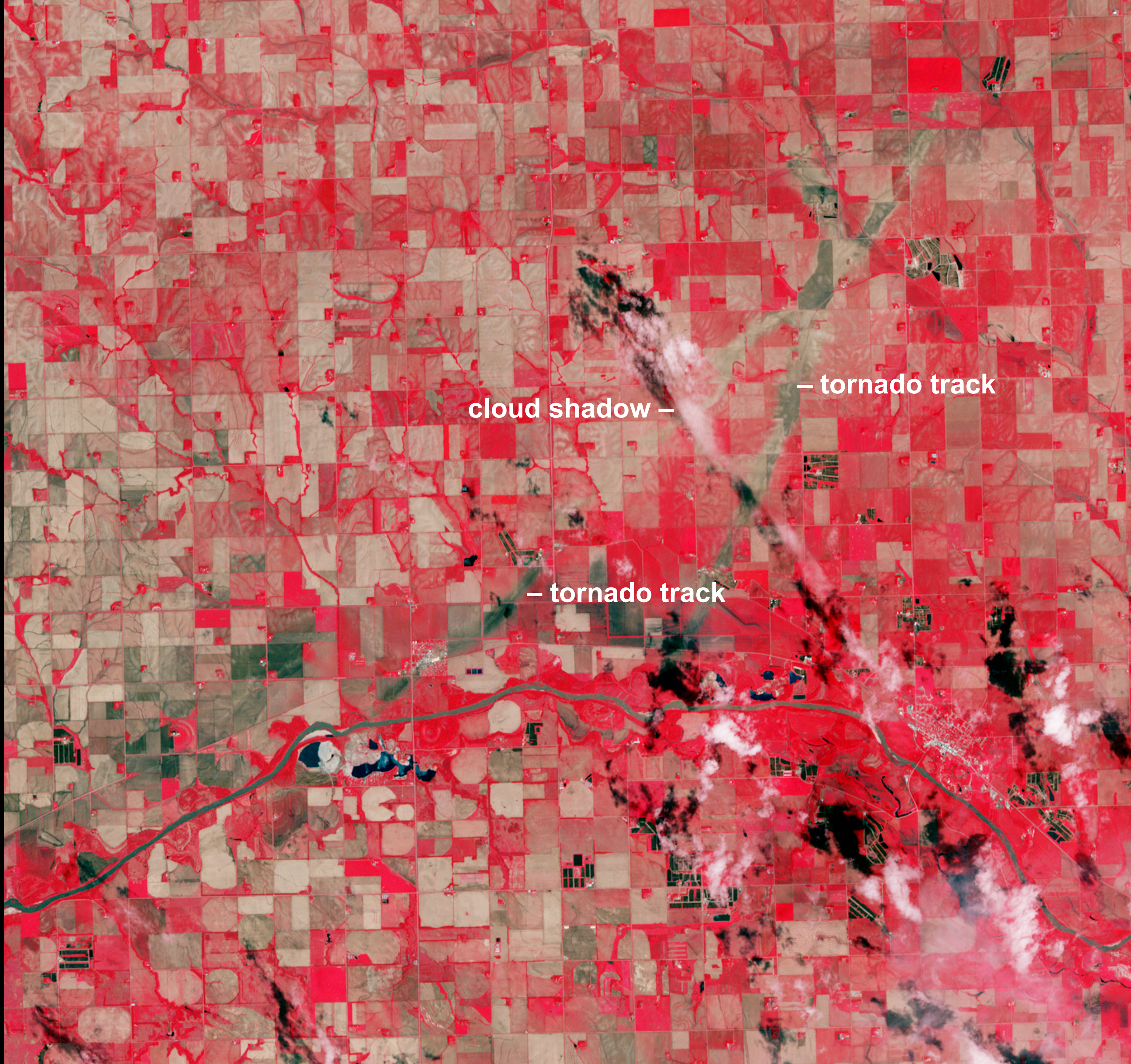


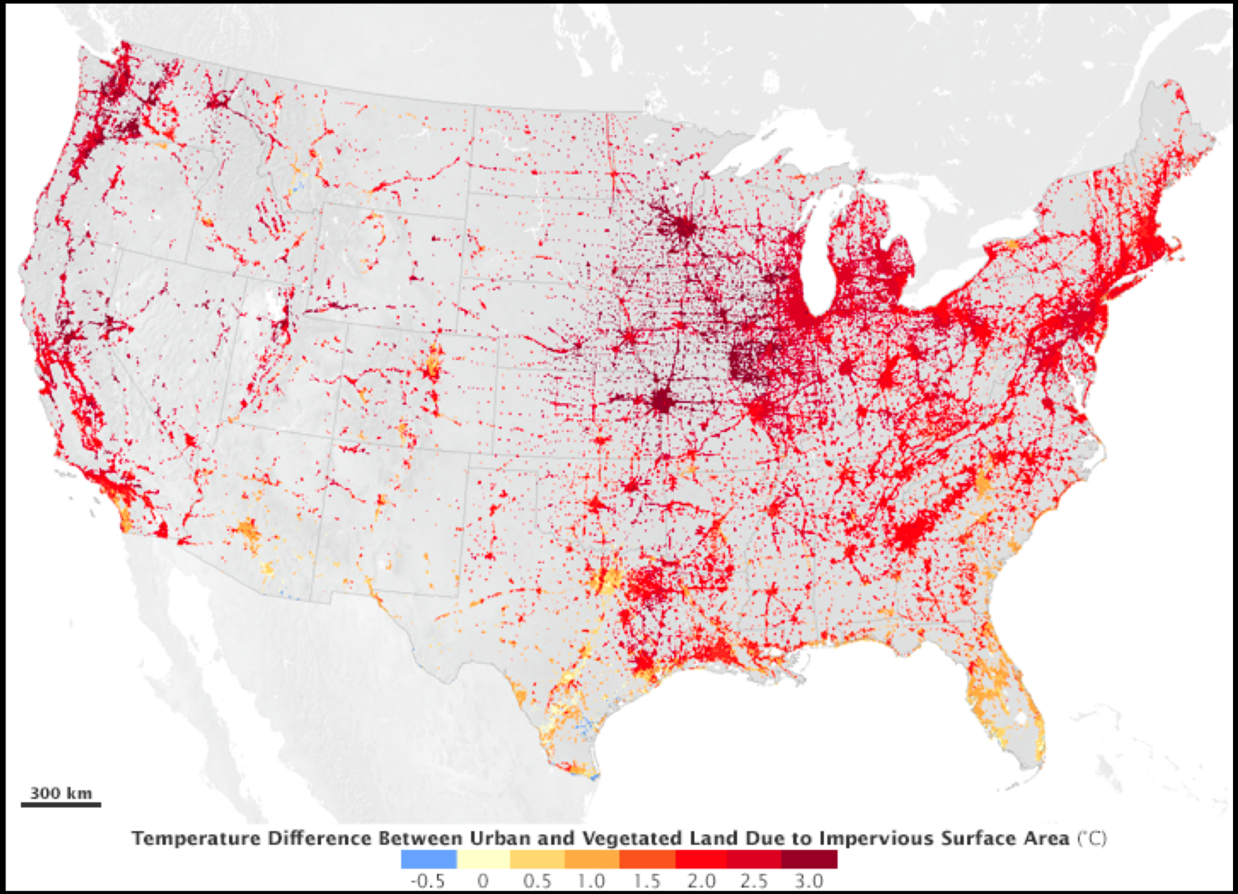
Revealing History in Rocks

ASTER collected specialized data from the short wave infrared part of the electromagnetic spectrum. By analyzing these wavelengths of light geologists can tell the difference between limestone and sandstone, as well as other types of rocks and minerals, from space.

Tracking Natural Disasters

False-color images like this show where disaster has struck. In this image from ASTER, two EF-4 tornado tracks are visible. The tracks are tan paths of bare ground across plant-covered fields, shown in red. Terra data are essential for disaster response, helping relief workers identify affected areas.



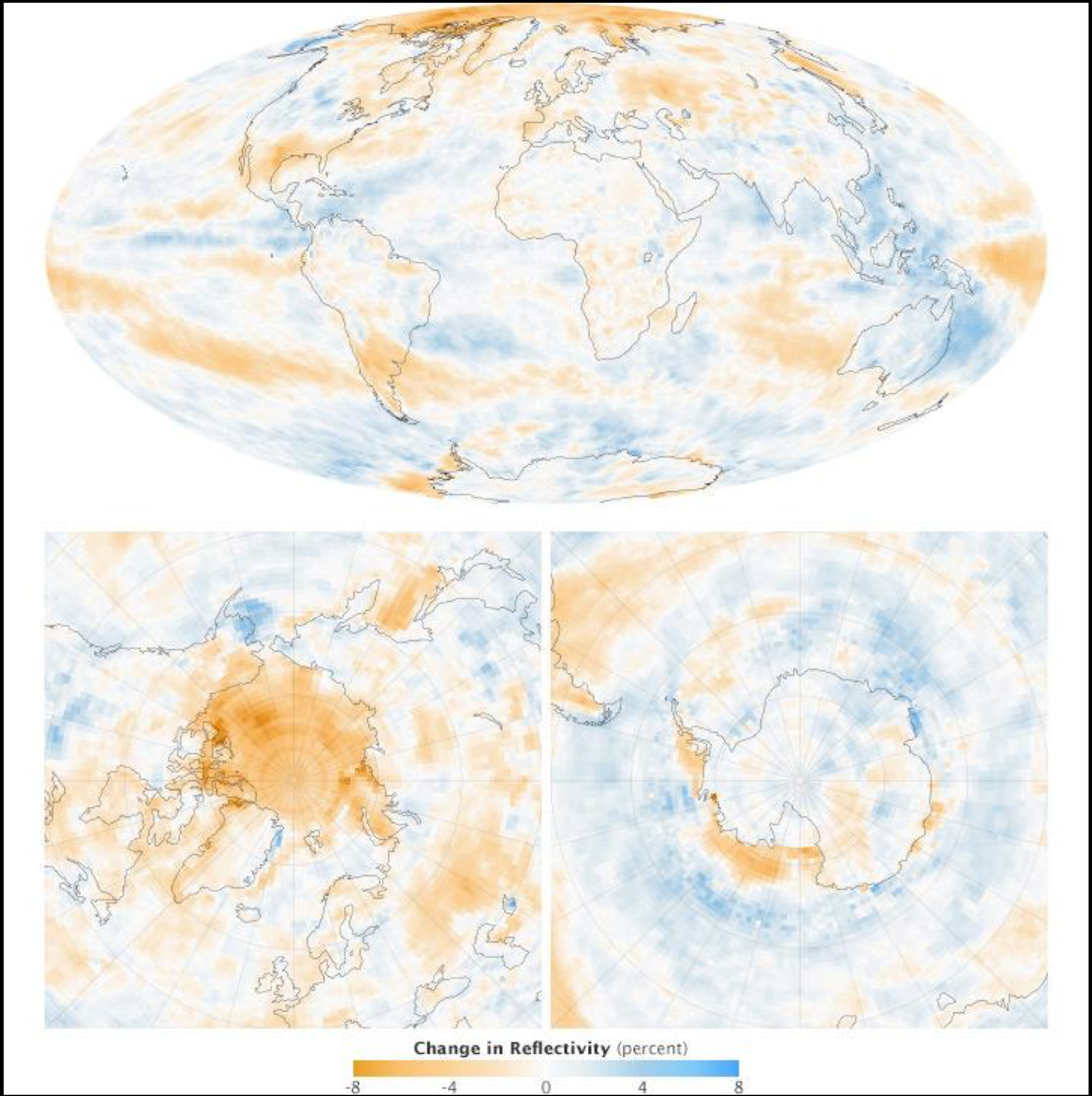


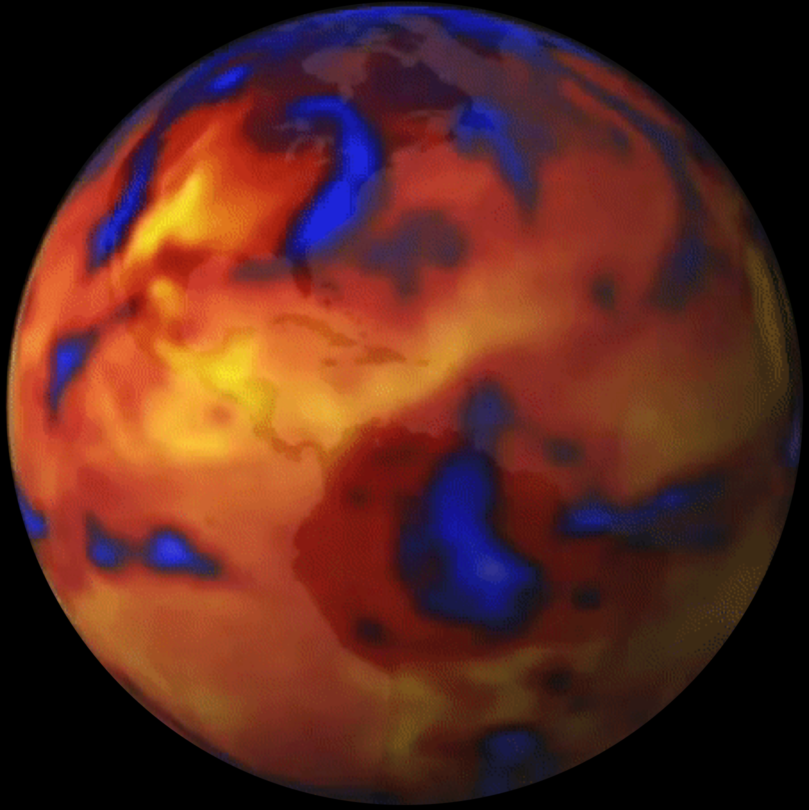
Vegetation Limits City Warming

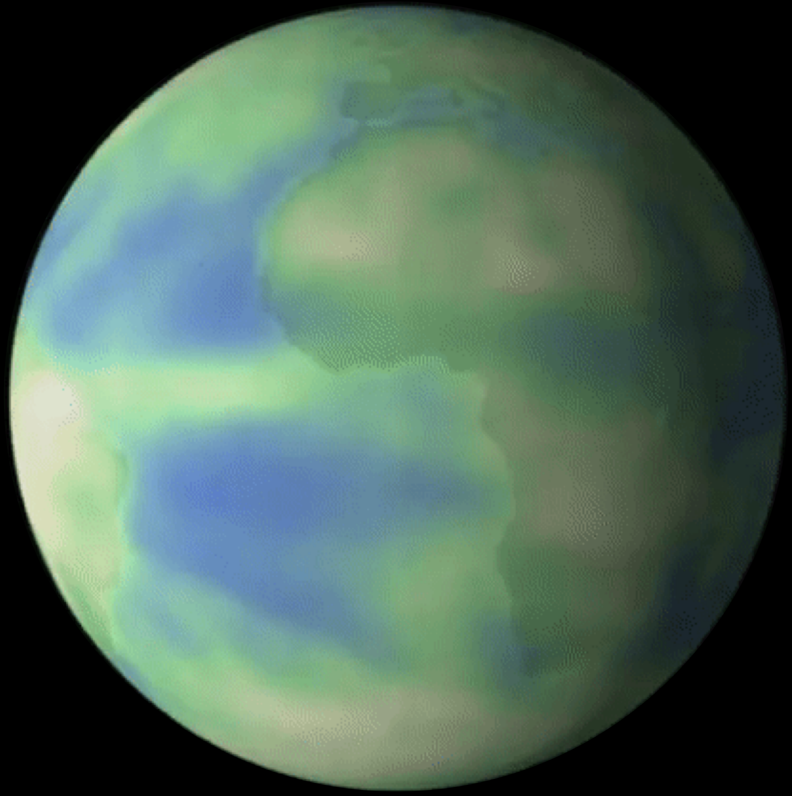
Terra surface temperature data along with data from other satellite missions were used to create a climate model, showing the interaction between vegetation, urbanization, and the atmosphere across the continental United States. This valuable data shows how plants along urban roads, in parks, and in wooded neighborhoods can regulate warming effects from urbanization.

Energy Balance

For over two decades CERES has documented Earth's energy as sunlight reflects off of Earth's surface and Earth releases its own energy. Differences in the amount of energy emitted and reflected can shed light on how Earth's energy budget is being maintained. While Earth's overall energy has stayed largely constant, regional patterns emerged. For example, at the North Pole, reflectivity decreased, a result of the declining sea ice on the Arctic Ocean and increasing dust and soot on top of the ice.





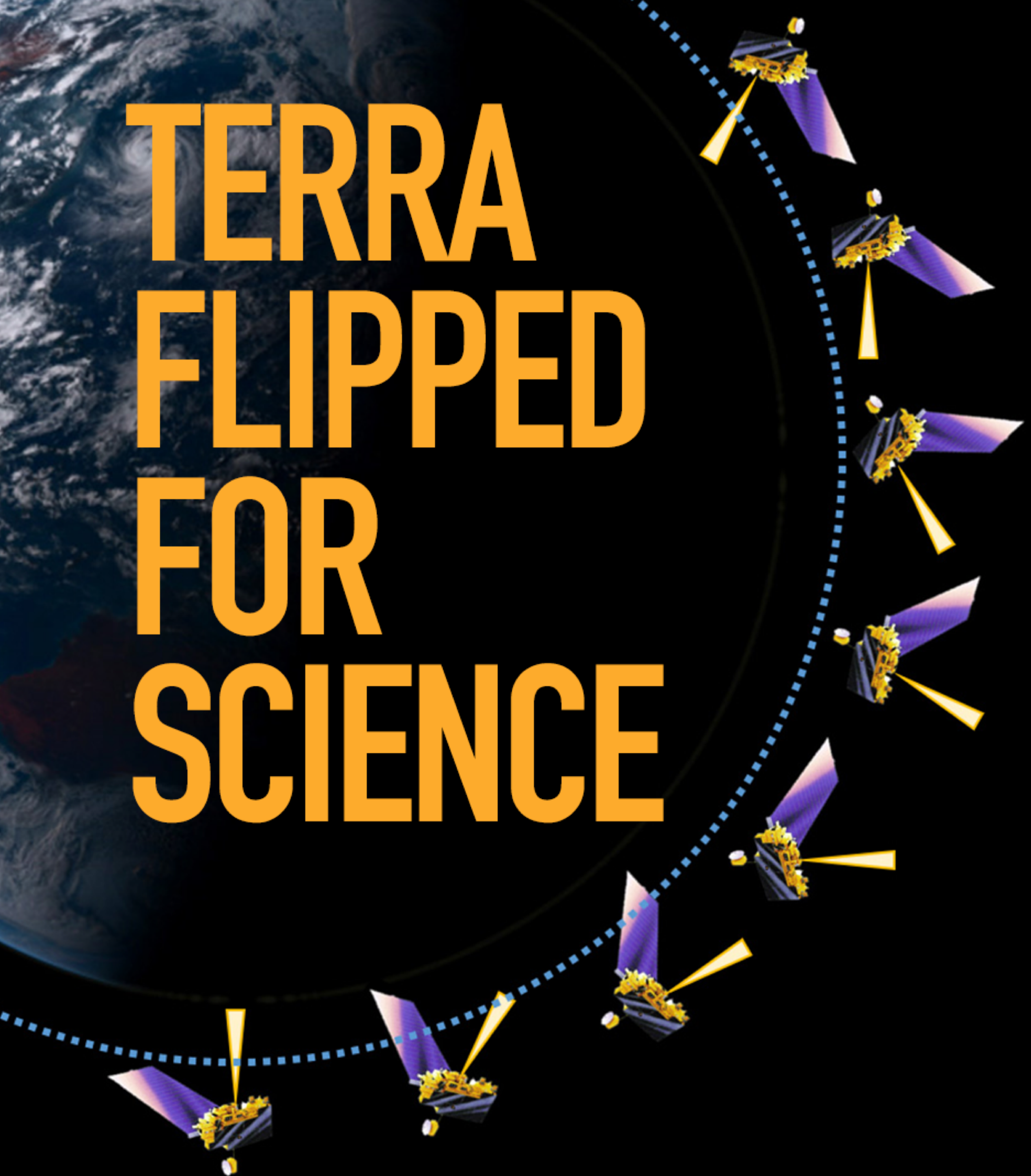


Taking Climate CERESly

Climate models rely on data to test their accuracy. Terra’s 20 years of data makes it possible to test climate models against collected data. Abnormally cloudy years like during the El Niño of 2015 can throw off results. Recently six different climate models were tested against CERES data. Of the six, one model resulted in accurately predicting results in line with the data collected.

Look mom! No hands!

When Terra has a problem, there is no one there to swap out parts or make small fixes. In 2009, a micrometeoroid struck a power cell, degrading the thermal control for the battery. The team of engineers used what they had to fix the problem, their problem solving skills and the battery itself. Using the charge and discharge cycle of the battery, enough heat is generated to keep the battery operating.



Looking Back for Black

In 2003 and 2018, the Terra flight operations team of engineers successfully executed a “backflip” for science. Terra flipped to look out into the black of deep space. This allowed Terra’s instruments to check the calibration of their optic sensors, which makes the data collected by Terra more accurate.

CREDITS

- All images and videos are provided by NASA's Science Visualization Studio, NASA Visible Earth or NASA Earth Observatory.
- Special thanks to the team of Terra scientists for their help in developing this presentation. This slideshow can be downloaded from https://terra.nasa.gov
- Presentation compiled by Tassia Owen, Senior Communications Specialist (Terra Mission).

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