15@15: 15 Things Terra has Taught Us in Its 15 Years in Orbit

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Introduction

Fittingly for NASA's then-nascent Earth Observing System (EOS), the first of what would become three "flagship" satellite missions was named *Terra.* Beginning with the prosaic designation of AM-1—because of its sun-synchronous polar orbit, with a descending-node 10:30 AM equator-crossing time—Terra, launched in December 1999, forged paths of science goals, design, and implementation that subsequent platforms have continued, with wonderful success. While Terra has not (yet) broken any records for longevity, it is still operating at near-full capability now nine years beyond its designed six-year lifetime, with only slight reductions in its data-gathering capabilities—as described here. The rest of the platform is in fine shape, and scientists and engineers expect it to continue to collect valuable data for almost another decade.

Terra's Origins and Mission

In the late 1980s and into the early 1990s, as EOS began to travel the long and difficult road from concept to reality[1], there was as yet no unified plan to explore the phenomena that together make up the Earth system. The concept of studying the Earth as a system of systems was a new paradigm—one that required new ways of exploring these phenomena.

It was clear from early investigations, and often from simple observation, that the Earth was in a constant state of flux, with data that showed that humans could have an effect on such phenomena. Furthermore, the success of pioneering programs such as Nimbus and follow-on missions (e.g., the Upper Atmosphere Research Satellite (UARS), Landsat, the Ocean Topography Experiment (TOPEX)/Poseidon, and the series of Total Ozone Mapping Spectrometer (TOMS) instruments[2]) had shown that satellites could be useful tools for studying Earth-system phenomena. Think, for example, of the historical underpinnings of the formation and causes of the Antarctic ozone "hole" that led to the 1987 Montreal Protocol that banned stratospheric ozone-depleting substances (ODS).

In this light, thousands of scientists, engineers, administrators, and managers worked to bring EOS into being, with plans to begin a systematic exploration of our home planet[3]. The first of the planned series of probes was Terra—an international mission, with major contributions from the U.S., Japan, and Canada.

Terra was to explore the state of and changes in specific phenomena—and interactions between them—in the atmosphere, in and over the ocean, on and over land masses, precipitation as snow and ice, land and sea ice, and Earth's energy budget.

Terra's Manifest

The Terra platform is approximately the size of a small school bus—6.8 m (22.3 ft) long by 3.5 m (11.5 ft) across, weighing just under 5190 kg (11,442 lbs). It orbits Earth at an altitude of 705 km (438 mi) at an inclination of 98.5°. This gives it an orbital period of 99 minutes, for 16 orbits per day. As mentioned earlier, it crosses the equator at 10:30 AM (and also at 10:30 PM). (In contrast, Aqua, the second "flagship" mission, crosses the equator at 1:30 PM (and also at 1:30 AM)—and was originally called PM-1.)

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[1] For an excellent compendium on the origins of EOS, download the special "Perspectives on EOS" issue of *The Earth Observer* found at *eospso.gsfc.nasa.gov/earthobserver/new-perspectives-eos*.
[2] TOMS flew onboard Nimbus-7 [1978-93], the Russian Meteor-*3M* satellite [1991-94], the Japanese Advanced Earth Observing Satellite (ADEOS) [1996-97], and Earth Probe [1996-2006]; QuikTOMS also carried a TOMS instrument onboard, but failed to reach orbit in 2001.
[3] For more information on the process, refer to the March-April 2014 issue of T*he Earth Observer* [**Volume 26**, **Issue 2**, pp. 4-13].

To meet the scientific mission requirements, Terra was outfitted with five instruments designed to explore phenomena at or near Earth's surface. These are the:

- Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), provided by the Japan Aerospace Exploration Agency (JAXA);
- Clouds and Earth's Radiant Energy System (CERES), provided by NASA;
- Multi-angle Imaging Spectroradiometer (MISR), provided by NASA;
- Moderate Resolution Imaging Spectroradiometer (MODIS), provided by NASA; and
- Measurements of Pollution in the Troposphere (MOPITT), provided by the Canadian Space Agency

In addition, NASA provided the spacecraft and launch vehicle, an Atlas II-*AS*[4].

While the instrument manifest is still largely operational, the short-wave infrared (SWIR) data from ASTER became unavailable after that subsystem's design life. The robust array of similar and extended-capability instrumentation currently in orbit on other Earth-observing platforms—both in the A-Train[5] and elsewhere—can make up for this small lack of data.

Terra's Data

A window into the scientific planning that formed the core of its implementation in *Terra* is provided by noting that together, the five instruments generate 79 data products, designed to provide their own information and to work in concert with other data products to further expand our knowledge of Earth's systems. The data are provided in *hierarchical data format* (HDF), a commonly used system across many disciplines and that has available many tools to search, browse, and display the resulting files.

Key to the success of EOS was the implementation of the EOS Data and Information System (EOSDIS[6]), with data repositories located at the Goddard Earth Sciences Data and Information Services Center and several discipline-specific Distributed Active Archive Centers (DAACs). Specifically, these include the Atmospheric Science Data Center (ASCD) Level 1 and Atmosphere Archive and Distribution System; the Land Processes DAAC; and the National Snow and Ice Data Center (NSIDC). Users with appropriate facilities may also access MODIS via *direct broadcast* capabilities. Additional information on Terra's data and acquisition and analytical capabilities is found at *terra.nasa.gov/data*.

For more than 15 years, the marvelous piece of technology called Terra has enabled new discoveries in Earth System Science. Dedicated engineers and scientists work together to calibrate instruments, process and store the vast quantities of data returned, validate results, and continue to coax cutting edge science out of aging hardware.

Terra's Findings

For more than 15 years, the marvelous piece of technology called *Terra* has enabled new discoveries in Earth System Science. Dedicated engineers and scientists work together to calibrate instruments, process and store the vast quantities of data returned, validate results, and continue to coax cutting edge science out of aging hardware. The results are manifold and too many to describe here. However, in an effort to provide at least a sense of what Terra has provided us, in the rest of this article we will explore 15 findings—on an instrument-by-instrument basis, listed alphabetically—that are interesting and useful in their own right, and that serve as examples of what Terra (and its follow-on EOS and international-partner missions) have accomplished and will continue to accomplish for years to come. Short descriptions of each instrument's observational capabilities will precede example findings. The order of the examples is in no way indicative of prioritization of relative importance.

[4] A complete description of the Terra mission, including its five instruments and data products, can be found in the *2006 Earth Science Reference Handbook* (*eospso.gsfc.nasa.gov/sites/default/files/publications/2006ReferenceHandbook.pdf*), pp. 225-237.

[5] For a description of the A-Train, refer to the January-February 2011 issue of *The Earth Observer* [**Volume 23**, **Issue 1**, pp. 12-23].

[6] For perspective on the development of EOSDIS, see "EOSDIS: Where We Were and Where We Are—Parts I and II" in the July–August 2009 [**Volume 21**, **Issue 4**, pp. 4-11] and September–October 2009 [**Volume 21**, **Issue 5**, pp. 8-14] issues of *The Earth Observer*.

ASTER

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is a high-spatial-resolution instrument—the only such on Terra—at resolutions ranging from 15 m (~49 ft) to 90 m (~194 ft). It images Earth in 14 wavelengths across visible and infrared wavelengths, to take measurements of land surface temperature, emissivity, reflectance, and elevation.

1. ASTER Global Digital Elevation Model (GDEM):

In 2009 the ASTER GDEM was completed, revealing the topography of the land surface of Earth at the highest spatial resolution then available. Instead of loading up equipment and supplies and then trekking into the most remote parts of the world (e.g., Siberia) and then repeating this task over every 30-m (~98-ft) section of land on Earth, many such trips are no longer necessary with the completion of the ASTER GDEM. Indeed, data from ASTER were used to create the most detailed inventory of topography on Earth. The map in **Figure 1** shows the resulting topography for Earth's land surfaces.

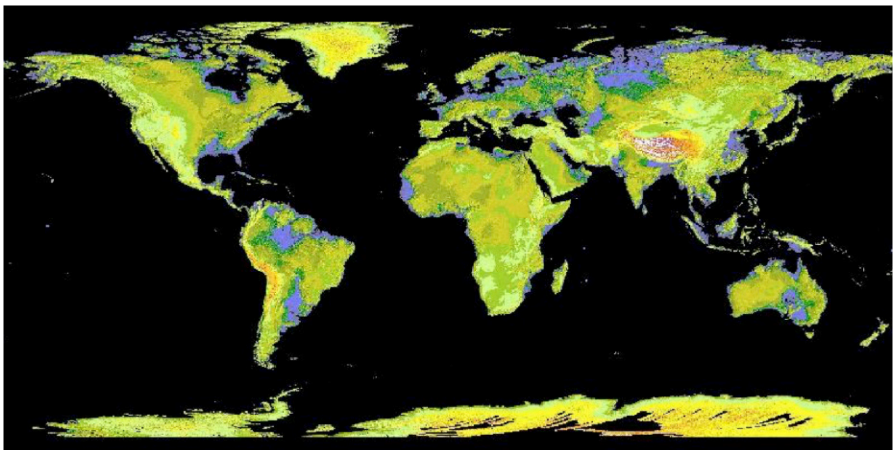

Figure 1. Blue and dark green areas are lower elevations than yellow areas. Red areas are higher elevations. These are highest over the Himalayas, the highest land elevations in the world. **Image credit:** NASA/Goddard Space Flight Center/METI/Japan Space Systems, and U.S./Japan ASTER Science Team

Such in-depth knowledge of Earth's topography is important in understanding climate impact studies that study how control factors such as evaporation, water flow, mass movement, and forest fires can impact climates and further change Earth's surface; the ASTER GDEM supports these studies. In addition, hydrologists use the information from the ASTER GDEM to understand the movement of water, glaciers, and ice over Earth's surface. Further, more accurate models of Earth's land surface leads to improvements in weather forecast models.

The ASTER GDEM is also used to help aircraft guidance systems locate potential risks in areas where there may be an unsupported airstrip, such as in military actions, or when assistance is being sent to areas affected by catastrophic events.

The ASTER GDEM is a collaboration between the Ministry of Economy, Trade, and Industry (METI) of Japan and NASA. The data are free to all users.

For more information about the ASTER GDEM, visit *asterweb.jpl.nasa.gov/gdem.asp*.

2. ASTER and Advanced Industrial Science and Technology (AIST) Global URban Area Map [AGURAM]:

AGURAM is the only high spatial resolution map of the extent of urban areas for the 3750 cities whose population is greater than 100,000.

While it's fun to look for notable landmarks in these images, these are more than just "pretty pictures;" there are a number of important applications. At a high resolution of 15 m (~49 ft) per pixel, these data give a unique view of human impact on the otherwise "natural" world, and help city planners and scientists better understand how these local impacts contribute to changes globally. For example, by looking at the image, it is easy to identify areas of permeable versus impermeable surfaces and to identify the effects these surfaces have on watersheds. AGURAM also allows scientists to study *urban heat islands* and their effects on biodiversity.

Not only are such data being used to track changes in and around cities, they are also used to compare city structure and to support planning for cities of similar size.

For an example of how ASTER/AIST AGURAM is being used, visit *cesa.asu.edu/urban-systems/100-cities-project*.

3. ASTER Global Emissivity Database (GED):

Emissivity is defined as how well Earth's surface emits radiation. Higher emissivity materials emit more radiation at a given temperature than low emissivity materials. Emissivity is directly related to the composition of Earth's surface; unlike surface temperature, it does not depend on weather conditions or the angle of the sun in relationship to Earth.

The ASTER GED is a global, 90-m (~295-ft) spatial resolution, emissivity map of Earth. Other orbiting instruments—e.g., the Moderate Resolution Imaging Spectroradiometer (MODIS), Tropospheric Emission Spectrometer (TES) onboard Aura, and Advanced Infrared Sounder (AIRS) onboard Aqua—used the ASTER GED to validate and improve their data products, e.g., atmospheric gas composition. Such information is also crucial for accurate retrieval of land surface temperature, a component of Earth's energy budget (see also CERES, following).

For more information about the ASTER GED, visit *emissivity.jpl.nasa.gov/aster-ged*.

CERES

There are two Clouds and the Earth's Radiant Energy System (CERES) instruments onboard Terra, designed to explore Earth's radiation budget and the roles that clouds play in modulating radiative fluxes from the surface to the top of the atmosphere by examining solar-reflected and Earth-emitted radiation. As of this writing, there are also operational CERES instruments on two other satellites: Aqua and Suomi National Polar-orbiting Partnership (NPP).

4. CERES measurements of Earth's albedo:

As is frequently the case in just about any kind of research, early results can change over time. In the early days of CERES data, Earth's *albedo*—the ratio of reflected radiation from the Earth to the incoming solar radiation—was thought to be in decline. Albedo is a function of the reflectivity of Earth's surface (land and ocean) and atmosphere, which makes it a key variable in understanding how Earth's energy balance is controlled. **Figure 2** shows by how much the amount of sunlight reflected into space changed between March 1, 2000 and December 31, 2011. This global picture of reflectivity (also called albedo) appears to be a muddle, with different areas reflecting more or less sunlight over the 12-year record. Based on these data, Earth's albedo didn't change much in 12 years—although there were substantial inter- and intrannual differences, particularly over specific regions, such as described in module #5, "Increased absorption of solar energy in the Arctic."

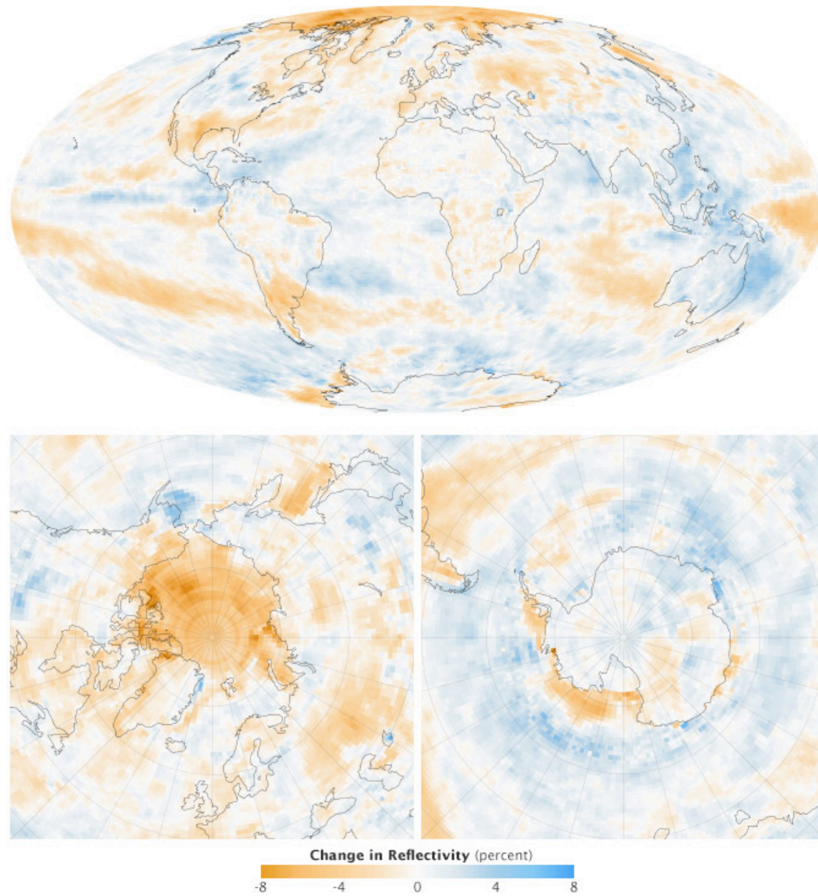

Figure 2. *Change in Earth's reflectivity as measured by CERES between March 1, 2000 and December 31, 2011 from three different viewpoints.* Shades of blue indicate areas that reflected more sunlight over time (indicating increasing albedo), while orange areas denote less reflection over time (decreasing albedo). **Image credit:** NASA's Earth Observatory and Robert Simmon

For more information, visit *terra.nasa.gov/news/measuring-earths-albedo*.

5. Increased absorption of solar energy in the Arctic:

Researchers using CERES data from Terra (and the Aqua and Suomi NPP platforms) have found a 5% increase in absorption of solar energy over the Arctic Ocean between 2000 and 2014. This increase is attributed to increased melting of surface ice in the region, with consequent decrease in albedo and increase in absorbance by the newly exposed darker ocean waters. The Arctic is presenting significant sensitivity to climate change, so data such as these are yet another "arrow" in the research quiver that may further allow greater insight into climate change phenomena.

For more on this finding and for a graphic representation of the data, see the News Story on **page 44** of this issue, and visit *www.nasa.gov/press/goddard/2014/december/nasa-satellites-measure-increase-of-sun-s-energy-absorbed-in-the-arctic/#.VJhm8kCbQg*.

MISR

Unlike many instruments that point in one direction—usually straight down (or *nadir*) or through the atmosphere at Earth's *limb*—Terra's Multi-angle Imaging SpectroRadiometer (MISR) points in nine different angles. Each camera takes measurements in four wavelengths across the visible and into the infrared. Its capabilities allow measurements of natural and human-caused particulate matter in the atmosphere, various cloud parameters, and the types and extent of land surface cover.

6. Eighty percent of the world's population breathes polluted air:

Data from MISR and MODIS have been combined to show that significant numbers of the world's population breathe polluted air. Before Terra, there was no method to use satellites to distinguish aerosols close to the ground from aerosols further up in the

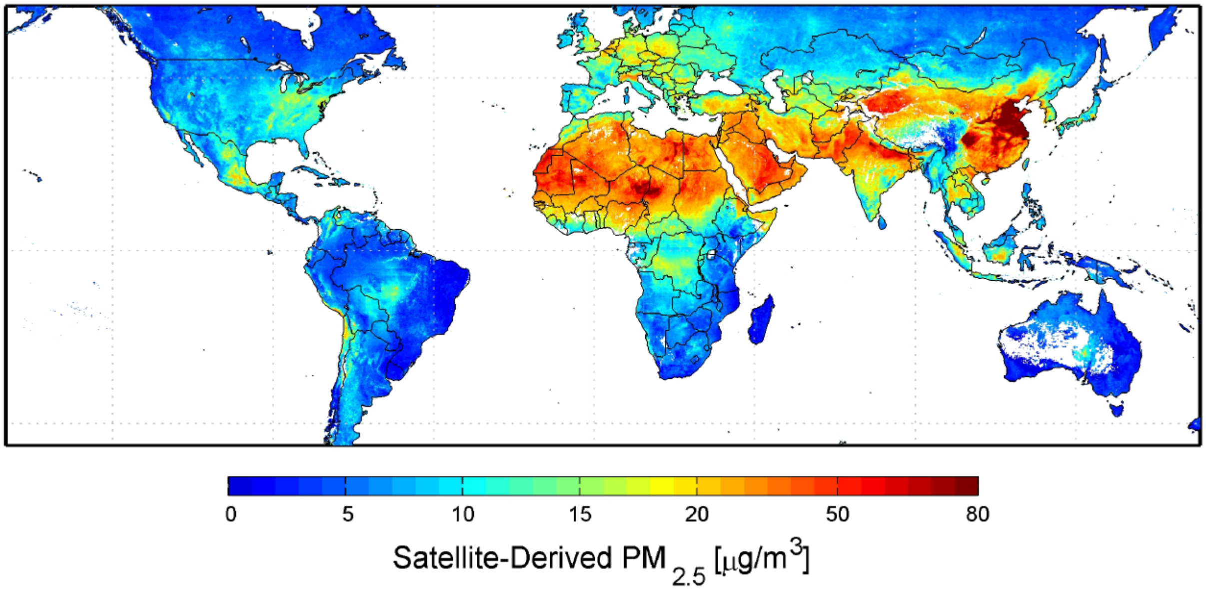

Figure 3. Global satellite-derived map of $PM_{2.5}$ averaged from 2001 through 2006. The map shows very high levels of $PM_{2.5}$ in a broad swath stretching from the Saharan Desert in Northern Africa to Eastern Asia. Levels of $PM_{2.5}$ are comparatively low in the U.S., although noticeable pockets are clearly visible over urban areas in the Midwest and East. Reds and oranges represent higher-levels of particules; blues and greens are lower concentrations. **Image credit:** Dalhousie University/Aaron van Donkelaar

atmosphere. MISR, with its multi-angle capabilities, is able to see the same column of air from multiple angles, thus making it possible to differentiate particles close to the ground from particles higher in the sky.

The map shown in **Figure 3** shows the global average levels of fine particulate matter ($PM_{2.5}$) between 2001 and 2006, the most comprehensive view of the health-sapping particles to date. While the data portrayed here are not the most accurate over developed countries, it is important to note that this is the first such satellite record over several developing countries. When compared with maps of population density, it suggests more than 80% of the world's population breathe polluted air that exceeds the World Health Organization's recommended level of 10 $\mu g/m^3$.

Using these datasets, epidemiologists can look more closely at how long-term exposure to particulate matter in rarely studied parts of the world affects human health. Some areas that are of particular interest include Asia's fast-growing cities or areas in North Africa with dust in the air.

For more information on the detrimental effects of air pollution on human health visit *www.nasa.gov/topics/earth/features/health-sapping.html*.

7. Wildfire plumes reach higher in the troposphere than once thought:

MISR smoke plume observations show that a significant fraction of wildfire plumes are injected into the *free troposphere*—i.e., the part above the temperature inversion layer. Such information is necessary to ascertain long-range dispersal of the particulates. Higher altitude plumes are associated with greater radiative fire heat flux, measured by MODIS. Data taken over North America have shown that between 10% and 30% of wildfire plumes reached the free troposphere as dust and smoke, with consequences for downstream air quality. Particles from these events can have longer lifetimes in the less-turbulent upper troposphere. Understanding such phenomena has significant value for modeling smoke environmental impacts and aerosol transport, with consequent effects on climate change.

For additional information, visit *climate.nasa.gov/news/41*.

8. Longer melt season from cloud cover over Arctic Ocean:

Another corroborative dataset made possible from Terra, combines data from MISR and the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP[7]). Data retrieved over the Arctic Ocean and the Beaufort and East Siberian Seas during the month of October from 2000 to 2010 shows that cloud coverage at altitudes between 0.5 and 2 km (~0.3 and 1.2 mi) has been increasing. Because lower clouds have a net warming effect on the surface in late fall and winter, these findings imply a longer melt season and positive cloud temperature feedback, providing significant support for a feedback hypothesis that involves interactions between boundary layer clouds, water vapor, temperature, and sea ice in the region.

More detailed information on this topic is available at *onlinelibrary.wiley.com/doi/10.1029/2011JD017050/full*.

MODIS

The Moderate Resolution Imaging Spectroradiometer (MODIS) has an extremely broad swath, at 2300 km (~1429 mi), but with a spatial resolution on the order of 250 m (~820 ft). With its 36 spectral bands and the ability to take measurements globally every couple of days, it is something of the "Swiss Army Knife" of sensors. Clouds, their properties, and locations are a clear target, as are aerosols, water vapor, and temperature. MODIS also addresses the global carbon cycle, with focus on the changes in land cover, either natural (e.g., due to fires) or anthropogenic (e.g., due to agriculture or city structure). A MODIS instrument also flies onboard Aqua.

9. Detailed views of hurricanes and related storms:

Among its many other capabilities, Terra tracks storms in the middle of the ocean before they enter the view of geostationary weather satellites. This makes it possible to monitor the hurricanes long before they make landfall. Before Terra, satellites like those in the Nimbus series (first launched in 1964) monitored hurricanes over the oceans, but resolution of what was then known as the "High-resolution Infrared Radiometer" was poor by today's standards, at only 10 mi (~16 km) per pixel at nadir. In contrast, when MODIS began collecting images in 2000, the resolution was far more detailed at 0.15 mi (~0.25 km) per pixel. This advance in technology allows researchers to study hurricanes in much greater detail and use the information to develop and implement better weather models, thereby helping people better prepare in advance for major hurricanes. For more comparisons between legacy and modern storm-tracking capabilities, visit *earthobservatory.nasa.gov/NaturalHazards/view.php?id=84542&src=nha*.

10. Tracking carbon from its source to its sink:

The chemistry of life is frequently referred to as "organic chemistry," which is more formally the chemistry of carbon, and is often measured in ecosystems as the net carbon uptake (incorporation into biomass) by vegetation. For the first time, change in this uptake, or *net primary production* (NPP) for Earth, globally, was calculated using MODIS data, making it possible to visualize and quantify how NPP changed due to rising global temperatures. Previous studies indicated that as temperatures increased, NPP also increased. This was found to be valid for the Northern Hemisphere, but unlike what was originally expected, global net productivity has actually decreased during the time Terra has been collecting data due to reductions in the Southern Hemisphere and the tropics, due to increased drought and dryness. NPP also is used to study the effects of El Niño events, climate change, droughts, pollution, land degradation, and agricultural expansion.

For more information on MODIS contributions to NPP, visit *earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD17A2_M_PSN*.

[7] CALIOP flies onboard NASA's Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) spacecraft.

11. Tracking seasonal and spatial distribution of fires worldwide with near-real-time data:

Fires occur year-round, but most fires occur in July, August, and September in both the Northern and Southern Hemispheres. MODIS on Terra has tracked fires globally for the last 15 years and will continue to monitor fires globally (along with MODIS on the later-launched Aqua platform). In addition to useful visible images (see **Figure 4**), the global distribution of *fire radiative power* (FRP)—the amount of thermal radiation (heat) emitted by a fire—could be identified via remotely sensed data. Low FRP is associated with cropland burning, such as slash and burn methods of farming, whereas high FRP is associated with grasslands in the tropics. However, in boreal regions high FRPs occur in areas with more tree cover.

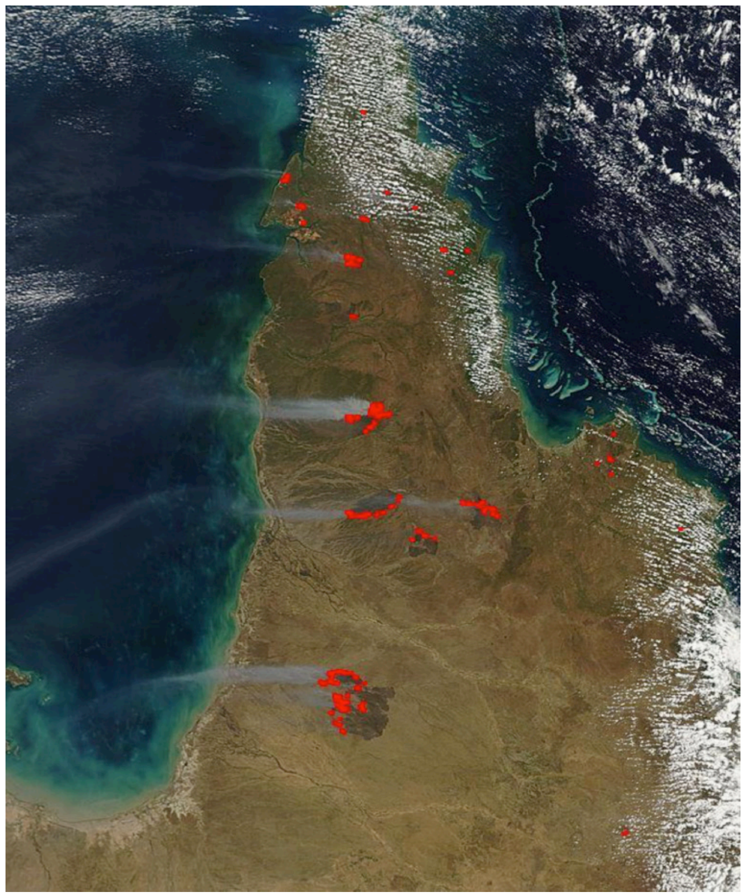

Figure 4. MODIS true-color image of fires across Cape York Peninsula on October 19, 2014; active fires are identifiable in this image by the red outlines at the leading edges of the smoke plumes from the fires, which are seen pointing west; north is up. **Image credit:** NASA/LANCE Rapid Response Team

An excellent discussion of these observations is found in the *Journal of Geophysical Research* paper that is available at *ftp://windhoek.nascom.nasa.gov/private/ichoku/PAPERS/Giglio_2006_JGR_modfire.pdf*.

MOPITT

The name—Measurements of Pollution in the Troposphere (MOPITT)—pretty much describes what MOPITT is designed to do. Specifically, it looks into the lower atmosphere—the troposphere—to explore interactions between that region and Earth's biosphere. Its main focus is on carbon monoxide and its distribution in the atmosphere.

12. First observations of volcanic carbon monoxide from space:

The composition and magnitude of volcanic gas emissions contain keys to understanding and predicting volcanic events. In addition some volcanic gases—e.g., sulfur dioxide (SO_2)—can impact climate by forming aerosols, which reflect solar radiation. Traditionally, volcanic gases are mostly measured from the ground or using airborne instruments, but MOPITT allows scientists to study carbon monoxide (CO) emissions from volcanoes from space, reducing sampling limitations and associated costs.

The identification of volcanic CO was achieved using data from MOPITT and the Infrared Atmospheric Sounding Interferometer (IASI[8]). Supporting data came from the Ozone Monitoring Instrument (OMI; onboard Aura), which measures SO_2 and aerosols and MODIS, which measures aerosols only. The four instruments together provide a complete picture of the impact of volcanoes on air quality and climate. Using this information, it is now known that CO from volcanic emissions is not negligible. Globally, on average CO emissions from volcanic sources are comparable to the amount of CO produced from fuels and biofuels in Australia.

For additional information on this topic, visit *www2.acd.ucar.edu/news/first-satellite-identification-volcanic-carbon-monoxide*.

13. MOPITT captures carbon monoxide emissions in Beijing before and during the 2008 Summer Olympics:

MOPITT allowed scientists to quantify and visualize the amount of CO emissions in Beijing, China before and after the 2008 Summer Olympics. Starting in August 2008—several months before the games—Beijing instituted traffic restrictions that had a profound impact on CO and carbon dioxide emissions. However, pollution levels increased to seasonal norms after the festivities ended.

For further information, visit *www.nasa.gov/topics/earth/features/earth20120724.html*.

14. Tropospheric carbon monoxide is decreasing:

In the last fifteen years, since MOPITT began collecting data, a trend in CO levels has emerged. Global levels of CO in the lower atmosphere declined since 2000 at a rate of about 1% per year; the reasons for the decrease are under examination. MOPITT data were combined with data from other instruments that are able to measure CO in the atmosphere: Observations from MOPITT, AIRS, TES, and IASI were all used. The study found that CO levels decreased in both the Northern and Southern Hemispheres, but there was a greater reduction in the Northern Hemisphere than the Southern Hemisphere. The mechanisms for these observations are still under study. For additional information, visit *www.nar.ucar.edu/2012/lar/nesl/iiih1-moppitt-highlight-regional-trends-co-decade-satellite-observations.html*.

15. Tropospheric carbon monoxide levels from biomass burning are greater than originally thought:

Before Terra, there were no long-term measurements of CO in the lower atmosphere that could show the globally transported pollution coming from *biomass burning*—the burning of vegetation from both human-caused and natural fires.

CO is the second most prevalent gas emitted from biomass burning, an example of which is found in **Figure 5**. It is second only to carbon dioxide. Tracking and monitoring CO is important to understanding air quality and is used to advise people when air quality is hazardous.

[8] IASI flies onboard European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)'s METOP satellites METOP-A and –B; a –C flight is due for launch in 2018. The METOP satellites are are among those described in "An Overview of Europe's Expanding Earth-Observation Capabilities" in the July-August 2013 issue of *The Earth Observer* [**Volume 25, Issue 4**, pp. 4-15].

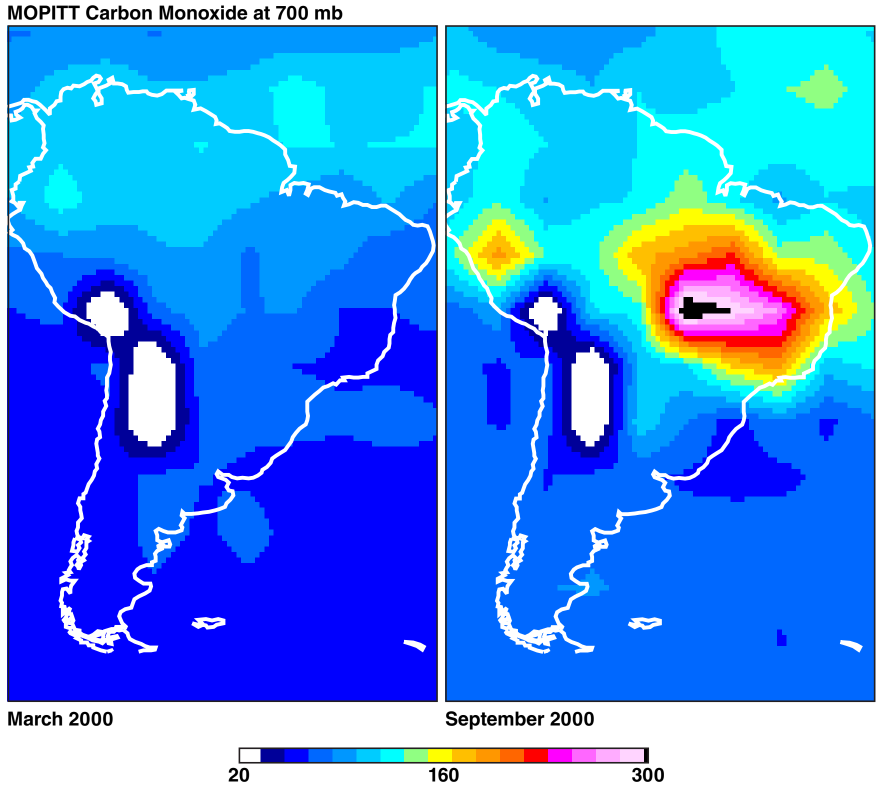

Figure 5. Mid-tropospheric CO levels at 12,000 ft (~4 km) altitude over South America. The high levels in September [*right*] over Brazil arise from biomass burning. Other relatively high levels as compared with March come from biomass burning in South Africa, transported by easterly winds over the Atlantic Ocean. **Image credit:** David Edwards, John Gille, MOPITT Science Team, NCAR

For more information on this finding, visit *www.nar.ucar.edu/2012/lar/nesl/iiih1-moppitt-highlight-regional-trends-co-decade-satellite-observations.html.*

Summary

The utility of the carefully designed complementarity of Terra's instruments is clearly evident in the data and research results represented here. The spacecraft continues to provide key data to address the interrelationships between Earth's various systems, long after its planned lifetime. With only one minor glitch, those data continue to be obtained and disseminated to a wide range of communities, giving further testimony to the excellence of those far-sighted individuals and organizations responsible for Terra and its increasingly large family of low-Earth-orbit remote-sensing instruments. Terra was the first such comprehensive platform; its success bodes well for continued examination of our home planet.

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