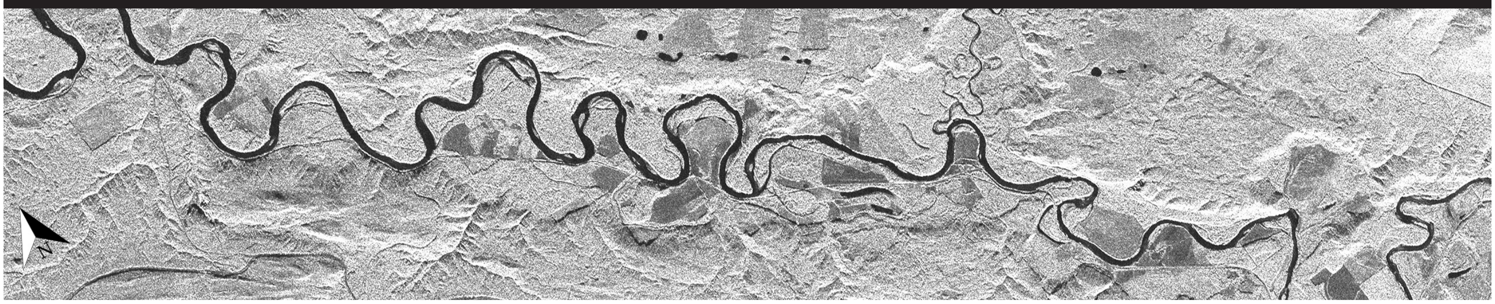
National Aeronautics and Space Administration

EOSDIS Update

FALL 2018

Earth Science Data and Information System (ESDIS) Project

A PUBLICATION OF THE EARTH OBSERVING SYSTEM DATA AND INFORMATION SYSTEM (EOSDIS), CODE 423



TOP STORIES

Terra: The Hardest Working Satellite in Earth Orbit

Since 1999, NASA's Terra Earth observing satellite has completed more than 100,000 orbits of Earth. The instrument data from this workhorse satellite has resulted in one of the longest continuous data records of our planet ever recorded from space.

Any great voyage of discovery begins with a first step. Or, in the case of a satellite mission, a successful launch. For NASA's Terra Earth observing satellite, this journey began on December 18, 1999, with its launch into a sunny sky over Vandenberg Air Force Base on the California coast northwest of Santa Barbara.

On October 6, 2018, after nearly 19 years in space, Terra completed its 100,000th orbit. During its journey, Terra has traveled about 2.5 billion miles (that's more than 450,000 round-trip flights between New York City and San Francisco, CA). Even more significantly, all major spacecraft systems are working fine and its five instruments continue to send back a steady stream of science-quality data.

The story of how the Terra spacecraft made it to this milestone and the challenges of keeping its 20th century systems operating is well-told in an article by the Terra team. This article tells the other half of the Terra story: the story of how Terra instrument data are brought back to Earth and turned into data products that constitute one of the longest continuous data records of our planet ever recorded from space.

"To have this much technology still operating after so much time in space is incredible," says Greg Dell, the NASA Earth Science Mission Operations (ESMO) Project Deputy Director-Operations. "And the data are still relevant; it's not

IN THIS ISSUE:

Unless otherwise noted, all articles written by Josh Blumenfeld, EOSDIS Science Writer.

like we've gotten leaps and bounds better quality data or next-generation spacecraft that have made Terra obsolete. People still want these data."

The Flagship Mission of NASA's Earth Observing System (EOS)

Terra was the first mission in NASA's Earth Observing System (EOS). Conceived in the 1980s and implemented in the 1990s, the EOS comprises an integrated collection of satellites, a science component, and a data system. The overall EOS objective is to provide a better understanding of the total Earth system and the effects of natural and human-induced changes on the environment through long-term global observations.

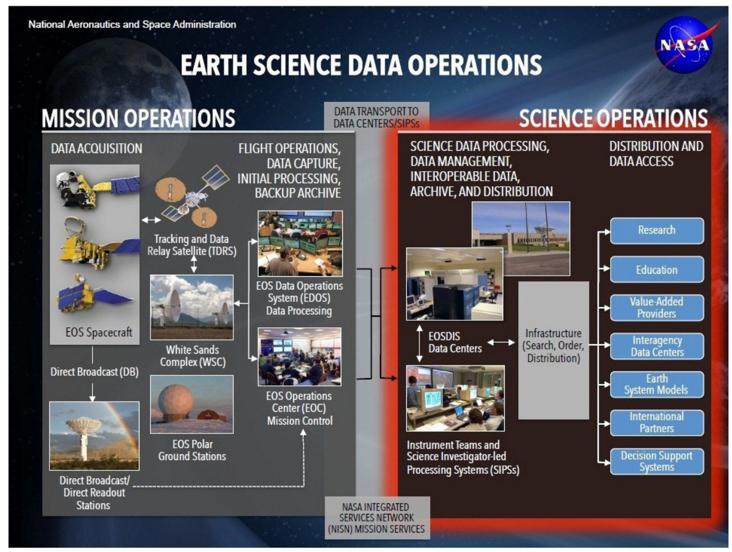
"Terra was the first of what was supposed to be three satellites," says Eric Moyer, the ESMO Project Deputy Director-Technical. "The plan was to launch AM-1, which was Terra, followed by an AM-2 and an AM-3 [satellite]. The three satellites together, with an expected five-year lifespan each, would be combined to generate a 15-year climate data record. While AM-2 and AM-3 were never built, we still achieved this [data record] with just one satellite—Terra."

Five instruments are aboard the Terra spacecraft:

- Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), which is a partnership between NASA, Japan's Ministry of Economy, Trade and Industry (METI), the National Institute of Advanced Industrial Science and Technology (AIST) in Japan, and Japan Space Systems (J-spacesystems);
- Clouds and the Earth's Radiant Energy System (CERES), which was built at NASA's Langley Research Center in Hampton, VA;
- Measurement of Pollution in the Troposphere (MOPITT), which was jointly developed by the Canadian Space Agency, the University of Toronto, and the National Center for Atmospheric Research (NCAR) in Boulder, CO;
- Moderate Resolution Imaging Spectroradiometer (MODIS), which was developed by NASA's Goddard Space Flight Center in Greenbelt, MD; and
- Multi-angle Imaging SpectroRadiometer (MISR), which was developed at NASA's Jet Propulsion Laboratory in Pasadena, CA.

Terra began returning data from all instruments in early 2000. Aside from the failure of ASTER's Short-Wave InfraRed (SWIR) system, all instruments continue to provide good quality science data.

Since Terra is an EOS satellite, its data are the responsibility of NASA's Earth Observing System Data and Information System (EOSDIS). The EOSDIS provides end-to-end management of NASA Earth science data from sources including satellites, aircraft, field measurements, and other programs, and is a core capability of NASA's Earth Science Data Systems (ESDS) Program.



EOSDIS Mission Operations are managed by the ESMO Project (left side of illustration). Satellite instrument data are processed into Level 0 data by the EOS Data Operations System (EDOS) and sent to the ESDIS Project (right side of illustration) for processing into Level 1-4 products, archiving, and distribution. This higher-level data processing is done primarily by Science Investigator-led Processing Systems (SIPS); processing for selected instruments is done by individual instrument processing teams at EOSDIS Distributed Active Archive Centers (DAACs). The NASA Integrated Services Network (NISN) (bottom center of illustration) is a global system of communications transmission, switching, and terminal facilities that provides NASA with wide area network (WAN) communication services and facilitates data transmission. NASA EOSDIS illustration.

The EOSDIS is divided into Mission Operations and Science Operations. Mission Operations are managed by the Earth Science Mission Operations (ESMO) Project, which is responsible for the maintenance and operation of Terra and other EOS spacecraft along with Earth science missions conducted by NASA's Earth Science Projects Division (ESPD).

Within the ESMO Project, overall satellite command and control, satellite and instrument health assessment, and the scheduling of satellite commands are the responsibility of the EOS Mission Operations System (EMOS). Instrument data capture and initial (Level 0) processing of instrument data is the responsibility of the EOS Data Operations System (EDOS).

Level 0 instrument data are sent from EOSDIS Mission Operations to EOSDIS Science Operations for higher level processing, archiving, and distribution. EOSDIS science operations are managed by the Earth Science Data and Information System (ESDIS) Project. ESDIS Project responsibilities include processing data into Level 1-4 standard data products, which are archived at and distributed through an integrated network of discipline-specific Distributed Active Archive Centers (DAACs). A majority of higher-level data processing is done by Science Investigator-led Processing Systems (SIPS), which are under the direct control of instrument Principal Investigators/Team Leaders or their designees (this is the case for Terra MODIS and MOPITT instrument data products). Along with the SIPS, standard products for some instruments are produced directly by teams at the DAACs (this is the case for Terra ASTER, CERES, and MISR instrument data products).

In addition, data and service metadata records are incorporated into the EOSDIS Common Metadata Repository, which is the authoritative management system for all EOSDIS metadata and facilitates search and discovery through the entire EOSDIS data collection.

From Terra to Terabytes: Getting Data Back from Space

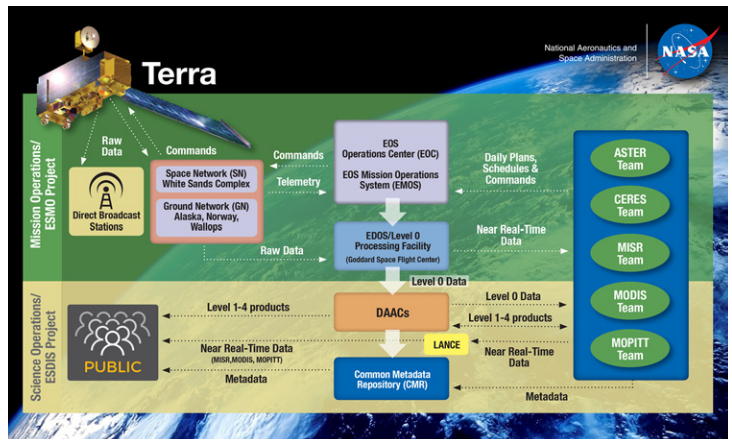
Getting Terra instrument data back from the spacecraft is the responsibility of the EOS Data Operations System (EDOS). EDOS has been performing continuous data capture and initial (Level 0) processing for Terra data since 1999. "The primary focus [of EDOS] is to capture the data, make sure it's of good quality, and then send it off to the different EOSDIS DAACs and SIPS for higher level processing," Moyer says.

Primary overall EDOS tasks include:

- Capturing spacecraft instrument science data at ground stations and performing front-end processing on these data;
- Transferring science data to NASA's Goddard Space Flight Center;
- Performing Level 0 science data processing at a centralized Level Zero Processing Facility (LZPF) at Goddard Space Flight Center; and
- Delivering Level 0 products in a variety of formats and protocols for higher level processing.

The EDOS ground system was built in the early-1990s for Terra data capture, but was designed from the start to be modular, flexible, and scalable to support multiple mission operations. "The modularity and scalability of EDOS is truly significant, and enables us to easily add new missions to the system," says Terri Wood, the EDOS Project Manager. "It's very easy to scale the ground system to handle a new mission or new mission requirements. If you have a network, we can deliver science data."

Along with Terra, EDOS currently supports seven other missions: the NASA Aqua, Aura, Orbiting Carbon Observatory-2 (OCO-2), Soil Moisture Active Passive (SMAP), and Ice, Cloud and land Elevation Satellite-2 (ICESat-2) and the joint NASA/NOAA Suomi National Polar-orbiting Partnership (Suomi-NPP) and Joint Polar Satellite System-1 (JPSS-1, now known as NOAA-20).



Simplified Terra ground system diagram. Direct Broadcast (DB) provides real-time MODIS data to more than 240 worldwide ground stations. Near Real-Time (NRT) data are available through the EOSDIS Land, Atmosphere Near real-time Capability for EOS (LANCE) system, which provides MISR, MODIS, and MOPITT instrument data generally within three hours of a satellite overpass. Illustration based on a NASA EDOS diagram.

Terra data are downlinked twice each orbit using NASA's Tracking and Data Relay Satellite System (TDRSS) to a ground station at White Sands, NM (the White Sands Complex). While Terra can transmit science data via ground stations located in Alaska, Norway, and at Wallops, VA (and does so for contingency purposes), Terra primarily transmits science data via TDRSS to White Sands. This is a data-driven system that is always listening for Terra's unique signal pattern. When the Terra signal is detected, ground station equipment automatically starts capturing data. "The system is looking for frame syncs," says Bruce McLemore, the EDOS Contractor Project Lead. "If the spacecraft ID and the frame sync match [one of our] supported missions it will lock onto the satellite and start collecting data. Not only this, but the five or six frames that came in before the ground station locks on to the satellite will be looped back through so we don't lose any data. It's a very spiffy design."

From the ground station, raw satellite data are sent via high speed communications links to the EDOS Level Zero Processing Facility (LZPF) at NASA's Goddard Space Flight Center. These Level 0 data are then sent to EOSDIS DAACs where they are retrieved by DAAC instrument teams and SIPS for processing into higher level products (ASTER Level 0 data are sent to the ASTER ground system in Japan for processing into Level 1A and 1B data, then to the Land Processes DAAC [LP DAAC] for higher level processing).

One significant evolution for Terra data capture has been the shift from schedule-driven to data-driven data acquisition. Unlike schedule-driven acquisition, where data could be lost due to changes in the system or poor communications at a scheduled data acquisition time, data-driven acquisition means the system is always listening for Terra data. "If a data bit [from Terra] hits the antenna, EDOS will capture it," says Greg Dell. "This gives the team the flexibility of doing blind data acquisitions. EDOS will capture the data even if you were not planning to capture data on a particular pass."

Terra Data Latency and Real-Time Data Capability

While the Terra instruments have not changed since their launch in 1999, technologies for delivering instrument data have. In the late-90s, physical data tapes still had to be shipped back from ground stations for initial processing, a process that could take as long as five to seven days. This significantly impacted the time it took for data to get from satellite to data user, which is called "latency." "When Terra was launched, the goal for the science data was long-term trending and producing a long-term climate record," says Greg Dell. "Now, it's how quick can you get us the data. This is a big paradigm shift over the course of the mission. We've been able to accommodate this paradigm shift with ground automation and better, faster networks."

A high objective of the EDOS team is to reduce latency and provide Level 0 data as quickly as possible to the DAACs. "We've worked very hard to reduce any bottlenecks in getting the data [from the satellite] to the ground station then from the ground station to [Goddard Space Flight Center] for initial processing and then to the end user," says Terri Wood. "We continually try to reduce our latency."

One significant improvement in data delivery is the ability to use a flexible network infrastructure. Data traditionally were transferred over a high-rate closed network. These types of networks provide security, but have a lower bandwidth. The alternative is an open network, which has higher bandwidth, but requires that data be fully encrypted for security before they are sent. Over time, the EDOS team developed the necessary security and capability to flow data over open internet connections. Now, both a closed and an open network are available for moving data—redundancy that ensures that all instrument data are captured at ground stations and sent back to Goddard Space Flight Center for initial Level 0 processing rapidly and securely.

Along with using open networks, EDOS also moved to a low-latency protocol. "Our goal is to move the data across the network as fast as it's coming down from the spacecraft," says Bruce McLemore. "Switching to a low-latency protocol over an open network allows us to easily keep up with the Terra data."

A unique feature of Terra is its Direct Broadcast (DB) capability, which enables anyone with a receiver to download raw MODIS data in real time. Today, more than 240 registered stations around the world receive and process Terra DB MODIS data. "It's all the MODIS data packaged in the raw format," explains Eric Moyer. "For a lot of countries that don't have a space program, it doesn't cost a whole lot to put up an antenna and capture the DB data and process it in real-time or near real-time so they can see how things are going in their area. It's very beneficial."

In addition to DB real-time data, the EOSDIS Land, Atmosphere Near real-time Capability for EOS (LANCE) system provides near real-time (NRT) data for Terra's MISR, MODIS, and MOPITT instruments (along with NRT data for more than half-dozen other instruments). LANCE data generally are available within three hours of a satellite overpass. While Terra LANCE and DB data do not have the processing, validation, or quality assurance required for use in scientific research, they are an invaluable resource for managing on-going events.

The Terra Data Record

Terra's data are its legacy, and the Terra data record represents one of the longest satellite climate data records ever compiled. While Terra has completed 100,000 orbits, it downlinked to transmit data twice each orbit—that's 200,000 downlinks. "To me, that's even more significant," says Bruce McLemore. "Some of these spacecraft downlink only once per orbit. Some in the future may be only, say, eight times per day."

Along with near real-time MISR, MODIS, and MOPITT data products distributed through LANCE, Terra Level 1-4 standard data products are archived at and distributed through numerous EOSDIS DAACs. ASTER data products are available through the LP DAAC, which operates as a partnership between NASA and the U.S. Geological Survey (USGS) and is located at the USGS Earth Resources Observation and Science (EROS) Center; CERES, MISR, and MOPITT data products are available through the Atmospheric Science Data Center (ASDC) DAAC at NASA's Langley Research Center (LaRC).

MODIS land products are available through the LP DAAC, while ocean color products are available through the Ocean Biology DAAC (OB.DAAC), and Level 1 and atmosphere products are available through the Level 1 and Atmosphere Archive and Distribution System (LAADS DAAC). Additional MODIS data products are available through the Goddard Earth Sciences Data and Information Services Center (GES DISC), the Global Hydrology Resource Center (GHRC) DAAC, the National Snow and Ice Data Center (NSIDC) DAAC, and the Physical Oceanography DAAC (PO.DAAC).

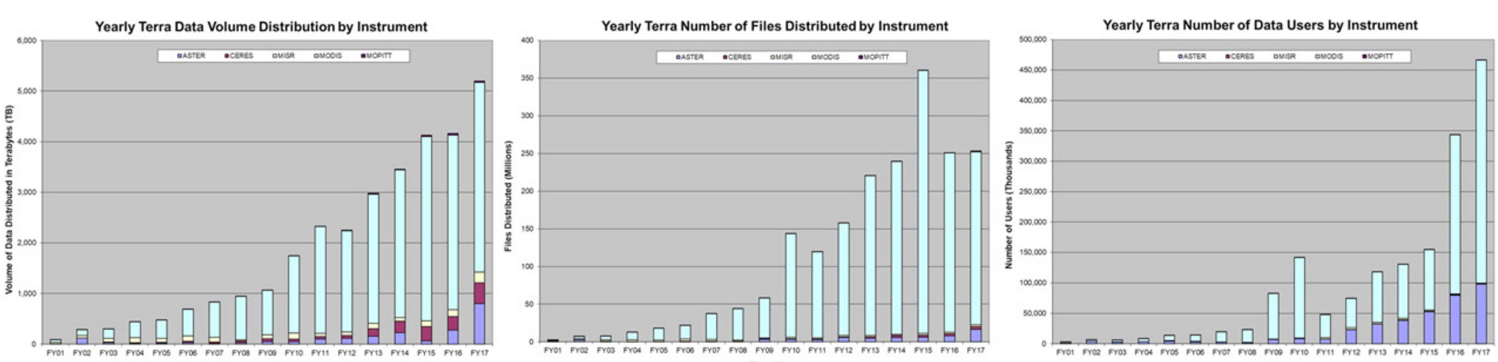
MODIS Land Product Subsets also are available through the Oak Ridge National Laboratory (ORNL) DAAC.

As of the end of NASA's 2017 Fiscal Year (the most recent year for which complete data are available), the total volume of Terra data in the EOSDIS archive is more than 5 petabytes (PB), according to metrics from the EOSDIS Metrics System (EMS). To put this into perspective, 1 PB is equivalent to about 20 million 4-drawer filing cabinets full of text. In addition, Terra data are some of the most popular EOSDIS data products. Almost 2 billion Terra data files from all instruments have been distributed to more than 1.6 million unique worldwide data users between when Terra data were first available in 2000 through September 30, 2017 (the end of the 2017 Fiscal Year).

The Future of the Terra Journey

Space is a harsh environment, and the fact that the Terra spacecraft and its five instruments have operated for far longer than their planned six-year life is a phenomenal accomplishment. Barring unforeseen incidents, Terra's instruments are expected to continue to collect data that will be added to the EOSDIS archive. Fuel, however, is the limiting factor, and Terra will only be able to maintain its 438-mile (705 km) science orbit for another few years.

As the satellite runs out of the fuel it needs to maneuver, its orbit gradually will lower and the instrument data will no longer have the validity needed for scientific research or be considered climate record data. "When we say that we won't be able to maintain the orbit, we mean we won't be able to maintain the satellite crossing the equator at 10:30



EMS metrics showing the distribution of Terra instrument data (left and middle tables) and the number of unique worldwide data users (right table) from Terra's launch through September 30, 2017. MODIS data products, aqua-colored bar, continue to be the most popular Terra products, both in terms of distribution and unique data users. The spike in MODIS files distributed in Fiscal Year (FY) 2015 (middle table) is due to a reprocessing of the entire MODIS data collection—data users were downloading both MODIS Collection 5 and Collection 6 during this time. The noticeable decline in unique MODIS users between FY10 and FY11 (right table) is due to a decrease in the number of MODIS data users in China. The EMS attributes this decrease to two factors: The use of better Domain Name System (DNS) look-up tables to identify unique users and a real decline in actual users of MODIS data in China. NASA EOSDIS graphics and metrics.

am [local time at the equator]," says Greg Dell. "As the satellite orbit lowers, it will cross the equator at an earlier time. You also can't maintain the same inclination, or tilt, relative to the sun. Once you drift far enough [off orbit], your sun angle is different and your science data become less useful."

"It's no longer climate record data," adds Eric Moyer. "It's still good data, but it's no longer climate record quality because we're no longer collecting these data at the same angle relative to the sun."

For researchers, the science-quality Terra instrument data in the EOSDIS archive constitute an invaluable almost two-decade-long record of a wide range of Earth processes.

These data, along with all data algorithms and supporting documentation, are archived by the ESDIS Project and available to worldwide data users under NASA's free and open data policy. "It's nice to say 100,000 orbits, but from the science side, this means 18 years of good, continuous data," says Moyer.

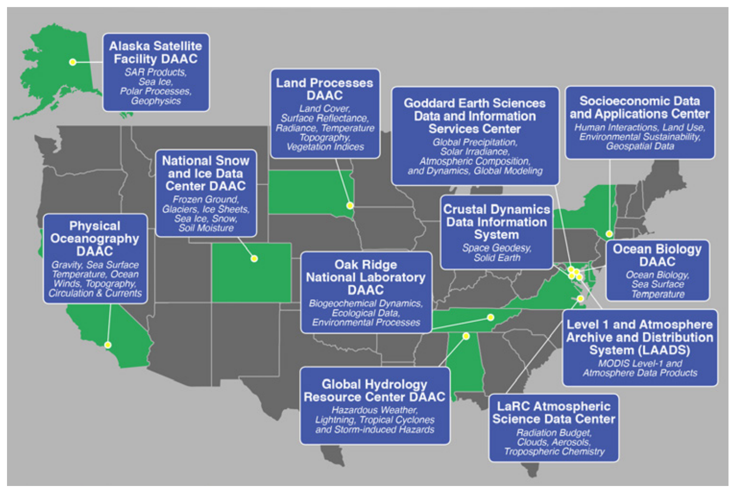
For NASA's EOSDIS, Terra sets the bar high for future missions that will build on its success. "It really is a testament to great work by the entire team for being able to keep this spacecraft up in the air and healthy and to be able to produce like it has," says Terri Wood. "It's people, processes, and programs that make this happen. I just think it's a real testament to what we can do around here." ■

EOSDIS DAACs Celebrate Milestones of Service to Global Data Users

For more than 25 years, EOSDIS Distributed Active Archive Centers (DAACs) have maintained the flexibility to serve ever-greater volumes of data to an ever-growing worldwide user community.

When NASA's Earth Observing System Data and Information System (EOSDIS) became operational as part of NASA's Earth Observing System (EOS) in 1994, it faced a daunting challenge. Charged with providing end-to-end capabilities for managing NASA's Earth science data from sources including satellites, aircraft, field measurements, and various other programs, the EOSDIS had to accomplish this using 1990s technology—personal computers with an average of 400 to 1,000 megabyte (MB) hard drives, 33 MHz processors, and 14.4k "high speed" modems. A critical EOSDIS need was to establish a structure that would enable efficient scaling to deal with the surge of data from planned and future EOS missions along with inevitable advances in technology.

To facilitate the archiving and dissemination of NASA Earth science data and account for the growth of data in this collection, a model for establishing a network of discipline-specific Distributed Active Archive Centers, or DAACs, was proposed as far back as 1986. This model was adopted by NASA for the EOS program, and the DAACs



NASA's Earth Science Data and Information System (ESDIS) Project manages the discipline-specific DAACs. DAACs are collocated with centers of science discipline expertise, and archive and distribute standard data products produced primarily by Science Investigator-led Processing Systems (SIPS). NASA ESDIS Project Graphic.

became part of the EOSDIS in 1994. From an initial collection of eight DAACs, the EOSDIS DAAC system has grown to include 12 DAACs across the U.S.

The EOSDIS enterprise architecture, developed in the 1990s, relies on distributed nodes (the DAACs) to most effectively and efficiently serve the science user community. These DAACs are managed by NASA's Earth Science Data and Information System (ESDIS) Project, which is responsible for EOSDIS science systems. This design not only spreads the load across many systems, it also allows individual DAACs to customize services to meet the needs of the specific science disciplines they serve, which include atmosphere, calibrated radiance and solar radiance, cryosphere, human dimensions, land, and ocean. In addition, by adopting a system using many DAACs to archive and distribute data, NASA ensures that the system can easily scale to meet the growing production of science data and handle future missions that will generate greater quantities of data.

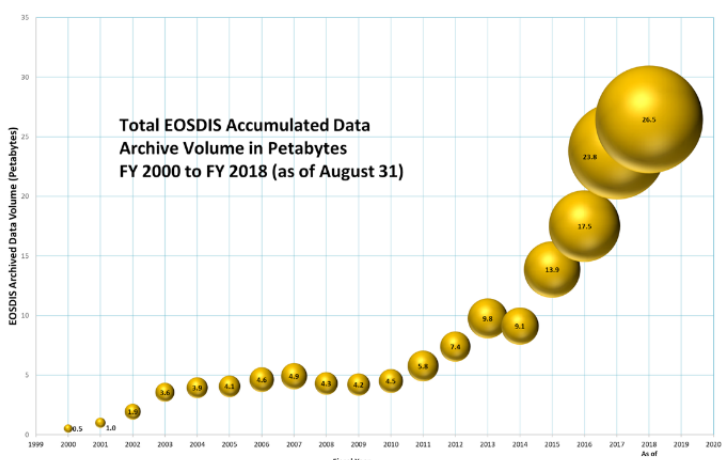
Over the past few years, numerous DAACs have achieved milestones of service to the global network of EOSDIS data users. The summer of 2018 saw the 25th anniversary of the National Snow and Ice Data Center (NSIDC) DAAC as well as the 20th anniversary of the relocation of the Center for International Earth Science Information Network to Columbia University, which is the home of NASA's Socioeconomic Data and Applications Center (SEDAC). The Land Processes DAAC (LP DAAC) observed its 25th anniversary in 2015, while the Alaska Satellite Facility DAAC (ASF DAAC) reached this milestone in 2016. The DAAC network and its partnership with academia, other federal agencies, and NASA has led to the development of a world-class science data system.

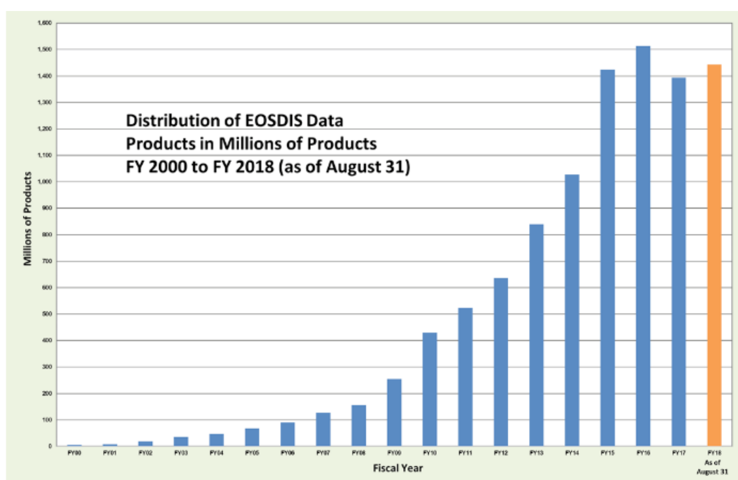
EOSDIS DAACs are custodians of EOS mission data and serve a broad and growing user community with both EOS data and non-EOS data (such as data from the European Space Agency [ESA] Sentinel-1 satellites, which is processed by ESA and has been distributed by the ASF DAAC since 2016). In addition, DAACs are leaders in data management and are at the forefront in developing new tools and technologies to manage and serve data, such as the AppEEARS subsetting application developed by the LP DAAC, the Giovanni data visualization and analysis tool created by the Goddard Earth Sciences Data and Information Services Center (GES DISC), and the SEDAC Hazards Mapper.

As EOSDIS metrics show, the amount of data archived and the number of EOSDIS products distributed have both grown significantly, especially with the return of the first data from NASA's Terra Earth observing satellite (the first EOS mission) in 2000. From an archive volume of at most 500 terabytes (TB) at the end of Fiscal Year (FY) 2000, the EOSDIS archive volume has grown to more than 26.5 petabytes (PB), according to preliminary figures for August 2018 from the Earth Science Data and Information System (ESDIS) Metrics System (EMS). Just as the EOSDIS archive volume has grown, so too has the number of EOSDIS data products distributed worldwide—from 5.52 million products in FY 2000 to almost 1.62 billion products as of August 31 for FY 2018 (the NASA fiscal year runs from October 1 through September 30).

Acting in concert, EOSDIS DAACs provide reliable, robust services to users whose needs may cross the traditional boundaries of specific science disciplines, while continuing to support the particular needs of users within their discipline communities.

All DAACs maintain User Services groups that are the primary points of contact for data users. Ongoing user feedback and DAAC outreach are critical to ensuring that EOSDIS data users have the specific data, tools, and services they need and that these data, tools, and services are available and working properly. In addition, DAACs provide a wealth of information—including tutorials,





Comparison of EOSDIS archived data volume (left) with distribution of EOSDIS data products (right) from FY 2000 to August 31, 2018. The significant increase in the volume of archived data starting in FY 2015 is due to the addition of products from the Aquarius, IceBridge, GPM, and ALOS PALSAR missions. The significant increase in data products distributed in FY 2015 and FY 2016 and the slight decrease seen in FY 2017 are due to two factors: 1) Terra and Aqua MODIS data were reprocessed in FY 2016 and both MODIS Collection 5 and Collection 6 data were distributed; MODIS Collection 5 products were no longer distributed starting in FY 2017, and 2) File Transfer Protocol (FTP) downloads were discontinued by various DAACs, which contributed to lower data product distribution in FY 2017. NASA EOSDIS graphics and metrics.

webinars, and data recipes—to show users how to work with specific data sets, manipulate and subset data, and share information.

Since DAACs are discipline-specific, they need to remain intimately connected with the science communities they serve. This is facilitated through individual DAAC User Working Groups (UWGs). UWG members are subject-matter experts who provide guidance and direction for the DAAC they serve. During calendar year 2017, 23 DAAC UWG meetings took place involving more than 260 DAAC, UWG, and ESDIS Project representatives.

Each UWG has a charter specifying the specific advisory services it provides. As noted by Ramapriyan and de Sherbinin (2018), general DAAC UWG advisory services include:

- Ensuring science user involvement in DAAC planning, development, and operations;
- Defining DAAC science goals;
- Providing recommendations on annual work plans and long-range planning;
- Representing the science user community in reviewing and guiding DAAC activities;
- Reviewing DAAC progress and performance;
- Assessing the quality of DAAC data-products and services;
- Communicating users' assessment of DAAC performance;
- Providing advice on the levels of service provided to the user community;
- Suggesting improvements to user access and interfaces along with helping to prioritize DAAC-related functions;
- Recommending new data products and services based on NASA research needs; and
- Providing research and development advice for product prototyping and generation.

Along with input from UWGs, the quality of DAAC products and services is evaluated annually through a formal survey of EOSDIS data users. These surveys have been conducted since 2004 and ask users to rate the services and products of the specific DAAC or DAACs from which they acquire data. The results of the 2017 survey indicate that all DAACs are providing high levels of customer service and high-quality data products, results that are consistent with all previous years. The 2018 survey is being conducted in September and October, with survey invitations sent worldwide to DAAC data users with a valid Earthdata Login email address. A key component of the survey is the opportunity for survey respondents to provide comments about the specific DAAC or DAACs they are rating, including comments about specific data products and services. These comments provide yet another opportunity for the DAACs to verify that they are developing the right data products in the appropriate formats to meet the needs of their user communities.

For more than a quarter-century, the DAACs have remained foundational components of the EOSDIS and play key roles in ensuring that the data in the EOSDIS collection are available fully and openly to data users. Their cutting-edge work in developing new tools and techniques for archiving, serving, and managing big data collections helps enable the flexibility necessary for NASA's EOSDIS to easily scale as the volume of its data collection, along with the global users of this collection, continues to increase. ■

Class Acts: Summer Interns Provide Key Support for ESDIS Projects

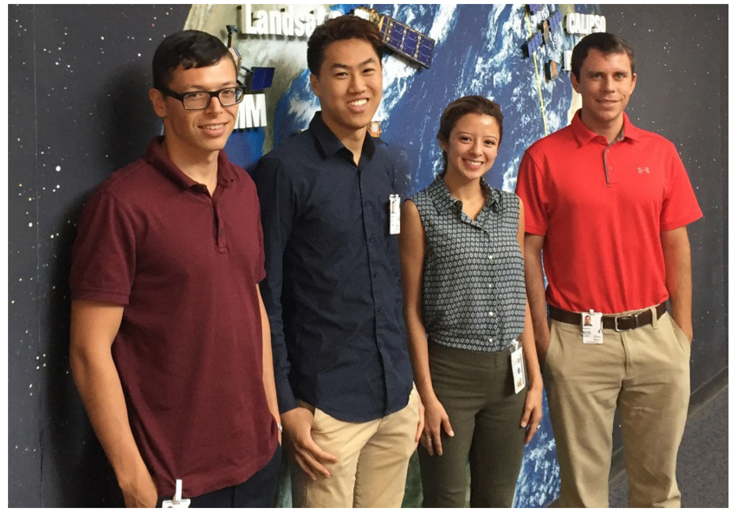
NASA interns are a tremendous asset for improving data, products, and services at the ESDIS Project Office and at DAACs across the country.

When anyone asks Jack Miller what he did this past summer, he can describe the new augmented reality version of the Worldview data visualization application that he helped create. Vincent Inverso and Mike Walker may soon be able to show colleagues an Earthdata Search data recommendation feature on which they collaboratively worked, and Paul Lin and Diane Portillo might see Earth science researchers learning how to more effectively write code for cloud computing using materials they helped develop.

These are some of the projects on which interns supporting NASA's Earth Science Data and Information System (ESDIS) Project Office worked this summer. The ESDIS Project manages the science systems of NASA's Earth Observing System Data and Information System (EOSDIS), including the EOSDIS Distributed Active Archive Centers (DAACs). Each summer the ESDIS Project hosts interns who work on various tasks in the ESDIS Project Office and at DAACs across the country. These internships provide a two-way benefit: For the interns, this is a real-world application of their academic training; for the EOSDIS, interns help advance numerous projects designed to improve data, products, and services.

The six ESDIS Project Office interns, along with two interns at the Goddard Earth Sciences Data and Information Services Center (GES DISC) DAAC, are among the more than 400 summer interns at NASA's Goddard space Flight Center in Greenbelt, MD. The high school, college, and graduate school students (including recent graduates) participating in this highly-selective program are helping to further mission and project-critical tasks, learning the intricacies of a government agency, and, of course, mastering reams of NASA acronyms.

"The work here is very applied," says ESDIS Project Office intern Vincent Inverso, a computer science Master's degree candidate at the University of Pennsylvania. "The work in school is more geared toward building up your theoretical



Four of the six ESDIS Project Office summer interns (left to right): Vincent Inverso, Paul Lin, Diane Portillo, and Mike Walker. NASA EOSDIS image.

knowledge, whereas this is more of a practical skillset that we're learning."

Vincent is working with Mike Walker, a University of Maryland-College Park rising senior information science major, on a market basket recommendation algorithm for Earthdata Search. Vincent and Mike describe their project as being similar to the recommendations customers receive when they order specific products from online services like Amazon. "Our goal is to enable recommendations of specific data sets based on what data users are downloading or searching for," says Mike.

Meanwhile, Paul Lin, a University of Pennsylvania rising sophomore earning a double-major in Earth science and international relations, and Diane Portillo, a recent Bachelor's degree graduate in environmental science from Chicago's DePaul University, are collaborating on an ESDIS Project cloud computing effort called Cloud Science Computing for Earth Scientists. "We are advocating for cloud computing among Earth scientists and teaching scientists without deep programming skills how to utilize programming within their knowledge and within their reach," Paul explains.

Another ESDIS Project Office intern, Mauricia Brown, is learning how to use Adobe Creative Suite and Adobe Connect to support ESDIS Project communications efforts. Mauricia is a rising sophomore general studies (science emphasis) major at Montgomery College in Silver Spring, MD. "These are opportunities I never would have at Montgomery College," she says. "Putting all of this work—the communication and the graphic design elements—together is really the icing on the cake for me."

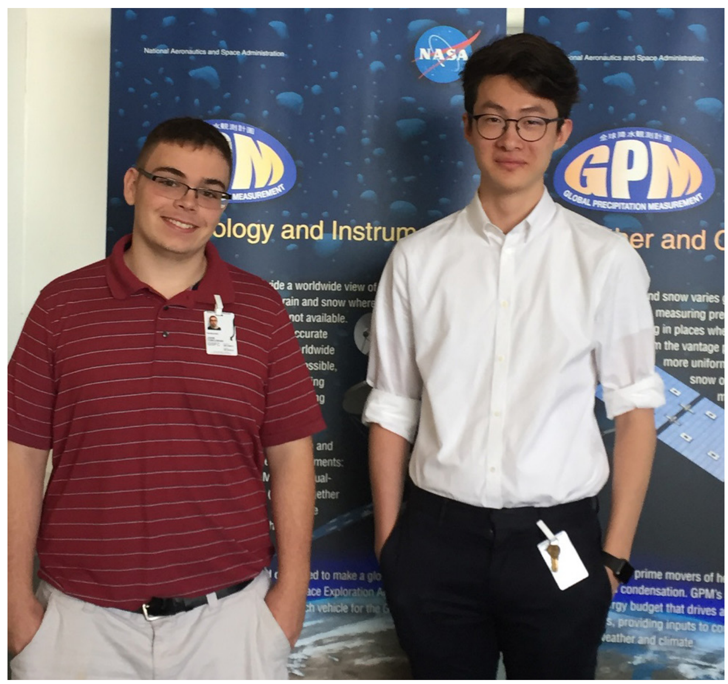
ESDIS Project Office intern Mauricia Brown displaying a poster about her work at the annual Goddard Summer Poster Session. NASA EOSDIS image.

Jack Miller, the final ESDIS Project Office intern, is developing a new Worldview Augmented Reality, or Worldview AR, application. Jack will finish his Master's degree in mechanical engineering and human computer interaction at Iowa State University in Ames, IA, this fall and concurrently start a PhD program. He is taking satellite imagery from [Global Imagery Browse Services] (GIBS) and incorporating it into an augmented reality application in order to visualize the imagery in the real world. "This is similar to the existing Worldview program, but this is in 3D," he says. "This is a new way to interact with and visualize GIBS imagery."

Jack's work this summer contributed to his being selected as one of 15 recipients of a [John Mather Nobel Scholarship]. The scholarship was established by Goddard Senior Astrophysicist, Goddard Fellow, and Nobel Laureate Dr. John Mather and his wife and is awarded to summer interns at Goddard. Along with being designated a "John Mather Nobel Scholar," Jack and his fellow award recipients each receive a $3,000 scientific travel grant over a two-year period.

Also working at Goddard this summer are two interns supporting GES DISC projects: Jack Corcoran and Sky Wang. The two are working on a project using imagery and documents from the Twitter social media platform to derive precipitation information to potentially help validate data from the joint NASA/Japan Aerospace Exploration Agency [Global Precipitation Measurement] (GPM) mission. Sky is drawing on his background in machine learning to use neural networks to classify tweets "The data that we're aiming to collect from the tweets includes not only whether it's precipitating or not, but also the precipitation type, like rain, snow, etc., along with the precipitation intensity, like how many millimeters per hour," says Sky, a rising sophomore computer science major at the University of Michigan.

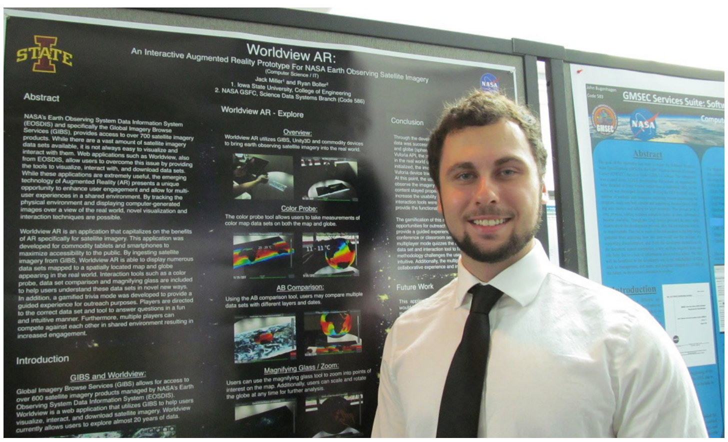
Jack, a rising senior mathematics major at Cornell University, is looking at images linked to tweets and classifying whether these images contain precipitation and related data or are not related to precipitation. "If you have a tweet that says 'it's raining at my child's birthday party' and you see an attached image of a child standing miserably in the rain, you can direct this to be classified as a rain image and it's pretty likely to be rain," Jack explains. "On the other hand, if you have a tweet saying 'I'm making it rain at the club' and you see an attached image of people inside a club at a party, then it's much less likely that the tweet relates to actual precipitation."



GES DISC interns Jack Corcoran (left) and Sky Wang (right) are using machine learning to explore the potential for using tweets to help validate GPM precipitation data. NASA EOSDIS image.

GES DISC scientists Arif Albayrak and Dr. Bill Teng are supporting Jack and Sky's work this summer and emphasize its importance. "Using social media to help verify precipitation data is something new," says Albayrak. "Knowing how to classify these organic data makes them very valuable for research and has worldwide applications. The work that Jack and Sky are doing is taking us to a very interesting place."

For Jack, his internship at the GES DISC is taking him back to familiar locations. Jack previously supported observational astronomy efforts at Goddard and is one of four of this summer's ESDIS Project Office and GES DISC interns who are returning NASA interns. ESDIS Project Office intern Mauricia Brown worked on heliophysics equations as a high school junior, and Paul Lin worked on Antarctic ice melt data. Mike Walker is participating in his fourth summer at Goddard. "I started as a high school intern working on image pre-processing for NASA's IMAGEs for Science, Education, Experimentation and Research (IMAGESEER) database," he says. "My second summer I was working at the Goddard Mission Service Evolution Center, or GMSEC. Last summer I was working with the Joint Polar Satellite System on validation tools for the Ozone Mapping Profiler Suite instrument."



ESDIS Project Office intern Jack Miller worked with his mentor, EOSDIS Data Visualization Lead Ryan Boller, to develop the Worldview Augmented Reality, or Worldview AR, application. NASA EOSDIS image.

Along with the interns supporting ESDIS Project and GES DISC work at Goddard, 12 NASA interns are spending the summer working at EOSDIS DAACs across the country. Interns are at the Alaska Satellite Facility (ASF) in Fairbanks, AK (eight interns), the Oak Ridge National Laboratory (ORNL) DAAC in Oak Ridge, TN (two interns), and the Atmospheric Science Data Center (ASDC) at NASA's Langley Research Center in Hampton, VA (two interns).

All NASA interns are assigned at least one mentor to guide their work and provide support through the summer. Mentors also view summer internships as an opportunity to increase their own knowledge. Jack Miller's mentor, EOSDIS Data Visualization Lead Ryan Boller, is enjoying the opportunity to learn about augmented reality and its potential applications to Worldview and EOSDIS data.

"We're excited to have an intern with his level of experience to show us how augmented reality can be used with our data sets," Boller says. "It's really interesting to see Jack's perspective on how augmented reality is used in other application areas. Jack has led a lot of what he's been doing because he knows the technology and we're learning a lot from Jack through his work. This has been a good benefit for both of us."

Dr. Justin Rice, an ESDIS Project systems engineer and the primary mentor for Vincent and Mike, notes that mentors should provide more than just task-specific feedback. "Outside of their summer projects, I want to help set them up to succeed in the future—whether it's with NASA or with any other organization," he says. "Mentors can make or break the summer experience for interns. Knowing this, I also want to do what I can to make their time here memorable, enjoyable, and fun. If we're not having fun, then I've failed somewhere!"

Among the activities Dr. Rice and his fellow ESDIS Project mentors helped coordinate for the interns were informal lunches with ESDIS managers and the opportunity to network with ESDIS and DAAC staff. "I make sure that the interns meet other people and work to expand their network," says Dr. Rice. "Hearing other people's stories increases their awareness of the work being done here and helps them to learn more about different career options."

The Goddard Education Office also coordinates activities to enhance the intern's summer experience. These activities include tours through Goddard laboratories, a Sciences and Exploration Directorate Science Jamboree showcasing the breadth of scientific work and research conducted at Goddard, and a wide range of talks and forums. As with previous years, one highlight for the interns is a presentation by Nobel Laureate Dr. John Mather.

As the ESDIS interns note, another highlight is simply the opportunity to work at NASA and gain valuable experience as they work on ESDIS projects. "In school, the impact is more for yourself, your own personal knowledge," says ESDIS Project Office intern Diane Portillo. "The project that Paul [Lin] and I are working on benefits not only the agency, it also benefits a global community of users. It's much bigger than just your own applications."

Fellow ESDIS Project Office intern Vincent Inverso agrees. "There is no other place in the country where you can do what you do here studying science and space," he says.

"It's an absolutely unique atmosphere and it permeates to everyone working here. This is a great place to be."

After 10 weeks of hard work, this year's interns are wrapping up their projects and preparing to continue their academic pursuits. If the past is any indication, it's likely some of these interns will return as future members of the EOSDIS team and have the opportunity to serve as mentors to the next generation of ESDIS Project interns—a two-way exchange that will continue to benefit both the EOSDIS and its worldwide data user community.

For more information about NASA Summer Internships and to apply for an internship, please visit the NASA Internships and Fellowships website: https://intern.nasa.gov. ■

USER **PROFILES:**

NASA Earth Science Data User Profiles highlight our diverse end-user community worldwide and show you not only how these data are being used for research and applications, but also where these data are being used – from the plains of West Texas to the Sea of Oman and everywhere in between. You'll also learn where you can download the data sets in each feature. https://earthdata.nasa.gov/user-resources/who-uses-nasa-earth-science-data-user-profiles

Dr. Mike Ramsey

Who uses NASA Earth science data? Dr. Mike Ramsey, for developing new ways to study active volcanoes and to provide data to support emergency response.

Professor of Volcanology and Planetary Science, Department of Geology and Environmental Science, University of Pittsburgh, Pittsburgh, PA

Research interests: Thermal infrared spectroscopy and remote sensing applied to a variety of Earth and planetary surface processes, especially the study of active volcanoes using ASTER data.

Dr. Mike Ramsey collecting thermal infrared data at a vent in the Leilani Estates subdivision near the eastern tip of the island of Hawaii in early June. The subdivision is located over part of the lower East Rift Zone of Kilauea. More than 27 homes in the subdivision have been destroyed as a result of eruptions that began this past May.

https://earthdata.nasa.gov/user-resources/who-uses-nasa-earth-science-data-user-profiles/user-profile-dr-mike-ramsey

Lela Prashad

Who uses NASA Earth science data? Lela Prashad, for exploring how people live in and experience urban environments.

CEO and Co-Founder of NiJeL, a data science company in Pheonix, AZ, focused on environmental and social sustainability; former director (2006-2011) of the NASA-funded 100 Cities Project at Arizona State University's School of Earth and Space Exploration

Research interests: Connecting satellite remote sensing data with ground-based monitors to build a more complete picture of urban environments and how people locally experience these environments.

Lela Prashad at her workstation. On the screen behind her is an image of ASTER normalized difference vegetation index (NDVI) and surface temperature data for Phoenix, AZ.

https://earthdata.nasa.gov/user-resources/who-uses-nasa-earth-science-data-user-profiles/user-profile-lela-prashad

Dr. Bridget Seegers

Who uses NASA Earth science data? Dr. Bridget Seegers, for developing new ways to study water quality and track harmful algal blooms.

Scientist (Oceanographer with the Universities Space Research Association [USRA]), Ocean Ecology Laboratory, NASA's Goddard Space Flight Center, Greenbelt, MD

Research interests: Using remotely-sensed satellite data for assessing water quality and harmful algal blooms (HABs) in fresh and salt water.

Dr. Bridget Seegers conducting a ballast check on a glider (yellow, airplane-looking object in water) during a West Coast project to better understand the initiation of harmful algal blooms (HABs).

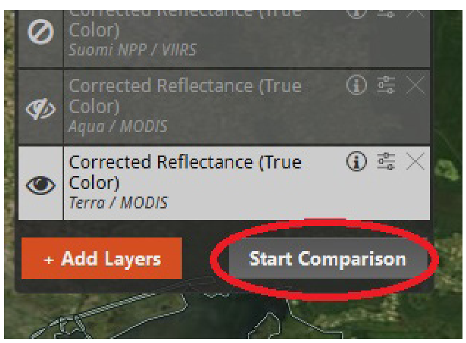
https://earthdata.nasa.gov/user-resources/who-uses-nasa-earth-science-data-user-profiles/user-profile-dr-bridget-seegers

Previous Versions of Worldview Just Can't "Compare"

A new comparison feature in NASA's Worldview data visualization application makes it easy to compare two images.

NASA's Worldview data visualization application has always been an easy way to interactively explore imagery created from data acquired by Earth observing satellites. A recent Worldview update takes care of numerous bug fixes and introduces an exciting new feature: A Comparison button that makes it easier than ever to look at two images at the same time.

Along with comparing imagery from two different dates, the feature allows comparisons of two sets of imagery from the same date or even two sets of imagery from different dates. For more detailed information, check out the post on the Global Imagery Browse Services (GIBS) Blog.

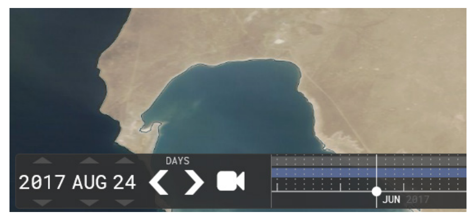


Enter the Worldview "Compare Mode" by clicking the "Start Comparison" button in the lower right corner of the Worldview control panel. This gives you three options for toggling between two images: swipe, opacity, or spy. "Swipe" is the default setting, and divides the Worldview screen into two halves representing the two images you want to compare: A (left side) and B (right side).

Let's say you want to do a simple comparison to look at how much the Aral Sea has decreased in size between 2000 and 2017. The Aral Sea, which is located between Kazakhstan in the north and Uzbekistan in the south, was once one of the largest lakes in the world. Diversion of rivers feeding the lake during the 1960s caused the lake to dramatically shrink in size. Today, vast stretches of this formerly huge water body are now desert.

For our first image, we'll select a relatively cloud-free true color image of the lake that was acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument aboard NASA's Terra Earth observing satellite on July 31, 2000. Select this date as your "A" image.

For our B-side image comparison, we'll use an image of the lake acquired in 2017. In this example we'll select a Terra MODIS true color image from August 24, 2017.

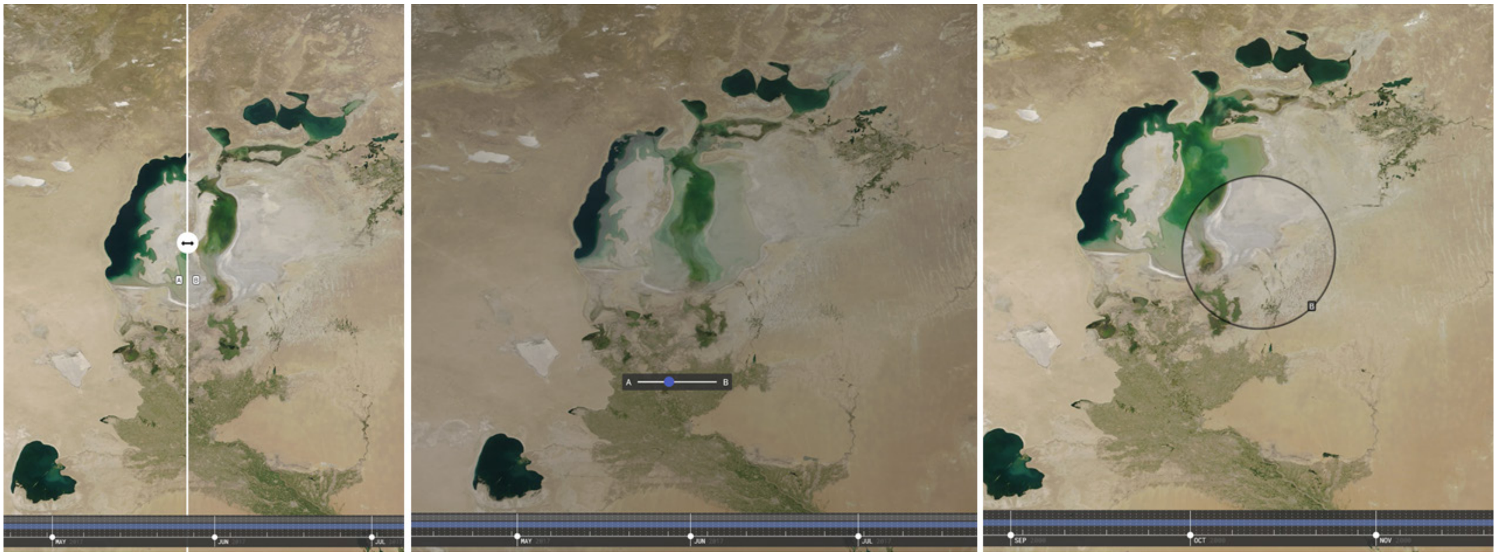


Click on the "B" tab to select it (the B tab turns white) and use the buttons on the date block (which is on the left side of the date slider at the bottom of the screen) to manually adjust the image date to "2017 August 24."

You now have two images on either side of a slider that runs down the center of the image: The A image is the Terra MODIS true color image from July 31, 2000, and the B image is the Terra MODIS true color image from August 24, 2017. Moving the slider icon left or right allows you to move between the two images and see the dramatic change in the lake's level over 17 years.

Another option is to use the "opacity" comparison button. This allows you to gradually fade from one image to another. The "spy" comparison option allows you to select either the "A" or "B" image to appear in a circular area that can be moved over the other image.

Here's how all three options look in Worldview:



Examples of the swipe (left image), opacity (middle image), and spy (right image) comparison options using Terra MODIS true color images from [July 31, 2000](#) (A image) and [August 24, 2017](#) (B image). The opacity comparison (middle image) is shown in the middle of the image transition. Note the small "B" icon in the lower-right ring of the spy image (right image) indicating that the smaller circular "spy" image is the August 24, 2017 image. NASA Worldview images.

Imagery available in Worldview come from NASA's Global Imagery Browse Services (GIBS), which is part of NASA's Earth Observing System Data and Information System (EOSDIS). GIBS provides quick access to more than 800 satellite imagery products covering every part of the world (including the poles). GIBS imagery can be interactively explored using Worldview or rendered in your own web client or GIS application using the GIBS API.

Check out the new Worldview comparison feature! While you're in Worldview, be sure to explore some of the other features of this powerhouse application (like making animated GIFs of individual images or viewing MODIS global daily base map images dating back to 2000). See how easy it is using Worldview to explore your world, your way! ■

2018 NASA International Space Apps Challenge: October 19-21

The world's largest hackathon challenges teams from around the world to collaboratively use NASA data to create open-source solutions to challenges for living on Earth and in space.

The 2018 NASA International Space Apps Challenge took place at more than 100 global locations—including virtually—October 19 through 21.

Over an exciting 48 hours, teams worked collaboratively developing open-source solutions to address global needs applicable to both life on Earth and in space based on specific challenges. Last year's hackathon brought together more than 25,000 participants at 187 event locations across six continents.

> hackathon [hak-uh-thon]; noun Digital Technology.
>
> A usually competitive event in which people work in groups on software or hardware projects, with the goal of creating a functioning product by the end of the event.
>
> *Dictionary.com*

This year's event featured teams at locations ranging from Abia State, Nigeria, to Zaragoza, Spain (as well as virtual participants who were located just about anywhere on Earth).

This year's theme was "Earth & Space," and featured challenges in six categories:

- Can you build a . . .: Challenges in this category required participants to use NASA data to develop apps to creatively solve problems and show how they would create items ranging from buildings, to robotic helpers, to tools for citizen science.

- Help others discover the Earth: Challenges in this category asked hackers to craft an app using NASA data that helped people discover how Earth works.
- Volcanoes, icebergs, and asteroids (oh my): These challenges required the development of apps to help anticipate, monitor, and recover from surprise events.
- What the world needs now is . . .: These challenges asked participants to develop apps to tackle problems affecting some important aspect of life in this world (or on others), and to interpret NASA data and concepts creatively to help find solutions.
- An icy glare: This challenge category entailed using NASA data to develop apps to better understand, monitor, and interpret Earth's (or another planet's!) cryosphere.
- A universe of beauty and wonder: Challenges in this category invited participants to think hard and be creative about space science and exploration, whether their view was scientific, technologic, artistic, or all three.

Many of this year's challenges required participating teams to use and incorporate NASA Earth science data or use services available through NASA's Earth Observing System Data and Information System (EOSDIS). The EOSDIS provides end-to-end capabilities for managing NASA's Earth science data collection. These data represent some of the most complex and diverse Earth science datasets on the planet, and are acquired from satellites, aircraft, field measurements, and numerous other programs. Through the EOSDIS Land, Atmosphere Near real-time Capability for EOS (LANCE) system, data are even available within hours of a satellite overpass—a great resource for tracking on-going events (such as volcanic eruptions or ice movement).

Participants creating apps addressing challenges in the Help Others Discover Earth, An Icy Glare, or What the World Needs Now . . . categories likely utilized the EOSDIS Global Imagery Browse Services (GIBS), which provides API access to more than 700 satellite imagery products that can be interactively explored using the EOSDIS Worldview satellite image visualization application. Participants searching for specific data products were able to explore the entire EOSDIS archive (more than 26 petabytes [PB] of data!) quickly and easily using Earthdata Search.

Since the NASA International Space Apps Challenge is a (friendly) competition, there are prizes. Judging took place at each Challenge location (including virtual teams) and apps were evaluated based on impact, creativity, validity, relevance, and presentation. Each local event could nominate up to two projects to advance to global judging. In addition, local awards were available at some locations.

For more information about this year's event, check out the Space Apps Challenge website (https://2018.spaceappschallenge.org), Twitter feed (https://twitter.com/spaceapps), or Facebook page (https://www.facebook.com/spaceappschallenge). ■

New OMPS Product Provides a Better View of High-Aerosol Events

A new pyrocumulonimbus product for the Ozone Mapping and Profiler Suite (OMPS) makes it easier to track and analyze high concentrations of aerosols from wildfires and similar events.

The 2018 wildfire season has been one for the record books. Along with historically high numbers of wildfires in the Western U.S. and in Canada, this season included rare wildfires above the Arctic Circle in Scandinavia and near the Russia-Finland border.

Along with the threat to lives and property, these fires also affect local weather. As heat from these fires rises into the atmosphere, it has the potential for producing pyrocumulonimbus (or pyroCb) events. A pyroCb is a fire-started or fire-augmented thunderstorm that in its most extreme manifestation pumps huge amounts of smoke and other biomass-burning emissions into the lower stratosphere. Smoke and other suspended particles in the atmosphere are known as "aerosols."

A new near real-time product available through NASA's

Land, Atmosphere Near real-time Capability for EOS (LANCE) system makes it easier to track the extent and spread of pyroCb and other high-aerosol events. This is vital information due to the many impacts caused by areas of high aerosol concentrations.

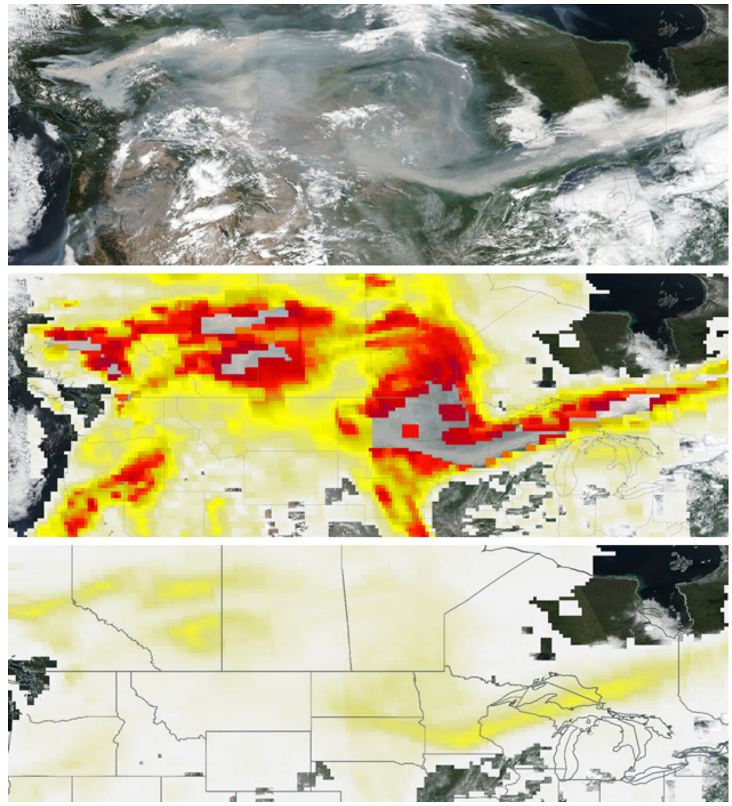
High aerosol concentrations not only can affect climate and reduce visibility, they also can impact breathing, reproduction, the cardiovascular system, and the central nervous system, according to the U.S. Environmental Protection Agency. Since aerosols are able to remain suspended in the atmosphere and be carried in prevailing high-altitude wind streams, they can travel great distances away from their source and their effects can linger.

Fortunately, their global movement can be tracked using instruments aboard Earth observing satellites. One of these instruments is the Ozone Mapping and Profiler Suite (OMPS) aboard the joint NASA/National Oceanic and Atmospheric Administration (NOAA) Suomi National Polar-orbiting Partnership (Suomi-NPP, launched in 2011) and NOAA-20 (launched in 2017) satellites.

The primary purpose of OMPS is to provide daily measurements of the global distribution of atmospheric ozone. Ozone is an important molecule in the atmosphere because it partially blocks harmful ultra-violet radiation from the sun. OMPS data help scientists monitor the health of this vital protective layer.

OMPS also can be used to measure concentrations of atmospheric aerosols from dust storms and similar events as well as sulfur dioxide (SO_2) from volcanic eruptions. One aerosol-related OMPS product is a value known as the "aerosol index," or AI. The AI value is related to both the thickness of the aerosol layer located in the atmosphere and to the height of the layer. For most atmospheric events involving aerosols, the AI ranges from 0 to 5.0, with 5.0 indicating heavy concentrations of aerosols that could reduce visibilities or impact health.

The AI product from the Suomi-NPP OMPS is produced by the LANCE system. LANCE is part of NASA's Earth Observing System Data and Information System (EOSDIS), and provides satellite imagery generally within three hours of a satellite overpass. While these near real-time images do not have the high level of processing required for use in scientific research, they are valuable tools for tracking and managing ongoing natural events, such as wildfires, volcanic eruptions, and dust storms. The OMPS AI product is available for viewing using the NASA Worldview satellite imagery exploration tool.



Suomi-NPP images from August 17, 2018, showing the utility of the new OMPS PyroCumuloNimbus AI product. Top image is a true color Visible Infrared Imaging Radiometer Suite (VIIRS) image of the Northern U.S. and Southern Canada. Milky white areas are smoke from wildfires in British Columbia (bright white areas are clouds or snow). Middle image is the same area overlain with the OMPS AI product. Note the red indicating AI values at the extreme high end of the AI scale and the gaps in the image where AI values are so high they are screened out. Bottom image is the same area overlain with the new OMPS PyroCumuloNimbus AI product. Note the correlation of the bright yellow areas in the lower image and the bright red areas in the middle image. Images courtesy of NASA Worldview.

Since the AI signal remains below 5.0 for most smoke and dust events, the OMPS AI product with an AI range of 0.0 to 5.0 satisfies the needs of most LANCE users. However, the AI signal for pyroCb events, which are both dense and high in the atmosphere, easily can be much larger than 5.0. In fact, the highest AI value ever observed (55.0) occurred during a pyroCb event in August 2017.

To provide better near real-time imagery for these high AI events, the OMPS and LANCE teams designed a new pyroCb product with an upper AI limit of 50.0. The design team also removed flags designed to screen out unusually high AI values. The resulting OMPS PyroCumuloNimbus AI product more accurately captures high AI events and makes it easier to track the spread of high aerosol concentrations in the atmosphere.

See for yourself, and use Worldview and the OMPS AI and PyroCumuloNimbus AI products to explore and track global high-aerosol events! ■

New Features in Giovanni

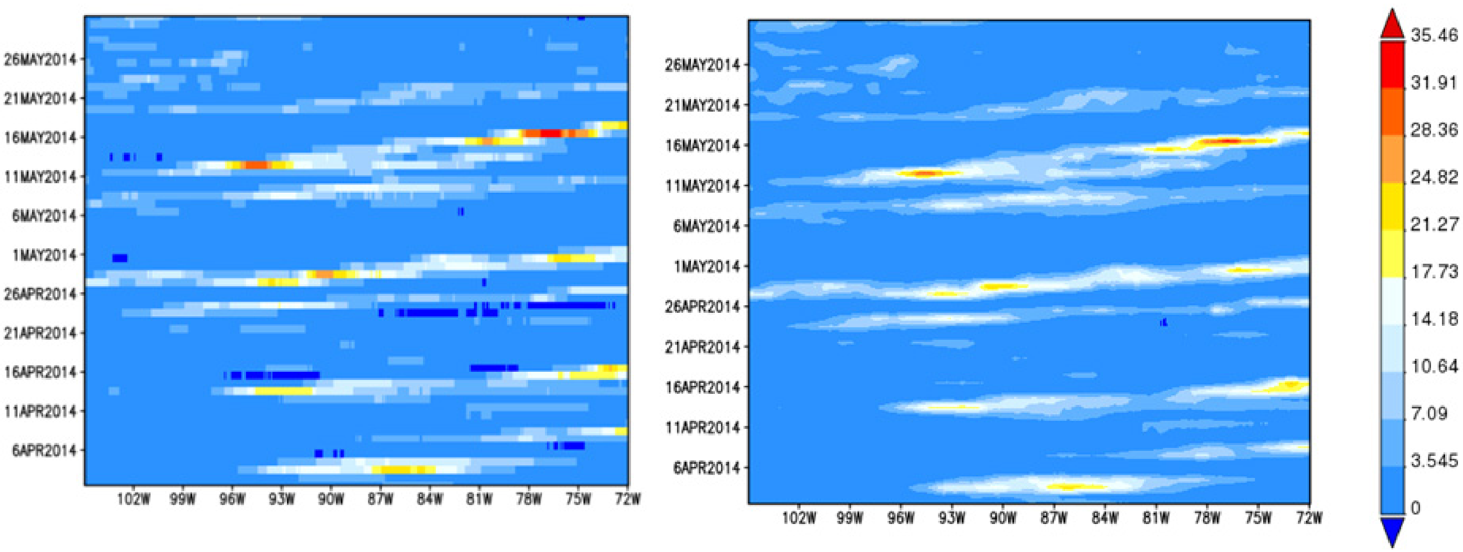
The release of Giovanni Version 4.28 by NASA's GES DISC brings improvements and enhancements to this data visualization and analysis tool.

NASA's Goddard Earth Sciences Data and Information Services Center (GES DISC) Distributed Active Archive Center (DAAC) released a new version of the Giovanni data visualization and analysis tool. Giovanni is a web-based application that provides a simple and intuitive way to visualize, analyze, and access vast amounts of Earth science remote sensing data without having to download the data.

New features in Giovanni V4.28 include:

- Hovmöller plots are now shown with contoured output, rather than a discrete pixel display *(see image below);*
- The Help and Feedback buttons have been integrated with the Giovanni toolbar, making the user interface easier to navigate;
- Bounding box input can now be cleared within the map selection tool; and
- Data grid information has been added to the caption for non-shapefile cases (this data grid information also is found in the comma-separated values [CSV] output file).

The GES DISC is the Earth Observing System Data and Information System (EOSDIS) DAAC responsible for a wide range of global climate data, primarily in the areas of atmospheric composition, atmospheric dynamics, global precipitation, and solar irradiance. It is located at NASA's Goddard Space Flight Center in Greenbelt, MD. ■



Comparison of Hovmöller plots showing daily averaged precipitation (combined microwave-IR) estimate for April 1 through May 31, 2014, in discrete pixel display (left) and contoured output in Giovanni V4.28 (right). Illustration created using data from the joint NASA/JAXA GPM mission and courtesy of NASA's GES DISC.

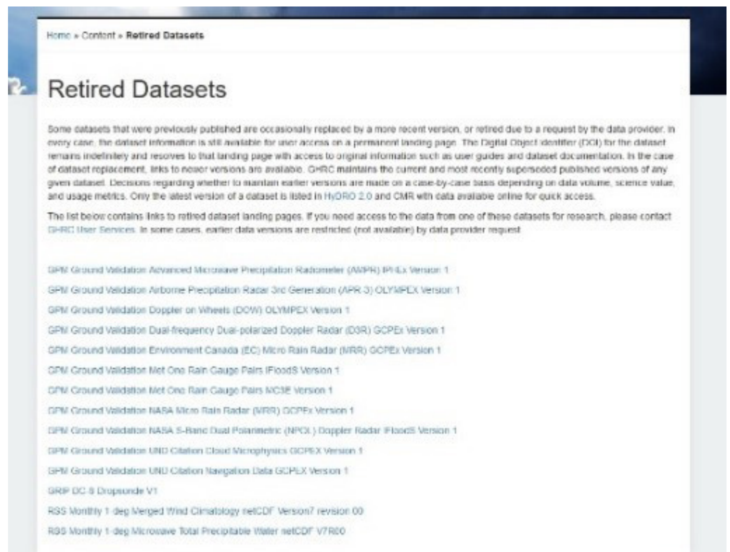
New GHRC Retired Datasets Page

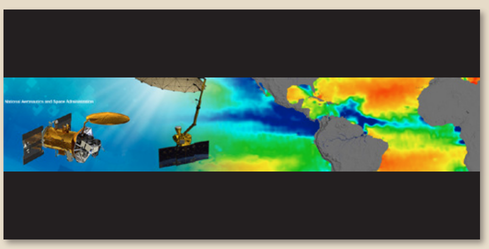
A new GHRC webpage provides links to datasets and dataset documents that are no longer part of the active GHRC dataset collection.

Like all NASA Earth Observing System Data and Information System (EOSDIS) Distributed Active Archive Centers (DAACs), the Global Hydrology Resource Center (GHRC) continually updates existing data products to ensure that the most accurate data for scientific research is always available. In some cases, this means that older datasets are replaced with updated versions based on new algorithms and some datasets are retired due to a request from the data provider. In every case, these older or retired datasets—along with all supporting dataset documentation—are still available for user access on a permanent landing page, although only the latest, most recent version of a dataset is listed on the GHRC's HyDRO 2.0 dataset search and discovery application and available through the EOSDIS Earthdata Search application.

A new GHRC Retired Datasets webpage provides links to retired dataset landing pages. It is important to note that these older or retired datasets may not be based on the most current data processing algorithms, and decisions on whether to maintain these older datasets are made on a case-by-case basis. Users needing access to data from these retired datasets for research should contact the GHRC User Services office.

The GHRC DAAC is responsible for EOSDIS data focusing on lightning, tropical cyclones, and storm-induced hazards. The DAAC is a joint venture of NASA's Marshall Space Flight Center in Huntsville, AL, and the University of Alabama in Huntsville's Information Technology and Systems Center (ITSC). ■

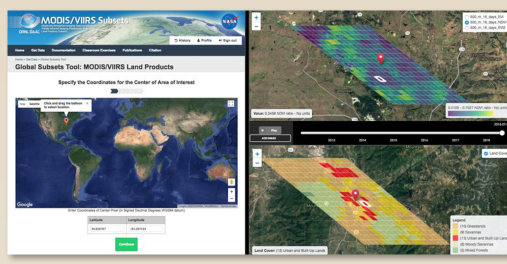




8/8/18

Don't Pass the Salt! NASA's Salinity Mission Continues with SMAP

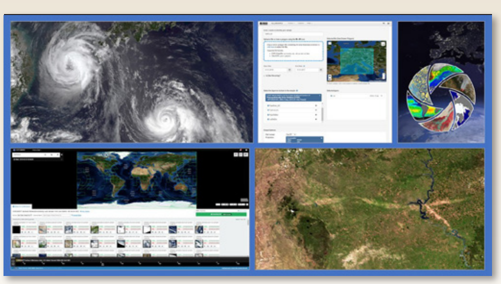
https://youtu.be/oQs-AhTdxE4



8/16/18

NASA ORNL DAAC MODIS and VIIRS Data Tools and Services at your Fingertips

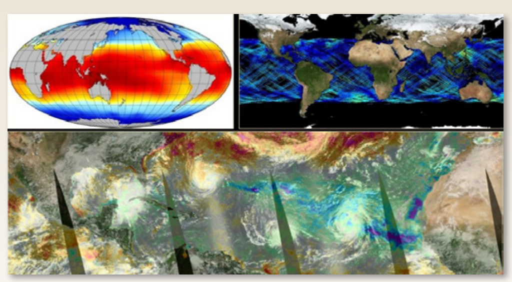
https://youtu.be/avMb7gtzIMI



9/26/18

Exploring Earth's Land Surface with Suomi-NPP NASA VIIRS Land Data

https://youtu.be/sMzA_DyhqEA



10/24/18

Goodbye FTP, New Ways to Access NASA's Physical Oceanography Data at PO.DAAC

https://youtu.be/kd8yjl6YiH8

DATA Recipes

Creating a Basic EC2 Instance within AWS

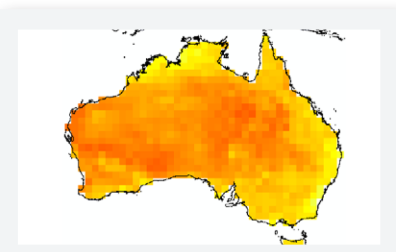
This recipe shows you how to create a basic Elastic Compute Cloud (EC2) instance within Amazon Web Services (AWS) to work with Synthetic Aperture Radar (SAR) data.

This recipe was developed by the NASA Alaska Satellite Facility Distributed Active Archive Center (ASF DAAC).

View recipe: http://bit.ly/2JeO3Tk

To see additional SAR data tutorials/recipes: https://www.asf.alaska.edu/asf-tutorials/data-recipes/

How to Correctly Import GRIB Format Data into ArcGIS



This data recipe shows an example on how to import GRIB data files correctly into ArcGIS. The recipe focuses on land data from the Global Land Data Assimilation System (GLDAS).

This recipe was developed by the NASA Goddard Earth Science Data and Information Services Center (GES DISC).

View recipe: https://go.nasa.gov/2ARCQFz

To view additional GES DISC data tutorials/recipes: https://disc.gsfc.nasa.gov/information/howto

Working with Daily NASA VIIRS Surface Reflectance Data

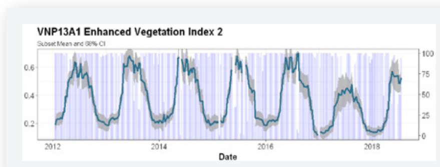
This tutorial demonstrates how to work with the daily Suomi-NPP NASA Visible Infrared Imaging Radiometer Suite (VIIRS) Surface Reflectance (VNP09GA.001) data product. In this tutorial, you will use Python to define the coordinate reference system (CRS) and export science dataset (SDS) layers as GeoTIFF files that can be loaded into a GIS and/or remote sensing software program.

This recipe was developed by the NASA Land Processes (LP) DAAC.

View recipe: http://bit.ly/2CcCxqi

To view additional LP DAAC data tutorials/recipes: https://lpdaac.usgs.gov/user_resources/e_learning

Access the MODIS/VIIRS Land Data Web Service Using R



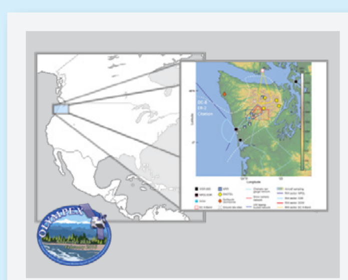
This data recipe shows how to access Moderate Resolution Imaging Spectroradiometer (MODIS) and Suomi-NPP Visible Infrared Imaging Radiometer Suite (VIIRS) land data via the NASA Oak Ridge National Laboratory (ORNL) DAAC web services using R and efficiently prepare a time series of data for further analysis.

View recipe: http://bit.ly/2qyeFGr

This recipe was developed by the NASA Oak Ridge National Laboratory (ORNL) DAAC.

To view additional ORNL DAAC data tutorials/recipes: https://daac.ornl.gov/resources/

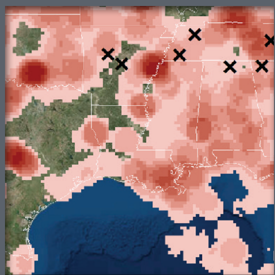
New! Featured Micro Article



What is a Micro Article? Micro Articles are concise and focused selections of information that allow users to quickly assess topics and locate the most useful or relevant associated data, information, and tools.

Olympic Mountains Experiment (OLYMPEX) Field Campaign Micro Article: https://go.nasa.gov/2RMsrB1

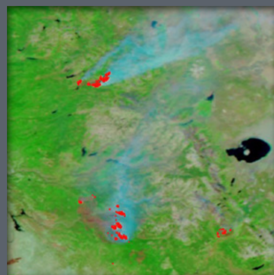
Latest NASA Earthdata Images



Sensing Lightning from Space

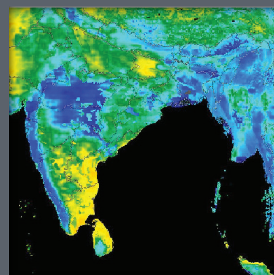
https://earthdata.nasa.gov/mastheads

(Published 8/13/18)



Donnell, Ferguson, and Lions Fire, CA, USA

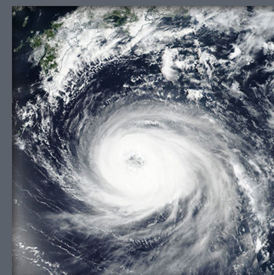
https://earthdata.nasa.gov/donnell-ferguson-and-lions-fire-ca-usa



Soil Moisture and the Asian Monsoon

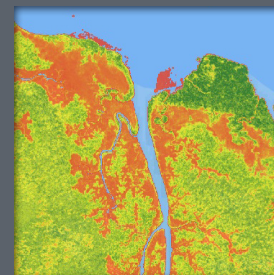
https://earthdata.nasa.gov/mastheads

(Published 8/20/18)



Typhoon Soulik

https://earthdata.nasa.gov/typhoon-soulik



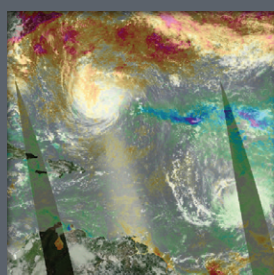
Sensing Forest Canopy Height

https://earthdata.nasa.gov/mastheads

(Published 9/17/18)

Hurricane Florence, Tropical Storm Isaac, and Hurricane Helene in the Atlantic Ocean

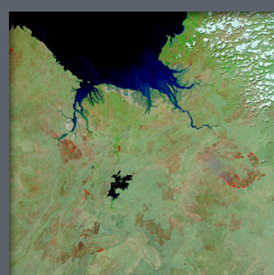
https://earthdata.nasa.gov/hurricane-florence-tropical-storm-isaac-and-hurricane-helene-in-the-atlantic-ocean



Looking at the State of the Ocean

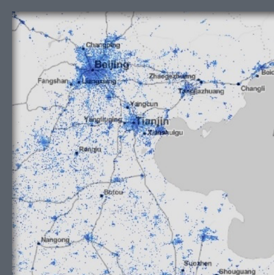
https://earthdata.nasa.gov/mastheads

(Published 9/24/18)



Fires in the Northern Territory and Western Australia

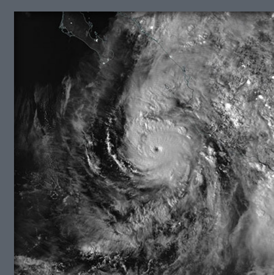
https://earthdata.nasa.gov/fires-in-the-northern-territory-and-western-australia



Mapping Impervious Surfaces in East Asia

https://earthdata.nasa.gov/mastheads

(Published 10/1/18)



Hurricane Willa approaching the west coast of Mexico

https://earthdata.nasa.gov/hurricane-willa-approaching-west-coast-of-mexico

About Us

Discover EOSDIS data, information, services, and tools. Tap into our resources! To learn more, visit our website at https://earthdata.nasa.gov

Connect with Us

Follow NASA Earthdata for Earth science data, services and tools, news, and updates on social media:

https://twitter.com/NASAEarthdata

https://www.facebook.com/NASAEarthdata

http://google.com/+NASAEarthdata

Subscribe to EOSDIS News

https://lists.nasa.gov/mailman/listinfo/eosdis-news

Feedback?

Email: support@earthdata.nasa.gov

Webinars, Tutorials, and Recipes

Watch data discovery and data access webinars, tutorials, and short data “how-to” recipes on YouTube at http://www.youtube.com/c/NASAEarthdata

View our webinar schedule and sign-up to receive webinar announcements at https://earthdata.nasa.gov/user-resources/webinars-and-tutorials

EXPLORE EARTH

www.nasa.gov