EOSDIS Update
National Aeronautics and Space Administration
WINTER 2020-2021
Earth Science Data and Information System (ESDIS) Project
A PUBLICATION OF NASA's EARTH OBSERVING SYSTEM DATA AND INFORMATION SYSTEM (EOSDIS), CODE 423

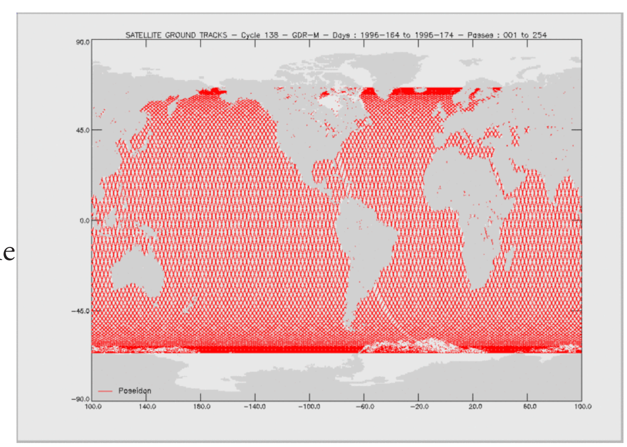
FEATURE ARTICLES

The Precision Behind Sea Level Rise

Knowing the precise location of a satellite in space is critical for determining sea surface height and, through this, the rate of global mean sea level rise.

For more than 28 years, a series of satellite ocean altimetry missions has compiled a record of sea surface height using the same global observational ground track. Starting with the Topographic Experiment (TOPEX)/Poseidon mission (operational 1992 to 2006) and continuing with the Jason-1, Ocean Surface Topography Mission (OSTM)/Jason-2, and Jason-3 series of satellites (operational 2001 to present), this consistent ocean altimetry data record continues with the launch of the Sentinel-6 Michael Freilich satellite. The result will be a more than 30-year time-series of satellite-acquired sea surface height data.

Sea level change, and the rate of this change, is derived from calculations of sea surface height. By averaging the hundreds of thousands of satellite-collected altimetry measurements acquired over the same orbital track by TOPEX/Poseidon, the Jason series of satellites, and, now, Sentinel-6 Michael Freilich, global mean sea level can be determined with a precision of several millimeters along with its change over time.



Red lines on this world map show the orbital tracks of the TOPEX/Poseidon, Jason-1, OSTM/Jason-2, Jason-3, and Sentinel-6 Michael Freilich ocean altimetry missions. These satellites are used as orbiting tide gauges that provide a snapshot of ocean surface height and pass over the same point every 9.9156 days. The result is a consistent record spanning more than 28 years. Image: AVISO (Toulouse, France).

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

"Sea surface height is telling you what the height of the water column is," explains Jessica Hausman, support scientist for NASA's Physical Oceanography Program. "There are a lot of factors that influence sea level change. You have water inputs from land, from glaciers, you have thermal expansion, and you have changes caused by differences in salt concentrations."

The fact that an altimeter aboard a satellite orbiting hundreds of miles above Earth and travelling tens of thousands of miles per hour can acquire accurate measurements of the range from the satellite to the ocean's surface is an indication of the incredible precision that is required – and achieved – in knowing the exact position of the satellite above a stable reference point on Earth. The technique for accomplishing this is called Precise Orbit Determination (POD).

POD is part of the Earth science discipline of geodesy, which is concerned with the shape, gravity field, and rotation of Earth and how these variables change over time. The process of POD involves doing a summation at every time step of all the forces acting on a spacecraft, and integrating equations of motion to determine the exact position of an orbiting satellite where a measurement is taken. As noted by Dr. Frank Lemoine, a geodesist with NASA's Space Geodesy Project and a member of NASA's Ocean Surface Topography science team, "If you don't do POD right, you're not going to get any sea level results."

And doing POD right requires numerous inputs. Here's where an image comes in handy (see illustration). As the OSTM/Jason-2 satellite (operational 2008 to 2019) shown in the image orbited 830 miles above Earth, its altimeter acquired range measurements from the satellite to the ocean's surface over the same locations every 9.9156 days – the same repeat time and orbital track as TOPEX/Poseidon, Jason-1, Jason-3, and Sentinel-6 Michael Freilich.

Determining the exact position of the satellite when an observation is acquired entails the use of several space geodetic techniques. A retroreflector attached to the satellite reflects laser beams that are directed toward it by satellite laser ranging (SLR) stations on the ground (*Laser Station* in the image). Altimeter satellites are tracked by a global network of stations operated by NASA and other countries organized under the aegis of the International Laser Ranging Service (ILRS).

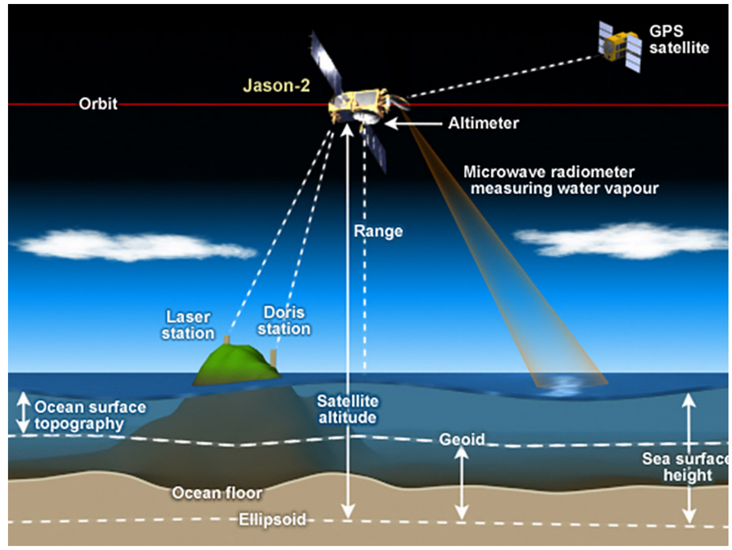


Image: NASA's Jet Propulsion Laboratory (JPL) and available at https://sealevel.jpl.nasa.gov/missions/technology.

Along with a retroreflector, Jason-2 also carried a Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS) receiver that detected radio signals broadcast by DORIS beacons on the ground (*DORIS Station* in the image). A third tracking system aboard the satellite was a global positioning system (GPS) receiver that used signals from a constellation of orbiting GPS satellites to determine the satellite's position (*GPS Satellite* in the image; GPS is the U.S. version of the Global Navigation Satellite System [GNSS]). TOPEX/Poseidon, Jason-1, Jason-3, and Sentinel-6 Michael Freilich all carried or carry DORIS and GPS receivers along with retroreflectors.

For links to additional information about sea level change, visit the NASA Earthdata Sea Level Change Data Resources *page.*

For ground-based geodetic stations like SLR and DORIS, the exact position of the station must be known. This is accomplished through the use of the *Terrestrial Reference Frame* (TRF). The TRF consists of a set of coordinates and velocities of reference points on Earth's surface whose positions are known very accurately as a function of time. These points define a realization of a spatial reference system that makes it possible to not only relate geodetic measurements from different stations, but have these measurements linked over space and time. Since Earth's tectonic plates are constantly moving, both horizontally and vertically, a realization of the TRF is re-calculated on a regular basis (typically every five to six years).

The TRF enables the precise positioning of geodetic stations that are used to calculate the position of a satellite in space. "Without a terrestrial reference frame, you're not going to be able to reliably determine mean sea level or interpret what you're actually seeing," says Dr. Lemoine.

Knowing where the satellite is through the use of SLR, DORIS, and GPS is only half the battle. The next step is determining the exact satellite altitude and, through this, sea surface height. Both the satellite altitude and sea surface height are calculated with respect to a solid, stable reference point called the *ellipsoid*.

Talking about the ellipsoid means we need to talk about Earth's shape. Contrary to what you may have heard (or seen in the shape of just about any schoolroom globe), our planet is not a perfect sphere. The shape is more like a ball with someone sitting on it – flatter at the top with a bulge in the middle. This resulting slightly-squashed shape is called an ellipsoid.

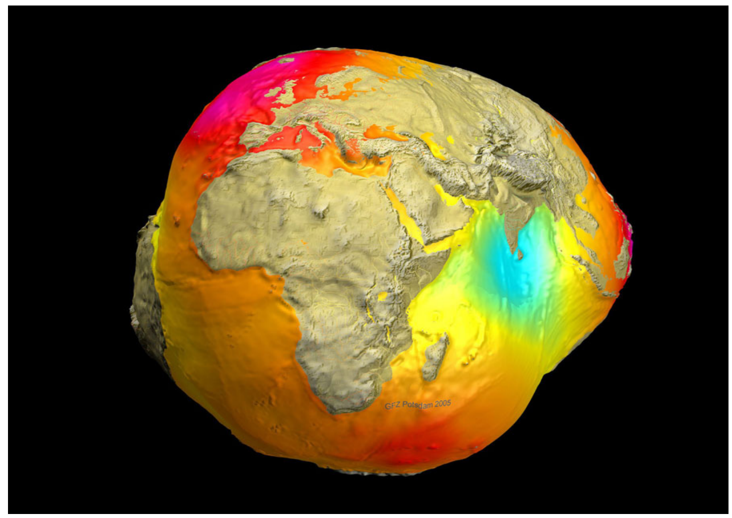
The *reference ellipsoid* is a smoothed mathematical representation of Earth's sea level surface that ignores the effects of tides, seasonal currents, and waves. It is from this smooth, consistent surface that satellite altitude and sea surface height are calculated.

"This is our starting point for all measurements," says Jessica Hausman. "TOPEX and all the Jason satellites used this same reference ellipsoid. This means that regardless of the satellite, we always have the same starting point."

It's important to remember that that when we talk about sea surface height, we're not talking about the distance from the satellite to the surface of the water – this is the range. Sea surface height, on the other hand, is the combination of the *geoid* and the ocean's dynamic topography (which includes tides, seasonal currents, and waves).

The geoid relates to Earth's gravity field. Gravity is not constant across Earth, and the amount of force exerted by gravity changes with changes in mass. These uneven mass distributions influence satellite trajectories since areas of higher mass exert more force than areas of lower mass (from Newton's Second Law of Motion: Force = mass x acceleration or F = ma).

If tides and currents (the dynamic ocean surface topography) were removed from the ocean, Earth would have an undulating shape, with hills of higher mass concentrations where the force of gravity is higher and valleys of lower mass concentrations where the force of gravity is lower. This irregular shape is called the geoid. Without a good model representing the distribution of Earth's mass, your satellite position will be in error. As noted by Dr. Lemoine, prior to the launch of TOPEX/Poseidon, errors in models of Earth's gravity field were the largest source of orbit error for satellite altimeter missions.



A geoid image of Earth showing Earth's gravity field anomalies as of 2005. This image, known as the Potsdam Gravity Potato, shows areas where Earth's gravity field is higher (darker colors) and areas where the gravity field is lower (lighter colors). Image credit: NASA, CHAMP, GRACE, GFZ, DLR.

Fortunately, orbiting satellites are able to provide precise measurements of how Earth's mass is distributed. Models of Earth's gravity field used for POD are based primarily on data from the joint NASA/German Aerospace Center (DLR) Gravity Recovery and Climate Experiment (GRACE; operational 2002 to 2017), the joint NASA/German Research Centre for Geosciences GRACE-Follow On (GRACE-FO; launched in 2018), and the European Space Agency's Gravity field and Ocean Circulation Explorer (GOCE; operational 2009 to 2013). Additional gravitational data are acquired by satellite laser ranging measurements to geodetic satellites, such as the LAser GEOdynamics Satellite (LAGEOS) and the LAser RElativity Satellite (LARES).

While the single GOCE spacecraft carried a gradiometer to acquire data, GRACE and GRACE-FO feature identical twin satellites flying in formation. By continually measuring minute changes in the distance between the two satellites to an accuracy of one micron (about 70 times smaller than the average diameter of a human hair), areas of higher and lower mass concentrations can be identified. Data from GOCE, GRACE, and GRACE-FO enable the determination of not just where mass concentrations are higher or lower, but also how mass is redistributed as fluid moves around Earth's surface and within the planet.

GRACE and GRACE-FO products also include snapshots of mass change on different temporal and spatial scales, including mass changes resulting from glacial rebound, hydrology changes on land surfaces and in river basins, and movement of ice sheets and glaciers. Model information from the GRACE missions, including these time-variable gravity variations, are used to create better models of spacecraft trajectory. In fact, if these models were not included in POD determinations, the calculated rates for mean sea level change would be off by a few tenths of a millimeter per year.

As you might infer from the above paragraphs, the geoid (unlike the ellipsoid) is not constant – and is anything but smooth. The geoid typically varies on the order of +/- 100 meters over the globe, sometimes running above the ellipsoid and sometimes below the ellipsoid. The ocean's dynamic surface topography extends from the top of the geoid to the ocean surface and varies on the order of about two meters.

Here's how everything comes together. The sea surface height is the combination of the geoid and the dynamic surface ocean topography. The satellite altitude over the ocean is the distance from the satellite to the ellipsoid. If you want to deduce the shape of ocean currents and how these change with time (the dynamic ocean surface topography), simply eliminate the geoid from the sea surface height determination. Dr. Lemoine points out that missions like GRACE, GRACE-FO, and GOCE have a direct benefit in that they enable a better calculation of ocean currents from satellite altimetry data, and an indirect benefit in that their data enable geodesists to more precisely calculate satellite trajectories.

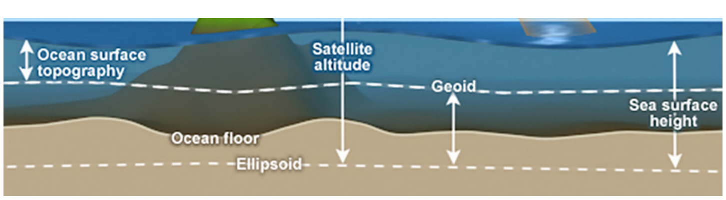


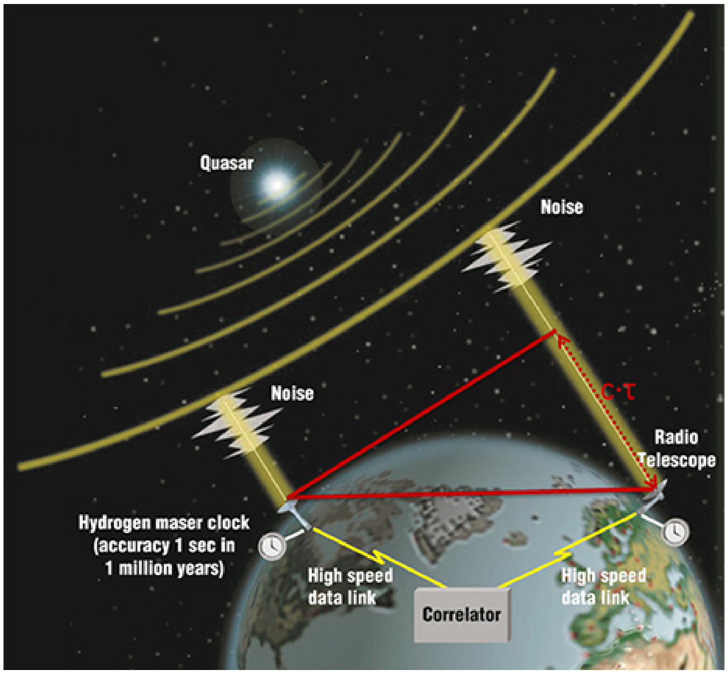
Image: JPL.

But there are still forces acting on the planet and on the orbiting satellite that can affect the actual position of the altimeter in space. For one, the atmosphere itself has mass and, through this, its own gravity field (the force of which is constantly changing). To account for this, space geodesists acquire numerical weather model output every three hours that transforms pressure fields into gravitational coefficients. These atmospheric gravitational coefficients are incorporated into the POD analysis.

And as Earth rotates about its axis, it also is wobbling. This leads to changes in the position of the center of rotation, or what we know as the Pole. Polar motion, the motion of Earth's rotational axis relative to its crust, can shift on the order of five to six meters. For this reason, the exact position of the Pole must be determined every day, primarily through GNSS (which can determine this to a few millimeters). As Dr. Lemoine points out, "If you don't model polar motion, then the location of your ground stations relative to your satellite could be in error by up to five or six meters."

An additional variable that needs to be considered for POD is changes in Earth's rotation. Not only is Earth rotating about a wobbling axis, but the speed of this rotation is slowing down. As noted above, the planet has areas of higher and lower mass concentrations that vary across its surface and are constantly shifting. As mass concentrations shift, this changes the distribution of mass relative to the planet's rotational axis and affects the speed of the planet's rotation. Even through these changes in rotational speed are on the order of tenths of milliseconds, this effectively changes the length of day by approximately one millisecond per year. This may not sound like much, but this translates to about 46 centimeters in longitude at the equator. As a result, changes in Earth's rotation with time are determined daily and input into POD.

Determining changes in Earth's rotation requires a specialized geodetic technique called Very Long Baseline Interferometry, or VLBI. VLBI uses pairs of radio telescopes to detect radio signals emitted by distant quasars. By measuring the difference in arrival time of a radio signal from a specific quasar being observed simultaneously by two radio telescopes, changes in Earth's rotation over time can be calculated. Depending on the networks or number and type of radio telescopes used, this can be determined with a precision of 5 to 15 microseconds.



How VLBI works. Differences in the time of arrival of radio signals emitted by a quasar detected by two radio telescopes enable the determination of a baseline that can be used to calculate minute changes in Earth's rotational speed. Image from NASA's Space Geodesy Project website.

When it comes to forces acting directly on the satellite, a real issue in POD is the effect of radiation pressure. Radiation pressure is the force exerted by photons (packets of light energy) on the spacecraft. While the primary source of photons is the Sun, they also can be reflected from Earth.

As these photons hit the spacecraft, this radiation pressure can cause slight changes in the spacecraft's trajectory. As a result, POD calculations have to account for whether the spacecraft is in full Sun or in Earth's shadow. While the most sophisticated models use a form of ray-tracing, Dr. Lemoine notes that POD calculations generally settle on the simplest modeling that satisfies how well the spacecraft trajectory needs to be calculated.

Geodetic techniques like SLR, GNSS, DORIS, and VLBI constantly are improving. More detailed information about these techniques is available through NASA's Crustal Dynamics Data Information System (CDDIS), which is the NASA Earth Observing System Data and Information System (EOSDIS) Distributed Active Archive Center (DAAC) responsible for NASA geodetic data. In addition, satellite altimetry and sea surface height data in the EOSDIS collection are freely available through NASA's Physical Oceanography DAAC (PO.DAAC).

Along with a retroreflector, star trackers, and a DORIS receiver, the Sentinel-6 Michael Freilich satellite also carries the next generation of GNSS receiver that enables the satellite to acquire signals from both the U.S. GPS and the European Galileo GNSS constellations. "This enables you to calculate the position of the satellite using two different GNSS constellations to see how well they agree" says Dr. Lemoine.

The enormous amount of time devoted to the calculations involved in POD ensure a consistent, scientifically accurate satellite altimetry record dating back to the early-1990s and a reliable assessment of the rate of sea level rise. Through the use of geodetic techniques and data from satellite missions like GOCE, GRACE, and GRACE-FO, the continuous satellite altimetry record initiated by TOPEX/Poseidon and the Jason series will continue with Sentinel-6 Michael Freilich well into the 21st century. ■

Additional Resources

POD Earthdata Webinar with Dr. Frank Lemoine: https://youtu.be/w6TwpsnFkis

NASA CDDIS Geodetic Techniques page: https://cddis.nasa.gov/Techniques/index.html

NASA PO.DAAC Ocean Surface Topography page: https://podaac.jpl.nasa.gov/OceanSurfaceTopography

Published November 5, 2020

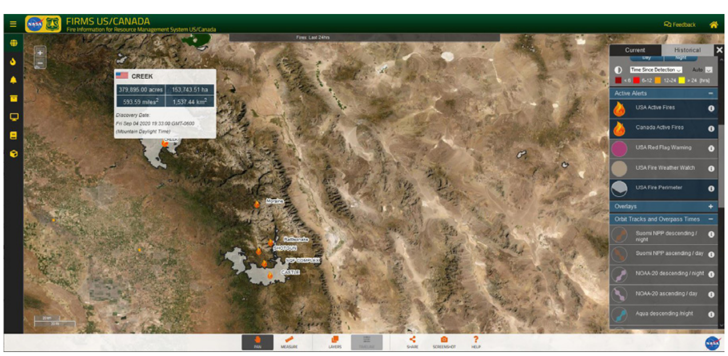
NASA, Forest Service Partnership Expands Active Fire Mapping Capabilities

A new Fire Information for Resource Management System (FIRMS) focused on the US and Canada provides expanded capabilities including additional map layers, ownership boundaries, and daily fire dangers.

Joeseph M. Smith, NASA EOSDIS Science Writer

By any measure, the 2020 wildfire season saw extreme fire activity in the western United States. Fueled by bone dry fuels and fanned by strong winds, fires ignited and combined into record-breaking conflagrations that burned more than 10 million acres, destroyed more than 10 thousand structures, and killed more than 35 people. During the response, federal and state agencies relied on a suite of technologies to keep emergency managers, first responders, firefighters, and other stakeholders informed with the latest fire information. Among those technologies was NASA's Land, Atmosphere Near Real-time Capability for EOS's (LANCE) Fire Information for Resource Management System (FIRMS), which distributes near real-time active fire data within three hours of a satellite observation. FIRMS data was integrated into the NASA Disasters Mapping Portal and used to generate maps of fire activity, position, perimeter, smoke direction, and other information critical to the fire response.

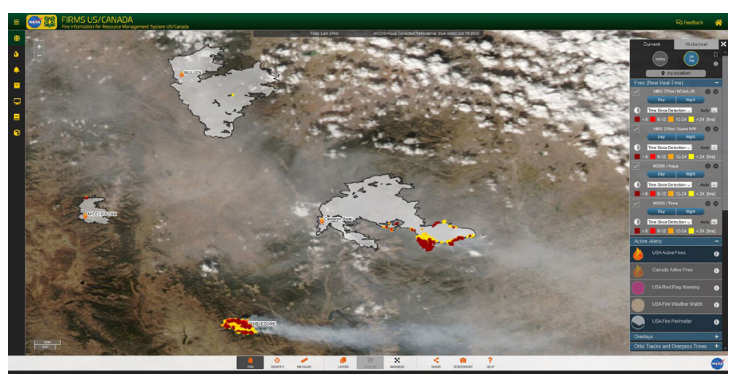
Recently, NASA's LANCE FIRMS developers partnered with the USDA Forest Service's Geospatial Technology and Applications Center (GTAC) to create FIRMS US/Canada, a new and expanded version of FIRMS released earlier this year.



A screenshot of the FIRMS US/Canada fire map highlighting the Creek Fire, which started on September 4, 2020 near Shaver Lake, California, as seen in the U.S. large incident locations layer (sourced from the Integrated Reporting of Wildland Fire and Information (IRWIN) and the USA fire perimeter layer (from the National Incident Feature Service (NIFS)).

FIRMS US/Canada is the result of an agreement between the GTAC and NASA to modernize and optimize the USDA Forest Service's distribution of active fire information by leveraging LANCE's web-based active fire mapping tools and capabilities for disseminating data, products, and services. This effort involved the migration of the Forest Service's upstream satellite data processing applications to a computing platform at NASA's Goddard Space Flight Center in Greenbelt, MD, and the development of a new instance of FIRMS focused on the U.S. and Canada tailored to the Forest Service and the wildland fire community's active fire mapping needs.

Like FIRMS, FIRMS US/Canada, provides active fire data, generally within three hours of a satellite observation, from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Aqua and Terra satellites, and the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard the National Oceanic and Atmospheric Administration's (NOAA) Suomi National Polar-orbiting Partnership (Suomi NPP) and NOAA 20 satellites. Imagery is typically available within three to four hours and can be viewed on an interactive Fire map application. In addition, FIRMS US/Canada meets the new Forest Service requirements by offering additional contextual layers and enhancements, including classifying fires to show time since detection to depict active fire fronts, incident locations and other information for current large fires in the US and Canada. FIRMS US/Canada provides current and historical corrected reflectance imagery from NASA and NOAA satellites, US and Canada administrative ownership boundaries, daily fire danger forecasts, and current National Weather Service fire weather watch and red flag warning areas.



A screenshot of the FIRMS US/Canada fire map showing active fire detections (in red, orange, and yellow) depicted as time since detection and fire affected areas (as grey polygons) from the NIFS USA Fire Perimeter layer overlaid on MODIS/Aqua Corrected Reflectance imagery from 15 October 2020.

The significance of this NASA-Forest Service partnership goes beyond the creation of FIRMS US/Canada. It establishes a single, authoritative source of near real-time fire mapping, visualization, and geospatial data products and information for the United States and Canada jointly supported and enabled by both agencies. This enhanced cooperation will boost the availability of selected contextual geospatial data to increase the utility of near real-time fire geospatial data products, as well as increase opportunities, under the auspices of LANCE, to evaluate and integrate additional sources of NASA, NOAA, and international space agency satellite data of value to the user community.

"NASA values our ongoing partnership with the Forest Service that is improving our ability to use near real-time satellite data to respond to forest fires," said Robert Wolfe, chief of the Terrestrial Information Systems Laboratory at NASA Goddard. "This joint effort to modernize GTAC's Active Fire Mapping functions by leveraging NASA's FIRMS both enhances our global FIRMS framework and focuses it on the needs of US and Canadian fire fighters."

Deb Oakeson, director of the Forest Service's GTAC, expressed similar appreciation for the NASA-Forest Service partnership.

"With our colleagues at NASA Goddard, we are excited to complete the first phase of the latest effort to ensure state-of-the-art active wildfire mapping," Oakeson said. "The new version of FIRMS US/Canada will allow us to continue to provide near real-time capabilities for the location, extent, and intensity of wildfire activity, which is crucial to strategic wildfire planning and response," she added.

Following the launch of FIRMS US/Canada, the Forest Service has announced that it will phase out its legacy fire mapping initiative, the Active Fire Mapping Program, in about a year.

"The period of overlap will provide a gradual sunset for the legacy platform," said Brad Quayle, a remote sensing and GIS specialist who leads active fire mapping for GTAC. "Wildfire agencies, decision support applications, and the public are ensured continual access to the legacy platform as they transition to FIRMS US/Canada."

During that time, LANCE and the Forest Service will implement additional enhancements and add new functionality to FIRMS US/Canada as necessary.

FIRMS Enables Response to Natural Disasters

The Land, Atmosphere Near Real-time Capability for EOS (LANCE) helps the NASA Earth Applied Sciences Disasters Program rapidly support disaster responses and aid in risk reduction. During the 2020 Western U.S. fires, LANCE FIRMS data were integrated into the NASA Disasters Mapping Portal and provided to stakeholders, including the California State Guard, Federal Emergency Management Agency, California Governor's Office of Emergency Services, and CalFire, who used them to generate maps of fire perimeter progression and understand the risk of debris flows. Knowledge of the geographical position and direction of smoke, and active fires provided critical information for disaster prediction and prevention.

FIRMS, the foundational application on which FIRMS US/Canada is based, was developed by researchers at the University of Maryland with funds from NASA's Applied Sciences Program and the United Nations Food and Agriculture Organization. It was transferred to NASA's LANCE system in 2012.

In addition to viewing active fires via the Fire Map application, FIRMS users can download active fire data for the last 24 hours, 48 hours, or week in shapefile, KML, WMS, or text file formats. (Data older than seven days can be obtained using the FIRMS Archive Download Tool.) Users may also sign up to receive email Fire Alerts notifying them of fires detected in specific areas of interest. Through this free service, alerts can be received in near real-time or as daily or weekly summaries. Every week approximately 15,000 FIRMS alerts (including daily alerts, Rapid Alerts, and weekly alerts) are sent to users in more than 160 countries, according to the FIRMS team.

To learn more about FIRMS and its data sources, or to see active fire maps, visit the FIRMS website.

To learn more about LANCE and how the data and imagery it provides is used to monitor a wide variety of natural and man-made phenomena, visit the LANCE website.

To learn more about GTAC's mission, projects, and publicly available geospatial applications, visit the USDA Forest Service website. ■

Published January 29, 2021

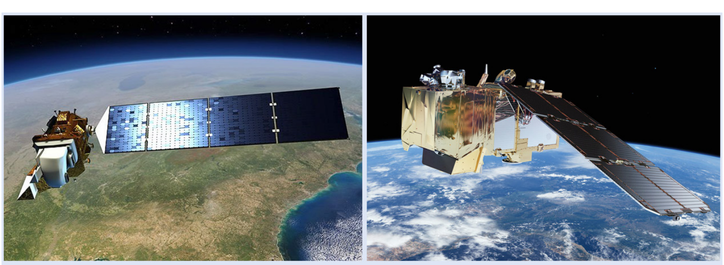
A Harmonious New Dataset

The provisional public release of the Harmonized Landsat Sentinel-2 (HLS) dataset through NASA's LP DAAC opens new avenues for global terrestrial research.

What do you get when you combine data from sensors aboard two groundbreaking Earth observing missions into a single dataset? When it comes to the provisional release of the Harmonized Landsat Sentinel-2 (HLS) dataset, the result is global land surface data products with high temporal and spatial attributes that are uniquely processed to facilitate a wide range of terrestrial Earth science research.

Available for download through NASA's Land Processes Distributed Active Archive Center (LP DAAC) and Earthdata Search, the provisional public release of HLS data products is the result of a collaborative NASA-led effort that provides data long-desired by researchers and land managers. HLS also is the first major Earth science dataset in NASA's Earth Observing System Data and Information System (EOSDIS) collection that is hosted fully in the commercial cloud. The development of HLS data products, their processing, and their distribution are a glimpse into the future of upcoming high-volume NASA Earth science data collections.

HLS is produced from data acquired by the Operational Land Imager (OLI) aboard the joint NASA/USGS Landsat 8 satellite (launched in 2013) and the Multi-Spectral Instrument (MSI) aboard the European Space Agency (ESA) Sentinel-2A and Sentinel-2B satellites (launched in 2015 and 2017, respectively). Two provisional HLS products currently are available publicly: the Landsat 30-meter (L30) product (doi:10.5067/HLS/HLSL30.015) and the Sentinel 30-meter (S30) product (doi:10.5067/HLS/HLSS30.015). Both are atmospherically-corrected surface reflectance products.



(Left image) Landsat 8 launched in 2013. (Right image) Sentinel-2A launched in 2015 and Sentinel-2B launched in 2017. Both Sentinel-2 satellites are identical. Landsat 8 image: USGS. Sentinel-2 image: ESA.

"Provisional release" means that the scientific validation of the data products is still ongoing and there could be minor issues with the data output. The HLS science team expects to finish their validation of the HLS atmospheric correction code over the next few months, at which time a new version of the data will be released (along with updated documentation and DOIs for both products).

The importance of HLS, though, is not that data products created from instruments aboard two different satellite platforms exist, but that they exist to be used together as if they come from a single instrument aboard one satellite. "Our definition of harmonized is that observations should be interchangeable for common [spectral] bands," says Dr. Jeff Masek, the HLS principal investigator (PI) and Landsat 9 project scientist. "By harmonizing the datasets and making the corrections so that it appears to the user that the data are coming from a single platform, it makes it easier for a user to put these two datasets together and get that high temporal frequency they need for land monitoring."

Along with being able to use data from the OLI and MSI instruments seamlessly, HLS provides the temporal frequency and spatial resolution long desired by the terrestrial observation community.

While Landsat 8's OLI acquires full global imagery every 16 days, the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments aboard NASA's Terra and Aqua satellites (launched in 1999 and 2002, respectively) and the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard the joint NASA/NOAA Suomi National Polar-orbiting Partnership (Suomi NPP) and NOAA-20 satellites (launched in 2011 and 2017, respectively) acquire full global imagery every one to two days. The MSI aboard both Sentinel-2 platforms, however, acquires full global imagery every five days. By harmonizing OLI and MSI observations, full HLS global coverage is achieved roughly every two to three days – a frequency that will greatly aid studies of change over time.

Improved spatial resolution is another benefit achieved through Landsat/Sentinel-2 harmonization. The MODIS spatial resolution ranges from 250 to 1,000 meters, depending on the spectral band. MSI, on the other hand, is produced with a spatial resolution ranging from 10 to 30 meters. OLI has a 30-meter multi-spectral spatial resolution.

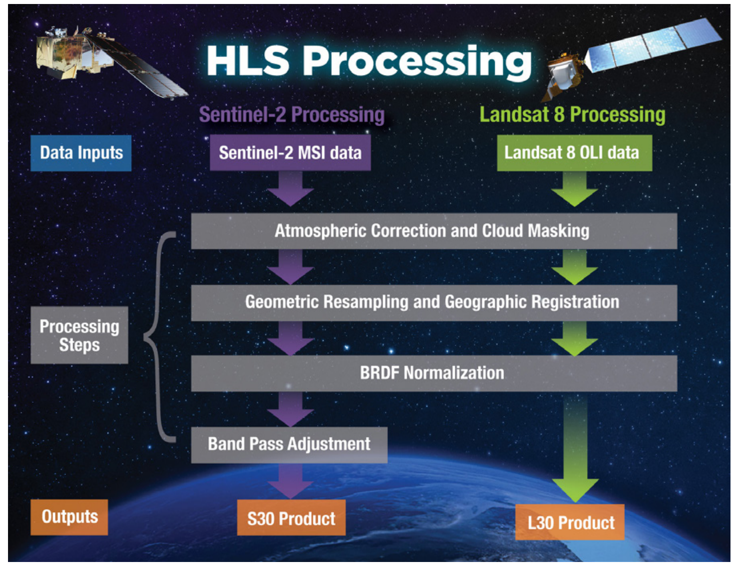
Sample HLS provisional S30 image showing San Francisco Bay, California, on January 9, 2021. Image: Masek, J., Ju, J., Roger, J., Skakun, S., Vermote, E., Claverie, M., Dungan, J., Yin, Z., Freitag, B. & Justice, C. (2020). HLS Sentinel-2 MSI Surface Reflectance Daily Global 30 m V1.5. NASA EOSDIS LP DAAC. Accessed January 12, 2021, from NASA Earthdata Search.

"What people have been looking for is a global dataset of land reflectance just like MODIS provides every day, but at much finer spatial resolution so you can actually see land management activities, fields, individual forests, urban areas, and so forth," says Dr. Masek. "[HLS] provides much better temporal resolution than Landsat has ever provided along with much better spatial resolution than MODIS [can provide]."

HLS products are produced on a common 30-meter grid. As Dr. Masek explains, having 30-meter resolution for both HLS products is the easiest way to get the highest quality imagery. "You can't really take a Landsat 30-meter resolution image down to 10-meters since you just don't have that information from Landsat captured originally," he says. "Instead, we average Sentinel data up to 30-meter resolution."

HLS also includes data from the Landsat 8 Thermal Infrared Sensor (TIRS) instrument, which records data on Earth's surface temperature. Although there is no comparable thermal infrared data from Sentinel-2, the HLS science team felt that providing the full Landsat spectral complement georegistered with Sentinel-2 was important.

Four steps are involved in HLS processing, with both Landsat and Sentinel-2 data going through the first three steps and Sentinel-2 having a fourth step (see processing illustration). This processing has evolved significantly since the effort began and involves several groups. Prior to the provisional public release, data were processed at NASA's Ames Research Center in Silicon Valley, California, using the NASA Earth Exchange (NEX) computing environment. This earlier version of HLS (version 1.4) mapped approximately 28% of Earth's land surface and was archived at NASA's Goddard Space Flight Center in Greenbelt, Maryland.



HLS processing steps. Bidirectional Reflectance Distribution Function (BRDF) Normalization accounts for changes in solar and view angles for the same ground target, which vary between the MSI and OLI sensors and causes slight measurement discrepancies. The MSI Band Pass Adjustment accounts for small differences between the equivalent spectral bands of MSI and OLI. Image based on a graphic originally created by the HLS science team.

Even though HLS was still in the prototype stage and covered less than a third of Earth's land surface, the potential value of this dataset was clear to the scientific community, including members of LP DAAC's User Working Group (UWG). LP DAAC is responsible for archiving and distributing data in the EOSDIS collection related to land cover and land use. The DAAC is a partnership between NASA and the USGS, and is located at the USGS Earth Resources Observation and Science (EROS) Center, which is where Landsat data are processed.

"In 2017, our User Working Group made a recommendation for us to engage with the HLS team and start investigating whether there were ways to ultimately bring the HLS collection into LP DAAC," says Tom Maiersperger, the LP DAAC project scientist. "I started having conversations with Jeff [Masek] around 2017."

Taking HLS land coverage from 28% of Earth's land surface to nearly 100% (Antarctica is excluded) and setting up a production stream to get data to LP DAAC for distribution was accomplished by NASA's Interagency Implementation and Advanced Concepts Team (IMPACT) located at NASA's Marshall Space Flight Center in Huntsville, Alabama. As Maiersperger observes, "IMPACT came in and made a big impact."

IMPACT is part of NASA's Earth Science Data Systems (ESDS) Program and works to maximize the scientific return of NASA's missions and experiments with a focus on interagency collaboration, assessment and evaluation, and advanced concepts. The current provisional release of HLS (version 1.5) is a global dataset mapping nearly 100% of Earth's land surface outside of Antarctica that is optimized for use in the Amazon Web Services (AWS) commercial cloud environment.

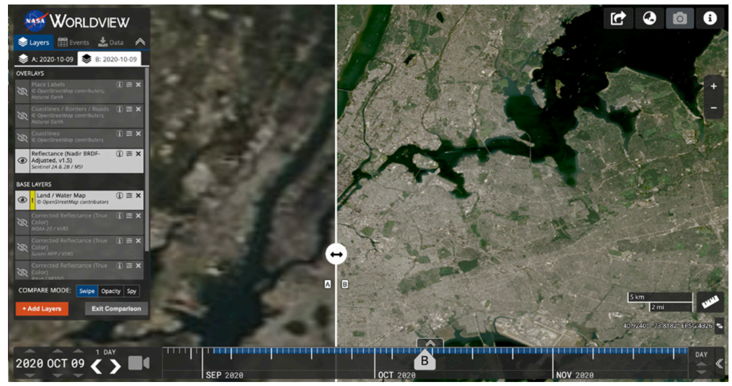
"[The IMPACT team] has taken our [research and development-level] code and refactored it, sped it up, and made it more suitable for routine processing on Amazon Web Services," says Dr. Masek. "They've done a lot of work to make sure that the data formats, the metadata, and the file names are all compliant. All of that has been done in collaboration with LP DAAC and with the EROS Center."

As IMPACT HLS Project Manager Dr. Brian Freitag explains, the IMPACT team produces the global HLS dataset, comprising the L30 and S30 products, and ensures data quality. "If there are granule failures, processing failures, or if there are inconsistencies with the archive at LP DAAC or the files we've generated on the IMPACT side, we'll be responsible for restaging the data for them," he says. "If there are reprocessing efforts that need to take place, we'll be the ones responsible for reprocessing the data."

The public release of HLS is for the forward-processing stream, meaning the initial data archive starts with the day the data first became publicly available (for S30 this is September 29, 2020; for L30 this is January 20, 2021). Upon the full release of HLS data in early- to mid-2021, IMPACT will begin back-processing to the beginning of the Landsat 8 and Sentinel-2 data records (2013 and 2015, respectively). The IMPACT team expects to have this back-processing completed by early-2022, according to Dr. Freitag.

Dr. Freitag and the IMPACT team also are preparing to add new satellites into the HLS data production stream. "Landsat 9 [scheduled for launch in 2021] and Sentinel-2C [scheduled for launch in 2023] will be integrated into the HLS product," he notes. "IMPACT will handle any additional processing that needs to be done to integrate these new missions into the stream while generating L30 and S30 products for LP DAAC."

Along with the S30 and L30 HLS data products available through LP DAAC and Earthdata Search, HLS imagery also is available through the EOSDIS Global Imagery Browse Services (GIBS) for interactive exploration using the NASA Worldview data visualization application. A Worldview HLS Tour Story provides information about the imagery and how to work with it in Worldview.



Comparison image from NASA Worldview showing the difference in resolution between MODIS (left image) and HLS (right image). Both images show the island of Manhattan on October 9, 2020. Interactively explore this image in NASA Worldview. NASA Worldview image.

A unique aspect of HLS is that it will be processed, archived, and distributed in the AWS commercial cloud. Data users, though, may not even notice this. "The initial access to HLS will look very traditional," says Tom Maiersperger at LP DAAC. "Earthdata Search will be the primary search and discovery portal for HLS and accessibility will be through Earthdata Search."

As Maiersperger notes, the LP DAAC goal is to integrate HLS into their Application for Extracting and Exploring Analysis Ready Samples (AppEEARS) tool. AppEEARS allows users to work with long time-series, transform data in various ways, and reduce data volumes. While currently running on-premises at LP DAAC, the DAAC is working to refactor the AppEEARS code to evolve the tool to run in the commercial cloud. Maiersperger notes that the DAAC's goal is to have this accomplished as soon as possible after the completion of the HLS historical record back-processing. "We've got a ways to go to complete not only the data record, but also for us to be able to provide the best level of service for these data that we can, but we'll get there," he says.

As Dr. Freitag at IMPACT observes, hosting HLS in the commercial cloud has significant benefits for data users.

"We're really trying to take data analysis to the next level where we're able to provide this large-scale processing without large-scale compute requirements – either downloading a lot of data requiring large amounts of storage or needing to have a lot of memory so you can run through all the files at once," he says. "For example, if you want to look at all the HLS data for a particular plot of land at the 30-meter resolution provided by HLS, you can do this using your laptop. Everything will be in cloud-optimized GeoTIFF format."

Of course, the purpose of NASA data is to enable research, and HLS is expected to contribute significantly to explorations into terrestrial processes. "HLS is really a big deal," says Tom Maiersperger. "For this dataset to have matured and for it to be global, which is unprecedented in earlier versions, just increases the significance of this product."

A principal HLS application area will be agriculture, including studies into vegetation health; crop development, management, and identification; and drought impacts. HLS data already have been used in the development of a new vegetation seasonal cycle dataset available through LP DAAC: the Multi-Source Land Imaging (MuSLI) Land Surface Phenology (LSP) Yearly North America product (doi:10.5067/Community/MuSLI/MSLSP30NA.001).

Another important benefit of HLS is that Landsat 8 and both Sentinel-2 satellites have equator crossing times of 10 am and 10:30 am local time, respectively. Currently, NASA's Terra satellite is the only MODIS or VIIRS platform with a morning crossing time (10:30 am local time). With Terra currently drifting in crossing time, HLS will become a primary source for global morning observations at a consistent equator crossing time.

The provisional release of HLS data products represents only the latest achievement of an on-going seven-year effort. Dr. Masek is quick to point out the challenges the team had to overcome to get to this point, including improving Sentinel-2 data processing and geolocation algorithms, developing better ways to correct for differences in view angles and surface reflectance from Landsat and Sentinel-2, and organizing the processing of such a high-volume dataset.

Dr. Masek also goes out of his way to highlight the particular contributions of Dr. Junchang Ju of NASA's Biospheric Sciences Laboratory and the University of Maryland to the HLS success. "He's really been the technical lead for this in terms of programming, validating the algorithm performance, catching mistakes, and working with [IMPACT] on implementing the code," he says. "I want to make sure he gets a lot of credit for the work that's gone on."

Dr. Freitag and Tom Maiersperger also stress the collaboration between federal agencies that helped make HLS possible, particularly with the USGS and their work preparing Landsat data and the atmospheric correction code for HLS.

The Seine River winds through Paris, France, in this HLS image from December 26, 2020. The Île de la Cité, with the Cathedral of Notre-Dame, is near the center of the image. Interactively explore this image in NASA Worldview. NASA Worldview image.

"I think that a lot of the success we've seen with the HLS effort can be tied back to the collaborative effort within the team and also the external collaboration between the federal partners," observes Dr. Freitag. "The applications that we'll see come out of HLS will be incredible."

"We know this will be really big for the community," adds Maiersperger. "There's a lot to be excited about."

What do you get when you give scientists and researchers an openly available, harmonized global dataset with high temporal and spatial attributes for Earth's land surface that's optimized for the cloud? As the leaders of the HLS effort point out, you get the potential for some amazing opportunities for discovery. ■

Published January 25, 2021

ORNL DAAC Releases New Version of Its Popular Daymet Meteorological Dataset

New Version Addresses Timing and Sensor Biases, Yields More Accurate and Precise Data

Joeseph M. Smith, NASA EOSDIS Science Writer

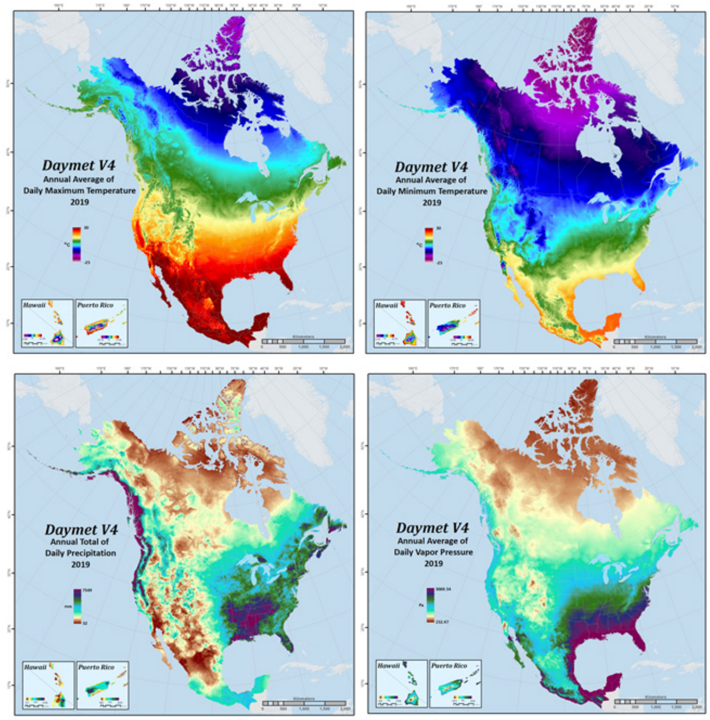
If the sun bakes a remote plain and there's no thermometer-wielding meteorologist or weather station there to record the surface temperature, will anyone ever know what it was? If that plain was in Hawaii, Puerto Rico, or anywhere between the northernmost reaches of the Arctic to the southernmost point in Mexico, then the answer is yes, for that data point will be collected in Daymet.

The Daymet dataset, available at NASA's Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC), provides daily gridded estimates of seven weather parameters—daily minimum and maximum temperature, precipitation, vapor pressure, shortwave radiation, snow water equivalent, and day length—produced on a 1 km x 1 km gridded surface over continental North America and Hawaii from 1980 through the end of 2019. (Data for Puerto Rico runs from 1950 through the end of 2019.)

Originally, Daymet was created to provide near-surface meteorological information for remote areas, or for areas with limited instrumentation, to be used as inputs for driving terrestrial ecosystem models. Since then, applications for its data have expanded significantly.

Access to daily high-resolution gridded surface weather data based on direct observations over long periods is essential for studies and applications pertaining to vegetation (forest, rangeland, crops, agricultural), wildlife (species of interest, biodiversity), soil health, hydrological modelling, remote sensing validation, and as driver data in earth system models. Given this wide variety of applications for Daymet's data, it's not difficult to understand why Daymet is among the ORNL DAAC's most popular data collections.

"People need this type of data. It has a lot of applications in wildlife, in hydrology, many types of vegetation modelling. Large agencies like the USDA Forest Service and USGS have made use of it and we've even had

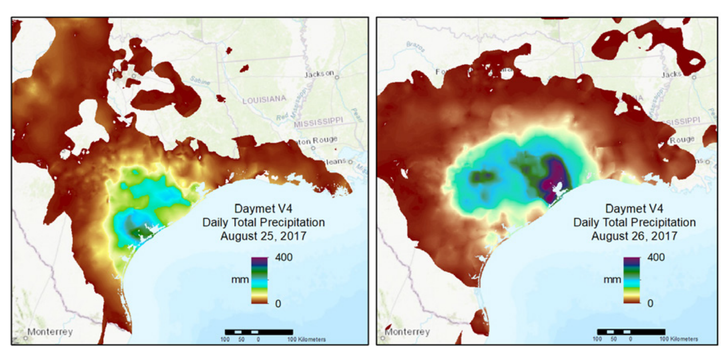


The panels in this image show Daymet Version 4 annual climatologies for maximum and minimum temperature, precipitation, and vapor pressure for 2019.

veterinarians use it to see how climate affects the spread of pathogens," said Thornton. "It's fairly fine resolution at one kilometer and the ORNL DAAC provides a lot of tools and services and a variety of ways for people to get the data that suits their needs."

The Daymet dataset is distributed by the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC), a partnership between NASA and the U.S. Department of Energy (DOE), which released a new and improved version of the dataset—Daymet Version 4—on December 15, 2020.

According to Thornton and her ORNL DAAC colleagues, Daymet Version 4 is an improvement to earlier versions because it provides effective solutions to known issues



This graphic offers a regional view of Daymet Version 4 daily total precipitation over two days as Hurricane Harvey made landfall on Texas and Louisiana in August of 2017.

with sensor and time of observation biases while taking advantage of the latest station observation datasets. For example, algorithm improvements address issues associated with bounded limits to the range of regression estimates in both temperature and precipitation, resulting in better estimations in all variables of the gridded data products. In addition, potential station input biases based on available time of observation were also evaluated for both temperature and precipitation. Cross validation analyses were used to quantify and correct biases related to temperature sensor replacement at high elevation stations. Taken together, these enhancements have resulted in data that is both more accurate and more precise.

"I'm excited to have the Daymet Version 4 released," said ONRL DAAC Daymet Lead Michele Thornton. "With this release we are able to provide the user community a continuation of the data project that they expect while addresses some known legacy issues and station-level input bias adjustments. Continuing to implement improvements and provide updates is important to staying relevant."

Thornton's assessment of the dataset's importance is supported by Daymet's usage statistics. According to metrics from NASA's Earth Science Data and Information System (ESDIS) Project, more than 80 terabytes of Daymet data were distributed during the 2020 Fiscal Year (October 1, 2019 through September 30, 2020).

Thornton added that, in early January, there were "hundreds of thousands of downloads" from Daymet's Single Pixel Extraction Tool, which enables users to acquire daily data from the nearest 1 km x 1 km Daymet grid cell for a single geographic point by latitude and longitude in decimal degrees.

The dataset's utility is also evident in the nearly 400 peer-reviewed papers that have used some aspect of Daymet data since 2012. Some recent uses of Daymet data include peer-reviewed research into the benefits of artificial drainage on soybean yield in the north central United States, the growth and expansion of birch shrubs in continental Canada, hot weather and risk of drowning in children, Avian responses to extreme weather, and heat wave severity and coverage across the United States. The popularity of Daymet also has led to the creation of community-developed open-source scientific command-line software such as daymetr (an R package) and daymetpy (a Python package), both of which are available through the ORNL DAAC Daymet Resources Learning page.

Yet, Daymet's impressive use metrics and popularity within the scientific community haven't stopped Thornton and her ORNL DAAC colleagues from working to make Daymet even better. Among the items on their to-do list are incorporating the meteorological data for 2020, which Thornton said is coming soon, and increasing the frequency of data updates.

"There is a community that wants [the data] to be lower latency," Thornton said. "We are working toward providing data on a monthly basis this summer."

Daymet began as a research project created to provide daily weather driver data for terrestrial biogeochemical modelling applications. Improvements to this early model and its algorithm led to the development of Daymet Version 1, a Conterminous US (CONUS) data product, in 1999. Daymet Version 2, which included data from a greater number of weather stations and additional updates, was made available through the ORNL DAAC in 2013. At the time, data was only available for CONUS, Hawaii, Puerto Rico, Mexico, and southern Canada up to 52 degrees North. The inclusion of data from additional weather stations and further algorithm enhancement led to the development of Daymet Version 3, which was released in 2016, offered spatial coverage of all of North America.

Improvements to Daymet's core algorithm and bias assessments were supported by the Office of Biological and Environmental Research within the DOE's Office of Science. The standardization, curation and distribution following FAIR data standards of Daymet V4 are supported by funding from NASA through its Earth Science Data and Information System (ESDIS) Project and the Terrestrial Ecology Program. The ORNL DAAC is responsible for managing, archiving, and distributing data in NASA's Earth Observing System Data and Information System (EOSDIS) collection pertaining to biogeochemical dynamics, ecology, and environmental processes.

To learn more about the ORNL DAAC data, services, and tools, visit the ORNL DAAC website.

To learn how to use Daymet and its data analysis tools, visit the Learning page on the Daymet website.

To discover and access ORNL data by scientific theme or NASA project, or to see a complete list of available datasets, visit the website's Get Data page. ■

Published January 27, 2021

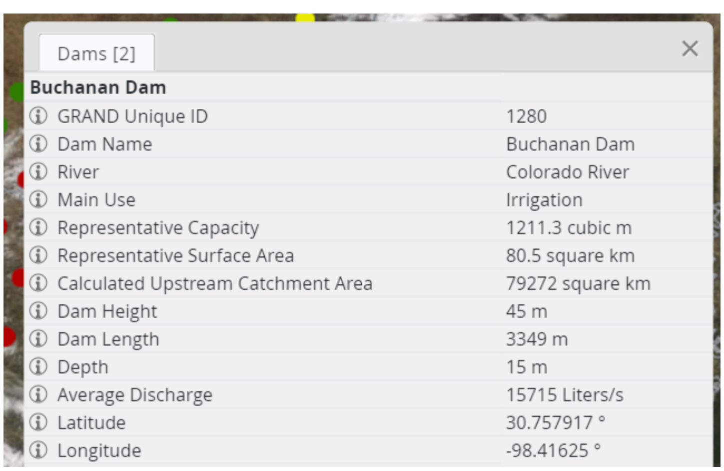
What's Your Vector?

NASA Worldview vector layers bring a wealth of additional information about thermal anomalies, dams, nuclear plants, and more.

If a wildfire starts in the woods and no one is around to see it, how do you know when it started? Thanks to vector layers in the NASA Worldview data visualization application, the time an active fire or other thermal anomaly was first detected by an orbiting sensor – along with the approximate latitude and longitude of the anomaly, the fire radiative power, the brightness temperature, and much more – is only a mouse click away.

The release of Worldview version 3.8.2 expands existing vector capabilities to include fire and thermal anomalies layers created from Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared and Imaging Radiometer Suite (VIIRS) sensor data. These vector layers join existing vector layers for dams, reservoirs, nuclear power plants, and settlements created from datasets available through NASA's Socioeconomic Data and Applications Center (SEDAC). A total of 19 vector layers currently are available.

A vector layer is different from an image layer. Image layers represent locations through a grid of cells or pixels with associated color values that, when combined, form an image. Vector layers, on the other hand, identify locations using points, line segments, or polygons. More importantly, vector layers have attribute information that can be examined when a vector feature is clicked. For example, when a vector point is clicked in the Dams layer, a table of attributes appears, including the dam name, river, main use, and representative capacity.

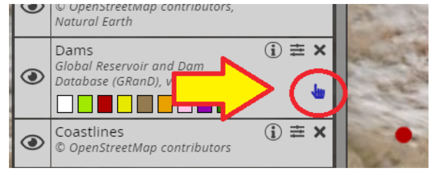


Dams [2]

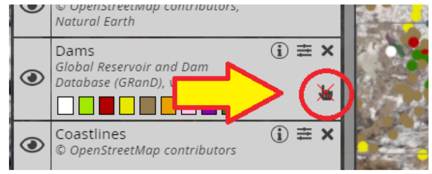
Buchanan Dam

GRAND Unique ID	1280
Dam Name	Buchanan Dam
River	Colorado River
Main Use	Irrigation
Representative Capacity	1211.3 cubic m
Representative Surface Area	80.5 square km
Calculated Upstream Catchment Area	79272 square km
Dam Height	45 m
Dam Length	3349 m
Depth	15 m
Average Discharge	15715 Liters/s
Latitude	30.757917 °
Longitude	-98.41625 °

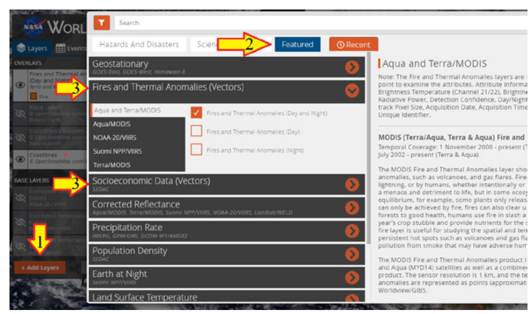
Vector information for Buchanan Dam near Austin, TX, USA, accessed on November 13, 2020. NASA Worldview image.



Just because a vector layer is loaded into the Worldview Layer List doesn't mean the vectors being displayed are active or clickable. If you see the blue pointer icon next to the vector layer in the Layer List on the left side of Worldview, you should be able to click on a colored vector dot to open a window with attribute information associated with that vector.



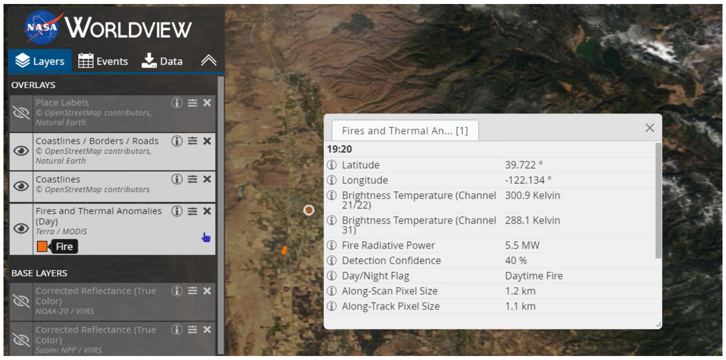
If you see a gray pointer with a red X over it, however, you are zoomed out too far and the vector layer is being rendered as an image. Simply zoom in until the red X changes to a blue pointer, indicating you can click on the vector dot to open the vector layer attribute information.



Adding vector layers to the Worldview Layer List is easy. You can access vector layers by clicking the orange "+ Add Layers" button at the bottom of the layer box on the left side of the main window (number 1 in the image at right). This opens the imagery layer category panel. Select the *Featured* tab along the top row of the Layer Picker (2), then select vector layers listed under *Fires and Thermal Anomalies (Vectors)* or *Socioeconomic Data (Vectors)* (3). You also can access vector layers by simply typing "vectors" into the search box.

Once you add a vector layer, colored dots appear on the Worldview map indicating the vectors you can select (remember, you might need to zoom in to make the pointer on the vector layer turn blue, indicating that the vector dots are clickable and not part of an image layer). Clicking on a vector brings up a box with the vector information.

While the latitude and longitude information provided in the dams, reservoirs, settlements, and nuclear power plant vectors is the exact location of the feature, the location information provided in fire and thermal anomalies vectors



NASA Worldview image.

is an *approximate* location of the detected thermal anomaly. Each MODIS thermal anomaly represents the center of an approximately 1 square kilometer (1 km^2) pixel flagged as containing one or more thermal anomalies (for VIIRS thermal anomalies, the location given for the thermal anomaly is the center of an approximately 375 square meter pixel).

Want to add NASA Worldview vector layers to your own client system? Since all NASA data are free and open, the code is yours to use. Check out NASA's Global Imagery Browse Services (GIBS) API for Developers: Vector API documentation and visit the gibs-web-examples GitHub repo to find some live examples.

Thanks to NASA Worldview vector layers, a wealth of information about specific wildfires, dams, reservoirs, and other features is only a click away. See for yourself, and start exploring all the new features of NASA Worldview. ■

Published November 19, 2020

Data 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 datasets in each feature.

https://earthdata.nasa.gov/profiles

Dr. Steven D. Miller

Senior Research Scientist, Colorado State University; Deputy Director, Cooperative Institute for Research in the Atmosphere (CIRA), Fort Collins, CO

Imagery of Earth at night provide unique opportunities for research. Dr. Miller uses these data in his studies of Earth's nocturnal environment.

http://go.nasa.gov/3qjzQIE

Dr. Thomas A. Herring

Professor of Geophysics; Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA

The Global Navigation Satellite System (GNSS) enables the precise location of points on Earth's surface. For geodesists like Dr. Herring, it also is a key geodetic technique for his studies of surface deformation processes.

http://go.nasa.gov/2PD8e4L

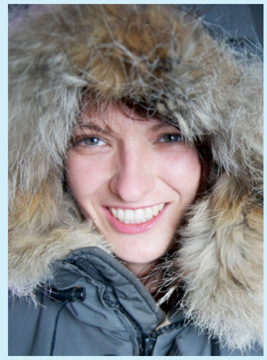
DATA CHATS

Drew Kittel

NASA ESDIS Project Science Operations Office Manager

EOSDIS DAACs will play a key role as EOSDIS data evolve to the commercial cloud. NASA's ESDIS Project Science Operations Office Manager, Drew Kittel, is working to ensure that DAAC services and support are ready.

http://go.nasa.gov/30ffYvN



Dr. Carmen Boening

Principal Investigator for NASA's Sea Level Change portal, NASA's Jet Propulsion Laboratory

The Global Sea Level Change portal is NASA's home for sea level change data and information. As the portal's principal investigator, Dr. Boening ensures that it remains a key resource for both scientists and the general public.

http://go.nasa.gov/208mIOS

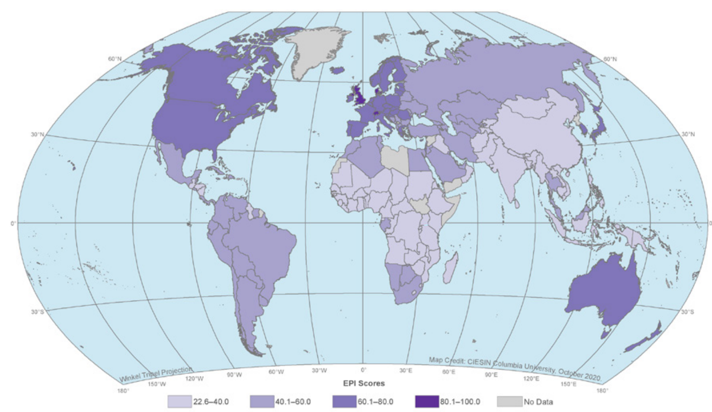
ANNOUNCEMENTS

New Environmental Performance Index (EPI) Available at NASA's SEDAC

The 2020 release of the EPI ranks 180 countries in environmental health and ecosystem vitality based on 32 indicators.

The 2020 release of the Environmental Performance Index (EPI) is now available at NASA's Socioeconomic Data and Applications Center (SEDAC). Produced every two years since 2006, the 2020 EPI (doi:10.7927/f54c-0r44) ranks 180 countries in environmental health and ecosystem vitality based on 32 performance indicators in 11 issue categories: air quality, sanitation and drinking water, heavy metals, waste management, biodiversity and habitat, ecosystem services, fisheries, climate change, pollution emissions, agriculture, and water resources. The 2020 release includes a report, data sets for download, and a gallery of nearly 100 maps visualizing changes in performance over more than two decades.

The EPI provides quantitative metrics for evaluating a country's environmental performance in different policy categories relative to clearly defined targets, and aggregates data on many indicators of sustainability into a single number – the EPI Score, which ranges from 0 to 100. Its proximity-to-target methodology facilitates cross-country comparisons among economic and regional peer groups.



Summary EPI 2020 global map available through NASA's SEDAC showing aggregate 2020 EPI scores, with darker colors indicating higher EPI scores. Click on image for larger view. Image: YCELP, Yale University, and CIESIN, Columbia University. 2020. 2020 Environmental Performance Index (EPI). Palisades, NY: NASA SEDAC. doi:10.7927/f54c-0r44. Accessed 25 November 2020.

Nations with the top five EPI scores in 2020 are Denmark (82.5), Luxembourg (82.3), Switzerland (81.5), the United Kingdom (81.3), and France (80.0). The United States received an EPI score of 69.3 (mainly due to low scores on Water Resources and Waste Management), ranking it in

24th place behind Malta. The five lowest-scoring nations in 2020 are Côte d'Ivoire (25.8), Sierra Leone (25.7), Afghanistan (25.5), Myanmar (25.1), and Liberia (22.6). For detailed information about the EPI methodology and a full summary of results, please see the 2020 EPI Report.

Developed by the Yale Center for Environmental Law and Policy (YCELP) and Columbia University's Center for International Earth Science Information Network (CIESIN), the EPI is archived at and distributed by SEDAC. SEDAC is the home for socioeconomic data in NASA's Earth Observing System Data and Information System (EOSDIS) collection. Hosted at CIESIN, SEDAC synthesizes Earth science and socioeconomic data and information in ways useful to a wide range of decision makers and other applied users, and serves as an "Information Gateway" between the socioeconomic and Earth science data and information domains.

Published December 1, 2020

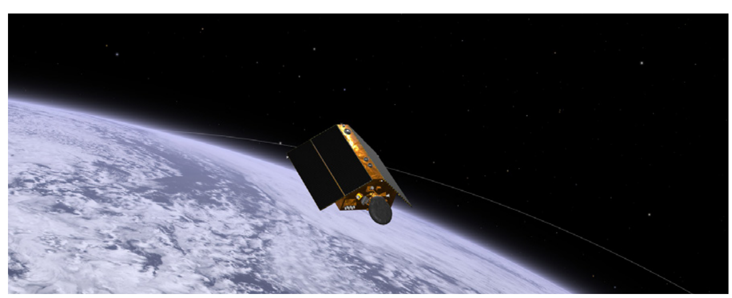
NASA EOSDIS 2020 Data User Profile Yearbook Released!

NASA's Earth Science Data and Information System (ESDIS) Project is pleased to present the 2020 Earth Observing System Data and Information System (EOSDIS) Data User Profile Yearbook. The 12 data users you'll read about in this year's edition are using Earth science data in the EOSDIS collection to support research in areas ranging from the Amazon rainforest to the New Zealand Alps and using data acquired from shallow ocean waters to quasars billions of light years from Earth. You'll read about how EOSDIS data are an integral component of research into ecosystem development, food security, public health, and much more.

The EOSDIS Data User Profile series showcases not only the work and research of scientists, researchers, managers, and educators using NASA data, but also the data products that help enable this work. The stories presented here only scratch the surface of the tremendous opportunities created by data that are freely and openly available to anyone anywhere in the world. Download your copy of the 2020 edition!

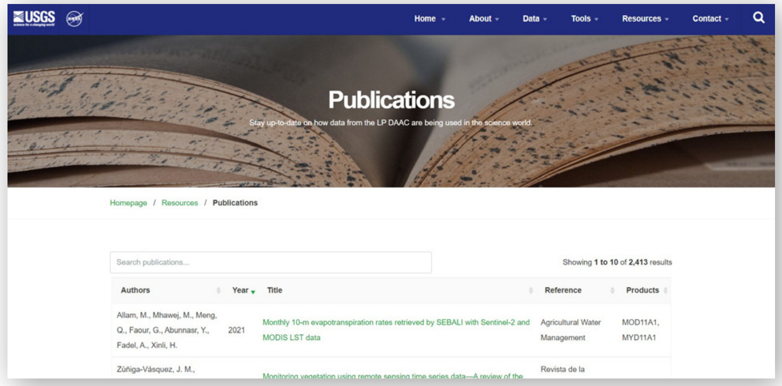
NASA's PO.DAAC is Archive for Sentinel-6 Michael Freilich Data

The Sentinel-6 Michael Freilich satellite, the first of two identical spacecraft, was successfully launched into Earth orbit on Saturday, 21 November 2020 to continue sea level observations for at least the next decade. The data from this mission will be managed, archived and distributed by NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC), the official NASA archive for physical oceanography data, services, and tools. Sentinel-6 Michael Freilich marks NASA's first natively cloud-hosted mission, which will allow researchers easy and efficient access to mission data in the NASA Earthdata AWS Cloud environment.



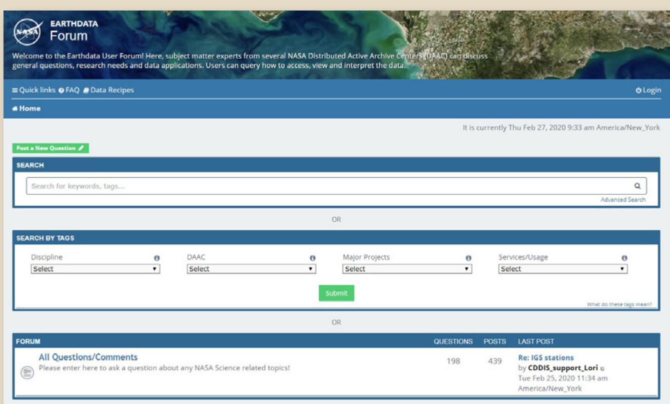
To learn more: https://podaac.jpl.nasa.gov/Sentinel-6

New Publications/Dataset Links Feature at NASA's Land Processes DAAC



Are you working with a specific dataset and interested in seeing how others are using the data? You can now find publications linked to that dataset on the LP DAAC website! Visit the "Using the Data" button on any data product's DOI Landing Page to find a list of research publications that used that dataset.

Visit the Publications page: https://lpdaac.usgs.gov/resources/publications/

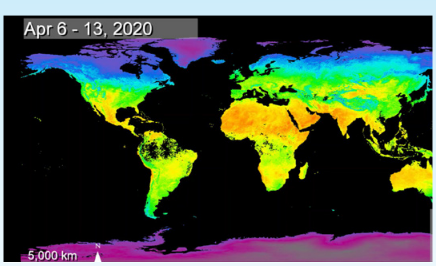


11/18/2020

NASA's Earthdata Forum: Connect to a Growing Body of Expertise

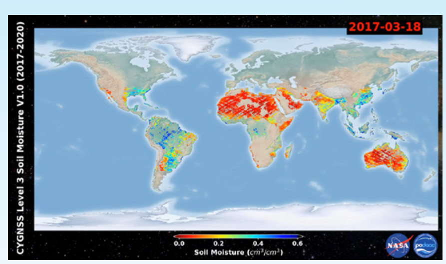
https://youtu.be/kCKyQscsXWA

SPECIAL FEATURE VIDEOS



Global Land Surface Temperature 2020 as observed by NASA's Terra MODIS Instrument

https://youtu.be/nhTSOssXiXY

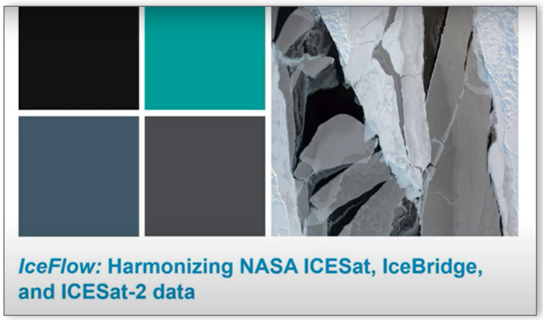


Soil Moisture Data from CYGNSS (March 2017-August 2020)

https://youtu.be/Vknoc-ewDNg

DATA Recipes & Tutorials

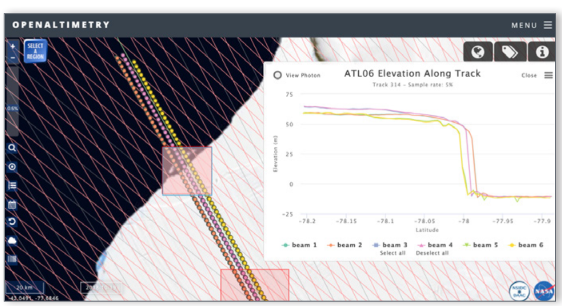
Video Tutorial- IceFlow: Harmonizing ICESat, Operation IceBridge, and ICESat-2 Data



Between 2003 and 2020, NASA's ICESat, IceBridge, and ICESat-2 missions have collected information on the evolution of land and sea ice. This tutorial, created by the National Snow and Ice Data Center DAAC, uses the IceFlow API and Jupyter Notebook to harmonize these datasets into similar formats, and applies the necessary geophysical corrections for users to immediately access and compare decades of data. The IceFlow Notebook also provides users with a map-based visualization and customized download widget and other data visualization options.

View Tutorial: https://youtu.be/c_7sdNS6vHc

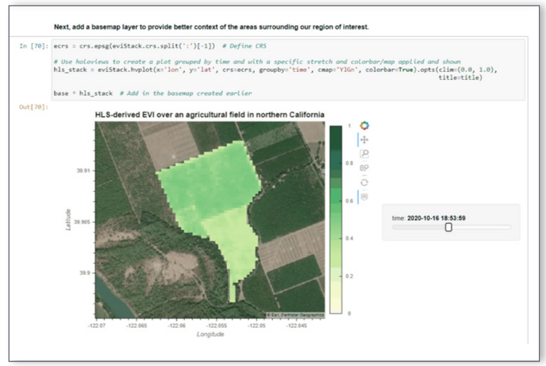
Video Tutorial- Open Altimetry: Advanced Discovery, Processing and Visualization Services for ICESat and ICESat-2 Data



This video tutorial, created by the NSIDC DAAC, demonstrates how to use Open Altimetry, an exploration and visualization tool for data from the NASA ICESat and ICESat-2 satellites. It allows users to quickly and easily search data, create simple visualizations, and get access to download data files. OpenAltimetry is a NASA-funded project and is a collaboration between NSIDC, the Scripps Institution of Oceanography, and the San Diego Supercomputer Center at the University of California-San Diego. Access OpenAltimetry: https://openaltimetry.org

View Tutorial: https://youtu.be/ZanKXh1oQYc

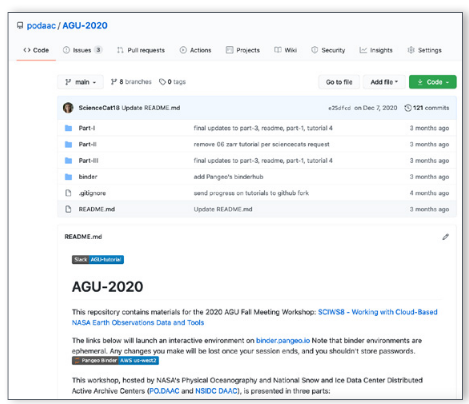
Getting Started with Cloud-Native Harmonized Landsat Sentinel-2 (HLS) Data in Python



In this tutorial developed by the NASA Land Processes DAAC, learn how to find, access, and process provisional Harmonized Landsat-8 Sentinel-2 (HLS) data in the cloud using the Common Metadata Repository (CMR) SpatioTemporal Asset Catalog (CMR-STAC). The tutorial goes through an example use case for processing HLS Landsat 8 (HLSL30.015) and Sentinel-2 (HLSS30.015) data into a single EVI time series for crop monitoring over a single large farm field in northern California.

Access tutorial: http://bit.ly/3nPR27Y

Workshop: Working with Cloud-based NASA Earth Observations Data & Tools

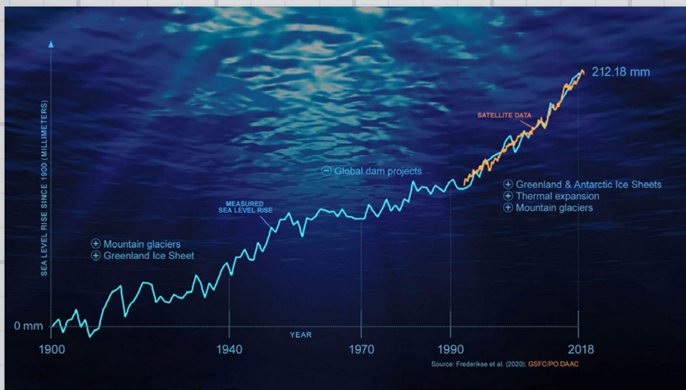


This workshop was hosted at the American Geophysical Union (AGU) Fall Annual Meeting 2020 by PO.DAAC and NSIDC DAAC. Within this workshop you will find a suite of tutorials that explore the latest advancements in data discovery, access and use in the Earthdata cloud environment, including the new Harmony capabilities. The workshop highlighted examples of science and applications workflows through data recipes and use cases from the ocean, cryosphere, hydrology, and coastal disciplines.

Access workshop tutorials: https://github.com/podaac/AGU-2020/

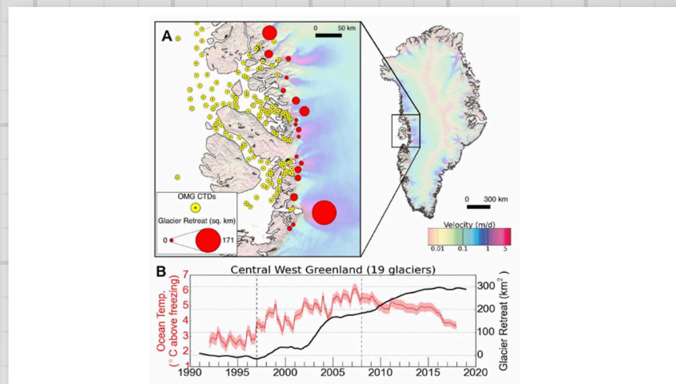
HIGHLIGHTS: DATA IN ACTION

Globally Averaged Sea Level



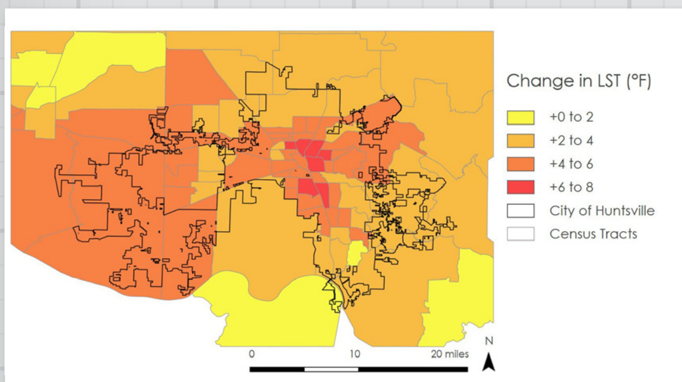
http://go.nasa.gov/3foH0HX

Glaciers Melt from Below



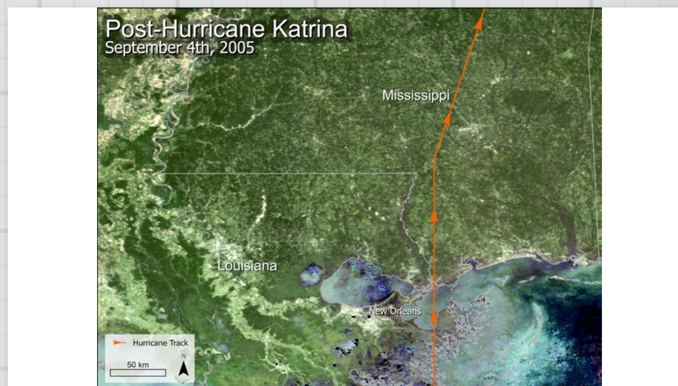
https://go.nasa.gov/3bVDNQI

Highlights from the NASA DEVELOP National Program Summer 2020 Term



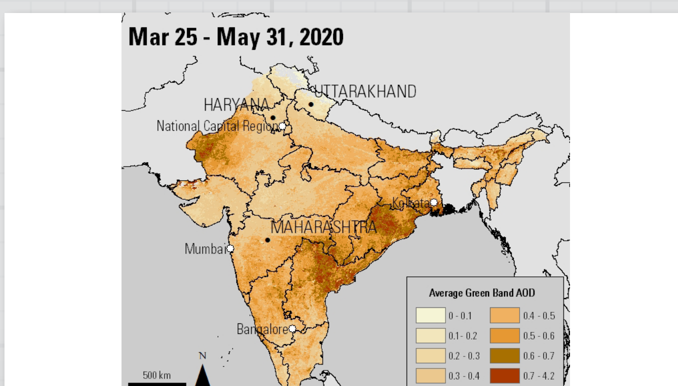
http://bit.ly/2UH2bLH

Highlights from the Literature: July to September 2020



http://bit.ly/388AkuS

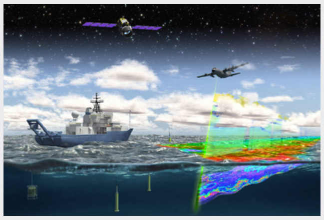
MODIS Captures Indirect Impacts of COVID-19 on the Environment



https://bit.ly/3nojOf6

STORYMAP

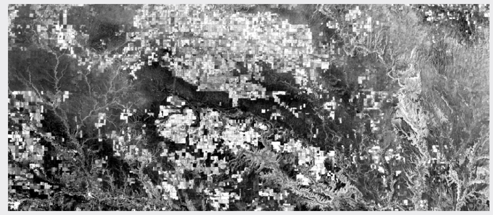
Exploring the Connection Between Plankton and Clouds – The NAAMES Mission



The North Atlantic Aerosols and Marine Ecosystems Study (NAAMES) set sail during various bloom seasons of 2015-2018 to investigate if there is a connection between the life cycle of plankton and cloud formation. In this NAAMES ArcGIS StoryMap created by NASA's Atmospheric Science Data Center (ASDC) you can: explore the science behind the mission, discover details of the research outcomes, learn about the researcher who lead the project, cruise through additional resources that provide a wealth of information about the mission, and access the archived data and go on your own exploration of the unknown!

View StoryMap: http://bit.ly/3q9AQ1V

Sentinel-1 On-Demand RTC using Vertex

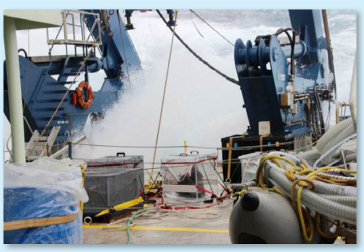


NASA's Alaska Satellite Facility Distributed Active Archive Center (ASF DAAC) now offers on-demand processing of Sentinel-1 synthetic aperture radar (SAR) datasets within the Vertex data discovery and data access portal, allowing users to submit GRD or SLC products for radiometric terrain corrected (RTC) processing. These on-demand products are generally available for download within 30 minutes of the request. This StoryMap introduces users to RTC SAR datasets and provides a tutorial for how to use Vertex to search for source granules, submit them for processing, and access the finished products.

View StoryMap: http://bit.ly/3mCuzLq

MICRO ARTICLES

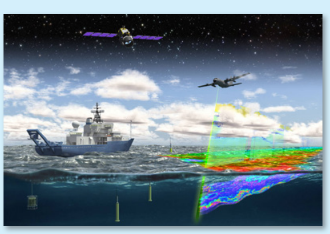
Observing Sea-to-Air Aerosol Gas Fluxes Under Extreme Weather Conditions



How does an extreme weather system impact sea-to-air aerosol gas fluxes? After mostly favorable weather conditions through the second field campaign of the North Atlantic Aerosols and Marine Ecosystems Study (NAAMES), an extreme weather system on May 30, 2016 provided a unique opportunity for scientists to measure atmospheric phenomena at sea. Despite posing hazardous conditions, the storm provided researchers with a unique opportunity to enhance their research by measuring sea-to-air aerosol gas fluxes in a severe weather event. The measurement of sea-to-air aerosol gas fluxes quantifies aerosols as they move from the ocean into the air, and these aerosol gas fluxes can be impacted by environmental disturbances such as a severe weather event. Image Credit: NASA/Christien Laber

Read Micro Article: https://go.nasa.gov/3e3ffWr

A Look into the North Atlantic Aerosols and Marine Ecosystems Study (NAAMES)



The NASA North Atlantic Aerosols and Marine Ecosystems Study (NAAMES) project was the first NASA Earth Venture – Suborbital mission focused on studying the coupled ocean ecosystem and atmosphere. NAAMES utilized a combination of ship-based, airborne, autonomous sensor, and remote sensing measurements that directly linked ocean ecosystem processes, emissions of ocean-generated aerosols and precursor gases, and subsequent atmospheric evolution and processing.

Read Micro Article: http://go.nasa.gov/307Nkwz

EARTHDATA TOOLKIT

Data Toolkits are designed as entry points to access NASA Earth science data resources organized by topic. They contain links to datasets, tutorials and how-tos, feature articles and Data User Profiles, as well as other useful information.

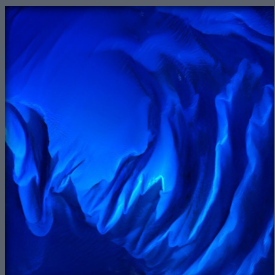
Tropical Cyclones

http://go.nasa.gov/384a3xY

Landslides

http://go.nasa.gov/3bSIDxf

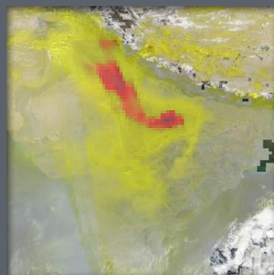
Winter 2020-2021 NASA Earthdata Images



Underwater Dunes

https://earthdata.nasa.gov/mastheads

(Published 11/2/20)



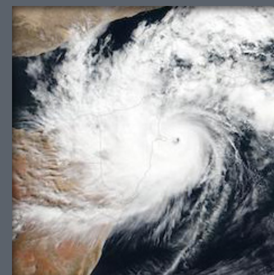
High Aerosol Index Over Northern India

http://go.nasa.gov/3nbD9jW

Human Modification of Terrestrial Systems

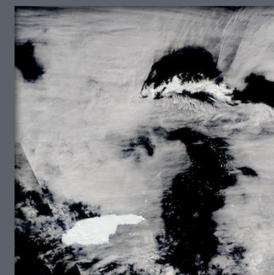
https://earthdata.nasa.gov/mastheads

(Published 11/9/20)



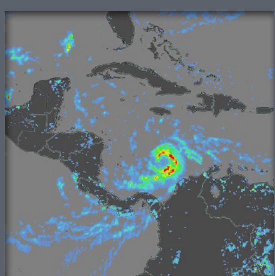
Tropical Cyclone Gati Makes Landfall in Somalia

http://go.nasa.gov/2NVgv3h



A-68A Approaching South Georgia Island

http://go.nasa.gov/33QnxeH



Hurricane Iota Approaches Central America

https://earthdata.nasa.gov/mastheads

(Published 11/23/20)

Tule Fog in the Central Valley, California

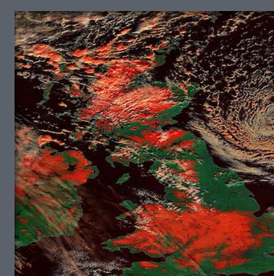
http://go.nasa.gov/3sHTDTP

Wilkinkarra/Lake Mackay, Australia

http://go.nasa.gov/3dVRAr8

Korean Peninsula at Night

http://go.nasa.gov/3b8mTgH



Snow in Great Britain

http://go.nasa.gov/2Psxvyv

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