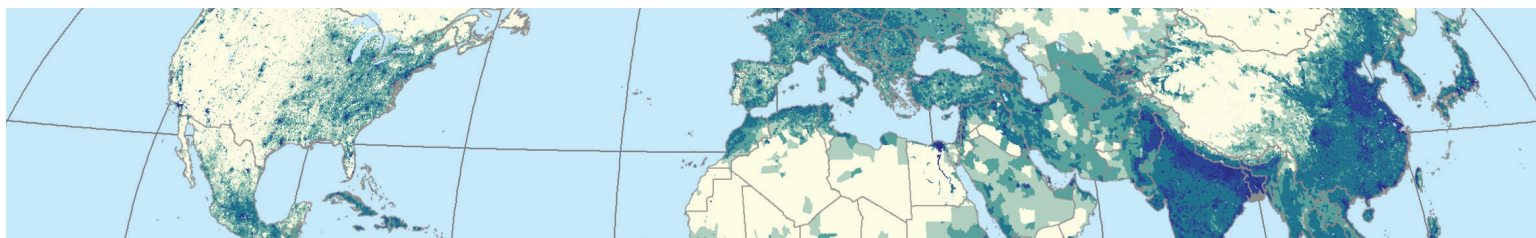
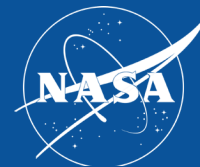


EOSDIS Update

Winter 2017

Earth Science Data and Information System (ESDIS) Project

National Aeronautics and
Space Administration



A Publication of the Earth Observing System
Data and Information System (EOSDIS), Code 423

NASA EOSDIS Role in the Big Earth Data Initiative

NASA's EOSDIS plays a key role in coordinating the federal Big Earth Data Initiative (BEDI), which aims to make federal civil Earth observing data more discoverable, usable, and accessible.

According to the National Plan for Civil Earth Observations, the U.S. federal government is the largest provider of civil Earth observation data in the world. Data users need quick, unhindered access to these vast Earth science data collections across the many federal agencies and organizations responsible for these data. Through the Big Earth Data Initiative (BEDI), federal agencies are working to make this a reality.

The overall goal of BEDI is to improve the interoperability of civil Earth observing data across U.S. federal agencies, systems, and platforms by improving the usability, discoverability, and accessibility of these data and systems along with improving data management practices. BEDI originated out of the National Strategy for Civil Earth Observations, which was released by the White House Office of Science and Technology Policy (OSTP) in 2013. The U.S. Group on Earth Observations (USGEO) is tasked with interagency coordination and oversight of BEDI. NASA plays a key role in USGEO activities coordinating BEDI, and is one of three U.S. agencies (along with NOAA and the USGS) to receive federal funding to implement BEDI objectives.

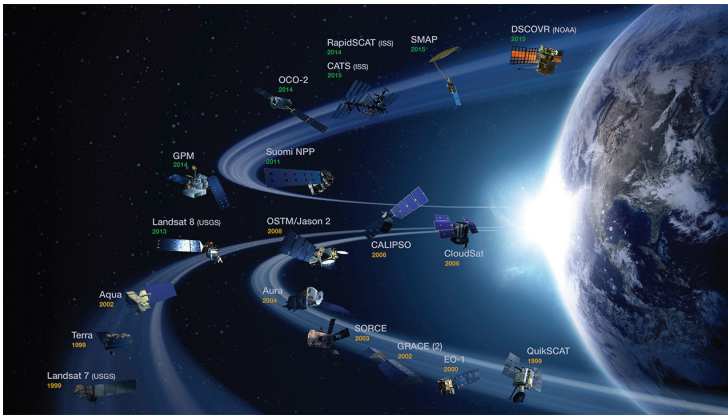
NASA's Earth Observing System Data and Information System (EOSDIS) has primary responsibility for NASA's Earth observing data collection, which currently contains more than 15 petabytes of Earth observing data acquired from satellite, airborne, and ground-based missions as well as socio-economic data. These data are managed by NASA's Earth Science Data and Information System (ESDIS) Project and processed, archived, and distributed through 12 discipline-specific Distributed Active Archive Centers (DAACs). In Fiscal Year 2015, EOSDIS delivered more than 1.42 billion data products to more than 2.6 million data users around the world.

Since NASA is not alone in collecting, managing, and distributing federally-funded civil Earth observing data, these data exist in different locations and may be in differ-

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Articles written by Josh Blumenfeld,
EOSDIS Science Writer



NASA Earth observation data managed by the ESDIS Project are collected from a fleet of orbiting satellites as well as through airborne and field campaigns. NASA graphic.

ent formats, use different metadata standards, and be searchable using different data discovery applications. Through BEDI, these data will become more standardized, easier to find, and usable across more processing systems. What this means for users of EOSDIS data and data products is continual improvements and refinements to EOSDIS systems and programs that will facilitate easier use of these data and the ability for these data to be used by a broader base of unique user communities.

NASA BEDI Basics

NASA's strategy for achieving BEDI objectives has four main elements:

- A focus on the pieces necessary to enable BEDI rather than end-user applications or the creation of new data products
- A drive toward community-driven, open standards for data formats, interfaces, and protocols as the key to achieving interoperability of data products within EOSDIS and with other U.S. federal agencies
- An effort to design and execute BEDI-related work activities so that the resulting output and products are beneficial and useful to both NASA and other U.S. federal agencies
- A strategy to leverage current NASA Earth observation plans and priorities to accelerate what NASA already is doing, planning to do, or wants to do.

The implementation of these elements involves not only enhancements to data held by EOSDIS DAACs, but also to EOSDIS services for searching, accessing, and using these data, such as Earthdata Search and Global Imagery Browse Services (GIBS). These enhancements will be integrated into a larger federal framework called the Common Framework for Earth Observation Data, which is a set of recommended standards and practices that all federal agencies will follow. As of the end of August 2016, EOSDIS DAACs participating in the BEDI data processing part of this effort (which includes 11 of the 12 DAACs) have completed more than 88% of required

BEDI tasks, including finishing a review of 1,118 datasets that will be included in EOSDIS BEDI efforts. These datasets represent more than 9,000 unique data products.

NASA BEDI Specifics: Enhancing EOSDIS data usability

A key BEDI-wide strategy to enhance data usability is the organization of data collections into 12 Societal Benefit Areas, or SBA. The BEDI SBA align with nine environmental fields adopted internationally by the Global Earth Observation System of Systems (GEOSS) project conducted by the Group on Earth Observations (GEO), of which the U.S. is one of more than 100 member nations. The BEDI SBA are overarching environmental fields of interest (such as disasters, energy, climate, and agriculture) that organize Earth science data into discrete fields where they can be more easily accessed and discovered by the global user community. EOSDIS DAACs are mapping individual datasets in their collections into these SBA, including ensuring that dataset imagery are available through GIBS, when applicable.

Just as EOSDIS will continue to increase the number of images available through GIBS, data users also can expect improvements to clients that use GIBS imagery, like Worldview. Recent Worldview enhancements based on SBA include the ability to search for imagery related to specific hazards and as well as by science disciplines.

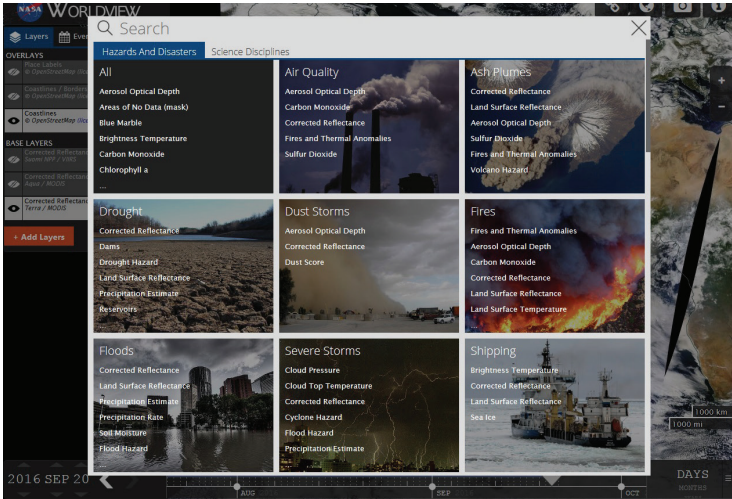
Data usability also is improved through systems designed to deliver data rapidly and with minimal processing for use in managing time-critical events, such as wildfires and ice floe assessments. One such service is the EOSDIS Land, Atmosphere Near real-time Capability for EOS (LANCE), which provides imagery of Earth observations generally within three hours of an observation. While not intended for scientific research, LANCE products help further the BEDI objectives of making Earth science data more easily usable by a broader base of user communities, such as resource managers, policy analysts, and local governments.

NASA BEDI Specifics: Enhancing EOSDIS data discoverability

A critical element to accomplishing BEDI goals and objectives is ensuring that the metadata associated with federal civil Earth observation data are complete and consistent. Improving EOSDIS data discovery begins with a thorough review of the metadata associated with EOSDIS data and datasets to verify that they are complete and meet international metadata standards.

Metadata are data about data, and include (but are not limited to) data attributes such as quality, lineage, and acquisition parameters. Metadata are used in all aspects of NASA's Earth

science data lifecycle, from initial measurements to the search and discovery of processed data. Earth observing missions use metadata in science data products when describing information such as the instrument/sensor, operational plan, or geographic region sampled. DAACs use metadata for preservation, access, and distribution of data and data products.



Clicking on the Worldview Add Layers tab allows users to search for imagery in categories based on BEDI SBA as well as by specific science disciplines. Image courtesy of Worldview.

As the EOSDIS data collection grew over the years, this led to EOSDIS metadata based on multiple and disparate systems, each requiring different formats and different mechanisms for submitting and updating data entries. This not only reduced the value of the metadata, but led to users having difficulty discovering relevant data and datasets. To correct this problem, EOSDIS created the Common Metadata Repository (CMR).

The CMR is a single, shared, scalable metadata repository for all NASA Earth science data that merges all existing capabilities and metadata from existing NASA Earth science metadata systems, such as the Global Change Master Directory (GCMD) and the EOSDIS' EOS Clearing House (ECHO). In addition, the CMR serves as the definitive management system for EOSDIS metadata, and includes metadata from EOSDIS data collections as well as from Earth science data collections outside EOSDIS (such as the GCMD). CMR metadata also are formatted to meet the International Standards Organization (ISO) 19100 series of standards, which applies to geophysical metadata (such as ISO 19115 and 19139).

Assembling metadata from Earth observing data collections into a single repository based on international metadata standards requires a review of DAAC dataset metadata, including metadata that are part of ECHO and GCMD datasets. This review includes the use of tools and techniques to:

- Compare metadata recommendations and dialects
- Identify the structure of metadata collections
- Compare the structure of metadata collections

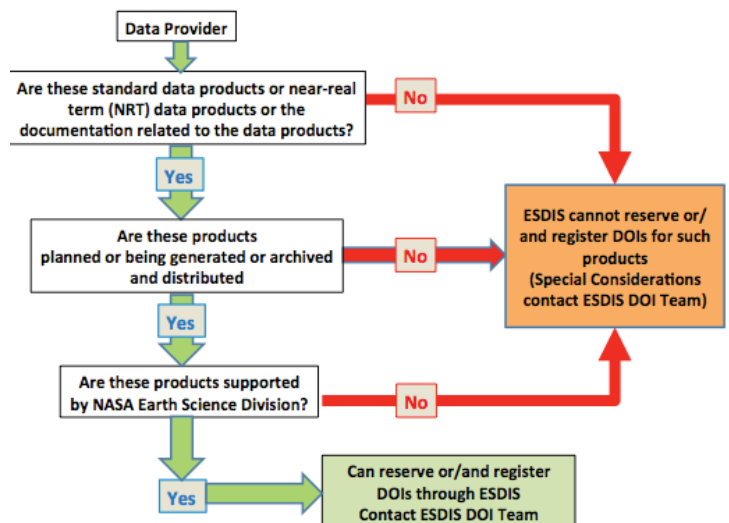
- Evaluate and measure metadata completeness with respect to recommendations
- Evaluate and measure metadata completeness with respect to specific organization goals

As of the end of August 2016, 95.8% of ECHO and GCMD BEDI metadata have been evaluated for completeness and accuracy; this process is still ongoing for CMR datasets and no metrics are currently available. Ensuring that EOSDIS metadata are complete, accurate, and adhere to international standards vastly improves the discovery, access, and use of Earth science data across organizations and, through this, significantly enhances data discovery.

The CMR also is the foundation for EOSDIS Earthdata Search. Earthdata Search provides access to EOSDIS services for data discovery, filtering, and visualization, and uses the CMR to conduct sub-second searches through the entire EOSDIS metadata catalog. Once BEDI is fully implemented, an EOSDIS data user will be able to use Earthdata Search to discover data across multiple agencies.

Along with ensuring that EOSDIS metadata are complete, easily searchable, and based on international standards, data discoverability is further enhanced by registering appropriate DAAC data with a digital object identifier (DOI). A DOI is a unique sequence of numbers and letters that identify an object, such as a dataset or journal article. DOIs are assigned and regulated by the International DOI Foundation (IDF) and based on international standards (ISO 26324, Digital Object Identifier System). According to the IDF, approximately 130 million DOIs have been assigned worldwide as of June 2016.

Registering a DOI with an object, such as an EOSDIS dataset, greatly enhances the discoverability of an object. Once registered, an object's DOI remains fixed, whereas the object's lo-



EOSDIS DAAC datasets are evaluated using the criteria in this flowchart to determine whether they will be assigned a DOI. NASA EOSDIS graphic.

cation and other metadata may change. Referring to an online dataset by its DOI provides a more stable linking than simply referring to it by its web address and makes it discoverable by anyone with an internet connection.

Researchers that acquire product data files should be able use the DOI to find the definitive documentation from NASA's Scientific and Technical Information archives. Adding DOIs to product metadata also enables tools for provenance tracking and allows data users to find more information about the creation of the data product. Additionally, a DOI gives appropriate credit to dataset authors. Datasets from the 11 EOSDIS DAACs participating in the BEDI data processing part of this effort are being evaluated and submitted for DOI registration. As of the end of August 2016 this effort was more than 97% complete.

NASA BEDI Specifics: Enhancing EOSDIS data accessibility

The BEDI objective of improving data accessibility ensures that once users discover the data they need they will be able to easily download and open these data files. While scientific data may be written in a wide range of data formats, a 2013 Executive Order requires that U.S. government data, including civilian Earth observing data, must be available in formats that are open and machine-readable. An open format is one that is platform independent and publically available without restrictions that could prevent the re-use of information; machine-readable means that the data are in a form that a computer can process.

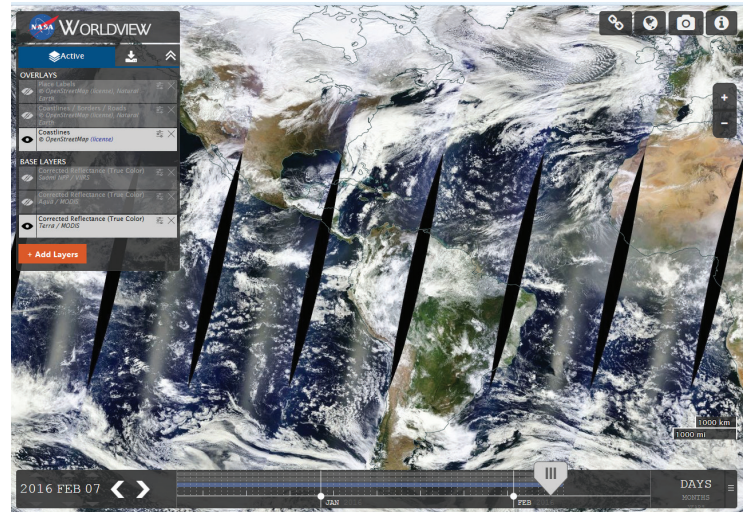
NASA launched its code directory (<https://code.nasa.gov>) in January 2012, and publishes open source projects through this portal. In addition, NASA uses multiple public, open source development repositories at SourceForge and GitHub to host NASA open source software releases. The NASA Open Source Agreement (NOSA) provides for public release of NASA-funded software. Since 2003, more than 60 NASA software projects have been released under NOSA. More detailed information about how NASA is addressing the 2013 Executive Order is in NASA's Open Government Plan 2016 and at the interactive open.nasa.gov website.

Converting existing Earth science data into formats that are open and machine readable is a time-consuming process. Fortunately, open standards designed for scientific data already are available that meet BEDI objectives by enabling users to access these data across multiple platforms and systems.

One open data standard utilized by EOSDIS is the Open Source Project for a Network Data Access Protocol (OPeNDAP). OPeNDAP enables users to easily access and transport scientific data and provides simple, remote access to large collections of datasets via the internet. OPeNDAP allows

large, rich, complex collections of NASA Earth science data to be quickly filtered and viewed on a user's desktop or mobile device. EOSDIS has applied BEDI resources to helping the OPeNDAP group make improvements to their software and enhance OPeNDAP capabilities. In addition, EOSDIS DAACs have been tasked with identifying and selecting BEDI datasets that are appropriate for integration with OPeNDAP. As of the end of August 2016, 879 datasets are supported or will be supported in OPeNDAP; 98.5% of selected DAAC BEDI datasets have been fully integrated into OPeNDAP.

Another EOSDIS effort to address BEDI accessibility requirements is making application program interfaces, or API, based on open standards. API are sets of requirements that govern how applications talk to other applications, and make it possible to move information between programs. EOSDIS has numerous API available that allow developers to create systems to use EOSDIS data. EOSDIS is working to have standard data formats utilized for DAAC datasets and for API.



The GIBS API allows users to create client systems similar to EOSDIS Worldview to use GIBS imagery. Image courtesy NASA Worldview.

Next Steps

What will BEDI success look like? Aside from being able to use a search engine from one government agency to search the entire collection of U.S. civil Earth observing data, BEDI will mean a new framework for collecting data that will rely on standardized metadata across agencies, standardized formats for these data, and the availability of these data in products designed for all levels of data user—from expert users to first-time explorers.

NASA's efforts to improve EOSDIS data usability, discoverability, and accessibility and to meet BEDI objectives are gradually coming together. The CMR is now the overall management system for EOSDIS metadata, and new data imagery products are being added to GIBS. OPeNDAP-based servers

and protocols are being implemented at EOSDIS DAACs, and more than 97% of EOSDIS datasets at DAACs participating in BEDI data processing efforts have registered DOIs. These EOSDIS efforts, along with the efforts of the other federal

agencies involved in BEDI, are creating a more coherent, collaborative collection of Earth observation data that is available to users around the world.

User Profile: Dr. Xiaofeng Li

Who Uses NASA Earth science data? Dr. Xiaofeng Li, to study atmospheric and oceanic processes.

Dr. Xiaofeng Li, Scientist; National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS)

Research interests:

Using remote sensing data, primarily synthetic aperture radar (SAR) data, to study atmospheric and oceanic processes.

Research highlights:

Radar is a simple concept—radio waves are sent out and their time and power of return are calculated to determine the range, angle, velocity, and characteristics of objects off of which the radar beam bounces. Synthetic aperture radar, or SAR, bounces a microwave radar signal off Earth's surface to detect physical properties. While the word “aperture” when used in reference to an optical instrument like a film camera refers to the size of an opening in a lens that lets light in, the term “aperture” in radar use refers to the antenna generating the microwave pulses. In general, the larger the radar antenna, the more information and better surface resolution the radar can produce. Since antenna size is limited on satellite instruments, scientists use the spacecraft's motion along with advanced signal-processing techniques to simulate a larger antenna and create high resolution images. This is where the “synthetic aperture” comes from. Significant advantages of SAR are that it can create high resolution images without the need for illumination (such as from the sun) and can penetrate clouds, fog, tree canopies, or other obstructions to create these images. This makes SAR ideal for use in Earth observing satellites.

Dr. Xiaofeng Li uses SAR data to study a wide range of processes occurring in the atmosphere and ocean, including air-sea interactions, ocean surface winds, waves, coastal upwelling, oil seeps, and tropical cyclones. In fact, SAR has been used to observe tropical cyclones since the launch of the first satellite-borne SAR aboard NASA's Seasat mission in 1978.

SAR reveals visible tropical cyclone features like eye structure, rain bands, and arc clouds, as well as features that may not be visible, such as the presence of high winds within a cyclone's eye. Dr. Li and his colleagues use SAR to better understand tropical cyclone morphology as well as to help determine physical parameters including wind speed and direction,



Dr. Xiaofeng Li on a 2013 research cruise in the Arctic Ocean. Image courtesy Dr. Xiaofeng Li.

rain rate, and eye location, all of which help improve cyclone tracking and intensity predictions.

In a recent study, Dr. Li and his colleagues combined SAR measurements of tropical cyclones with cloud pattern data from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument aboard NASA's Terra and Aqua Earth observing satellites. The combination of these data allowed the team to study cyclone tilt, which is one indicator of storm intensity (strong, developing storms tend to tilt from the storm base to the storm top, generally tilting toward cooler upper-level air). For physical wind retrievals, conventional radar signals tend to produce ambiguous returns under hurricane conditions and very high winds. To alleviate this problem, Dr. Li and his colleagues developed high-wind retrieval algorithms using cross-polarization SAR measurements along with SAR-derived hurricane morphological information. These cross-polarization measurements exhibit less scattering at high wind speeds and allow for more accurate wind retrievals. The research team compared their SAR-derived hurricane wind measurements with wind measurements from the airborne Stepped-Frequency Microwave Radiometer (SFMR), which is part of NOAA's Hurricane Research Division.

Dr. Li also uses SAR to develop algorithms for tracking changes in coastlines and the movement of oil seeps and spills. Since SAR images can be captured day or night and in almost all kinds of weather, long-term coastline changes

can be observed and tracked over time easily. In addition, oil on the sea surface tends to damp, or flatten, surface capillary waves and make the sea surface smooth. These patches of oil-dampened water appear as dark features in SAR images and can be used to study ocean currents underneath the oil as these currents move the oil. Dr. Li and his colleagues used multiple SAR observations and oil drifting models to identify the movement of oil at sea and assess spots where oil might come ashore.

In another recent study, Dr. Li and his colleagues used SAR data to observe ocean waves called internal solitary waves (ISW), which are large amplitude ocean waves that tend to occur in areas where water density increases rapidly with depth. One area where these waves are common is the South China Sea. The specific waves Dr. Li and his colleagues studied are generated by internal tides occurring at the Luzon Strait in the South China Sea. These waves move westward toward mainland China at roughly 3 m/s toward the continental shelf. Dr. Li and his colleagues chose to look at how the Dongsha Atoll affected the movement of these internal waves. The atoll (a ring-shaped island made of coral) is located at the edge of the continental shelf roughly 450 km (about 280 miles) west of the Luzon Strait. As these undersea waves hit and move around the atoll, the incoming wave is split and then re-joins on the western side of the atoll. This change in wave direction is called “refraction.” The research team used SAR imagery to map ISW signatures around the atoll in order to understand their generation mechanisms, type, spatial distribution, propagation speed, refraction, and other processes.

Data products used:

- SAR data sets available through NASA’s Alaska Satellite Facility Distributed Active Archive Center (ASF DAAC), including:
 - o Seasat
 - o European Remote Sensing Satellite-1 (ERS-1) and ERS-2
 - o RADARSAT-1
 - o Advanced Land Observing Satellite-1 (ALOS-1)
 - o Sentinel-1
 - o Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR)
- MODIS sea surface temperature (SST) and ocean color data from Terra [doi: 10.5067/TERRA/MODIS_OC.2014.0] and Aqua [doi: 10.5067/AQUA/MODIS_OC.2014.0] available through NASA’s Ocean Biology DAAC (OB.DAAC)
- ALOS-2 data available through the Japan Aerospace Exploration Agency
- Envisat data available through the European Space Agency
- SST data available through NOAA’s Comprehensive Large Array-data Stewardship System (CLASS) and CoastWatch

Research findings:

In his research into hurricane morphology, Dr. Li and his colleagues found that storm eye shapes in tropical cyclones can be categorized using SAR imagery and that stronger storms tend to have more symmetrical eyes. Also, heavy rain and atmospheric properties can interfere with the radar beam and cause false returns to appear over land and sea. Through the use of the high-wind retrieval algorithms developed by Dr. Li and his colleagues, the team was able to mitigate this beam interruption and reconstruct a complete tropical cyclone wind map, including both speed and direction.

In his work on oil tracking, Dr. Li and his colleagues developed new oil detection methods based on statistical and physical approaches. Using SAR images of oil slicks and seeps as tracers, the research team found that the movement of oil slicks and seeps in the Gulf of Mexico is directed by currents that are affected by the Earth’s rotation (Coriolis force). A sudden wind blowing over the water tends to cause surface water initially to move in the direction of the wind, but then turn this water to the right-hand side of the wind direction in the Northern Hemisphere because of the Coriolis force. Once this motion is established, the surface water continues moving in a circle. Oil is carried along with this water, and can be more easily tracked. Algorithms developed by Dr. Li and his colleagues as a result of this research have been used in NOAA’s daily oil slick monitoring operations.

Finally, in his research into internal waves near Dongsha Atoll, Dr. Li found unusual wave refraction patterns revealed by the SAR imagery. The research team noticed that after the wave hit the atoll and split, the wave closest to the atoll moved around the atoll in a circular pattern while the other side of the split wave continued moving west toward the continental shelf. Dr. Li and his colleagues found that this phenomenon was caused by the asymmetry of the tidal current near the atoll and hypothesize that the observed wave refraction is caused by changes in water depth around the atoll.

Read about the research:

Li, X., Jackson, C.R. & Pichel, W.G. (2013). “Internal solitary wave refraction at Dongsha Atoll, South China Sea.” *Geophysical Research Letters*, 40(12) [doi: 10.1002/grl.50614].

Li, X., Zhang, J.A., Yang, X., Pichel, W.G., DeMaria, M., Long, D. & Li, Z. (2012). “Tropical cyclone morphology from spaceborne synthetic aperture radar.” *Bulletin of the American Meteorological Society*, 94(2) [doi: 10.1175/BAMS-D-11-00211.1].

Li, X., Li, C., Yang, Z. & Pichel, W. (2012). “SAR imaging of ocean surface oil seep trajectories induced by near inertial oscillation.” *Remote Sensing of Environment*, 130 [doi: 10.1016/j.rse.2012.11.019].

User Profile: Dr. Anne Nolin

Who Uses NASA Earth science data? Dr. Anne Nolin to study mountain ecosystems.

Dr. Anne Nolin, Professor; College of Earth, Ocean, and Atmospheric Sciences; Oregon State University

Research Interests:

Mountain hydroclimatology, remote sensing of snow, and mountain social-ecological systems.

Research Highlights:

It is impossible to underestimate the importance of mountain snowpacks and associated glaciers to water resources. As Dr. Anne Nolin notes, snowpacks and glaciers are the lifeblood of the western U.S. and similar regions around the world, storing water in winter and gradually releasing this water during spring (from snow) and summer (from glaciers) as the snow and ice melt. Dr. Nolin's work on snowpack and mountain environments attempts to map, monitor, and characterize these vital ecosystems.

Satellite remote sensing data are a critical component of Dr. Nolin's research. Not only do these satellite data provide imagery of remote, often inaccessible mountainous areas, they also provide data for computer models designed to mathematically represent environmental conditions and are used to update these models as they run. In addition, Dr. Nolin and her colleagues use remotely-sensed data to validate model output and augment snow information from ground-based mountain monitoring stations, which may be few in number, spread out over large distances, or difficult to reach.

Research by Dr. Nolin shows that global warming is leading to changes in these ecologically sensitive regions. These changes affect not only mountain ecosystems, but also the resources that flow from mountain regions. As Dr. Nolin and her colleagues observe, "Mountain snowpack is a key common-pool resource, providing a natural reservoir that supplies water for drinking, worship, hydropower, agriculture, ecosystems, industry, and recreation for over 1 billion people globally." Changes in these snowpack resources also affect the human mountain communities depending on these resources. Dr. Nolin's work seeks to understand mountain regions as a system that couples human dimensions with these biophysical areas.

In a recent study, Dr. Nolin and her colleagues looked at the impacts of climate and precipitation changes on maritime mountain snowpack in the McKenzie River Basin (MRB) in Oregon's Cascade Mountains. While about one-third of the annual mountain precipitation in this region falls as snow, much of this snowfall occurs at temperatures close to 0°C (32°F). This means that only a small increase in temperature



Dr. Anne Nolin on Mt. Hood, Oregon, in July 2014. The instrument in her backpack is a snow tube, which is used to measure snow water equivalent (SWE). Image courtesy of Oregon State University.

is needed to change the precipitation from snow to liquid. Since the snowpack stores water in the winter and gradually releases this stored water during the melt season, an increase in temperature can significantly impact water for forests, fish, energy, production, and agriculture in this region. Through the use of model simulations and remotely-sensed data (including data from the Landsat Thematic Mapper) coupled with ground-based observations of precipitation, temperature, and the amount of water contained in the snowpack (called "snow water equivalent," or SWE), Dr. Nolin and her colleagues evaluated the sensitivity of this snowpack to projected temperature increases of 2°C and variabilities in precipitation of ±10%.

As rising temperatures reduce snowpacks, research in the Western U.S. shows that one consequence is an increase in wildfire frequency, size, intensity, and duration. When a forest burns, charred debris (such as burned trees) falls onto the forest floor. Dr. Nolin and her colleagues investigated how this charred debris changes the amount of light and radiation that is absorbed or reflected from the forest floor and the impact of these changes in reflectance on snowmelt rates and intensity.

The amount of light and radiation reflected by a surface is called albedo. Fresh snow reflects a high percentage of light and radiation that strikes it and has a high albedo. Charred debris, on the other hand, reflects much less light and radiation, and has a much lower albedo. Solar radiation that is not reflected by a surface (such as sunlight striking dirty snow) is absorbed, causing the upper layers of the surface to increase in temperature. Remotely sensed data, specifically a spatial analysis combining snow cover, fire, and forest cover data from the Moderate Resolution Imaging Spectroradiometer

(MODIS) instrument, allowed the research team to calculate the amount of burned area in their study sites and monitor the changes in albedo in these areas as they recovered.

Dr. Nolin and her colleagues also are using MODIS snow cover data to develop new snow metrics as geospatial products to support the National Climate Assessment. These snow data products will soon be available through Google Earth Engine, which will allow users to tailor the web-based maps and data output to individual needs. In addition, Dr. Nolin and her colleagues developed a remote sensing glacier-mapping pilot project called IceTrendr. IceTrendr uses Landsat time-series data to capture, label, and map glacier change for use in climate science, hydrology, and Earth science education. The interactive web interface the team developed allows them to map glacier change and label the change processes.

Finally, Dr. Nolin and her colleagues used data from the Multi-angle Imaging SpectroRadiometer (MISR) instrument aboard NASA's Terra Earth observing satellite to map and analyze Greenland ice sheet roughness. Since the surface of the Greenland ice sheet is shaped by wind, melting processes, and glacier dynamics, the roughness of this ice sheet causes changes in the amount of heat reflected or absorbed by the ice sheet surface and can impact ice sheet development.

Data products used:

- MODIS/Terra snow cover, Daily, 500-m grid (MOD10A1, doi: 10.5067/MODIS/MOD10A1.006), available through NASA's National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC)
- MODIS snow-covered area and grain size (MODSCAG) 500-m grid, available through the Snow Data System portal at NASA's Jet Propulsion Laboratory
- MISR Level 1B2 Terrain Data: terrain projected top of atmosphere radiance, resampled at the surface and topographically corrected (MI1B2T, doi: 10.5067/Terra/MISR/MI1B2T_L1.003), available through NASA's Atmospheric Science Data Center (ASDC) DAAC
- Landsat Thematic Mapper (TM) and Operational Land Imager (OLI) data, available through the U.S. Geological Survey's EarthExplorer and Global Visualization Viewer (GloVis)

Research findings:

Results from Dr. Nolin's exploration into the effects of projected climate changes on maritime mountain snowpack in the Oregon Cascades found that this snowpack is highly sensitive to increasing temperatures, with snowpack between elevations of 1,000 and 2,000 meters (about 3,280 to 6,560 feet) being particularly sensitive. Specifically, she and her colleagues found that peak SWE decreases 56% when temperature increases by 2°C. Also, projected warmer temperatures hasten the snowpack melt cycle, with peak SWE occurring 12 days sooner. The research team found that while temperature

increases are the primary driver of diminished snowpack accumulation, variabilities in precipitation produce noticeable changes in the timing and storage of water in the snowpack. The combination of diminished snowpack resulting from projected temperature increases along with expected increases in the population that will depend on water from this snowpack could lead to water management concerns. Since maritime snow comprises about 10% of Earth's seasonal snow cover, Dr. Nolin and her colleagues observe that the results from this case study can be applied to areas of maritime snowpack around the world.

In her study of the effects of burned debris on snowmelt, Dr. Nolin found that snow accumulation was greater in a burned forest study area when compared with an unburned study area. However, the snowpack in the burned study area disappeared 23 days earlier and had twice the melting or evaporation rates than in the unburned forest. Snow albedo was 50% lower in the burned forest, leading to a substantial increase in heat absorbed by the upper layers of soil in the burned area.

Looking at the surface roughness of the Greenland ice sheet, Dr. Nolin and her colleagues found that the ice sheet's surface roughness changes significantly over the course of the melt season, primarily from April to July, and varies from year to year depending on the amount of melt and the dynamics of the outlet glaciers along the ice sheet margin. Dr. Nolin also found that roughness values are lower in the dry, snow-covered interior of the ice sheet and much higher along the crevassed margins of the ice sheet.

Read about the research:

Gleason, K.E. & Nolin, A.W. (2016). "Charred forests accelerate snow albedo decay: parameterizing the post-fire radiative forcing on snow for three years following fire." *Hydrological Processes*, 30(21) [doi: 10.1002/hyp.10897].

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Earthdata Developer Portal

The newly released Earthdata Developer Portal is for application developers who wish to build applications that search, access, and browse NASA's Earth science data.

Earthdata Developer Portal for Application Developers

The newly released Earthdata Developer Portal, at <https://developer.earthdata.nasa.gov>, is for application developers who wish to build applications that search, access, and browse NASA's Earth science data by leveraging the Earth Observing System Data and Information System (EOSDIS) enterprise tools and services. The Earthdata Developer Portal provides centralized and uniform access to public Application Programming Interfaces (APIs) and other documentation.

Current documentation includes:

- Common Metadata Repository (CMR), EOSDIS data search engine
- Earthdata Login, EOSDIS user registration system
- Earthdata Search, EOSDIS front-end to CMR
- Global Imagery Browse Services (GIBS), EOSDIS browse image repository

The Earthdata Developer Portal is still alpha and documentation for additional tools and services will be added. In the meantime, NASA is seeking feedback from the community via the feedback tab on the portal.

The screenshot shows the Earthdata Developer Portal homepage. At the top left is the NASA logo and the text "EARTHDATA Developer Portal". To the right are navigation links: "CMR", "EARTHDATA LOGIN", "EARTHDATA SEARCH", "EARTHDATA TOOLS", and "GIBS". The main heading reads "Get started exploring and developing with NASA Earthdata". Below this are two primary actions: "Search and Get Earth Science Data" (represented by a magnifying glass icon) and "Host an Application on Earthdata" (represented by a server rack icon). A "Feedback" tab is visible on the left side. Below the main content is a section titled "NASA Earth Science Data At Your Fingertips" with a sub-heading "The Earthdata Developer Portal is the central location for all publicly accessible developer documentation related to EOSDIS enterprise services and applications." The footer contains the "EARTHDATA EOSDIS" logo and contact information: "NASA Official: Stephen Berrick", "FOIA", "NASA Privacy Policy", "USA.gov", and "Contact Us".

Data Chat: Talking about NASA's EOSDIS Earth Science Data Collection with Program Executive Kevin Murphy



Kevin Murphy, Program Executive for the NASA Earth Science Data Systems Program

NASA's Earth Observing System Data and Information System (EOSDIS) currently archives more than 17.5 petabytes of Earth science data collected from satellites, airborne campaigns, and field observations. The more than 11,000 unique data products produced from these data represent one of the largest collections of Earth observing data in the world. Overseeing the ingesting, processing, archiving, and distributing

of these products is one of the many responsibilities of Kevin Murphy, the Program Executive for Earth Science Data Systems within NASA's Earth Science Division. The fact that all of these data are delivered under a free and open data policy entails a number of unique challenges for Mr. Murphy and NASA, along with the prospect of exciting new products being available in the not-too-distant future.

[You are the 2016 recipient of the American Geophysical Union's Charles S. Falkenberg Award, which recognizes "an early- to middle-career scientist who has contributed to the quality of life, economic opportunities and stewardship of the planet through the use of Earth science information and to the public awareness of the importance of understanding our planet." What does this award mean to you in your work developing NASA's EOSDIS Earth science data collection?](#)

I originally wanted to become a geographer to work on trees and look at land cover and understand how the environment works. One of the things I saw that needed to be done is better access to environmental information so people can be more informed about their decisions. I'm just really honored that the path that led me to this award was able to help people better understand their environment and make better decisions about their environment. This is one of the things I think you see throughout NASA and this whole community—they are really interested in looking at the whole context of decisions and making this information available so people can make informed decisions. Sometimes we don't have much time to make these important decisions about the environment.

[What is the overall significance of NASA's Earth science data?](#)

Climate signals and long-term global processes happen over decades. You need these long-term data to tease the inter-

annual variability from the trend. Earth systems science is an integrated science. You want to be able to go and look at multiple measurements to get a global picture of what's going on at a variety of spatial and temporal resolutions. Through Earth systems science, we try to understand how the Earth works and how we can understand the trends in these processes. This is not just learning for the sake of learning. We have to live here. We have to understand how hurricanes form, we have to understand how crops are grown, we have to understand how much fresh water there is and how clean this water is, we have to understand aerosols and how these impact human health. These are all things we can do.

[How do you see NASA accomplishing this?](#)

The first thing we have to do is to maintain stewardship [of these data]. This means more than just putting something in a box and knowing where it is. You have to make the data available to people as technology changes. When NASA's Earth Observing System first got started, you would order a data tape from somebody over the phone and they would mail the physical data tape to you. Today we've moved well beyond this. All our data are on spinning disks and you can go to an internet address and download these data. We have to make sure that we maintain a sufficient amount of investment to make sure that we keep the technology current. This is a continuous evolution process. Also, NASA is not the only organization, public or private, that collects these data. So we have to have a lot of relationships with international communities, other government agencies, and with the private sector.

[A key component of NASA data is that they are free and open to the public. What are the challenges of this policy?](#)

There are a variety of challenges. Not only are our data free and open, they also are provided as soon as feasible after the launch of a mission or the completion of a ground survey or airborne campaign. This means that our data also have to have a low latency to really make this policy work. We have millions of [data] users, and that's a lot of products that go out every year. It's not only to U.S. users; these products go out all over the world. There's no period of exclusive access for anyone. We have to be able to maintain our systems in a fashion that allows the users to get these data pretty easily. We take very seriously the need to engineer our products and systems so they are robust. They have to have a lot of up time; they can't go down.

Also, the algorithms and the software that go into creating [different data products] also have to be free and open or

else you don't know how you got from one [data product] to the next. The calibration information has to be free and open. This becomes very difficult when you're working across international communities that have different legal frameworks or when you're working with commercial companies that want to protect their investments.

[These data are produced, archived, and distributed by 12 discipline-specific Distributed Active Archive Centers \(DAACs\). Does this create any additional challenges?](#)

The good news is that we have a great set of people doing this work [at the DAACs]. This makes it possible for us to support an undertaking of this size.

Certainly a challenge is that each discipline has its unique requirements. When you want to bring together products from different disciplines to address an integrated science question, some of those formats, or projections, or technical aspects of data that one community might want may not meet the same needs of another community.

Additionally, each DAAC has a User Working Group comprising scientists in the discipline supported by that DAAC. These working groups serve as a bridge to the scientists in that community. We have to make sure that we balance the requirements, needs, and priorities that the working groups give to the DAACs among our programmatic requirements of stewardship and distribution.

This is all on top of maintaining a technology footing that's secure, managing things efficiently and effectively so we don't have duplication of activities, and supporting the user requirements so our data users can do their fundamental job, which is science.

[You spoke earlier about international collaborations. Tell me about some of these and how they will affect data products our users might see in the near future.](#)

There are a lot of new [international] data products coming. In fact, once we bring on some of the international partners, we may almost double our ingest rate from the original [Earth Observing System] missions. We have a bilateral [agreement] with the European Space Agency [ESA], we also have a bilateral with the European Commission for Sentinel [satellite mission] products to be distributed from NASA.

Not only do we get their data, but they get ours; it's a two-way street. We've been providing free and open data for a long time, but we have increasing interoperability among our metadata catalogs. If you search from a portal in Europe, you can find NASA data and vice versa here in the U.S. We've supported the repatriation of some of our data products, such as from the Alaska Satellite Facility to ESA so they can look

at glacier calving events back to 1979 or 1980 to the present using SAR data.

We work very closely with CEOS [the international Committee on Earth Observation Satellites]. This effort is really aimed at merging the capabilities of space agencies that are interested in Earth and have assets to provide. There's interoperability from about 26 different space agency's metadata catalogs so we can look across the variety of different areas and capabilities of these different countries.

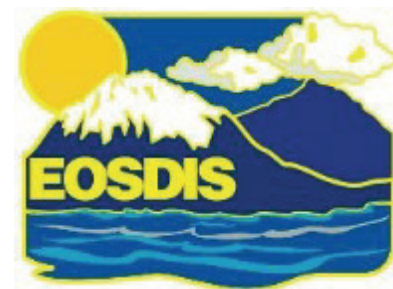
We also work with GEO [the international Group on Earth Observations] in not only advocating for free and open data, but also looking at infrastructures so our products and other nation's products can be combined—not only space observations, but also ground-based observations, economic observations, maps, and other observations. You not only need the environmental context, but also the socioeconomic context to provide the full picture of how humans are utilizing the Earth and how the environment influences their usage patterns.

[Where do you see NASA Earth science headed?](#)

I think we're making a lot of effort to see how we can enhance our products so a broader base of users can use our data products in a scientifically valid way. The other thing that I hope [to see] is the merging of observational data with model output in a more cohesive manner, making it so that the forecast we have and the hindcast we have can be compared with the observations that we take. This is a little difficult since these are totally different things; one is a model and the other is a measurement. It would be nice to see if these two streams of information can be used together.

I think that at some point in the future, I'd like to see environmental information as ingrained in people's decision making as looking at what today's weather is going to be—something that you almost take for granted that it's part of your decision making process. Maybe that's not tomorrow, but you can see this happening as our capabilities improve over the next 10 to 15 years.

*Interview conducted and edited by Josh Blumenfeld,
EOSDIS Science Writer*



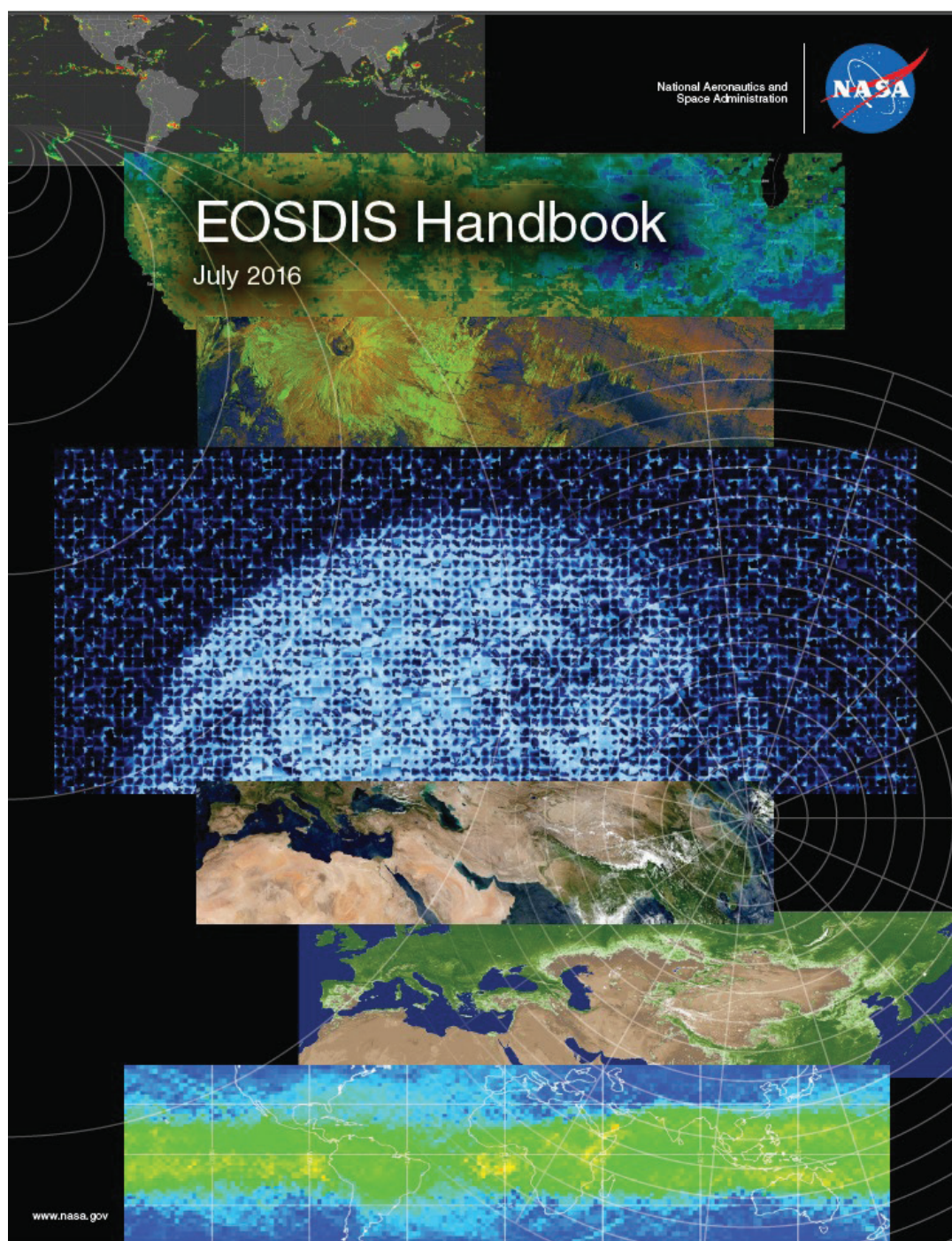
EOSDIS Releases New Handbook

EOSDIS has released a new EOSDIS Handbook. The Handbook describes EOSDIS's functions, architecture and information model, that is, how EOSDIS is put together. It is likely to be most useful to practitioners in the field of data management and affiliated data science disciplines.

A Getting Started guide for end users of EOSDIS data is under construction and will be released soon.

To download the EOSDIS Handbook in pdf format

<https://earthdata.nasa.gov/files/EOSDISHandbookWebFinal1.pdf>



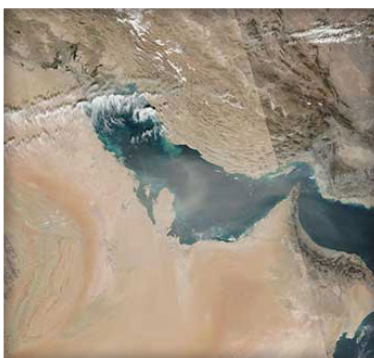
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Looking at Global Vegetation

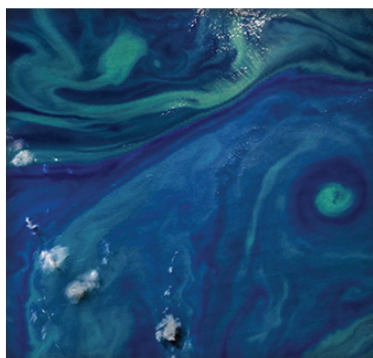
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Published on September 26, 2016



Dust Storm off West Africa

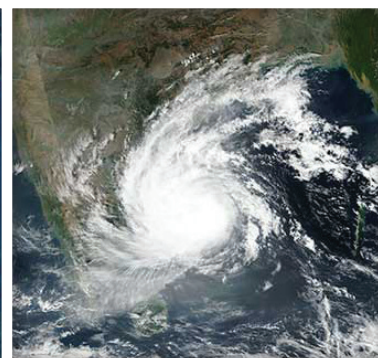
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Phytoplankton in the Falklands

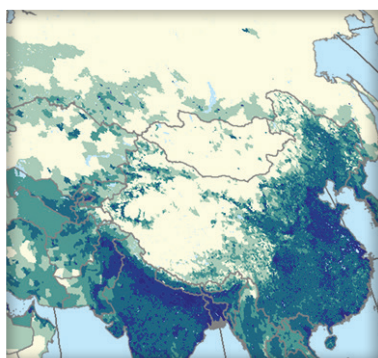
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Tropical Cyclone Vardah

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Gridded Population of the World (GPW), Version 4

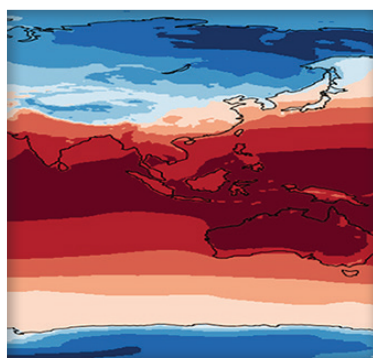
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Published on November 21, 2016



Lake Manicouagan Quebec, Canada

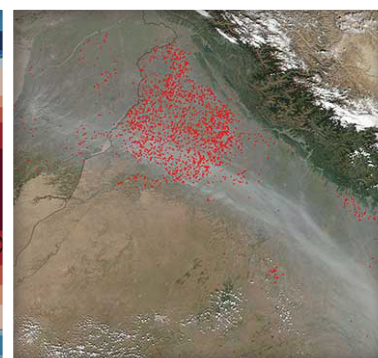
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Published on December 11, 2016



Fires in northwest India

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Published on August 29, 2016

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