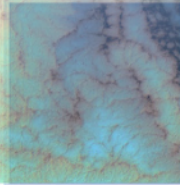
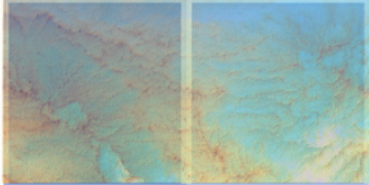
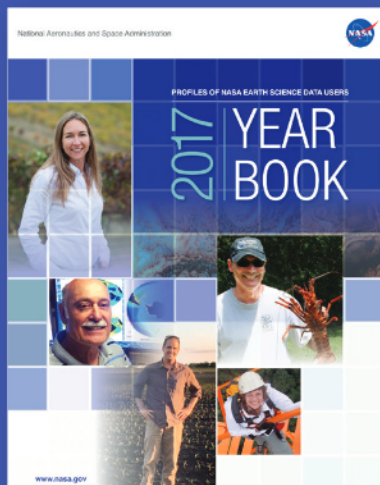




PROFILES OF NASA EARTH SCIENCE DATA USERS

2017 | YEAR BOOK





COVER: (Counterclockwise from upper left) Dr. Nancy Glenn, Dr. Sergio Signorini, Dave Johnson, Dr. Rachel Albrecht, and Dr. John Wilkin.

NASA's Earth Observing System Data and Information System (EOSDIS) is pleased to present the 2017 EOSDIS Data User Profile Yearbook. From pinpointing global lightning hotspots to tracking deadly bacteria in Chesapeake Bay, EOSDIS data users are applying NASA Earth observing data to a wide range of research. The EOSDIS Data User Profile series showcases these scientists, researchers, managers, and educators along with the data products that make their work possible. Our Data User Profile Yearbook gives you a taste of the breadth of research enabled by the vast NASA EOSDIS data collection—a collection that is yours to use, fully and without restriction.

EOSDIS provides end-to-end capabilities for managing NASA's Earth science data from satellites, aircraft, field measurements, and various other programs. These data are managed, archived and distributed by discipline-specific Distributed Active Archive Centers (DAACs) to a diverse worldwide user community.

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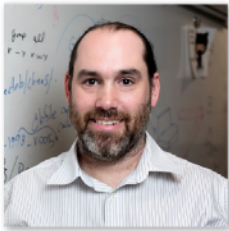
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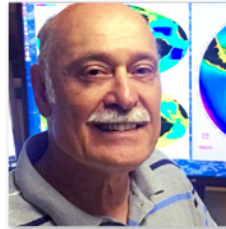
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Who Uses Earth Science Data?

Dr. Rachel Albrecht, to pinpoint global lightning hotspots.



Dr. Rachel Albrecht climbing to the observation level of the Amazonian Tall Tower Observatory (ATTO), located in the Amazon rain forest near Manaus, Brazil. Image courtesy of Dr. Albrecht.

Dr. Rachel Albrecht

Professor,
Department of Atmospheric
Sciences, University of
São Paulo, Brazil

Research interests: Cloud electrification, lightning, nowcasting of severe weather, cloud-aerosol-precipitation interactions (CAPI), and local circulation effects in deep convection.

Research highlights: If you live an 80-year life, your [odds of being struck by lightning](#) are 1 in 13,500, according to the [National Weather Service \(NWS\)](#), with a 1 in 1,083,000 chance of being struck in a given year. But lightning seems to play favorites, both for people and locations.

Roy Sullivan, for example, had what could be described as an attractive personality. Sullivan (1912-1983), a park ranger in Shenandoah National Park in Virginia, was [reportedly struck by lightning seven times](#) between 1942 and 1977. Aside from his hair catching on fire (several times) and burns from the strikes, he was otherwise unharmed. Or take the Empire State Building in New York City. This architectural landmark is [hit an average of 23 times a year](#), according to the NWS.

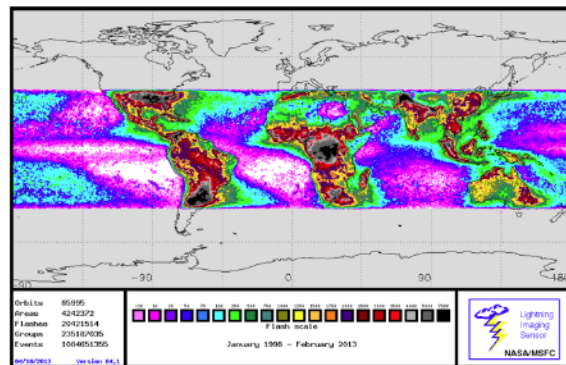
And then there is Lake Maracaibo in Venezuela.

Recent research by Dr. Rachel Albrecht and her colleagues shows that Lake Maracaibo is Earth's lightning hotspot. Using 16 years of lightning flash data collected by the [Lightning Imaging Sensor \(LIS\)](#) aboard the joint NASA/ [Japan Aerospace Exploration Agency \(JAXA\) Tropical Rainfall Measuring Mission \(TRMM\)](#) satellite (operational 1998 to 2015), the research team determined that the lake has a [Flash Rate Density \(FRD\)](#) of more than 233 lightning flashes per square kilometer per year, surpassing the previous lightning hotspot of Kabare in the Democratic Republic of the Congo (which has a FRD of 205 flashes/km²/year). Dr. Albrecht's research shows that lightning hotspots are created by local air circulations and the interactions of these circulations with surrounding topography. She also notes that the top 30 lightning hotspots identified by her research are related to complex terrain.

So why is Lake Maracaibo a natural lightning rod? Dr. Albrecht identifies several factors that work together to make the lake conducive to storms with an unusually high amount of lightning. For one, the lake is quite large (13,210 km²), with warm waters surrounded by mountains. The mountains channel mountain-valley and land-lake breezes over the lake at night where these air masses gain moisture from the lake as they are lifted. The result of this moist, unstable, uplifted air is localized nocturnal thunderstorms that persist over the lake.

Of course, you can't have a thunderstorm without lightning. As these storms rise into much colder air high above the ground, the cloud droplets freeze and ice crystals, graupel, and hail

(Continued)



This image shows the more than 1.08 billion lightning flashes detected between roughly 35° north and south latitude by the LIS instrument aboard the TRMM satellite from January 1998 to February 2013. Darker areas have higher concentrations of lightning flashes. A new LIS instrument aboard the International Space Station (ISS) detects lightning flashes between roughly 54° north and south latitude. TRMM and ISS LIS data are available through NASA's Global Hydrology Resource Center Distributed Active Archive Center (GHRC DAAC). Image courtesy NASA/MSFC.

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form. When these ice crystals, graupel, and hail pellets collide within the cloud, the cloud's electrical charge becomes separated. After millions of collisions, so much charge is built up that a lightning discharge occurs, temporarily returning the cloud to a neutral charge. This process rapidly repeats as frozen droplets continue to collide.

Of the 500 global lightning hotspots ranked by Dr. Albrecht and her colleagues, 283 occur in Africa, which is the continental landmass with the highest number of hotspots (hotspots in other continental landmasses: Asia, 87; South America, 67; North America, 53; Oceania, 10). As a professor at the University of São Paulo, Dr. Albrecht notes that the top Brazilian lightning hotspot is found in the Amazon on the eastern shore of the Rio Negro River a few hundred kilometers from Manaus. Along with investigating the origins of this hotspot and the influence of river breezes on thunderstorm development, she also is investigating the impact of human-caused pollution on these thunderstorms.

For her atmospheric work in the Amazon, Dr. Albrecht integrates remotely-sensed satellite data with field data collected using two unique research tools—the [Amazonian Tall Tower Observatory \(ATTO\)](#) and the [High Altitude and Long-range \(HALO\)](#) research aircraft.

Located 150 km northeast of Manaus, Brazil, ATTO is a joint German/Brazilian project soaring 325 meters (more than 1,000 feet) above the forest canopy and studded with instruments for measuring various greenhouse gases, analyzing aerosols, and collecting weather data. Research conducted at the tower is designed to collect data on the influence of the Amazonian rainforest on climate; understand sources and sinks of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O); investigate the formation of aerosols and their role in cloud formation; and study long-range transport processes of air masses and the influence of the Amazonian forest on these air masses.



(L) Dr. Albrecht standing on the highest ATTO platform (320 meters/1,050 feet above ground level) on 8 January 2015. The sea of green behind Dr. Albrecht is the Amazon rain forest. (R) Dr. Albrecht standing beside the HALO aircraft at the Manaus airport on 6 September 2014 before a 7.5 hour flight to study biogenic, biomass, and urban aerosol processes and their impact on cloud formation. Images courtesy of Dr. Albrecht.

The HALO aircraft soars even higher above the forest canopy. With its cruising altitude of more than 15 km (almost 50,000 ft.), a payload of up to three tons, and a range of more than 8,000 km (almost 5,000 miles), this unique German research aircraft facilitates continental-scale atmospheric measurements at altitudes as high as the lower stratosphere.

(Continued)

Who Uses Earth Science Data?

Dr. Albrecht points out that the Amazon is one of the few continental areas where it is still possible to observe atmospheric conditions during the wet season that resemble those that existed in pre-industrial times, especially in regard to aerosol concentrations. “Aerosol” is the term used to describe minute solid particles or liquid droplets that are suspended in air. Common aerosols include dust, water vapor, and smoke.

During the Amazon dry season, a majority of regional aerosols are from biomass burning. In addition, the city of Manaus in the heart of the Amazon is a source for aerosols from urban pollution throughout the year. These human-created aerosols serve as cloud condensation nuclei around which water vapor collects to form cloud droplets and, when large enough, rain and ice. The interaction of aerosols with cloud condensation nuclei and the impact of this on precipitation is referred to as Cloud-Aerosol-Precipitation Interactions (CAPI), which is a focus of Dr. Albrecht’s research.

Dr. Albrecht was part of a large multi-national campaign called the [Aerosol, Cloud, Precipitation, and Radiation Interactions and Dynamics of Convective Cloud Systems \(ACRIDICON\)](#), which used the HALO aircraft for atmospheric sampling across northern Brazil over Amazonia. ACRIDICON was conducted in conjunction with another campaign called [Cloud processes of the main precipitation systems in Brazil: A contribution to cloud resolving modeling and the Global Precipitation Measurement](#), or CHUVA (*chuva* is the Portuguese word for rain). The CHUVA campaign collected data for the precise localization of intra-/inter-cloud and cloud-to-ground lightning in and around São Paulo and contributed data to the joint NASA/JAXA [Global Precipitation Measurement \(GPM\)](#) mission (operational 2014-present). The goal of ACRIDICON-CHUVA was to quantify CAPI and thermodynamic, dynamic, and radiative effects of CAPI processes by combining field measurements with remotely-sensed satellite data.

One important finding from this campaign is that aerosols from urban pollution lead to a higher concentration of cloud condensation nuclei, which compete with water vapor to form cloud droplets. As a result, clouds in more polluted areas have a higher number of very small cloud droplets. The small size of these cloud droplets suppresses the process necessary for these small droplets to combine into large raindrops. This suppression, in turn, can result in no rain at all or it can give the cloud the extra time necessary to grow vertically to freezing temperatures and for the cloud droplets to freeze. As noted above, it is the collision of these frozen particles that leads to a separation of electrical charge in the cloud and the resulting lightning discharge.

Dr. Albrecht calls the Amazon a living laboratory for her studies of CAPI, cloud electrification, and lightning. As her research shows, certain areas have the right combination of ingredients to create hotspots for these powerful electrical displays—a fact the lightning-prone Roy Sullivan knew all too well.

Representative data products used:

- TRMM LIS 0.1 Degree Very High Resolution Gridded Lightning Climatology Data (DOI: [10.5067/LIS/LIS/DATA306](#)); available through NASA’s [Global Hydrology Resource Center \(GHRC\) Distributed Active Archive Center \(DAAC\)](#)
- MODIS/Terra value-added Aerosol Optical Depth (MODAODHD; DOI: [10.5067/MODIS/MODAODHD.NRT.006](#)); available through NASA’s [Level 1 and Atmosphere Archive and Distribution System \(LAADS\) DAAC](#)
- Various data products from the [National Oceanic and Atmospheric Administration’s Comprehensive Large Array-Data Stewardship System \(CLASS\)](#)

(Continued)

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- Data from the [GoAmazon dataset](#); available through the U.S. Department of Energy's [Atmospheric Radiation Measurement \(ARM\)](#) Climate Research Facility
- Data and research from the [Amazonian Tall Tower Observatory \(ATTO\)](#)
- [HALO data from the ACRIDICON-CHUVA mission](#); available through the [HALO database](#)

Read about the research:

Braga, R.C., Rosenfeld, D., Weigel, R., Jurkat, T., Andreae, M.O., Wendisch, M., Pöschl, U., Voigt, C., Mahnke, C., Borrmann, S., **Albrecht, R.I.**, Molleker, S., Vila, D.A., Machado, L.A.T. & Grulich, L. (2017). "Aerosol concentrations determine the height of warm rain and ice initiation in convective clouds over the Amazon basin." *Atmospheric Chemistry and Physics* (in review, 2017) [doi: [10.5194/acp-2016-1155](#)].

Cecchini, M.A., Machado, L.A.T., Andreae, M.O., Martin, S.T., **Albrecht, R.I.**, Artaxo, P., ... Wendisch, M. (2017). "Sensitivities of Amazonian clouds to aerosols and updraft speed." *Atmospheric Chemistry and Physics*, 17(16): 10037-10050 [doi: [10.5194/acp-2017-89](#)].

Albrecht, R.I., Goodman, S.J., Buechler, D.E., Blakeslee, R.J. & Christian, H.J. (2016). "Where Are the Lightning Hotspots on Earth?" *Bulletin of the American Meteorological Society*, 97(11): 2051-2068 [doi: [10.1175/bams-d-14-00193.1](#)].

Wendisch, M., Pöschl, U., Andreae, M.O., Machado, L.A.T., **Albrecht, R.**, Schlager, H., ... Afchine, A. (2016). "ACRIDICON-CHUVA Campaign: Studying Tropical Deep Convective Clouds and Precipitation over Amazonia Using the New German Research Aircraft HALO." *Bulletin of the American Meteorological Society*, 97(10): 1885-1908 [doi: [10.1175/bams-d-14-00255.1](#)].

Machado, L.A.T., Silva Dias, M.A.F., Morales, C., Fisch, G., Vila, D., **Albrecht, R.**, ... Tokay, A. (2014). "The Chuva Project: How Does Convection Vary across Brazil?" *Bulletin of the American Meteorological Society*, 95(9): 1365-1380 [doi: [10.1175/bams-d-13-00084.1](#)].

Albrecht, R.I., Morales, C. A. & Silva Dias, M.A.F. (2011). "Electrification of precipitating systems over the Amazon: Physical processes of thunderstorm development." *Journal of Geophysical Research*, 116(D8) [doi: [10.1029/2010jd014756](#)].

Who Uses Earth Science Data?

Dr. Michael Dietze, to improve ecological models through the integration of remotely-sensed data.



Dr. Isterm Fer (L) and Dr. Michael Dietze (R) studying seedlings at the Bartlett Experimental Forest in Bartlett, NH. Photograph by Cydney Scott and courtesy of Dr. Michael Dietze.

Dr. Michael Dietze

Associate Professor,
Department of Earth and
Environment, Boston
University

Research interests: Ecological forecasting, with a particular interest in integrating remotely-sensed environmental data into environmental models as a means of improving model forecasts and outputs.

Research highlights: A model is a representation of reality. While a model of an aircraft might be built using plastic and glue, scientific models designed to represent terrestrial ecological processes are constructed using algorithms and years of Earth observing data from many sources. One of these sources is remotely-sensed data collected by instruments aboard satellites, such as NASA's [Terra](#) and [Aqua](#) Earth observing satellites. These data facilitate the development of a wide range of individual data products that can be used to compare processes occurring in the real world with output from ecological models. NASA's [Earth Observing System Data and Information System \(EOSDIS\)](#), for example, currently archives more than 22 petabytes of Earth observing data from satellite, airborne, and *in situ* missions. Through NASA's [Earth Science Data and Information System \(ESDIS\) Project](#), EOSDIS provides access to more than 10,000 unique research products.

With so much data and so many data products, one challenge for researchers is effectively utilizing and synthesizing existing data. Through the [Predictive Ecosystem Analyzer](#), or PEcAn, Dr. Michael Dietze and his colleagues are attempting to address this challenge and improve the accuracy of ecological models by making it easier to integrate existing data into these models.

PEcAn, which was developed by Dr. Dietze, is an open-source ecoinformatics system that provides a common set of software tools that allow users to integrate multiple ecosystem models and data so they can efficiently be used together. One benefit of being able to constantly add new data or data variables to an environmental model is that the model can better represent the effects of ongoing events in a specific area to ecological processes, such as forecasting the leaf-out times of plant species in that area or region.

PEcAn manages the integration and conversion of data into environmental models along with model execution, and provides a variety of tools for analyzing and visualizing data output. Dr. Dietze and his colleagues have used PEcAn in a wide range of projects across most of the world's terrestrial biomes.

Much of Dr. Dietze's current research and work is focused on comparing outputs from multiple environmental models with terrestrial ecosystem data to identify cases where data can help differentiate between competing hypotheses of how Earth processes work; cases where current models do not capture a process correctly; and instances where data are insufficient to differentiate among multiple hypotheses. Dr. Dietze and his colleagues also are working on developing new ecological theories and statistical tools to better understand why certain ecological processes are more or less predictable, and then using these theories and tools to compare the sources of uncertainty that affect model forecasts of these processes.

In a recent project, Dr. Dietze led a team that examined ways of fusing predictions of leaf phenology (the date that plant leaves unfold) generated by terrestrial ecosystem models with phenological data from NASA's satellite-based [Moderate Resolution Imaging](#)

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Who Uses Earth Science Data?

[Spectroradiometer \(MODIS\)](#) instrument [Leaf Area Index \(LAI\)](#) products and [AmeriFlux](#) Fraction of Absorbed Photosynthetically Active Radiation (fAPAR) products. MODIS is a key instrument aboard NASA's Terra and Aqua satellites; AmeriFlux is a network of field sites measuring ecosystem carbon dioxide, water, and energy fluxes across North, Central, and South America.

Building upon this research, Dr. Dietze is part of a team working on an approach integrating remotely-sensed data with model data that will enable terrestrial ecosystem models to predict reflectance spectra. Reflectance spectra are a measure of the wavelengths of light that are returned rather than absorbed by a plant or other object. When sunlight strikes a plant leaf, certain wavelengths of this visible light are absorbed and other wavelengths are reflected. Healthy vegetation absorbs most of the visible light that hits it (which is used for photosynthesis) and reflects a large portion of light in near-infrared wavelengths. Unhealthy or sparse vegetation reflects more visible light and less near-infrared light. By analyzing the spectra of returned radiation detected by a sensor aboard an aircraft or satellite, the composition, structure, disturbance, or other variables of vegetation can be measured.

In this work, spectral data collected over Eastern U.S. temperate forests by NASA's [Airborne Visible/Infrared Imaging Spectrometer \(AVIRIS\)](#) are assimilated into models designed to analyze canopy optical properties with the goal of improving the sensitivity and accuracy of these models. As Dr. Dietze notes, once this data/model integration is successful, this approach will be applied to multispectral data, such as data from the [Visible Infrared Imaging Radiometer Suite \(VIIRS\)](#) aboard the joint NASA/NOAA [Suomi National Polar-orbiting Partnership \(Suomi-NPP\)](#) satellite along with MODIS data. The research team also intends to see if this approach can be extended to Light Detection and Ranging (LIDAR) systems, such as the upcoming NASA [Global Ecosystem Dynamics Investigation \(GEDI\)](#) mission, as well as thermal imagery, such as the upcoming NASA [ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station \(ECOSTRESS\)](#) mission, both of which will be installed on the International Space Station (ISS).

Representative data products used:

- MODIS LAI products from NASA's Terra and Aqua Earth observing satellites; available through NASA's [Land Processes Distributed Active Archive Center \(LP DAAC\)](#):
 - MOD15A2H (Terra), DOI: [10.5067/MODIS/MOD15A2H.006](https://doi.org/10.5067/MODIS/MOD15A2H.006)
 - MYD15A2H (Aqua), DOI: [10.5067/MODIS/MYD15A2H.006](https://doi.org/10.5067/MODIS/MYD15A2H.006)
 - MCD15A2H (Terra + Aqua), DOI: [10.5067/MODIS/MCD15A2H.006](https://doi.org/10.5067/MODIS/MCD15A2H.006)
 - MCD15A3H (Terra + Aqua), DOI: [10.5067/MODIS/MCD15A3H.006](https://doi.org/10.5067/MODIS/MCD15A3H.006)
- [North American Land Data Assimilation System \(NLDAS\)](#) and [Global Land Data Assimilation System \(GLDAS\)](#) data; available through NASA's [Goddard Earth Sciences Data and Information Services Center \(GES DISC\)](#)
- AVIRIS data over eastern temperate forests; available through the [AVIRIS Data Products Portal](#)
- AmeriFlux fAPAR data; available through the [AmeriFlux website](#)

(Continued)

Who Uses Earth Science Data?

- [National Land Cover Database \(NLCD\)](#); available through the [Multi-Resolution Land Characteristics \(MRLC\) Consortium](#), a partnership of Federal agencies led by the U.S. Geological Survey (USGS)
- [North American Regional Reanalysis \(NARR\)](#) data; available through NOAA's [National Centers for Environmental Information \(NCEI\)](#)

Read about the research:

Shiklomanov A., **Dietze, M.C.**, Viskari, T., Townsend, P.A. & Serbin, S.P. (2016). "Quantifying the influences of spectral resolution on uncertainty in leaf trait estimates through a Bayesian approach to RTM inversion." *Remote Sensing of Environment*, 183: 226-238 [doi: [10.1016/j.rse.2016.05.023](https://doi.org/10.1016/j.rse.2016.05.023)].

Viskari, T., Hardiman, B., Desai, A.R. & **Dietze, M.C.** (2015). "Model-data assimilation of multiple phenological observations to constrain and predict leaf area index." *Ecological Applications*, 25(2): 546-558 [doi: [10.1890/14-0497.1](https://doi.org/10.1890/14-0497.1)].

Who Uses Earth Science Data?

Dr. Nancy Glenn, to study dryland ecosystems.



Photo of Dr. Nancy Glenn by Allison Corona, Boise State University.

Dr. Nancy Glenn

Professor,
Department of Geosciences
and Director, Boise Center
Aerospace Laboratory
(BCAL), Boise State
University

Research interests: Using remotely sensed data to analyze and characterize ecosystem responses to human activity with a focus on dryland ecosystems and the response of these areas to disturbance and climate change.

Research highlights: It is easy to overlook waxflower (*Jamesia tetrapetala*). This fragrant flowering shrub clings to alpine and subalpine cliffs and rock slopes at elevations between roughly 2,100 and 3,400 meters (about 6,900 and 11,100 feet) and stands about 3-10 decimeters (about 1-3 feet) tall. But if you happen across this small shrub with the four-petaled white flowers in the wild you know you are in the Great Basin of the United States. Waxflower is one of about six plant species found only in the Great Basin, and nowhere else in the world, according to the U.S. Forest Service. This region, and the plant and animal species within it, is extremely sensitive to the effects of climate change, human development, and excessive water use. Dr. Nancy Glenn conducts research and leads research teams to help quantify the sensitivity of the Great Basin to these effects.

A much more common Great Basin plant species, one that is impossible to overlook, is sagebrush (*Artemisia* sp.), which is the dominant plant across much of the region and helps define the region. With its waxy, hairy silver-gray leaves and deep, broad root system, sagebrush, like waxflower, has adapted to the harsh conditions of this high desert environment, which is characterized by hot, dry summers; cold, snowy winters; and an average of 230-300 millimeters (about 9-12 inches) of precipitation a year.

Precipitation also helps define the Great Basin, since all precipitation that falls in the Great Basin does not naturally flow into an ocean, gulf, or sea. In fact, the Great Basin is the largest area of contiguous contained watersheds in North America.

Collecting data to study the ecology of an area encompassing approximately 541,730 km² (209,162 square miles) across parts of five western states is a job perfectly suited for remote sensing instruments carried aboard satellites and aircraft. As Director of the [Boise Center Aerospace Laboratory \(BCAL\)](#) at Boise State University, Dr. Glenn uses remotely sensed data to conduct and coordinate research across the region in vegetation, soils, and landscape change. While most of the lab's research is conducted in the Great Basin, BCAL projects also include studies in the peatlands of northern Minnesota and in wetland areas along the Lower Colorado River.

Much of the lab's work utilizes [LIDAR](#) and hyperspectral remote sensing with instruments on ground-based, airborne, and satellite platforms. LIDAR, which is an acronym for "light detection and ranging," is a remote sensing technique that uses laser beam pulses to measure the distance of objects from the LIDAR instrument. When paired with a global positioning system (GPS) receiver, LIDAR can be used to create extremely accurate 3-D measurements of Earth. LIDAR is most commonly carried aboard an aircraft to provide measurements over broad areas, and can be used to measure features on land (topography) or under water (bathymetry).

In a recent study, Dr. Glenn and her colleagues used ground-based and airborne LIDAR to calculate aboveground biomass estimates at regional scales for sagebrush in drylands. Biomass measurements provide critical data for ecological modeling. These dryland plant

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communities, however, are often low-lying and sparse, which makes them difficult to measure. Dr. Glenn and her colleagues wanted to see how LIDAR improves both the ease of making these measurements and the accuracy of the resulting biomass estimates.

In a similar study, Dr. Glenn used ground-based LIDAR to estimate sagebrush [leaf area index \(LAI\)](#), which is an important indicator of energy, water, and carbon exchange between vegetation and the atmosphere. LIDAR was used to determine height, canopy cover, and volume for sagebrush in study sites in the Snake River Plain, Idaho. These LIDAR data were then used to estimate LAIs, which were compared with results made using a field method for estimating LAI called point-intercept sampling. Point-intercept sampling is a more time-intensive method that samples plant species variation within a sample plot and quantifies changes in plant species cover, height, and/or ground cover over time.

Along with ground-based and airborne instruments, sensors aboard orbiting satellites also are vital tools for studying ecosystems. In another recent study, Dr. Glenn and her colleagues investigated the use of data from the [Landsat](#) series of satellites to quantify the distribution of above-ground carbon and for long-term, large-area studies to calculate changes in above-ground biomass and vegetation cover, especially in dryland ecosystems. The research team looked specifically at the possibility of coupling these Landsat measurements with similar measurements that will be available from NASA's upcoming [Ice, Cloud, and Land Elevation Satellite-2 \(ICESat-2\)](#), which is tentatively scheduled for launch in 2018.

In their study, Dr. Glenn and her colleagues documented the capabilities of Landsat 8's [Operational Land Imager \(OLI\)](#) instrument to provide better predictions of vegetation characteristics relative to similar data collected by Landsat 5's [Thematic Mapper \(TM\)](#) instrument (the specific data products are noted in the Data Products Used section). The research team also examined how the integration of OLI and LIDAR data could improve estimates of vegetation structure. Finally, Dr. Glenn and her colleagues looked at the potential for using a combination of OLI and ICESat-2 data for vegetation analysis. The ability to couple Landsat and ICESat-2 data will allow researchers to examine many ecological variables, including quantifying fuel loads, investigating habitat quality, estimating biodiversity, measuring carbon cycling, and monitoring desertification. While data from ICESat-2's [Advanced Topographic Laser Altimeter System \(ATLAS\)](#) instrument won't be available until after launch, the research team used simulated ATLAS data from the [Multiple Altimeter Beam Experimental LiDAR \(MABEL\)](#) instrument, which was developed by NASA as a demonstrator instrument for ATLAS.

Along with her personal research, Dr. Glenn oversees and coordinates numerous student-centered BCAL research projects, which give students project-based learning opportunities. Current student projects include research in radiative transfer modeling and full-waveform analysis in order to measure biophysical traits (such as height and biomass) and functional traits (such as nitrogen use). These data help determine the stability of plant communities and enable teams to track how plants respond to environmental changes, including how these changes may allow non-native plant species to invade. Dr. Glenn's students also are participating in the upcoming [NASA SnowEx campaign](#) to quantify how vegetation affects snow distribution and melt. Other BCAL remote sensing projects help land managers with restoration planning, and Dr. Glenn and her students are working with the U.S. Bureau of Land Management, Bureau of Reclamation, and the military to develop multi-year monitoring efforts to prioritize and track these restoration efforts.

(Continued)

Who Uses Earth Science Data?

Data products used:

- Data products from the [Moderate Resolution Imaging Spectroradiometer \(MODIS\)](#) instrument aboard NASA's [Terra](#) and [Aqua](#) Earth observing satellites, available through NASA's [Land Processes Distributed Active Archive Center \(LP DAAC\)](#):
 - Vegetation Indices
 - ◆ Terra products: [MOD13A1](#), [MOD13A2](#), [MOD13A3](#) (MODIS Version 6 DOIs: [10.5067/MODIS/MOD13A1.006](#), [10.5067/MODIS/MOD13A2.006](#), [10.5067/MODIS/MOD13A3.006](#))
 - ◆ Aqua products: [MYD13A1](#), [MYD13A2](#), [MYD13A3](#) (MODIS Version 6 DOIs: [10.5067/MODIS/MYD13A1.006](#), [10.5067/MODIS/MYD13A2.006](#), [10.5067/MODIS/MYD13A3.006](#))
 - Land Surface Reflectance
 - ◆ Terra products: [MOD09A1](#), [MOD09GA](#) (MODIS Version 6 DOIs: [10.5067/MODIS/MOD09A1.006](#), [10.5067/MODIS/MOD09GA.006](#))
 - ◆ Aqua products: [MYD09A1](#), [MYD09GA](#) (MODIS Version 6 DOIs: [10.5067/MODIS/MYD09A1.006](#), [10.5067/MODIS/MYD09GA.006](#))
- Various data products from NASA's [Airborne Visible/Infrared Imaging Spectrometer, Next Generation \(AVIRIS-NG\)](#); available through NASA's [Jet Propulsion Laboratory \(JPL\)](#)
- Data from NASA's [Airborne Snow Observatory \(ASO\)](#); available through JPL
- [MABEL data](#); available through NASA's [ICESat-2 portal](#)
- Landsat OLI and TM data, including Simple Vegetation Index (SVI), Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), Modified Soil Adjusted Vegetation Index (MSAVI2), Moisture Stress Index (MSI), MSI2, Normalized Difference Water Index (NDWI), and NDWI2; available through the U.S. Geological Survey's [EarthExplorer](#) data visualization and download interface, which is accessible through LP DAAC

Research findings: In her sagebrush biomass study, Dr. Glenn and her colleagues found that the integration of ground-based and airborne LIDAR measurements enhance estimates of aboveground biomass. The research team notes that while the model developed in this study is optimized for sagebrush-steppe environments, it may be readily applied to other shrub-dominated drylands in the Great Basin and similar shrub-dominated ecosystems globally.

Ground-based LIDAR also was found to be a promising tool for estimating shrub LAI. Dr. Glenn and her colleagues note the relative ease of use of this technique for measuring LAI at the shrub-level. Based on this initial research, the team recommends further work expanding these measurements to larger scale study plots using airborne lasers or regional-level studies using satellite-borne sensors.

In her comparison of Landsat sensor data with the potential for coupling these data with measurements from the upcoming ICESat-2 mission, Dr. Glenn and her colleagues found that data from Landsat's OLI and TM sensors may be used together for long-term time-series analysis. The team notes that OLI does a good job predicting shrub and herbaceous cover and that a combination of OLI with LIDAR improves these estimates and reduces their uncertainty. To evaluate the potential use of OLI and ICESat-2 data, the team

(Continued)

Who Uses Earth Science Data?

used simulated ICESat-2 data from MABEL to predict vegetation structure. While the team note that the low stature and sparse cover of dryland ecosystems present a challenge for utilizing ICESat-2 data, the team found that, overall, a combination of Landsat 8 and ICESat-2 data may improve estimates of above-ground biomass and carbon storage in drylands meeting certain minimum thresholds, which the team concludes is at minimum 30% vegetation cover at 1 meter vegetation height. One of Dr. Glenn's graduate students is investigating similar relationships through a NASA fellowship at NASA's [Goddard Space Flight Center](#) in Greenbelt, MD, in support of the upcoming [Global Ecosystem Dynamics Investigation LIDAR \(GEDI\)](#) mission.

Research findings in some of the general BCAL projects include better documentation in changes from native to non-native vegetation in the Great Basin and the causal relationships of fire and disturbance to these changes. In addition, BCAL teams identified priority areas for restoration planning based on a multi-temporal remote sensing-based map of native and non-native species that they compiled. Finally, BCAL teams recently completed work identifying the vegetation structure necessary for restoration on the Lower Colorado River for several key bird species. The students are now working with partners to apply these methods to other areas along the Lower Colorado River.

Read about the research:

Glenn, N.F., Neuenschwander, A., Vierling, A.A., Spaete, L.P., Li, A., Shinneman, D., Pilliod, D.S., Arkle, R. & McIlroy, S. (2016). "Landsat 8 and ICESat-2: Performance and potential synergies for quantifying dryland ecosystem vegetation cover and biomass." *Remote Sensing of Environment*, 185: 233-242 [doi: [10.1016/j.rse.2016.02.039](#)].

Olsoy, P.J., Mitchell, J.J., Levia, D.F., Clark, P.E. & **Glenn, N.F.** (2016) "Estimation of big sagebrush leaf area index with terrestrial laser scanning." *Ecological Indicators*, 61(2): 815-821 [doi: [10.1016/j.ecolind.2015.10.034](#)].

Li, A., **Glenn, N.F.**, Olsoy, P.J., Mitchell, J.J. & Shrestha, R. (2015). "Aboveground biomass estimates of sagebrush using terrestrial and airborne LIDAR data in a dryland ecosystem." *Agricultural & Forest Meteorology*, 213: 138-147 [doi: [10.1016/j.agrformet.2015.06.005](#)].

Who Uses Earth Science Data?

Dave Johnson, to estimate U.S. crop production.



Dave Johnson standing in a freshly planted cornfield in Iowa. Iowa and Illinois, the top corn-producing states, typically account for about one-third of U.S. corn production, according to the USDA. Image courtesy of Dave Johnson.

Dave Johnson

Senior Geographer,
United States Department of
Agriculture (USDA)/National
Agricultural Statistics Service
(NASS)

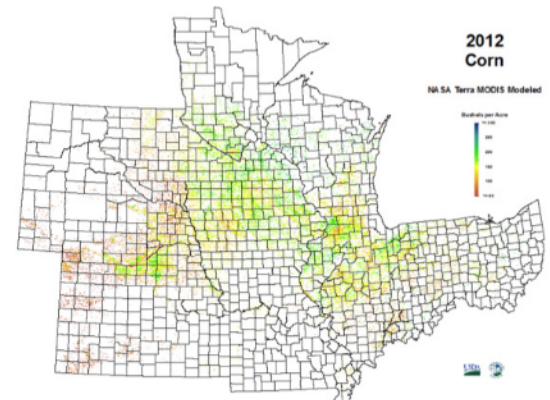
Research interests: Using remotely-sensed data to provide quantitative estimates of crop production for major U.S. commodities, such as corn, soybeans, cotton, wheat, and rice.

Research highlights: When America's amber waves of grain need to be quantified, this job falls to the [National Agricultural Statistics Service \(NASS\)](#). NASS continually collects and maintains detailed national, state, and county-level statistics of commodities being grown across the country, and disseminates these data through numerous reports. These statistical summaries can significantly affect commodities markets, so their timeliness and accuracy are critical. [According to the USDA](#), the total value of livestock and crops produced in the U.S. in 2015 was almost \$400 billion, with crops accounting for the largest share of the value of U.S. agricultural production.

Until the advent of Earth observing satellites, agricultural statistics were collected primarily through personal interviews with farmers and growers along with telephone and mail surveys. These methods are still employed, however they are now augmented and cross-checked with data collected by satellite-borne instruments, especially for calculating crop production. Sensors aboard satellites can survey huge swaths of land during a single overpass and provide information that helps NASS statisticians distinguish what crops are being grown, determine where they are being grown, assess their level of maturity, and calculate overall productivity. As NASS Senior Geographer Dave Johnson notes, using remotely-sensed agricultural data not only improves the robustness of NASS statistics, but also places less burden on farmers being asked to respond to ongoing surveys.

Much of Johnson's research concentrates on quantifying crops in the Corn Belt region, or as he describes it, the "I" states—Illinois, Indiana, and Iowa (along with surrounding states). The primary crops in this region, by far, are corn (maize) and soybeans, two crops that represent the flagship agricultural products traded on U.S. commodity markets. Along with corn and soybeans, Johnson and his colleagues also apply their research to quantifying wheat (grown throughout the U.S., but most common in the Great Plains region from Texas north through the Dakotas), cotton (primarily found throughout the Southern and Southeastern states), and rice (dominant along the Mississippi River Alluvial Plain, which stretches from southern Louisiana to southern Illinois).

NASS crop production statistics are commonly broken into two components: area and yield. Area is the amount of land used for planting and harvesting; yield is the weight of the crop produced per unit area. Both of these variables fluctuate year-to-year based on controlled



2012 corn yield across the U.S. Corn Belt based on MODIS/Terra data. Green/blue pixels = areas of greater corn yield (200 or more bushels/acre); yellow/orange/red pixels = areas of lesser corn yield (150 or less bushels/acre). 2012 was a significant drought year, with corn production down about 15%. USDA/NASS graphic derived from NASA MODIS data.

(Continued)

Who Uses Earth Science Data?

factors (such as planting and management decisions) and uncontrolled factors (such as climate and weather). While Johnson's work and research concentrates on both area and yield, he spends much of his time on the yield side of the equation.

For yield monitoring, Johnson notes that it is best to track crop progress at the county, state, or national level throughout the entire growing season. His sensor of choice for acquiring these data is the [Moderate Resolution Imaging Spectroradiometer \(MODIS\)](#) aboard NASA's [Terra](#) and [Aqua](#) satellites. For Johnson, MODIS benefits include its near daily revisit rate, adequate spatial resolution of 250m, 15-plus years of well-calibrated and consistent data, and the large amount of research that has been done with the sensor. Johnson also cites the low latency of MODIS products along with straightforward data handling as additional benefits.

One unique aspect of NASS work pointed out by Johnson is that unlike work done in a pure research setting, involving lengthy peer reviews and replications of experiments, NASS works with tight, government-mandated deadlines for reporting crop statistics. Remotely-sensed information used by Johnson and his colleagues needs to be timely and produced with as little delay as possible between the sensor collection of raw data and data product availability. MODIS, even though designed as a research platform, provides [near real-time products](#) meeting both of these critical criteria.

The MODIS data of most interest to Johnson and his colleagues are surface reflectance and temperature products that have been "composited" over 8 or 16 days to remove cloud and noise effects. In research conducted comparing multiple MODIS data products, Johnson found that certain products are more beneficial for his work on crop estimates. He points in particular to the MODIS [Normalized Difference Vegetation Index \(NDVI\)](#) product, which is positively correlated with crop yields during the peak of the growing season (that is, higher chlorophyll concentrations in healthy vegetation are sensed at the peak of growing season). Land surface temperature, in contrast, is inversely correlated with crop yields during peak growing season (that is, higher land surface temperature readings generally indicate less vegetation cover). The integration of these metrics over the growing season, and the historical performance of these metrics when compared with historical yield information, forms the foundation of NASS crop yield models.

In his research comparing NDVI across a wide range of crops, Johnson finds that the positive correlation between NDVI and yield holds up. The one exception he has found is for rice, which does not appear to have a positive correlation between high NDVI and high yields. Johnson also has looked at relationships between land surface temperature and crop yields, but finds that the results for a range of crops are more mixed and muted when compared with NDVI.

While the overall goal of crop production has not changed in terms of maximizing yield for a given planted area, the use of remotely-sensed data adds greater precision for quantifying the harvest and ultimately improving the NASS mission of providing timely, accurate, and useful statistics in service to U.S. agriculture. The end result is not only better data about crop production, but better economics for both producers and consumers.

Representative data products used:

■ Primary products:

- MODIS/Terra 250m, 8-day surface reflectance (MOD09Q1, DOI: [10.5067/MODIS/MOD09Q1.006](https://doi.org/10.5067/MODIS/MOD09Q1.006)) and MODIS/Aqua 1km, 8-day surface temperature (MYD11A2, DOI: [10.5067/MODIS/MYD11A2.006](https://doi.org/10.5067/MODIS/MYD11A2.006)); both products available through NASA's [Land Processes Distributed Active Archive Center \(LP DAAC\)](#)

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Who Uses Earth Science Data?

- Land cover masks from the NASS [CropScape-Cropland Data Layer](#) to help relate MODIS pixels to specific crops
- Additional MODIS products (all available through LP DAAC):
 - MODIS/Terra Land Surface Temperature and Emissivity 8-Day (MOD11A2, DOI: [10.5067/MODIS/MOD11A2.006](#))
 - MODIS/Terra Vegetation Indices 16-Day L3 Global 250 m (MOD13Q1, DOI: [10.5067/MODIS/MOD13Q1.006](#))
 - Leaf Area Index - Fraction of Photosynthetically Active Radiation 8-Day L4 Global 1km ([MOD15A2](#)); MODIS Version 6: MYD15A2H, DOI: [10.5067/MODIS/MYD15A2H.006](#)
 - Gross Primary Productivity 8-Day L4 Global 1km ([MOD17A2](#)); MODIS Version 6: MOD17A2H, DOI: [10.5067/MODIS/MOD17A2H.006](#)
 - MODIS/Aqua Surface Reflectance 8-Day L3 Global 250m (MYD09Q1, DOI: [10.5067/MODIS/MYD09Q1.006](#))
 - Leaf Area Index - Fraction of Photosynthetically Active Radiation 8-Day L4 Global 1km ([MYD15A2](#)); MODIS Version 6: MOD15A2H, DOI: [10.5067/MODIS/MOD15A2H.006](#)
 - Gross Primary Productivity 8-Day L4 Global 1km ([MYD17A2](#)); MODIS Version 6: MYD17A2H, DOI: [10.5067/MODIS/MYD17A2H.006](#)

Read about the research:

Johnson, D.M. (2016). "A comprehensive assessment of the correlations between field crop yields and commonly used MODIS products." *International Journal of Applied Earth Information and Geoinformation*, 52: 65-81 [doi: [10.1016/j.jag.2016.05.010](#)].

Johnson, D.M. (2014). "An assessment of pre- and within-season remotely sensed variables for forecasting corn and soybean yields in the United States." *Remote Sensing of Environment*, 141: 116-128 [doi: [10.1016/j.rse.2013.10.027](#)].

Who Uses Earth Science Data?

Brian Knosp, to improve Earth observing data products and systems.



Brian Knosp in his NASA Jet Propulsion Laboratory (JPL) office. On the screen is the JPL Microwave Limb Sounder (MLS) page for NASA's Aura mission. Image courtesy of Brian Knosp.

Brian Knosp

Scientific Applications Software Engineer,

NASA's Jet Propulsion Laboratory
(JPL) at the California Institute
of Technology

Research interests: Database development and software engineering, with the goal of finding better ways to make Earth observing data available to science teams.

Research highlights: When a sensor aboard an Earth observing satellite collects data, these data are strings of numbers representing physical properties of the area being sampled. In their raw state, these data are difficult if not impossible to use until they are processed into individual data product files. Processing Earth observing data into thousands of useful data products and getting these products to the appropriate discipline-specific [Distributed Active Archive Center \(DAAC\)](#) is a principal task of NASA's [Earth Observing System Data and Information System \(EOSDIS\)](#). This work relies not only on powerful computers, but also on skilled software and systems engineers who continuously adjust and improve systems and products to ensure that NASA Earth observing data accurately and precisely represent physical processes, meet the needs of science teams, and are delivered as rapidly as possible to data users.

Brian Knosp's work at JPL deals with managing large Earth science data sets and making them accessible to various science teams, both at NASA and at numerous other organizations using these data. As Knosp points out, there are many ways to make data "accessible." Accessible can simply mean making the data available on a local filesystem or ingesting data into a database where science analysis tools can be used to intelligently search for the data. Still another way data can be made accessible is by plotting data on maps and statistical graphs that can be used by science teams and even the general public.

Many of the data sets Knosp works with are [standard data products](#) that have the extensive processing, quality assurance (QA) reviews, and validation necessary for use in scientific research. He also works with near real-time (NRT) data, which do not have the extensive processing and validation required for use in scientific research, but are available generally within hours of a sensor overpass and are a valuable resource for managing on-going events.

While Knosp works with data from numerous individual instruments aboard NASA Earth observing satellites as well as with model data, his primary work is as the Data Operations Manager for the [Microwave Limb Sounder \(MLS\)](#) Project, which is part of NASA's [Aura](#) mission. The Aura satellite was launched in 2004 to collect data about ozone, aerosols, and atmospheric gases. MLS is one of Aura's four instruments, and measures atmospheric gases, temperature, pressure, and cloud ice. Knosp is responsible for cataloging mission data at the MLS [Science Computing Facility \(SCF\)](#) at JPL, which receives standard MLS data products from the [MLS Science Investigator-led Processing System \(SIPS\)](#), which also is located at JPL. Once these processed data arrive, Knosp and his colleagues sort them, ingest them into a database, incorporate them onto standard plots, and send them to external sources such as the EOSDIS [Worldview](#) system or NASA's [Eyes on the Earth](#) application.

Knosp also works on NASA's [Orbiting Carbon Observatory-2 \(OCO-2\)](#) mission. OCO-2 launched in July 2014 to collect global measurements of atmospheric carbon

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Who Uses Earth Science Data?

dioxide (CO₂). OCO-2 data help characterize regional CO₂ sources and sinks, and provide precise measurements of CO₂ variability over yearly seasonal cycles. Knosp specifically works with the [CO₂ Virtual Science Data Environment](#), which brings together different CO₂ data sets and allows users to customize CO₂ data products.

Another major project on which Knosp works is the JPL [Tropical Cyclone Information System \(TCIS\)](#). The TCIS was originally a development project that started out of a need to collect hurricane data in one central location. Today, the TCIS system is used in multiple NASA airborne campaigns to provide NRT large-scale environmental information and as a research tool for information about past storms. The TCIS provides data and visualizations for studying hurricane processes, validating and improving models, and developing new algorithms and data assimilation techniques.

As the TCIS database lead, Knosp is in charge of developing the TCIS database architecture used to store different types of satellite, model, and aircraft data sets. He notes that these data sets need to be quickly searched so that plots can be presented to users on a virtual globe in a web browser. An integral part of his work entails making sure the TCIS databases are finely tuned so that database queries run quickly and users do not wait long to access data.

Knosp recently has been working to set up a filesystem that can be mounted to multiple science computing centers at JPL so that research teams can share large data sets like NASA's [Modern-Era Retrospective analysis for Research and Applications, Version 2 \(MERRA-2\)](#) and the [European Centre for Medium-Range Weather Forecasts' \(ECMWF\) ERA-5](#). This requires setting up a system of software to routinely download, compress, and catalog data, which enables science teams to access data in a central, local location that could, in the future, be moved to a computing cloud-based solution.

Knosp points out that while he does not personally conduct scientific research using Earth science data, his work makes these data available rapidly and in the wide range of formats needed by those who do. The behind-the-scenes work of engineers like Brian Knosp is vital to fulfilling the EOSDIS mission of ensuring that NASA Earth observing data are [fully and openly available to data users around the world](#).

Representative data products used most often:

- Available through NASA's [Goddard Earth Sciences Data and Information Services Center \(GES DISC\)](#)
 - [Microwave Limb Sounder \(MLS\)](#)
 - ◆ [MLS Level 2 standard products](#)
 - ◆ [MLS Level 2 near real-time \(NRT\) data](#)
 - [Orbiting Carbon Observatory-2 \(OCO-2\)](#)
 - ◆ [OCO2 L2 Standard](#)
 - ◆ [OCO2 L2 Lite FP](#)
 - [Modern-Era Retrospective analysis for Research and Applications, Version 2 \(MERRA-2\) 3d,3-Hourly,Instantaneous,Model-Level,Assimilation,Assimilated Meteorological Fields V5.12.4 \(M2I3NVASM, DOI: \[10.5067/WWQSQ8IVFW8\]\(#\)\)](#)

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Who Uses Earth Science Data?

- [Ozone Monitoring Instrument \(OMI\)/Aura Ozone \(O3\) Total Column 1-Orbit L2 Swath 13x24 km V003 \(OMTO3, DOI: \[10.5067/Aura/OMI/DATA2024\]\(#\)\)](#)
 - [Atmospheric Infrared Sounder \(AIRS\)](#)
 - ◆ [AIRS/Aqua L2 Standard Physical Retrieval V006 \(AIRX2RET, DOI: \[10.5067/AQUA/AIRS/DATA201\]\(#\)\)](#)
 - ◆ [AIRS/Aqua L2 CO2 in the free troposphere V005 \(AIRX2STC, DOI: \[10.5067/AQUA/AIRS/DATA218\]\(#\)\)](#)
 - ◆ [AIRS NRT data](#)
- Available through NASA's [Atmospheric Science Data Center \(ASDC\)](#) in Hampton, VA.
- [Tropospheric Emission Spectrometer \(TES\)/Aura L2 Carbon Monoxide \(CO\) Nadir \(TL2CON, DOI: \[10.5067/AURA/TES/TL2CON_L2.007\]\(#\)\)](#)
 - [Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations \(CALIPSO\)](#)
 - ◆ [CAL_LID_L2_05kmAPro-Standard-V4-10 \(DOI: \[10.5067/CALIOP/CALIPSO/LID_L2_05kmAPro-Standard-V4-10\]\(#\)\)](#)
 - ◆ [CAL_LID_L2_05kmCPro-Standard-V4-10 \(DOI: \[10.5067/CALIOP/CALIPSO/LID_L2_05kmCPro-Standard-V4-10\]\(#\)\)](#)
- Available through the [National Center for Atmospheric Research \(NCAR\) Research Data Archive](#)
- [Climate Forecast System Reanalysis-Version 1 \(CFSR v1\), DOI: \[10.5065/D69K487J\]\(#\)\)](#)
 - [Japan Meteorological Agency \(JMA\) 55-year Reanalysis, Daily 3-Hourly and 6-Hourly Data \(JRA-55, DOI: \[10.5065/D6HH6H41\]\(#\)\)](#)
- Available through the [European Centre for Medium-range Weather Forecasts \(ECMWF\)](#)
- [ERA-5 global climate reanalysis](#)

Read about the work:

Manney, G.L., Hegglin, M.I., Lawrence, Z.D., Wargan, K., Millán, L.F., Schwartz, M.J., Santee, M.L., Lambert, A., Pawson, S., **Knosp, B.W.**, Fuller, R.A. & Daffer, W.H. (2017) "Reanalysis comparisons of upper tropospheric/lower stratospheric jets and multiple tropopauses." *Atmospheric Chemistry and Physics Discussions*, 17(18): 1-39 [doi: [10.5194/acp-2017-400](#)].

Knosp, B., Gangl, M., Hristova-Veleva, S., Kim, R., Li, P., Turk, J. & Vu, Q. (2015) "A Look Under the Hood: How the JPL Tropical Cyclone Information System Uses Database Technologies to Present Big Data to Users." Invited Presentation at the 2015 American Geophysical Union Fall Meeting, San Francisco, CA. 18 December 2015. [Presentation file](#).

Who Uses Earth Science Data?

Dr. Brian Mapes, to study large-scale weather and climate processes.



Dr. Brian Mapes at the Ellora Caves in Maharashtra, India, which is about 300 km (190 miles) east-northeast of Mumbai in western India. The Asian Monsoon plays a key role in the economy and livelihood of India and is one of the atmospheric processes studied by Dr. Mapes. Image courtesy of Dr. Mapes.

Dr. Brian Mapes

Professor,
Rosenstiel School of Marine
and Atmospheric Science,
University of Miami

Research interests: Role of vertical convection in the form of cumulus clouds and storms in large-scale (regional and global) weather and climate.

Research highlights: To Dr. Brian Mapes, the study of water vapor is more interesting than many people appreciate. In fact, water vapor is one of the most important determinants of Earth's weather and climate. Along with transporting tremendous amounts of water around the globe, water vapor's ability to store, release, and redistribute heat helps keep Earth habitable. As water vapor rises, cools, and condenses, the result can be convective storms. The role of atmospheric convection and the impact of these convective storms on weather and climate across large regions (such as India and the subtropics) are a focus of Dr. Mapes' research.

But not all large-scale convective systems are equal. As Dr. Mapes notes, the "big gorilla" is the Asian Monsoon.

If you look at the plots of [Global Monthly Rainfall Averages from 1998 to 2010](#) created from data collected by the joint NASA/[Japan Aerospace Exploration Agency \(JAXA\) Tropical Rainfall Measuring Mission \(TRMM\)](#) (operational from 1997 to 2015), it's hard to miss the band of higher than average rainfall stretching roughly across the equator. This belt of precipitation is the [intertropical convergence zone \(ITCZ\)](#), and is an area where Northern and Southern Hemisphere air masses converge and are forced to rise, resulting in higher than average precipitation. During the Northern Hemisphere summer, warmer temperatures and the resulting uneven heating of land and water force the ITCZ to move from the equator to stretch across Asia; during the Northern Hemisphere winter, the ITCZ is depressed back across the equator as cold, dense air settles into central Russia and creates an immense area of high pressure called the Siberian High.

This seasonal, predictable change in subtropical wind direction—from cool, dry air from middle latitudes in winter to warm, moist air from tropical latitudes in summer—defines the word *monsoon*. As warm, moisture-laden tropical air masses rise in the subtropics during summer, the result is convective storms capable of producing significant amounts of precipitation. The Asian Monsoon affects the lives of roughly a third of the world's population, and is one of the planet's most significant large-scale convective systems. The Asian Monsoon sometimes is also referred to as the Asian-Australian Monsoon system, since the January rains of the [Australian Monsoon](#) are a similar counterpart to the July rains over Asia.

In a recent study, Dr. Mapes looked at how a regional monsoon can have a global impact. Dr. Mapes and his co-researcher, Dr. Patrick Kelly, examined the relationship between dry conditions in southeastern Brazil and the Australian Monsoon. Specifically, they looked at the role of atmospheric heating associated with rainfall during the Australian Monsoon (which brings heavy precipitation to Northern Australia from December to March) to reduced rainfall in southeastern Brazil during the month of February. This study is similar to their 2013 work linking Asian Monsoon wet years to reductions in rainfall in the Caribbean, and both studies used the [Community Atmosphere Model \(CAM\)](#) developed at the U.S. [National Center for Atmospheric Research \(NCAR\)](#).

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Who Uses Earth Science Data?

Dr. Mapes and Dr. Kelly used the CAM to run experimental global climate simulations with enhanced Asian-Australian monsoons. Enhancements to these climate simulations were created by artificially darkening the soil cover over India to absorb more sunlight (which adds heat) and by adding heat in the troposphere (the lowest level of Earth's atmosphere) near Australia to the CAM temperature equation. In both studies, this artificially enhanced monsoon heating in the Eastern Hemisphere contributed to a westward displacement of the overall weather pattern in the western Atlantic in the resulting model output. CAM data indicate that this, in turn, led to reduced rainfall in the Caribbean (in July) or southeastern Brazil (in February). This research shows that while convective clouds are local, their large-scale envelope (the monsoon) can affect regional rainfall on the other side of the globe.

Dr. Mapes also recently completed a near-global survey of heavy precipitation events. Using the TRMM 3B42 precipitation product, he assembled data for the greatest 1- and 3-day precipitation accumulations from 1998 and 2007 occurring between 50° north and south latitude. As Dr. Mapes observes, this study highlights the importance of convective and mesoscale processes in extreme precipitation events on these short time scales. In meteorology, a mesoscale process is one that takes place at a scale larger than a storm-scale cumulus convective event, like an isolated storm, and can range in horizontal extent from roughly 5 km to several hundred km. Mesoscale events include thunderstorm complexes, sea breezes, lake effect snow, fronts, and squall lines.

Dr. Mapes created an [interactive web atlas](#) where users can examine an archive of record precipitation events, including links to satellite imagery and event case studies. Examination of some cases reveals that while tropical cyclones (such as hurricanes) are responsible for record precipitation in many of the locations studied, the drawing out of tropical water vapor by systems just outside the tropics (called *extratropical*) can also lead to heavy precipitation events, for instance in the Caribbean in late spring. Sometimes these water vapor filaments can be very long, and are called *atmospheric rivers*. Atmospheric rivers transport tremendous amounts of water vapor and are capable of producing intense precipitation.

Along with TRMM data, Dr. Mapes also relies on global climate reanalysis data created by NASA's [Goddard Earth Observing System Model, Version 5 \(GEOS-5\)](#) team. GEOS-5 is a system of integrated models combining several data sources into a single best estimate (or reanalysis) of the state of the atmosphere. Specific data used by Dr. Mapes from this reanalysis are the Modern-Era Retrospective analysis for Research and Applications and [Modern-Era Retrospective analysis for Research and Applications, Version 2 \(MERRA/MERRA-2\)](#) products, which are historical climate analyses dating back to 1979 for a broad range of weather and climate time scales.

The GEOS-5 model also can be configured to run freely without specific observation data. This creates detailed, self-consistent simulations of credible weather that never actually occurred, such as the high-resolution [GEOS-5 Nature Run \(G5NR\)](#). Dr. Mapes explores these data simulations to see how atmospheric processes fit together in rare events that have not been observed, but obey the laws of physics encoded in the model.

Representative data products used:

- MERRA/MERRA-2 reanalysis including hourly data (M2T1NXSLV, DOI: [10.5067/VJAFPLI1CSIV](#)); available through NASA's [Goddard Earth Sciences Data and Information Services Center \(GES DISC\)](#)

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Who Uses Earth Science Data?

- [TRMM 3B42 rainfall product](#); available through the [NASA Goddard Earth Sciences Data and Information Services Center \(GES DISC\)](#) and the [Precipitation Measurement Missions \(PMM\)](#) website.
- [GEOS-5 Nature Run \(G5NR\)](#) data; available through NASA's [Global Modeling and Assimilation Office \(GMAO\)](#)
- [Community Atmosphere Model \(CAM\)](#); available through the [University Corporation for Atmospheric Research \(UCAR\)](#)

Read about the research:

Allen, T.L. & **Mapes, B.E.** (2017). "The late spring Caribbean rain-belt: climatology and dynamics." *International Journal of Climatology*, 37(8) [doi: [10.1002/joc.5136](#)]. An animation of this research is available at [youtube.com/watch?v=VTcLXfaYeGY](#).

Kelly, P. & **Mapes, B.E.** (2016). "February drying in southeast Brazil and the Australian monsoon: Global mechanism for a regional rainfall feature." *Journal of Climate*, 29(20): 7529–7546 [doi: [10.1175/JCLI-D-15-0838.1](#)].

Kelly, P. & **Mapes, B.E.** (2013). "Asian monsoon forcing of subtropical easterlies in the Community Atmosphere Model: Summer climate implications for the Western Atlantic." *Journal of Climate*, 26(9): 2741–2755 [doi: [10.1175/JCLI-D-12-00339.1](#)].

Mapes, B.E. (2011). "Heaviest precipitation events, 1998–2007: A near-global survey." Chapter 2 in *World Scientific Series on Asia-Pacific Weather and Climate, Vol. 5: The Global Monsoon System: Research and Forecast, 2nd Edition*, pp. 15–22 [doi: [10.1142/9789814343411_0002](#)].

Who Uses Earth Science Data?

Katherine Pitts, to study the impacts of climate change and analyze remotely-sensed geophysical data.



Katherine Pitts recording data from a water meter at NASA's Ames Research Center in 2011 as part of a NASA DEVELOP study to determine the amount of water the center uses for irrigation. Image courtesy of Katherine Pitts.

Katherine Pitts

Engineering Scientist Associate,
Applied Research Laboratories, University of Texas at Austin

Research interests: Comparisons of global climate models to observation-based data; analyzing, developing, and testing algorithms for processing geophysical satellite data.

Research highlights: NASA's [DEVELOP](#) program provides opportunities for early-career scientists to use Earth observations to conduct research related to a wide range of global environmental issues. Started in 1999, DEVELOP is part of NASA's [Applied Sciences Program](#), and addresses environmental and policy concerns through the practical application of NASA Earth observations to the areas of agriculture, climate, disasters, ecological forecasting, energy, health and air quality, oceans, water resources, and weather. More than 350 DEVELOP participants each year conduct research at NASA centers and regional locations across the country.

Katherine Pitts participated in the DEVELOP program in 2010 and 2011 while earning her master's degree in meteorology at San Jose State University. Her research during two, 10-week DEVELOP program sessions at NASA's [Ames Research Center](#) at Moffett Field, CA, (about 40 miles south of San Francisco) is a good example of how early-career scientists in the program use Earth observation data to foster research designed to "bridge the gap between NASA Earth science and society" to address community concerns.

During her first summer in the DEVELOP program, Pitts and her research team used the Environmental Protection Agency's (EPA) [Better Assessment Science Integrating point & Nonpoint Sources \(BASINS\)](#) model to evaluate flood risk at Ames under future climate scenarios. Because Ames is located at the southern end of San Francisco Bay, evaluations must consider not only rainfall, but also the risk of damage from erosion and flooding from tidal actions and storm surges, especially when combined with the effects of El Niño. A warming climate is expected to produce more frequent and intense rain events in this location. Flood risk at Ames also is expected to rise with a projected increase in impervious surfaces (such as roads) as the area grows in population.

To study past flooding events, the team collected measurements from the Moffett Field meteorological station, the National Centers for Environmental Information (formerly the National Climatic Data Center), the California Irrigation Management Information System, and the National Solar Radiation Database. They also collected digital elevation models from the United States Geological Survey (USGS). These data were used to run the BASINS model to simulate the mean daily streamflow across Ames when rain events similar to those that occurred during the strong 1997/1998 El Niño happen in a projected warmer climate.

During her second summer in the DEVELOP program at Ames, Pitts and her colleagues used the Ames [Terrestrial Observation and Prediction System \(TOPS\)](#) to analyze the impacts of projected climate change on different California ecosystems for the period 1950-2099 based on climate data from the National Oceanic and Atmospheric Administration's (NOAA's) [Geophysical Fluid Dynamics Laboratory \(GFDL\)](#) models. TOPS uses input from satellite, aircraft, and ground sensors as well as output from weather, climate, and application models to make forecasts of ecosystem conditions. The California state data were separated into regions of similar climate and watersheds of interest. The team conducted a statistical analysis of the TOPS output of monthly temperature, precipitation, gross primary productivity, evapotranspiration, soil runoff, and vapor pressure deficit.

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Who Uses Earth Science Data?

After completing her DEVELOP work and earning a second master's degree in atmospheric sciences, Pitts began her full-time science career as part of the Geospatial Laser Applications and Measurements group at the [Applied Research Laboratories at the University of Texas at Austin](#). Pitts' work includes analyzing 3-D point cloud data that are produced from [LIDAR](#) measurements and developing algorithms to identify and label the data points as various natural or manmade features, such as trees, buildings, and roads. One of her current projects focuses on developing algorithms for geophysical data products over land for NASA's upcoming [Ice, Cloud, and Land Elevation Satellite-2 \(ICESat-2\)](#), which is scheduled for launch in 2018. The specific data product on which Pitts is working is called ATL08, and will provide along-track terrain and canopy heights derived from laser altimetry measurements that will aid in applications such as mapping forest structures, estimating biomass, and improving digital terrain models.

The [Advanced Topographic Laser Altimeter System \(ATLAS\)](#), a photon counting LIDAR, is the sole instrument aboard ICESat-2. ATLAS data will be used primarily to produce extremely accurate measurements of polar ice sheet thickness and topography as well as height differences between the polar oceans and sea ice. ATLAS also will be used to produce highly accurate measurements of land topography and to characterize vegetation.

Since ATLAS data won't be available until after ICESat-2 is in orbit, algorithm testing is being conducted using an instrument called MABEL. MABEL, the [Multiple Altimeter Beam Experimental LIDAR](#), was developed by NASA to serve as a testbed for ATLAS. Pitts utilizes MABEL data to analyze, test, and develop her geophysical algorithm. In addition to MABEL data, the algorithm on which Pitts is working also incorporates data from the Landsat Tree Cover dataset to set a flag indicating whether vegetation is expected in the location being processed. Additional algorithm testing is being conducted utilizing data derived from sampling [Goddard LIDAR, Hyperspectral and Thermal Imager \(G-LiHT\)](#) airborne LIDAR measurements and adding noise at rates that are expected when ATLAS is in orbit.

Representative data products used:

- [Moderate Resolution Imaging Spectroradiometer \(MODIS\)](#) data products, available through NASA's [Land Processes Distributed Active Archive Center \(LP DAAC\)](#):
 - Leaf Area Index, 8-Day, Global ([Terra](#) satellite, [MOD15A2](#) [MODIS Version 6 DOI: [10.5067/MODIS/MOD15A2H.006](#)])
 - Global Land Cover Type, Yearly, Global (Combined [Aqua](#) and Terra satellite MODIS data, [MCD12Q1](#))
- [MABEL](#) data; available through NASA's [ICESat-2](#) website
- [G-LiHT](#) data; available through the [G-LiHT Data Center](#) at NASA's [Goddard Space Flight Center](#)
- [Landsat Tree Cover](#) continuous fields; available through the University of Maryland's [Global Land Cover Facility](#)
- Ecosystem model data from the BIOME-BGC model [DOI: [10.3334/ORNLDAAAC/805](#)]; available through NASA's [Oak Ridge National Laboratory \(ORNL\) DAAC](#)
- [National Centers for Environmental Information \(NCEI\)](#) Daily Summaries; available through the NCEI [Climate Data Online Search](#)
- [California Irrigation Management Information System \(CIMIS\)](#), evapotranspiration point data for San Jose, CA (CIMIS Station #69)

(Continued)

Who Uses Earth Science Data?

■ [National Solar Radiation Database](#), solar radiation point data for Mountain View Moffett Field, CA

Research findings: During her first summer of DEVELOP research, Pitts and her team used the BASINS model to evaluate various scenarios to determine which environmental and human changes might have the greatest effect on flooding at Ames. Changes in the models that decreased flooding potential were an increase in temperature and the conversion of urban lands to wetlands, which help retain water and slow the movement of water; changes in the models that led to an increased risk of flooding were increases in frequency and intensity of precipitation as well as increases in urban land surfaces (such as roads), which tend to allow water to flow more quickly. While the increase in precipitation frequency simulated the highest potential for flooding in the models, an increase in storm intensity also can produce a high risk of flooding if pumps at Ames cannot expel water faster than water enters retention ponds, as was experienced during the 1997/1998 El Niño season. The team notes that these results will assist master planners in developing new procedures for future Ames development with a better awareness of anticipated climate change effects.

In her work looking at the projected impacts of climate change on California ecosystems during her second DEVELOP summer, Pitts and her colleagues found that increases in maximum and minimum temperatures led to declines in peak gross primary productivity, length of growing seasons, and overall declines in runoff in the ecosystems they studied. However, changes in climate coupled with increases in impervious area due to intense urbanization are associated with an increase in winter runoff.

Ames is located within the Coyote Watershed of California. Projections of increased temperatures and increased urbanization in this watershed show the potential for an extended dry summer season, which could threaten water availability. To counter this risk at Ames, Pitts was part of a team that conducted a study of the irrigation system to evaluate the amount of total fresh water used for irrigation alone. This study found that 41% of total water used at Ames went to irrigation. To address these issues, Ames plans to use reclaimed water for irrigation and expand the use of native landscaping. Along with these efforts, the research team recommended that Ames can further conserve water by implementing additional sustainability measures, such as increasing the number of timers and meters used in irrigated areas.

Finally, in her current work developing the ATL08 algorithm for processing ICESat-2 ATLAS instrument data, Pitts verified that the algorithm is returning expected results. Soon, Pitts will begin work developing an algorithm for a related ATLAS data product called ATL18 that will provide gridded ground surface height, canopy height, and canopy cover estimates. Due to larger than desired orbital spacing in lower latitudes, ATL08 data may be combined with data from the [Global Ecosystem Dynamics Investigation LIDAR \(GEDI\)](#) mission to create a combined ATL18-GEDI product. GEDI, which is scheduled for launch in 2019, is a LIDAR that will be attached to the International Space Station (ISS) and used to measure ecosystem structure.

Read about the research:

Pitts, K., Little, M., Lowenstein, M., Iraci, L., Milesi, C., Schmidt, C. & Skiles, J.W. (2012). "Climate Adaptation Science Investigation (CASI) at NASA Ames Research Center: Using the Terrestrial Observation and Prediction System (TOPS) to analyze impacts of climate change on California ecosystems." Proceedings paper, ASPRS Annual Conference, Sacramento, CA, 19-23 March 2012 [<https://www.asprs.org/a/publications/proceedings/Sacramento2012/files/Pitts.pdf>].

Pitts, K., Gonzales, A., Lowenstein, M., Iraci, L., Milesi, C. & Skiles, J.W. (2011). "NASA Ames Research Center climate change effects and adaptation research: Hind- and forecasting flood risk of NASA Ames Research Center using the BASINS model." Proceedings paper, ASPRS Annual Conference, Milwaukee, WI, 1-5 May 2011 [<http://www.asprs.org/wp-content/uploads/2010/12/Pitts.pdf>].

Who Uses Earth Science Data?

Dr. Karen Seto, to study the environmental effects of urbanization.



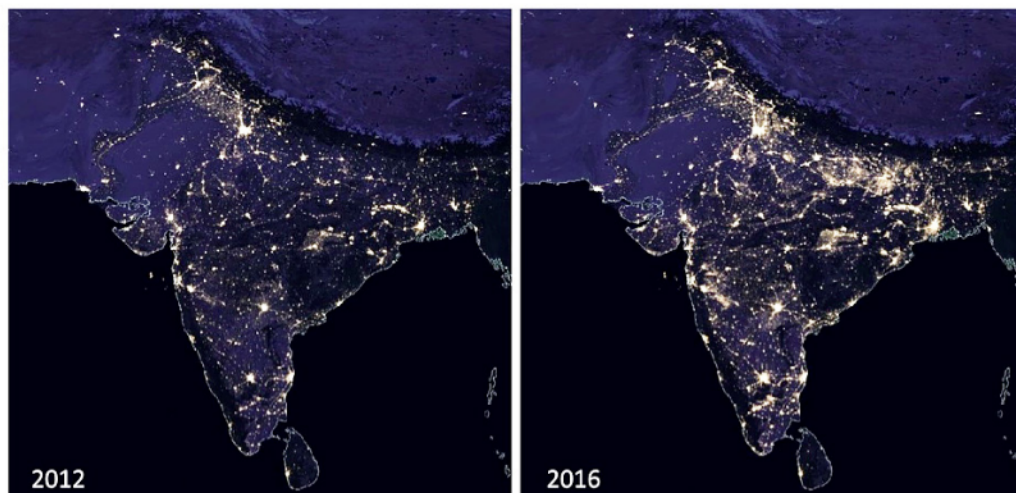
Image of Dr. Karen Seto courtesy of Yale University.

Dr. Karen Seto

Frederick C. Hixon
Professor of Geography
and Urbanization
Science and Associate
Dean for Research,
Yale School of Forestry &
Environmental Studies;
Director of the Seto Lab at
Yale University

Research interests: Urbanization and its effects on local and global environments, with a particular research emphasis on India and China.

Research highlights: In 1950, the population of India was slightly less than 400 million people. Today, India's population is more than 1.3 billion people, according to figures from the United Nations. The growth and spread of the Indian population can be tracked not only formally through India's national census, but also informally by instruments aboard orbiting Earth observing satellites. For example, a comparison of 2012 and 2016 nighttime lights imagery created from data collected by the [Visible Infrared Imaging Radiometer Suite \(VIIRS\)](#) aboard the joint NASA/NOAA [Suomi National Polar-orbiting Partnership \(Suomi-NPP\)](#) satellite shows a dramatic increase in anthropogenic, or human-created, lights along the northern border of India, indicating continued population growth in an area that has some of the country's highest population densities. The combination of field and remotely-sensed data provides a more complete picture of the effects of urbanization on biodiversity, croplands, and energy use.



NASA Black Marble nighttime lights imagery of India from 2012 (left) and 2016 (right) created from Suomi-NPP/VIIRS data via NASA's Earth Observatory and displayed using the EOSDIS Worldview application. Notice the dramatic increase in lit areas in the 2016 image, especially along the northern border of India. Explore these images using Worldview (left image: go.nasa.gov/2qX0SKS; right image: go.nasa.gov/2rVfO9v). Images courtesy of Worldview.

Dr. Karen Seto's research into how urbanization is changing our planet relies on this combination of field and remotely-sensed data. Her research has shown that over the last 30 years urbanization has taken place on some of Earth's most fragile lands, making cities and other clusters of human population more vulnerable to the impacts of climate change. In addition, she has found that urbanization significantly affects biodiversity in areas of high conservation value. High conservation value, or HCV, areas are those with biological, ecological, social or cultural value of outstanding significance or critical importance, according to the [HCV Resource Network](#).

Dr. Seto coordinates much of her work and research through the [Seto Lab](#) at Yale University. Dr. Seto and the students, postdoctoral researchers, and staff in her lab

(Continued)

Who Uses Earth Science Data?

explore the linkages between urbanization, global change, and sustainability, with a specific focus on India and China—two countries undergoing the largest urban transitions in the world. As noted on the lab’s website, global satellite imagery provides unique insight into urban land-use change and its economic and environmental effects at a global scale.

In a recent study, Dr. Seto and Bhartendu Pandey, a Ph.D. student in the Seto Lab, used satellite data and imagery of India along with Indian census data to examine the impacts of urbanization on the loss of agricultural land, which also is called the “urban conversion of agricultural land” or UCAL. The research team used satellite data to assess agricultural land loss and compared these satellite-derived estimates with Indian agricultural census data. An analysis of [Moderate Resolution Imaging Spectroradiometer \(MODIS\)](#) vegetation imagery along with nighttime lights data were used to construct land-cover change histories. Results of the research indicate that UCAL in India is greater in Indian states where urbanization and economic growth are high, with agricultural land loss concentrated around smaller cities more than larger cities. The data also show that the total area under UCAL in India between 2001 and 2010 has been increasing since 2006, but is still relatively low.

The use of remotely-sensed nighttime lights imagery is a powerful tool for tracking urbanization. Dr. Seto was part of a team that used nighttime lights imagery from the [Defense Meteorological Satellite Program/Operational Linescan System \(DMSP/OLS\)](#) combined with 10 years of vegetation datasets from the European [Satellites Pour l’Observation de la Terre \(SPOT\)](#) program to map Indian urban areas at the national scale. This research also utilized data from the [Global Rural-Urban Mapping Project \(GRUMP\), Version 1](#), which is available through NASA’s [Socioeconomic Data and Applications Center \(SEDAC\)](#), to help identify urban areas. This was the first investigation of urban growth in India using nighttime lights imagery.

The results showed that DMSP/OLS nighttime lights imagery, if intercalibrated to enable a series of images over time to be compared at similar scales, can be an effective tool for examining changes and growth in urban areas. While the DMSP/OLS nighttime lights imagery offer a unique archive spanning over 20 years, the data are collected using different satellites. Dr. Seto and her team are working on methods to improve the comparability of the time series from these data.

Nighttime lights imagery also can be used to monitor short-term changes in urban areas, such as power failures caused by hurricanes or changes in human activity related to other events. Another of Dr. Seto’s Ph.D. students, Eleanor (Kellie) Stokes (a NASA Harriett Jenkins Fellow) is developing techniques to use VIIRS nighttime lights signals to identify temporary changes (such as blackouts from power failures), seasonal changes (like holiday lights), and other long-term changes (including urbanization or changes in electrification rates). [VIIRS Day/Night Band \(DNB\)](#) imagery is available as a base layer in the [Earth Observing System Data and Information System \(EOSDIS\) Worldview](#) data visualization application.

Finally, Dr. Seto and her colleagues combined DMSP/OLS nighttime lights imagery with data from NASA’s SeaWinds microwave scatterometer aboard NASA’s [Quick Scatterometer \(QuikSCAT\)](#) Earth satellite (operational from 1999 to 2009) to examine changes in built-up infrastructure (e.g., buildings and other construction) in global urbanized areas. These urban landscapes, characterized by large areas of impervious surfaces, contribute significantly to local and regional changes in climate (such as the creation of areas of elevated temperature called *urban heat islands*), hydrology, biodiversity, land use (agricultural vs. forested land), and biogeochemical cycles (such as the effects of atmospheric pollutants leading to the creation of smog and acid rain).

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Who Uses Earth Science Data?

While the primary purpose of the SeaWinds scatterometer was to study surface ocean wind vectors and the instrument was not intended for use over terrestrial areas, analysis of SeaWinds data indicated that this instrument could detect reflected radiation (also called backscatter) from major urban areas. Construction in urban areas leads to numerous surfaces that backscatter radiation, which can be detected by microwave sensors like scatterometers. Dr. Seto and her colleagues explored whether this remotely-sensed backscatter can be used to analyze changes in urban areas over time. After analyzing nighttime lights and microwave backscatter data for 100 large cities on six continents, the research team found that these measurements provide a means of evaluating the physical dimensions of urban change (such as increases in building size and volume) over time in large cities. As caveats, the team notes that sensor saturation limits the utility of nighttime lights data for studying core areas of large cities and the coarse resolution of SeaWinds data makes this sensor unable to detect small cities or resolve spatial details of structural change in large cities.

Dr. Seto recently received NASA funding for a project that will use multi-scale and multisource satellite data to examine urban growth in the Hindu Kush Himalayan (HKH) region. This region extends across eight countries (from Afghanistan in the west to Myanmar in the east) and is home to about 210 million people. The primary goals of this research are to characterize and quantify land cover and land use change associated with urban settlement change in the HKH and assess the vulnerability of urban settlements in this region to hazards.

As Dr. Seto notes on the Seto Lab website, we are now in the urban century, with unprecedented growth in urban areas. The availability of more than 40 years of Earth observing satellite data gives scientists studying the effects of urbanization a unique global view of this growth and the effects of these changes on our planet.

Representative data products used:

- MODIS/Terra Vegetation Indices 16-Day Level 3 Global 250 m Grid SIN V006 (MOD13Q1, DOI: [10.5067/MODIS/MOD13Q1.006](https://doi.org/10.5067/MODIS/MOD13Q1.006)); available through NASA's [Land Processes Distributed Active Archive Center](#) (LP DAAC)
- [VIIRS DNB daily product](#); available through NASA's [Level 1 and Atmosphere Archive and Distribution System](#) (LAADS) [Distributed Active Archive Center](#) (DAAC)
- [GRUMPv1 data](#); available through SEDAC
- Mean summer backscatter power ratio (PR) data from the [SeaWinds scatterometer](#) aboard QuikSCAT; available through NASA's [Physical Oceanography Distributed Active Archive Center](#) (PO.DAAC)
- Global maps of urban extent based on NASA MODIS 500 m satellite data; available through the University of Wisconsin at nelson.wisc.edu/sage/data-and-models/schneider.php
- [Global Human Settlement Layer](#) (GHSL) product derived from Landsat data; available through the [European Commission, Joint Research Centre](#) (JRC)
- [DMSP/OLS Nighttime Lights data](#); available through the NOAA [National Centers for Environmental Information](#) (NCEI)
- SPOT Vegetation (VGT) data set; available at vito-eodata.be

(Continued)

Who Uses Earth Science Data?

Read about the research:

Zhang, Q., Pandey, B. & **Seto K.C.** (2016). "A Robust Method to Generate a Consistent Time Series from DMSP/OLS Nighttime Light Data." *IEEE Transactions on Geoscience and Remote Sensing*, 54(10): 5821-5831 [doi: [10.1109/TGRS.2016.2572724](https://doi.org/10.1109/TGRS.2016.2572724)].

Román, M.O. & Stokes, E.C. (2015). "Holidays in lights: Tracking cultural patterns in demand for energy services." *Earth's Future*, 3(6): 182-205 [doi: [10.1002/2014EF000285](https://doi.org/10.1002/2014EF000285)].

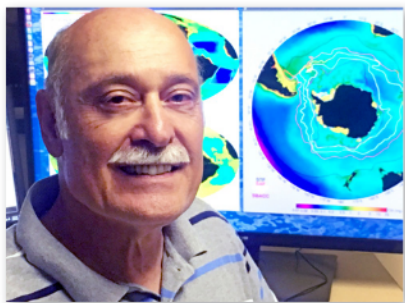
Pandey, B. & **Seto, K.C.** (2015). "Urbanization and agricultural land loss in India: Comparing satellite estimates with census data." *Journal of Environmental Management*, 148(15 January 2015): 53-66 [doi: [10.1016/j.jenvman.2014.05.014](https://doi.org/10.1016/j.jenvman.2014.05.014)].

Frolking, S., Milliman, T., **Seto, K.C.** & Friedl, M.A. (2013). "A global fingerprint of macro-scale changes in urban structure from 1999 to 2009." *Environmental Research Letters*, 8(2) [doi: [10.1088/1748-9326/8/2/024004](https://doi.org/10.1088/1748-9326/8/2/024004)].

Pandey, B., Joshi, P.K. & **Seto, K.C.** (2013). "Monitoring urbanization dynamics in India using DMSP/OLS night time lights and SPOT-VGT data." *International Journal of Applied Earth Observation and Geoinformation*, 23(August 2013): 49-61 [doi: [10.1016/j.jag.2012.11.005](https://doi.org/10.1016/j.jag.2012.11.005)].

Who Uses Earth Science Data?

Dr. Sergio Signorini, to study the impact of climate variability on phytoplankton and Earth's oceans.



Dr. Sergio Signorini with a SeaWiFS image showing averaged chlorophyll concentrations around Antarctica and South America. Yellow and green colors in the image are areas of higher chlorophyll concentrations. Image courtesy of Dr. Signorini.

Dr. Sergio Signorini

Principal Research Scientist,
Science Applications International
Corporation (SAIC)/NASA
Goddard Space Flight Center

Research interests: The ocean carbon cycle and the impact of climate variability on the ocean's physical and biological properties.

Research highlights: The color of the ocean tells an ever-changing story. From the swirls of blue-green phytoplankton indicating masses of living microorganisms to dark areas of suspended sediment discharged by rivers where they meet the sea, ocean color data help unlock vital information about an ecosystem that covers more than 70% of Earth's surface and makes up about 97% of Earth's water, according to the [National Oceanic and Atmospheric Administration \(NOAA\)](#).

NASA's primary source for ocean color data is the [Ocean Biology Distributed Active Archive Center \(OB.DAAC\)](#) at NASA's [Goddard Space Flight Center](#) in Greenbelt, MD. This is also where Dr. Sergio Signorini conducts research using a combination of remotely-sensed ocean color data from satellites and field data from ship surveys, ocean buoys, floats, and other sources.

One of Dr. Signorini's research interests is investigating ocean acidification, or OA. OA occurs when carbon dioxide (CO_2) is absorbed by seawater and dissolves, forming carbonic acid and lowering overall seawater pH. A pH lower than 7 on the 0 to 14 pH scale is considered acidic; a pH above 7 is considered alkaline. Historically, ocean pH is about 8.2, or slightly alkaline. However, ocean pH has decreased to closer to 8.0 since the start of the industrial revolution and continues to become more acidic, according to data from NASA's [Carbon Monitoring System \(CMS\)](#) and NOAA's [Ocean Carbon and Acidification Data Portal](#) at the [National Centers for Environmental Information \(NCEI\)](#).

Lower ocean pH can inhibit shell growth in marine animals and may cause reproductive disorders in certain fish species. In a study of ocean and coastal acidification off New England and Nova Scotia, Dr. Signorini was part of a team that determined that the input of significant freshwater into the ocean from rivers and other sources has reduced the ability of these ocean waters to neutralize carbonic acid and made these areas more susceptible to acidification. Dr. Signorini notes that despite the vulnerability of these waters to acidification and the impact lower ocean pH may have on fisheries, it's unclear at this time how the region's ecosystems will respond to acidification.

A key parameter for monitoring OA is the partial pressure of CO_2 (denoted $p\text{CO}_2$) in seawater. In a study of $p\text{CO}_2$ conducted along the eastern North American continental shelf, Dr. Signorini used satellite data (primarily data collected by the [Moderate Resolution Imaging Spectroradiometer \(MODIS\)](#) instrument aboard NASA's [Aqua](#) satellite) and field data to relate surface ocean $p\text{CO}_2$ values and changes in sea-air CO_2 exchanges to sea surface temperature (SST), surface salinity, and chlorophyll concentrations. Dr. Signorini and his colleagues used the resulting equations, along with inputs from corresponding satellite products, to assess the spatial and temporal variability of surface ocean $p\text{CO}_2$ and changes in sea-air CO_2 for the North American East Coast. The research team found that temperature and changes in the amount of dissolved inorganic carbon are the most influential factors driving seasonal changes in

(Continued)

Who Uses Earth Science Data?

$p\text{CO}_2$ values along the U.S. East Coast and note that the sea-air CO_2 flux estimates provide an important component of the inorganic carbon budget on the continental shelf. In fact, the algorithm developed during this research also was used in Dr. Signorini's previously mentioned investigations of OA in coastal oceans.

Coastal oceans also are a critical component of the global carbon cycle. Dr. Signorini currently is part of a multi-disciplinary, multi-institutional investigation studying the carbon budget of the eastern U.S. continental shelf (the [U.S. Eastern Continental Shelf Carbon Budget: Modeling, Data Assimilation, and Analysis](#), or US-ECoS). As part of this investigation, data from satellite and ocean model products are integrated to examine dissolved organic carbon (DOC) fluxes in the Middle Atlantic Bight, or MAB. A "bight" is the name given to a bend or curve in a coastline or a bay formed by this sort of curve; the MAB is the gradual curve in the U.S. Atlantic Coast extending from Massachusetts to North Carolina. The objective of this research is to develop satellite algorithms to retrieve DOC concentrations and then combine the resulting satellite data with physical circulation model products to quantify changes in DOC flux on the continental shelf boundaries. Dr. Signorini and his colleagues already have found that the discharge of water from estuaries into the MAB plays an important role in the seasonal and interannual variability of DOC and DOC flux on the continental shelf, as well as on the overall coastal carbon budget.

CO_2 and DOC also are important aspects of ocean net primary productivity. Phytoplankton (microscopic plant-like organisms that make up the base of the ocean's food pyramid) convert atmospheric CO_2 into food via photosynthesis, much like vegetation on land. In fact, phytoplankton comprise about half of Earth's net primary production, which is the amount of CO_2 a plant takes in during photosynthesis minus how much CO_2 the plant releases during respiration. Chlorophyll in phytoplankton are responsible for photosynthesis and energy production, and chlorophyll concentrations can be measured from space by sensors such as MODIS/Aqua (operational 2002-present), the [Visible Infrared Imaging Radiometer Suite \(VIIRS\)](#) (2011-present), and the [Sea-Viewing Wide Field-of-view Sensor \(SeaWiFS\)](#) (1997-2010). In addition to chlorophyll, many other important ocean color data products can be retrieved from these satellites, as seen in the representative data products used section.

In a global survey of ocean phytoplankton that is part of the American Meteorological Society's [State of the Climate in 2016](#), Dr. Signorini and colleagues used combined MODIS, VIIRS, and SeaWiFS observations to evaluate global chlorophyll concentrations. These remotely-sensed chlorophyll concentrations are then used as a proxy for determining phytoplankton abundance, and were compared with the 19-year record of satellite chlorophyll observations (starting with SeaWiFS in 1997). Variations in SST, nutrient availability, and the amount of light available for photosynthesis are the primary factors affecting chlorophyll and, through this, phytoplankton concentrations.

The research team note that 2016 was a transition year from El Niño conditions (warmer than normal SST off the western coast of South America) to La Niña conditions (cooler than normal SST off the western coast of South America). This transition was the dominant driver of phytoplankton concentrations along the equatorial Pacific Ocean, which were elevated 10% to 20% over the climatological mean. North and south of the equatorial Pacific Ocean, chlorophyll concentrations were lower relative to climatological values.

Dr. Signorini observes that satellite data provide an invaluable global view of the oceans, with temporal and spatial resolutions far superior to what can be achieved with more traditional ocean-based data collection methods. The color of the ocean, especially when observed from space, can give scientists and researchers like Dr. Signorini their first indication of a new story being told by this vital resource.

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Who Uses Earth Science Data?

Representative data products used:

- Various ocean color products from NASA's OB.DAAC, including:
 - MODIS products from NASA's Aqua satellite:
 - ◆ Level-2 Ocean Color Data Version 2014 product, including Sea Surface Temperature (SST) and Chlorophyll-a Concentration (DOI: [10.5067/AQUA/MODIS_OC.2014.0](https://doi.org/10.5067/AQUA/MODIS_OC.2014.0))
 - ◆ Level-3 Chlorophyll-a (DOI: [10.5067/AQUA/MODIS/L3B/CHL/2014](https://doi.org/10.5067/AQUA/MODIS/L3B/CHL/2014))
 - ◆ [Generalized Inherent Optical Properties \(GIOP\)](#) products, Level-2 (DOI: [10.5067/AQUA/MODIS/L2/IOP/2014](https://doi.org/10.5067/AQUA/MODIS/L2/IOP/2014)) and Level-3 (DOI: [10.5067/AQUA/MODIS/L3B/IOP/2014](https://doi.org/10.5067/AQUA/MODIS/L3B/IOP/2014))
 - [SeaWiFS products](#), primarily Level-2 products at 1km and 9 km resolution; Level-3b and -3m daily, 8-day, and monthly products (excluding SST products)
 - [VIIRS products](#), primarily Level-2 products at 1km and 4 km/9 km resolution; Level-3b and -3m daily, 8-day, and monthly products (excluding SST products)
- Ocean color measurements derived from Landsat 8 [Operational Land Imager \(OLI\)](#) data, available for viewing using the OB.DAAC [SeaWiFS Data Analysis System \(SeaDAS\)](#)
- [Satellite altimetry data products](#) from the French AVISO active archive data center at the [Centre National d'Etudes Spatiales \(CNES\)](#), the French Space Agency
- Various numerical model products from the [Hybrid Coordinate Ocean Model \(HYCOM\)](#) and the [Regional Ocean Modeling System \(ROMS\)](#)
- Data from the [World Ocean Database](#) and the [Optimum Interpolation Sea Surface Temperature \(OISST\)](#) data product; available through the NOAA NCEI
- $p\text{CO}_2$ and CO_2 data from the [Surface Ocean \$\text{CO}_2\$ Atlas \(SOCAT\)](#)

Read about the research:

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Mannino, A., **Signorini, S.R.**, Novak, M.G., Wilkin, J., Friedrichs, M.A.M. & Najjar, R.G. (2016). "Dissolved organic carbon fluxes in the Middle Atlantic Bight: An integrated approach based on satellite data and ocean model products." *Journal of Geophysical Research: Biogeosciences*, 121(2): 312-336 [doi: [10.1002/2015JG003031](https://doi.org/10.1002/2015JG003031)].

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Who Uses Earth Science Data?

Mark Trice, to monitor the health of Chesapeake Bay.



Mark Trice in his Maryland DNR office. The body of water on the map behind his left shoulder is Chesapeake Bay and the Atlantic Ocean. Image courtesy of Mark Trice.

Mark Trice

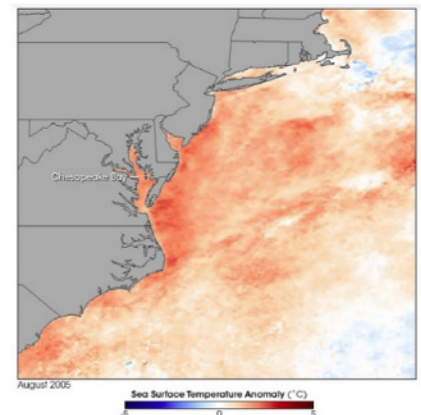
Program Chief,
Water Quality Informatics; Tidewater
Ecosystem Assessment Division,
Maryland Department of Natural
Resources (DNR)

Work and research interests: Tidewater quality and aquatic habitat monitoring and assessment.

Work and research highlights: In 2005, a fisherman crabbing on Maryland's Eastern Shore was pinched in the leg by a crab. Shortly after the incident, an infection attributed to the pinch caused the fisherman's leg to swell to the point where it had to be amputated. But it was too late—a bacteria-borne blood infection already had spread through his body, and the fisherman died. Data from the [Moderate Resolution Imaging Spectroradiometer \(MODIS\)](#) instrument aboard NASA's [Terra](#) and [Aqua](#) Earth observing satellites helped provide one potential clue behind this mysterious death. The cause was a waterborne bacteria called *Vibrio vulnificus*, and Mark Trice had the MODIS imagery to show how this lethal microorganism could have found a home in Chesapeake Bay.

Trice and his colleagues monitor the health of Chesapeake Bay, focusing on the habitat conditions of key aquatic species such as blue crabs, fish, oysters, and underwater grasses. Along with research vessels, habitat surveys, and approximately 40 near- and real-time continuous water quality monitoring sites throughout the bay, another key data source Trice relies on is imagery derived from data collected by NASA's constellation of Earth observing satellites. One of Trice's sources for these data is NASA's [Land, Atmosphere Near real-time Capability for EOS \(LANCE\)](#) system, which provides near real-time data from orbiting satellites generally within three hours of an observation.

In 2005, the same year as the fisherman's mysterious death, the Maryland DNR collaborated with NASA and the National Oceanic and Atmospheric Administration (NOAA) to document extreme high summer water temperatures in Chesapeake Bay. Unusually warm temperatures can be stressful to fish, reduce oxygen in the water column, and cause die-offs of underwater grasses. MODIS data provided by NASA showed warmer than normal sea surface temperatures all along the East Coast and extending throughout Chesapeake Bay. This warmer water provided a good breeding ground for *V. vulnificus* bacteria, which are commonly found in the Gulf of Mexico and other warm bodies of salt water. Through a pinch by a crab claw, the bacteria entered the fisherman's body and caused the infection that killed him.



MODIS Sea Surface Temperature Anomaly along the U.S. East Coast for August 2005 showing warmer than normal temperatures (orange/red areas) throughout Chesapeake Bay. NASA image by Jesse Allen, Earth Observatory Team, based on data provided by Ron Vogel, Terrestrial Information Systems Branch, Goddard Space Flight Center.

(Continued)

Who Uses Earth Science Data?

Starting in 2007, the Maryland DNR's [Eyes on the Bay](#) website, which was co-created by Trice in 2003, began posting and archiving daily MODIS imagery along with chlorophyll, surface temperature, turbidity, and suspended matter data provided by NOAA's [CoastWatch](#) program. Eyes on the Bay allows citizens, scientists, and managers to view and access local and bay-wide water quality data and imagery. These data and imagery are critical for assessing the health of an ecosystem that not only supports a wide range of commercial activities, but also is easily susceptible to pollutants.

Trice notes that images created from data collected by NASA satellites have been an excellent communication tool for the DNR. The watershed images draw many followers to the Eyes on the Bay website and social media outlets, and expose viewers to other data-driven content they may not otherwise have followed or discovered. Trice and his colleagues also use these images as teaching and communication tools by highlighting features such as seasonal changes in land cover, impervious surfaces in urban areas, sediment plumes, and algal blooms. In some cases, satellite imagery of chlorophyll helped confirm highly ephemeral algal blooms as the cause of fish kills in the bay. In turn, the data collected by the Maryland DNR and their Virginia counterparts help improve the accuracy of the satellite chlorophyll algorithms used to estimate Chesapeake Bay algal conditions by providing hard data collected at the source to validate the remotely-sensed satellite data. Although not yet implemented, Trice and his colleagues hope to use satellite data to assess regulatory criteria for chlorophyll concentrations. These chlorophyll concentrations must meet water quality standards set by the U.S. Environmental Protection Agency (EPA) to maintain the bay as a healthy ecosystem.

Along with his work on the Eyes on the Bay website, Trice has been part of numerous research teams looking at productivity in Chesapeake Bay and the effects of pollutants and other impacts on bay species. Estuaries like Chesapeake Bay are very productive ecosystems. However, this productivity has to remain in balance. Excess nutrients such as nitrogen and phosphorus, introduced through septic and sewage waste; agricultural, urban, and lawn fertilizer run-off; sediment erosion; and atmospheric deposition from the burning of fossil fuels, can lead to excess productivity by fueling the growth of algae in the water. When these algae die, they are decomposed by bacteria that consume oxygen and reduce concentrations of oxygen in the water. This reduction in oxygen can impact the growth, reproduction, and even the survival of aquatic organisms and lead to conditions of low dissolved oxygen, or hypoxia.

Trice was part of a research team examining the effects of cyclic hypoxic conditions on the progression of an oyster pathogen called *Perkinsus marinus*, which leads to a disease called "dermo" that is responsible for declines in oyster populations. Levels of dissolved oxygen change throughout the day in a cyclic pattern (called diel-cycling), and reach their lowest levels in the early morning hours due to daily cycles of photosynthesis (which requires light) and respiration. The team explored diel-cycling hypoxia to better understand how these conditions, which are widespread in shallow portions of estuaries like Chesapeake Bay, affect bay organisms.

In another study, Trice and his research colleagues studied factors contributing to harmful algal blooms (HABs), which occur when colonies of algae grow out of control while producing toxic or harmful effects on other organisms. The team used fixed monitors to document the hourly to monthly variability in nutrients and the resulting response of phytoplankton to these varying nutrients. The team deployed monitors throughout Chesapeake Bay to measure a range of nutrients, including nitrate+nitrite, ammonium, phosphate, and urea, and the response over time by algae to changes in these nutrients.

(Continued)

Who Uses Earth Science Data?

Data products used:

- [LANCE Rapid Response](#) MODIS imagery, AERONET [Wallops Subsets](#); available through NASA's [LANCE-MODIS Data System](#)
- Various data products from NOAA [CoastWatch, East Coast Node](#)

Work and research findings: In his research into hypoxia, Trice and his colleagues found that human-caused increases in nutrient loads into shallow waters can increase diel-cycling hypoxic conditions and, through this, increase oyster disease problems in shallow waters. The team also found that the diel-cycling of hypoxia increased the acquisition and progression of infections from *P. marinus* more strongly in younger oysters (1 year old) than in older oysters (2-3 years old). The team hypothesize that the effects of hypoxia on lowering the oyster immune response is the likely mechanism leading to elevated infections in oysters in hypoxic environments. Looking at the larger picture, the team notes that hypoxia, including diel-cycling hypoxia, may impact the success of oyster restoration not only directly (through lower concentrations of dissolved oxygen), but also indirectly (through impacts on the oyster immune system that provide a gateway for disease).

While looking at changes in nutrients and the effects of this on algae and HABs, Trice and his colleagues note that fixed monitors constantly collecting data provide a better measure of dynamics than traditional manual sampling. Data collected by the monitors indicate that levels of nutrient concentrations can change rapidly (over a span of hours) through tidal oscillations and algal uptake or more slowly (over several days) in relation to rain events that wash nutrients into the bay. While the data show that increases in nutrients following rainfall events are significant, the time-scale of nutrient response varies. The team found that phosphate and urea show rapid increases with rain events followed by a longer-term sustained increase, while increases in nitrate+nitrite and ammonium lag rainfall events by several days and generally persist for several days.

Read about the work and research:

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Who Uses Earth Science Data?

Dr. John Wilkin, to study coastal ocean circulation, marine ecosystem processes, and the occasional rock lobster.



Dr. John Wilkin holding a *Jasus edwardsii*, commonly known as the southern rock lobster, New Zealand crayfish, or koura. Image courtesy of Dr. Wilkin.

Dr. John Wilkin

Professor of Marine and Coastal Sciences,
Rutgers, The State University of New Jersey

Research interests: Ocean simulation modeling, data assimilation, and remote sensing of estuaries, the coastal ocean, and the deep sea adjacent to the continental shelf to study nutrient and carbon cycling, larval dispersal, and ocean transport, weather, and ecosystem forecasting.

Research highlights: The rock lobster is responsible for some of Dr. John Wilkin's first work with satellite data. As a scientist at the [Commonwealth Scientific and Industrial Research Organisation \(CSIRO\)](#) in Australia, Dr. Wilkin was part of a research team that estimated ocean surface velocities from satellite sea surface height data to chart ocean current variability in the eastern Indian Ocean. The research team used these data to simulate how ocean currents affect the dispersal of rock lobster larvae from spawning locations off the west coast of Australia. Dr. Wilkin conducted additional work in New Zealand on lobster larva dispersal in the Tasman Sea along with studies into ocean current estimation using sequences of ocean temperature imagery before joining the faculty of Rutgers University in 2001. Dr. Wilkin's current research using remotely-sensed satellite data covers a wide range of topics, including nutrient and carbon cycling; ocean transport, weather, and ecosystem forecasting; and continued investigations into larval dispersal.

As Dr. Wilkin and his co-authors note in a recent paper, satellite remote sensing plays a vital role in oceanography. The use of satellites to measure the height of the ocean surface through a technique called radar altimetry is a key technique in operational oceanography. Altimeter satellites, such as the European Space Agency's [Sentinel](#) series and the joint NASA/NOAA/European [Jason](#) series, provide high precision, high resolution sea level data along the satellite track. In addition to sea surface height, satellites are valuable for measuring and monitoring sea surface temperature, ocean color, sea ice, surface winds, sea surface salinity, and waves. Data from many of these satellite missions are available through NASA's [Physical Oceanography Distributed Active Archive Center \(PO.DAAC\)](#).

Dr. Wilkin's current research integrates satellite and *in situ* ocean observation, simulation, and analysis to study the role that ocean physics plays in weather, climate, ocean transport pathways, marine environmental health, and ecosystem functioning in the coastal ocean and adjacent deep sea. He also is involved with the international [Ocean Surface Topography Science Team \(OSTST\)](#), which is a group of interdisciplinary scientists using satellite altimetry data to study ocean processes.

Much of Dr. Wilkin's research focuses on the Mid-Atlantic Bight and Gulf of Maine regions of the northeast U.S. continental shelf, which is an area delimited by Cape Hatteras, NC, in the south to Halifax, Nova Scotia, in the north (a "bight" is the name given to a bend or curve in a coastline or a bay formed by this sort of curve). In addition to remotely-sensed satellite data, this area also has a rich collection of data gathered by sensors, buoys, and other ocean-based instruments that are available through the [Mid-Atlantic Regional Association Coastal Ocean Observing System \(MARACOOS\)](#) and the [Northeastern Regional Association of Coastal Ocean Observing Systems \(NERACOOS\)](#), which are regional associations of the U.S. [Integrated Ocean Observing System \(IOOS\)](#).

(Continued)

Who Uses Earth Science Data?

Dr. Wilkin and his colleagues built a system that assimilates recent (less than three days old) observations of sea level from satellites, temperature from infrared and microwave sensors, surface current data from shore-based radar systems, and observations of subsurface temperature and salinity from ships, autonomous vehicles, and moorings. Dr. Wilkin uses these assimilated data to launch short-term (three-day) forecasts of conditions in the Mid-Atlantic Bight. These forecasts also go into data services maintained by MARACOOS for ingest into systems such as the [IOOS Environmental Data Server](#).

Dr. Wilkin uses the same modeling system, but without data assimilation, to drive biogeochemical and ecosystem models of the region to simulate nitrogen and carbon cycling as well as to assess primary productivity. Primary productivity refers to the production of energy, typically through photosynthesis, by organisms that form the base of the food chain. In fact, ocean primary production in the continental margins studied by Dr. Wilkin comprise as much as one-fifth of global marine primary production.

In a recent study, Dr. Wilkin and his colleagues used an integration of satellite data and ocean model products to study changes in dissolved organic carbon (DOC) in the Mid-Atlantic Bight. DOC is one of the greatest cycled reservoirs of organic matter on Earth, accounting for up to 20% of all organic carbon. As noted by Dr. Wilkin and his colleagues, 50-70% of the global transfer of organic carbon to the seabed occurs in continental margins, with DOC accounting for up to 90% of organic carbon in the coastal ocean.

The study includes data from the [Moderate Resolution Imaging Spectroradiometer \(MODIS\)](#) instrument aboard NASA's [Aqua](#) Earth observing satellite (launched in 2002), the [Sea-Viewing Wide Field-of-View Sensor \(SeaWiFS\)](#) aboard Orbital Sciences Corporation's [SeaStar](#) spacecraft (launched in 1997 and no longer reporting data), and from numerous study sites and stations along the Mid-Atlantic Bight. These data were analyzed using models to produce vertical profiles of DOC. Among their findings, the research team notes that their approach of combining satellite observations, field measurements, and model results provides a good overall assessment of DOC stocks and changes in DOC in the continental shelf. In fact, the integration of remotely-sensed data with model results is essential for capturing the DOC variability observed in the Mid-Atlantic Bight over monthly, seasonal, and interannual time scales.

Representative data products used:

- Sea surface temperature (SST) data from the following satellites/sources:
 - [Group for High Resolution SST \(GHRSST\) Level 2P Global Subskin SST from the Advanced Microwave Scanning Radiometer 2 \(AMSR2\) on the GCOM-W Satellite](#); available through PO.DAAC
 - GHRSST Level 2P Gridded Global Subskin SST from WindSat polarimetric radiometer on the Coriolis satellite [DOI: [10.5067/GHWST-2GR01](#)]; available through PO.DAAC
 - Infrared GOES hourly SST; available from NOAA's [Environmental Research Division Data Access Program \(ERDDAP\)](#)
- [SeaWiFS data](#); available through NASA's [Ocean Biology Distributed Active Archive Center \(OB.DAAC\)](#)
- [Aqua MODIS data](#); available through OB.DAAC
- Sea level anomaly data derived by satellite altimetry from the Jason, AltiKa, Cryosat, and Sentinel-3A missions; these data are available through the [Radar Altimeter Database System \(RADS\)](#), which provides a unified interface to multiple satellite missions operated by NASA and other institutions

(Continued)

Who Uses Earth Science Data?

■ [Infrared Advanced Very High Resolution Radiometer \(AVHRR\) data](#); available through MARACOOS

Read about the research:

Mannino, A., Signorini, S.R., Novak, M.G., **Wilkin, J.**, Friedrichs, M.A.M. & Najjar, R.G. (2016). “Dissolved organic carbon fluxes in the Middle Atlantic Bight: An integrated approach based on satellite data and ocean model products.” *Journal of Geophysical Research: Biogeosciences*, 121(2): 312-336 [doi: [10.1002/2015JG003031](https://doi.org/10.1002/2015JG003031)].

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