NASA Applied Sciences' Capacity Building Program's
DEVELOP National Program
2019 SUMMER
PROJECT BOOKLET

Letter from the
National Program Office

Thank you for taking the time to review the DEVELOP 2019 summer project booklet. Our projects are designed to provide a better understanding of how NASA Earth observations can benefit the public. This summer term included another outstanding DEVELOP team of 89 participants and 39 science advisors conducting 22 Earth science feasibility projects impacting 59 partners. These efforts impacted 20 states within the U.S. and 7 countries.

2019 is DEVELOP's 21st year of operation. Our outstanding participants, along with guidance from their science advisors, mentors, and partners, continue to conduct projects that provide innovative and high-quality results to communities. DEVELOP has now included over 4,800 participants who conducted over 950 projects supporting domestic and international partners since 1998.

As you review this booklet, we hope you gain an appreciation for the broad geographic reach of DEVELOP. This is made possible by our outstanding network of supporters. To those who have contributed to our success, we extend our gratitude. To those interested in learning more about the DEVELOP Program, we encourage you to visit our website and contact us with any questions.

We hope our projects provide you with an increased awareness of the many ways NASA science serves society.

With appreciation,
The **DEVELOP** National Program Office

CONTENTS

DEVELOP'S Vision
Shaping the future by integrating Earth observations into global decision making

About **DEVELOP**

DEVELOP addresses a wide array of environmental and public policy issues by partnering with a diverse group of end users. This partnership conducts interdisciplinary research projects that apply the lens of NASA Earth observations to community concerns around the globe. DEVELOP is NASA's answer to society's need for rapid, reliable, and responsive application of the agency's Earth observations for data-driven decision making.

DEVELOP's dual-capacity building model cultivates skills and knowledge of NASA Earth observations in participants and partners. The program utilizes a rapid response and nimble program structure to expedite the project lifecycle through a short 10-week project timeline. This enables end-users to experience timely benefits from sustainable tools and information specifically tailored to their decision-making needs.

About **Projects**

The foundation of DEVELOP is a portfolio of applied science projects focused on connecting NASA Earth science data to end users globally. Through 70-80 projects each year, DEVELOP engages with a broad array of current and potential users of NASA Earth observations—always striving for innovative, practical, and beneficial use.

As part of the Applied Sciences Program, DEVELOP works within the thematic application areas of Agriculture & Food Security, Disasters, Ecological Forecasting, Energy, Health & Air Quality, Transportation & Infrastructure, Urban Development and Water Resources.

Each DEVELOP project is driven by a community concern that presents a decision-making need for one or more end-user groups. DEVELOP partners with those end users to create tailored tools–based on NASA Earth observations, which can then be sustainably used to enhance the partner's decision making. In order to engage with as many end-users as possible, DEVELOP conducts projects on a 10-week timeline–fostering rapid applied benefit.

About **Participants**

As a program with the goal of building broad capability to utilize NASA Earth observations for societal benefit, DEVELOP accepts participants with a variety of skills, backgrounds, and education levels.

Offering over 200 participant opportunities each year, the main requirements to be a DEVELOPer are a strong interest in Earth science and a passion for one's work to benefit society.

DEVELOPers fall into five categories: currently enrolled college students, recent graduates, early career professionals, transitioning career professionals, and active or recently transitioned U.S. military service members.

The program offers a unique opportunity for each individual to expand and enhance their personal and professional development in a challenging, but rewarding environment.

About **Partners**

A wide variety of project partners are a vital ingredient in the DEVELOP model. Each year, DEVELOP collaborates with over 100 organizations to generate and conduct projects that apply NASA Earth observations to decision-making processes around the globe.

Partners can include local and state governments, regional consortiums, federal agencies, non-governmental and private organizations, academic institutions, and international governments and aid organizations.

By collaborating with DEVELOP, partners are introduced to NASA's Earth Science Division and its Earth observation resources. End users gain insight into satellite and airborne Earth observation capabilities and how they can augment and enhance their current decision-making practices. This provides potential cost and time savings, as well as the opportunity to engage with the future workforce, who will be well-versed in the use of NASA Earth observations.

2019 **Summer Term**

DEVELOP's 2019 summer term has been one of exciting collaborations with engaged partners in support of their decision-making needs. 89 DEVELOPers and 59 partners collaborated within the DEVELOP framework to conduct 22 rapid feasibility projects. These projects utilized NASA's Earth observations to monitor changes in the landscape that affect decision making and provide a synoptic view for understanding the Earth from the unique vantage point of space. Earth observations from 21 sensors, including data from 10 of NASA's spaceborne missions, were applied by the DEVELOP project teams to eight of the NASA Applied Sciences' thematic application areas –Agriculture & Food Security, Disasters, Ecological Forecasting, Energy, Health & Air Quality, Transportation & Infrastructure, Urban Development, and Water Resources.
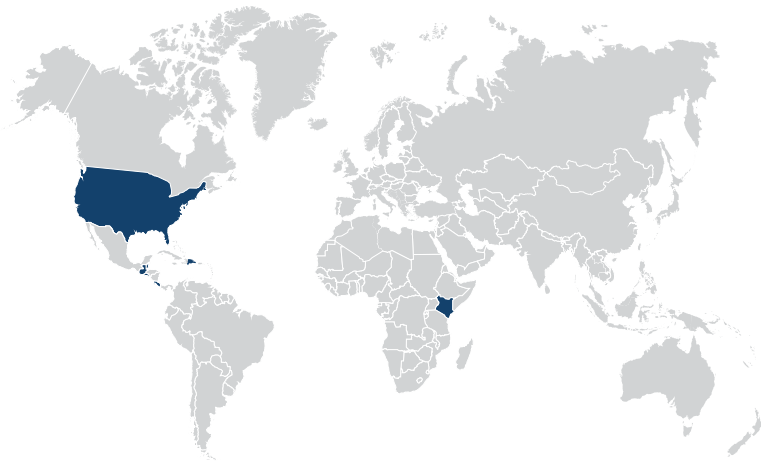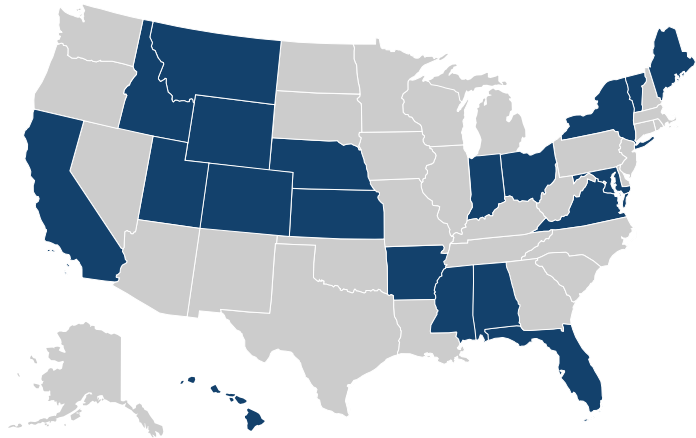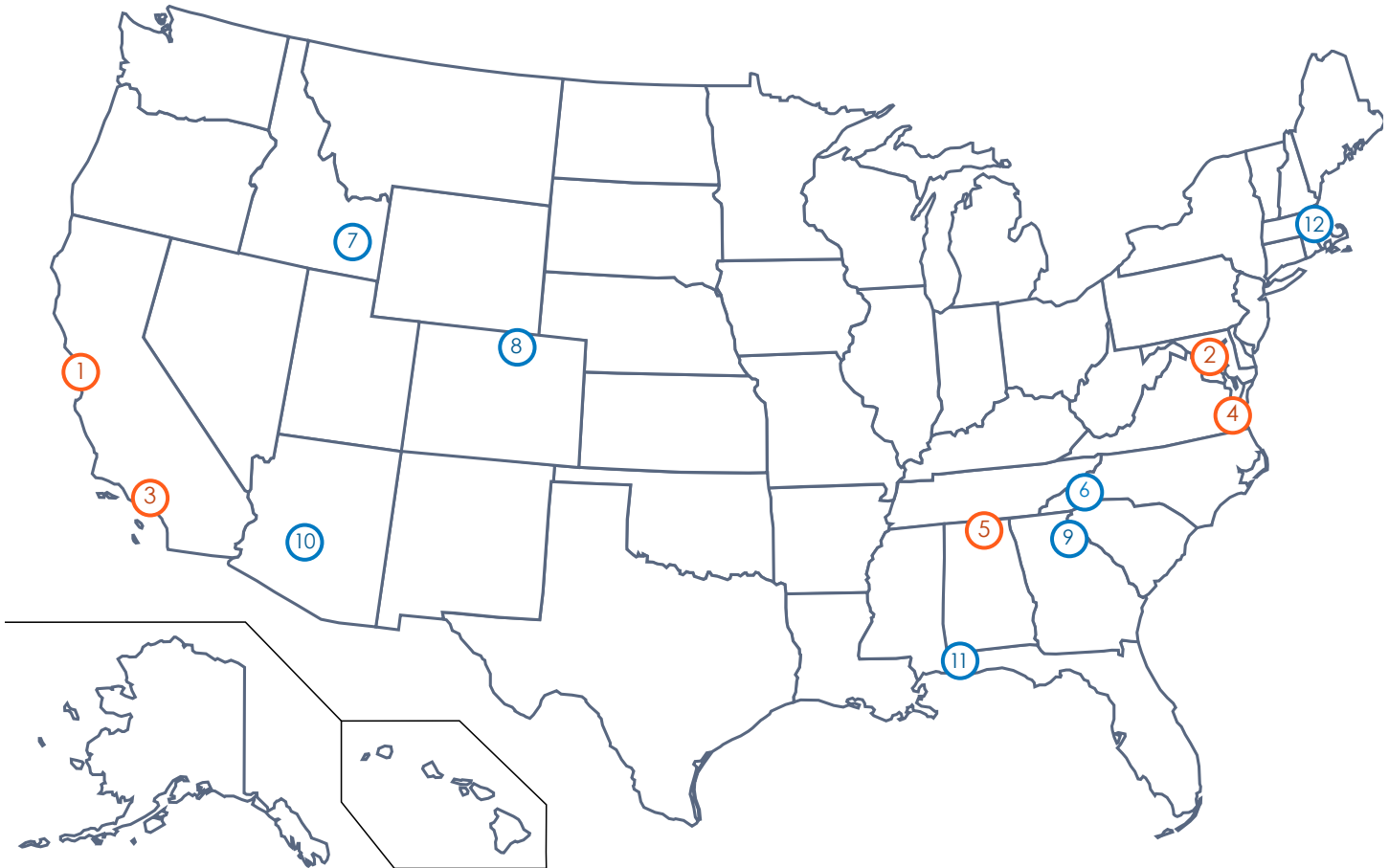
Partner organizations collaborating with DEVELOP represented a variety of sectors, including state, local, and federal agencies, international governments, non-governmental organizations, academic institutions, and consortiums. DEVELOP collaborated with government agencies in Central America in partnership with Sistema de la Integración Centroamericana (SICA), or the Central American Integration System, on three projects to address a variety of environmental concerns across the region.

NASA Center Locations

1. California – Ames
2. Maryland – Goddard
3. California – JPL
4. Virginia – Langley
5. Alabama – Marshall

Regional Locations

6. North Carolina – NCEI
7. Idaho – Pocatello
8. Colorado – Fort Collins
9. Georgia – Athens
10. Arizona – Tempe
11. Alabama - Mobile
12. Massachusetts - Boston

2019 **Summer Projects**

HEALTH & AIR QUALITY

TRANSPORTATION & INFRASTRUCTURE

URBAN DEVELOPMENT

WATER RESOURCES

Agriculture & Food Security

OVERVIEW

DEVELOP's Agriculture & Food Security projects promote innovative use of NASA satellite data, model products, and scientific findings to assist with agricultural monitoring and management. The projects focus on topics associated with the production and availability of food products around the globe. This summer, DEVELOP's Agriculture & Food Security projects partnered with international governmental organizations, state governments, and academic institutions to support agricultural management, policy making, and global food security.
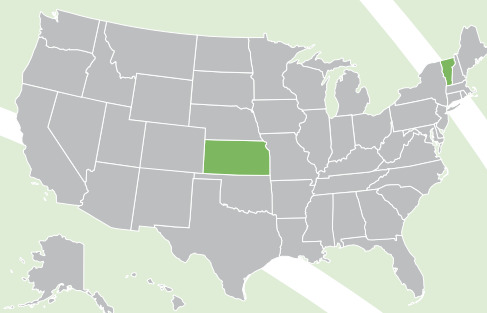
Agriculture & Food Security Projects

SENSORS

Aqua MODIS
GPM DPR
Landsat 5 TM
Landsat 8 OLI
SMAP L-band Radiometer
Terra ASTER
Terra MODIS

PORTFOLIO

Kansas Agriculture & Food Security: Modeling Soil Drydown Parameters for Drought Mitigation in Cropland and Rangeland of Kansas Using NASA Earth Observations

Kenya Agriculture & Food Security: Utilizing NASA Earth Observations in the RHEAS Model to Enhance Drought Monitoring and Mitigation in Kenya

Northern Forest Agriculture & Food Security: Identifying Environmental Stressors Impacting Sugarbush Longevity and Maple Syrup Agroforestry in Vermont

PARTNERS

Desert Research Institute
Kansas State University, Kansas Office of the State Climatologist
Kansas State University, Department of Agronomy
Kansas Water Office
National Drought Management Authority (Kenya)
Regional Centre for Mapping of Resources for Development (RCMRD)
University of Vermont, Extension Maple Program
University of Vermont, Proctor Maple Research Center
University of Vermont, Spatial Analysis Laboratory

Kansas Agriculture & Food Security

Modeling Soil Drydown Parameters for Drought Mitigation in Cropland and Rangeland of Kansas Using NASA Earth Observations
North Carolina - NCEI

TEAM: Danika Mosher (Project Lead), Max Dunsker, Krishna Tiwari
PARTNERS: Desert Research Institute, Western Regional Climate Center; Kansas State University, Department of Agronomy; Kansas State University, Kansas Office of the State Climatologist; Kansas Water Office
EARTH OBSERVATIONS: SMAP L-band Radiometer

Kansas is a leading state in agricultural production; however, during recent droughts, farmers experienced decreased yields that negatively impacted the state and national economies. The exponential decay of soil moisture content is a major consequence of drought, stymieing plant growth. This study examined the rate of soil moisture drydown to understand and mitigate the damage caused by soil water shortage. Soil Moisture Active Passive (SMAP) L-band Radiometer rootzone soil moisture imagery from March 2015 to the present was used to understand the minimum and maximum soil moisture capacity. The variables selected from SMAP, and parameters derived from *in situ* data, were input into an exponential model. The model forecasted, for a given length of time, the rootzone soil moisture, while assuming no precipitation. Another model was used to identify areas in Kansas currently below a given percentage of their relative soil moisture saturation, measured as a function of minimum, maximum, and current soil moisture, and forecasted the number of days until the other pixels would reach that level. The data were observed at a spatial resolution of 9 km × 9 km. These outputs were compared to Evaporative Drought Demand Index (EDDI) data to understand the relationship between agricultural and meteorological drought for our partners at Kansas State University and the Desert Research Institute. Additionally, the project assisted the Kansas Water Office and Kansas Office of the State Climatologist at Kansas State University in creating statewide drought mitigation plans and disseminating comprehensive information to farmers.

Kenya Agriculture & Food Security

Utilizing NASA Earth Observations in the RHEAS Model to Enhance Drought Monitoring and Mitigation in Kenya

Alabama - Marshall

TEAM: Ryan Good (Project Lead), Ryan Marshman, Chiara Phillips, Amanda Tomlinson

PARTNERS: National Drought Management Authority (Kenya); Regional Centre for Mapping of Resources for Development (RCMRD)

EARTH OBSERVATIONS: Aqua MODIS, GPM DPR, SMAP L-band Radiometer, Terra MODIS

Many regions of Kenya historically and regularly experience severe drought, necessitating a robust and well-informed response to drought events to protect agricultural production and minimize drought impact on food security. The National Drought Management Authority currently publishes monthly Early Warning Bulletins that depend on Moderate Resolution Imaging Spectroradiometer (MODIS) indices that are not sufficient in assessing current drought status, nor predicting its trajectory. This project utilized Soil Moisture Active Passive (SMAP) L-band Radiometer, Aqua and Terra MODIS, and Global Precipitation Measurement Core Observatory (GPM) Dual-Frequency Precipitation Radar (DPR) data as inputs into the Regional Hydrologic Extremes Assessment System (RHEAS). This model supports an unlimited number of variables, relying on a land surface model that can be easily customized, allowing data from multiple resolutions to be used without the need for preprocessing. Using inputs from the Regional Centre for Mapping of Resources for Development, the team created multiple drought time series to better assist stakeholders in implementing drought mitigation and adaptation measures. Initial results showed that drought indices that cover a longer time period provided a clearer trend of drought conditions by county. The team also provided partners an initial analysis of the indices produced and a story map derived from the time series. Follow on work will validate these products and create training documents for end users.
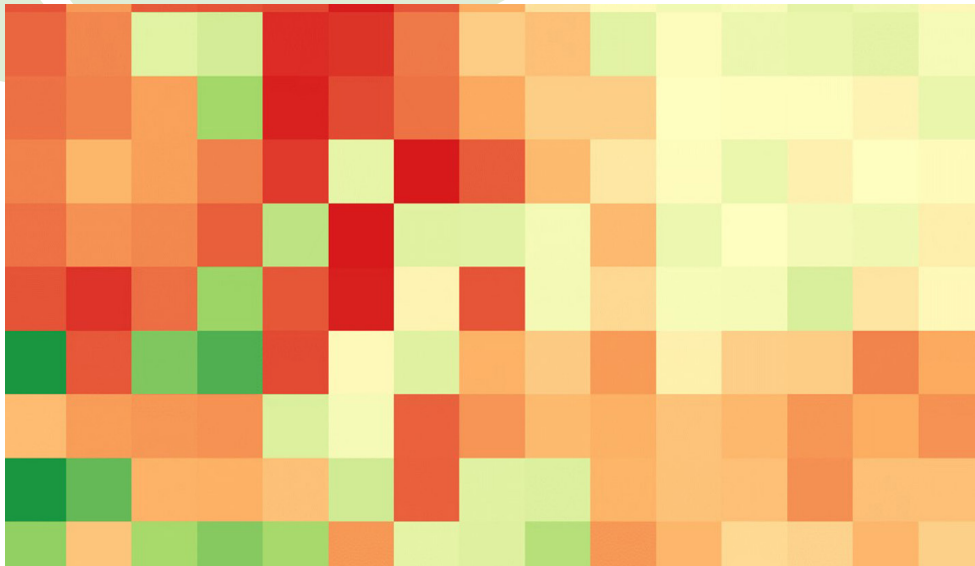
Northern Forest Agriculture & Food Security

Identifying Environmental Stressors Impacting Sugarbush Longevity and Maple Syrup Agroforestry in Vermont

Georgia - Athens

TEAM: Brooke Bartlett (Project Lead), Shannon Healy, Li-Wei Lin, Melanie Rausch
PARTNERS: University of Vermont, Extension Maple Program; University of Vermont, Proctor Maple Research Center; University of Vermont, Spatial Analysis Laboratory
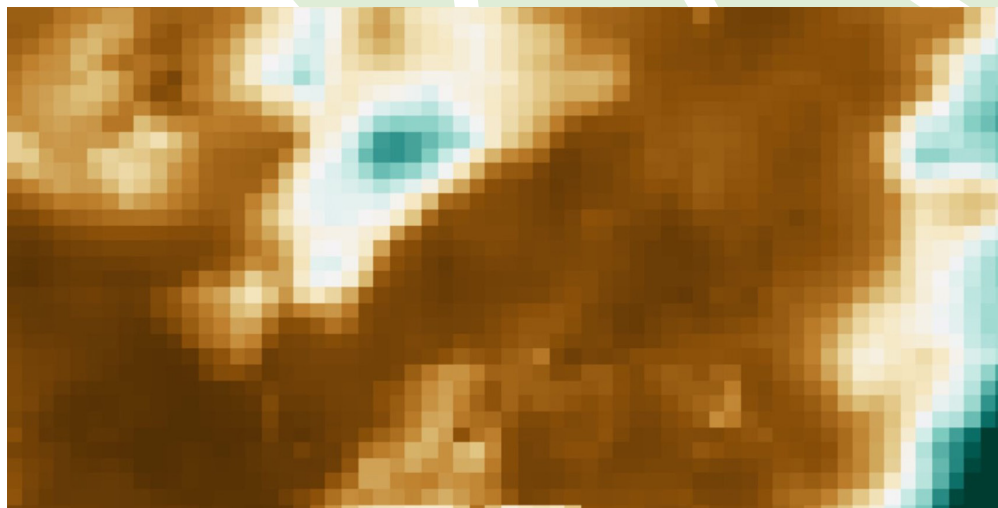**EARTH OBSERVATIONS:** Landsat 5 TM, Landsat 8 OLI, Terra ASTER
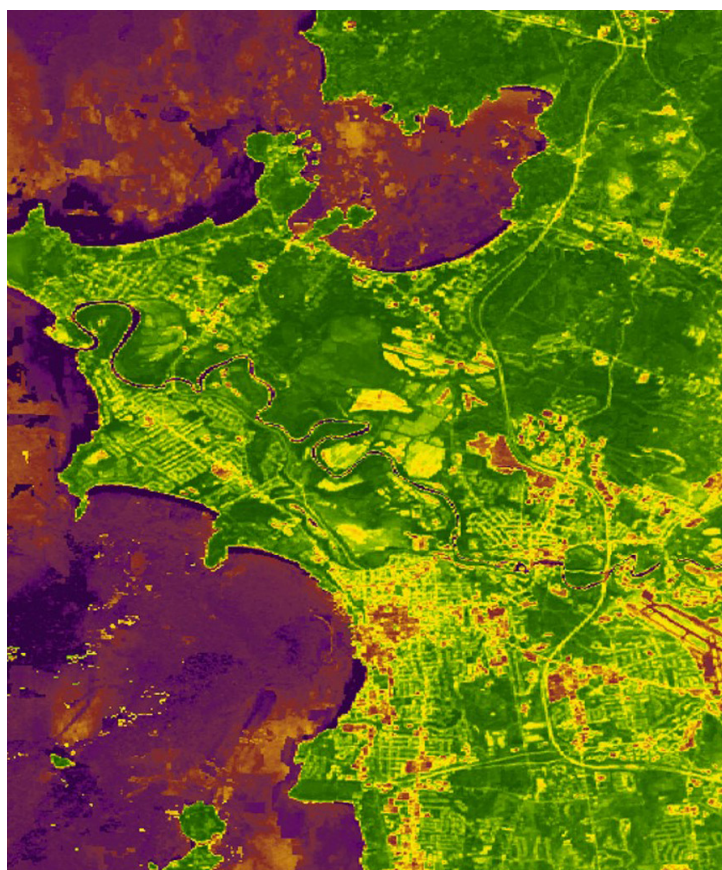
Maple syrup production has historically been at the heart of Vermont's cultural and economic identity. In 2018, the state was the leading producer in the US, generating 46.6 percent of the country's maple syrup. However, temperature fluctuations, drought, and variable defoliation caused by the forest tent caterpillar (*Malacosoma disstria*), impacted the sugar maple tree (*Acer saccharum*), a keystone species and agroforestry crop necessary for maple syrup production. NASA DEVELOP partnered with the University of Vermont's (UVM) Proctor Maple Research Center, Extension Maple Program, and Spatial Analysis Laboratory to analyze sugar maple stand longevity and habitat suitability. Satellite imagery was utilized from Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI), and Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) to conduct sugarbush health analyses and create a model for suitable sugarbush habitat. The Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) time series were created to analyze vegetation trends between January 1987 and June 2019. A sugarbush habitat suitability model was also conducted, utilizing the results from the EVI time series along with soil and terrain data. Analysis of the sugarbush habitat suitability model allowed for the identification of optimal maple stands for maple syrup production in the state of Vermont.

Disasters

OVERVIEW

DEVELOP's Disasters projects utilize NASA's capabilities in spaceborne, airborne, and surface observations, as well as modeling and data analysis, to improve natural disaster forecasting, mitigation, and response. The projects contribute to improved understanding of the natural processes that produce hazards, the vulnerability of local communities, and development of hazard mitigation technologies. This summer, DEVELOP's Disasters projects partnered with decision makers around the globe to provide disaster-related information where and when it is needed.

■ Disasters Projects
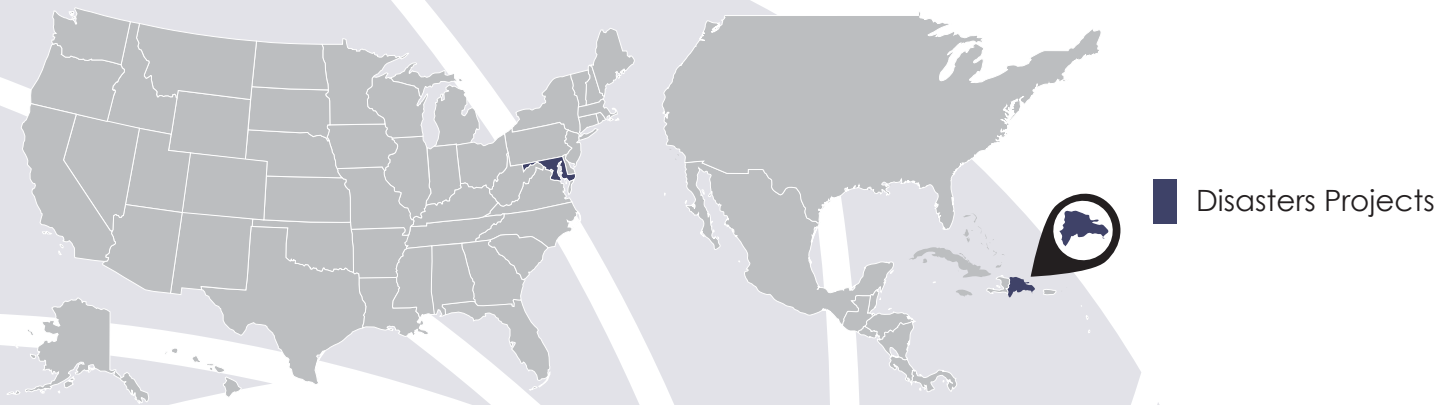
PORTFOLIO

Dominican Republic Disasters: Mapping Landslide Susceptibility and Exposure in the Dominican Republic Using NASA Earth Observations

Ellicott City Disasters: Applying NASA Resources to a Statistical Flood Risk Model to Improve Early Warning Systems and Public Safety

PARTNERS

Howard County Government, Office of Emergency Management
Howard County Government, Stormwater Management Division
Oficina Nacional de Meteorología (Dominican Republic)
NOAA, National Weather Service, Baltimore-Washington Weather Forecast Office
Servicio Geológico Nacional (Dominican Republic)

SENSORS

Aqua AMSR-E
GPM IMERG
SMAP L-band Radiometer
SRTM
TRMM TMI

Dominican Republic Disasters

Mapping Landslide Susceptibility and Exposure in the Dominican Republic Using NASA Earth Observations
Virginia - Langley

TEAM: Sarah Aldama (Project Lead), Chelsea Dandridge, Kyung "Robin" Kim, Gigi Pavur
PARTNERS: Oficina Nacional de Meteorología (Dominican Republic); Servicio Geológico Nacional (Dominican Republic)
EARTH OBSERVATIONS: GPM IMERG, SRTM

Rainfall-triggered landslides associated with tropical storms cause devastating damage to the communities in the Dominican Republic and surrounding Caribbean islands. With the predicted increase in the frequency and intensity of storms, the region would benefit from reliable disaster monitoring. Partnering with Servicio Geológico Nacional (SGN) and Oficina Nacional de Meteorología (ONAMET), the team created local landslide susceptibility maps and used them in combination with NASA Earth observations as inputs to the Landslide Hazard Assessment for Situational Awareness (LHASA) model to visualize potential landslide activity in near real-time. Susceptibility maps were based on slope derived from elevation data from the Shuttle Radar Topography Mission (SRTM), geology, road networks, fault lines, and forest loss. In LHASA, each map was combined with near real-time rainfall data from the Global Precipitation Measurement (GPM) mission. Using model outputs, the team identified areas of moderate and high potential landslide activity in a northern region of interest identified by our partners. Additionally, exposure maps were generated using a bivariate method that combined susceptibility with population and critical infrastructure data. The team created a LHASA standard operating procedure document for the end users at SGN and ONAMET. The partners can use this to update the susceptibility maps as new data becomes available and run the LHASA model independently to monitor near real-time landslide potential.
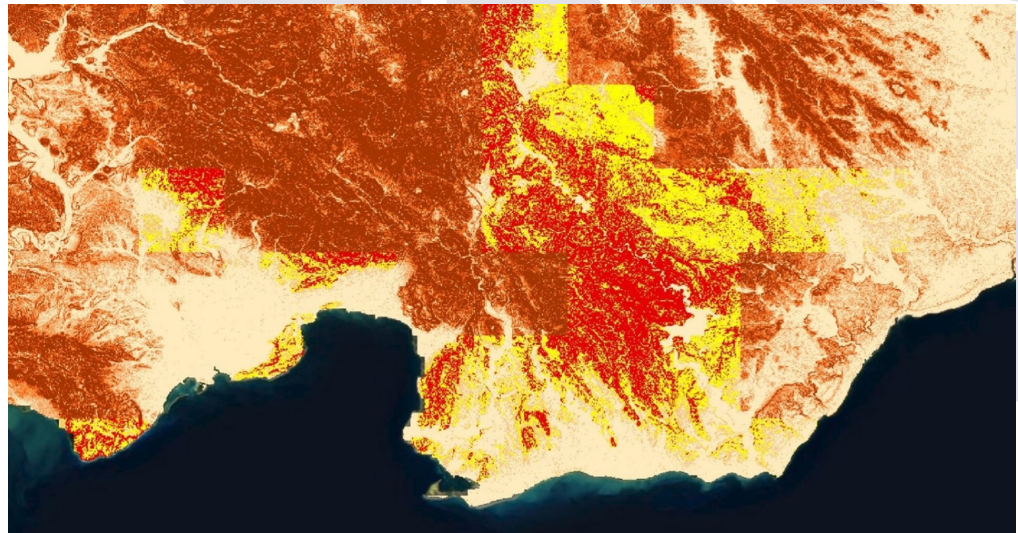
Ellicott City Disasters

Applying NASA Resources to a Statistical Flood Risk Model to Improve Early Warning Systems and Public Safety
Maryland - Goddard

TEAM: Terra Edenhart-Pepe (Project Lead), Julio Peredo, Caroline Resor, Callum Wayman
PARTNERS: Howard County Government, Office of Emergency Management; Howard County Government, Stormwater Management Division; NOAA, National Weather Service, Baltimore-Washington Weather Forecast Office
EARTH OBSERVATIONS: Aqua AMSR-E, SMAP L-band Radiometer, TRMM TMI

As flooding events in the United States grow in frequency and intensity, the use of technological advancements and applied science is increasingly necessary for effective flood monitoring and warning systems. Governments are exploring new ways of using science and technology to solve public safety and environmental problems. The NASA DEVELOP Ellicott City Disasters project investigated two extreme flood events in 2016 and 2018 within Ellicott City, Maryland. The project supported the efforts of the Howard County Office of Emergency Management (OEM), and represents the first step in improving early warning system capabilities using open data and NASA Earth observations. The resultant flood model ("Flood Learning Model Environment" or FLuME) evaluated the statistical significance of features engineered from NASA resources, such as North American Land Data Assimilation System (NLDAS) and Soil Moisture Active Passive (SMAP), and utilized stream gauge data from the Department of Homeland Security, OEM, and the United States Geological Survey. The project products included data visualizations and a model framework for exploring factors influencing flood severity. The model was trained on two years of discharge data and was subsequently used to hindcast the May 2018 flood of Ellicott City. This exploratory analysis informs OEM decision-making processes and will help the county effectively allocate monitoring technology within the Patapsco watershed, thereby increasing public safety and reducing risk.

Ecological Forecasting

OVERVIEW

DEVELOP's Ecological Forecasting projects assist decision makers with access to science-based tools in order to understand and predict the impacts of environmental change on the ecosystems that support the existence of life on Earth. The projects apply NASA remote sensing and technologies to topics like conservation, habitat health and suitability, land use practices and planning, and invasive species. This summer, DEVELOP's Ecological Forecasting projects partnered with local and state governments, non-governmental organizations, federal agencies, and international organizations to provide reliable forecasts to improve natural ecosystem management.
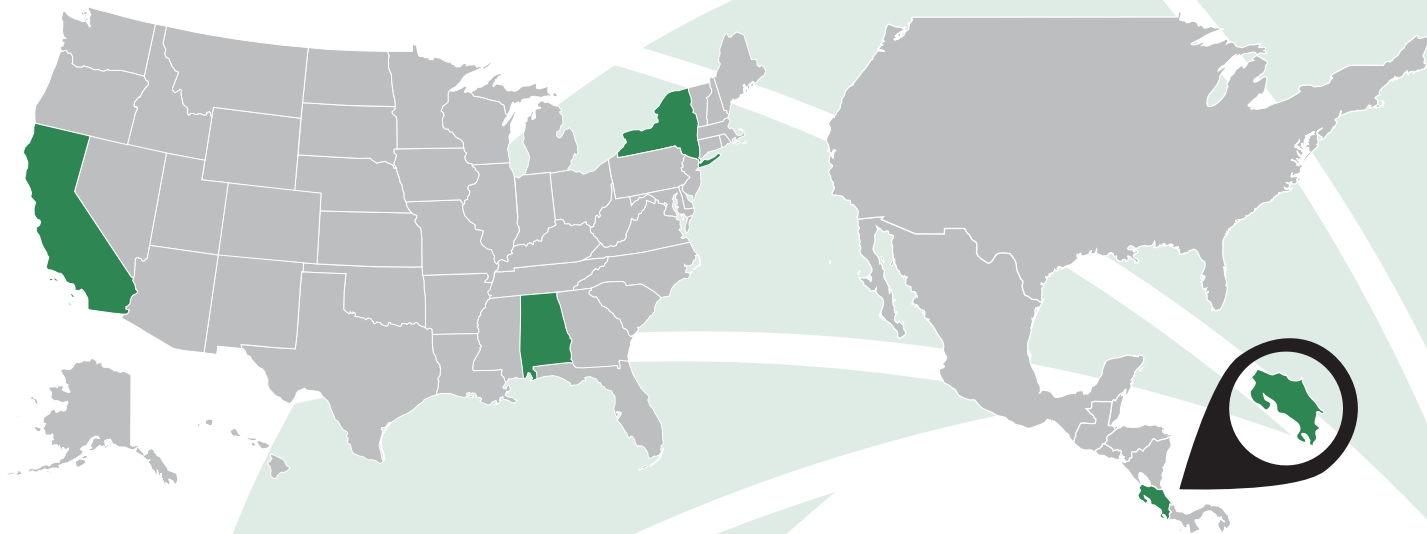
Ecological Forecasting Projects

SENSORS

ER-2 Jet AVIRIS	RapidEye	SRTM
Landsat 5 TM	Sentinel-1 C-SAR	Terra ASTER
Landsat 8 OLI	Sentinel-2 MSI	

PORTFOLIO

Conecuh National Forest Ecological Forecasting: Evaluating Current and Potential Habitats for the Endangered Gopher Frog by Assessing Wetland Environments and Land Cover Trends in the Conecuh National Forest

Monongahela National Forest Ecological Forecasting: Forecasting Forest Restoration Using NASA Earth Observations to Support the US Forest Service Monongahela National Forest

New York Ecological Forecasting II: Comparing Efficiency of Space-based Imagery to AVIRIS Airborne Data for the Identification of Hemlock Forests to Mitigate Invasive Species Expansion

Talamanca-Osa Ecological Forecasting II: Assessing Habitat Suitability and Human-Jaguar Conflict Areas to Identify Potential Jaguar Corridors Connecting La Amistad and Corcovado National Parks in Costa Rica

Santa Monica Mountains Ecological Forecasting III: Analyzing Recent Wildfire Impacts to Assist the Resource Conservation District of the Santa Monica Mountains in Identifying Tree Species to Replant

PARTNERS

Adirondack Research LLC
Alabama Department of Conservation and Natural Resources
Arizona Center for Nature Conservation - Phoenix Zoo
California Department of Parks and Recreation, Los Angeles Division
Cornell University, New York Invasive Species Research Institute
County of Los Angeles Fire Department, Prevention Services Bureau, Forestry Division
County of Los Angeles Department of Regional Planning
Mississippi State University, College of Forest Resources
National Park Service, Santa Monica Mountains National Recreation Area
New York State Department of Environmental Conservation, Partnership for Regional Invasive Species Management, Adirondack Park Invasive Plant Program (APIPP)
New York State Department of Environmental Conservation, Partnership for Regional Invasive Species Management, Saint Lawrence - Eastern Lake Ontario (SLELO PRISM)
Osa Conservation
Resource Conservation District of the Santa Monica Mountains
University of Montana, Department of Geography
University of Vermont, Rubenstein School of Environment and Natural Resources
USDA, US Forest Service, Conecuh National Forest

Conecuh National Forest Ecological Forecasting

Evaluating Current and Potential Habitats for the Endangered Gopher Frog by Assessing Wetland Environments and Land Cover Trends in the Conecuh National Forest

Alabama - Marshall

TEAM: Kara Cassano (Project Lead), Jacob Goff, Sierra Laltrello, Stefan Perritano
PARTNERS: Alabama Department of Conservation and Natural Resources; Mississippi State University, College of Forest Resources; USDA, US Forest Service, Conecuh National Forest
EARTH OBSERVATIONS: Landsat 5 TM, Landsat 8 OLI, Sentinel-1 C-SAR, Sentinel-2 MSI, SRTM

The gopher frog (*Lithobates capito*) is an endangered species facing extinction within the next century due to loss and alteration of its habitat. With limited active gopher frog habitats in Alabama, it is crucial to maintain these areas. The Gopher Frog Working Group (GFWG) works to ensure the protection and rehabilitation of gopher frog habitats to protect the survival of the species. The NASA DEVELOP Conecuh National Forest Ecological Forecasting team partnered with the Alabama Department of Conservation and Natural Resources, the United States Forest Service's Conecuh National Forest, and the Mississippi State University College of Forest Resources, which are all part of the GFWG, to identify potential habitats for the gopher frog in Conecuh National Forest. As the environment fluctuates over time, present and probable breeding wetlands are threatened. The team identified the environmental concerns endangering the breeding habitats utilizing Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI), the Shuttle Radar Topography Mission (SRTM), and Sentinel-1 C-band Synthetic Aperture Radar (C-SAR) satellite imagery. The team produced a series of map products to evaluate the status of the current breeding region, as well as forecast the future suitability of the habitat. These products enabled the GFWG to determine where to create new breeding habitats in the Conecuh National Forest.
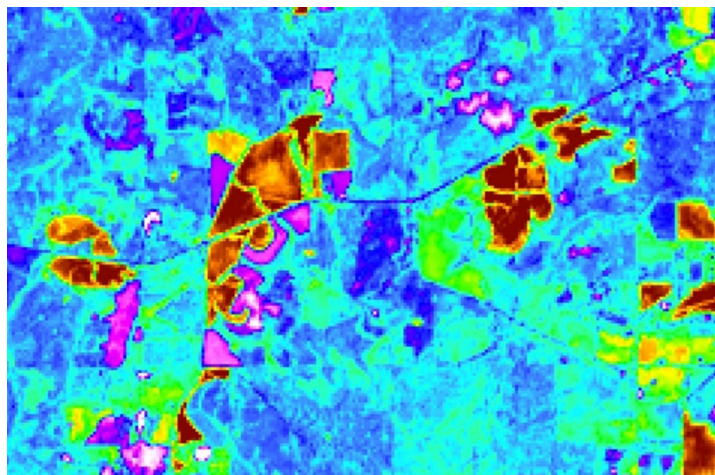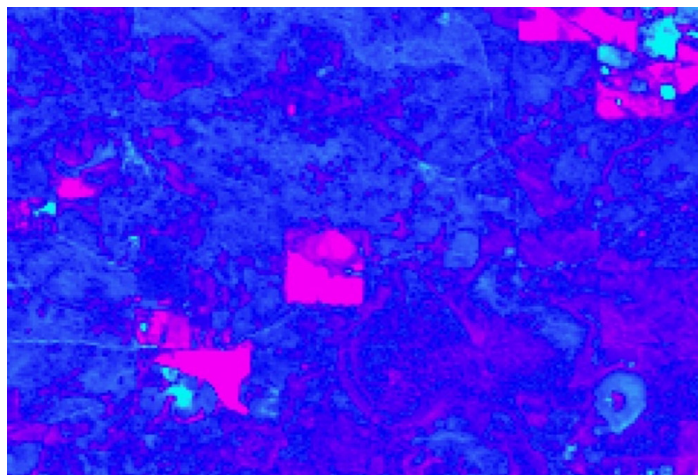
Monongahela National Forest Ecological Forecasting

Forecasting Red Spruce Restoration Using NASA Earth Observations to Support Decision Making in the USFS Monongahela National Forest

Idaho - Pocatello

TEAM: John Dialesandro (Project Lead), Mason Bull, Tia Francis, Katherine Yut
PARTNERS: USDA, US Forest Service, Monongahela National Forest; USDA, US Forest Service, Northern Institute of Applied Climate Science
EARTH OBSERVATIONS: Landsat 5 TM, Landsat 8 OLI, SRTM

Within the Monongahela National Forest (MNF), situated in the Allegheny Highlands of West Virginia, extensive logging and mining practices significantly altered the structure and composition of flora and fauna over the past two centuries. Of particular concern to MNF land managers are red spruce (*Picea rubens*) stands, which provide shelter and food to several endangered and threatened species. To aid red spruce restoration, this study mapped current and historical stands and identified non-native stands with suitable habitats for red spruce in the Sharp Knob Red Spruce Restoration Area. Data from Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI), and Shuttle Radar Topography Mission (SRTM) were input into classification tree and fuzzy logic algorithms. Furthermore, 2018 classification maps were utilized in the TerrSet Land Change Modeler to forecast red spruce extent up to 2040. As a product of these analyses, we produced three sets of maps: four time series maps of red spruce stands from 1989 to 2018, a map that identifies suitable stands for future restoration efforts, and a red spruce land cover change map up to 2040. Our results indicate that 562 hectares are suitable for future restoration in Sharp's Knob, with an 8% gain in red spruce stands from 1989 to 2018. However, forecasting results indicate that management intervention will be necessary for this trend to continue.
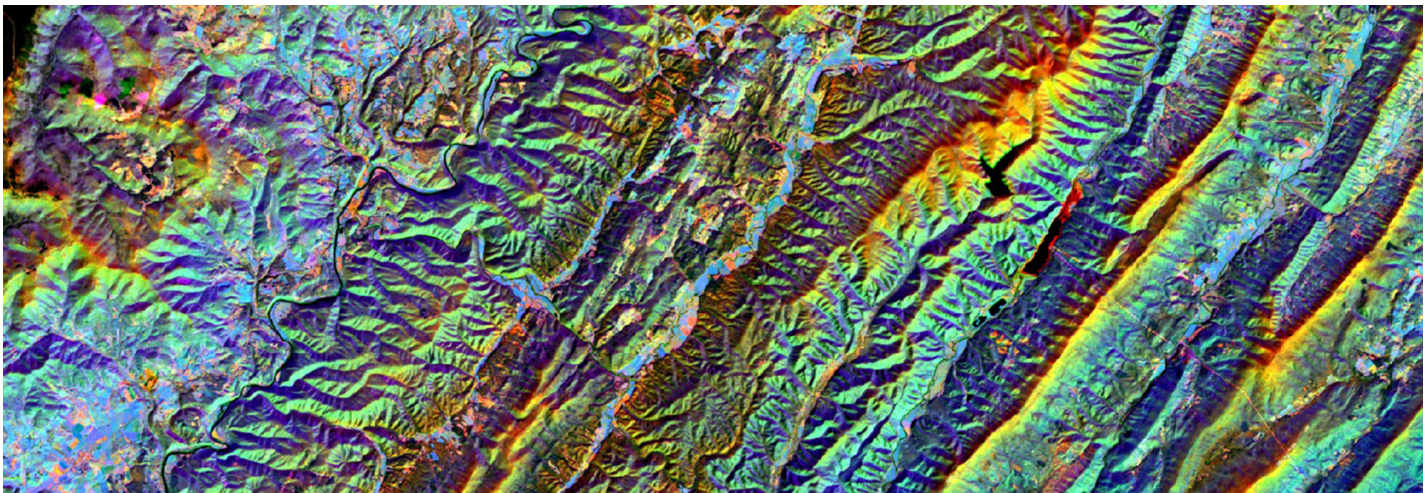
New York Ecological Forecasting II

Comparing the Efficiency of Space-Based Imagery to AVIRIS Airborne Data for the Identification of Hemlock Forests to Mitigate Invasive Species Expansion
Maryland - Goddard

TEAM: Rya Inman (Project Lead), Abigail Barenblitt, Ryan Hammock, Niharika 'Chitra' Kokkirala
PARTNERS: Adirondack Research LLC; Cornell University, New York Invasive Species Research Institute; New York State Department of Environmental Conservation, Partnership for Regional Invasive Species Management, Adirondack Park Invasive Plant Program (APIPP); New York State Department of Environmental Conservation, Partnership for Regional Invasive Species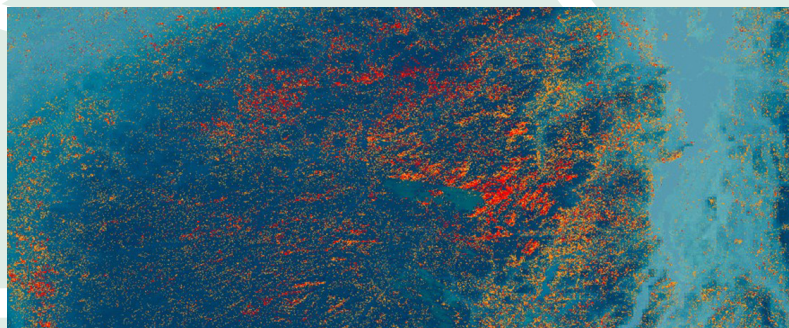 Management, Saint Lawrence - Eastern Lake Ontario (SLELO PRISM); University of Vermont, Rubenstein School of Environment and Natural Resources
EARTH OBSERVATIONS: Landsat 8 OLI, Sentinel-2 MSI, SRTM, Terra ASTER

Hemlock woolly adelgid (HWA; *Adelges tsugae*) is an invasive species that threatens eastern hemlock (*Tsuga canadensis*) in US forests. Eastern hemlock has a greater capacity to store carbon, regulate stream temperatures, and provide habitat for wildlife compared to sympatric tree species. The New York Ecological Forecasting II team partnered with the New York State Department of Environmental Conservation's Partnership for Regional Invasive Species Management, Adirondack Park Invasive Plant Program (APIPP) and Partnership for Regional Invasive Species Management, Saint Lawrence - Eastern Lake Ontario (SLELO PRISM), Adirondack Research, Cornell University, and the University of Vermont to support their hemlock conservation efforts. APIPP and SLELO currently lack detailed location data on hemlock stands. We created three hemlock distribution maps modeled using a random forest (RF) classifier in Google Earth Engine (GEE), each using data from either Landsat 8 Operational Land Imager (OLI), Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), or Sentinel-2 Multispectral Imager (MSI), as well as variables closely linked to hemlock habitat (e.g. elevation, slope, aspect, distance to nearest stream, soil type, temperature). Ground-surveyed hemlock presence points allowed the team to train and validate these models and compare the accuracy of previous Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) models to satellite-based models. Our team then used ancillary datasets, including HWA presence data and distance to the nearest stream, to predict hemlock mortality in New York and forecast forest stream resiliency through 2049. These maps aim to improve APIPP's and SLELO's current hemlock inventories and HWA early detection efforts. Hemlock distribution maps created from OLI, AVIRIS, and MSI provide more efficient, repeatable models of hemlock distribution than those created with AVIRIS data alone. Our forecasting model also supports predictions that HWA spread will result in stream health decline across NY through 2049.

Talamanca-Osa Ecological Forecasting II

Assessing Habitat Suitability and Human-Jaguar Conflict Areas to Identify Potential Jaguar Corridors
Connecting La Amistad and Corcovado National Parks in Costa Rica
Georgia - Athens

TEAM: Samuel Furey (Project Lead), Iris Fynn, Olivia Landry, Samantha Trust
PARTNERS: Arizona Center for Nature Conservation - Phoenix Zoo; Osa Conservation
EARTH OBSERVATIONS: Landsat 5 TM, Landsat 8 OLI, PlanetScope, Terra ASTER

La Amistad International Peace Park in the Talamanca Mountains and Corcovado National Park on the Osa Peninsula in Costa Rica are home to two isolated jaguar (*Panthera onca*) populations. As agricultural and urban land uses have expanded
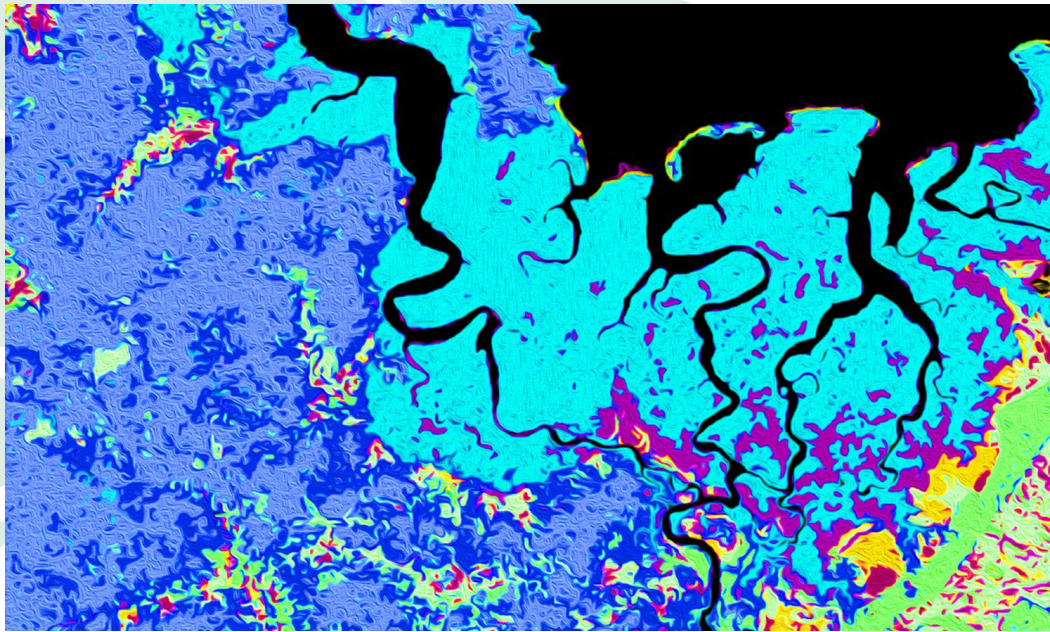
in Costa Rica, jaguar home ranges have been reduced by 40 percent. NASA DEVELOP collaborated with the Arizona Center for Nature Conservation – Phoenix Zoo and Osa Conservation to design optimal corridors between these two protected areas to reconnect isolated populations. This project used Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI) to assess trends in land use and land cover (LULC) from 1987 to 2019. From these analyses, in conjunction with elevation data from Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) as well as vector data of roads and urban centers, we forecasted LULC to 2030 using the TerrSet Land Change Modeler. These data were then used to identify forecasted human-jaguar conflict risk areas created by urban and agricultural expansion. A compilation of these inputs informed a suitability assessment that was used in Linkage Mapper to model wildlife corridors. The results from Linkage Mapper highlighted a potential corridor through the Buenos Aires Canton of the study area. Our partners will use these findings for monitoring and educational outreach efforts, and the implementation of a jaguar corridor.

Santa Monica Mountains Ecological Forecasting III

Analyzing Recent Wildfire Impacts to Assist the Resource Conservation District of the Santa Monica Mountains in Identifying Tree Species to Replant
California - JPL

TEAM: Melissa Ferriter (Project Lead), Laura Jessup, Roger Ly, Joshua Spector
PARTNERS: California Department of Parks and Recreation, Los Angeles Division; County of Los Angeles Department of Regional Planning; County of Los Angeles Fire Department, Prevention Services Bureau, Forestry Division; National Park Service, Santa Moni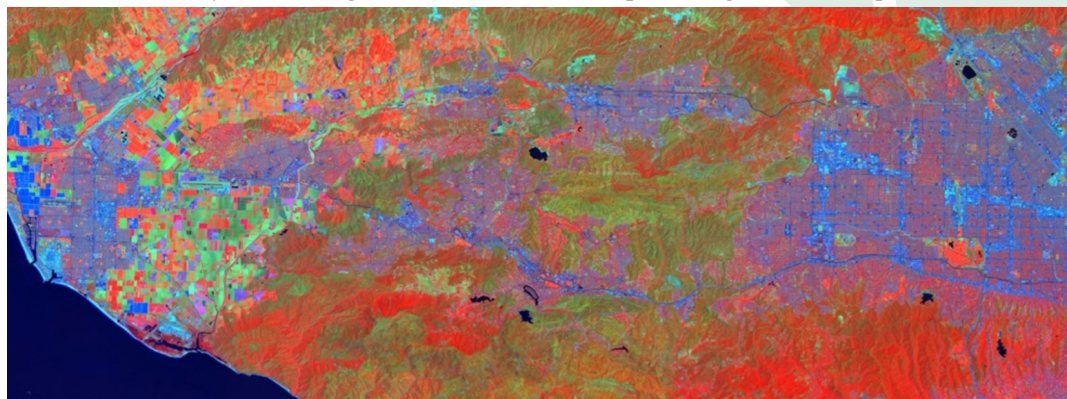ca Mountains National Recreation Area; Resource Conservation District of the Santa Monica Mountains; University of Montana, Department of Geography
EARTH OBSERVATIONS: ER-2 Jet AVIRIS, Landsat 8 OLI, RapidEye, SRTM

The Woolsey Fire began on November 8, 2018 and lasted for almost two weeks, during which it burned almost 100,000 acres of valuable landscape and habitat, including a vast area of woodland. The persistence of key woodland species provides aesthetic, monetary, and ecological value to the landscape through carbon sequestration, air temperature moderation, and

erosion mitigation, among other ecosystem services. This study investigated the impact of the Woolsey Fire on native woodland species distributions and identified areas suitable for restoration within the Santa Monica Mountains National Recreation Area. The team partnered with the Resource Conservation District of the Santa Monica Mountains; National Park Service, Santa Monica Mountains National Recreation Area; California Department of Parks and Recreation, Los Angeles County Division; County of Los Angeles Fire Department, Prevention Services Bureau, Forestry Division; County of Los Angeles Department of Regional Planning; and the University of Montana. The Earth observations used include data from Landsat 8 Operational Land Imager, NASA ER-2 Jet Airborne Visible InfraRed Imaging Spectrometer, Shuttle Radar Topography Mission, and RapidEye. The team produced maps of burn severity from the Woolsey Fire, its impact on plant species distributions, and habitat suitability projections for 2050 and 2099 to assist partners in prioritizing areas for restoration. A plant community classification was successfully created using Multiple Endmember Spectral Mixture Analysis (MESMA). Overall accuracy was assessed at 90.54% by comparing the classification to validation pixels derived from ground truth information provided by our partners.

Energy

OVERVIEW
DEVELOP's Energy projects support activities with the management, monitoring, and forecasting of critical energy resources including coal, oil, and gas, as well as renewable energy sources such as solar, wind, and hydropower. The projects apply NASA satellite data and derived products to identify site sustainability for renewable energy production. This summer, DEVELOP's Energy projects partnered with local governments to improve energy management strategies.

Energy Projects
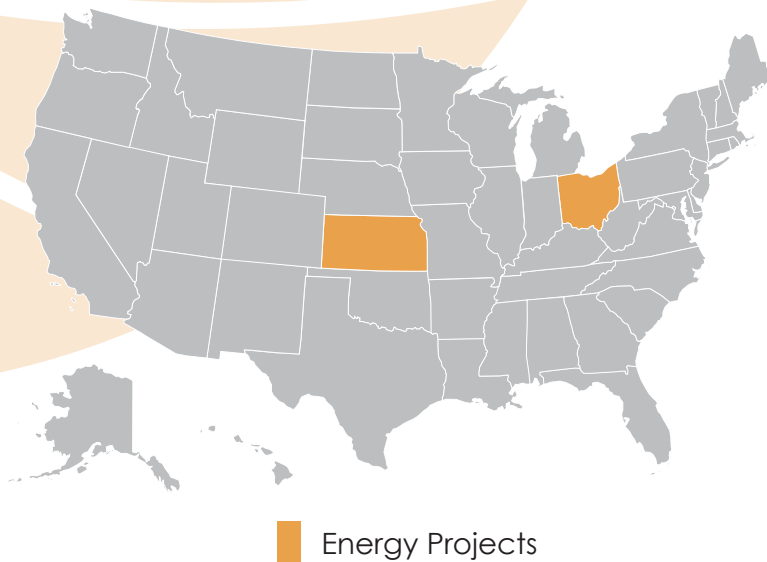
PORTFOLIO
Douglas County Energy: Identifying Areas with High Solar Power Potential in Kansas via NASA Earth Observations and LiDAR

Ohio Energy: Restructuring the Energy Balance in Ohio by Quantifying Energy Loss and Solar Potential Using NASA Earth Observations and LiDAR

PARTNERS
City of Cleveland, Office of Sustainability
Cuyahoga County, Department of Sustainability
Douglas County, Kansas

SENSORS
Aqua CERES   SRTM
Aqua MODIS   Terra CERES
Landsat 8 OLI   Terra MODIS

Douglas County Energy

Identifying Areas with High Solar Power Potential in Kansas via NASA Earth Observations and LiDAR
California - JPL

TEAM: Robert Cecil Byles (Project Lead), Thomas Crimmel, Erica O'Conner, Charlotte Stanley
PARTNER: Douglas County, Kansas
EARTH OBSERVATIONS: Aqua CERES, Aqua MODIS, Landsat 8 OLI, SRTM, Terra CERES, Terra MODIS

The City of Lawrence and Douglas County, Kansas, are working to reduce greenhouse gas emissions and achieve 100 percent renewable energy. The NASA DEVELOP team used Shuttle Radar Topography Mission (SRTM) and LiDAR elevation data, along with Landsat 8 Operational Land Imager (OLI) surface reflectance data and National Agriculture Imagery Program (NAIP) aerial imagery in order to create a solar insolation map, which identifies areas of high solar energy potential in both the City of Lawrence and Douglas County. Using this solar insolation product, the team created a solar panel site suitability map that incorporates factors, such as land cover/use, building footprints, parcel ownership, floodplain extent, and protected land areas. This product both identifies solar potential and determines the most feasible and effective properties for the installation of rooftop solar panels and ground-mounted solar farms. Our team found that Douglas County, Kansas, receives an average solar insolation of 1,982 kilowatt-hours per square meter annually and building rooftops in Lawrence receive an average of 950 kilowatt-hours per square meter annually. Additionally, we found that Douglas County and Lawrence have a great capacity for solar power, with 30 percent of Douglas County's land area and 52 percent of Lawrence's building rooftop area being highly suitable for solar panel installation. The results of this project will be utilized by Douglas County to better understand the factors that dictate solar potential and suitability, enabling personnel to make informed decisions about the ideal placement of solar panels.
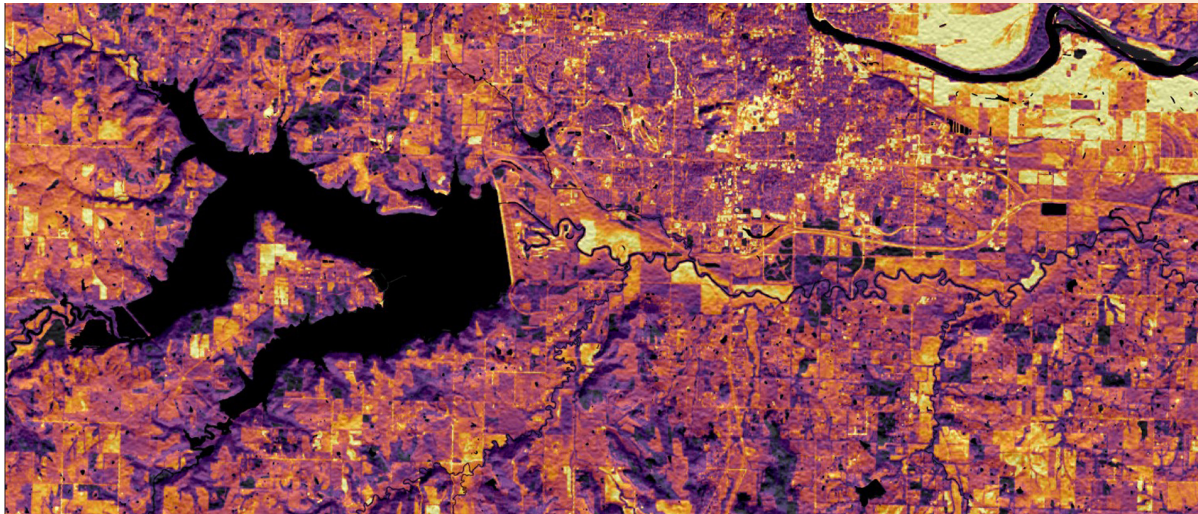
Ohio Energy

Restructuring the Energy Balance in Ohio by Quantifying Energy Loss and Solar Potential Using NASA Earth Observations and LiDAR
Arizona - Tempe

TEAM: Hannah Besso (Project Lead), Sihang Chen, Yiyi He, Crystal Wespestad
PARTNERS: City of Cleveland, Office of Sustainability; Cuyahoga County, Department of Sustainability
EARTH OBSERVATIONS: SRTM

The City of Cleveland and Cuyahoga County in Ohio are joining local governments around the globe in committing to 100% renewable energy goals by encouraging the use of solar technologies. Our team developed a method for estimating rooftop solar power potential using NASA Prediction of Worldwide Energy Resources (POWER) data to assist the City of Cleveland and Cuyahoga County with their renewable energy goals. POWER provides an estimate of incoming solar irradiation on a tilted surface by accounting for the light scattering and filtering effects of clouds and aerosols. Our methods improve on existing solar potential estimation tools through the inclusion of POWER data adjusted for roof slope, and a high-resolution (1 ft) digital surface model derived from LiDAR data, which allowed for detailed shadow, slope, and aspect modeling. To avoid overestimation, we calculated the solar potential for individual roof segments and removed those unsuitable for solar panel
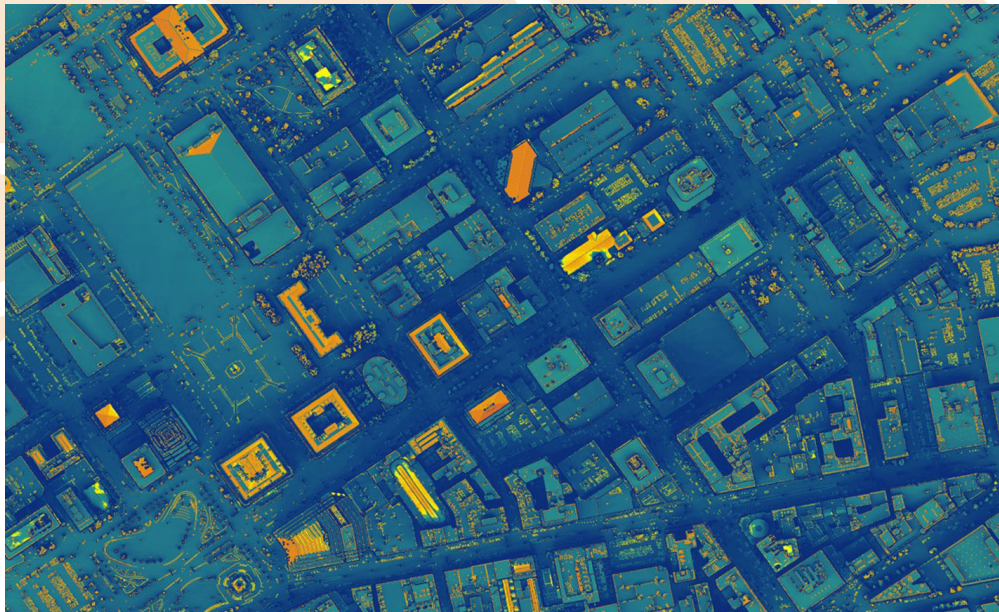
installation. We then applied our methods to a 5.38 square mile test area within the county, and found a total rooftop solar potential of over 100,000 MWh/yr. Of all the buildings with solar power potential, 19% could supply 85% of the total potential energy. These methods have the capacity to be applied to the entire county and to other regions seeking to efficiently utilize solar energy.

Health & Air Quality

OVERVIEW

DEVELOP's Health & Air Quality projects utilize satellite and airborne Earth observations, model products, and scientific findings to support air quality and public health management, as well as policy makers. This summer, DEVELOP's Health & Air Quality project partnered with state and non-governmental organizations to better understand and improve public health.
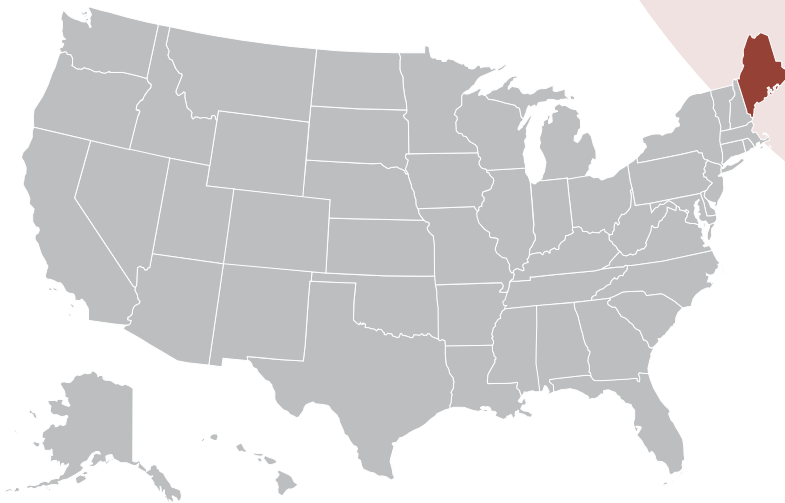
SENSORS
Aqua MODIS
Landsat 8 OLI
Terra MODIS

■ Health & Air Quality Projects

PORTFOLIO

Southern Maine Health & Air Quality: Examining Tick-Borne Illness Risk by Evaluating Land Cover and Tick Habitat Suitability in Southern Maine

PARTNERS

Bigelow Laboratory for Ocean Sciences
Maine Medical Center Research Institute, Lyme & Vector Borne Disease Laboratory
Maine Vector-Borne Disease Working Group

Southern Maine Health & Air Quality

Examining Tick-borne Illness Risk by Evaluating Land Cover and Tick Habitat Suitability in Southern Maine
Massachusetts - Boston

TEAM: Celeste Gambino (Project Lead), Britnay Beaudry, Madison Berman, Monica Colmenares
PARTNERS: Bigelow Laboratory for Ocean Sciences; Maine Medical Center Research Institute, Lyme & Vector Borne Disease Laboratory; Maine Vector-Borne Disease Working Group
EARTH OBSERVATIONS: Aqua MODIS, Landsat 8 OLI, Terra MODIS

Tick-borne diseases are a public health issue in southern Maine, and recent estimates completed by the State of Maine suggest that as little as 1 in 10 cases of Lyme disease are actually reported. There are three tick-borne diseases known to occur in Maine that can be transmitted by the deer tick (*Ixodes scapularis*). Due to the higher prevalence and attention from Maine public health institutions, Lyme disease was the predominant focus in this study. The Massachusetts – Boston NASA DEVELOP team partnered with the Maine Medical Center Research Institute, Lyme & Vector-Borne Disease Laboratory; Maine Vector-Borne Disease Working Group; and Bigelow Laboratory for Ocean Sciences to assist with Maine's tick-borne disease mitigation efforts. The team utilized NASA data from Landsat 8 Operational Land Imager (OLI), Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS), NASA Global Land Data Assimilation System (GLDAS), and NASA Daymet V3, as well as other ancillary datasets, from January 2008 to June 2019. Accurate land cover and tick-borne disease risk maps were created for Cumberland County, Maine. The land cover map allows for improved public awareness of areas conducive to tick encounter. The risk maps illustrate how variations in temperature, humidity, vapor pressure deficit, and precipitation contribute to the spatial distribution of tick-borne illness risk as well as determines the estimated number of actual Lyme disease incidents per year in every town. In addition, the team created a time series analysis that informs the end-users research related to the impact of environmental parameters on tick distribution.
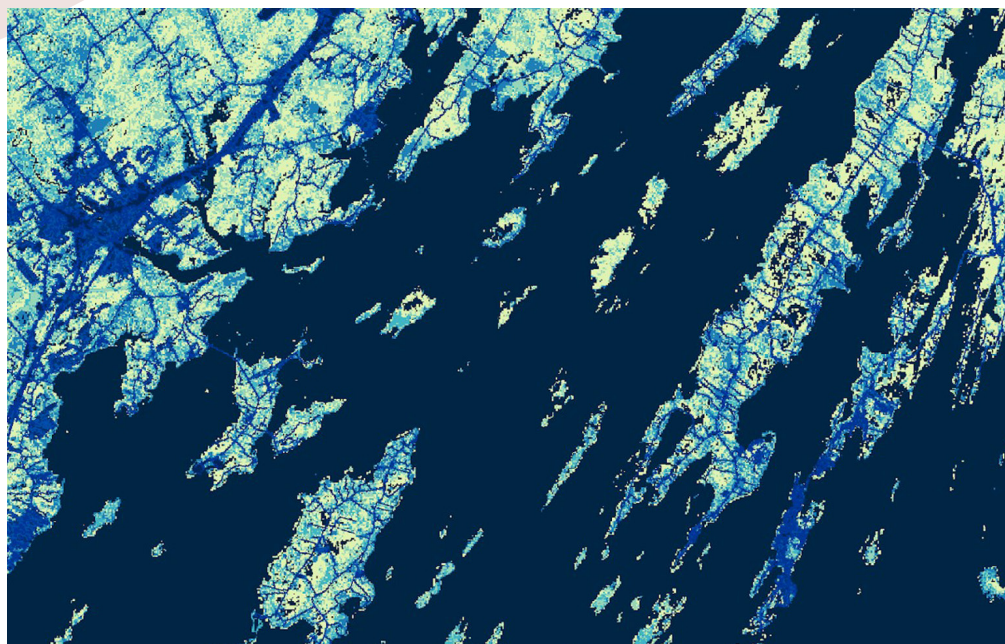
Transportation & Infrastructure

OVERVIEW

DEVELOP's Transportation & Infrastructure projects focus on the application of NASA Earth observations to support planning, monitoring, and management of infrastructure (dams, roads, rail, ports, and pipelines) and transportation (air, land, and sea). This summer, DEVELOP's Transportation & Infrastructure projects partnered with non-governmental organizations, academic institutions, consortiums, and international government organizations to support disaster response and land disturbance from mining impacts and reclamation efforts.
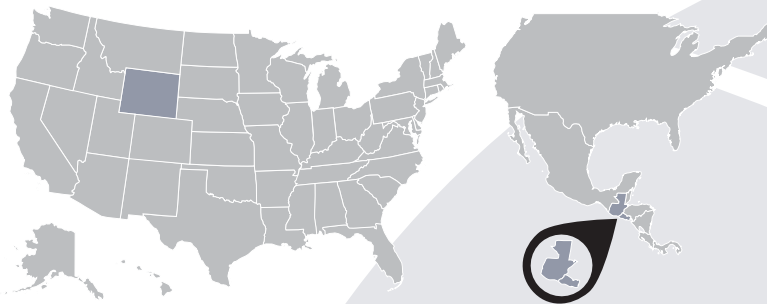
Transportation & Infrastructure Projects

PORTFOLIO

Central America Transportation & Infrastructure:
Employing NASA Earth Observations to Map Historic Flooding in Guatemala and El Salvador

Powder River Basin Transportation & Infrastructure:
Monitoring Land Disturbances Caused by Coal Mining in the Powder River Basin Using Remote Sensing

SENSORS

ALOS PALSAR   Landsat 8 OLI
Landsat 5 TM   Sentinel-1 C-SAR
Landsat 7 ETM+   SRTM

PARTNERS

Clemson University, Energy-Economy-Environment Systems Analysis Group
Coordinadora Nacional para la Reducción de Desastres (Guatemala)
Instituto Nacional de Sismología, Vulcanología, Meteorología, e Hidrología (Guatemala)
Ministerio de Medio Ambiente y Recursos Naturales, Observatorio Ambiental (El Salvador)
NASA SERVIR Science Coordination Office
Powder River Basin Resource Council
Western Organization of Resources Councils
SkyTruth

Central America Transportation & Infrastructure

Employing NASA Earth Observations to Map Historic Flooding in Guatemala and El Salvador

Alabama - Marshall

TEAM: Vanesa Martin (Project Lead), Sam Heagney, Carly Muir, Gentry Patterson
PARTNERS: Coordinadora Nacional para la Reducción de Desastres (Guatemala); Instituto Nacional de Sismología, Vulcanología, Meteoro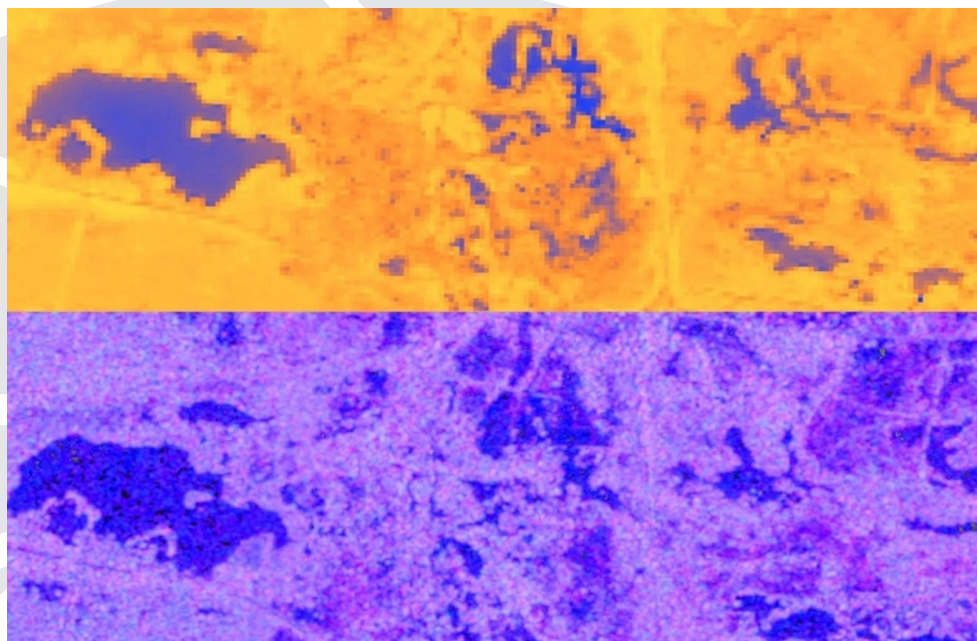logía, e Hidrología (Guatemala); Ministerio de Medio Ambiente y Recursos Naturales, Observatorio Ambiental (El Salvador); NASA SERVIR Science Coordination Office
EARTH OBSERVATIONS: ALOS PALSAR, Sentinel-1 C-SAR, SRTM

Central America is one of the world's most vulnerable regions to natural disasters, including landslides and precipitation-driven flooding. In an effort to support disaster management and emergency response planning, this project developed a methodology that employed NASA Earth observations to map historic riparian flooding extents near the Pacific coast of Guatemala and El Salvador. Radar-based techniques were used to detect inundation impact to areas near rivers. Specific Earth observations consisted of moderate resolution remote sensing systems, such as the Shuttle Radar Topography Mission (SRTM), the ALOS Phased Array type L-band Synthetic Aperture Radar (PALSAR), and the C-band synthetic aperture radar (SAR) sensor aboard Sentinel-1. End users for this project were Guatemala's Coordinadora Nacional para la Reducción de Desastres (CONRED) and the Instituto Nacional de Sismología, Vulcanología, Meteorología, e Hidrología (INSIVUMEH), and El Salvador's Observatorio Ambiental, all of which focus on disaster monitoring and response. This research was intended for the broader benefit of the Central American political and economic organization known as Sistema de la Integración Centroamericana (SICA), with the aim of integrating NASA Earth observations into its environmental decision making.

Powder River Basin Transportation & Infrastructure

Monitoring Land Disturbances Caused by Coal Mining in the Powder River Basin Using Remote Sensing
California - Ames

TEAM: Gina Cova (Project Lead), Andrew Bake, Claudia Herbert, Hayley Pippin
PARTNERS: Clemson University, Energy-Economy-Environment Systems Analysis Group; Powder River Basin Resource Council; SkyTruth; Western Organization of Resources Councils
EARTH OBSERVATIONS: Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI

Coal mines in the Powder River Basin of Wyoming account for approximately 41 percent of coal production in the United States, causing significant land disturbances. Without proper reclamation practices, orphan mines create barren, unstable lands unlikely to recover. Where mines have been successfully reclaimed, human and natural communities benefit from reconnected hydrology, functioning ecosystems, and economic opportunities, but the financial decline of the coal industry has raised concerns about the stability of long-term reclamation efforts. The Powder River Basin Transportation & Infrastructure team partnered with the Powder River Basin Resource Council and the Western Organization of Resource Councils to create a Coal Mining Assessment Tool (CMAT) in Google Earth Engine to monitor the impacts and reclamation efforts of coal mines in the basin. The tool incorporates Earth observations from Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), and utilizes the LandTrendr change detection algorithm to assess land disturbance. CMAT outputs include land disturbance maps and charts showing how land cover, Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and tasseled cap transformations have changed from 1985 to 2018. In a case study of three neighboring mines, results showed that the mine nationally recognized for its reclamation practices recovered land up to 78 percent faster than its neighbors. The ability to visualize and assess how coal mining and reclamation has progressed over the study period will allow partners to better understand and advocate for regional reclamation practices.
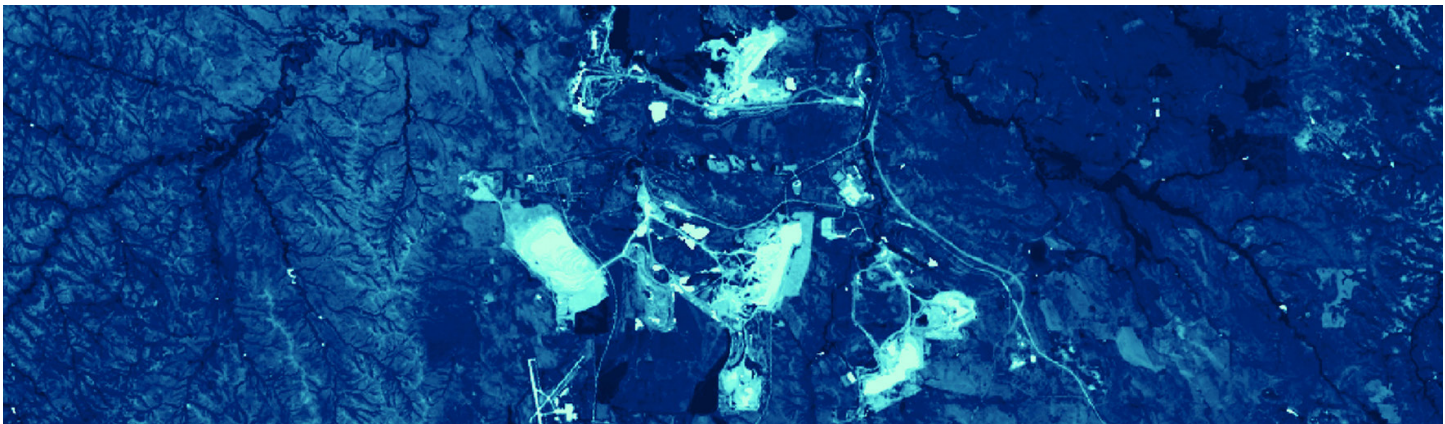
Urban Development

OVERVIEW

DEVELOP's Urban Development projects focus on the application of NASA Earth observations to enhance urban planning, monitoring of land change over time, assessment of urban footprints, and the development of sustainable and resilient urban environments. These projects support sustainability, resilience, and safety of cities and human settlements through informed planning and management of climate and disaster risks. This summer, DEVELOP's Urban Development projects partnered with state and federal agencies to address urban issues.
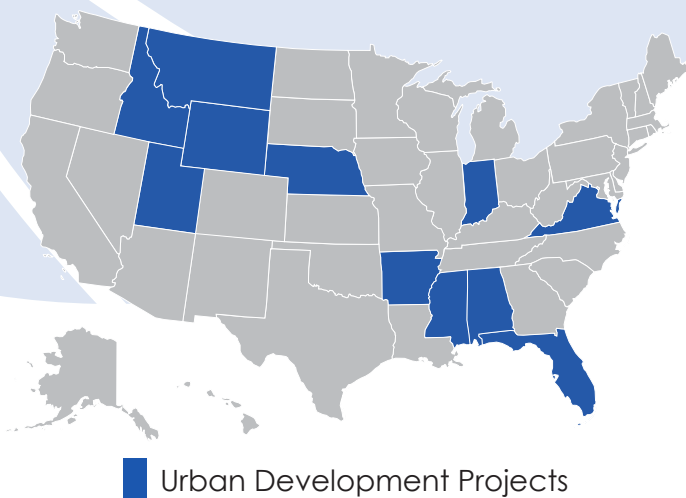
SENSORS

Landsat 5 TM	Sentinel-2 MSI
Landsat 8 OLI	Suomi NPP VIIRS
Landsat 8 TIRS	SRTM
Sentinel-1 C-SAR	Terra MODIS

PARTNERS

Boise State University
City of Hampton
Groundwork USA, Groundwork Mobile County
National Park Service, Natural Sounds and Night Skies
Division, Night Skies Program
Waggonner & Ball Architecture/Environment

■ Urban Development Projects

PORTFOLIO

Hampton Roads Urban Development II: Assessing Urban Tree Canopy and Impervious Surface Distribution to Inform Urban Planning in Hampton, Virginia

Mobile Urban Development: Evaluating Urban Heat Islands and Flooding to Enhance Green Infrastructure Initiatives in Coastal Communities in Mobile, Alabama

US Urban Development II: Utilizing Skyglow Tools to Assist in the Management of Light Pollution in US National Parks

Hampton Roads Urban Development II
Assessing Urban Tree Canopy and Impervious Surface Distribution to Inform Urban Planning in Hampton, Virginia
Virginia - Langley

TEAM: Stephanie Kealy (Project Lead), Sophie Barrowman, Paige Haley, Alina Schulz
**PARTNERS:** City of Hampton; Waggonner & Ball Architecture/Environment
EARTH OBSERVATIONS: Landsat 5 TM, Landsat 8 OLI

Hampton Roads' 1.6 million residents thrive on bustling military, harbor, and environmental industries. The region's stakeholders identified an increasing flood and water quality risk due to urbanization, a changing climate, and sea-level rise. These hazards threaten not only the livelihood of Hampton Roads residents, but also the well-being of the entire country, as several key federal facilities exist in the region. Impervious surface cover and urban tree canopy cover are two known variables that influence flood risk. Using Landsat 5 Thematic Mapper and Landsat 8 Operational Land Imager, the team created maps of impervious surface and tree canopy cover change from 2000 to 2019 for the City of Hampton. These maps supported City of Hampton officials in directing resiliency efforts towards areas of greatest vulnerability within their municipality. Additionally, the team used the Impervious Surface Analysis Tool (ISAT) to illustrate how changes in impervious surface coverage impact local water quality and how different land management scenarios might alter these consequences. The team's methodology will allow city officials to create updated impervious surface and tree canopy cover maps any time new imagery becomes available. Moreover, the team supported the city officials' goals of using a place-based approach by demonstrating how the methodology can be applied to the smaller Newmarket Creek watershed in order to empower residents as active custodians of the environment.
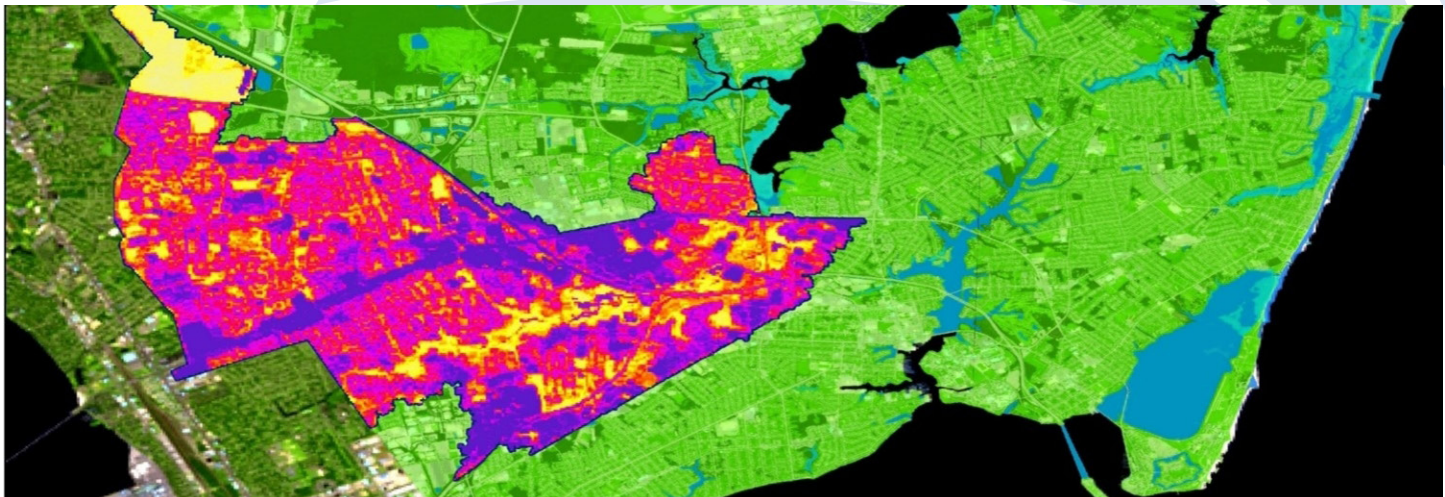
Mobile Urban Development

Evaluating Urban Heat Islands and Flooding to Enhance Green Infrastructure Initiatives in Coastal Communities in Mobile, Alabama

Alabama - Mobile

TEAM: Lydia Stanley (Project Lead), Arman Bajracharya, Kelly Dunn, Filoteo Gomez-Martinez
PARTNER: Groundwork USA, Groundwork Mobile County
EARTH OBSERVATIONS: Landsat 5 TM, Landsat 8 OLI, Landsat 8 TIRS, Sentinel-1 C-SAR, Sentinel-2 MSI, SRTM, Terra MODIS

This project utilized satellite Earth observations to assess locations in Mobile County, Alabama, that are vulnerable to the urban heat island (UHI) effect and flood impacts. Our partner, Groundwork Mobile County (GWMC), and other local entities need information on UHIs and flooding risk to develop mitigation strategies for reducing such threats. To locate communities with UHI impacts between 2005 and 2019, our team used Landsat 5 Thematic Mapper (TM), Landsat 8 Thermal Infrared Sensor (TIRS), and Terra Moderate Resolution Imaging Spectroradiometer (MODIS) to evaluate land surface temperature. Low elevation areas susceptible to flooding were distinguished using Shuttle Radar Topography Mission (SRTM) data. The team assessed flash flood vulnerability with Sentinel-1 C-band Synthetic Aperture Radar (C-SAR) and LiDAR elevation data. Lastly, the team processed data from Landsat 5 TM and Landsat 8 Operational Land Imager (OLI) to compute the Normalized Difference Vegetation Index (NDVI), compared that data with Sentinel-2 Multispectral Instrument (MSI) data to evaluate impervious surface area, resulting in the increase in urban development over time. A Social Vulnerability Index (SoVI) was produced for Mobile County based on a five-point scale, comparing demographic characteristics with UHIs and flood potential. To compute social vulnerability maps, the team retrieved data from the Agency of Toxic Substances and Disease Registry (ATSDR) dataset. Of the 114 census tracts, 11 tracts showed high risk for both flooding and extreme urban heat. Our project provided GWMC with end products that help in planning mitigation strategies for reducing flood risks and UHI effects.

US Urban Development II
Utilizing Skyglow Tools to Assist in the Management of Light Pollution in US National Parks
Virginia - Langley

TEAM: Rachel Luo (Project Lead), Sarah Parker, Charlotte Rivard, Elise Turrietta
PARTNERS: Boise State University; National Park Service, Natural Sounds and Night Skies Division, Night Skies Program
EARTH OBSERVATIONS: Suomi NPP VIIRS

The expansion of cities and infrastructure networks has raised concerns regarding the impact of growing artificial light pollution on wildlife and human well-being. In addition to degrading night skies for aesthetic viewing, this 'skyglow' interferes with ecosystems by disrupting plant life, animal behavior, and human circadian rhythms. In partnership with the National Park Service (NPS), this project created a tool to facilitate the estimation of skyglow in national parks. To conduct this work, the team used the Skyglow Estimation Toolbox (SET), a Python-based program that calculates artificial skyglow by applying a model of light propagation to visible light radiance imagery from the Suomi National Polar-orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB). A previous group enhanced SET's abilities through the creation of a graphic user interface, and the current team focused on finalizing and validating SET. By comparing skyglow estimations from SET for select parks with the NPS's ground truth data, the team confirmed that the two showed a tight linear correlation for most parks, and that SET outputs closely aligned with NPS data after a simple calibration factor. The team trained NPS officials to use SET, and produced 3D hemispheric brightness maps for six parks and three additional regions to visualize the prevalence of light pollution.

Water Resources

OVERVIEW

DEVELOP's Water Resources projects address concerns and decision processes that are related to water availability, water forecasting, and water quality. The goal of the Water Resources theme is to apply NASA satellite data to improve the decision support tools of user groups that manage water resources. This summer, DEVELOP's Water Resources projects partnered with international organizations, local and federal agencies, and non-governmental organizations to improve water management around the globe.
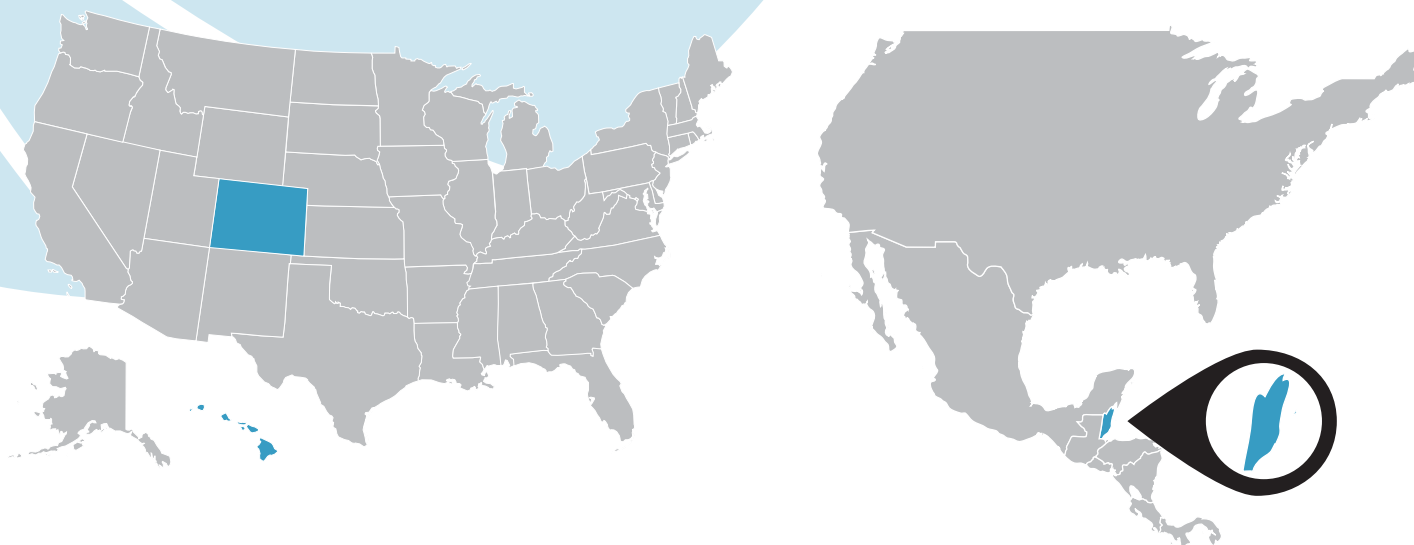
Water Resources Projects

PORTFOLIO

American Samoa Water Resources: Evaluating the Impacts of Land Cover and Water Quality Changes in American Samoa to Improve Watershed Management

Belize Water Resources: A Google Earth Engine Dashboard for Assessing Coastal Water Quality in Belize's Coral Reefs to Identify Sustainable Development Goals (SDGs) for Achieving Sustainable Use of Natural Resources

Moloka'i Water Resources: Employing NASA Earth Observations to Map the Impacts of the 'Ohi'a Rust on Forest Health and Coastal Turbidity on Moloka'i, Hawaii

Rocky Mountain Water Resources II: Employing NASA and ESA Earth Observations to Monitor Alpine Lake Algal Productivity in Rocky Mountain National Park

PARTNERS

American Samoa Department of Marine and Wildlife Resources, Coral Reef Advisory Group
Coastal Zone Management Authority and Institute (Belize)
National Park Service, Rocky Mountain National Park
Pu'u O Hoku Ranch
The Nature Conservancy
US Coral Reef Task Force, Watershed Partnership Initiative
USGS, Fort Collins Science Center
Wildlife Conservation Society

SENSORS

Aqua MODIS   Sentinel-1 C-SAR   Terra MODIS
Landsat 8 OLI   Sentinel-2 MSI

American Samoa Water Resources

Evaluating the Impacts of Land Cover and Water Quality Changes in American Samoa to Improve Watershed Management
California - Ames

TEAM: Marshall Worsham (Project Lead), Melissa Collin, Eric Davis, Arev Markarian
PARTNERS: US Coral Reef Task Force, Watershed Partnership Initiative; American Samoa Department of Marine and Wildlife Resources, Coral Reef Advisory Group
EARTH OBSERVATIONS: Landsat 8 OLI

For at least the past two decades, the coral reefs and coastal ecosystems of the American Samoan island of Tutuila have experienced deteriorating water quality. Increased levels of sedimentation, nutrients, and other land-based sources of pollution (LBSP) have negatively impacted these systems and the local fishery-based economy. Traditional efforts to monitor these systems, such as *in situ* water quality sampling studies and field surveys of piggery operations, have proven insufficient, prompting the US Coral Reef Task Force (CRTF) Watershed Partnership Initiative (WPI) and the American Samoa Department of Marine and Wildlife Resources (DMWR) Coral Reef Advisory Group (CRAG) to seek new strategies. This project provided the partners with maps and geospatial data products to support management interventions designed to mitigate the impacts of land use and land cover change. A time series analysis deployed Earth observations from Landsat 8 Operational Land Imager (OLI) to analyze changes in land cover and chlorophyll-a (Chl-a) concentrations, a proxy for water quality, from 2013 to 2019, at an island-wide scale. Ancillary data products from the United States Department of Agriculture Natural Resources Conservation Service were used to depict change patterns in land cover at a more granular scale, using the Tafuna Plain and Faga'itua Bay as sample sites because of the biodiversity and vulnerability of their marine ecosystems. The end products supplied project partners with knowledge and tangible decision-support tools to maintain the structure and function of vital coastal ecosystems.
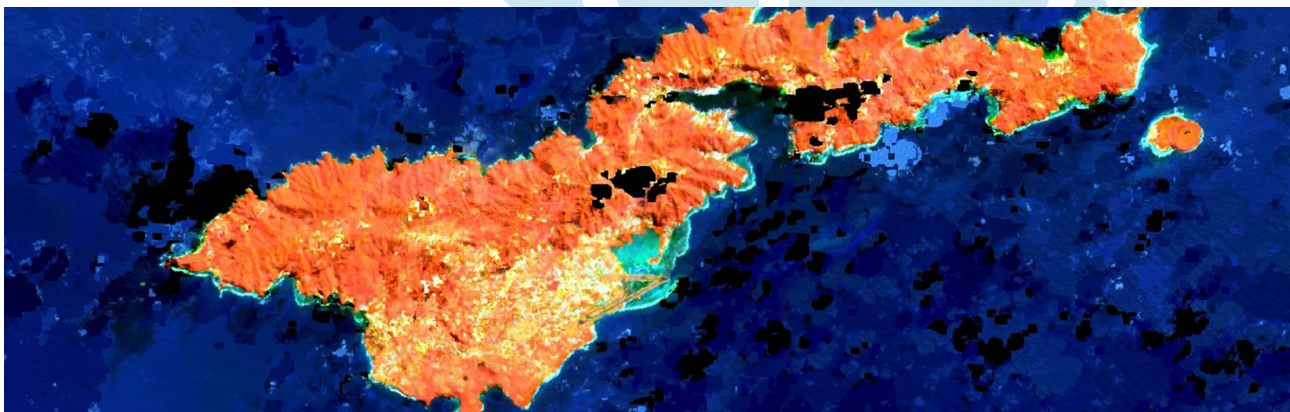
Belize Water Resources

A Google Earth Engine Dashboard for Assessing Coastal Water Quality in Belize's Coral Reefs to Identify Sustainable Development Goals for Achieving Sustainable Use of Natural Resources
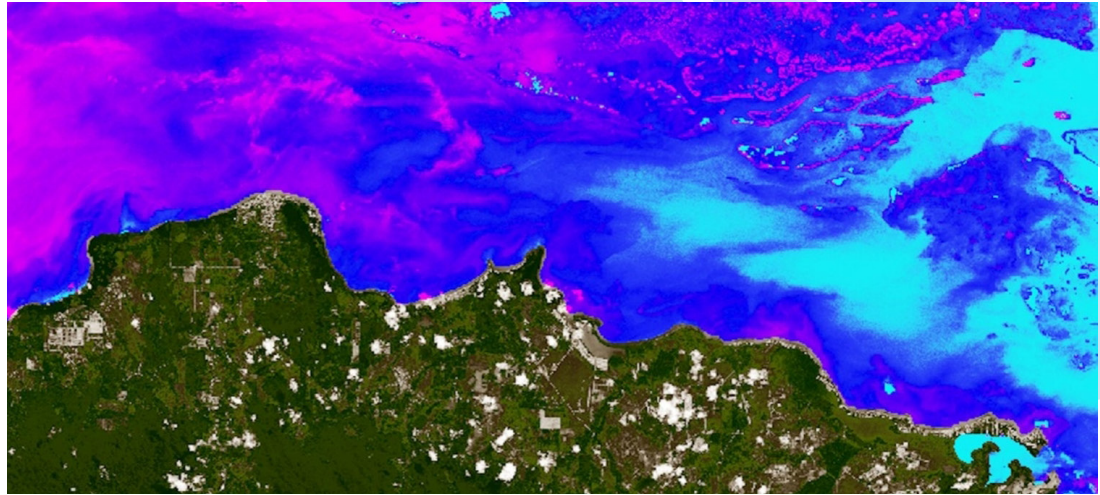*California - Ames & California - JPL*

TEAM: Charlie Devine (Project Co-Lead), Alice Lin (Project Co-Lead), Alana Higgins, Sophia Skoglund
PARTNERS: Coastal Zone Management Authority and Institute (Belize); Wildlife Conservation Society
EARTH OBSERVATIONS: Aqua MODIS, Landsat 8 OLI, Sentinel-2 MSI, Terra MODIS

The Belize Barrier Reef is a biodiverse marine ecosystem and the largest coral reef system in the western hemisphere. The reef also provides ecosystem services in the form of fisheries and tourism and is estimated to be responsible for 12 to 15 percent of the nation's gross domestic product. Retaining these ecosystem functions requires sustainable coastal management and preservation of water quality, especially in the face of global changes in climate and local anthropogenic impacts. The Belize Water Resources team at NASA Jet Propulsion Laboratory and NASA Ames Research Center partnered with the Coastal Zone Management Authority and Institute, a Belizean governmental agency, and the Wildlife Conservation Society to evaluate water quality conditions and inform coastal management decisions. Using Google Earth Engine, we developed a tool that outputs a time series of sea surface temperature, turbidity, and chlorophyll-a concentration derived from Landsat 8 Operational Land Imager (OLI) and Sentinel-2 Multispectral Instrument (MSI), Aqua Moderate Resolution Imaging Spectroradiometer (MODIS), and Terra MODIS satellite imagery. With optical data available from 2013 onward, our partners can efficiently identify reef areas threatened by depreciating water quality, designate Marine Protected Areas and no-take zones, and conduct temporal analyses of water quality changes following environmental disturbance events, such as hurricanes. Additionally, this tool will assist in identifying indicators that may be used to measure Belize's progress towards Sustainable Development Goals regarding marine environments. Using the tool, partners can better monitor changing water quality and make decisions accordingly in regards to sustainable resource use, coral reef conservation practices, and environmental capital.

Moloka'i Water Resources

Employing NASA Earth Observations to Map the Impacts of the 'Ohi'a Rust on Forest Health and Coastal Turbidity on Moloka'i, Hawaii

Colorado - Fort Collins

TEAM: Nicole Pepper (Project Lead), David Fluharty, Sophia Leiker, Caroline Odell
PARTNERS: Pu'u O Hoku Ranch; The Nature Conservancy; USGS, Fort Collins Science Center
EARTH OBSERVATIONS: Landsat 8 OLI, Sentinel-1 C-SAR, Sentinel-2 MSI
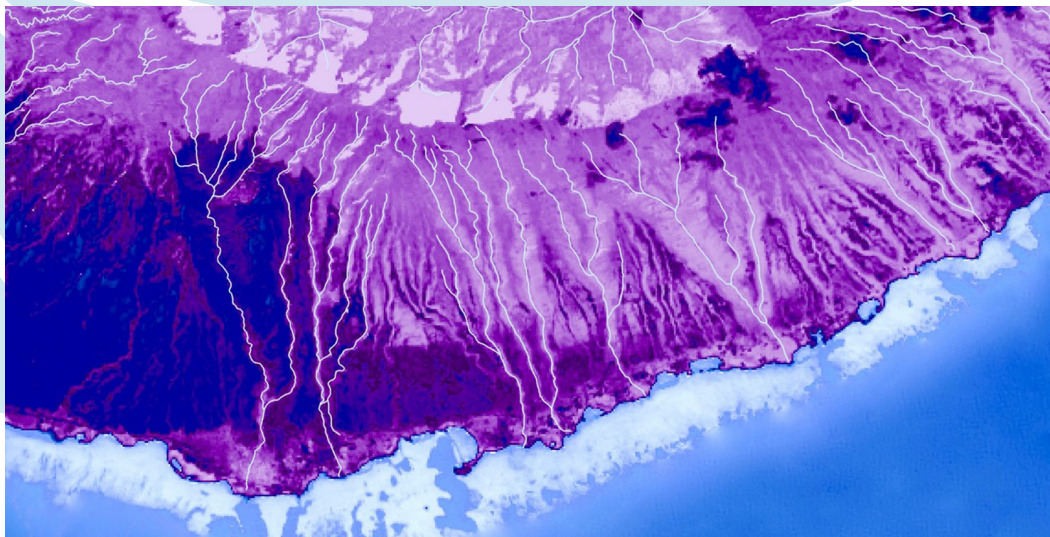
The threat of invasive species has impacted fragile forests across the globe; such impacts can be particularly damaging on island ecosystems where a loss in vegetation can lead to increased runoff. In 2017, a fungal pathogen outbreak of *Puccinia psidii* impacted 'ohi'a *(Metrosideros polymorpha)* on Moloka'i, Hawaii, causing widespread defoliation and tree mortality. The impacts of this disease have been intensified by invasive ungulates, which stress the trees and increase their vulnerability to disease. Our team partnered with The Nature Conservancy and the United States Geological Survey to better understand the impacts of rust outbreak on forest health and resulting changes in watershed dynamics on Moloka'i. The Nature Conservancy constructed exclosures around the island to protect vital sections of the forest from ungulates, which can overgraze forest understory, damage trees, and increase their susceptibility to pathogen outbreaks. This project assessed the feasibility of using Landsat 8 Operational Land Imagery and Sentinel-2 MultiSpectral Instrument to map the impact of 'ohi'a forest health, evaluate the effectiveness of fenced exclosures, and assess the feasibility of detecting turbid events from 2013 to 2019. Our results demonstrated a general decline in spectral vegetation indices within impacted areas of the forest, while within the exclosures vegetation indices improved over time. Additionally, we found that we were unable to significantly distinguish between turbid and non-turbid events. With an increased understanding of the rust outbreak impacts, our partners can make better informed management decisions to conserve the 'ohi'a and maintain its crucial ecosystem services, such as providing habitat, storing water, and maintaining the island's hydrologic cycle.

Rocky Mountain Water Resources II

Employing NASA and ESA Earth Observations to Monitor Alpine Lake Algal Productivity in Rocky Mountain National Park
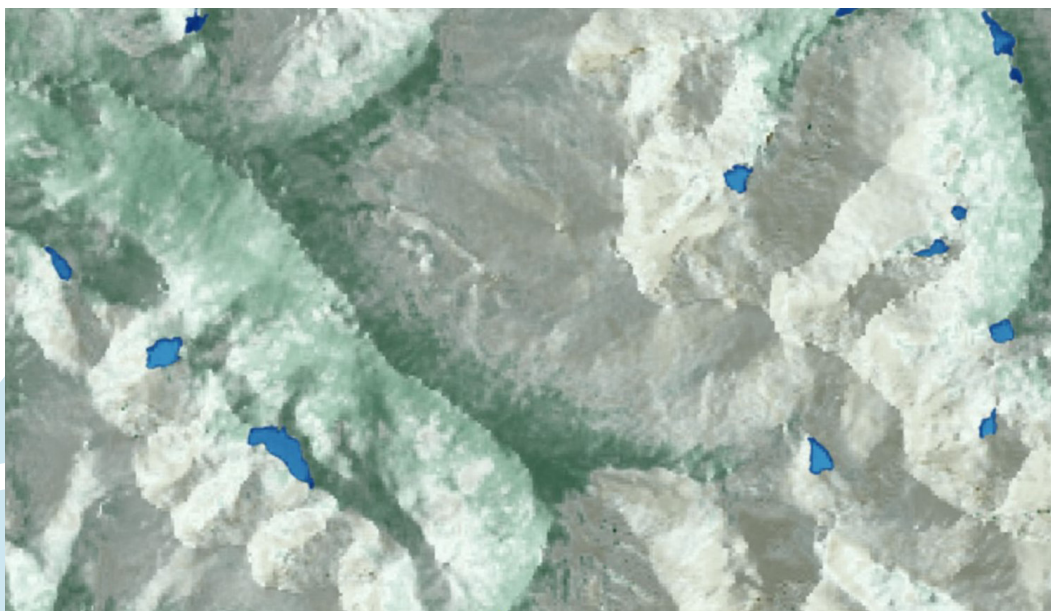*Colorado - Fort Collins*

TEAM: Anastasia Kunz (Project Lead), Genevieve Clow, Natalie Schmer, Sarah Wingard
PARTNERS: National Park Service, Rocky Mountain National Park; USGS, Fort Collins Science Center
EARTH OBSERVATIONS: Landsat 8 OLI, Sentinel-2 MSI

Alpine lakes in Rocky Mountain National Park (RMNP) serve as an important habitat and water source for wildlife, and contribute to the overall aesthetic value of the park. However, since the 1960s, alpine lakes within RMNP have experienced intensified algal productivity as a result of rising temperatures and increased nitrogen and phosphorus deposition. This increased algal productivity may have negative impacts on water quality, ecological function, and park aesthetic. Due to the remote location of many of these lakes, continuous monitoring of algal productivity is difficult. In order to assist in the surveillance of these lakes, the Rocky Mountain Water Resources II team partnered with the United States Geological Survey's Fort Collins Science Center, and the National Park Service at RMNP, to develop a methodology integrating satellite imagery for monitoring chlorophyll-a concentration as a proxy for algal productivity. In 2016, DEVELOP's Rocky Mountain Climate team utilized Landsat 8 Operational Land Imager (OLI) to predict chlorophyll-a levels, but were limited by the spatial and temporal resolution of the data. This feasibility analysis compared the efficacy of integrating higher resolution Sentinel-2 Multispectral Instrument (MSI) data with Landsat 8 OLI indices in detecting chlorophyll-a at two RMNP focal lakes, Sky Pond and The Loch. An increased understanding of the algal productivity of these lakes will allow our partners to promote best management practices in maintaining the resilience and preserve the beauty of these fragile ecosystems.

2019 **Summer Participants**

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Get **Involved**

DEVELOP is a dynamic program that offers multiple avenues for involvement to a wide variety of people. **If interested, we suggest reaching out to the program today!**

Engage as a **DEVELOPer:**

DEVELOP has three application periods per year—spring, summer, and fall. Anyone over the age of 18 who is interested in Earth science and remote sensing is eligible to apply. This includes currently enrolled college students, recent graduates, early career professionals, transitioning career professionals, and active & recently transitioned U.S. military service members. Individuals from all education levels and backgrounds are welcome to apply.

Applicants must have a minimum 3.0 GPA on a 4.0 scale at their current or last institution of higher learning, the ability to transport themselves to and from the DEVELOP location, and a strong desire to learn more about NASA Earth observations, GIS, and remote sensing.

U.S. CITIZENS – Eligible to apply to all DEVELOP locations in the United States.
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Engage as an **ADVISOR:**

A broad spectrum of advising supports DEVELOP projects, ranging from remote sensing experts to specialists in specific project topics. If you are interested in volunteering your time advising a DEVELOP project, please contact the DEVELOP National Program Office to discuss potential opportunities at **NASA-DL-DEVELOP@mail.nasa.gov.**

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