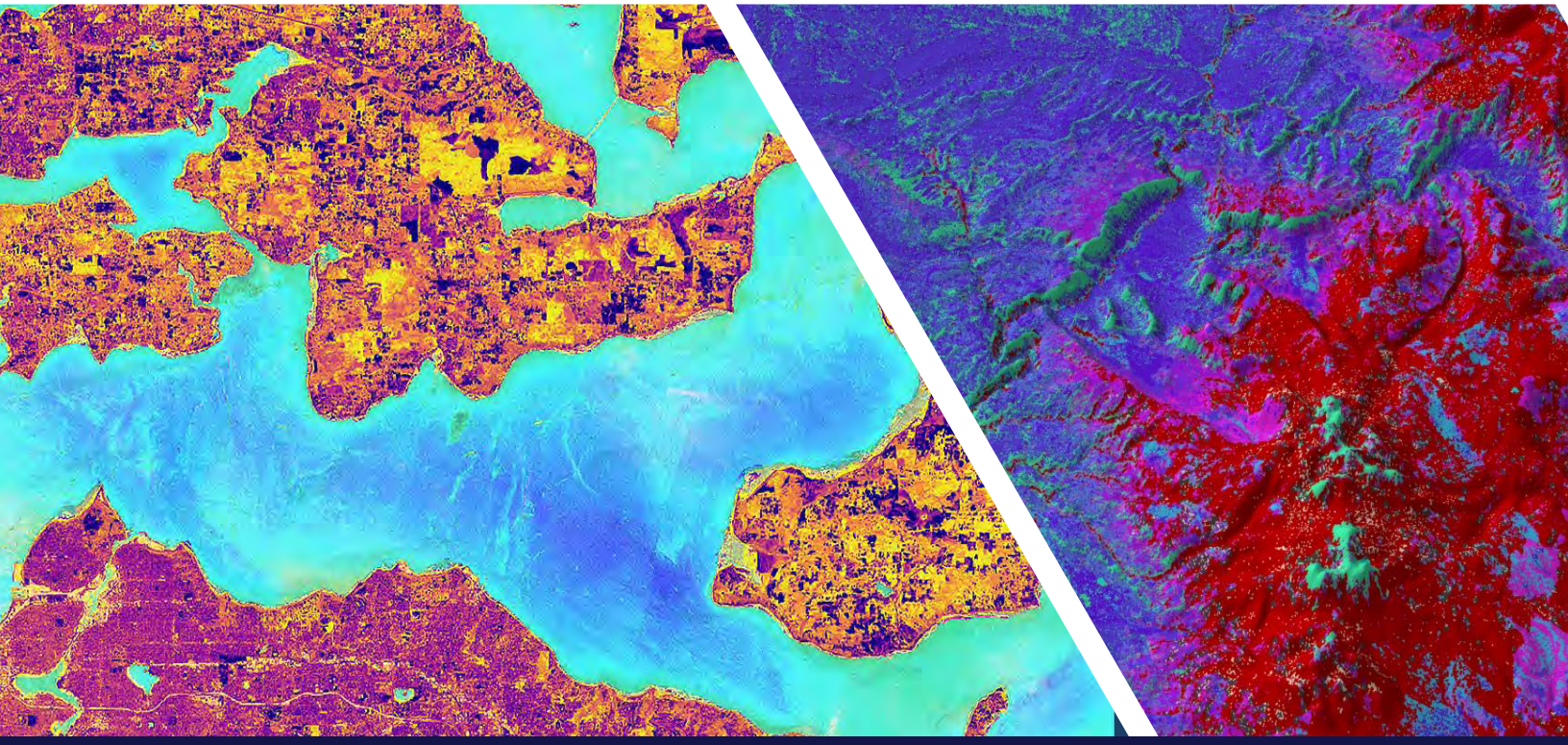
National Aeronautics and Space Administration

NASA Applied Sciences' Capacity Building

DEVELOP

National Program

2022 SUMMER PROJECT BOOKLET



Letter from the **National Program Office**

Thank you for taking the time to review the DEVELOP 2022 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 cohort of 110 participants conducting 27 Earth science feasibility projects impacting 68 partners. Participants represented 23 different states and 11 countries, while the projects impacted 18 states within the U.S. and 6 countries.

2022 is DEVELOP's 24th year of operation and the DEVELOP model continues to evolve. We are excited that this summer, 11 project teams were able to return onsite and experience what in-person DEVELOP has to offer, as well as glad that 16 project teams were able to continue in the virtual space.

As you review this booklet, we hope you gain an appreciation for the broad reach of DEVELOP. This is made possible by our outstanding network of science advisors and 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

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DEVELOP Program Manager

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DEVELOP Science Manager

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DEVELOP Science Lead - SSAI

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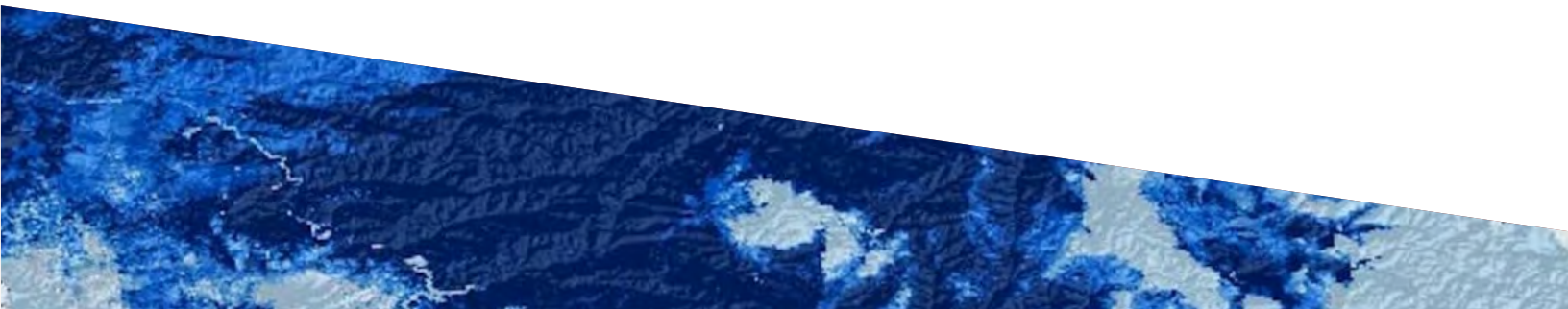
CONTENTS



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.

For more information, go to **Get Involved**.

DEVELOP'S Vision

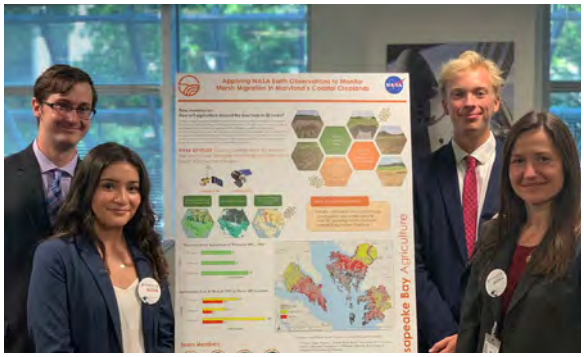
Shaping the future by integrating Earth observations into global decision making

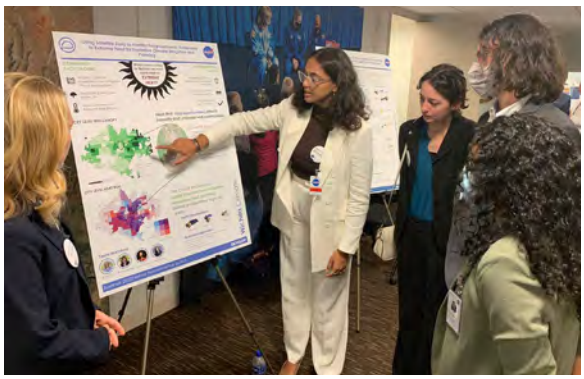
About **Projects**

The foundation of DEVELOP is a portfolio of applied science projects focused on connecting NASA Earth science data to end users globally. Through 50 -70 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, Climate, Disasters, Ecological Forecasting, Energy, Health & Air Quality, Urban Development, Water Resources, and Wildfires.

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 **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.

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:

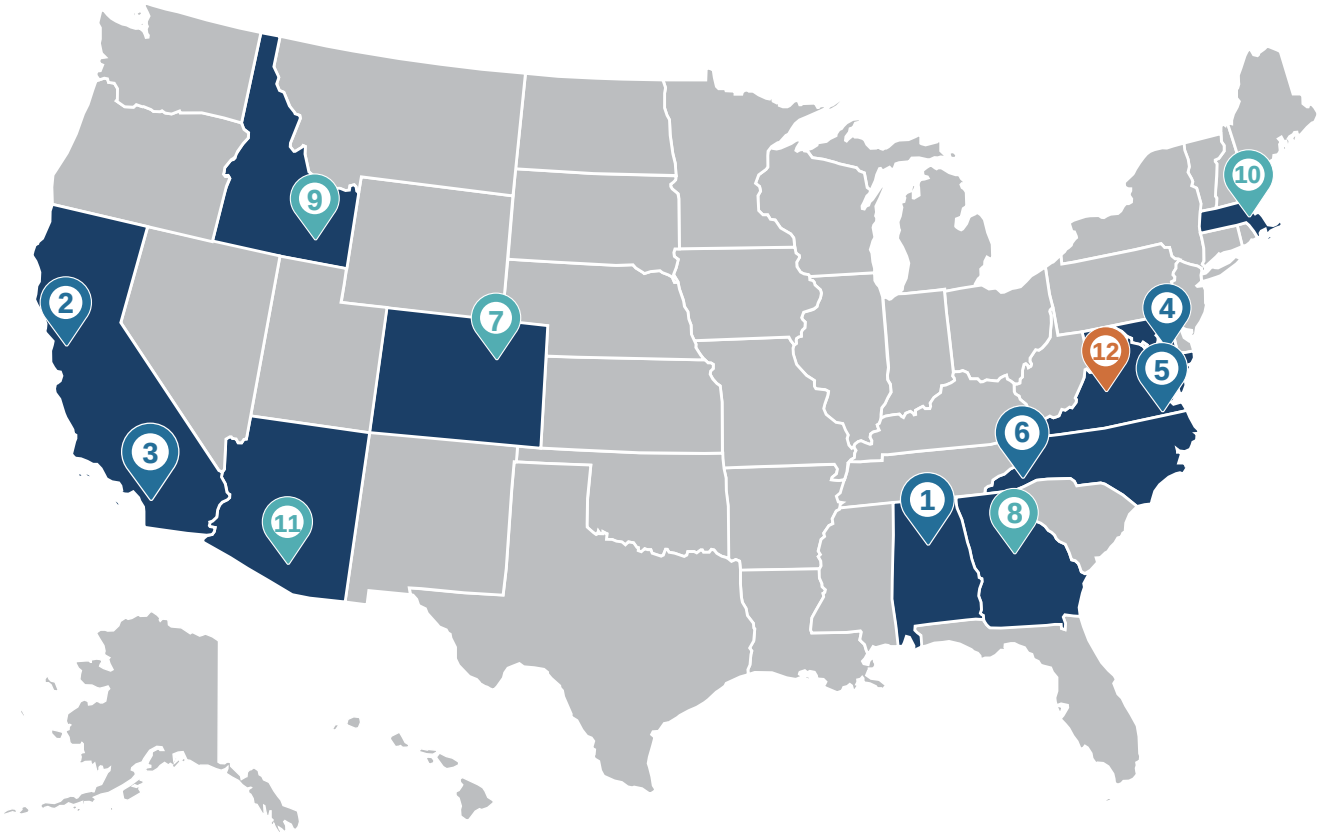
- **currently enrolled college students**
- **recent graduates**
- **early career professionals**
- **transitioning career professionals**
- **active or recently transitioned U.S. military service members.**

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

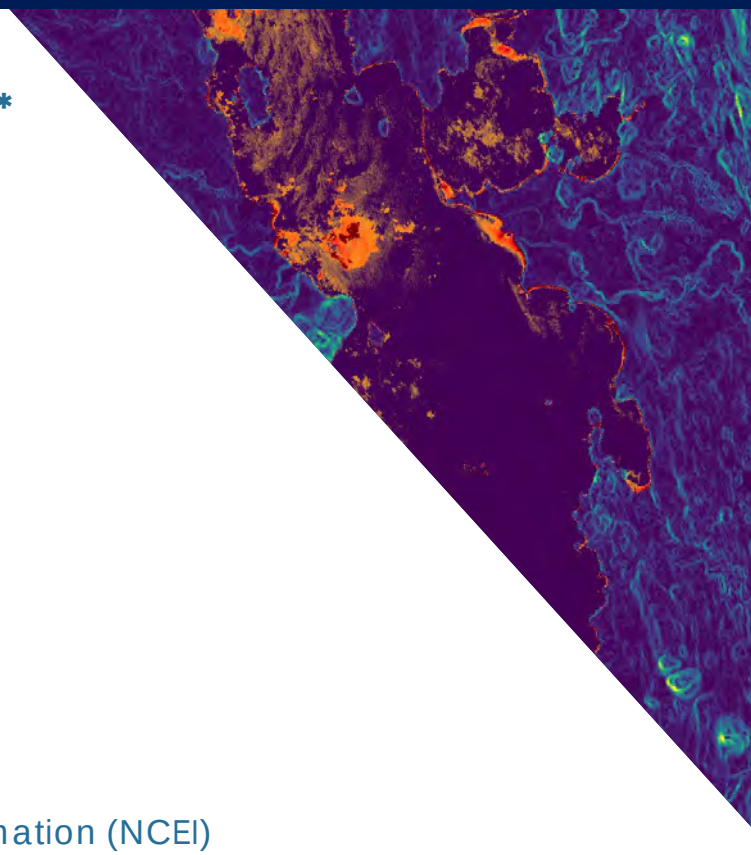
Where Can You Find DEVELOP?

The National Program Office (NPO), DEVELOP's Headquarters, resides at NASA Langley Research Center and oversees activity across our network of offices. A DEVELOP Fellow leads each office. Fellows are early career professionals who manage the projects and participants for their office. They engage with potential partners to develop project ideas, which the DEVELOP NPO and NASA Headquarters review, and approved projects are conducted in an upcoming term.

DEVELOP OFFICE LOCATIONS



To learn more about the individual offices, visit
https://appliedsciences.nasa.gov/what-we-do/capacity-building/develop/about



DEVELOP NASA & NOAA Offices *

1. **Alabama - Marshall**
   Marshall Space Flight Center (MSFC)
2. **California - Ames**
   Ames Research Center (ARC)
3. **California - JPL**
   Jet Propulsion Laboratory (JPL)
4. **Maryland - Goddard**
   Goddard Space Flight Center (GSFC)
5. **Virginia - Langley**
   Langley Research Center (LaRC)
6. **North Carolina - NCEI**
   National Centers for Environmental Information (NCEI)

DEVELOP Regional Offices *

7. **Colorado - Fort Collins**
   Colorado State University (CO)
8. **Georgia - Athens**
   University of Georgia (GA)
9. **Idaho - Pocatello**
   Idaho State University (ID)
10. **Massachusetts - Boston**
    Boston University (MA)
11. **Arizona - Tempe**
    Arizona State University (AZ)

DEVELOP Pop-Up (PUP) Offices *

12. **University of Virginia (UVA)**

DEVELOP Virtual Offices *

Virtual Environmental Justice (VEJ)

* Some locations offer **both** in-person & virtual projects, some only offer in-person **or** virtual. Check the proposed project list for the in-person versus virtual designation.

2022 **Summer Projects**

This summer, DEVELOP conducted 27 feasibility studies focused on the application of satellite data to address real-world issues and inform future action. Small teams of participants collaborated with partner organizations to co-develop solutions tailored to end user decision-making processes and introduce the capabilities and benefits of Earth observations.

10 Agriculture

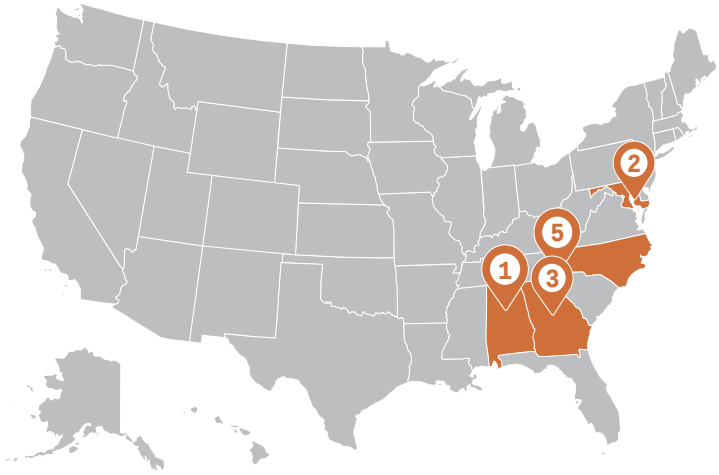
16 Climate

19 Disasters

21 Ecological Forecasting

Agriculture

DEVELOP's Agriculture projects promote innovative use of NASA satellite data, model products, and scientific findings to assist with agricultural management. The projects focus on topics associated with the production and availability of food products around the globe.



Agriculture Projects

DEVELOP OFFICE LOCATIONS

1. Alabama - Marshall
2. Maryland - Goddard
3. Georgia - Athens
4. Pop-Up Project
5. North Carolina - NCEI

PORTFOLIO

Bhutan Agriculture II: Creating a Graphical User Interface, Crop Mask, and Data Collection Protocol for Analysis of Rice Crop in Bhutan Using Remotely Sensed Data

Chesapeake Bay Agriculture: Applying Earth Observations to Monitor Marsh Migration in Maryland's Coastal Croplands

Haiti Agriculture II: Evaluating the Success of Reforestation Practices in Haiti

Maipo River Valley Agriculture: Determining Crop Coefficients Using Remote Sensing for the Maipo River Valley Basin in Chile

Mato Grosso Agriculture: Enhancing Crop Classification Mapping Using Optical and Radar Satellite Sensors to Inform Agricultural Management and Policymaking in Mato Grosso, Brazil

PARTNERS

Bhutan Department of Agriculture

Bhutan Foundation

Ugyen Wangchuck Institute of Conservation and Environmental Research

Eastern Shore Land Conservancy

Maryland Department of Planning

Haiti Reforestation Partnership

Comprehensive Development Project

Centro de Información de Recursos Naturales

Embassy of Chile (Agricultural Office)

USDA Foreign Agricultural Service

USDA Office of Chief Economist

SENSORS

ISS ECOSTRESS

Landsat 5 TM

Landsat 7 ETM+

Landsat 8 OLI

Landsat 9 OLI-2

Sentinel-1 C-SAR

Sentinel-2 MSI

SRTM

Terra MODIS

Bhutan Agriculture II - MSFC

Creating a Graphical User Interface, Crop Mask, and Data Collection Protocol for Analysis of Rice Crop in Bhutan Using Remotely Sensed Data

TEAM

Wangdrak Dorji (Project Co-Lead)
Tenzin Wangmo (Project Co-Lead)
Karma Dorjee
Sonam S Tshering

EARTH OBSERVATIONS

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

PARTNERS

Bhutan Department of Agriculture; Bhutan Foundation; Ugyen Wangchuck Institute of Conservation and Environmental Research

A false-color imagery from Landsat 8 surface reflectance collection. The composite image depicts the landscape and vegetation sites in the regions of western Bhutan, precisely the districts of Punakha, Wangdue Phodrang, Thimphu, and Paro, over the whole year of 2021. The band combinations highlights fallow agriculture fields in light brown, dense urban areas in purple, forest cover in green, snow in light blue, and rocky areas in darker brown.

Agriculture is an important sector in Bhutan, accounting for 19.63% of Bhutan's GDP in 2020 (World Bank) while also providing livelihoods for approximately 57% of the population (World Bank, 2017). The Department of Agriculture (DoA) in Bhutan still relies on in-field reporting for crop monitoring, which is time-consuming and labour intensive. To promote efficiency in these efforts, the team partnered with the DoA, the Bhutan Foundation, and the Ugyen Wangchuck Institute of Conservation and Environmental Research (UWICER). The team, with the help of the science advisors from NASA SERVIR, expanded the crop mask created in the previous term to the whole country of Bhutan and streamlined the sampling protocols for applicability to any available crop data. The team also created a graphical user interface (GUI) which provided a visual representation of current trends and rice distribution across Bhutan. The team utilized NASA Earth observations, including Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), and Shuttle Radar Topography Mission (SRTM), as well as other Earth observations including Sentinel-1 C-band Synthetic Aperture Radar (C-SAR). This project refined the previous term's methodology to help supplement crop monitoring and increase the frequency of data collected to aid decision-making processes with the use of remote sensing data.

Project URL: Bhutan Agriculture II - MSFC

Chesapeake Bay Agriculture - GSFC

Applying Earth Observations to Monitor Marsh Migration in Maryland's Coastal Croplands

TEAM

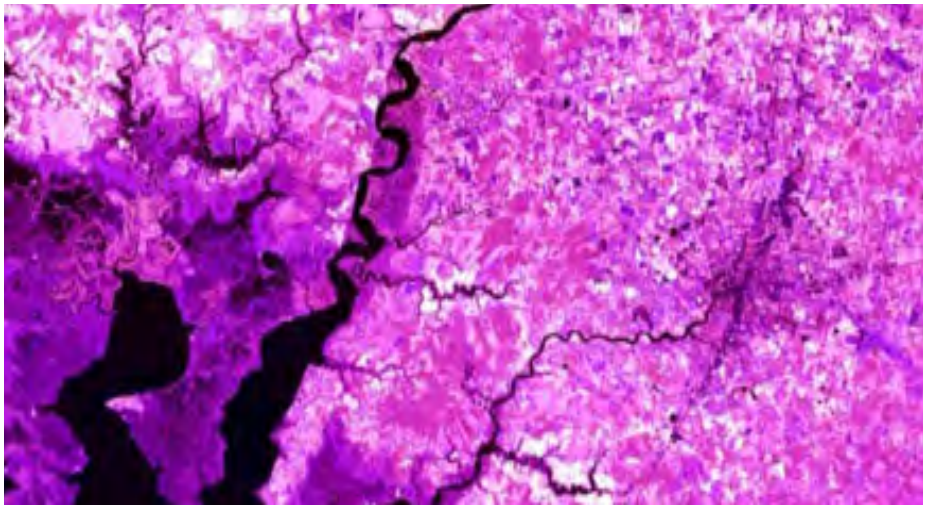
Alexia Hernandez (Project Lead)
Matthew Borden
Clay Hays
Arina Morozova

EARTH OBSERVATIONS

Landsat 5 TM
Landsat 8 OLI

PARTNERS

Eastern Shore Land Conservancy; Maryland Department of Planning



The image displays vegetation indices derived from summer 2021 Landsat 8 OLI data. NDVI, MSAVI, and BI were calculated to create a land cover classification in the Chesapeake Bay. Water is displayed as black, dark purple represents wetlands, and white highlights agricultural land. Magenta hues represent all other land cover classes. Vegetation indices represented soil moisture, wetlands, and crops, and these maps can be used to display marsh migration and loss of croplands.

The Chesapeake Bay boasts some of the nation's oldest farms which have continually served the greater Maryland community for centuries. Rising sea levels induced by global climate change threaten these critical coastal croplands via saltwater intrusion (SWI). The effects of SWI are widespread yet enigmatic, as crops and forests seemingly die with no apparent cause. Local farmers now face decreasing crop yields and unfavorable soil conditions that disrupt their established livelihoods. The project team partnered with the Eastern Shore Land Conservancy (ESLC) who collaborates with farmers to understand how the region may be affected by climate change, and with the Maryland Department of Planning who informs state and local policy to adapt to SWI. In response to this problem, the team applied NASA Earth observation data, which included measurements from Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI). The team created land use land cover maps of cropland and marsh migration in the Chesapeake Bay from 2001 to 2021 and forecasted maps to 2040. The project team discovered that 60,000 acres of farmland in the study area have already been lost to marsh migration since 2001, with another 58,000 acres projected to be lost within the next twenty years. These maps will inform the ESLC and the Maryland Department of Planning of vulnerable regions in the bay to aid farmers in planning for saltwater intrusion and salinization.

Project URL: Chesapeake Bay Agriculture - GSFC

Haiti Agriculture II - GA

Evaluating the Success of Reforestation Practices in Haiti

TEAM

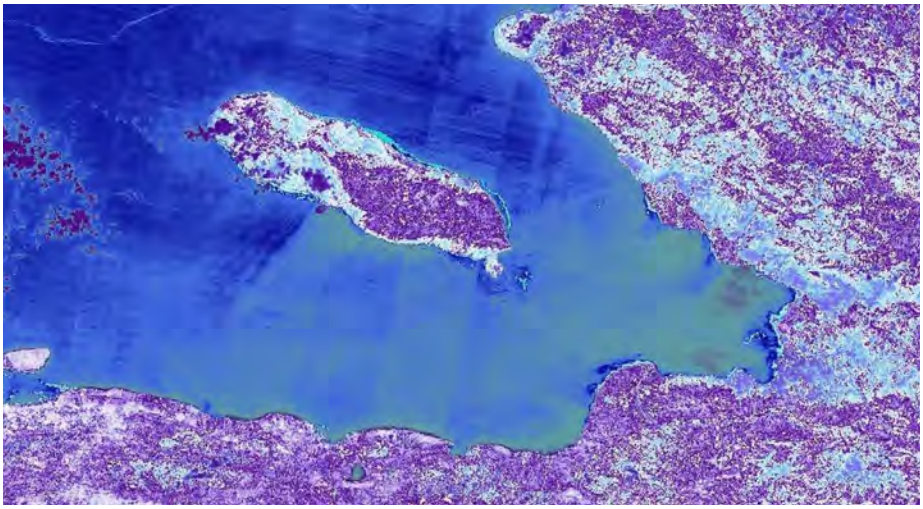
Kelli Roberts (Project Lead)
Monique Howlett
Justin Meyer
Rajneesh Sharma

EARTH OBSERVATIONS

Landsat 8 OLI
Landsat 9 OLI-2
Sentinel-2 MSI

PARTNERS

Haiti Reforestation Partnership; Comprehensive Development Project



NDVI-processed imagery using 2021 Landsat 8 OLI data. The south-western portion of Haiti, including the capital city of Port-au-Prince, is displayed. Water detected appears blue due to lack of vegetation presence. Lighter shades of blue indicate moderate vegetation and shades of purple indicate substantial levels of vegetation. Through the visualization of vegetation presence, prior reforestation efforts can be evaluated and future decisions can be made.

The Caribbean country of Haiti has an extensive history of deforestation and environmental degradation stemming from French colonization. Over the past 33 years, the Haiti Reforestation Partnership (HRP) and their partners, Comprehensive Development Program (CODEP), have planted approximately 15.52 million trees. However, these efforts lacked scientific guidance to ensure successful forest stand survival. The NASA DEVELOP team partnered with the HRP to create a habitat suitability model (HSM) by using PlanetScope and Sentinel-2 Multispectral Instrument (MSI) imagery. The team also incorporated Landsat 8 & 9 OLI surface temperature, Centre National de L'Information Geo-Spatiale (CNIGS) Airborne Lidar, and ancillary datasets to analyze areas suitable for future reforestation efforts. The habitat model suggested locations with higher forest stand survival based on topography, soil health, climate, and feasibility to access suggested locations. We validated the HSM through a cross-analyzation of high enhanced vegetation index (EVI) values. Areas with lower EVI values and higher suitability based on the HSM were suggested for future planting as they lack well-established forest stands but have optimal conditions for growth. Through the creation of the HSM, the team provided the HRP with static maps of high suitability, a 3D printed elevation model, and a guidebook for animators. Additionally, the team provided a structured video highlighting the HRP's efforts. Effective reforestation and better forest stand survival would help to achieve the goal of securing community food security. This would also serve as a guide to expand planting efforts into other locations and communities.

Project URL: Haiti Agriculture II - GA

Maipo River Valley Agriculture - PUP

Determining Crop Coefficients Using Remote Sensing for the Maipo River Valley Basin in Chile

TEAM

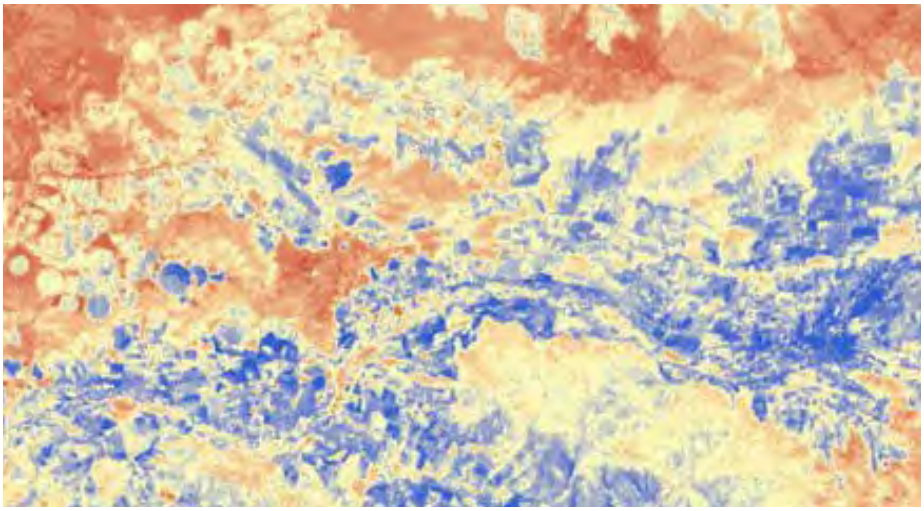
Benjamin Goffin (Project Lead)
Sarah Carlos
Duncan Srsic
Rishudh Thakur

EARTH OBSERVATIONS

ISS ECOSTRESS
Landsat 8 OLI
Terra MODIS

PARTNERS

Centro de Información de Recursos Naturales; Embassy of Chile (Agricultural Office)



Median Daily Evapotranspiration (ET) from September 2021 to May 2022 calculated from ISS ECOSTRESS. The developed image covers the agricultural fields adjacent to the Maipo River. Color scale ranges from red to blue where blue represents higher ET. ET has been used to estimate the crop irrigation requirements. Water stress in this semi-arid basin is well represented by the image, as the irrigated agricultural fields have higher ET values than the surrounding landscape.

Agriculture is the primary use of water in the Maipo River Valley of Central Chile, accounting for ~ 75% of the total demand. Assessment of irrigation needs for agricultural production in the region has commonly relied on reference crop coefficients (Kc) derived from geographic and climatic conditions that differ from those of Chile. This work focused on calculating site-specific Kc values tailored to crop production in the water-stressed Maipo River Valley over consecutive growing seasons from 2019–2022. Two distinct approaches were implemented, each relying on remotely sensed Earth observation datasets from NASA. The first method estimated Kc values based on their linear relationship with the Normalized Difference Vegetation Index (NDVI) obtained from either Terra Moderate Resolution Imaging Spectroradiometer (MODIS) or Landsat 8 Operational Land Imager (OLI) surface reflectance. The second technique leveraged information from the ISS Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) by computing the ratio between actual crop evapotranspiration and potential evapotranspiration. Both procedures showed promising results that can build on one another. The former approach best captured vegetation signals of annual crops while the latter appeared best suited for perennials. Overall, this study provides a strong basis and novel way to accurately estimate Kc using remote sensing, with the potential for improved irrigation management and reduction in water consumption.

Project URL: Maipo River Valley Agriculture - PUP

Mato Grosso Agriculture - NC

Enhancing Crop Classification Mapping Using Optical and Radar Satellite Sensors to Inform Agricultural Management and Policymaking in Mato Grosso, Brazil

TEAM

Max Rock (Project Lead)
Elijah Dalton
Aidan Harvey
Kate Reynolds

EARTH OBSERVATIONS

Landsat 8 OLI
Sentinel-1 C-SAR
SRTM

PARTNERS

USDA Foreign Agricultural Service; USDA Office of Chief Economist

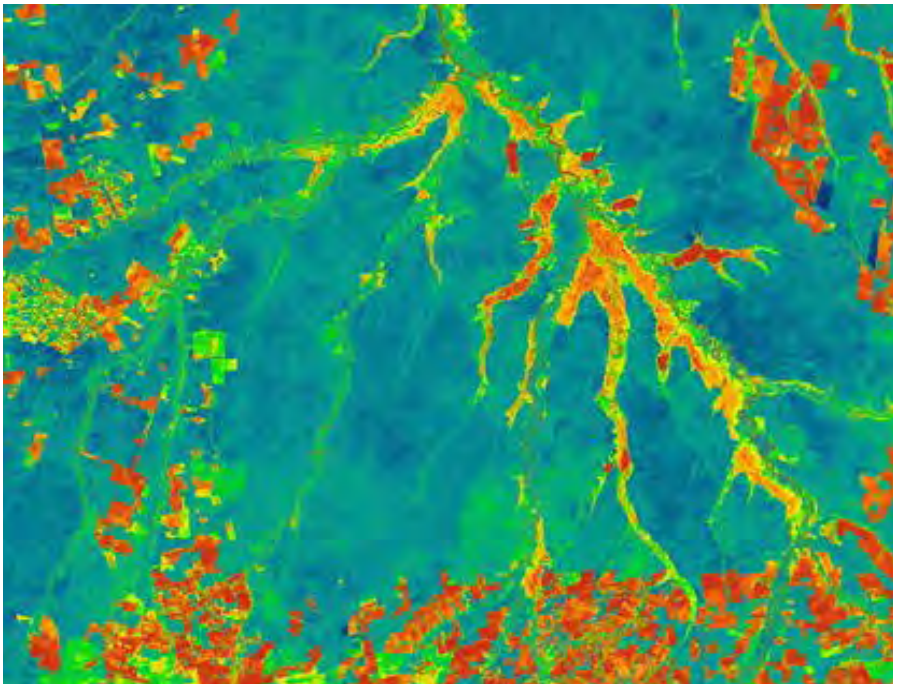


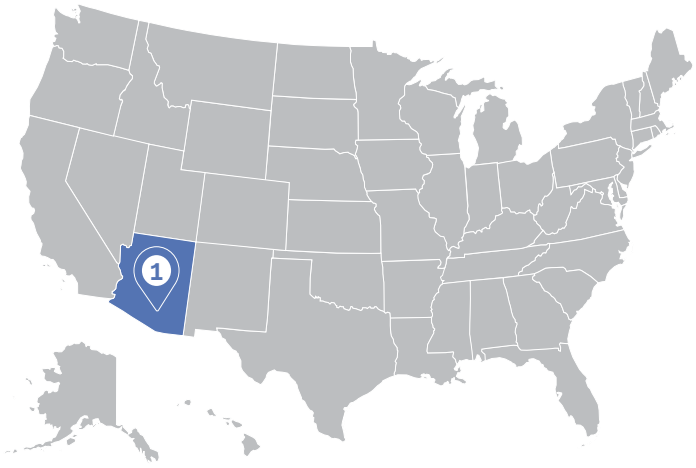
Image depicting Normalized Difference Vegetation Index (NDVI) over Mato Grosso, Brazil from Landsat-8 OLI from March of 2021. NDVI can indicate vegetation health based on how plants reflect ranges of electromagnetic spectrum. In this case, as we go from orange to blue NDVI gets higher. High NDVI values (green & blue) are indicative of dense vegetation found in tropical and temperate forests or crops at their peak growth while low values (yellow & red) depict barren land, water, and moisture stressed vegetation. Understanding where areas are most stressed through NDVI analysis, decision makers can quickly make data driven decisions that may aid in food security and efficient agricultural responses to ensure a more productive yield.

Ranked as the fourth largest food producer in the world, Brazil is an agricultural powerhouse. Agricultural production at this scale warrants accurate crop monitoring and classification, however, this tropical area is frequently concealed by dense cloud cover in standard optical imagery. To improve the accuracy and spatial coverage of current crop monitoring operations, the team incorporated radar data capable of penetrating cloud coverage to classify second season corn and cotton fields. Utilizing optical imagery from Landsat 8 Operational Land Imager (OLI) as well as radar imagery from Sentinel-1 C-band Synthetic Aperture Radar (C-SAR), and topographic imagery from Shuttle Radar Topography Mission (SRTM), the NASA DEVELOP team worked with the United States Department of Agriculture (USDA) Foreign Agricultural Service (FAS) and World Agricultural Outlook Board to generate a crop classification procedure using a random forest model for accurate mapping and crop area estimates. Additionally, accuracy assessments were performed to ensure confidence in classification accuracy and to allow for comparison with previous classification maps of the area. Classification maps and area estimates produced will be used by the USDA FAS to generate accurate estimates of available commodities as well as assist in agricultural policy decision making.

Project URL: Mato Grosso Agriculture - NC

Climate

DEVELOP's Climate application area supports communities with information to help identify and address climate risks to critical infrastructure, policy analysis, and resilience planning.



Climate Projects

DEVELOP OFFICE LOCATIONS

1. Arizona - Tempe
2. Virtual Environmental Justice

PORTFOLIO

Hawaii Island Climate: Utilizing Earth Observations to Model Probable Wetland Extents, Model Sea-Level Rise Inundation Risk, and Assess Impacts on Historic Hawaiian Lands

Wichita Climate: Using Satellite Data to Identify Neighborhoods Vulnerable to Extreme Heat for Equitable Climate Mitigation and Planning

PARTNERS

County of Hawai'i, Planning Department

Hawai'i Department of Land and Natural Resources

Arizona State University, Center for Global Discovery and Conservation Science

City of Wichita

SENSORS

Aqua AMSR-E

Aqua MODIS

CORIOLIS WINDSAT

GCOM-W1 AMSR2

Landsat 8 OLI/TIRS

Jason-1 Microwave Radiometer/POSEIDON-2

Jason-2 Advanced Microwave Altimeter/POSEIDON-3

Jason-3 POSEIDON-3B/AMR

NOAA-19 AVHRR-3

PlanetScope

Sentinel-1 C-SAR

Terra MODIS

TOPEX POSEIDON TMR/SSALT

Hawaii Island Climate - AZ

Utilizing Earth Observations to Model Probable Wetland Extents, Model Sea-Level Rise Inundation Risk, and Assess Impacts on Historic Hawaiian Lands

TEAM

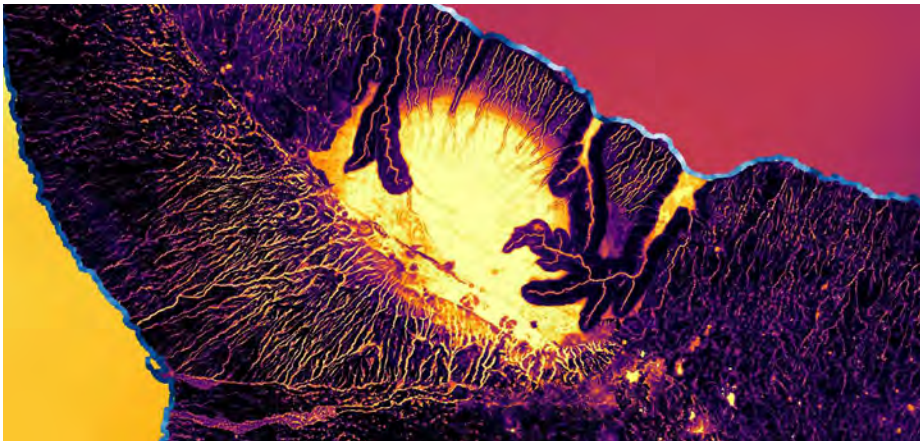
Lisa Tanh (Project Lead)
Matilda Anokye
Ian Lee
Connor Racette

PARTNERS

County of Hawai'i, Planning Department; Hawai'i Department of Land and Natural Resources; Arizona State University, Center for Global Discovery and Conservation Science

EARTH OBSERVATIONS

Jason-1 Microwave Radiometer/POSEIDON-2
Jason-2 Advanced Microwave Altimeter/POSEIDON-3
Jason-3 POSEIDON-3B/AMR
TOPEX POSEIDON TMR/SSALT
Terra MODIS
Aqua MODIS
Aqua AMSR-E
Sentinel-1 C-SAR
CORIOLIS WINDSAT
NOAA-19 AVHRR-3
GCOM-W1 AMSR2
PlanetScope



Present day Island of Hawai'i coastal flood risk, with higher risk indicated in dark blue, was modeled to aid the County of Hawai'i in their shoreline setback plan. Sea Surface Temperature Anomaly (SSTA) data from 2022 GHRSST MODIS indicate low temperatures in the East (red) to high in the West (orange). Inland, high probability locations of wetlands are shown in bright yellow and will aid in climate adaptation planning.

Climate induced sea-level rise poses a risk to coastal areas on the Island of Hawaii and many of the island's historic cultural lands are in danger of becoming inundated. In partnership with the County of Hawaii, the State of Hawaii Department of Land and Natural Resources, and Arizona State University, NASA DEVELOP modeled near-term sea-level rise inundation risk and wetland extent. The team utilized NASA Earth observations over a 10-year span (2013-2022) that included data from NASA MEaSUREs Gridded Sea Surface Height Anomalies (SSHA) and the Group for High Resolution Sea Surface Temperature (GHRSST) to model sea level rise inundation risk. We used a random forest model to classify near-term inundation risk along the entire coast of Hawaii for 5 known local flood events from 2019 – 2021, using physically related features like sea surface height anomalies and soil permeability. Additionally, the team compared the in situ local tidal gauge data around Hawaii to the SSHA data. Current wetland extents and probabilistic locations of new wetlands were modeled with data from PlanetScope Surface Reflectance optical imagery (2022), United States Geographic Survey (USGS) 3D Elevation Program 10m DEM (2013), temperature and precipitation data from the Hawaii Climate Atlas (2021), and soils data from the Hawaii Soil Atlas (2014) using the Wetland Intrinsic Potential (WIP) tool. Results indicated locations with the highest probability of wetlands. The project deliverables will assist our partners in their efforts to meet regulatory requirements for wetlands protection, evaluate near-term sea level inundation risk, and guide decision-making for Shoreline Setback and Climate Adaption plans.

This project was the runner up for the **Summer Project Image Contest!**

Project URL: Hawaii Island Climate - AZ

Wichita Climate - VEJ

Using Satellite Data to Identify Neighborhoods Vulnerable to Extreme Heat for Equitable Climate Mitigation and Planning

TEAM

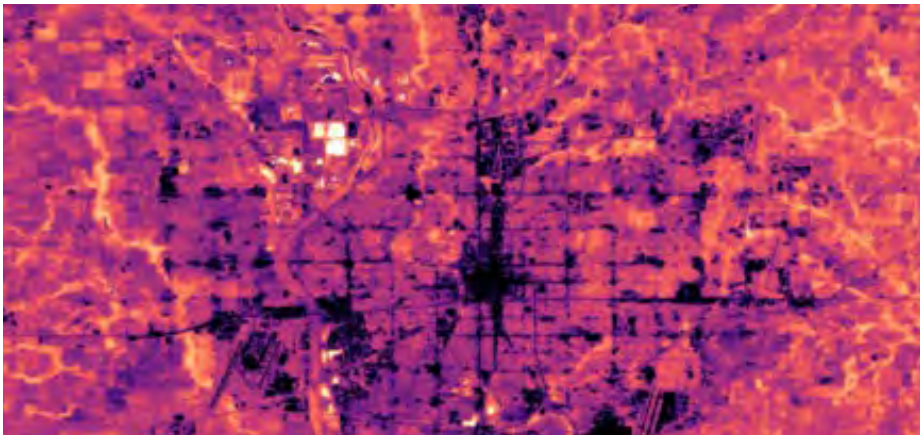
Brooke Laird (Project Lead)
Melissa Ashbaugh
Muskaan Khemani
Sadie Murray

EARTH OBSERVATIONS

Aqua MODIS
Landsat 8 OLI/TIRS
PlanetScope

PARTNERS

City of Wichita



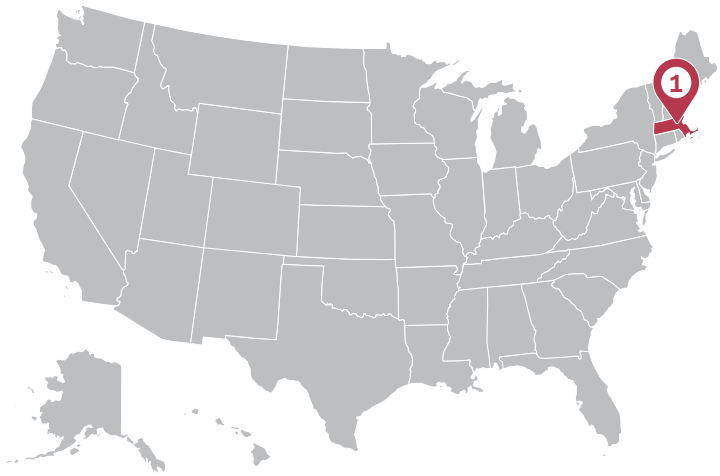
NDVI-processed imagery from Landsat 8 OLI data. This composite image of Wichita was created using 2018-2022 summer imagery. Lighter shades of yellow indicate limited vegetation in built-up areas and bodies of water, while darker shades of purple indicate dense vegetation. Understanding the spatial distribution of vegetation, such as tree canopy, is essential to recognizing and mitigating heat risk.

Wichita, Kansas is facing a host of climate threats, one being extreme heat that is manifested through the urban heat island (UHI) effect. Varying heat exposure and vulnerability mean that heat risk is not evenly spatially distributed, which is an environmental justice issue. We worked with the City of Wichita to map heat exposure, tree canopy, and heat risk. To visualize heat exposure, we quantified and mapped average summer heat from 2013–2021 using Landsat 8 Land Surface Temperature (LST) and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) night-time LST. To understand tree canopy cover gaps, we created a tree canopy map using 2021 PlanetScope imagery, which identified 20% more trees than the US Geological Survey's (USGS) National Land Cover Database (NLCD) tree canopy coverage estimates for Wichita. To characterize high risk areas, we used socioeconomic census data and existing social vulnerability indices, highlighting populations that were exposed and vulnerable to extreme heat. The spatial analyses demonstrated that heat exposure is concentrated in the city center and southwest Wichita, areas that are also low in tree canopy coverage. The 3 census block groups and 17 census tracts with the highest heat risk primarily circle the city center, in areas home to more socially vulnerable populations and near enough to the dense urban center to feel significant urban heat island effects.

Project URL: Wichita Climate - VEJ

Disasters

DEVELOP's Disasters projects use NASA's capabilities in spaceborne, airborne, surface observations, modeling, and data analysis to improve natural disaster forecasting, mitigation and response. The projects contribute to an improved understanding of the natural processes that produce hazards, the vulnerability of local communities, and the development of hazard mitigation technologies.



Disaters Projects

DEVELOP OFFICE LOCATIONS

1. Massachusetts - Boston

PORTFOLIO

Kansas City Disasters: Assessing Environmental and Socioeconomic Factors of Urban Flood Vulnerability in Kansas City, Kansas

PARTNERS

Groundwork Northeast Revitalization Group

Groundwork USA

SENSORS

GPM IMERG

Kansas City Disasters - MA

Assessing Environmental and Socioeconomic Factors of Urban Flood Vulnerability in Kansas City, Kansas

TEAM

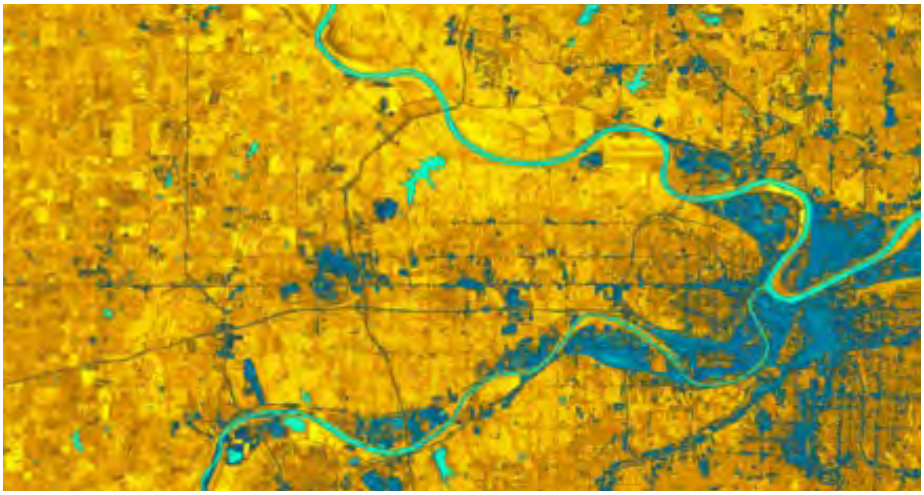
Marissa (René) Castillo (Project Lead)
Hadwynne Gross
Eric Sjöstedt
Raychell Velez

EARTH OBSERVATIONS

GPM IMERG

PARTNERS

Groundwork Northeast Revitalization Group; Groundwork USA



2021 – 2022 NDWI-processed imagery of the greater Kansas City, Kansas region. This image combines Landsat 5, 7, and 8 highlighting dry areas in yellow through orange. Areas classified as water are identifiable in aqua blue. Areas of darker blue are considered wet, but include cityscape. A major problem for urban flooding identification is the mixture of cityscape in wet areas, making it important for further investigation and data processing.

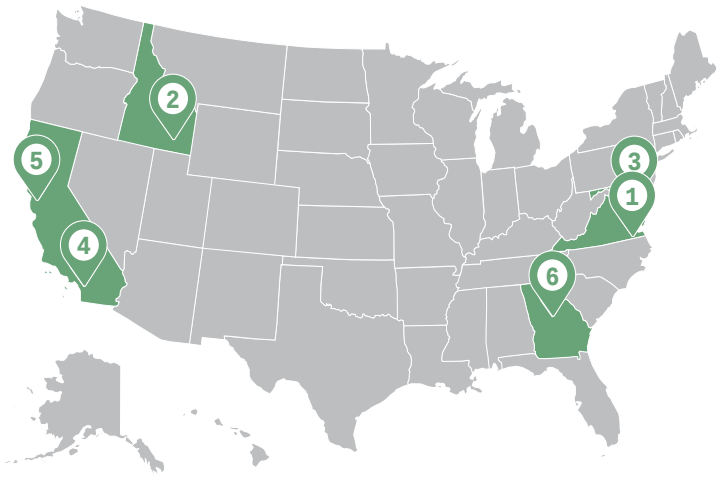
Pluvial flooding, over-saturated ground, and poor drainage systems disproportionately impact historically disinvested neighborhoods during extreme rainfall events independently of overflowing water bodies. These communities are impacted by physical and socioeconomic factors that make them vulnerable to flooding events, such as high concentration of impervious landcover, high precipitation rates, and a combined sewer system framework. Despite known vulnerability to environmental hazards, there is a lack of data supporting the potential pluvial street-level flooding events. The DEVELOP team investigated flooding events from June 2010 through June 2021 in Google Earth Engine (GEE) using NASA Earth observation products from the Global Precipitation Measure. Alongside the satellite imagery and ancillary datasets, Natural Capital Project's Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Urban Flood Risk Mitigation model was utilized to generate outputs of runoff retention and potential economic damage for risk mapping of Kansas City, Kansas to aid in identifying areas where future intervention is necessary. Then a cloudburst blue spot model produced spatially-explicit outputs of how pluvial flooding would accumulate across the surface elevation gradients. These resulting maps identify the most vulnerable neighborhoods throughout Kansas City, alongside potential economic damage from flooding. The resulting methodology and end products provide partners from Groundwork USA and Groundwork Northeast Revitalization Group (Groundwork NRG) with a detailed analysis of urban flood risk throughout Wyandotte County, Kansas, while simultaneously streamlining the methodology to provide neighborhood-scale vulnerability to Groundwork USA's Climate Safe Neighborhoods project.

This project won the **Summer Project Image Contest!**

Project URL: Kansas City Disasters - MA

Ecological Forecasting

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.



Ecological Forecasting Projects

DEVELOP OFFICE LOCATIONS

1. Virginia - Langley
2. Idaho - Pocatello
3. Maryland - Goddard
4. Califonia - JPL
5. California - Ames
6. Georgia - Athens

PORTFOLIO

Delaware Basin Ecological Forecasting: Identifying Vegetation Trends and Atmospheric Stressors in the Guadalupe Mountains and Carlsbad Caverns National Parks

Grand Valley Ecological Forecasting II: Forecasting Trends in Pinyon-Juniper and Sagebrush Habitat Relative to Wildfire, Drought, Beetle Disturbance, and Treatment Impact for Management Planning

Maine Ecological Forecasting III: Utilizing Earth Observations to Monitor Federally Endangered Atlantic Salmon (*Salmo salar*) Habitat in Maine: An Interactive Workshop

Lower Illinois River Valley Ecological Forecasting: Inundation Mapping of the Lower Illinois River Valley Using Synthetic Aperture Radar and Optical Satellite Imagery for Wetland Conservation and Restoration Prioritization Efforts

New York Ecological Forecasting: Utilizing NASA Earth Observations to Map Ash Density and Inform Emerald Ash Borer Control

Yellowstone Ecological Forecasting: Assessing Change in Aspen Extent and Health in Northern Yellowstone National Park

PARTNERS

National Park Service, Carlsbad Caverns National Park

National Park Service, Guadalupe Mountains National Park

National Park Service Intermountain Region

National Park Service, Colorado National Monument

Bureau of Land Management, McInnis Canyons and Domingues-Escalante National Conservation Areas

Maine Department of Marine Resources

Downeast Salmon Federation

The Great Rivers Land Trust

National Great Rivers Research & Education Center

American Geophysical Union, Thriving Earth Exchange

Principia College

The Nature Conservancy, Adirondack Chapter, Adirondack Park Invasive Plant Program.

National Park Service, Colorado National Monument

SENSORS

GPM IMERG

Landsat 5TM

Landsat 7 ETM+

Landsat 8 OLI

TOPEX/Poseidon

Jason-1

Jason-2

Jason-3

Terra MODIS

Sentinel-1 C-SAR

Delaware Basin Ecological Forecasting - LaRC

Identifying Vegetation Trends and Atmospheric Stressors in the Guadalupe Mountains and Carlsbad Caverns National Parks

TEAM

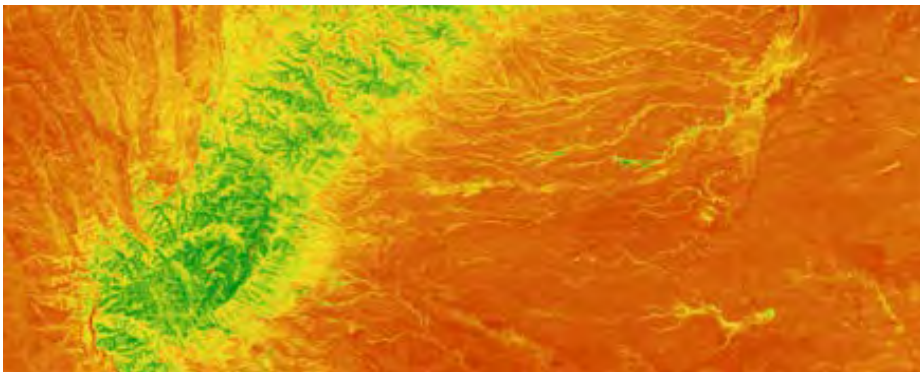
Jack Mezger (Project Lead)
Mark Bossinger
Quinn Heiser
Gillian McNamara

EARTH OBSERVATIONS

GPM IMERG
Landsat 5TM
Landsat 7 ETM+
Landsat 8 OLI

PARTNERS

National Park Service, Carlsbad Caverns National Park; National Park Service, Guadalupe Mountains National Park; National Park Service Intermountain Region



The image displays NDVI calculated over the Guadalupe Mountain Range in Western Texas captured on May 2020 by Landsat 8 OLI. Areas shaded green indicate tree canopy while yellow and red areas indicate arid landscapes. NDVI was used to visualize vegetation health and inform the National Park Service's future management initiatives.

The Guadalupe Mountains and Carlsbad Caverns National Parks, located in the Delaware Basin in the southwestern United States, observed both a decrease in precipitation and an increase in temperature over the last decade. Furthermore, activity from local oil fields generated nitrogen dioxide (NO_2) plumes that spread over the parks and augmented the effects of the drought. NO_2 is a precursor for tropospheric ozone (O_3) which is known to have adverse effects on vegetation and ecosystems at large. These new climate dynamics prompted the National Park Service (NPS) to collaborate with NASA DEVELOP to assess the impact on vegetation within the parks. We used NASA Earth observations including Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper (ETM+), Landsat 8 Operational Land Imager (OLI), and Global Precipitation Measurement Integrated Multi-Satellite Retrievals (GPM IMERG) to assess vegetation health, water stress, and precipitation in the affected parks. After creating a homogenous reference area in the Sierra Diablo Mountains (SDM), the team visualized vegetation health through a Normalized Difference Vegetation Index (NDVI) time series map from 2010-2021. This did not show strong evidence that the NO_2 plume is causing vegetation decline. Following this, we created a water stress map with a Normalized Difference Moisture Index (NDMI) time series map from 2010-2021, which revealed a pattern of increasing water stress. We also confirmed that precipitation in the region decreased over the span of 2010-2021. These observations and findings will allow the NPS Intermountain Region to more effectively plan for the preservation and maintenance of vegetation health within the parks.

Project URL: Delaware Basin Ecological Forecasting - LaRC

Grand Valley Ecological Forecasting II - ID

Forecasting Trends in Pinyon-Juniper and Sagebrush Habitat Relative to Wildfire, Drought, Beetle Disturbance, and Treatment Impact for Management Planning

TEAM

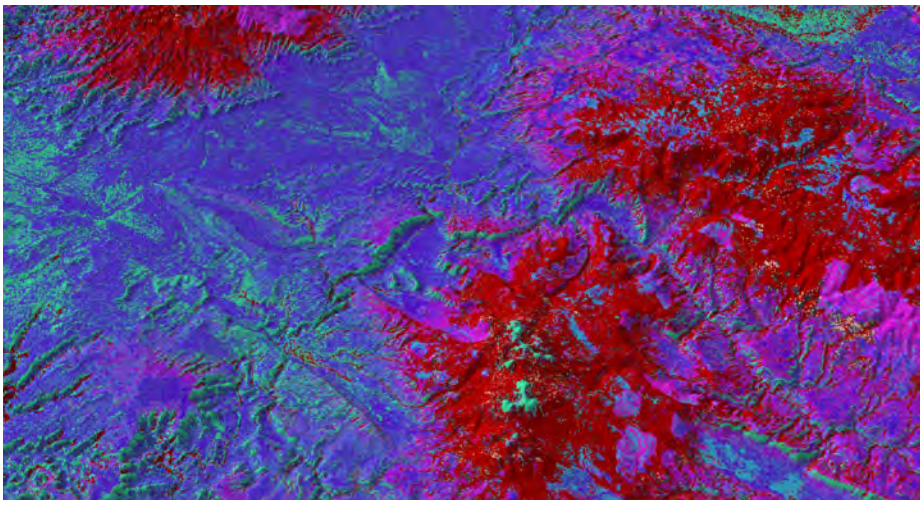
Bill Curtiss (Project Lead)
Sam Majumder
Rhea Martinez
Aliza White

EARTH OBSERVATIONS

Landsat 5 TM
Landsat 8 OLI
TOPEX/Poseidon
Jason-1
Jason-2
Jason-3

PARTNERS

National Park Service, Colorado National Monument; Bureau of Land Management, McInnis Canyons and Domingues-Escalante National Conservation Areas



Vegetation productivity decline was calculated from the yearly maximum NDVI for 1986-2021. Representing areas of 1-5 consecutive years of declining productivity (red/tan) and is derived from Landsat 5/7/8 data. Draped on the 2021 Landcover Change Monitoring System composite, constructed from Landsat 8 OLI. Blue, Purple, Pink representing Grasses & Forbes, Shrubs, Trees, respectively. Red over Pink indicative of beetle and drought disturbance in the Grand Valley region.

Disturbances and landcover change in pinyon-juniper and sagebrush ecosystems are enhanced by environmental conditions such as variability in climate characteristics. DEVELOP partnered with the National Park Service (NPS) in Colorado National Monument and the Bureau of Land Management (BLM) in McInnis Canyons and Dominguez-Escalante National Conservation Areas to investigate these disturbances. NPS partners were interested in identifying areas at risk of pinyon-juniper die-off or encroachment by invasive species. The BLM partners prioritized identifying areas suitable for fire prevention treatment. To address these concerns, we forecasted landcover change in the Grand Valley region of Colorado. We used NASA Earth observation data, from Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper (ETM+), Landsat 8 Operational Land Imager (OLI) and Moderate Resolution Imaging Spectroradiometer (MODIS) aboard Terra and Aqua, collected and analyzed in conjunction with Term I of this project. We found that the primary driver variables for forecasted landcover change in the study area were aspect and elevation. Our forecasted landcover change maps, created using the Idrisi TerrSet Land Change Modeler, addressed the needs of both partner organizations by showing potential habitat suitability trends, which will inform management planning. Forecasted land cover maps indicated that by 2040, ecosystems within partner management perimeters will likely see tree encroachment on shrublands.

Project URL: Grand Valley Ecological Forecasting II - ID

Lower Illinois River Valley Ecological Forecasting - JPL

Inundation Mapping of the Lower Illinois River Valley Using Synthetic Aperture Radar and Optical Satellite Imagery for Wetland Conservation and Restoration Prioritization Efforts

TEAM

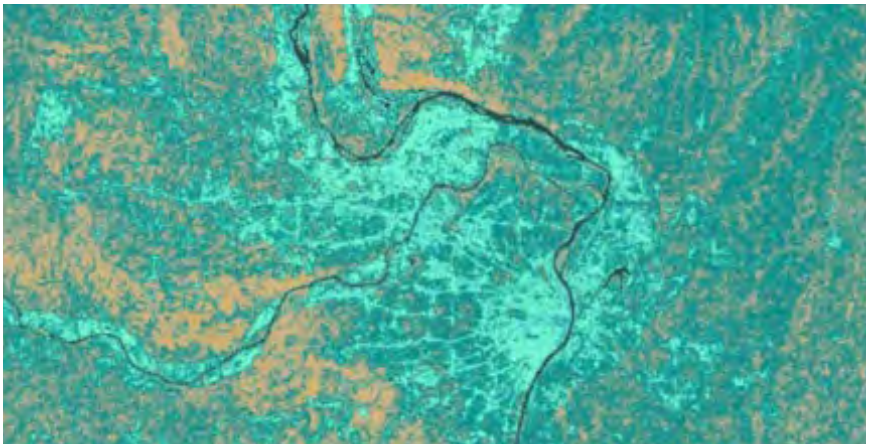
Vanessa Machuca (Project Lead)
Dana Myers
Hannah Rigdon
Christiana Saldana

EARTH OBSERVATIONS

Landsat 8 OLI
Sentinel-1 C-SAR

PARTNERS

The Great Rivers Land Trust; National Great Rivers Research & Education Center; American Geophysical Union, Thriving Earth Exchange; Principia College



NDWI-processed composite image from Landsat 8 OLI data of the Lower Illinois River Valley and surrounding landscapes from summer 2021. Shades of pale yellow indicate dry vegetation and dark teal represents open water, while brighter turquois values depict wet vegetation. Areas of high NDWI values are demonstrative of high presence of wet vegetation and are of interest to the Great Rivers Land Trust in identifying areas of interest for wetland conservation.

The Lower Illinois River Valley (LIRV) is home to some of the richest agricultural lands in the United States and its wetlands provide key ecosystem services like clean water and flood reduction. It has also experienced extensive degradation due to development and urban pollution. The Great Rivers Land Trust (GRLT), the National Great Rivers Research & Education Center, Principia College, and the American Geophysical Union's (AGU) Thriving Earth Exchange sought to incorporate remotely sensed layers into their geodatabases to more accurately identify priority areas for wetland restoration. This project used remote sensing data to determine the feasibility of detecting inundation extent and duration along the valley. The team used Sentinel-1 C-band Synthetic Aperture Radar (SAR) data to classify open water, inundated vegetation, and not inundated vegetation within our study site. The open water classification was compared to calculated Dynamic Surface Water Extent (DSWE) derived from Landsat 8 Operational Land Imager. The team successfully created layers of inundation minimum and maximum extent, as well as inundation duration, across the study area for 2019 and 2020. The open water classification resulted in an overall accuracy of 91% when validated against DSWE classifications. These analyses will help end users in determining high priority areas along the LIRV for land conversions in the future.

Project URL: Lower Illinois River Valley Ecological Forecasting - JPL

Maine Ecological Forecasting III - GSFC

Utilizing Earth Observations to Monitor Federally Endangered Atlantic Salmon (Salmo salar) Habitat in Maine: An Interactive Workshop

TEAM

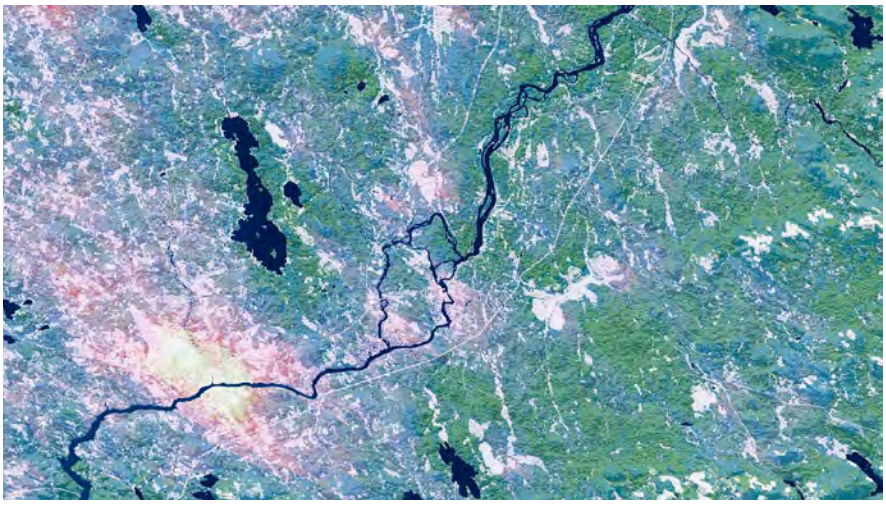
Jonathan Falciani (Project Lead)
Colin Hogan
Linda Mitchell
Makario Sarsozo

EARTH OBSERVATIONS

GPM IMERG
Landsat 5 TM
Landsat 8 OLI
Terra MODIS

PARTNERS

Maine Department of Marine Resources; Downeast Salmon Federation



Forest cover and land surface temperature (LST) around Maine's Penobscot River during Summer 2021. The shades of green distinguish between evergreen (dark) and deciduous (light) forest which were classified using Landsat 8 OLI imagery. The purple gradient corresponds to LST derived from Terra MODIS where the warmest areas, including Bangor, are white. Changing land use and warming temperatures along Maine's rivers are associated with reducing juvenile Atlantic salmon (*Salmo salar*) survivorship.

Shifting patterns in land use and land cover (LULC), temperature, and precipitation have exacerbated a rapid decline in Federally Endangered wild Atlantic salmon (*Salmo salar*) populations. The team at NASA DEVELOP partnered with the Maine Department of Marine Resources (DMR) and the Downeast Salmon Federation (DSF) to create a comprehensive workshop designed to demonstrate the applicability of Earth observations in examining these threats using the Penobscot, Union, and Machias Rivers as case studies. This entailed curating tutorials for acquiring and analyzing satellite data using Google Earth Engine, EarthExplorer, and Earthdata. The team demonstrated how to classify LULC in ArcGIS Pro from 1985 until 2021 using Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI), Sentinel-2 MultiSpectral Instrument (MSI), and datasets from the United States Geological Survey (USGS) National Land Cover Database (NLCD), showing an overall transition from coniferous forests to other LULC classes. The team also demonstrated how to use historical data from Terra Moderate Resolution Imaging Spectroradiometer (MODIS) and Integrated Multi-satellite Retrievals for Global Precipitation Measurement (GPM IMERG) to generate 2021 land surface temperature (LST) and precipitation maps, respectively, showing that Maine was abnormally dry during the summer in an increasingly warm region. These workshop materials will aid the partners in integrating NASA Earth observations into their future salmon habitat restoration initiatives.

Project URL: Maine Ecological Forecasting III - GSFC

New York Ecological Forecasting - ARC

Utilizing NASA Earth Observations to Map Ash Density and Inform Emerald Ash Borer Control

TEAM

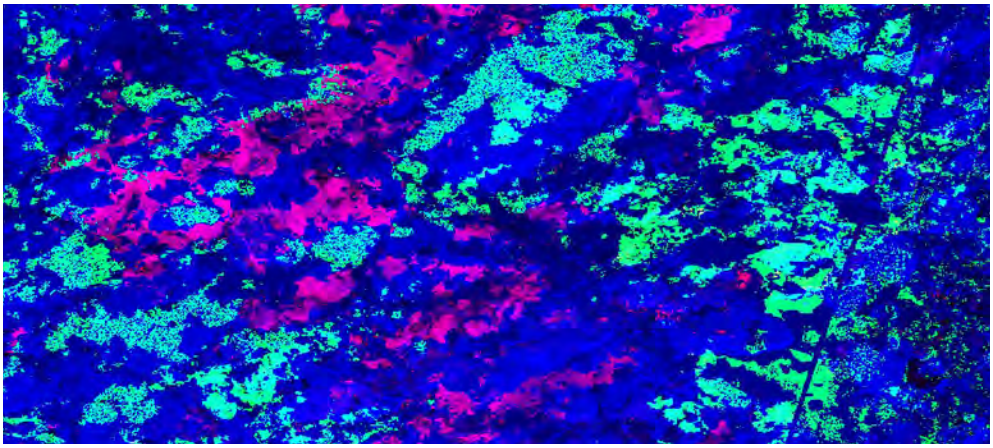
Liam Megraw (Project Lead)
Jesse Carlson
Samantha Kelly
Stefanie Dimayuga Mendoza

EARTH OBSERVATIONS

ER-2 AVIRIS
Landsat 7 ETM+
SRTM

PARTNERS

The Nature Conservancy, Adirondack Chapter, Adirondack Park Invasive Plant Program.



NDVI timeseries regression for the year 2021 using Landsat 8 Enhanced Thematic Mapper Plus data within the Adirondack Park in upstate New York. Red represents the amplitude of the regression, green represents the phase of the regression, and blue represents the median NDVI. This imagery was used to help determine where ash trees are present.

Intensifying weather events, sea level rise, and extensive coastal development in Southwestern Florida are escalating the need for Florida's mangrove conservation. These mangroves are imperative for coastline stabilization, habitat provision for native species, and water quality management. Our partner, the Florida Department of Environmental Protection (FDEP), Office of Resilience and Coastal Protection is tasked with monitoring and conserving the Charlotte Harbor, Estero Bay, Rookery Bay, and Pinellas County Aquatic Preserves. We developed a Google Earth Engine toolset for partners to determine mangrove forest extent in various years, analyze mangrove forest health, and collect several water quality parameters within the preserves from January 2002–August 2022. The toolset provides easily accessible data from Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Landsat Operational Land Imager (OLI), Landsat 9 Operational Land Imager 2 (OLI-2) and Thermal Infrared Sensor 2 (TIRS-2), Sentinel-2 Multispectral Imager (MSI), and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS). Using training datasets of known mangrove forest locations, we also established a machine learning approach to create mangrove extent maps. Maps from all four Aquatic Preserves indicated migration of mangrove forests inland as the greatest areas of change were transitional zones. Additionally, normalized difference vegetation index (NDVI), normalized difference turbidity index (NDTI), and chlorophyll-a maps were generated for the partners. This project provides decision makers with a useful tool for understanding temporal changes in Florida's aquatic preserves, identifying areas of ecological stress, and providing actionable data to make informed plans for mangrove preservation.

Project URL: New York Ecological Forecasting - ARC

Yellowstone Ecological Forecasting - GA

Assessing Change in Aspen Extent and Health in Northern Yellowstone National Park

TEAM

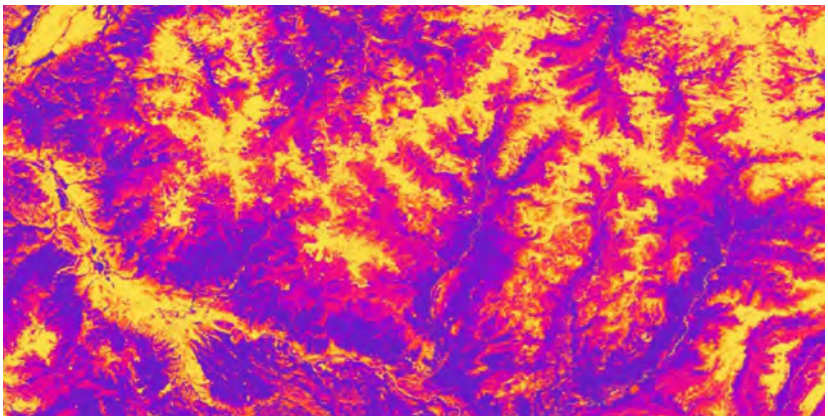
Kyle Steen (Project Lead)
Vanessa Bailey
Gabriella Boodhoo
Barry McLaughlin

EARTH OBSERVATIONS

ISS GEDI
Landsat 5 TM
Sentinel 2-MSI

PARTNERS

National Park Service, Colorado National Monument; Bureau of Land Management, McInnis Canyons and Domingues-Escalante National Conservation Areas



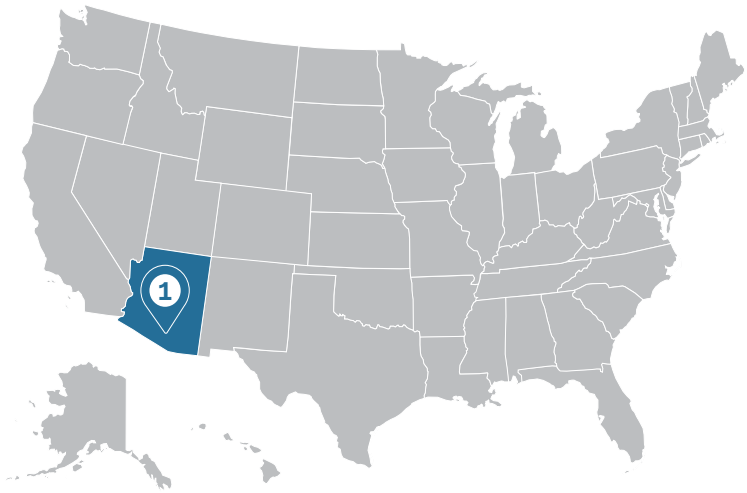
Tasseled cap greenness calculated from a June 15th, 2021 image taken from Landsat 8 OLI data. The dark shades of pink and purple represent high vegetation areas in the northern range of Yellowstone National Park. Bright yellow represent non-vegetation areas, mainly open ground and bare soil. Tasseled cap transformations are helpful in showing the visual extent of greenness and important for modelling aspen extent over time within Yellowstone and beyond.

The removal and reintroduction of the gray wolf (Canis lupus) in Yellowstone National Park have played an important role in shaping the ecological composition of this distinct landscape, and it is a textbook example of multi-trophic dynamics. With particular importance to conservation science, the inter-trophic cascades between wolves and species such as the elk (Cervus canadensis) and the quaking aspen (Populus tremuloides) have been extensively studied. In conjunction with the National Park Service, Yellowstone National Park, Utah State University, and the University of Wisconsin–Stevens Point, this project utilized satellite remote sensing to investigate the long-term trends in aspen extent. Through random forest modeling and phenological approaches, Sentinel-2 Multispectral Instrument (MSI; years 2017–2019) and Landsat 5 Thematic Mapper (TM; years 1987–2011) datasets were used to derive an Enhanced Vegetation Index (EVI), a Normalized Difference Vegetation Index (NDVI), Tasseled Cap Indices (Brightness, Greenness, Wetness), and RGB true color composites. The International Space System Global Ecosystem Dynamics Investigation (ISS GEDI) was used to analyze canopy height. Results were consolidated into maps and time-series that provide an in-depth and intricate depiction of aspen stand extent. The end products will assist the National Park Service in its management practices and inform wildlife restoration and rewilding decisions within and beyond the contexts of Yellowstone National Park.

Project URL: Yellowstone Ecological Forecasting - GA

Urban Development

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. The goal is to support the sustainability, resilience, and safety of cities and human settlements through informed planning and management of climate and disaster risks.



Urban Development Projects

DEVELOP OFFICE LOCATIONS

1. Arizona - Tempe
2. Virtual Environmental Justice

PORTFOLIO

Albuquerque Urban Development: Enhancing Urban Cooling Interventions by Modeling Urban Forestry Through NASA Earth Observations in Albuquerque, New Mexico

Milwaukee Urban Development: Assessing the Drivers of Urban Flooding Vulnerability in Milwaukee Using NASA Earth Observation Data

PARTNERS

City of Albuquerque, Department of Environmental Health

City of Albuquerque, Department of Parks and Recreation

Groundwork Milwaukee

Groundwork USA

Let's Plant Albuquerque!

SENSORS

GPM IMERG

ISS ECOSTRESS

Landsat 7 ETM +

Landsat 8 TIRS

Albuquerque Urban Development - AZ

Enhancing Urban Cooling Interventions by Modeling Urban Forestry Through NASA Earth Observations in Albuquerque, New Mexico

TEAM

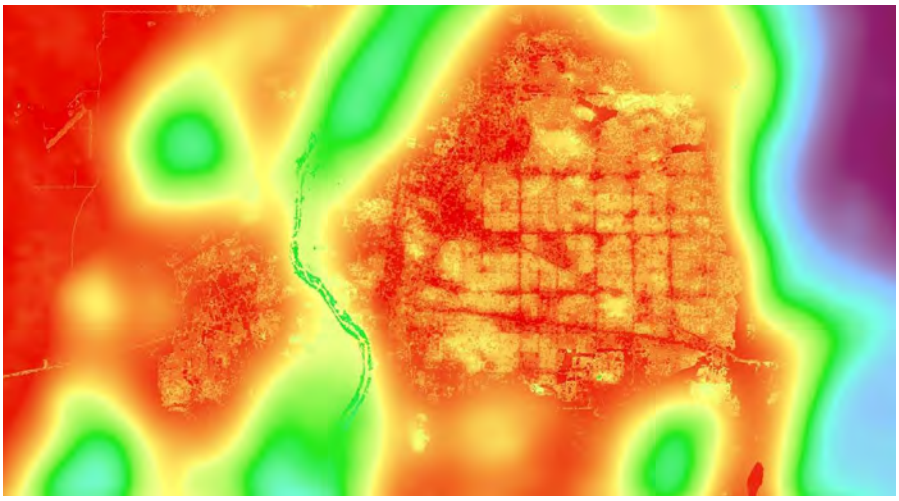
Max Stewart
Christina Dennis
Ritisha Ghosh
Richard Kirschner
Steven Nystrom

EARTH OBSERVATIONS

ISS ECOSTRESS
Landsat 8 TIRS

PARTNERS

City of Albuquerque, Department of Environmental Health; City of Albuquerque, Department of Parks and Recreation; Let's Plant Albuquerque!



Heat Mitigation Index calculated from a composite 2019-2021 ISS ECOSTRESS evapotranspiration image, run with other environmental data through the InVEST Urban Cooling model. The warmer colors indicate an area that does a worse job at mitigating urban heat. The purple in the east shows the Sandia Mountains, and the green through the middle surrounds the Rio Grande. Heat mitigation indices help urban foresters plan where to plant trees to reduce the urban heat island effect.

The City of Albuquerque, New Mexico is experiencing increasing urban heat island (UHI) effects, which impact the community's health, safety, and comfort. In partnership with the City of Albuquerque Department of Environmental Health, Department of Parks and Recreation, and Lets Plant Albuquerque!, this project used satellite Earth observations from April 2016 to August 2022 to model increases in tree canopy within the City of Albuquerque. These models were applied to help combat the urban heat island in the city's warmer areas over the next decade. Using Landsat 8's Thermal Infrared Sensor (TIRS), Landsat 9's TIRS-2, and the ISS's ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) and Global Ecosystem Dynamics Investigation (GEDI) sensors, along with the InVEST Urban Cooling and ENVI-Met models, the team modeled tree cover interventions and created land surface temperature maps. Outputs from the InVEST model work in confluence with the UHEAT vulnerability index to show potential cooling capacity for priority neighborhoods. These results communicate to project partners how an increased canopy can mitigate urban heat and assist the city to make data-driven decisions for their tree planting goal in a targeted approach.

Project URL: Albuquerque Urban Development - AZ

Milwaukee Urban Development - VEJ

Assessing the Drivers of Urban Flooding Vulnerability in Milwaukee Using NASA Earth Observation Data

TEAM

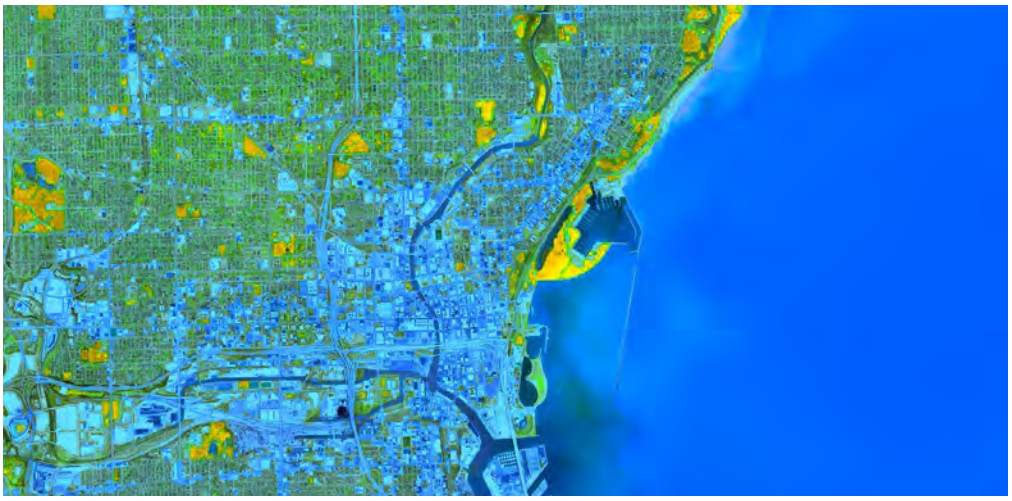
Madeleine Tango (Project Lead)
Jack Acomb
Annika Harrington
Lisa Son

EARTH OBSERVATIONS

GPM IMERG
Landsat 7 ETM +

PARTNERS

Groundwork USA; Groundwork Milwaukee



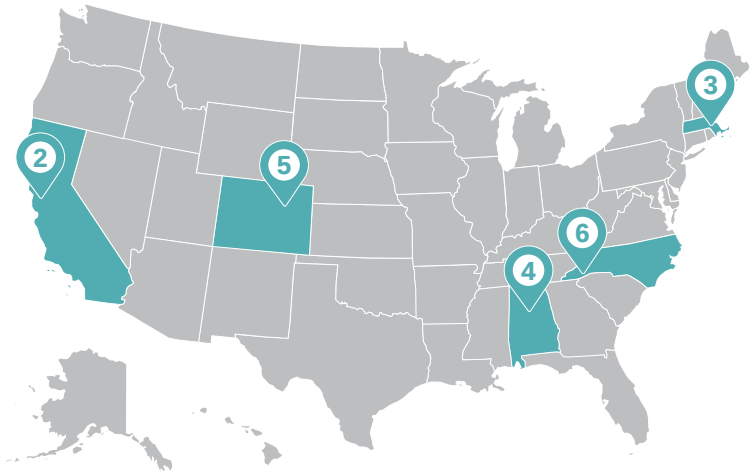
NDWI-processed image derived from Landsat 7 ETM+ data captures the aftermath of a 3-inch rainstorm in Milwaukee, Wisconsin. The composite image shows inundated areas in blue and dried areas in orange a few days after an April 2015 storm. Satellite imagery used in conjunction with hydrological models allow the city to identify areas in need of flood mitigation strategies.

Milwaukee County has experienced an increase in flooding due to climate change and urbanization. The frequency and severity of flooding vary spatially due to differences in land cover, surface permeability, and infrastructure. Marginalized communities tend to experience disproportionately high flooding and damage due to infrastructural inequalities and limited access to resources. To quantify these differences, we used the Natural Capital Project's Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Urban Flood Risk Mitigation Model to calculate and create maps of runoff retention, nominal flood depth, and economic damage to buildings in Milwaukee. Our model inputs included land cover, surface permeability, and rainfall. To inform our precipitation inputs, we used NASA's Integrated Multi-satellite Retrievals for Global Precipitation Measurement (GPM IMERG) and National Weather Service (NWS) data. We assessed the relationship between flood risk and social and environmental spatial data including redlining, racial demographics, green space, and community resilience. The data demonstrate that flood risk is higher in historically redlined neighborhoods, majority Hispanic and Black census block groups, areas that lack parks and trees, and areas of low community resilience as measured by the Census Bureau's Community Resilience Estimates. These findings will support our partners, Groundwork Milwaukee and Groundwork USA, in their efforts to promote the equitable distribution of resources and support environmental health in urban spaces. The end products of this project provide our partners with tools to assess urban flooding vulnerability, guide future intervention projects, quantify the effects of environmental injustice, and improve stakeholder accessibility to data.

Project URL: Milwaukee Urban Development - VEJ

Water Resources

DEVELOP's Water Resources projects address concerns and decision processes that are related to water availability, water forecast, and water quality. The goal of the Water Resources theme is to apply NASA satellite data to improve the Decision Support Tools (DSTs) of user groups that manage water resources.



Water Resources Projects

DEVELOP OFFICE LOCATIONS

1. Pop-Up Office
2. California - Ames
3. Massachusetts - Boston
4. Alabama - Marshall
5. Colorado - Fort Collins
6. North Carolina - NCEI

PORTFOLIO

Chesapeake Bay Water Resources: Characterization of Sediment Dynamics for Enhanced Water Quality Monitoring in the Chesapeake Bay

Florida Water Resources: Assessing Coastal Resiliency Across Florida's Aquatic Preserves in Response to Hurricane Forces

Great Slave Lake Water Resources: Mapping Long-term Changes in the Hydroecology of the Slave River Delta Using NASA Earth Observations

Lake Champlain Water Resources: Using NASA Earth Observations to Identify Spatial and Seasonal Trends of Harmful Algal Events in Lake Champlain

Puget Sound Water Resources: Using Earth Observations to Map Bull Kelp in the Puget Sound, Washington, to Support Conservation and Restoration

Western Sonoran Water Resources: Evaluating Rock Pool Hydroperiod Fluctuation using Climate Variables to Inform Habitat Monitoring and Protection in the Western Sonoran Desert

Yampa Water Resources: Monitoring Water Quality and Evaluating Potential Drivers of Algal Blooms in the Upper Yampa River Watershed

PARTNERS

Akaitcho Territory Government

Chesapeake Bay National Estuarine Research Reserve

Colorado State University

Colorado State University, Agricultural Water Quality Program

Committee on Earth Observation Satellites, Coastal Observations, Applications, Services, and Tools

Deninu K'ue First Nation

Enviornment and Climate Change Canada

Florida Department of Environmental Protection, Office of Resilience and Coastal Protection

Fort Resolution Metis Government

Group on Earth Observations, AquaWatch

National Park Service, Organ Pipe Cactus National Monument

Port of Seattle

United States Department of Agriculture, Natural Resources Conservation Service (Northwest Region)

University of Arizona

Upper Yampa Water Conservancy District

Virginia Department of Environmental Quality

Washington Department of Natural Resources

SENSORS

Aqua MODIS

GPM IMERG

ISS DESIS

Jason-1

Jason-2

Jason-3

Landsat 5 TM

Landsat 7 ETM+

Landsat 8 OLI

Landsat 9 OLI-2

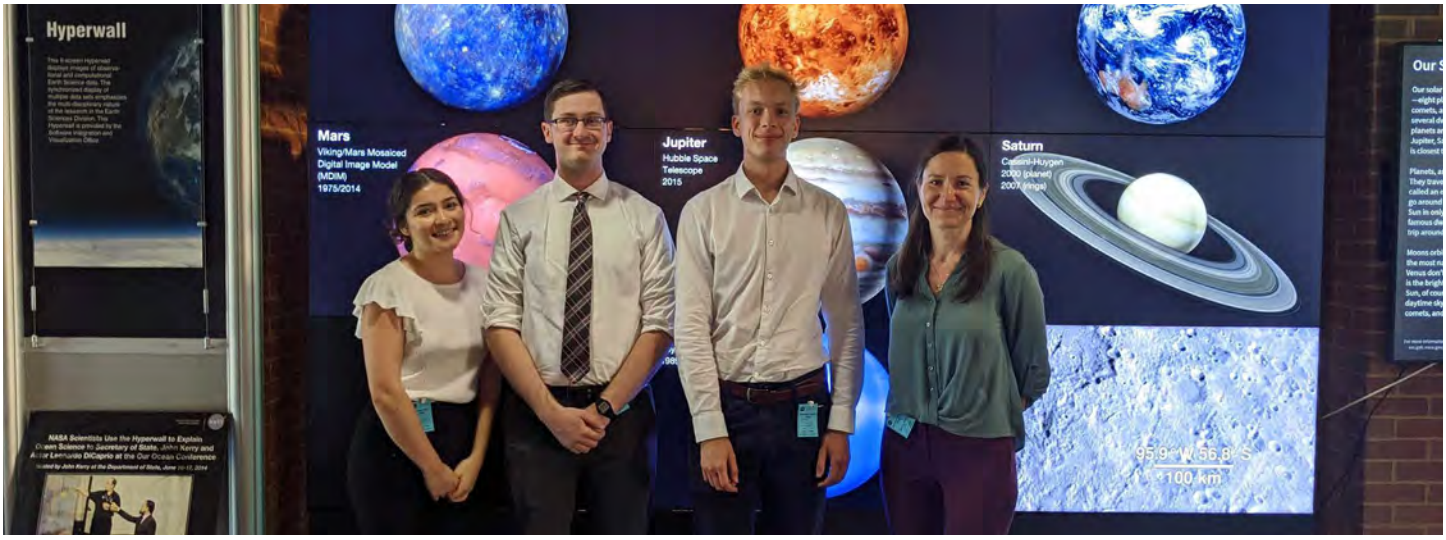
Sentinel-2 MSI

Sentinel-3 OLCI

SRTM

Terra MODIS

TOPEX/Poseidon



Chesapeake Bay Water Resources - PUP

Characterization of Sediment Dynamics for Enhanced Water Quality Monitoring in the Chesapeake Bay

TEAM

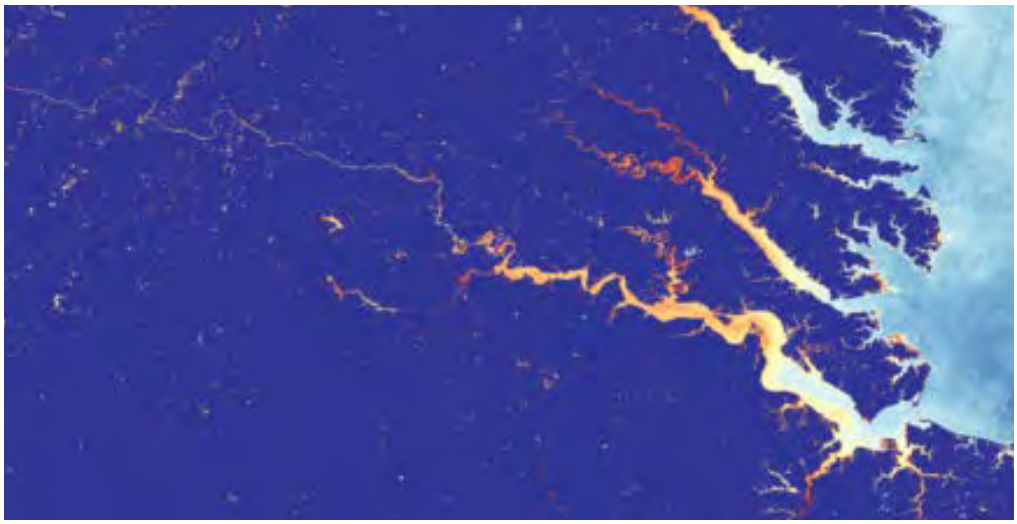
Julia Atayi
Katherine Hahn
Julia Portmann
Abigail Sgan

EARTH OBSERVATIONS

GPM IMERG
Landsat 5 TM
Landsat 7 ETM+
Landsat 8 OLI
Sentinel-2 MSI

PARTNERS

Virginia Department of Environmental Quality; Chesapeake Bay National Estuarine Research Reserve; Group on Earth Observations, AquaWatch; Committee on Earth Observation Satellites, Coastal Observations, Applications, Services, and Tools



This image of the Chesapeake Bay is derived from NASA Landsat 7 and Landsat 8 imagery. It represents median Normalized Difference Turbidity Index (NDTI) turbidity levels from January 2020 through June 2022. Yellow and orange areas indicate higher turbidity levels. This imagery can be used to determine areas of the bay in which turbidity poses a threat to water quality.

An increase in total suspended sediment (TSS) concentrations and turbidity have contributed to poor water quality in the Chesapeake Bay since the 1970s. Although turbidity and TSS have been moderately improving over the past few decades, poor water quality is detrimental to the Chesapeake Bay's ecosystems and the surrounding watersheds. The Summer 2022 Chesapeake Bay Water Resources project observed sediment dynamics and turbidity in the York River watershed using remote sensing tools and Earth observations including the NASA/United States Geological Survey (USGS) Landsat satellite series and NASA DEVELOP's Optical Reef Coastal Area Assessment Tool 2.0 (ORCAA). Weather data, a digital elevation model, soil types, and land cover were input to Soil and Water Assessment Tool (SWAT). Collaborating with the Chesapeake Bay National Estuarine Research Reserve (CBNERR), Group on Earth Observations (GEO) AquaWatch, the Committee on Earth Observation Satellites Coastal Observations, Applications, Services and Tools (CEOS COAST), and the Virginia Department of Environmental Quality (VA DEQ), the team concluded that TSS concentrations somewhat increased in the York River watershed from 2009 to 2019. During most seasons, turbidity was correlated with higher precipitation levels. However, TSS did not consistently correlate with precipitation across the study period, so other factors may be involved in sedimentation trends. Considerable work has been conducted to improve water quality, but additional efforts are needed. The team also identified specific areas to focus restoration, like planting riparian buffers to reduce runoff. This allowed the team's end user, the VA DEQ, to inform their policymaking regarding future Bay conservation efforts.

Project URL: Chesapeake Bay Water Resources - PUP

Florida Water Resources - ARC

Assessing Coastal Resiliency Across Florida's Aquatic Preserves in Response to Hurricane Forces

TEAM

Samuel Perrello (Project Lead)
Emily Heltzel
Koya Oki
Kyle Stark

EARTH OBSERVATIONS

Landsat 7 ETM+
Landsat 8 OLI
Landsat 9 OLI-2
Sentinel-2 MSI
SRTM

PARTNERS

Florida Department of Environmental Protection, Office of Resilience and Coastal Protection

Water Quality timeseries regression for the year 2020 using Landsat 8 Enhanced Thematic Mapper Plus data of Aquatic Preserves in Florida. Dark Green represents the amplitude of Clorophyll-A levels, DEM model overlayed on top represents Submerged Aquatic Vegetation. This imagery was used to help determine water quality for mangroves in 2020.

Mangrove forests are an important part of Florida's coastal ecosystem. They absorb excess water and prevent erosion during extreme weather, filter nutrients and pollutants to protect water quality, and provide habitat for many fish species. Florida is at a high-risk for hurricanes which leads to increased coastal erosion and a potential human safety concern. Anthropogenic expansion into these habitats are further threatening the extent, health and water quality of these vital ecosystems.

Project URL: Florida Water Resources - ARC

Great Slave Lake Water Resources - MA

Mapping Long-term Changes in the Hydroecology of the Slave River Delta Using NASA Earth Observations

TEAM

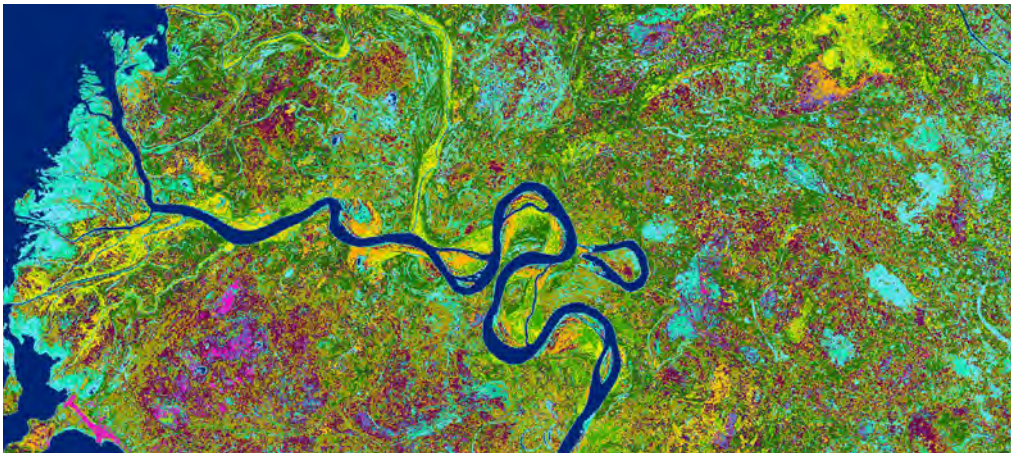
Yuhe Chang (Project Lead)
Virgil Alfred
Ethan McIntosh
Catherine Shea

EARTH OBSERVATIONS

Jason-1
Jason-2
Jason-3
Landsat 5 TM
Landsat 8 OLI
TOPEX/Poseidon

PARTNERS

Fort Resolution Metis Government; Deninu K'ue First Nation; Akaitcho Territory Government; Enviornment and Climate Change Canada



Enhanced Wetland Classification of the Slave River Delta, NWT, Canada using Landsat 8 OLI imagery from June – August 2021. Most of the colors represent different categories of wetland. Many of the darker green areas represent areas where wetlands have transitioned to dryer forests or shrubs in recent decades.

Indigenous communities around the Great Slave Lake (GSL) in Canada's Northwest Territories have observed long-term changes in water levels within the Slave River Delta, causing concern over the alteration and loss of natural and cultural resources. Changes in delta water dynamics have impeded fishing and transportation accessibility and threatened to alter important wetland ecosystems, leading to greater uncertainty in natural resources management. In partnership with the Fort Resolution Métis Government (FRMG), the Deninu K'ue First Nation (DKFN), the Akaitcho Territory Government (ATG), and Environment and Climate Change Canada (ECCC), this project provided a visual archive of water patterns and land cover in the Great Slave River Delta for summer months (May to October) from 1984 to 2021. We produced time series animations, maps, and charts of land cover and delta morphology changes using data from NASA's Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI) missions, augmented with other NASA-supported satellite imagery, land cover classifications, and precipitation datasets. Satellite observations confirm that changes in surface water and wetland extent in the delta tend to correlate with changes in Slave River discharge and precipitation in the drainage basin. However, we identified several water channels in the Slave River Delta and several areas of former wetland whose drying trends have persisted despite increases in precipitation and discharge from 2010 to 2020. By synthesizing various Earth observations into understandable and accessible data visualizations, the project strengthened decision-makers' overall understanding of drivers of change in the Slave River Delta.

Project URL: Great Slave Lake Water Resources - MA

Lake Champlain Water Resources - MSFC

Using NASA Earth Observations to Identify Spatial and Seasonal Trends of Harmful Algal Events in Lake Champlain

TEAM

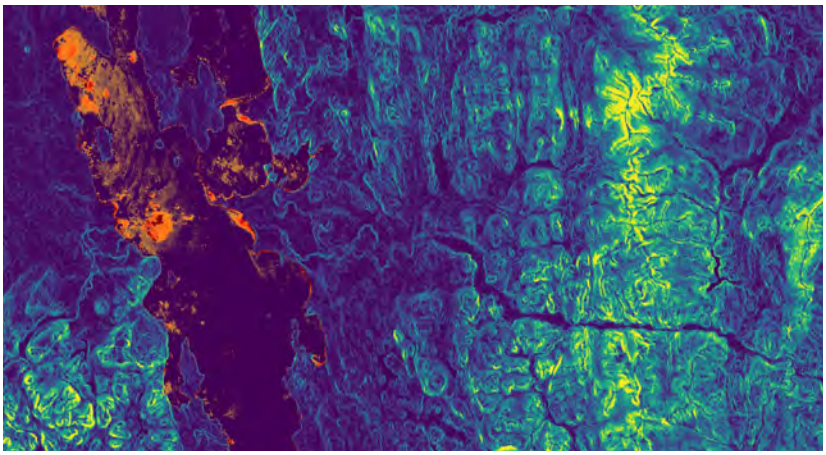
Brianne Kendall (Project Lead)
Aaron Carr
Laramie Plott
Ian Turner

EARTH OBSERVATIONS

ISS DESIS
Landsat 8 OLI
Landsat 9 OLI-2
Sentinel-2 MSI
Sentinel-3 OLCI
SRTM

PARTNERS

United States Department of Agriculture, Natural Resources Conservation Service (Northwest Region)



Top Layer (Lake): NDTI processed imagery of Lake Champlain derived from Landsat 8 TOA data (5/1/21 - 9/30/21). Bright orange and red represent areas of greater turbidity, which often corresponds to algal presence, whilst dark areas indicate low turbidity. Bottom layer: Slope imagery from SRTM (last updated 11/2018) of the Lake Champlain Watershed. Yellow shows areas with higher slopes, which have a greater risk of phosphorus runoff, while blue shows areas with a lesser slope.

Ranked as the fourth largest food producer in the world, Brazil is an agricultural powerhouse. Agricultural production at this scale warrants accurate crop monitoring and classification, however, this tropical area is frequently concealed by dense cloud cover in standard optical imagery. To improve the accuracy and spatial coverage of current crop monitoring operations, the team incorporated radar data capable of penetrating cloud coverage to classify second season corn and cotton fields. Utilizing optical imagery from Landsat 8 Operational Land Imager (OLI) as well as radar imagery from Sentinel-1 C-band Synthetic Aperture Radar (C-SAR), and topographic imagery from Shuttle Radar Topography Mission (SRTM), the NASA DEVELOP team worked with the United States Department of Agriculture (USDA) Foreign Agricultural Service (FAS) and World Agricultural Outlook Board to generate a crop classification procedure using a random forest model for accurate mapping and crop area estimates. Additionally, accuracy assessments were performed to ensure confidence in classification accuracy and to allow for comparison with previous classification maps of the area. Classification maps and area estimates produced will be used by the USDA FAS to generate accurate estimates of available commodities as well as assist in agricultural policy decision making.

Project URL: Lake Champlain Water Resources - MSFC

Puget Sound Water Resources - CO

Using Earth Observations to Map Bull Kelp in the Puget Sound, Washington, to Support Conservation and Restoration

TEAM

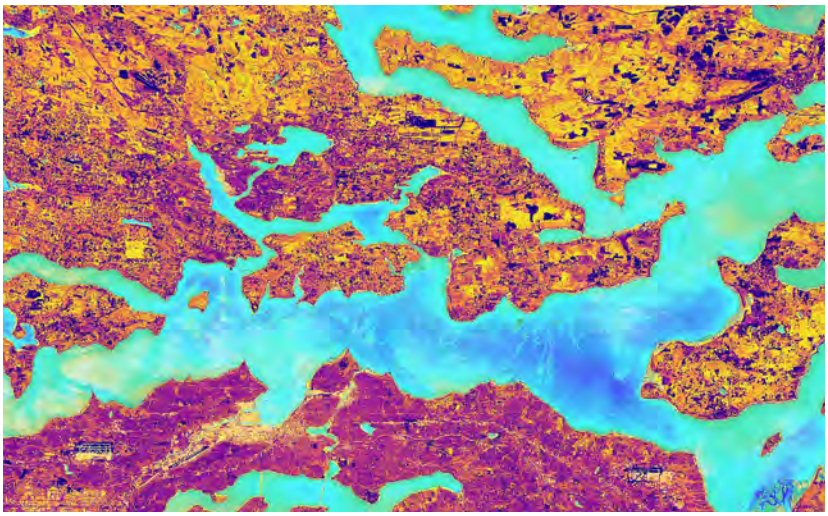
Mike Hitchner (Project Lead)
Sofia Fall
Lily Oliver
Lyndsay Zemanek

EARTH OBSERVATIONS

Landsat 8 OLI
Sentinel-2 MSI

PARTNERS

Port of Seattle; Washington Department of Natural Resources



This composite image of Puget Sound, Washington displays 2020 and 2021 mean NDVI from scenes acquired between June and September. NDVI shows the spectral vegetation response and is shown here in a custom palette that visually separates terrestrial and aquatic areas. Darker blues show the lowest spectral vegetation response, typically highlighting open, deeper portions of Puget Sound. Teals and light greens represent a higher aquatic vegetation spectral response. NDVI can be used to help identify kelp in aquatic ecosystems due to the difference in values between water and kelp canopy.

Bull kelp (Nereocystis luetkeana) is a critical and iconic component of nearshore ecosystems in the Puget Sound region of the Salish Sea. The Port of Seattle and Washington State Department of Natural Resources identified possible reductions in bull kelp extent and presence throughout the Central Puget Sound near Seattle, Washington. The reduction in bull kelp threatens the local ecosystems and wildlife, critical ecological services, as well as important cultural resources for the Coast Salish people of the region. The Port of Seattle and Washington State Department of Natural Resources partnered with NASA DEVELOP to examine the current extent of the near-shore urban kelp beds as well as develop a time-series highlighting changes in kelp presence and extent over the last 10 years. The NASA DEVELOP team utilized the Landsat 8 Operational Land Imager (OLI) and Sentinel-2 Multispectral Instrument (MSI) in conjunction with MAXAR WorldView-2 and National Agriculture Imagery Program (NAIP) data to map current kelp extent and understand how these kelp beds have changed over the last decade. The team also explored the feasibility of different remote sensing techniques to detect changes in these relatively under-studied urban coastal environments. Additionally, remote sensing methods are a useful tool in mapping and tracking many of the larger near-shore urban kelp beds. However, these methods have limited ability to map and track the smaller or less dense kelp beds in the region due to the limited resolution of the data.

Project URL: Puget Sound Water Resources - CO

Western Sonoran Water Resources - NC

Evaluating Rock Pool Hydroperiod Fluctuation using Climate Variables to Inform Habitat Monitoring and Protection in the Western Sonoran Desert

TEAM

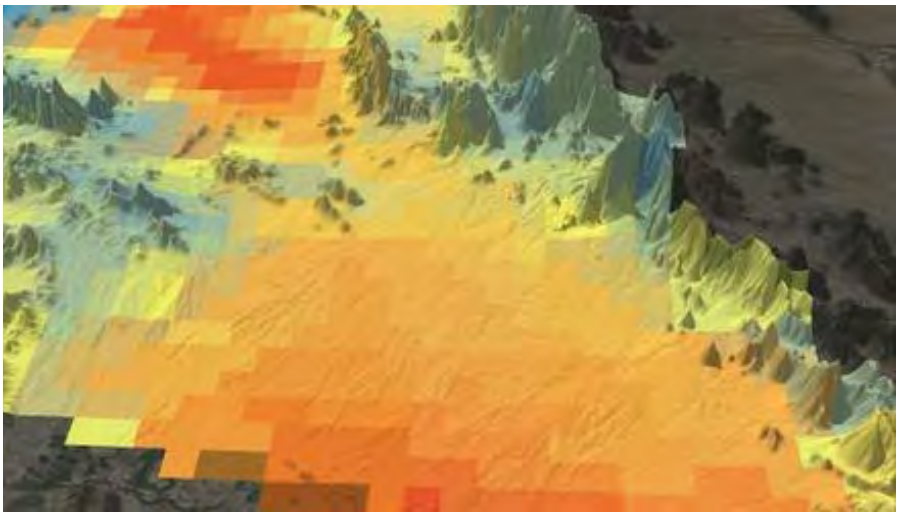
Anne Britton (Project Lead)
Deirdre An
Seamus Geraty
Charles Nixon

EARTH OBSERVATIONS

Terra MODIS
Aqua MODIS

PARTNERS

National Park Service, Organ Pipe Cactus National Monument; University of Arizona



Aqua MODIS-derived nighttime land surface temperature climate normal for 2002 - 2022 across the southeastern portion of Organ Pipe Cactus National Monument. Shades of green and blue indicate lower mean nighttime temperatures while shades of orange and red indicate higher mean nighttime temperatures. Tinajas in areas with higher nighttime temperatures may be at an increased risk as warming and drying trends continue across the western Sonoran Desert.

Ephemeral freshwater rock pools, known as tinajas, have great biologic and cultural importance as sources of surface water in the western Sonoran Desert (WSD). Tinaja flooding and drying cycles, known as hydroperiods, vary based on meteorologic and climatologic conditions; however, a lack of extensive research relating climatic impacts to tinajas puts these critical ecosystems further at risk. The physical and ecological condition of tinajas in Organ Pipe Cactus National Monument (OPCNM), AZ, are monitored by the National Park Service (NPS) and the University of Arizona using resource intensive strategies: in situ trail cameras and direct measurements. To aid monitoring efforts, the NASA DEVELOP team aimed to incorporate remote sensing into NPS strategies by analyzing spatiotemporal climate data and tinaja hydroperiods in OPCNM between 1979–2022. Using Aqua and Terra Moderate Resolution Imaging Spectroradiometers (MODIS), University of Idaho Gridded Surface Meteorological Dataset (gridMET), and OpenET data, the team generated climatology maps and time series for OPCNM. These data were then compared to daily in situ hydroperiod observations from the University of Arizona between 2019–2022. Climate maps and time series showed increases in temperature and solar radiation ($p<0.05$), while analyses of in situ data showed correlations of hydroperiods with precipitation and evapotranspiration. End products identified high-risk tinajas and demonstrated that Earth observations can successfully be correlated with in situ hydroperiod observations. These results will support NPS efforts to prioritize water resource management and inform protocols driving the conservation of tinajas in OPCNM.

Project URL: Western Sonoran Water Resources - NC

Yampa Water Resources - CO

Monitoring Water Quality and Evaluating Potential Drivers of Algal Blooms in the Upper Yampa River Watershed

TEAM

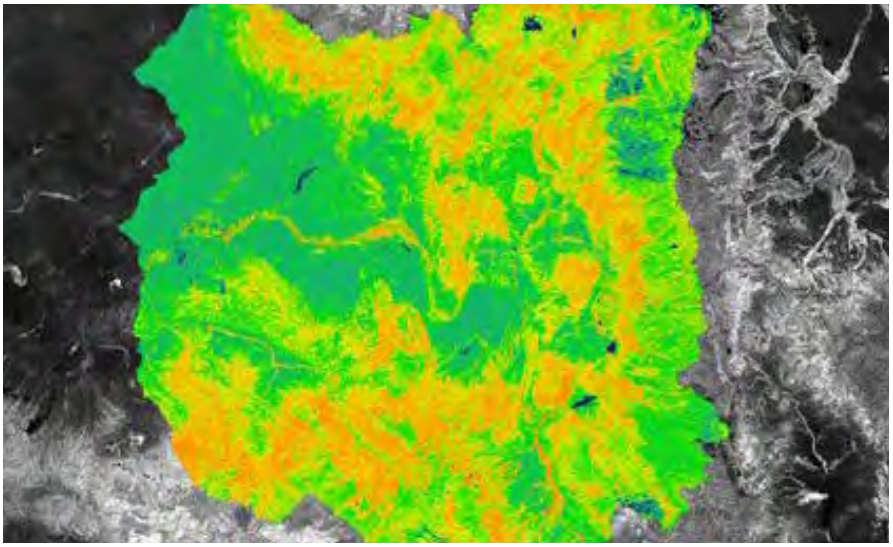
Samrin Sauda (Project Lead)
Ethan Gates
Morgan Guttman
Erin Weitzel

EARTH OBSERVATIONS

Landsat 5 TM
Landsat 7 ETM+
Landsat 8 OLI

PARTNERS

Upper Yampa Water Conservancy District; Colorado State University; Colorado State University, Agricultural Water Quality Program



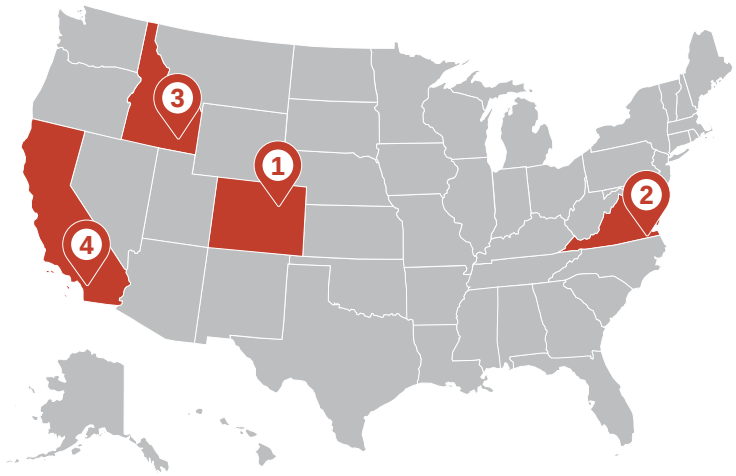
Normalized difference vegetation index (NDVI) processed using Landsat 8 OLI from August 2021 for the Upper Yampa Watershed located in Northern Colorado. The concentrated orange areas represent high vegetation and chlorophyll-a presence while the deeper blue exhibits lower vegetation and chlorophyll-a values. NDVI calculations helped to inform water resource managers of the limitations associated with spectral indices when utilizing remote sensing tools to observe harmful algal blooms.

The Upper Yampa River Watershed (UYRW), located in northwestern Colorado, plays a key role in providing water to the Colorado River. However, the UYRW has been impacted by increasingly frequent and widespread harmful algal blooms (HABs) which have largely deteriorated the water quality. Partnering with the Upper Yampa Water Conservancy District and the Colorado State University (CSU) Agricultural Water Quality Program, the DEVELOP team utilized Earth observations from Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI) to analyze trends in water quality from 1984 to 2022 for 9 waterbodies. The team generated time series plot and maps exhibiting greenness, temperature, Apparent Visible Wavelength (AVW) and Broad Wavelength Algae Index (BWAI). Evaluation plots were created to analyze the correlation between indices and in-situ measurements. Mixed trends were found among the 3 lakes for the greenness, temperature, AWV, and BWAI timeseries. The lack of significant evaluation data made it difficult to assess the viability of using remote sensing to monitor water quality in this region.

Project URL: Yampa Water Resources - CO

Wildfires

DEVELOP's Wildfires application area supports pre-fire (fuel loading, fire risk), during (active fire detection), and post-fire (fire extent, intensity) monitoring and modeling.



Wildfires Projects

DEVELOP OFFICE LOCATIONS

1. Colorado - Fort Collins
2. Virginia - Langley
3. Idaho - Pocatello
4. California - JPL

PORTFOLIO

Black Hills Wildfires: Mapping Post-fire Conifer Regeneration using Snow-on Imagery

Chile Wildfires: Utilizing NASA and NOAA Earth Observations to Determine Lightning-induced Wildfire Risks in Chile's Valparaíso Region

Idaho Wildfires: Assessing Drought and Fire Conditions, Trends, and Susceptibility to Inform Mitigation Efforts and Bolster Monitoring Protocol in North Central Idaho

Oregon Wildfires:
Integrating ECOSTRESS to Map and Analyze Vegetation Moisture for Improved Wildfire Behavior Modeling

PARTNERS

USDA, US Forest Service, Black Hills Experimental Forest

USDA, US Forest Service, Rocky Mountain Research Station

United States Geological Survey, Geosciences and Environmental, Change Science Center

Corporación Nacional Forestal

Embassy of Chile (Agricultural Office)

Idaho Office of Emergency Management

Idaho Department of Water Resources

Idaho Department of Lands

Pacific Northwest National Laboratory

USDA, US Forest Service

SENSORS

Aqua MODIS

GOES-16

ISS ECOSTRESS

Landsat 8 OLI

Sentinel-2 MSI

SRTM

Suomi NPP VIIRS

Terra MODIS

Black Hills Wildfires - CO

Mapping Post-fire Conifer Regeneration using Snow-on Imagery

TEAM

Casey Menick (Project Lead)
Heidi Rogers
Yeshey Seldon
Haley Stuckmeyer

EARTH OBSERVATIONS

Landsat 8 OLI
Sentinel-2 MSI

PARTNERS

USDA, US Forest Service, Black Hills Experimental Forest; USDA, US Forest Service, Rocky Mountain Research Station; United States Geological Survey, Geosciences and Environmental, Change Science Center

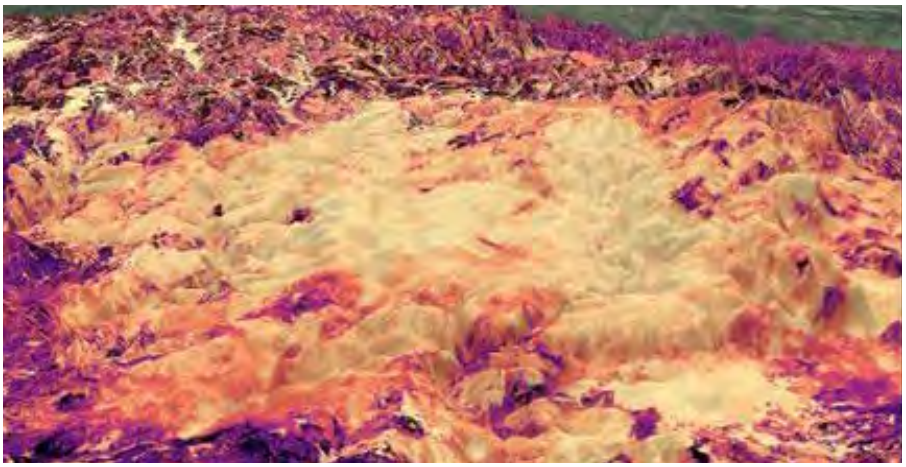


Image depicts median NDVI measured December, 2021 through January, 2022 by Landsat-8 OLI in the Black Hills of South Dakota. Light yellow indicates low NDVI and darker purple indicates high NDVI. The Jasper Fire burn, initiated in 2000, can still be seen in yellow in the center of the image. Snow cover NDVI is used as a primary variable in remote sensing detection of conifer regeneration in the severe burn area of the Jasper Fire.

The 2000 Jasper Fire in the Black Hills of South Dakota was the largest wildfire to date in the region, burning over 83,000 acres of ponderosa pine forest. In collaboration with partners from the United States Forest Service (USFS) Black Hills Experimental Forest, USFS Rocky Mountain Research Station, and United States Geological Survey Geosciences and Environmental Change Science Center, we characterized post-fire forest regeneration within high severity burn patches. We accomplished this by implementing novel conifer detection techniques using a snow index mask to create a winter, snow-on image composite from Landsat 8 Operational Land Imager (OLI) and Sentinel-2 Multispectral Instrument (MSI) data. We utilized 2015 USFS stem maps of field-observed regeneration plots and ocularly sampled additional reforestation sites planted in 2001–2013. In Google Earth Engine (GEE), the field data and imagery were used to train a Random Forest (RF) model. The RF model classified 2021 conifer regeneration density as low, medium, or high across the high-severity burn area with an overall accuracy of 81.3%. Approximately 45.9% of the high-severity burn had low or no regeneration (0-40 trees per acre) 20 years post-fire. Given our partners' desire to find easily accessible low conifer regeneration zones, we identified 4,079 acres of priority planting sites that were within 1,500 feet of roads, had not been planted previously, and were larger than 50 acres. This method supports the use of snow-on imagery as a successful technique to identify conifer regeneration

Project URL: Black Hills Wildfires - CO

Chile Wildfires - LaRC

Utilizing NASA and NOAA Earth Observations to Determine Lightning-induced Wildfire Risks in Chile's Valparaíso Region

TEAM

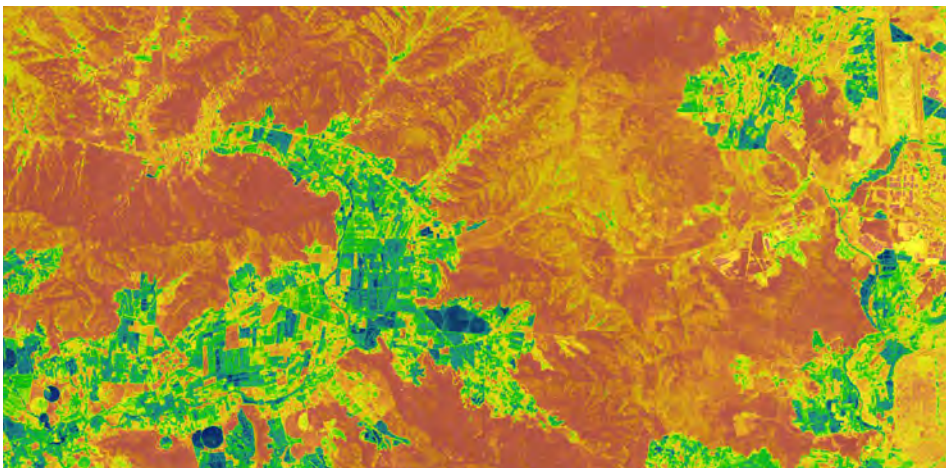
Chris Matechik (Project Lead)
Reuben Alter
Jennifer Ruiz
Stephen Sene

EARTH OBSERVATIONS

GOES-16
Landsat 8 OLI
Suomi NPP VIIRS

PARTNERS

Corporación Nacional Forestal; Embassy of Chile (Agricultural Office)



Results from the study found the greatest risk of lightning-ignited wildfires to be in the northern third of the study area during Chile's active fire season. Cumulative risk was calculated by first summing the risk ranks for fuel moisture (derived from NDMI), land surface temperature (LST), and lightning frequency. This sum was then multiplied by the percent area of fuel in each cell.

In recent years, Central Chile has experienced wildfires of increasing frequency and intensity which threaten natural resources and communities. The Corporación Nacional Forestal (CONAF) is charged with planning for, detecting, and responding to wildfires caused by a variety of ignitions. Lightning is one ignition source for wildfires, but the rate of lightning-induced wildfire ignitions is unknown. In collaboration with CONAF and the Embassy of Chile, Agricultural Office, the team used Earth observations to visually assess potential relationships between lightning strikes and wildfire ignitions and then created a wildfire risk map for Central Chile. The Active Fire Product of Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) provided footprints of fires, which the team compared to lightning events detected by GOES-16's Geostationary Lightning Mapper (GLM) to determine the relationship between lightning strikes and wildfire ignitions. Next, the team aggregated and mapped lightning strikes from February 2018 through December 2021 across Central Chile. Finally, the team calculated and mapped a relative estimate of lightning-ignited wildfire vulnerability by aggregating the following ranked factors: lightning frequency, land surface temperature, and vegetation moisture content. The team was unable to establish a relationship between lightning strikes and wildfires hitherto, due to a confounding effect from fires started by other sources. However, the team successfully created wildfire risk maps for central Chile.

Project URL: Chile Wildfires - LaRC

Idaho Wildfires - ID

Assessing Drought and Fire Conditions, Trends, and Susceptibility to Inform Mitigation Efforts and Bolster Monitoring Protocol in North Central Idaho

TEAM

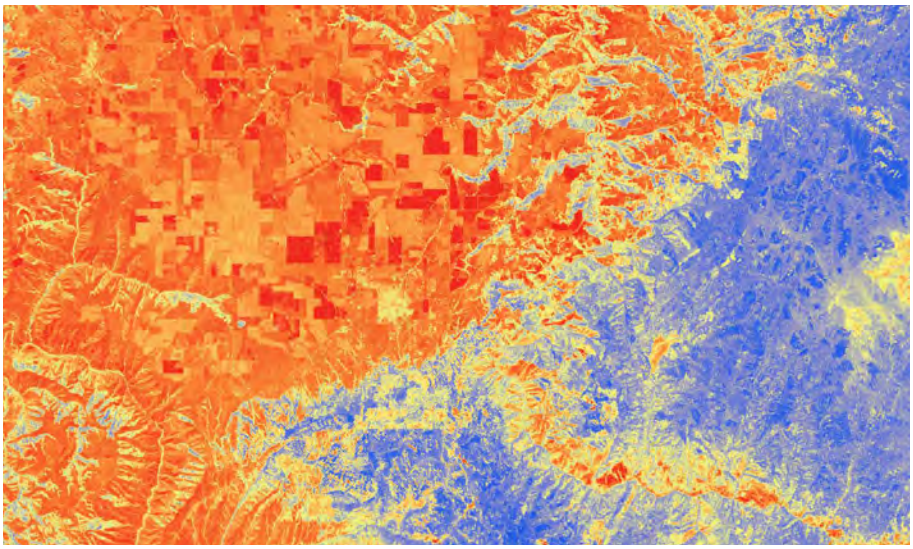
Ford Freyberg (Project Lead)
Brenner Burkholder
Jessica Hiatt
Carson Schuetze

EARTH OBSERVATIONS

Aqua MODIS
Landsat 8 OLI
Terra MODIS

PARTNERS

Idaho Office of Emergency Management; Idaho Department of Water Resources; Idaho Department of Lands



NDMI across a selection of the study area, derived from Landsat 8 OLI imagery on 08/30/2021. This image focuses on the interface between the agricultural Palouse region and surrounding areas, including mountainous and forested land. Dark red indicates low NDMI while dark blue indicates high NDMI (scale: -1 to 1). NDMI describes vegetative water content, thus acting as an indicator of vegetation's response to drought. These data can highlight areas of concern during wildfire season.

The frequency and intensity of drought and wildfires continue to increase, resulting in more difficult and costly mitigation and recovery efforts. The Palouse ecoregion, historically a native grassland, has largely been converted to an agricultural epicenter. Understanding soil health, drought susceptibility/conditions, and fire susceptibility in this unique ecosystem is critical to improving land management practices. The NASA DEVELOP team partnered with the Idaho Office of Emergency Management, Idaho Department of Water Resources, and Idaho Department of Lands (IDL) to gather information using NASA Earth observations to update Idaho drought and fire mitigation plans. The team utilized Landsat 8 and Terra observations to improve the predictive power of IDL's existing fire risk model. In addition, the team created a tutorial workflow allowing partner organizations to adjust the model as further data becomes available.

Project URL: Idaho Wildfires - ID

Oregon Wildfires - JPL

Integrating ECOSTRESS to Map and Analyze Vegetation Moisture for Improved Wildfire Behavior Modeling

TEAM

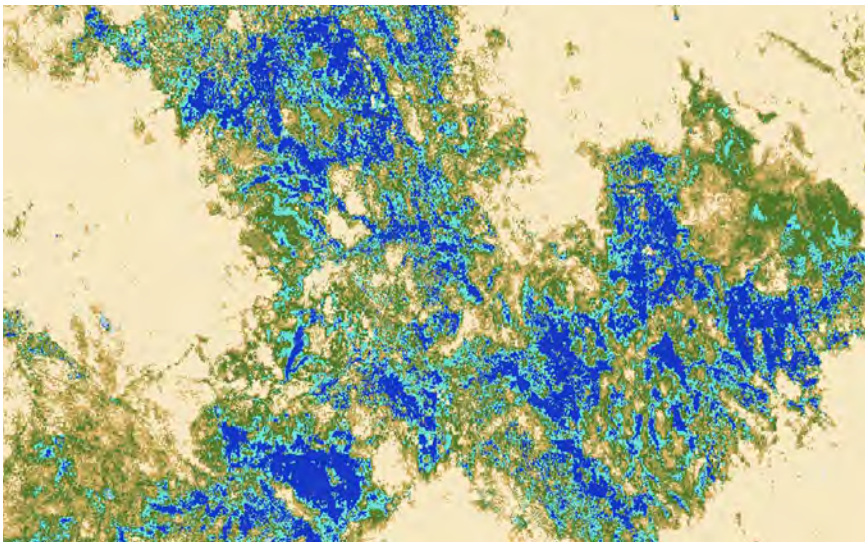
Brenna Hatch (Project Lead)
Kenya Creer
Nicole Roberts
Jennifer Sobolewski

EARTH OBSERVATIONS

ISS ECOSTRESS
SRTM

PARTNERS

Pacific Northwest National Laboratory; USDA, US Forest Service



Median June composite of daily evapotranspiration from ECOSTRESS before the start of the Bootleg Fire on July 6th, 2021. Evapotranspiration is shown in millimeters per day across Klamath and Lake counties in Oregon, with dark blue indicating areas with higher evapotranspiration and light tan indicating lower evapotranspiration. Evapotranspiration is an indicator of vegetation moisture and can aid wildfire modeling by locating areas undergoing water-stress and susceptible to fire.

Wildfire season in the western USA is starting earlier and gaining in intensity. The Bootleg Fire in Southern Oregon began on July 6th, 2021, and burned over 1675 km2 before it was fully contained on August 14th, 2021. Evapotranspiration (ET) is one indicator of vegetation moisture and there is interest in using high resolution ET products from ECOsystem and Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) in future wildfire modeling. In partnership with the Pacific Northwest National Laboratory and US Forest Service, the team examined ECOSTRESS ET for the two years prior to the Bootleg Fire and assessed the relationship between ET, topography, and vegetation type. Remotely sensed data from Shuttle Radar Topography Mission along with ancillary data from the National Land Cover Database and Landfire Existing Vegetation Type was incorporated. These parameters were examined in relationship to soil burn severity from the Burned Area Emergency Response program. From ET median composites for April 1 – July 5, 2021 and 2019, the Bootleg Fire area showed a 7 mm/day decrease in ET and a relative 90% decrease in ET between 2019 and 2021. Approximately 6% of the Bootleg Fire area was identified as having a high soil burn severity and these areas were found predominantly in the evergreen forest land cover class and northward facing slopes with a mean ET decrease of 3 mm/day between 2019 and 2021. The end products will allow the partners to assess if higher resolution vegetation moisture datasets from ECOSTRESS will improve wildfire modeling for other susceptible areas.

Project URL: Oregon Wildfires - JPL

2022 **Summer Participants**

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Senior Fellow	**PC Fellow**	**Fellow**	Assistant Fellow	Project Lead
+++	++	+	**	*

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Wynnie Gross
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Catherine Shea
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Raychell Velez

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Max Rock *
Deirdre An
Elijah Dalton
Seamus Geraty
Aidan Harvey
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Kate Reynolds

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Sarah Da Conceicao Carlos
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Rishudh Thakur

VIRGINIA – LANGLEY

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Tamara Barbakova ++
Adriana Le Compte +
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Jack Mezger *
Reuben Alter
Mark Bossinger
Quinn Heiser
Shanise Hunter
Gillian McNamara
Jennifer Ruiz
Stephen Sene

VIRTUAL ENVIRONMENTAL JUSTICE

Marco Vallejos +
Remi Work * *
Brooke Laird *
Madeleine Tango *
Jack Acomb
Melissa Ashbaugh
Annika Harrington
Muskaan Khemani
Sadie Murray
Lisa Sun

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. **Apply online at** https://appliedsciences.nasa.gov/nasadevelop.

PARTICIPANT OPPORTUNITIES

Both In-Person & Virtual Opportunities:

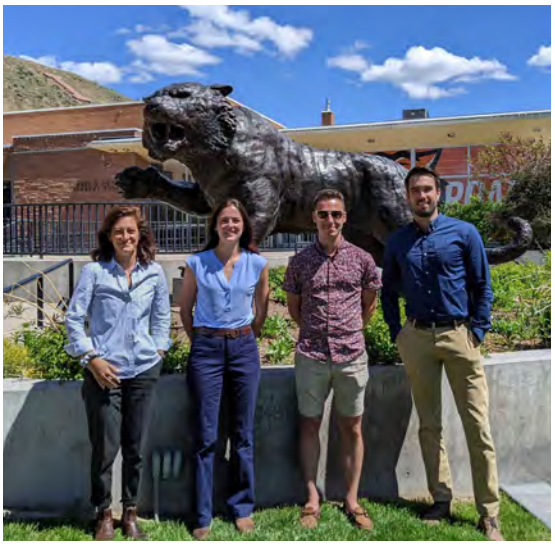
- Conduct a 10-week feasibility study w/guidance of DEVELOP Advisors
- Learn to apply Earth observation and geospatial data
- Close daily collaboration with team members
- Engagement with a decision-making partner organization
- Creation of a set of deliverables that communicate the project's methods and results
- Professional development opportunities & building of "soft" skills

Additional In-Person Opportunities:

- In-person tours, field trips, and meetings
- Access to a variety of onsite resources
- Enhanced team building and networking opportunities

Additional Virtual Opportunities:

- Ability to participate when you are not geographically near a DEVELOP location
- Increased flexibility in the virtual environment (ex. no commute)



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

U.S. CITIZENS – Eligible to apply to all DEVELOP locations in the United States.

FOREIGN NATIONALS – International applicants who are currently enrolled or recently graduated from a U.S. accredited university are eligible to apply to DEVELOP's regional locations, but not NASA or NOAA locations. Acceptance of foreign nationals is conditional upon proof of a valid visa, I-20 form, and an approved CPT/OPT that allows legal employment within the United States. Applicants who do not meet these requirements are not eligible to participate.

Engage as a **PROJECT PARTNER:**

Any organization making decisions related to environmental concerns and interested in incorporating NASA Earth observations into their decision-making process is welcome to contact DEVELOP to discuss potential collaborations. A project request form can be found on the DEVELOP website at https://appliedsciences.nasa.gov/what-we-do/capacity-building/develop/partner. Please visit the website for more information on partnering with DEVELOP.

PROJECT PROCESS:

Partner & DEVELOP discuss potential project & draft a proposal based on Partner needs

↓

NASA reviews and selects proposals

↓

DEVELOP team conducts project with Partner input and feedback throughout the course of the 10-week term

↓

DEVELOP hands off project results and methods to Partner

↓

Partner utilizes results & methods in decision-making process

BENEFITS OF WORKING WITH DEVELOP:

- **Build** your organization's capacity to utilize NASA Earth science data and expand the tools and resources available when making decisions.
- **DEVELOP** teams conduct feasibility projects that identify methods, prepare and analyze preliminary results, and create a set of deliverables (technical paper, poster, presentation).
- **Partner** organizations are empowered to self-sustainably use Earth observation data through the methods identified by DEVELOP.
- **Partnering** with DEVELOP may decrease data collection costs, streamline decision making, and fill in data gaps.

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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