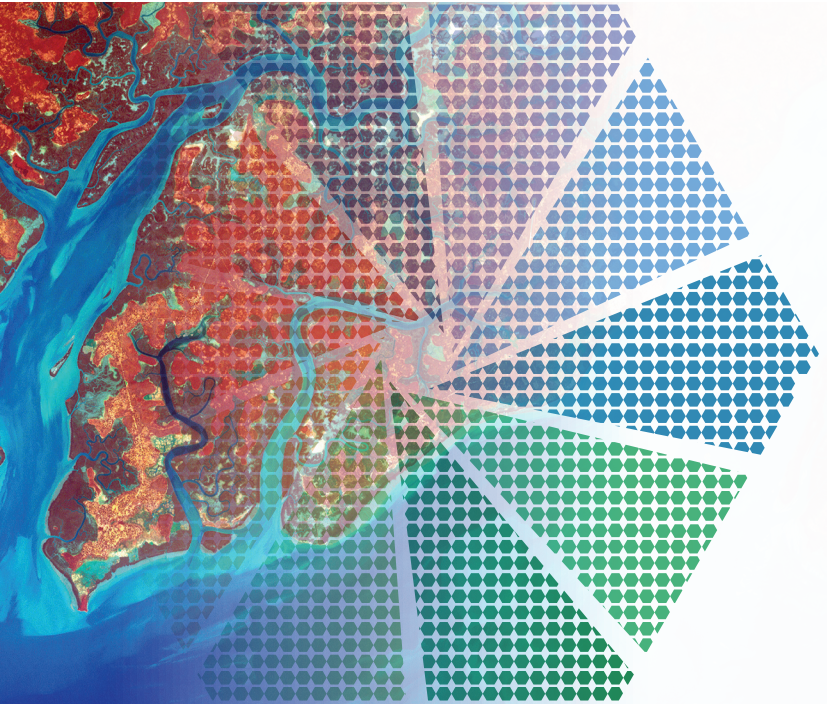
National Aeronautics and Space Administration



NASA Applied Sciences' Capacity Building Program's

DEVELOP National Program

2017 Summer Project Booklet

www.nasa.gov

Letter from the
National Program Office

The DEVELOP National Program is proud to present our 2017 summer projects. Our DEVELOP teams consistently excel in conducting applied science research projects, and we hope you gain a better understanding of the Capacity Building Program, where we apply science in service of society.

This summer, DEVELOP has continued a tradition of producing relevant project results, engaging diverse partners, and delivering useful end products to our communities, fellow federal agencies, and NASA. DEVELOP's amazing innovation, driven by our outstanding participants, science advisors, mentors, and partners, with expanded projects and new initiatives resulting in high quality, script-based, decision-support tools. As a team, we continue to be honored to support many great US institutions, including the National Park Service, National Oceanographic and Atmospheric Administration, United States Geological Survey, Bureau of Land Management, US Fish and Wildlife Service, US Department of Agriculture, and of course, NASA. This past year, we demonstrated our broad national reach, from monitoring air quality in our national parks in Virginia to assessing the impacts of a changing climate on invasive species in Alaska to evaluating a fish species response to changing environmental conditions off the coast of California. Our efforts also span globally, from assessing wetland extent in Rwanda to studying variations in social vulnerability to typhoon risk in the Philippines and water quanity and glacier extent in Chile. These are but a few of our global efforts this summer, and we invite you to review the 30 projects that our 138 DEVELOPers conducted at 12 locations working with 68 partners in the summer of 2017. We hope that our capacity building efforts provide you with a better understanding of the many ways NASA science serves society.

We are very grateful to our partners and end users, for without "customers", DEVELOP would not be where we are today. Our science advisors, mentors, and participants are the key to DEVELOP's success, as their commitment and dedication to improve our planet is unparalleled. We honor them. And to our sponsors at NASA and beyond, we know that without your support progress would not be possible.

We extend our thanks to you, our audience, for taking the time to learn more about DEVELOP.

With appreciation,
The DEVELOP National Program Office

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DEVELOP Vision

Shaping the future by integrating Earth observations into global decision making

About DEVELOP

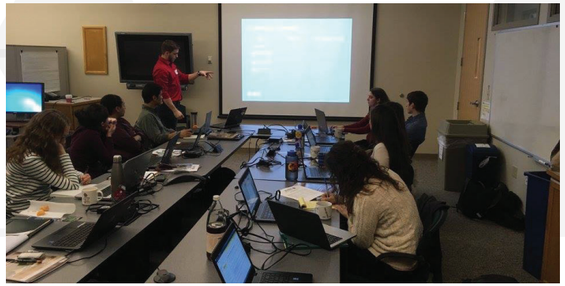
DEVELOP addresses a wide array of environmental and public policy issues by partnering with a diverse group of end-users to conduct interdisciplinary research projects that apply the lens of NASA Earth observations to community concerns around the globe.

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—from local to international, oceans to the atmosphere, and focused to expansive.

DEVELOP's dual-capacity building model cultivates skills and knowledge of NASA Earth observations in participants and partners alike. 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 benefit from sustainable tools and information specifically tailored to their decision-making needs.

Discovery

Innovation



About Projects

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

As part of the Applied Sciences Program, DEVELOP works within the thematic application areas of Agriculture, Climate, Disasters, Ecological Forecasting, Energy, Health & Air Quality, Oceans, Water Resources, Weather, and Cross-Cutting.

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–that can then be sustainably used to enhance the partner's decision making. In order to engage with as many end-users as possible, DEVELOP conducts projects on a 10-week timeline–fostering rapid applied benefit.

About Participants

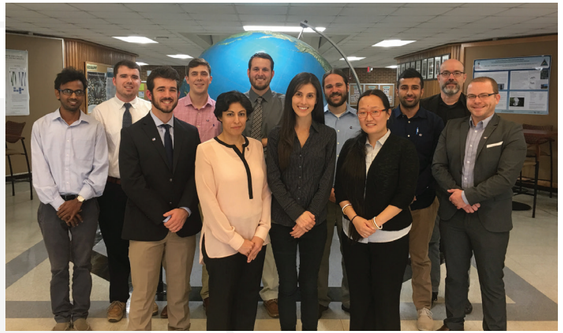
As a program with the goal of building broad capability to utilize NASA Earth observations for societal benefit, DEVELOP accepts participants with a variety of skills, backgrounds, and education levels. Offering over 300 participant opportunities each year, the main requirements to be a DEVELOPer are a strong interest in Earth science and a passion for one's work to benefit society.

DEVELOPers fall into five categories: currently enrolled college students, recent graduates, early career professionals, transitioning career professionals, and active and 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.

Passion

Collaboration



About Partners

A wide variety of project partners are a vital ingredient in the DEVELOP model. Each year DEVELOP collaborates with over 125 organizations to generate and conduct projects that apply NASA Earth observations to decision-making processes around the globe.

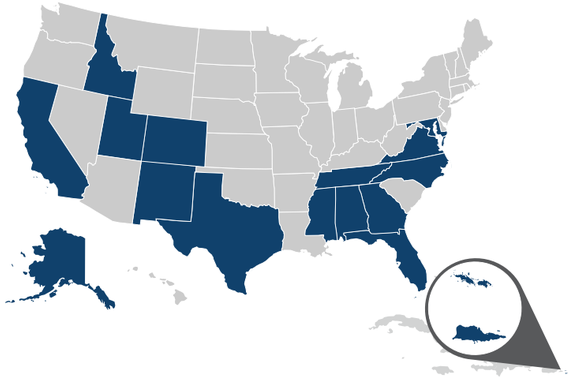
Partnerships often occur with local and state governments, regional consortiums, federal agencies, non-governmental and private organizations, academic institutions, and international governments and aid organizations.

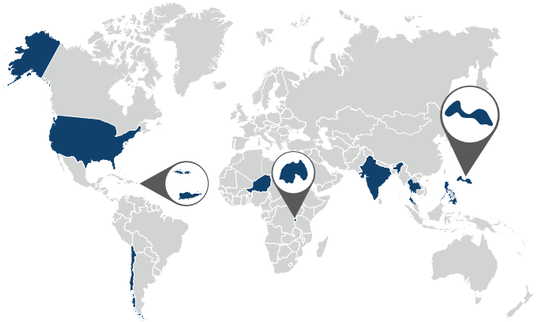
By collaborating with DEVELOP, partners are introduced to NASA's Earth Science Division and its Earth observation resources. End-users gain insight into satellite and airborne Earth observation capabilities and how they can augment and enhance their current decision-making practices. This provides potential 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.

2017 Summer Term

DEVELOP's 2017 Summer Term has been one of exciting collaborations with engaged partners in support of their decision-making needs. 138 DEVELOPers and 68 partners collaborated within the DEVELOP framework to conduct 30 rapid feasibility projects. These projects utilized NASA's Earth observations to monitor changes in the landscape that affect decision making and provide a synoptic view for understanding the Earth from the unique vantage point of space.

Earth observations from 33 sensors were applied by the DEVELOP project teams to seven of the NASA Applied Sciences' National Application Areas– Agriculture, Climate, Disasters, Ecological Forecasting, Health & Air Quality, Oceans, and Water Resources—as well as the interdisciplinary Cross-Cutting theme.





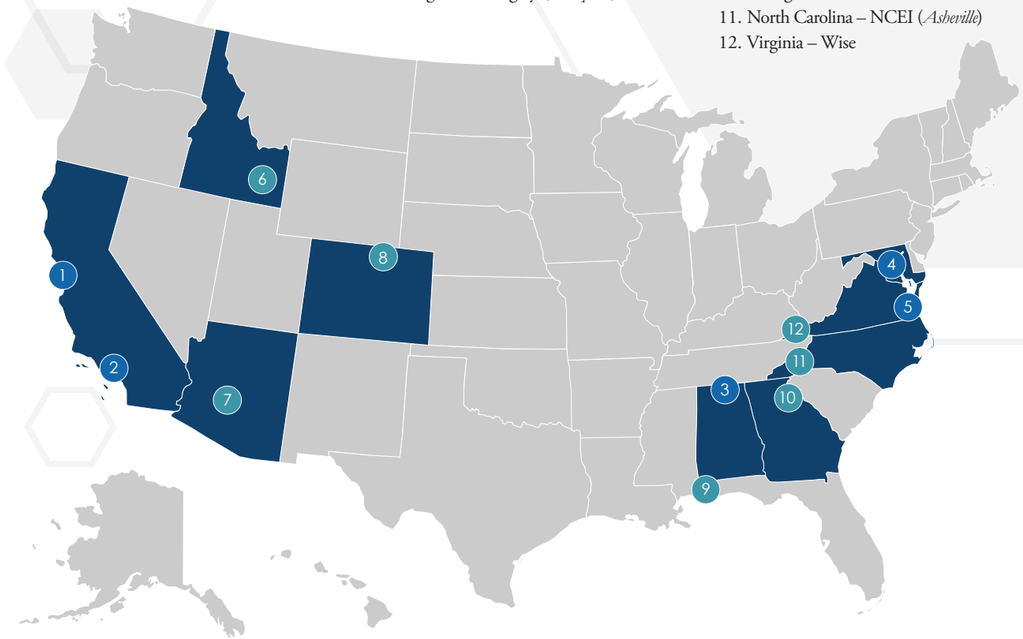
Partner organizations engaged with DEVELOP represented a variety of sectors, including state, local and federal agencies, international governments, non-governmental organizations (NGOs), academic institutions, and regional organizations. In continued collaboration with the National Park Service, DEVELOP worked on four projects with national parks, monuments, and inventory and monitoring networks across the country. DEVELOP conducted projects with several embassy partners including the Embassy of Chile, Embassy of Costa Rica, and the Embassy of Thailand. In addition, several DEVELOP projects utilized Earth observations to examine social vulnerability both in the US, and abroad, with health and disaster applications. DEVELOP projects also supported the effort to apply Earth observations in support of the United Nations' Sustainable Development Goals.

NASA Center Locations

1. California – Ames (*Moffett Field*)
2. California – JPL (*Pasadena*)
3. Alabama – Marshall (*Huntsville*)
4. Maryland – Goddard (*Greenbelt*)
5. Virginia – Langley (*Hampton*)

Regional Locations

6. Idaho – Pocatello
7. Arizona – Tempe
8. Colorado – Fort Collins
9. Alabama – Mobile
10. Georgia – Athens
11. North Carolina – NCEI (*Asheville*)
12. Virginia – Wise



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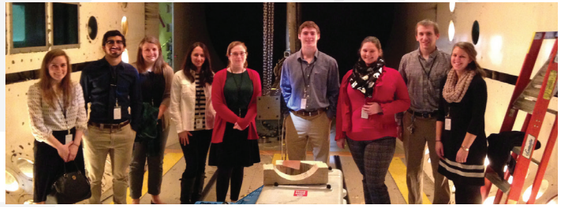


OVERVIEW:

DEVELOP's Water Resources projects address concerns and decision processes that are related to water availability, water forecasting, and water quality. The goal of the Water Resources theme is to apply NASA satellite data to improve the decision support tools of user groups that manage water resources. This summer, DEVELOP's seven Water Resources projects partnered with 11 organizations to improve water management in six states and three countries.

PORTFOLIO

Chesapeake Bay Water Resources II: Assessing and Assisting Monitoring Efforts of Water Clarity to Identify Potential Areas of Submerged Aquatic Vegetation (SAV) in the Chesapeake Bay (*Virginia – Langley*)

Chile Water Resources II: Remote Monitoring of Glacier Dynamics and Hydrologic Indicators in Chile's Aconcagua River Valley (*California – Ames*)

Colorado River Basin Water Resources: Utilizing NASA Earth Observations to Evaluate Invasive Species Cover in Riparian Areas of the Colorado River Basin (*Colorado – Fort Collins*)

Miami Beach Water Resources: Assessing the Feasibility of Using NASA Earth Observations to Monitor Trends in Runoff and Storm Water Discharge of the Biscayne Bay (*Virginia – Langley*)

Mississippi Sound Water Resources II: Analyzing the Impact of Environmental Disturbances on Oyster Reef Health in the Mississippi Sound Using NASA Earth Observations (*Virginia – Langley*)

Niger Water Resources: Implementing a Global Tool for Mercy Corps Based on Spatially Continuous Precipitation Analysis for Resiliency Monitoring and Measuring at the Community-Scale (*Maryland – Goddard*)

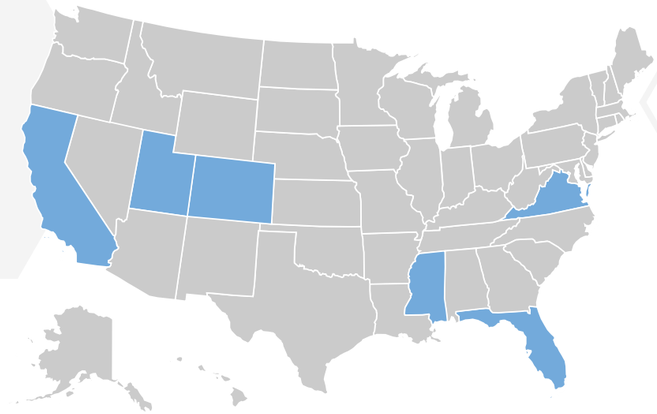
San Francisco Bay-Delta Water Resources: Utilizing NASA and ESA Earth Observations to Monitor Turbidity Conditions in the San Francisco-Bay Delta (*California – JPL*)

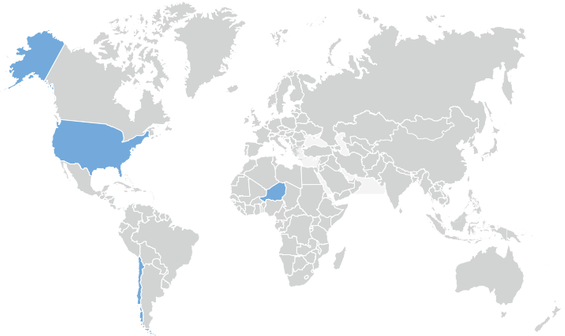
PARTNERS

City of Miami Beach, Public Works Department
Mercy Corps
Metropolitan Water District of Southern California
Ministerio de Agricultura (Chile)
Mississippi Department of Marine Resources
Oficina Agrícola de la Embajada de Chile en los Estados Unidos de América (Chile)
USGS, Water Science Center
USGS, Fort Collins Science Center
USGS, North Central Climate Science Center
Virginia Department of Environmental Quality
Walton Family Foundation

SENSORS

Aqua AMSR-E/MODIS
GPM DPR
Landsat 5 TM
Landsat 7 ETM+
Landsat 8 OLI/TIRS
MUR
Sentinel-2 MSI
Sentinel-3 OLCI
SMAP
SRTM V2/V4
Terra MODIS
TRMM PR/TMI/VIRS





Water Projects

Chesapeake Bay Water Resources II

Assessing and Assisting Monitoring Efforts of Water Clarity to Identify Potential Areas of Submerged Aquatic Vegetation (SAV) in the Chesapeake Bay

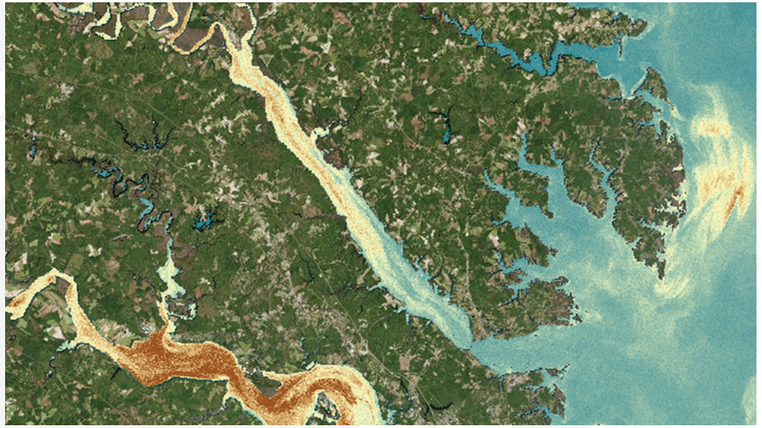
Virginia – Langley

Team – Eli Simonson, Antonio Alvarado, William Crowley

Partners – Virginia Department of Environmental Quality; USGS, Water Science Center

Earth observations – Landsat 8 OLI, Sentinel-2 MSI

Submerged Aquatic Vegetation (SAV) is vitally important to the Chesapeake Bay, serving as one of the primary food sources for the organisms that inhabit the bay. This project evaluated the efficacy of remote sensing applications to monitor water quality parameters, specifically turbidity, to indicate areas that can potentially support healthy SAV populations in the Chesapeake Bay. The resources and methods included visual analysis of the Chesapeake Bay by utilizing Landsat 8 Operational Land Imager (OLI) and Sentinel-2 MultiSpectral Instrument (MSI) through the algorithms incorporated in ACOLITE software, allowing for atmospheric correction of spatial and temporal surface reflectance satellite imagery. By correlating Landsat- and Sentinel-derived output turbidity products to the Virginia Institute of Marine Sciences' *in situ* monitoring data, a model was created that provided an estimate of water clarity throughout the entire bay and its associated tributaries. This model can be used as an additional resource for the Virginia Department of Environmental Quality to aid the monitoring of turbidity variations within the Chesapeake Bay. These techniques will also assist in determining Total Maximum Daily Load calculations and the resulting effects on SAV growth.



Chile Water Resources II

Remote Monitoring of Glacier Dynamics and Hydrologic Indicators in Chile's Aconcagua River Valley

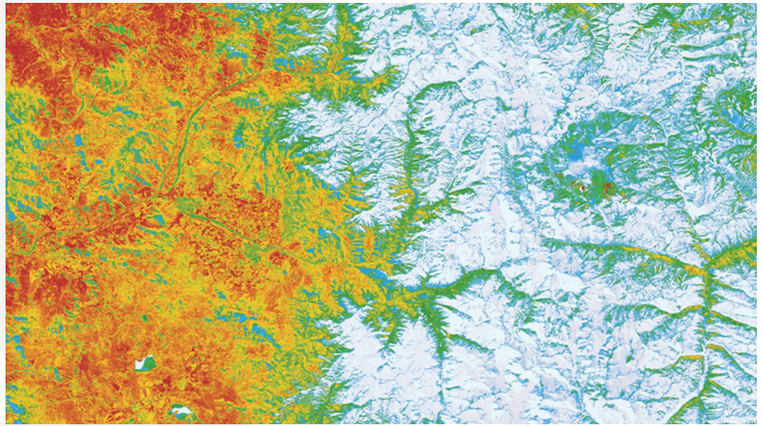
California – Ames

Team – Mariana Webb, Billy Babis, Stuart Deland

Partners – Ministerio de Agricultura (Chile); Oficina Agrícola de la Embajada de Chile en los Estados Unidos de América (Chile)

Earth observations – Landsat 5 TM; Landsat 8 OLI; Terra MODIS; TRMM PR, TMI, VIRS; SMAP; Aqua AMSR-E

The Aconcagua basin of Central Chile, just north of the capital city of Santiago, is an arid region dominated by the Andes Mountains and heavily dependent on glaciers and seasonal meltwater for its water reserves. Due to the orographic nature of precipitation within the basin, rain events occur sporadically in the late autumn and winter months of the year, accounting for 80% of total annual precipitation, while drought conditions prevail in the austral spring and summers. The Mediterranean-type ecosystem supports agricultural practices such as fruit and vegetable farming, which account for 70% of regional water usage. Around the globe, weather intensification and the rising zero-degree isotherm are poised to threaten glacial retreat or complete wastage during the upcoming decades. The Aconcagua basin is especially vulnerable to these changes as a result of its large population, increasing water demands, and reliance on meltwater during the summer months. In response to the concerns articulated by the Chilean Ministry of Agriculture, the research team created a time series of seasonal NDSI from 1988 to 2017 to quantify glacier change using TerrSet software. The team replicated the time series analysis in near-real time with server-side processing using Google Earth Engine and compared the results of the parallel analyses. Google Earth Engine was also used to build a tool that combines NASA Earth observations with *in situ* hydrologic data for a comprehensive overview of regional factors affecting agriculture. The analysis tools created provide an enhanced understanding of glacial meltwater and agricultural water usage and can be used to supplement the Chilean Ministry of Agriculture's water resource management decision making.



Colorado River Basin Water Resources

Utilizing NASA Earth Observations to Evaluate Invasive Species Cover in Riparian Areas of the Colorado River Basin

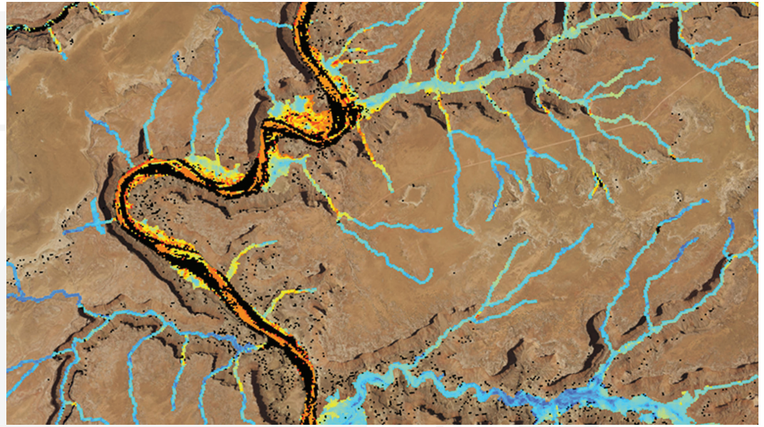
Colorado – Fort Collins

Team – Megan Vahsen, Emily Campbell, Daniel Carver, Julia Sullivan, Chanin Tilakamonkul, Brian Woodward

Partners – Walton Family Foundation; USGS, Fort Collins Science Center; USGS, North Central Climate Science Center

Earth observations – SRTM V2, Landsat 8 OLI and TIRS, Landsat 7 ETM+, Landsat 5 TM, Sentinel-2 MSI

Riparian corridors are inhabited by unique and biodiverse plant communities that control erosion, manage sediment loads, and filter pollutants. These ecosystems are transitional zones between terrestrial and aquatic systems that provide important wildlife habitat and maintain the overall health of rivers. The Colorado River Basin not only serves as an important ecological system, but also provides a water supply to more than 40 million people in the western United States. However, the spread of invasive species such as tamarisk (Tamarix spp.) impacts the ecosystem functionality of this river basin by altering flow regimes, sediment loads, and evapotranspiration rates. This project utilized Shuttle Radar Topography Mission (SRTM) topographic data, Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 5 Thematic Mapper (TM) to map and distinguish tamarisk cover from that of riparian species in 2006 and 2016 in the Green River watershed of the Colorado River Basin. Further, for 2016 tamarisk cover maps, we compared Landsat 8 to Sentinel-2 Multispectral Instrument (MSI) in a cross-platform analysis. Invasive species cover maps and an in-depth tutorial allow partners at the Walton Family Foundation to create effective management plans and to reproduce this methodology for future planning.



Miami Beach Water Resources

Assessing the Feasibility of Using NASA Earth Observations to Monitor Trends in Runoff and Storm Water Discharge of the Biscayne Bay

Virginia – Langley

Team – Pamela Kanu, Danielle Quick, Randolph Colby

Partners – City of Miami Beach, Public Works Department

Earth observations – Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, Sentinel-2 MSI

Submerged Aquatic Vegetation (SAV) is an important component of coastal ecosystems, and is vulnerable to increased turbidity in the water column. It provides stability and protection to sediment deposits, and offers food and shelter to economically valuable species of marine life. Recent urban development and population growth in the Miami area have resulted in an increase in stormwater discharge connected to changing water quality in Biscayne Bay. The project used Earth observation data from a suite of sensors including Landsat 8 OLI, Landsat 7 ETM+, Landsat 5 TM, and Sentinel-2 MSI in conjunction with *in situ* water quality monitoring data. Turbidity, chlorophyll-a concentration, Normalized Difference Turbidity Index (NDTI), absorbance due to dissolved and non-algal detrital material (A_{DG}), and Total Suspended Matter (TSM) data were used to develop a tool to view both historic and current water quality parameters in Biscayne Bay. The results of this project will assist the City of Miami Beach Public Works Department in decision making and predicting future water quality trends in Biscayne Bay and the surrounding area.

Mississippi Sound Water Resources II

Analyzing the Impact of Environmental Disturbances on Oyster Reef Health in the Mississippi Sound Using NASA Earth Observations

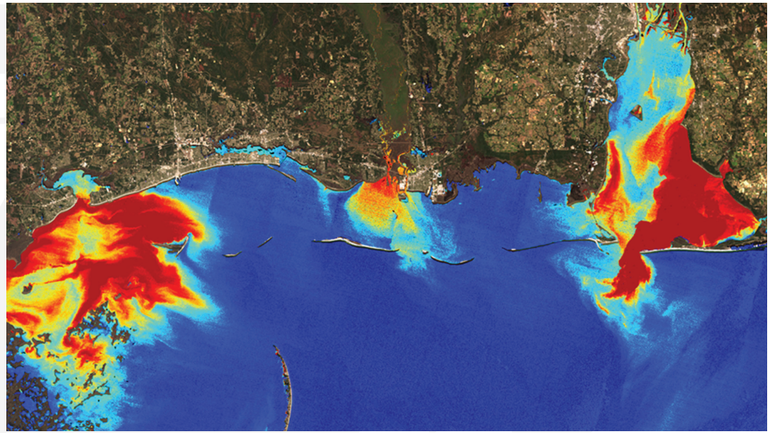
Virginia – Langley

Team – Carter Grimm, Rachael Green, Hannah Russ

Partner – Mississippi Department of Marine Resources

Earth observations – Aqua MODIS, Terra MODIS, SMAP, Landsat 7 ETM+, Landsat 8 OLI and TIRS, MUR, Sentinel-2 MSI

Oysters are vital to the environmental health of the Mississippi Sound and a critical part of Mississippi's economy. Environmental disturbances, such as Hurricane Katrina, major flooding events, and the Bonnet Carré spillway openings, have caused oyster populations to decline and have negatively affected the water quality and economy of the Sound. Oysters purify water via filter feeding and a decline in their population could lead to increased levels of dissolved solids in the waterways. In collaboration with the Mississippi Department of Marine Resources (MDMR), the team focused on specific case studies of significant disturbances by combining data gathered in the Spring 2017 Term with data on the degradation of marshlands in the area. The team investigated the relationships between extreme weather events, salinity, freshwater discharge and diversion, chlorophyll-a, and oyster reef health. These case studies will help inform MDMR about how these factors are interdependent and impact the overall health of the Sound. This information will assist the MDMR in making better-informed decisions in preparing for and managing ecological stressors.



Niger Water Resources

Implementing a Global Tool for Mercy Corps Based on Spatially Continuous Precipitation Analysis for Resiliency Monitoring and Measuring at the Community-Scale

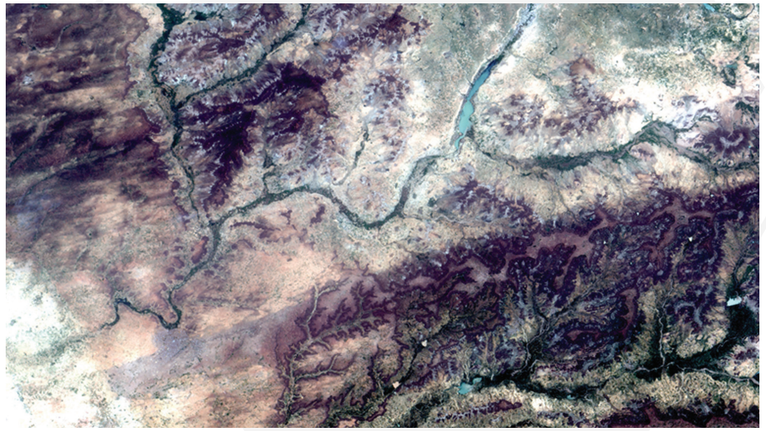
Maryland – Goddard

Team – Jared Tomlin, Raghda "Didi" El-Behaedi, Ryan Lingo, Sean McCartney, Alison Thieme

Partner – Mercy Corps

Earth observations – GPM DPR, TRMM PR, Terra MODIS, SRTM V4

Global water resources are important for societies, economies, and the environment. In Niger, limited water resources restrict the expansion of communities and agriculture. Mercy Corps currently works in over 40 countries around the world to address a variety of stresses which include water resources and building long-term food resilience. As Mercy Corps seeks to integrate the use of Earth observations into their resilience building process, NASA established a partnership to help facilitate this effort incorporating the Tropical Rainfall Measuring Mission (TRMM), Global Precipitation Measurement (GPM), Terra MODIS and Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) to analyze seasonal trends in changes to the start of the rainy season in Niger. The team created a Google Earth Engine tool that combines precipitation data with other metrics of stress in Niger. The system was designed to be able to incorporate groundwater storage data as they become available. This tool allows for near real-time updates of trends in precipitation and improves Mercy Corps' ability to spatially evaluate changes in resiliency by monitoring shocks and stressors.



San Francisco Bay-Delta Water Resources

Utilizing NASA and ESA Earth Observations to Monitor Turbidity Conditions in the San Francisco-Bay Delta

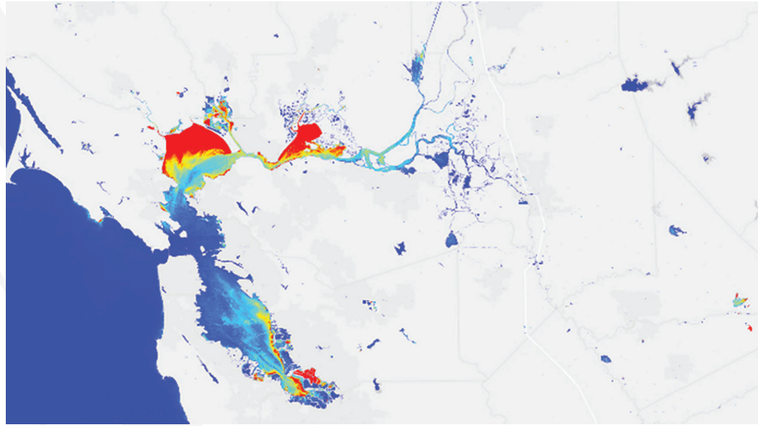
California – JPL

Team – Katherine Cavanaugh, Leah Kucera, Molly Spater

Partner – Metropolitan Water District of Southern California (MWD)

Earth observations – Landsat 8 OLI, Sentinel-2 MSI, Sentinel-3 OLCI

Water quality is a critical element of freshwater supply, particularly in times and areas of drought. Limited water resources can be further strained if water quality concerns are not effectively and efficiently addressed. While there are measures in place to protect human and environmental health from poor and risky water quality conditions, implementation of these measures is frequently reliant on physical water samples and fixed station data, both of which have gaps in spatial and temporal coverage of water quality conditions. This consideration is especially important in environments that are highly complex and heterogeneous, such as the San Francisco Bay-Delta, as well as in budget-constrained areas or sites that are remote and are challenging to access. Remotely sensed information can help supplement existing data, supporting more informed water management practices and representing a wealth of information that has yet to be fully leveraged. In this project, we evaluated the application of remote sensing-derived turbidity from three Earth observing satellites in the San Francisco Bay-Delta and conducted comparisons with *in situ* turbidity data from USGS and the California Data Exchange Center (CDEC) water quality stations. The Semi-Empirical Single Band Turbidity Algorithm yielded a 1:1 relationship with *in situ* turbidity when calculated values were less than 15 to 20 FNU. This relationship did not extend to higher turbidity values, which yielded significantly lower slopes. Incorporating site-specific constants into the algorithm to correct for this deviation must be explored further. Higher resolution Sentinel-2 was the only satellite able to pick up turbidity values in the smaller tributaries of the Bay-Delta.



OVERVIEW: DEVELOP's Ecological Forecasting projects assist decision makers with access to science-based tools in order to understand and predict the impacts of environmental change on the ecosystems that support the existence of life on Earth. The projects apply NASA remote sensing and technologies to topics like conservation, habitat health and suitability, land use practices and planning, and invasive species management. This summer, DEVELOP's five Ecological Forecasting projects partnered with 13 organizations to improve monitoring and forecasting in two states, one US territory, and three countries.

PORTFOLIO:

Chesapeake Bay Ecological Forecasting: Utilizing NASA Earth Observations to Monitor Marsh Health in the Chesapeake Bay to Support the Maryland Department of Natural Resources Coastal Resiliency Assessment (*Maryland – Goddard*)

Colorado National Monument Ecological Forecasting: Identifying Early Season Invasives for Monitoring and Management in the Colorado National Monument (*Virginia – Langley*)

Eastern India Ecological Forecasting III: A Multi-Sensor Approach to Enhance the Prediction of Mangrove Biophysical Characteristics in Chilika Lagoon and Bhitarkanika Wildlife Sanctuary, Odisha, India (*Georgia – Athens*)

Rwanda Ecological Forecasting: Utilizing NASA Earth Observations to Classify Wetland Extent in Rwanda in the Support of United Nations' Sustainable Development Goals (*Alabama – Marshall*)

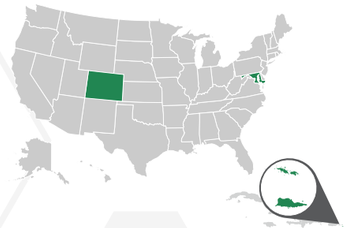
US Virgin Islands Ecological Forecasting: Using NASA Earth Observations to Monitor Land-use Change and Map At-risk Coastal Habitats in the US Virgin Islands (*California – Ames*)

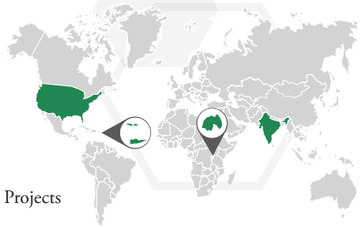
PARTNERS:

Maryland Department of Natural Resources
The Nature Conservancy
National Park Service, Colorado National Monument
Colorado Mesa University
Government of Odisha, Department of Forest and Environment, Chilika Development Authority (India)
Rwanda Environment Management Authority
Regional Centre for Mapping of Resources for Development (RCMRD)
Group on Earth Observations, GEO-Wetlands Initiative
NASA SERVIR Science Coordination Office at MSFC
US Virgin Islands Department of Planning and National Resources, Coastal Zone Management
University of the Virgin Islands
College of Charleston
Kent State University

SENSORS

Landsat 5 TM
Landsat 7 ETM+
Landsat 8 OLI / TIRS
Sentinel-1 C-SAR
Sentinel-2 MSI
Terra MODIS





Eco Projects

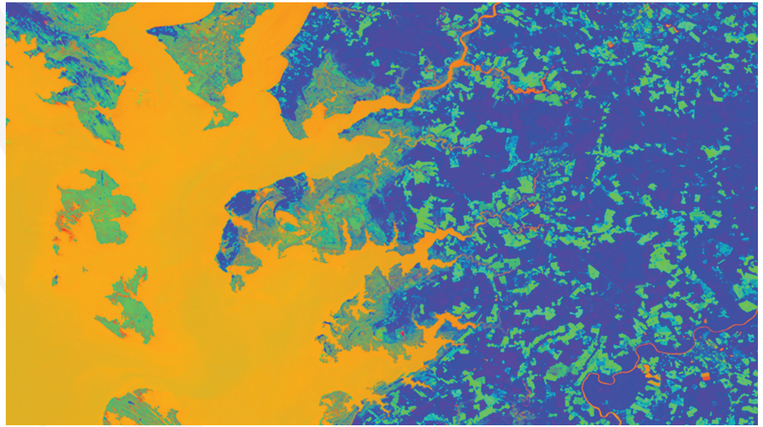
Chesapeake Bay Ecological Forecasting

Utilizing NASA Earth Observations to Monitor Marsh Health in the Chesapeake Bay to Support the Maryland Department of Natural Resources Coastal Resiliency Assessment

Maryland – Goddard

Team – Victor Lenske, John Fitz, Dr. Sara Lubkin, Sean McCartney, Helen Plattner
Partner – Maryland Department of Natural Resources; The Nature Conservancy (TNC)
Earth observations – Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, Sentinel-2 MSI

Tidal wetlands, such as marshes, are among the Chesapeake Bay's most protective natural features. Not only do they provide vital ecological services such as breeding grounds and water purification, but wetlands also deliver direct benefits to coastal communities through water absorption, wave attenuation, and sediment stabilization. Thus, marshes can buffer vulnerable communities from erosion, flooding, and storm damage. The Maryland Department of Natural Resources partnered with The Nature Conservancy (TNC) to conduct a Coastal Resiliency Assessment to identify coastal habitats that provide protective benefits to vulnerable coastal communities. While healthy marshes were determined to have high risk-reduction potential, the quality of coastal habitats on the Maryland shoreline is difficult to assess without historical context. The goal of this study was to utilize NASA Earth observations to analyze trends in marsh health on the Maryland coast of the Chesapeake Bay from 1984 to 2017 and to forecast changes in marsh health from 2017 to 2030. Vegetation, soil, and water indices calculated from Landsat and Sentinel-2 imagery were used to detect changes in marsh health over the past 33 years. A change detection algorithm was used to detect changes in marsh elevation and location of high marsh and low marsh over the study period. The Maryland Department of Natural Resources and The Nature Conservancy will use these results to supplement their Coastal Resiliency Assessment and develop more informed decision-making plans regarding restoration and conservation in the Chesapeake Bay.



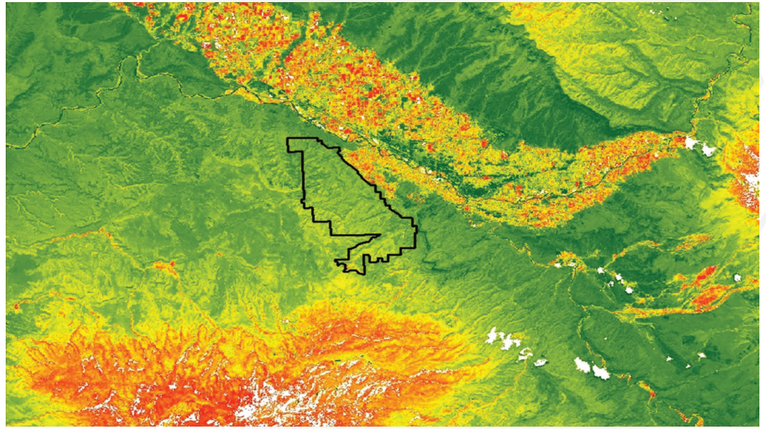
Colorado National Monument Ecological Forecasting

Identifying Early Season Invasives for Monitoring and Management in the Colorado National Monument

Virginia – Langley

Team – Zac Peloquin, James Ficklin, Kayla Rini, Owen Cox
Partner – National Park Service, Colorado National Monument; Colorado Mesa University
Earth observations – Landsat 5 TM, Landsat 8 OLI and TIRS, Sentinel-2 MSI, Terra MODIS

Bromus tectorum, otherwise known as cheatgrass, is an invasive grass from Europe that has increased its presence all over the world by out-competing native grasses due to its adaptability and lifecycle. During the end of its life cycle, typically occurring in the summer, its flammable remains often create the conditions for forest fires to start early in the season. This alters native wildlife's previous response to wildfires and increases the overall frequency of fires. As a result, cheatgrass often disrupts the necessary recovery time for native wildlife after habitat destruction. This NASA DEVELOP project utilized Landsat 5 TM, Landsat 8 OLI and TIRS, Terra MODIS, and Sentinel-2 data to study the spread of cheatgrass throughout the Colorado National Monument and the surrounding area to determine locations at risk of being invaded by cheatgrass. The results of the study included historical and current cheatgrass population maps, multi-criteria evaluation (MCE) analysis, and forecasted cheatgrass spread. The MCE analysis assessed the factors and constraints that contribute to the vulnerability to cheatgrass invasion. The results from this project will assist the National Park Service in improving their monitoring and management efforts and help contribute to the prevention of cheatgrass in Colorado National Monument.



Eastern India Ecological Forecasting III

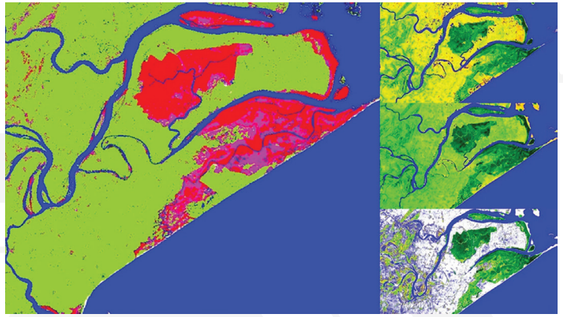
A Multi-Sensor Approach to Enhance the Prediction of Mangrove Biophysical Characteristics in Chilika Lagoon and Bhitarkanika Wildlife Sanctuary, Odisha, India

Georgia – Athens

Team – Abhishek Kumar, Isabel Miranda, Maria Luisa Escobar Pardo, Taufiq Rashid, Shanti Shrestha

Partner – Government of Odisha, Department of Forest and Environment, Chilika Development Authority (India)

Earth observations – Terra MODIS, Landsat 5 TM, Landsat 8 OLI, Sentinel-1 C-SAR



Across the globe, mangroves play a major role in coastal ecosystem processes mitigating erosion and serving as barriers against storm surges. India holds approximately 5% of the world's mangroves, over half of which are along its east coast. Situated in the state of Odisha, Chilika Lagoon and Bhitarkanika Wildlife Sanctuary sustain mangrove sites of local importance in need of effective management. This study demonstrated the use of Terra, Landsat, and Sentinel-1 satellite data for spatio-temporal monitoring of mangrove health for both sites. Several indices including Normalized Difference Vegetation Index and Enhanced Vegetation Index, were examined to develop biophysical prediction tools and derive a 17-year time-series (2000 to 2016) of leaf chlorophyll (CHL), Leaf Area Index (LAI), and Gross Primary Productivity (GPP). Parallel to this assessment, a long-term (2000 to 2016) analysis of meteorological factors such as precipitation and temperature was completed to determine an association between these parameters. The correlation between meteorological parameters and mangrove biophysical characteristics enabled forecasting of mangrove health and productivity. A historical analysis of land cover maps was produced using Landsat 5 and 8 data to determine decadal changes in mangrove area estimates between 1995 and 2017. This analysis was used to predict land use-land cover change or fragmentation of Bhitarkanika mangroves. Based on IPCC data availability, the soft prediction map for 2050 showed the probability of mangrove risk to disturbance in the eastern part of Bhitarkanika. This study revealed the advantages of using a multi-sensor approach to monitor mangrove health and inform monitoring protocols.

Rwanda Ecological Forecasting

Utilizing NASA Earth Observations to Classify Wetland Extent in Rwanda in Support of the United Nations' Sustainable Development Goals

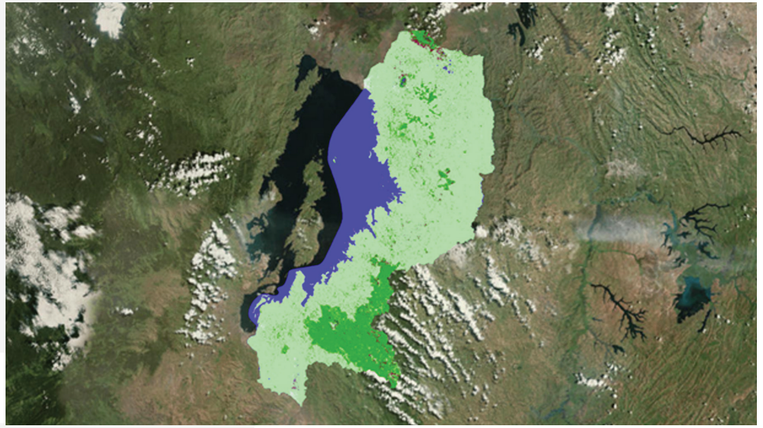
Alabama – Marshall

Team – Nicholas McVey, Julia Bayer, Jennifer Gelmis, Dashiell Cruz

Partner – Rwanda Environment Management Authority; Regional Centre for Mapping of Resources for Development (RCMRD); Group on Earth Observations, GEO-Wetlands Initiative; NASA SERVIR Science Coordination Office at MSFC

Earth observations – Landsat 8 OLI, Landsat 5 TM

Balancing the demands of economic development and environmental protection is a challenge which requires policy-makers to be well informed about the extent and value of key natural ecosystems. Wetlands have long been known to regulate hydrological processes, reduce erosion and flooding, safeguard local biodiversity, mitigate changes in climate, and contribute to food security. Nonetheless, due to the coupled threat of increasing population and lack of land use classification, east African wetlands face eradication if a concerted effort to identify, map, and protect these areas is not rapidly undertaken. To advance the wetland conservation efforts of the Rwanda Environmental Management Authority (REMA) and the UN's Sustainable Development Goals (SDG), a time series and land change extent model were generated to provide a baseline inventory of Rwandan wetlands and pinpoint critical areas that should be targeted for enhanced research and protection. Wetlands were identified by a supervised maximum likelihood classification conducted in Google Earth Engine API using Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI) data. The TerrSet Land Change Modeler software was used to generate a forecast of the land changes predicted to occur by the year 2030. These predictive models will optimize REMA's conservation efforts of wetlands, and provide researchers with a replicable methodology that can be used to continue monitoring global wetland extent.



US Virgin Islands Ecological Forecasting

Using NASA Earth Observations to Monitor Land-use Change and Map At-risk Coastal Habitats in the US Virgin Islands

California – Ames

Team – Rebecca Lehman, Bretton Alwood, Carrie Boyle, Erica Ta

Partner – US Virgin Islands Department of Planning and National Resources, Coastal Zone Management; University of the Virgin Islands; College of Charleston; Kent State University

Earth observations – Landsat 5 TM, Landsat 8 OLI, Sentinel-2 MSI

The United States Virgin Islands (USVI) are home to an array of diverse and stunning habitats. The beauty of the islands has continued to attract visitors and residents, which over time has increased human development and impact. The resulting land use change increases sediment loads and the flow of pollutants into surrounding nearshore environments such as coral reefs, mangroves, and seagrass beds. Coral reefs, the most diverse marine habitats on Earth, are particularly susceptible to these inputs. Compounded with regional climate-related processes such as rising ocean temperatures and acidification, future land-use change poses a formidable threat to the marine environment. Without a healthy environment, the USVI economy also becomes endangered because it is mainly supported by tourism and recreation. In order to assess land use change in the USVI, we utilized Landsat 5 TM, Landsat 8 OLI and TIRS, and Sentinel-2 MSI data to map land use and analyze land cover change dating back to 1985. We then extrapolated the models to the year 2025. Our work will provide the USVI Department of Planning and Natural Resources, Division of Coastal Zone Management (CZM) with a tool to better understand land use trends, identify at-risk coastal habitats, and strengthen existing knowledge of the link between land use and coastal ecosystem health.

OVERVIEW: DEVELOP's Disasters projects utilize NASA's capabilities in spaceborne, airborne, and surface observations, as well as modeling and data analysis, to improve natural disasters forecasting, mitigation, and response. The projects contribute to improved understanding of the natural processes that produce hazards, the vulnerability of local communities, and development of hazard mitigation technologies. This summer, DEVELOP's four Disasters projects partnered with 12 organizations in five states and two countries to provide disasters-related information when and where it is needed.

PORTFOLIO:

Lassen Volcanic National Park Disasters: Understanding Fuel Loading in Lassen Volcanic National Park through Earth Observation to Manage Wildland Fire Risk (*California – Ames*)

Philippines Disasters II: Utilizing NASA and NOAA Earth Observations to Enhance Cyclone Movement and Intensity Measurements to Improve Disaster Relief Planning in the Philippines (*North Carolina – NCEI*)

Southern Appalachia Disasters II: Using NASA Earth Observations to Monitor Vulnerability, Wildfire Damage, and Recovery in the Appalachian Forests (*Georgia – Athens*)

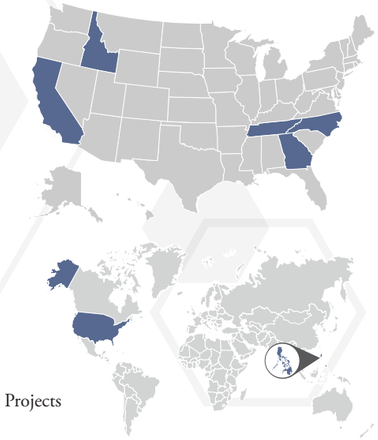
Southern Idaho Disasters: Enhancing Pre- and Post-Wildfire Vegetation Type Characterization Using NASA Earth Observations (*Idaho – Pocatello*)

PARTNERS:

Bureau of Land Management, Pocatello Field Office
Idaho Department of Fish and Game, Southeast Regional Office
Idaho Department of Fish and Game, Upper Snake Regional Office
NASA RECOVER Science Team
National Park Service, Lassen Volcanic National Park
Netherlands Red Cross
NOAA, National Environmental Satellite, Data, and Information Service (NESDIS)
United Nations Institute for Training and Research, Operational Satellite Applications Programme
United Nations Office for the Coordination of Humanitarian Affairs
USDA Agricultural Research Service, Northwest Watershed Research Center
USDA, US Forest Service, Eastern Forest Environmental Threat Assessment Center
USDA, US Forest Service, Southern Research Station

SENSORS

Aqua MODIS
G-LiHT
HURSAT-B1
ITBrACS
Landsat 5 TM
Landsat 7 ETM+
Landsat 8 OLI
Sentinel-2 MSI
SRTM
Terra MODIS



■ Disasters Projects

Lassen Volcanic National Park Disasters

Understanding Fuel Loading in Lassen Volcanic National Park Through Earth Observation to Manage Wildland Fire Risk

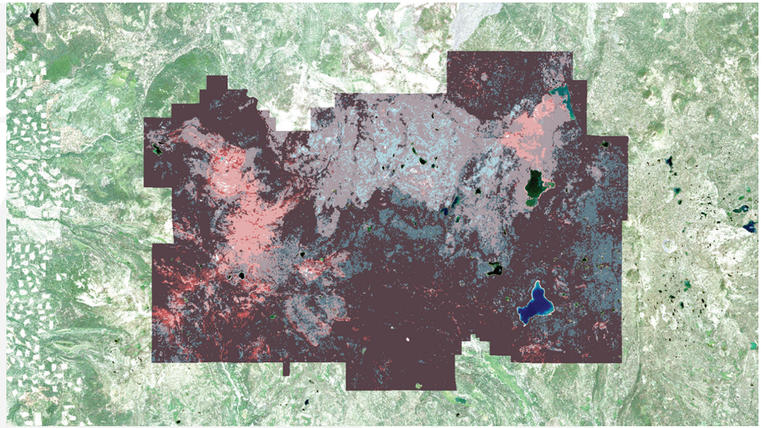
California – Ames

Team – Joshua Verkerke, Anna McGarrigle, John Dilger

Partner – National Park Service, Lassen Volcanic National Park

Earth observations – Landsat 8 OLI, Landsat 7 ETM+, Landsat 5 TM, G-LiHT, Sentinel-2 MSI, SRTM

Nearly three quarters of Lassen Volcanic National Park (LVNP) is designated as Wilderness under the Wilderness Act of 1964, meaning it is to be managed "to preserve its natural conditions… with the imprint of man's work substantially unnoticeable." This prevents land managers from clearing excess vegetative fuels that have accumulated due to fire suppression policy. Therefore, LVNP must rely on fire to restore healthy levels of vegetation. Devastation following the 2012 Reading Fire demonstrated the strength of accumulated fuel loads. Detailed cataloguing of fuel loads is necessary to predict the behavior and severity of any fire allowed to burn in LVNP. To provide these estimates, NASA Earth observations were used to generate maps of historical and present-day tree mortality, and to evaluate advantages in using NASA Goddard's LiDAR, Hyperspectral and Thermal (G-LiHT) Airborne Imager data to obtain detailed fuel load measurements. We estimated tree mortality using a linear trend regression analysis implemented in Google Earth Engine (GEE), to process time series of multispectral data from Sentinel-2 and the Landsat series (TM, ETM+, OLI). LiDAR data were related to spatial layers of species coverage and other environmental factors to estimate fuel loads. These products will help partners at LVNP to periodically update their mortality maps and fuel loading estimates in their ongoing efforts to maintain a healthy and safe Wilderness.



Philippines Disasters II

Utilizing NASA and NOAA Earth Observations to Enhance Cyclone Movement and Intensity Measurements to Improve Disaster Relief Planning in the Philippines

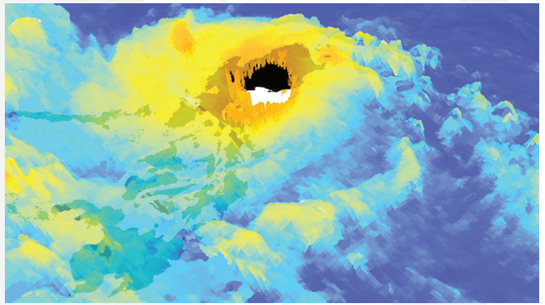
North Carolina – NCEI

Team – Michael Marston, Aaron Mackey, Brittany Thomas

Partner – United Nations Office for the Coordination of Humanitarian Affairs (OCHA); United Nations Institute for Training and Research, Operational Satellite Applications Programme (UNOSAT); Netherlands Red Cross; NOAA, National Environmental Satellite, Data, and Information Service (NESDIS)

Earth observations – SRTM, ITBrACS, HURSAT-B1

The Philippine islands, located within the northwest Pacific Ocean basin, are frequently affected by tropical cyclones. During and after tropical cyclones, the number of gender-based violence (GBV) crimes increase. To assist the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), a cyclone vulnerability assessment for each municipality within the Philippines is created and streamlined with demographic data to identify at risk communities. For this effort, hurricane satellite (HURSAT-B1) data were downloaded for each tropical cyclone that affected the Philippines from 1985 to 2009. To include the recent record, data were gathered for tropical cyclones affecting the study area from 2010 to 2015 from the Cooperative Institute for Research in the Atmosphere's (CIRA) Multiplatform Tropical Cyclone Surface Wind Analysis (MTCSWA). The HURSAT and CIRA products were used to derive estimates of the 18 m/s, 26 m/s, and 33 m/s wind radii for each of the four quadrants (i.e. northwest, northeast, southeast, southwest) of each tropical cyclone at a 6-hour temporal resolution. The wind radii estimates were provided by the National Oceanic and Atmospheric Administration's National Environmental Satellite, Data, and Information Service (NESDIS). The wind speed data were then used to estimate the Integrated Kinetic Energy (IKE) of each tropical cyclone in the study period. IKE values were then accumulated over the entire study period for the Philippines and used to generate a climatology of cyclone intensity for each municipality. Additionally, areas susceptible to rainfall-triggered landslides were mapped using slope data from Shuttle Radar Topography Mission.



Southern Appalachia Disasters II

Using NASA Earth Observations to Monitor Vulnerability, Wildfire Damage, and Recovery in the Appalachian Forests

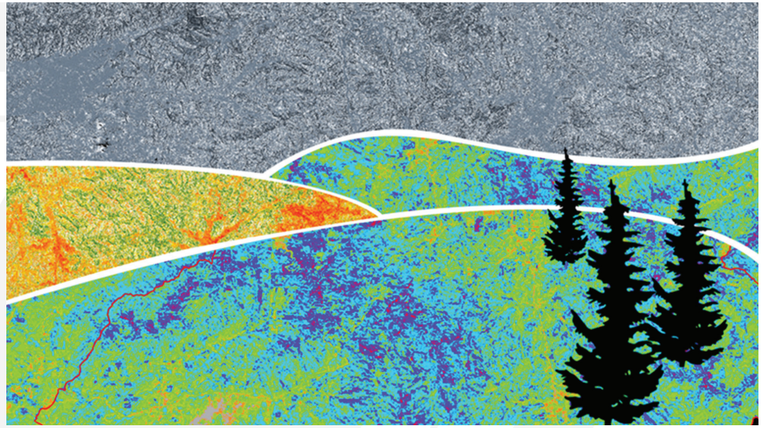
Georgia – Athens

Team – Amanda Aragón, Ruth Buck, Christopher Cameron, Jayanta Ganguly, Matthew Hevert, Holly Hutcheson, Caren Remillard, David Rickless, Yangjiaxin Wei

Partner – USDA, US Forest Service, Southern Research Station; USDA, US Forest Service, Eastern Forest Environmental Threat Assessment Center

Earth observations – Landsat 8 OLI, Terra MODIS, Aqua MODIS

Wildfires in the southeastern US are understood less than those in other portions of the nation. In October and November 2016, over sixty individual wildfires ignited among seven states in the Southern Appalachian region. These fires damaged hundreds of buildings, caused numerous power outages, and resulted in fatalities. These unusually destructive events highlight the need to improve awareness of fire susceptibility and risk in the southeastern US. The US Forest Service requires a thorough understanding of wildfire vulnerability, damage, and recovery to effectively help local communities respond to and prepare for these events. The University of Georgia NASA DEVELOP team partnered with US Forest Service Southern Research Station to assess vegetation dynamics before and after the 2016 wildfire events, focusing on GA, NC, and TN. This was accomplished by utilizing Landsat 8 OLI, Terra ASTER, and Terra MODIS data to evaluate land cover changes from October to December 2016 and assess the severity of these fires. In addition, this project incorporated demographic data to examine the association between fire risk and under-managed lands, such as heirs' properties, and to construct a model of social vulnerability to wildland fire hazards in the study area. The results of this project provided researchers at the US Forest Service with an increased understanding of how property ownership and community management practices can affect future wildfires, as well as how the spatial distribution of socioeconomic variables affects residents' ability to adapt and recover.



Southern Idaho Disasters

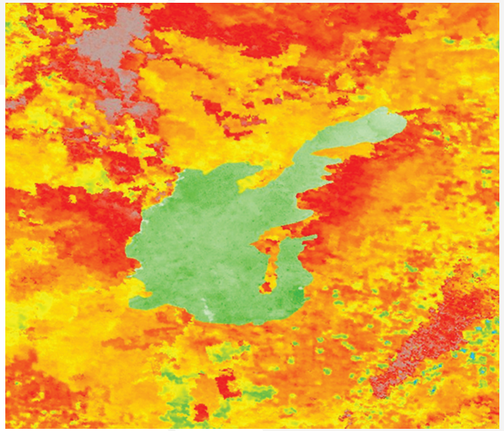
Enhancing Pre- and Post-Wildfire Vegetation Type Characterization Using NASA Earth Observations

Idaho – Pocatello

Team – Austin Counts, Nicholas Olsen, Cassidy Quistorff, Caitlin Toner, Courtney Ohr

Partner – Bureau of Land Management , Pocatello Field Office; USDA Agricultural Research Service, Northwest Watershed Research Center; Idaho Department of Fish and Game, Southeast Regional Office; Idaho Department of Fish and Game, Upper Snake Regional Office; NASA RECOVER Science Team

Earth observations – Landsat 5 TM, Landsat 8 OLI, SRTM V2, Terra MODIS, Aqua MODIS



Increasing wildfire frequency has emphasized the importance of post-wildfire recovery efforts in southern Idaho's sagebrush-steppe ecosystem. The changing fire regime favors annual invasive grass species while hindering native grasses and sagebrush habitat regeneration, causing a positive feedback cycle of invasive plants. Due, in part, to this undesirable process the sagebrush-steppe ecosystem is one of the most endangered in the US. In this project, the Idaho NASA DEVELOP team partnered with the Bureau of Land Management, Idaho Department of Fish and Game, and the US Department of Agriculture to characterize ecosystem recovery following the 2006 Crystal wildfire. Vegetation recovery following the Crystal fire (2006) was observed from 2001 to 2016 using NASA Earth observations Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI), Aqua and Terra Moderate Resolution Imaging Spectroradiometer (MODIS), and the Shuttle Radar Topography Mission (SRTM). In addition, significant factors affecting recovery were identified, and recovery of the landscapes carbon sequestration capacity was assessed. Key variables analyzed included biomass production, seasonally accumulated precipitation, max seasonal temperature, and elevation including slope and aspect. These factors affect land management by driving the success or failure of recovery efforts.

OVERVIEW

DEVELOP's Health & Air Quality projects utilize satellite and airborne Earth observations, model products, and scientific findings to support air quality and public health management, as well as policy makers. This summer, DEVELOP's four Health & Air Quality projects partnered with eight organizations in four states to improve monitoring and support a healthier existence for life on Earth.

PORTFOLIO

California Health & Air Quality: Identifying Methane Emissions Patterns from Dairy Farms Using Aircraft Remote Sensing Observations and Image Classification (*California – JPL*)

Las Cruces Health & Air Quality: Assessing Urban Heat as it Relates to Social Vulnerability and Land Use Changes in Las Cruces, New Mexico (*Arizona – Tempe*)

Shenandoah Health & Air Quality: Monitoring Air Quality in Shenandoah National Park to Address National Park Service Initiatives Using NASA Earth Observations (*Virginia – Langley*)

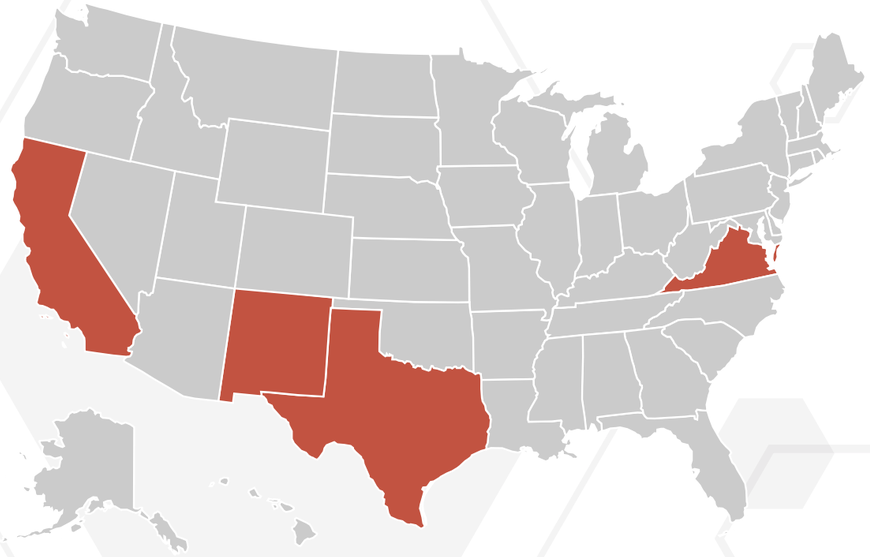
Texas Health & Air Quality: Monitoring Exceptional Air Pollution Events in Texas using NASA Earth Observations (*Virginia – Wise*)

PARTNERS

Arizona State University, Urban Climate Research Center
California Air Resources Board
City of Las Cruces, Sustainability Office
Climate Assessment for the Southwest (CLIMAS)
National Park Service, Air Resources Division, Research & Monitoring Branch
National Park Service, Shenandoah National Park
Texas Commission on Environmental Quality, Air Quality Division
University of California, Riverside

SENSORS

Aura OMI
AVIRIS-NG
CALIPSO CALIOP
HyTES
Landsat 5 TM
Landsat 8 TIRS/OLI
RapidEye
Suomi NPP VIIRS
Terra ASTER/MODIS
Terra MOPITT



Health & Air Quality Projects

California Health & Air Quality

Identifying Methane Emissions Patterns from Dairy Farms Using Aircraft Remote Sensing Observations and Image Classification

California – JPL

Team – Jacob Arndt, Kelsey Foster, Erika Higa

Partner – California Air Resources Board; University of California, Riverside

Earth observations – AVIRIS-NG, HyTES, RapidEye

Methane (CH_4) is a potent greenhouse gas (GHG) with a lifetime of less than 10 years and a global warming potential that is 25 times greater than carbon dioxide (CO_2) over a 100 year time period. Between the energy, industrial processes and product use, agriculture, and waste sectors, the majority of CH_4 emissions in the United States come from the agriculture sector. Within this sector, enteric fermentation by domestic livestock and manure management are the largest sources of emissions. California is the leading dairy producer in the United States and thus, enteric fermentation and manure management make substantial contributions to the state's CH_4 budget. Furthermore, a number of studies suggest that EPA bottom-up methodologies are underestimating CH_4 emissions in many regions across California. Total number, location, size, and manure management infrastructure of dairy farms throughout the state is also uncertain. Given these uncertainties, in addition to dairy production's large contribution to CH_4 emissions, its industrialization, and the need to more accurately account for and understand CH_4 emissions, we located and inventoried dairy farms across California's Central Valley using RapidEye imagery and image classification techniques. We used the resulting classifications to create a spatial dataset of dairy farms and that was used to help interpret AVIRIS-NG and HyTES CH_4 plume data collected over the dairy farms. This will ultimately provide insight into an important source of CH_4 and help policy makers, dairy farmers, and management officials make more informed decisions on how best to mitigate CH_4 emissions within the state of California.

Las Cruces Health & Air Quality

Assessing Urban Heat as it Relates to Social Vulnerability and Land Use Changes in Las Cruces, New Mexico

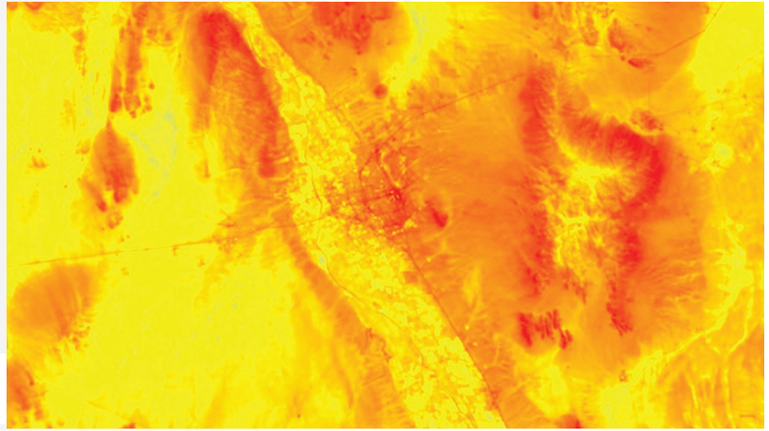
Arizona – Tempe

Team – Jonathan O'Brien, Rebia Khan, Chris Wilson, Fanqi Jia

Partner – City of Las Cruces, Sustainability Office; Climate Assessment for the Southwest (CLIMAS); Arizona State University, Urban Climate Research Center

Earth observations – Landsat 8 TIRS and OLI, Landsat 5 TM, Terra ASTER

Extreme heat during the summer months is a major public health issue in many cities worldwide. Local governments are increasing efforts to mitigate heat in cities through the implementation of infrastructure adaptations, including expansion of the urban tree canopy and white roofing, as well as revising design guidelines and principles for new construction. These strategies will be most beneficial for public health if they are deployed in places where risks of heat exposure are elevated as a result of higher temperatures and higher social vulnerability. Spatial variability in heat in the city arises because of the different ways in which the built environment impacts energy exchange between the surface and atmosphere. Social vulnerability is also unevenly distributed across urban areas and previous research demonstrates that socially disadvantaged populations often live in the hottest parts of the city. In this project, we used Landsat and Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) data to construct a time series of Las Cruces' urban heat patterns and assess the influence that urban morphology has on those patterns. Extreme heat vulnerability indicators were developed utilizing census and health records and aerial imagery from the National Agriculture Imagery Program (NAIP). These heat vulnerability indicators describe the sensitivity of the population to extreme heat and identify where vulnerable populations reside. The Las Cruces Sustainability Office will use the heat vulnerability indicators, urban heat island assessment, and urban heat island morphology comparison to improve the city's resilience and mitigation efforts.



Shenandoah Health & Air Quality

Monitoring Air Quality in Shenandoah National Park to Address National Park Service Initiatives Using NASA Earth Observations

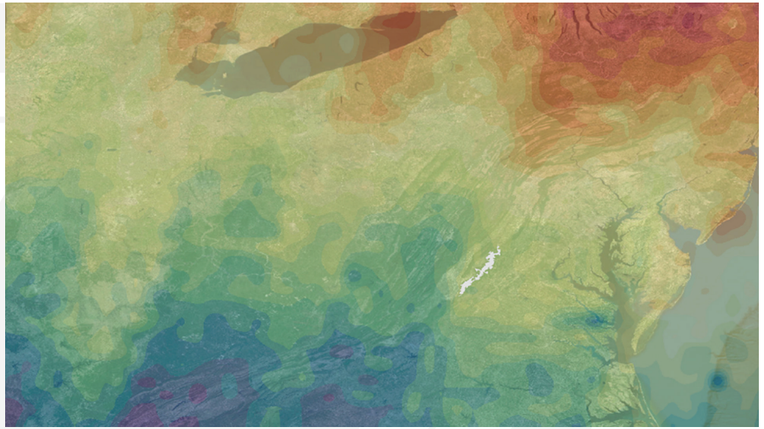
Virginia – Langley

Team – Ellen Bubak, Amanda Clayton, Doug Gardiner, Nicholas Lenfant, Julie Terhune

Partner – National Park Service, Shenandoah National Park; National Park Service, Air Resources Division, Research & Monitoring Branch

Earth observations – Aura OMI

Gases such as ozone (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) have impeded visibility and impacted air health in Shenandoah National Park, one of the primary attractions of Virginia. Air quality is considered one of the park's fundamental resources and is essential to maintaining its significance as a premier park with world-class views. This project utilized NASA Earth observations, including Aura's Ozone Monitoring Instrument (OMI), to monitor ozone and nitrogen dioxide that threaten visibility and plant, animal, water, and human health in the park. Trend maps were created to assess spatial and temporal trends in pollutant species over Shenandoah National Park and the surrounding airshed. A methodology was created to help the National Park Service incorporate remote sensing data into their management decisions related to park health and air quality concerns. *In situ* station data from Big Meadows monitoring station were used to validate the NASA Earth observations. This information will aid in future decisions related to visitor education and ecological management in accordance with mandates from the Clean Air Act, the National Park Service Organic Act of 1916, and the Wilderness Act.



Texas Health & Air Quality

Monitoring Exceptional Air Pollution Events in Texas using NASA Earth Observations

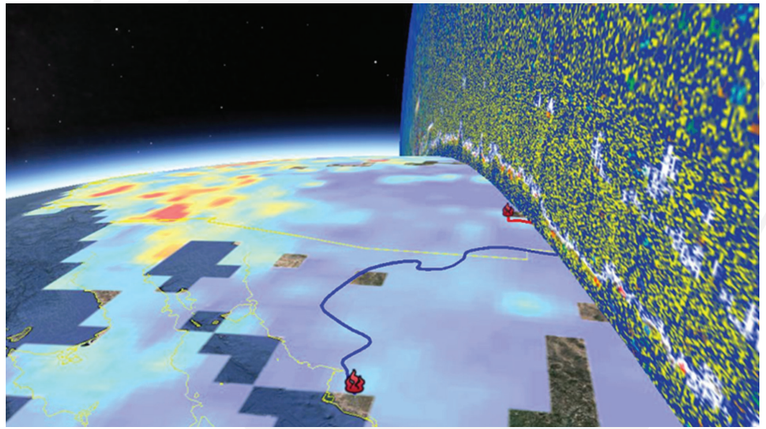
Virginia – Wise

Team – Eric White, Brooke Colley, Kannikha Kolandaivelu, Audrey Odwuor

Partner – Texas Commission on Environmental Quality, Air Quality Division

Earth observations – Terra MODIS, Suomi NPP VIIRS, CALIPSO CALIOP, Terra MOPITT

Wildfires in Texas have the potential to impact not only the areas of origin but also the entire state. Smoke plumes from wildfires travel across the state with trajectories that are greatly influenced by meteorological conditions. The plumes transport pollutants, which include those present in the ambient atmosphere, like volatile organic compounds and nitrous oxides, as well as those produced by wildfires, like aerosols. Aerosols have several negative effects on the environment and human health. Smoke plumes have the potential to negatively impact numerous lives when meteorological conditions allow them to reach highly populated metropolitan areas. For these reasons, the U.S. Environmental Protection Agency (EPA) has set standards to regulate the levels of these pollutants in the atmosphere. Observations from field monitors assist the Texas Commission on Environmental Quality (TCEQ) in ensuring that these standards are met. When these standards are exceeded, the TCEQ can claim an exceptional event, but it is often difficult to use *in situ* data alone to trace the origins of the pollutants that caused this. This project used data from Terra MODIS and CALIPSO CALIOP to observe the aerosol optical thickness and vertical composition of plumes, respectively, and to perform 3-D spatial-temporal plume tracking. Data from Terra MOPITT were used to distinguish smoke plumes from ambient air and thermal anomaly maps from Suomi NPP VIIRS were used for fire detection. The products of this project helped the TCEQ observe wildfire smoke plumes and monitor the origin, transport, and deposition of wildfire aerosols.



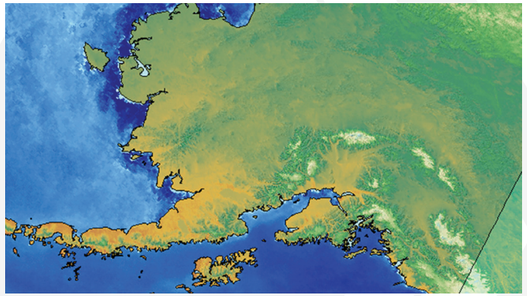
OVERVIEW: DEVELOP's Climate projects support activities associated with the implementation of climate standards, policies, and regulations for environmental, economic, and human welfare. The projects apply NASA satellite and airborne data, model products, and scientific findings to climate mitigation and adaption decisions. This summer, DEVELOP had one Climate project in its portfolio that partnered with the US Fish and Wildlife Service in Alaska to explore invasive species risk and forecasting relating to changing climate trends.

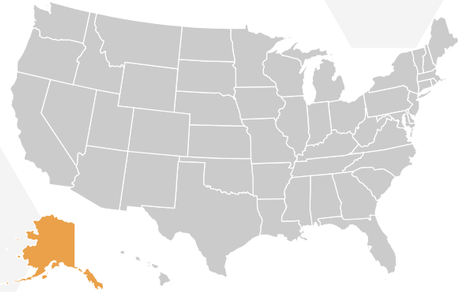
Alaska Climate (*Colorado – Fort Collins*)

Utilizing NASA Earth Observations to Model Potential Suitable Habitat of Invasive Species Threatening Alaskan Wetlands

Team – Emma Hatcher, Sarah Carroll, Timothy Mayer, Audrey Martinez
Partner – US Fish and Wildlife Service, Alaska Region
Earth observations – Aqua MODIS, SRTM V3, Terra MODIS

The rapid expansion of purple loosestrife (*Lythrum salicaria*) and reed canarygrass (*Phalaris arundinacea* L.) into aquatic and wetland systems has reduced native plant abundance, decreased species diversity, and degraded wildlife habitats for birds and amphibians throughout North America. The expansion of these invasive species into northern latitudes as a result of changing climate trends poses mitigation challenges to natural resource managers. In the United States, this trend is particularly concerning in Alaska, where wetlands are of major economic and ecological importance. This project developed habitat suitability models utilizing spectral data from Terra and Aqua MODIS in conjunction with topographic and climatic variables to map historic and current suitable habitat for purple loosestrife and reed canarygrass across Canada and the United States. The resulting habitat suitability maps will support decision making and the planning of management actions by partners at the Alaska Region US Fish and Wildlife Service in the "Early Detection, Rapid Response" program for invasive species management.





Climate Project

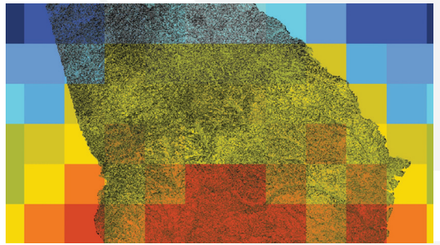
OVERVIEW: DEVELOP's Energy projects support activities associated with the management, monitoring, and forecasting of critical energy resources including coal, oil and gas, as well as renewable energy sources such as solar, wind, and hydropower. The projects apply NASA satellite data and derived products to effective siting of energy production. This summer, DEVELOP had one Energy project in its portfolio that partnered with The Nature Conservancy, Georgia Department of Natural Resources, and the US Fish and Wildlife Service in Georgia to help identify locations with high generation potential yet low impact to sensitive habitats.

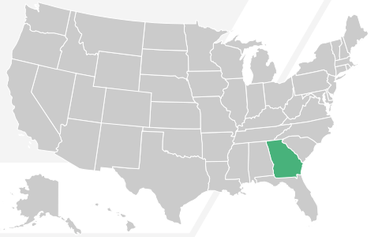
Georgia Energy (*Georgia – Athens*)

Reducing Conflicts in Siting Solar Power Facilities by Identifying Sensitive Habitats and Wildlife Populations in Areas with High Generation Potential

Team – Lynn Abdouni, Emad Ahmed, Natalia Bhattacharjee, Roger Bledsoe, Christopher Cameron, Suravi Shrestha, Austin Stone
Partner – The Nature Conservancy (TNC); Georgia Department of Natural Resources; US Fish and Wildlife Service, Georgia Ecological Services Field Office
Earth observations – Landsat 8 OLI, Terra CERES, Aqua CERES

Solar energy is a rapidly growing industry in the state of Georgia. The increasing popularity of solar farms is encouraging decision-makers and developers to incorporate a sustainable plan for utility-scale solar developments. However, the construction and siting of solar farms could have a threatening impact on environmentally sensitive habitats and associated species. NASA DEVELOP partnered with The Nature Conservancy and the Georgia Department of Natural Resources to conduct an analysis to inform solar site planning and to communicate with key stakeholders. The team analyzed land cover trends from Landsat 8 OLI in addition to solar insolation data sets from Terra CERES. These Earth observations were combined to classify and extract data layers for a solar site suitability and conflict identification model following the Land Use Conflict Identification Strategy (LUCIS). Additionally, the DEVELOP team utilized endangered species habitat layers, with a focus on the gopher tortoise (Gopherus polyphemus) primarily due to its role as a keystone species in these sensitive areas. These data were used to generate end products that depict potential conflicts between ideal solar energy sites and endangered species habitats, and prioritize development areas outside of these conflicts. This project also developed a case study with higher resolution and supplementary ancillary data in Taylor County, GA. The results of this project will be utilized by The Nature Conservancy and Georgia Department of Natural Resources to recommend suitable sites for environmentally conscious solar farm construction.





Energy Project

OVERVIEW

DEVELOP's Ocean projects utilize NASA Earth observations to understand changes in ocean health, salinity, and water quality. These projects help monitor current and future trends in our planet's interconnected oceans to assist decision makers in resource management. This summer, DEVELOP had four Oceans projects in its portfolio that partnered with nine organizations to improve monitoring capabilities and support effective management of critical species of three states, 5 US territories, and two countries.

PORTFOLIO

Coastal Alabama Oceans: Using NASA Earth Observations to Evaluate Water Quality in Coastal Alabama to Enhance Marine Wildlife Management (*Alabama – Mobile & Alabama – Marshall*)

Costa Rica Oceans: Assessing Changes in Vegetation and Marine Environments at the Isla del Coco Marine Reserve with Satellite Imagery (*Alabama – Mobile & Georgia – Athens*)

Southern California Oceans: Analyzing NASA Earth Observation Data to Evaluate Grunion Response to Ecosystem Changes Forced by Recent Environmental Conditions in California's Oceans (*California – JPL*)

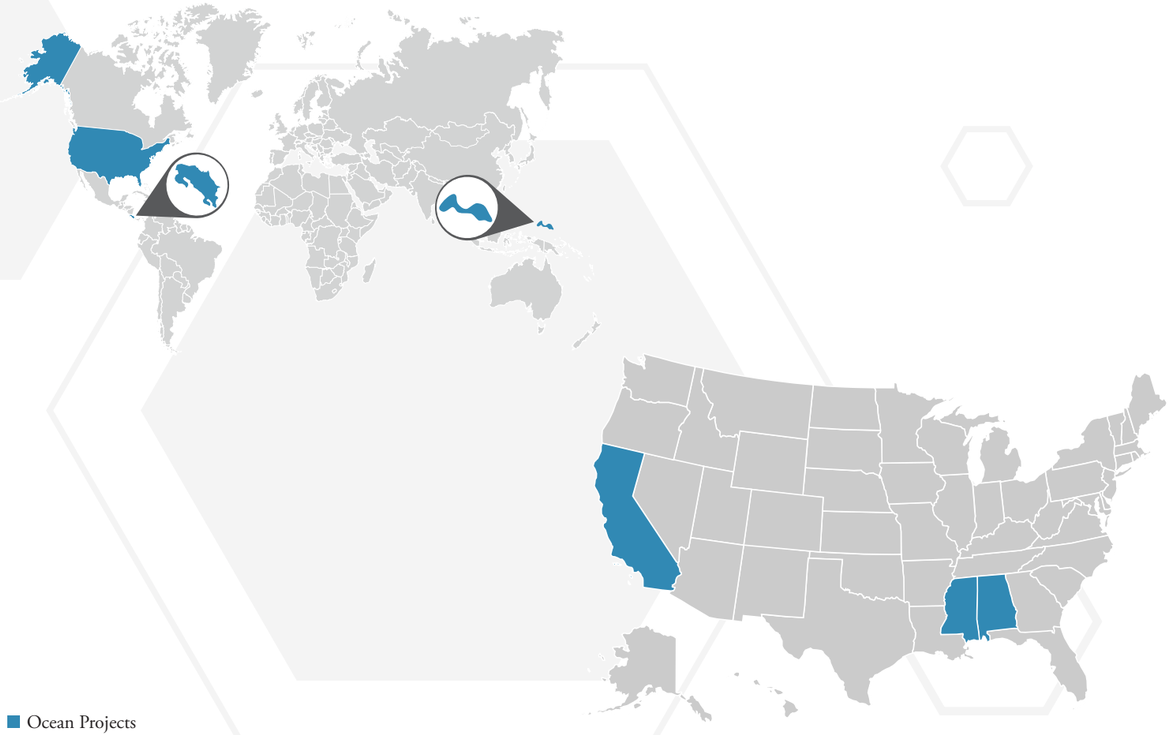
US Pacific Islands Oceans: Utilizing the NASA and NOAA Joint Ocean Surface Topography Mission and Modeled Wave Data to Assess Patterns and Trends in Sea-surface Height in the US Affiliated Pacific Islands (*North Carolina – NCEI*)

PARTNERS

Alabama Coastal Foundation (ACF)
Dauphin Island Sea Lab, Manatee Sighting Network
Embassy of Costa Rica to the United States
Ministry of Environment and Energy, Water Directorate (DA-MINAE) (Costa Rica)
Grunion Greeters Project
NOAA Regional Climate Services, Pacific Region
NOAA, Center for Satellite Applications and Research (STAR), Satellite Oceanography & Climatology Division
Sistema Nacional de Áreas de Conservación de Costa Rica, Área de Conservación Marina Isla del Coco (ACMIC) (Costa Rica)
The Nature Conservancy (TNC)
University of Hawaii, Sea Level Center

SENSORS

Aqua MODIS
Envisat MERIS
Jason-1
Jason-3
Landsat 5 TM
Landsat 7 ETM+
Landsat 8 OLI/TIRS
MUR
OSTM/Jason-2
POES AVHRR
Sentinel-2 MSI
Sentinel-3
Terra MODIS
Topex/Poseidon



Coastal Alabama Oceans

Using NASA Earth Observations to Evaluate Water Quality in Coastal Alabama to Enhance Marine Wildlife Management

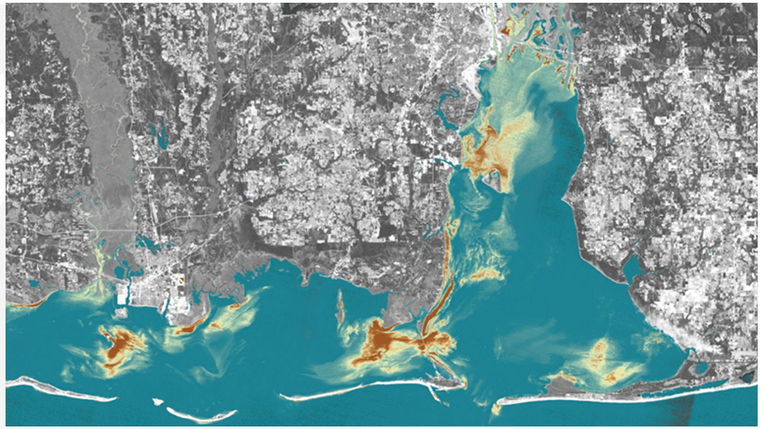
Alabama – Mobile & Alabama – Marshall

Team – Mercedes Bartkovich, Xin Hong, Leah Parker, Amy Schwarber

Partner – Alabama Coastal Foundation (ACF); The Nature Conservancy (TNC); Dauphin Island Sea Lab, Manatee Sighting Network

Earth observations – Aqua MODIS, Landsat 5 TM, Landsat 8 OLI and TIRS, Sentinel-2 MSI

The Mobile Bay and Mississippi Sound are the main coastal estuaries along the Alabama and Mississippi Gulf Coast. They serve as the primary drainage outlets for the Mobile Bay and Pascagoula River watersheds and provide a gradient of coastal water salinity conditions needed for a diversity of wildlife species and coastal habitat types. Coastal water "health" conditions have a direct impact on the native biota that are sensitive to water quality, including the Eastern oyster (*Crassostrea virginica*), a keystone species, and the West Indian manatee (*Trichechus manatus*), a vulnerable species. This project addressed the dynamic coastal ecosystem by creating time series analyses to monitor salinity, temperature, and turbidity changes for the Mobile Bay and Mississippi Sound from June 2007 to May 2017. The Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) was used to detect salinity and sea surface temperature, while Landsat 5, Landsat 8, and Sentinel-2 Multispectral Instrument (MSI) were employed to detect turbidity levels and validate sea surface temperature. Such data products were used to compute habitat suitability maps for oysters and manatees in the Mobile Bay and Mississippi Sound to assess the optimal areas and conditions for habitat restoration initiatives. Project partners will use product results to better understand manatee movements and habitat suitability for oysters.



Costa Rica Oceans

Assessing Changes in Vegetation and Marine Environments at the Isla del Coco Marine Reserve with Satellite Imagery

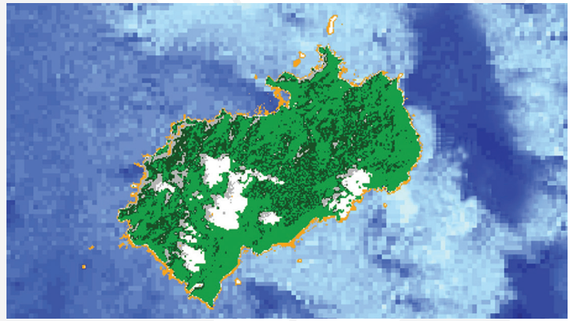
Alabama – Mobile & Georgia – Athens

Team – Dionne Blanks, Yu Chuan Shan, Farnaz Bayat, Samantha Darring, Elaina Gonsoroski, Andrew Knight, Manasi Parkhi

Partner – Sistema Nacional de Áreas de Conservación de Costa Rica, Área de Conservación Marina Isla del Coco (ACMIC) (Costa Rica); Embassy of Costa Rica to the United States; Ministry of Environment and Energy, Water Directorate (DA-MINAE) (Costa Rica)

Earth observations – Landsat 7 ETM+, Landsat 8 OLI, Envisat MERIS, Sentinel-2 MSI, Aqua MODIS, Terra MODIS, POES AVHRR

The Isla del Coco Marine Reserve, located off the coast of Costa Rica, is experiencing several environmental challenges including rising sea surface temperature (SST), coral reef bleaching, coastal erosion, and loss of cloud coverage above its cloud forest. These challenges not only threaten the well-being of vegetation and the marine ecosystem, but also the national park's infrastructure. Therefore, this project aimed to provide a better understanding of the problem by conducting time series analysis on changes in vegetation on the island, SST, total suspended sediments (TSS), and biophysical parameters in the surrounding ocean. Satellite data from Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), Moderate Resolution Imaging Spectroradiometer (MODIS), and Medium Resolution Imaging Spectrometer (MERIS) were collected for the period March 2002 to October 2016 to analyze vegetation health and cloud forest coverage and its impact on vegetation. NetCDF data products of SST, remote sensing reflectance, and inherent optical properties were converted to raster and windows representing the study area were applied to extract data for trend analysis. MERIS level 2 products were used in combination with products derived from Sentinel-2 level 1 data to create a time series analysis ranging from 2002 to 2016 for TSS. Results of this project are important for Sistema Nacional de Áreas de Conservación de Costa Rica, Embassy of Costa Rica to the United States, and the Ministry of Environment and Energy-Water Directorate to make informed decisions to protect the marine reserve.



Southern California Oceans

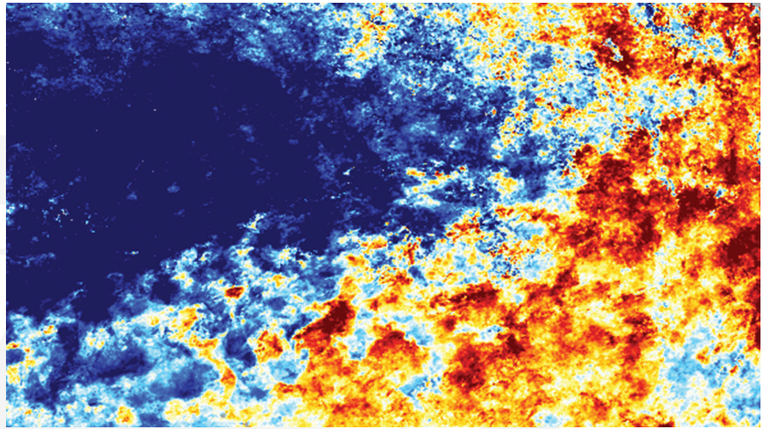
Analyzing NASA Earth Observation Data to Evaluate Grunion Response to Ecosystem Changes Forced by Recent Environmental Conditions in California's Oceans

California – JPL

Team – Lael Wakamatsu, Sol Kim, Ariana Nickmeyer

Partner – Grunion Greeters Project

Earth observations – Aqua MODIS, MUR



The California grunion is an endemic fish species vital to the California coast, acting as a versatile food source for many species such as seabirds, large mammals, and other fish in the food web. This species, known primarily for the unique way in which they spawn, have two specialized regions. Historically, they only occur in Southern California and northern Baja California and are vulnerable to air and ocean temperature changes. In the last 16 years, scientists recorded grunion spawning further north to the San Francisco Bay area. In response to air and ocean temperature increases, the fish migrate to cooler waters to which they are more adapted. This is an issue due to the fact that the grunion found here are much smaller in size, indicating the north coast may not be as suitable for the species. Increased beach activity, beach cleaning practices, and coastal erosion significantly contribute to the decrease in population and the significant shift of spawning areas. This project, in collaboration with the Grunion Greeters Project, used Aqua MODIS satellite data for sea surface temperature (SST) and chlorophyll-a concentration to create a time series of the California coast from 2002 to 2017. Analyzing this product will help predict grunion spawning areas and can be used to develop beneficial management practices as well as establish new protective areas to keep the species thriving and safe.

US Pacific Islands Oceans

Utilizing the NASA and NOAA Joint Ocean Surface Topography Mission and Modeled Wave Data to Assess Patterns and Trends in Sea-surface Height in the US Affiliated Pacific Islands

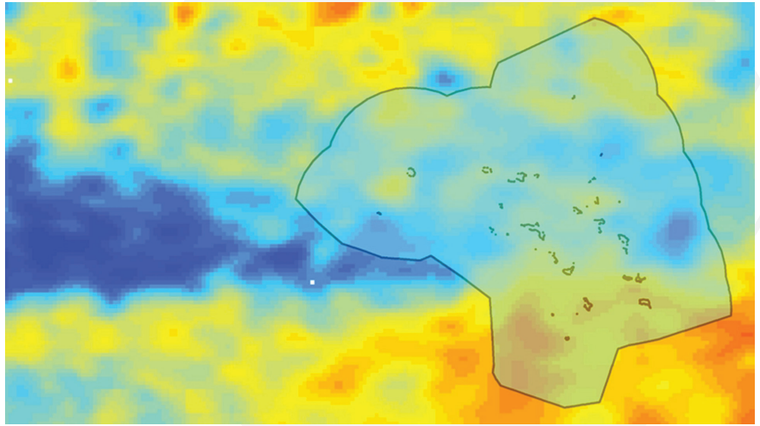
North Carolina – NCEI

Team – India Young, Alec Courtright, Katie Walker, Saraneh Fitzgerald

Partner – NOAA Regional Climate Services, Pacific Region; University of Hawaii, Sea Level Center; NOAA, Center for Satellite Applications and Research (STAR), Satellite Oceanography & Climatology Division

Earth observations – OSTM/Jason-2; Jason-3; Sentinel-3; Topex/Poseidon; Jason-1

The project team partnered with the Regional Climate Services Director (RCSD) for the Pacific Region, Dr. John J. Marra, under NOAA National Centers for Environmental Information (NCEI) to analyze near-real time (i.e., weekly) spatial and temporal patterns and trends in sea-surface height (SSH) around the US Affiliated Pacific Islands (USAPI). Ocean Surface Topography Mission data and current tidal data from in situ measurements were used. *In situ* and satellite data from buoys, tide gauges, NASA's Sea Surface Height (SSH) climate record derived from the TOPEX/Poseidon mission and Ocean Surface Topography Mission data from Jason-2 and Jason-3 satellites, and a blend of satellites for NOAA's CoastWatch and OceanWatch will be utilized. The team produced a significant wave height climatology, a wave direction climatology, a 1 week to 3 week outlook, and a categorical inundation risk metric to assess island inundation risk. End users Dr. John Marra and Dr. Matthew Widlansky will use the risk metric tool set climatologies and distribute this information to coastal hazard and climate adaptation decision makers in the USAPI.



OVERVIEW

DEVELOP's Cross-Cutting projects extend beyond application exploration of Earth observations across a variety of environmental themes to incorporate additional societal concerns. These projects focus on innovative technologies and methods to apply NASA satellite and airborne data to create new decision-making tools and management applications. This summer, four projects partnered with nine organizations to illustrate the ability of Earth observations to support the enhancement of satellite data visualization tools, creation of a poverty index, and monitoring of light pollution in two states and two countries.

PORTFOLIO

CALIPSO Cross-Cutting: Enhancements to Visualization of CALIPSO (VOCAL) through Case Studies of Saharan Dust (*Virginia – Langley*)

Pacific Southwest Cross-Cutting: Utilizing NASA Earth Observations to Develop a Land-Use Change Detection Tool for Habitat Conservation Plan Areas (*Virginia – Langley*)

Thailand Cross-Cutting: Utilizing Suomi NPP's Day-Night Band to Assess Energy Consumption and Investigate its Suitability as a Proxy for Poverty in Thailand (*Alabama – Marshall*)

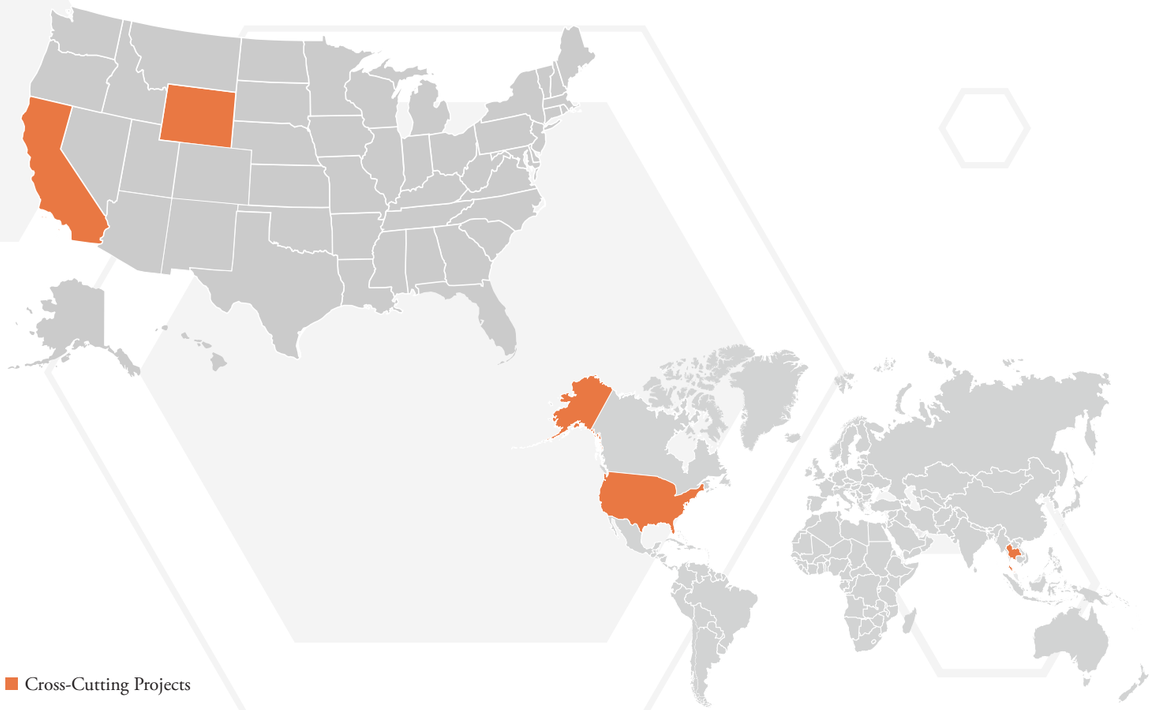
Wyoming Cross-Cutting II: Detecting Changes in Nighttime Sky Brightness over Grand Teton National Park with the Suomi NPP VIIRS Sensor (*Virginia – Wise*)

PARTNERS

Asian Disaster Preparedness Center (ADPC)
NASA CALIPSO Science Team
National Park Service, Grand Teton National Park
National Park Service, Intermountain Region
National Park Service, Natural Sounds and Night Skies Division
Royal Thai Embassy, Office of Science and Technology
NASA SERVIR Science Coordination Office
US Fish and Wildlife Service, Midwest Region, National Wetland Inventory
US Fish and Wildlife Service, Pacific Southwest Region, Ecological Services Program
Wyoming Stargazing

SENSORS

Aqua MODIS
CALIPSO CALIOP
Landsat 5 TM
Landsat 8 OLI
Sentinel-2 MSI
Suomi NPP VIIRS
Terra MODIS



Cross-Cutting Projects

CALIPSO Cross-Cutting

Enhancements to Visualization of CALIPSO **(VOCAL) through Case Studies of Saharan Dust**

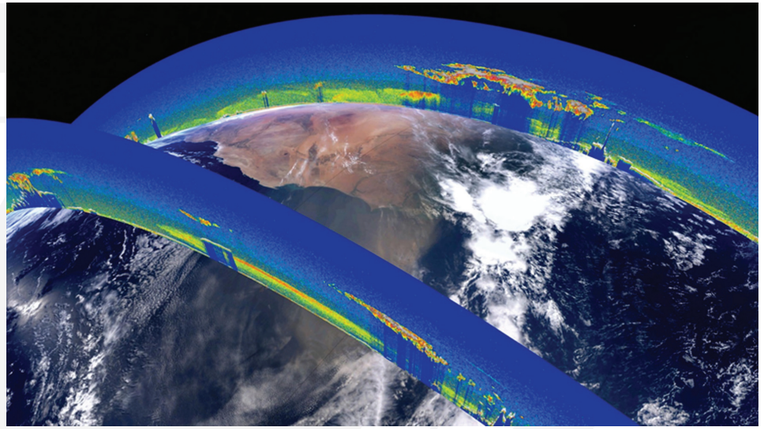
Virginia – Langley

Team – Collin Pampalone, Ryan Avery, William Turner

Partner – NASA CALIPSO Science Team

Earth observations – CALIPSO CALIOP, Aqua MODIS, Terra MODIS

The Cloud-Aerosol LiDAR and Infrared Pathfinder Satellite Observation (CALIPSO) satellite's CALIOP sensor generates vertical LiDAR profiles of the atmosphere at a global scale. Currently, the standard visualization tool for these data is written in Interactive Data Language (IDL), a proprietary language that does not support features for tracking aerosols, selecting data, or sharing those selected sections. This makes working with CALIPSO data difficult for researchers and does not allow them to visually identify aerosol features from these data. Previous DEVELOP teams have built a working version of the Visualization of CALIPSO (VOCAL) software, a Python language replacement for this IDL-based software. During this term, the team enhanced VOCAL by improving the shape drawing tool, adding the capability to view multiple levels of data, and more flexible data inputs and outputs that support a decentralized database in the form of a CSV file. These features will increase the usability of VOCAL, expediting the process of visually identifying features and analyzing the resulting subsets of data. Finally, the DEVELOP team conducted a case study with Saharan Dust transport over the Atlantic Ocean to test the capabilities of the VOCAL software and to produce a database of dust events. The database and case study will help members of the CALIPSO Science Team compare the performance of classification algorithms used to create Level 2 (L2) CALIPSO data products, and will also support preliminary analysis of the atmospheric interactions and consequences related to long range dust transport.



Pacific Southwest Cross-Cutting

Utilizing NASA Earth Observations to Develop a Land-Use Change Detection Tool for Habitat Conservation Plan Areas

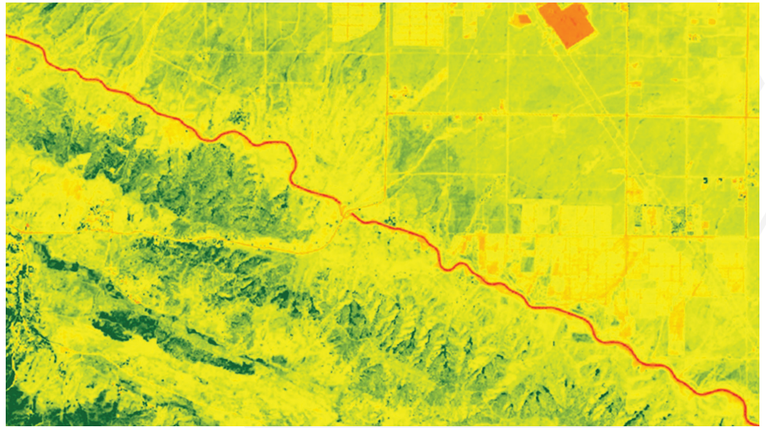
Virginia – Langley

Team – Sean Robison, Liz Dyer, Katie Thomas

Partner – US Fish and Wildlife Service, Pacific Southwest Region, Ecological Services Program; US Fish and Wildlife Service, Midwest Region, National Wetland Inventory

Earth observations – Landsat 5 TM, Landsat 8 OLI, Sentinel-2 MSI

Habitat Conservation Plans (HCPs) were designed to protect and manage areas where desired economic development is in conflict with the needs of threatened and endangered species. Each plan is developed through collaboration between the United States Fish and Wildlife Service (USFWS) and a landowner or other project proponent. Regulations restrict activities within HCP boundaries to minimize impacts to listed species while still allowing for land development. The USFWS does not have the capacity to closely monitor and assess the millions of acres of private- and publically-owned lands to ensure compliance with restrictions. In order to assist monitoring efforts by the USFWS, a methodology was constructed that uses remote sensing data and the Normalized Difference Vegetation Index (NDVI) to detect land use change. Past land use change from 1995 to 2017 in the Pacific Southwest HCPs was analyzed. This methodology used publically available satellite data from Landsat 5, Landsat 8, and Sentinel-2, and was implemented in the open source Google Earth Engine (GEE) API. The USFWS will be able to use this tool on the GEE platform to continue evaluating HPCs for disturbance, saving significant travel time and effort.



Thailand Cross-Cutting

Utilizing Suomi NPP's Day-Night Band to Assess Energy Consumption and Investigate its Suitability as a Proxy for Poverty in Thailand

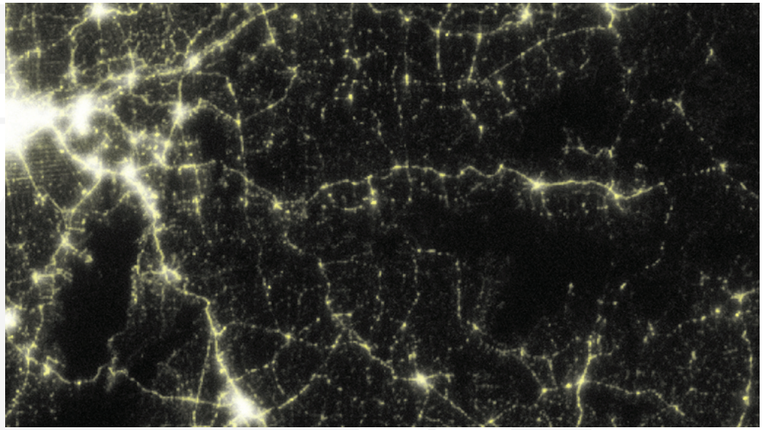
Alabama – Marshall

Team – Helen Baldwin, Maggi Klug, Krisda Tapracharoen, Chayanan Nan Visudchindaporn

Partner – Asian Disaster Preparedness Center (ADPC); Royal Thai Embassy, Office of Science and Technology; NASA SERVIR Science Coordination Office

Earth observations – Suomi NPP VIIRS

While poverty in Thailand has decreased from 67% in 1986 to 13% in 2012, 6.7 million people were still living within 20% of the poverty line in 2014. Economic uncertainty caused by recurring droughts and decreasing agricultural prices puts this vulnerable part of the population at risk of dropping below the national poverty line in the future. In order to address this issue, the DEVELOP team worked with the Office of Science and Technology (OSTC) at the Royal Thai Embassy, Asian Disaster Preparedness Center (ADPC), and the NASA SERVIR Coordination Office to formulate a new method of analyzing poverty within Thailand. This project utilized the monthly composite product for 2012-2015 produced by the Earth Observations Group (EOG) at National Oceanic and Atmospheric Administration (NOAA) and National Geophysical Data Center (NGDC). Additionally, this project incorporated socio-economic data from Thailand's Ministry of Information and Communication Technology's National Statistical Office and Ministry of Education's National Education Information System to create an enhanced poverty index. This new poverty index will provide the Thai government a cost-effective way to analyze changes of poverty within the nation and inform policy making.



Wyoming Cross-Cutting II

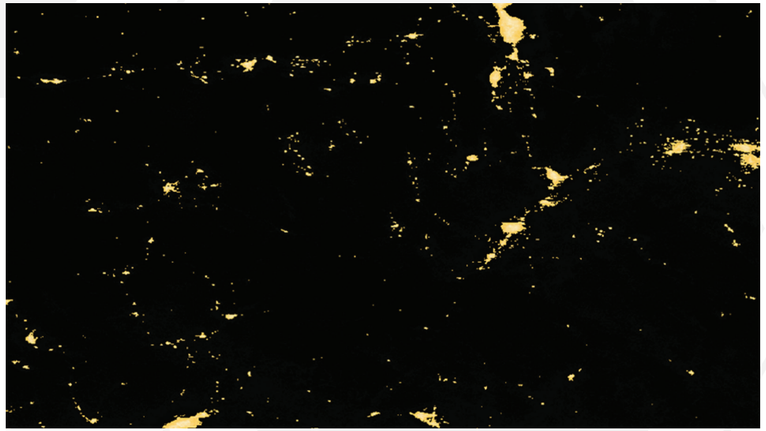
Detecting Changes in Nighttime Sky Brightness over Grand Teton National Park with the Suomi NPP VIIRS Sensor

Virginia – Wise

Team – Veronica Warda, Ryan Avery, Steven Chao, Stanley Yu

Partner – National Park Service, Grand Teton National Park; National Park Service, Intermountain Region; National Park Service, Natural Sounds and Night Skies Division; Wyoming Stargazing

Earth observations – Suomi NPP VIIRS



As more outdoor lighting is installed for safety and development, light pollution has become a growing problem that threatens the quality of life for humans and wildlife. The onset of light pollution in cities and dark sky areas not only hinders humans from seeing the stars and the Milky Way but also has been linked to health disorders in humans and behavioral changes in flora and fauna. Park officials at Grand Teton National Park (GRTE) are concerned about light pollution's impacts on visitor experience and the environment. Thus, in collaboration with the National Park Service and Wyoming Stargazing, our team created the Skyglow Estimation Toolbox (SET), a Python program that calculates images of artificial sky glow from the vantage point of a viewer on the ground. SET processes visible light radiance imagery collected by the Suomi National Polar-orbiting Partnership Visible Infrared Imaging Radiometer Suite Day/Night Band. By processing the pixel values in VIIRS imagery with convolution, the Toolbox applies Cinzano (2001) and Garstang's (1989) model of light propagation to create artificial skyglow maps to measure skyglow at a user-supplied viewing angle and location. We applied this program to a 300 km square buffer of our study area, GRTE, and created multi-annual composites of sky glow over the summer months (July, August, and September) of 2014, 2015, and 2016. With further development and model validation, SET will help government officials and communities quantify the impact of light sources to their night skies and will help inform decisions regarding lighting ordinances in nearby Teton County.

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