National Aeronautics and Space Administration

NASA Applied Sciences' Capacity Building Program's **DEVELOP National Program**

2015 Summer Project Booklet

Letter from the **National Program Office**

This year has been one of the most thrilling in DEVELOP history as we set new records for the number of projects conducted and people involved. DEVELOP engaged 407 participants and 156 unique partners through 91 application projects in fiscal year 2015.

It's an exciting time in NASA Earth Science with five Earth observing missions launched in the last year. This freely-available data provides limitless capabilities for improving people's lives around the world. From monitoring and forecasting floods, wildfires and droughts to forecasting suitable habitat for conservation of endangered species and the restoration of wetlands, NASA Earth observations are unlocking key information for improving life here on Earth.

Each term brings with it a unique set of challenges and objectives. This summer, it has been electrifying to work with 175 participants conducting the largest number of projects accomplished in one term—38! Each of these projects highlights the wide variety of applications of NASA's suite of satellite and airborne sensors and harnesses their potential for improving decision making.

At DEVELOP we believe Earth observations are key to enabling policy makers, government agencies and other stakeholders to make more informed decisions on critical issues around the globe. We hope you will join us as we enthusiastically work towards our mission to integrate NASA Earth observations with society, foster innovation and tomorrow's decision makers, and address diverse environmental issues today.

Thank you!
DEVELOP's National Program Office

DEVELOP Vision

Shaping the future by integrating Earth observations into global decision making.

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About **DEVELOP**

DEVELOP addresses a wide array of environmental & 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, from oceans to the atmosphere, from 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 so that end-users can experience timely benefit from sustainable tools and information specifically tailored to their decision making needs.

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 400 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 & recently transitioned U.S. military service members.

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

About **Projects**

The foundation of DEVELOP is a portfolio of applied science projects focused on connecting NASA Earth science data to end-users around the world. Through 90+ 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.

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

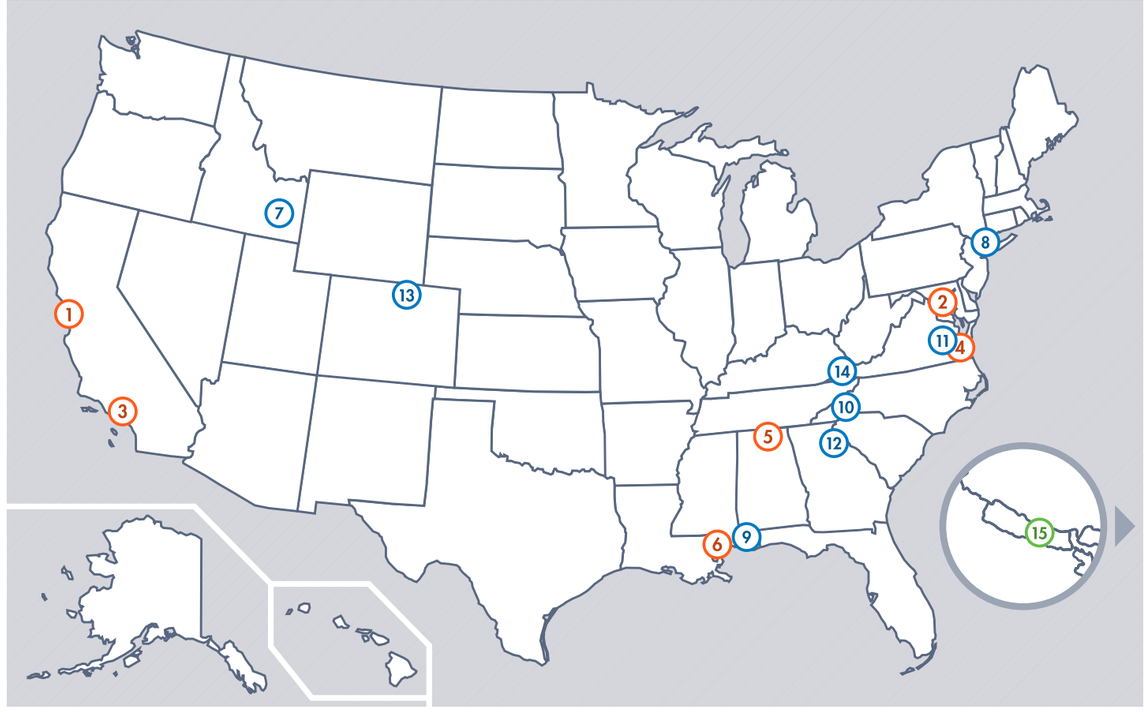
Each DEVELOP project is driven by a community concern that is presenting a decision-making need for one or more end-user groups. DEVELOP partners with those end-users to create tailored tools—based on NASA Earth observations—that can then be sustainably used to enhance the partner's decision-making.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

About **Partners**

A wide variety of project partners are a vital ingredient in the DEVELOP model. Each year DEVELOP collaborates with over 150 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 well-versed in the use of NASA Earth observations.



NASA Center Locations

1. **NASA Ames Research Center (ARC)** — *Moffett Field, CA*
2. **NASA Goddard Space Flight Center (GSFC)** — *Greenbelt, MD*
3. **NASA Jet Propulsion Laboratory (JPL)** — *Pasadena, CA*
4. **NASA Langley Research Center (LaRC)** — *Hampton, VA*
5. **NASA Marshall Space Flight Center at NSSTC (MSFC)** — *Huntsville, AL*
6. **NASA Stennis Space Center (SSC)** — *Stennis, MS*

Regional Locations

7. **BLM at Idaho State University GIS TReC (BLM-ISU)** — *Pocatello, ID*
8. **International Research Institute for Climate and Society (IRI)** — *Palisades, NY*
9. **Mobile County Health Department (MCHD)** — *Mobile, AL*
10. **NOAA National Centers for Environmental Information (NCEI)** — *Asheville, NC*
11. **Patrick Henry Building (PHB)** — *Richmond, VA*
12. **University of Georgia (UGA)** — *Athens, GA*
13. **USGS at Colorado State University (USGS-CSU)** — *Fort Collins, CO*
14. **Wise County and City of Norton Clerk of Court's Office (WC)** — *Wise, VA*

International Location

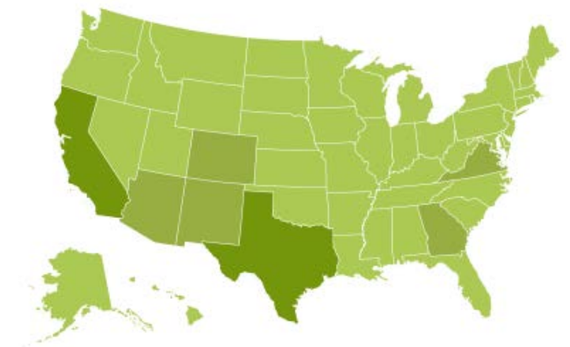
15. **International Centre for Integrated Mountain Development (ICIMOD)** — *Kathmandu, Nepal*

2015 **Summer Term**

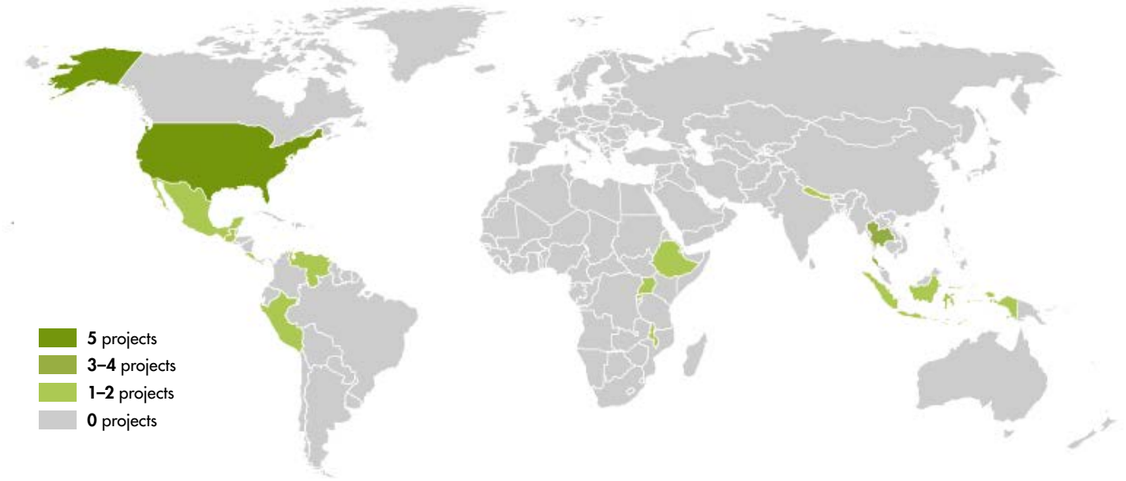
DEVELOP's 2015 Summer Term has been one of the largest and most exciting in the program's history. 175 participants and 88 partners collaborated within the DEVELOP framework to conduct 38 rapid feasibility projects. These projects utilized NASA's Earth observations and models to monitor changes in the landscape that affect decision making and provide a synoptic view for understanding the Earth from a new vantage point.

Earth observations from 43 sensors, including data from 15 of NASA's spaceborne missions, were applied by the DEVELOP project teams to six of the NASA Applied Sciences' National Application Areas—Agriculture, Climate, Disasters, Ecological Forecasting, Health & Air Quality, and Water Resources.

Partner organizations collaborating with DEVELOP represented a variety of sectors, including state and local governments, Federal agencies, international and tribal governments, non-governmental organizations (NGO), academic institutions, and regional organizations.



5 projects **3–4** projects **1–2** projects **0** projects



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AGRICULTURE

Overview

DEVELOP's Agriculture projects promote innovative use of NASA satellite data, model products, and scientific findings to assist with agricultural monitoring and management. The projects focus on topics associated with the production and availability of food products around the globe. This summer, DEVELOP's Agriculture projects partnered with state and federal agencies, regional consortiums, and international governments and aid organizations to support agricultural management, policy-making, and global food security.

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Partners

Royal Thai Embassy
SERVIR Mekong
Asian Disaster Preparedness Center (ADPC)
Ben Delatour Scout Ranch
Bioenergy Alliance Network of the Rockies
Colorado State Forest Service
USDA Agriculture Research Service (USDA-ARS)

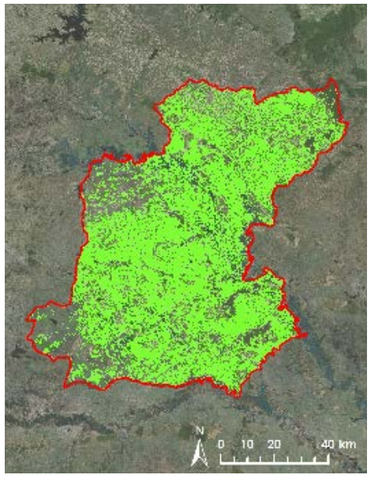
Sensors

GPM DPR
Landsat 1–3 MSS
Landsat 4–5 TM
Landsat 7 ETM+
Landsat 8 OLI/TIRS
Suomi NPP VIIRS
Terra ASTER
Terra/Aqua MODIS
TRMM PR

THAILAND AGRICULTURE — Monitoring Food Crop Health and Stress Due to Changing Climate for Enriched Agricultural Land Management

NASA Marshall Space Flight Center at NSSTC / Wise County and City of Norton Clerk of Court's Office

Team – Tim Klug (Project Lead), Komsan Rattanakijsuntorn, Arom Boekfah, Chayanit Choomwattana, Watanyoo Suksa-ngiam, Atipat Wattanuntachai
Partners – Royal Thai Embassy, SERVIR Mekong, Asian Disaster Preparedness Center
Earth observations – Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI/TIRS, Terra ASTER, TRMM PR, GPM DPR, Terra/Aqua MODIS, Suomi NPP VIIRS



possible rice field

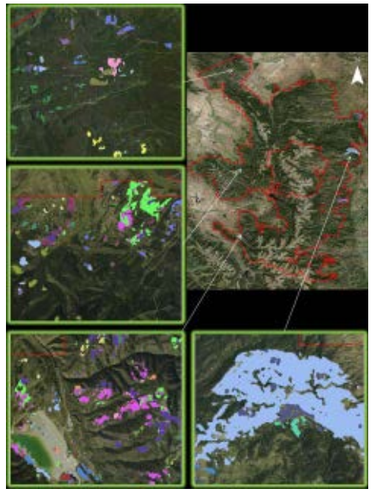
Monitoring climate change is crucial for the Thailand agricultural industry. Climate change results in shifting rainfall patterns which in turn affect the management of crop production. Northeastern Thailand grows the majority of the country's rice, but the rice yield per hectare is relatively low. One primary factor is uncertainty surrounding the ability to monitor and assess climate change. This project aims to assess changing climate patterns to improve the understanding of environmental variables, such as precipitation and temperature, to understand risks and impacts of floods, storms, and drought, and to determine relationships between seasonal rainfall patterns and production areas of rice crop. This study used satellite imagery from Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). Precipitation data from the Tropical Rainfall Measuring Mission (TRMM) and Global Precipitation Measurement (GPM), land surface temperature data from Moderate Resolution Imaging Spectroradiometer (MODIS), land surface temperature data from Visible Infrared Imaging Radiometer Suite (VIIRS), and a digital elevation model from The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). The images were analyzed by using land cover classifications, Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and/or Normalized Multi-band Drought Index (NMDI). Understanding the changing climate patterns assisted the end-users in initiating the best policies to tackle the challenges of climate change. In addition, the results of this research contributed to the scientific body of knowledge, in particular earth and agricultural sciences.

COLORADO AGRICULTURE II — Reconstructing Forest Harvest History in Northern Colorado and Southern Wyoming Using the Landsat Time Series

USGS at Colorado State University

Team – Brian Woodward (Project Lead), Stephanie Krail, Eric Rounds, Christina Welch
Partners – Ben Delatour Scout Ranch, Bioenergy Alliance Network of the Rockies, Colorado State Forest Service
Earth observations – Landsat 1–3 MSS, Landsat 4–5 TM, Landsat 7 ETM+, Landsat 8 OLI

Timber harvests are a crucial part of Northern Colorado and Southern Wyoming's local economy. The future health of the forests and ecological diversity are contingent upon appropriately managing the present forest resources. However, incomplete records of past harvests expose disparities concerning the accurate location, timing, and extent of the forest harvests. This project was designed to provide natural resource managers with a reliable map of the forest harvest history in an effort to facilitate the most educated decision making process. At the request of the three project partners, Ben Delatour Scout Ranch (BDSR), Bioenergy Alliance Network of the Rockies (BANR), and Colorado State Forest Service (CSFS), the team spectrally linked 41 years of Landsat data to create a continuous map delineating forest harvest history, wildfires, and mountain pine beetle kill. By accessing the Landsat archives, this project utilized 1974-2014 imagery from Landsat 1–3 Multispectral Scanner (MSS); Landsat 4–5 Thematic Mapper (TM); Landsat 7 Enhanced Thematic Mapper Plus (ETM+); and Landsat 8 Operational Land Imager (OLI). These collected scenes were preprocessed using Landsat-Linkr to acquire consistent images atmospherically corrected for surface reflectance, masked for cloud cover, and stacked in a Tasseled Cap (Tcap) composite. The generated inputs were run through the Landsat-based Detection of Trends in Disturbance and Recovery (LandTrendr) model to produce a visual representation of all magnitudes of disturbances within the designated area. By prioritizing timber harvest as a key disturbance, LandTrendr accurately delineated an annual forest harvest history in Northern Colorado and Southern Wyoming.



High Magnitude Disturbances (Years)

1987	1994	2000	2006
1988	1995	2001	2007
1989	1996	2002	2008
1990	1997	2003	2009
1992	1998	2004	2010
1993	1999	2005	

NORTHWEST U.S. AGRICULTURE III — Applying Future Climate Patterns to Project Suitable Apple Orchard Conditions in Washington State

NASA Langley Research Center

Team – Madeline Ruid (Project Lead), Teresa Fenn, Matthew Mullen, Sarah Philbrick, James Hendrickson
Partner – USDA Agriculture Research Service (USDA-ARS)
Earth observation – Aqua MODIS

Plant Hardiness Zones (2002–2015)

5a	7a	9a
5b	7b	9b
6a	8a	10a
6b	8b	

Washington State produces 65% of the nation's apples, adding 2.2 billion dollars to the nation's economy. Washington's warm, dry summers and cool, wet winters provide excellent conditions for apple growth. However, there is a strong likelihood that Washington's suitability for apple farming could be altered by current and future climate change. Currently, the USDA determines which plant species will thrive in a particular location based on their Plant Hardiness Zone (PHZ) Map. Apples grow best when climate conditions match zones 5, 6, or 7. By creating maps of current and projected PHZs, apple growers will be able to decide both if it would be beneficial to move apple orchards in the upcoming decades and where the most suitable conditions will be located. Using Aqua MODIS Land Surface Temperature (LST) from 2002 to 2015, minimum temperatures per day and month were extracted to create a present-day PHZ map. Additionally, future climate model air temperature forecasts from the Coupled Model Intercomparison Project phase 5 (CMIP5) for 2020 to 2100 were used to determine future PHZs. Growing Degree Days (GDD) were also calculated to create orchard suitability maps. Since the ability of apple trees to thrive is dependent on GDDs, PHZs, and average growing season temperature, these maps provided further insight into which regions of Washington State may be suitable for apple orchards in the future. Final maps of current and forecasted PHZs will allow stakeholders to identify regions that are currently optimal for apple production, and see how those regions may move with forecasted climate change.

Overview

DEVELOP's Climate projects support activities associated with the implementation of climate standards, policy, 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 adaptation decisions. This summer, DEVELOP had one Climate project in its portfolio that partnered with tribal government organizations to improve adaptation and mitigation decisions on tribal lands in the United States.

Portfolio

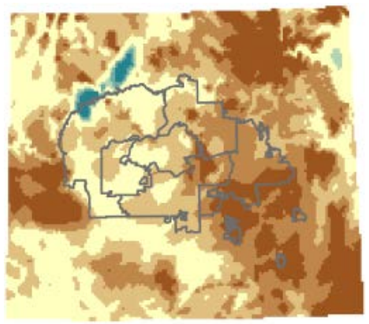
p. 8 **Navajo Nation Climate II** A Drought Monitoring Decision Support Tool for Customized Calculation of a Standardized Precipitation Index Value in the Navajo Nation — *ARC*

Partners

Navajo Nation Department of Water Resources
Navajo Technical University, Geographic Information Science Lab

Sensors

GPM DPR/GMI
TRMM PR



NAVAJO NATION CLIMATE II — A Drought Monitoring Decision Support Tool for Customized Calculation of a Standardized Precipitation Index Value in the Navajo Nation
NASA Ames Research Center

Team – Cheryl Cary (Project Lead), Michael Gao, Vickie Ly, Anton Surunis, Sophie Turnbull-Appell
Partners – Navajo Nation Department of Water Resources; Navajo Technical University, Geographic Information Science Lab
Earth observations – TRMM PR, GPM DPR/GMI

The Navajo Nation, a 65,700 km2 Native American territory located in the southwestern United States, has been increasingly impacted by severe drought events and changes in climate. These events are coupled with a lack of domestic water infrastructure and economic resources, leaving approximately one-third of the population without access to potable water in their homes. Current methods of monitoring drought are dependent on state-based monthly Standardized Precipitation Index value maps calculated by the Western Regional Climate Center. However, these maps do not provide the spatial resolution needed to illustrate differences in drought severity across the vast Nation. To better understand and monitor drought events and drought regime changes in the Navajo Nation, this project created a geodatabase of historical climate information specific to the area, and a decision support tool to calculate average Standardized Precipitation Index values for user-specified areas. The tool and geodatabase use Tropical Rainfall Monitoring Mission (TRMM) and Global Precipitation Monitor (GPM) observed precipitation data and Parameter-elevation Relationships on Independent Slopes Model modeled historical precipitation data, as well as NASA's modeled Land Data Assimilation Systems deep soil moisture, evaporation, and transpiration data products. The geodatabase and decision support tool will allow resource managers in the Navajo Nation to utilize current and future NASA Earth observation data for increased decision-making capacity regarding future climate change impact on water resources.

Overview

DEVELOP's Cross-Cutting technology projects focus on increasing accessibility of NASA's satellite and airborne data for the public. This summer, one technology project partnered with the CALIPSO Science Team to improve the interface for CALIPSO data users.

Portfolio

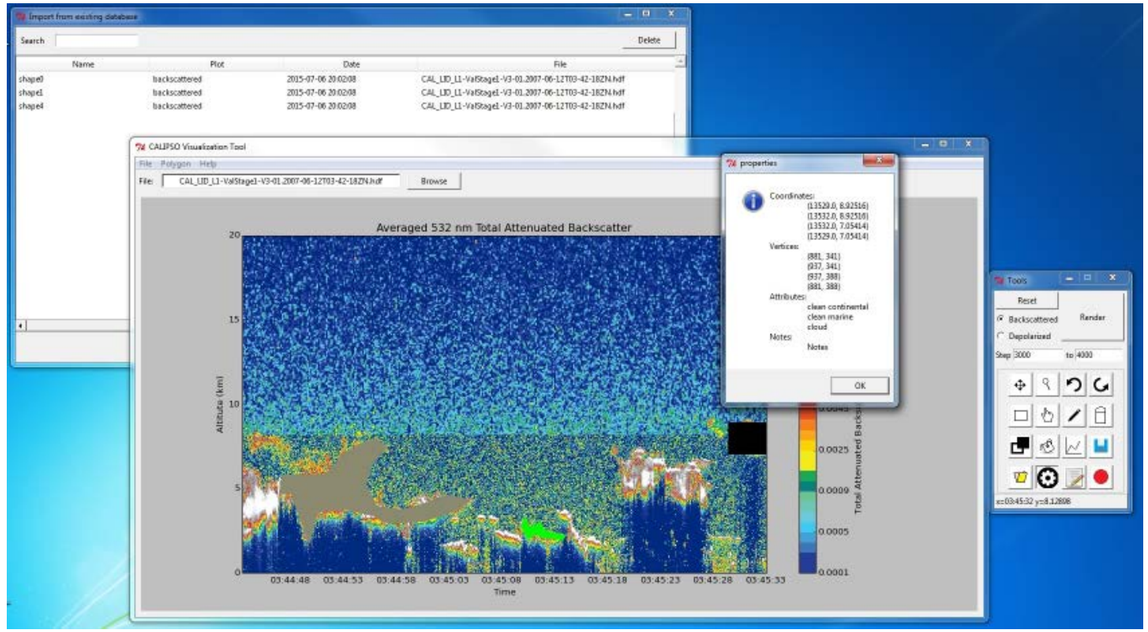
p. 9 **CALIPSO Cross-Cutting** Interfacing CALIPSO Data through a Graphical User Interface — *LaRC*

Partner

CALIPSO Science Team

Sensor

CALIPSO CALIOP



Building off a previous DEVELOP team's work, this updated CALIPSO Visualization Tool provides Earth scientists with new features and functionalities that allow easier identification of aerosol sources and their impact on Earth's climate.

CALIPSO CROSS-CUTTING — Interfacing CALIPSO Data through a Graphical User Interface
NASA Langley Research Center

Team – Grant Mercer (Project Lead), Nathan Qian
Partner – CALIPSO Science Team
Earth observation – CALIPSO CALIOP

The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) satellite is a NASA Earth observation that analyzes aerosol particles suspended in the Earth's atmosphere. Researchers use visualized CALIPSO data to track the global distribution, dispersion, and source of aerosols. However, the current visualization tool for displaying CALIPSO data does not support needed features for tracking aerosols such as selecting areas of data and sharing those selected sections, making tracking specific airborne objects difficult for researchers. Adding these necessary features to the current CALIPSO visualization tool is difficult, as the tool is written in Interactive Data Language (IDL), a proprietary and obscure language, and writing additional features for the tool would require a specialized development team. For the 2015 summer term, our team was focused on the development of the Visualization of CALIPSO (VOCAL) Python program. VOCAL will serve as the successor to the current visualization tool for CALIPSO data. We built off a previous DEVELOP team's work and implemented a number of new features and offer new functionalities to Earth scientists to more easily identify the sources of aerosols and their impact on Earth's climate.

DISASTERS

Overview

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

Portfolio

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Partners

Albany Utilities
Asian Disaster Preparedness Center
Bogor Agricultural University (IPB)
Bureau of Land Management, Idaho State Office
California Department of Forestry and Fire Protection (CAL FIRE)
Center for International Forestry Research (CIFOR)
City of Albany and Dougherty County Planning and Development Services
Climate Assessment for the Southwest (CLIMAS)
Idaho Department of Lands, Boise Field Office
Instituto Nacional de Defensa Civil del Peru (INDECI)
International Centre for Integrated Mountain Development (ICIMOD)
Malawi Red Cross Society
NASA HyspIRI Science Team
NASA RECOVER
SERVIR Coordination Office at MSFC
NASA Terrestrial Hydrology Program at Goddard Space Flight Center
National Safety Council of Thailand
Red Cross/Red Crescent Climate Centre (RCRCCC)
Regional Centre for Mapping of Resources for Development (RCMRD)
Royal Thai Embassy
SERVIR Applied Sciences Team at NASA GSFC
SERVIR Mekong
Southwest Georgia Water Resources Task Force
Texas Forest Service
Thai Department of Disaster Prevention and Mitigation
U.S. Coast Guard
U.S. Coast Guard Auxiliary University Programs (USCG AUP)
US Forest Service Remote Sensing Activities Center (RSAC)
US Geological Survey
USDA Forest Service Eastern Forest Environmental Threat Assessment Center (EFETAC)
USDA Forest Service ForWarn
USDA Forest Service Remote Sensing Applications Center (RSAC)
USDA Forest Service Rocky Mountain Research Station, Missoula Fire Sciences Laboratory
Water For People
Western Regional Climate Center (WRCC)

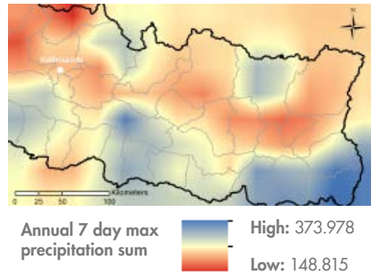
Sensors

Aqua AMSR-E
Aqua AMSU-A
Aqua/Terra MODIS
AVHRR
CMORPH-CDR
DMSP SSM-I
ER-2 AVIRIS/MASTER (simulated HyspIRI)
ERS 1 & 2
EUMETSAT METOP ASCAT
GPM DPR/GMI
GRACE
Landsat 5 TM
Landsat 7 ETM+
Landsat 8 OLI/TIRS
PERSIANN-CDR
RADARSAT 1 & 2
Sentinel-1
SMOS MIRAS
SRTM
Terra ASTER
TerraSAR-X
TRMM PR/TMI/VIRS
UAVSAR

HIMALAYA DISASTERS II — Utilizing a Landslide Identification Product and a Hazard Assessment Model for Enhanced Landslide Detection

NASA Goddard Space Flight Center / International Centre for Integrated Mountain Development

Team – Justin Roberts-Pierel (Project Lead), Aakash Ahamed, Jessica Fayne, Binu Maharajan, Kanti Sen Ojha, Ang Dawa Sherpa, Amanda Schochet
Partner – International Centre for Integrated Mountain Development (ICIMOD)
Earth observations – Landsat 8 OLI, TRMM TMI, GPM DPR, SRTM, Terra ASTER, Aqua/Terra MODIS

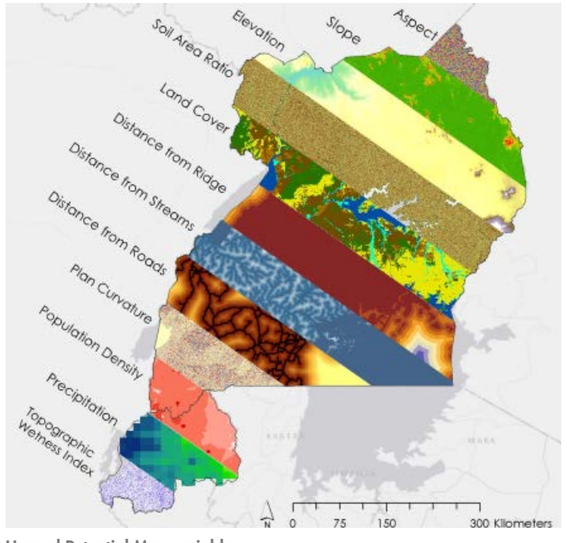


Nepal and the Himalayan region are hotspots for landslide activity due to mountainous topography, complex terrain, and monsoon rains. This study combined NASA Earth Observation data from Landsat 8, Shuttle Radar Topography Mission (SRTM), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Tropical Rainfall Measuring Mission (TRMM) and the Global Precipitation Measurement Mission (GPM) with various ancillary datasets to create two products for use in the region: the Sudden Landslide Identification Product (SLIP), and Detecting Real-time Increased Precipitation (DRIP). SLIP will help identify landslides in near real-time using Landsat 8 and elevation products, as well as provide damage assessments by mapping landslides automatically after a disaster such as the Gorkha earthquake in May 2015. DRIP will monitor precipitation levels extracted from the GPM-IMERG 30-minute product to create alerts when current rainfall levels exceed calculated threshold values. SLIP and DRIP were also integrated to provide a more comprehensive landslide notification system for the region. The DRIP-SLIP model combination will be used by the International Centre for Integrated Mountain Development (ICIMOD) to: 1) protect and manage ecosystems and villages in Nepal, 2) prevent future loss of life and infrastructure due to landslides, and, 3) reduce poverty through integrated natural resource management and regional cooperation.

EAST AFRICA DISASTERS — Using NASA Satellite Data to Predict Landslide Hazard in Uganda and Rwanda

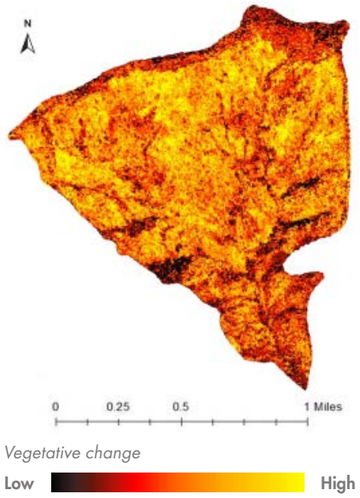
NASA Marshall Space Flight Center at NSSTC

Team – Leigh Sinclair (Co-Project Lead), Padraic Conner (Co-Project Lead), Tyler Finley, Jeanné le Roux
Partners – NASA SERVIR Coordination Office at MSFC, SERVIR Applied Sciences Team at NASA GSFC, Regional Centre for Mapping of Resources for Development (RCMRD)
Earth observations – Landsat 8 OLI, TRMM TMI, GPM DPR, SRTM



Hazard Potential Map variables

The International Emergency Disasters Database indicates that a total of 482 people have been killed and another 27,530 have been affected by landslides in Rwanda and Uganda, although the actual numbers are thought to be much higher. Data for individual countries are poorly tracked, but hotspots for devastating landslides occur throughout Rwanda and Uganda due to the local topography and soil type, intense rainfall events, and deforestation. In spite of this, there has been little research in this region that utilizes satellite imagery to estimate areas susceptible to landslides. This project utilized Landsat 8 Operational Land Imager (OLI) data and Google Earth to identify landslides that occurred within the study area. These landslides were then added to SERVIR's Global Landslide Catalog (GLC). Next, Landsat 8 OLI, the Tropical Rainfall Measuring Mission (TRMM), the Global Precipitation Measurement (GPM), and Shuttle Radar Topography Mission Version 2 (SRTM V2) data were used to create a Landslide Susceptibility Map. This was combined with population data from the Socioeconomic Data and Applications Center (SEDAC) to create a Landslide Hazard map. A preliminary assessment of the relative performance of GPM and TRMM in identifying landslide conditions was also performed. The additions to the GLC, the Landslide Susceptibility Map, the Landslide Hazard Map, and the preliminary assessment of satellite rainfall performance will be used by SERVIR and the Regional Centre for Mapping of Resources for Development (RCMRD) for disaster risk management, land use planning, and determining landslide conditions and moisture thresholds.

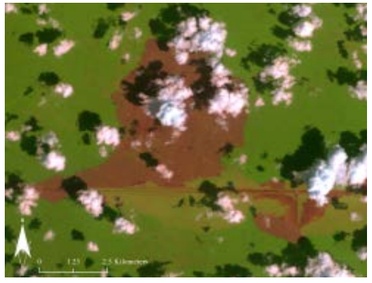


CALIFORNIA DISASTERS II — A New Method for Providing Near-Real-Time Active-Fire and Post-Burn Support to Fire Responders Using Data Products Derived from NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR)

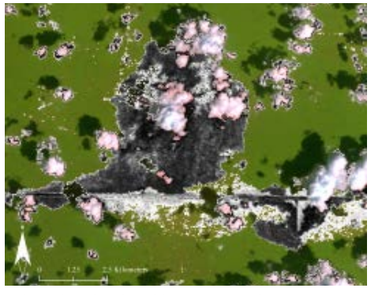
NASA Jet Propulsion Laboratory

Team – Jerry Heo (Project Lead), Christine Rains, Erika Higa, Mark Barker
Partners – California Department of Forestry and Fire Protection (CAL FIRE), US Forest Service Remote Sensing Activities Center (RSAC)
Earth observations – UAVSAR, Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, MODIS

The need for efficient wildfire monitoring and assessment is paramount in California due to increasing ecological and economical losses caused by wildfire. The California Disasters II team at the Jet Propulsion Laboratory partnered with the California Department of Forestry and Fire Protection (CAL FIRE) and the US Forest Services Remote Sensing Activities Center (RSAC) to examine the potential of using radar-derived imagery from NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) sensor for active fire assessment. Currently, remote sensing support for active fire response is limited to infrared-detecting satellites with relatively low spatial or temporal resolutions, or to airborne sensors that have limited availability and that may be interfered by cloud and smoke. The UAVSAR instrument mounted on NASA's Gulfstream III plane, however, has a high spatial resolution of 5m, can be flown day or night, and can penetrate cloud and smoke. The team studied wildfires throughout California from 2009 to the present and analyzed the ability of the UAVSAR sensor to detect burn scars and classify burn severity using a simple method with minimal computational demands. The results showed that the UAVSAR sensor is capable of detecting changes in vegetation due to wildfires. This preliminary study suggests that polarimetric SAR has the potential to become a powerful tool for active fire response.



MIR, NIR, and Red false-color composite



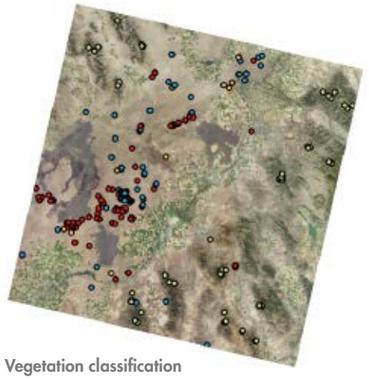
Selected and isolated hues (greyscale), corresponding to burn scars

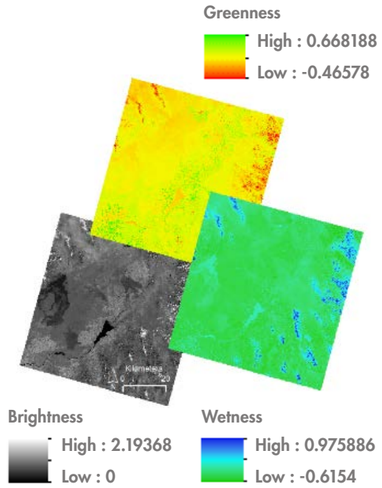
INDONESIA DISASTERS — Creating an Enhanced Methodology for Mapping Burn Scars in Indonesia by Transforming Red Green Blue False Color Composites to Hue Saturation Value (HSV) Images using Landsat

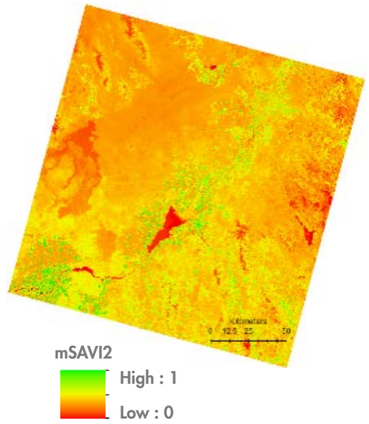
International Research Institute for Climate and Society

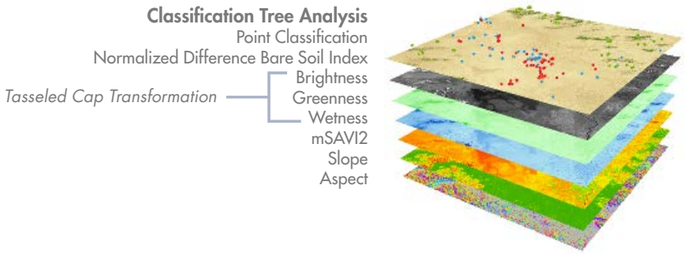
Team – Jerrod Lessel (Project Lead), Alex Sweeney
Partners – Bogor Agricultural University (IPB), Center for International Forestry Research (CIFOR)
Earth observations – Landsat 5 TM, Landsat 7 ETM+, Terra/Aqua MODIS

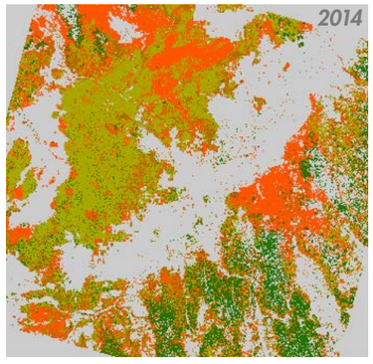
Fires associated with land use conversion activities such as agricultural expansion, palm and pulp plantations, peat land alteration, and industrial deforestation are significant in the country of Indonesia. The use of remotely sensed data to assess deforestation and carbon emissions over Indonesia is crucial in the monitoring of fires, as ground-based methods are not viable. Fires are currently mapped using data from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensors, but its spatial resolution (500 m) is not ideal for accurate mapping of burn scars in the region. Thus, researchers have sought to map burn scars at a higher spatial resolution. This study utilized Landsat to accomplish this task, given its spatial resolution of 30 m and tested a new methodology for identifying burn scars utilizing remotely sensed products over Central Kalimantan, Indonesia using scenes from Landsat's Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+). These scenes were used to assess a technique of transforming Red, Green, and Blue (RGB) color space to Hue, Saturation, and Value (HSV) space to decouple the hue from the saturation and value. When this technique was applied to a mid-infrared (MIR), near-infrared (NIR), and red false color composite, it enhanced the discrimination between vegetation, soil, and water—distinguishing burn scars from their surroundings. A hue value range for burn scars was determined; however, clouds were a limiting factor in the analysis. The approach was a good first step in reducing the amount of information one must sift through to isolate burn scars; however, more work is needed to improve this technique and develop a more automated approach for their detection.









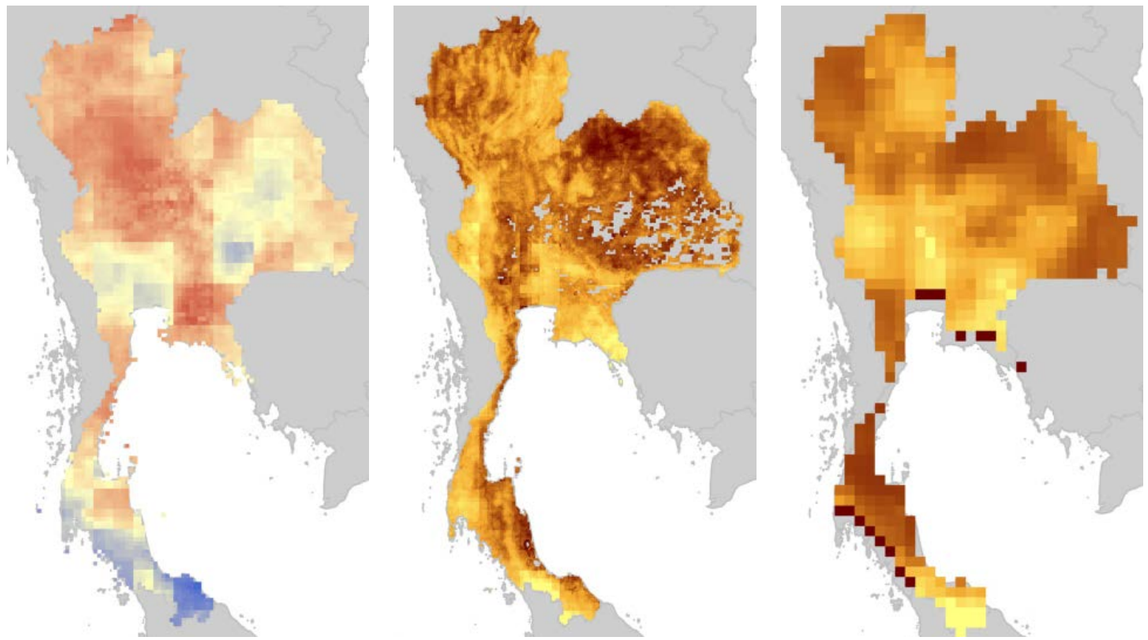


IDAHO DISASTERS III — Using Landsat 8 Earth Observations to Identify Increased Fire Susceptibility Due to Invasion of Cheatgrass (*Bromus tectorum*)

BLM at Idaho State University GIS TReC

Team – Jeff May (Project Lead), Jenna Williams, Zachary Simpson
Partners – Bureau of Land Management, Idaho State Office; Idaho Department of Lands, Boise Field Office; NASA RECOVER; US Geological Survey
Earth observation – Landsat 8 OLI

Wildfires, coupled with the presence of invasive plant species, are primary drivers of change in semi-arid savanna ecosystems. These wildfires disrupt ecosystems, human localities, critical habitats of the endangered Greater Sage Grouse (Centrocercus urophasianus), and create opportunities for invasive species to expand their populations. Wildland fire regimes have changed dramatically due to cheatgrass (Bromus tectorum), an invasive annual grass, which has effectively lengthened the wildfire season and increased fire frequency. Cheatgrasses ability to quickly establish in disturbed areas creates a positive feedback cycle with wildland fire, resulting in landscapes that burn more frequently and become increasingly dominated by this invasive plant. This creates a need for more advanced landscape and wildfire monitoring tools that can identify the prominence of invasive plants in order to provide better information regarding fire susceptibility. Currently, there are no active cheatgrass management plans in Idaho due to the overwhelming capabilities of the plant to dominate landscapes. However, effective management of this species requires knowledge of its distribution in order to evaluate wildfire regimes and prevent cheatgrass expansion in recently disturbed landscapes. This study used spring and summer 2013, 2014, and 2015 imagery from Landsat 8 Operational Land Imagery (OLI) and decision-tree-based classification to create a vegetation distribution map of SE Idaho that identified cheatgrass and was subsequently used to create a fire susceptibility map for the study area. These results enhance the decision making processes of the Bureau of Land Management and Idaho Department of Land with respect to resource allocations and supports post-fire rehabilitation planning and fuel reduction programs.



THAILAND DISASTERS — Monitoring Risk and Extent of Drought for Enhanced Decision Making and Resource Allocation in the Kingdom of Thailand

NASA Goddard Space Flight Center / Wise County and City of Norton Clerk of Court's Office

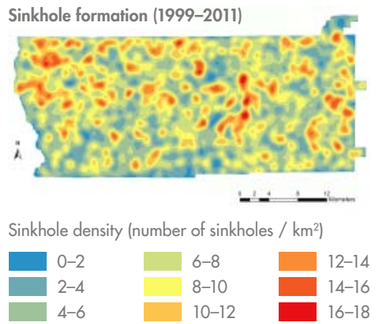
Team – Sean McCartney (Project Lead), Nobphadon Suksangpanya, Chisaphat Supunyachotsakul, Srisunee Wuthiwongyothin, Sahakait Benyasut, Thanapat Vichienlux
Partners – Royal Thai Embassy, Asian Disaster Preparedness Center, SERVIR Mekong, Thai Department of Disaster Prevention and Mitigation, National Safety Council of Thailand
Earth observations – TRMM TMI, GPM GMI, Terra/Aqua MODIS, SMOS MIRAS

Drought is a natural disaster impacting agricultural, environmental, and economic livelihoods. The Kingdom of Thailand is impacted by drought due to the variability of monsoon rains as well as other unfavorable meteorological conditions. The drought of 2015 was the worst drought to impact Thailand in over 15 years. As one of the biggest exporters of rice in the world, drought has the ability to impact the economy of Thailand in a big way. The available drought monitoring system in Thailand looked at only agricultural drought. This was insufficient for analyzing accurate risk management and decision-making. Using data from various Earth observing satellites, such as Terra Moderate Resolution Imaging Spectroradiometer (MODIS), Aqua MODIS, Tropical Rainfall Measuring Mission (TRMM) and Global Precipitation Measurement (GPM), and in situ stations, this study utilized three indices to analyze and monitor the current state of meteorological, hydrological and agricultural drought across Thailand. The Standardized Precipitation Index was used in monitoring meteorological drought, the Stream-Flow Drought Index was used in monitoring hydrological drought, and the Drought Severity Index was used in monitoring agricultural drought. All indices were based on a monthly temporal resolution for monitoring drought. The study demonstrated how a combination of various indices can offer better understanding of drought conditions, with data derived from Earth observing satellites offering the ability to monitor drought across the entire country and in near-real time.

GEORGIA DISASTERS — Utilizing NASA Earth Observations to Monitor Sinkhole Development and Identify Risk Areas in Dougherty County, GA

University of Georgia

Team – Matthew Cahalan (Project Lead), Mohamed Amin, Kimberly Berry, Wenjing Xu, Tunan Hu
Partners – City of Albany and Dougherty County Planning and Development Services, Southwest Georgia Water Resources Task Force, Albany Utilities
Earth observations – Terra ASTER, SRTM, ERS 1 & 2

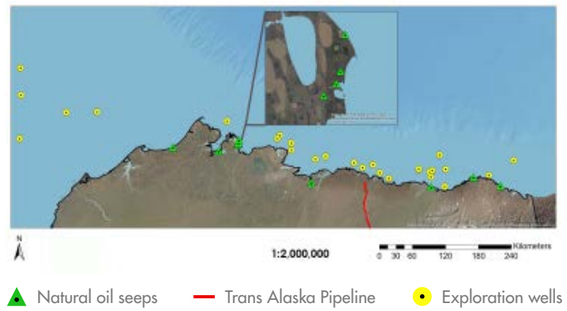


Located in southwest Georgia, Dougherty County has a growing populace in an agricultural region that relies heavily on groundwater resources. Partly due to escalated groundwater extraction, this area has experienced an increase in sinkhole development over the last decade. Sinkholes pose a threat to infrastructure development, groundwater pollution, and land use operations. The NASA DEVELOP Georgia Disasters and Water Resources team partnered with the City of Albany and Dougherty County Planning and Development Services (PDS) and the Southwest Georgia Water Resources Task Force (SGWRTF) to assess past sinkhole development and identify areas susceptible to future sinkhole formation. Sinkhole mapping was completed utilizing a time-series of elevation data (1999–2011) from NASA's SRTM and ASTER missions, as well as European Remote-Sensing (ERS-1 and 2) satellite-derived elevation data. The sinkhole inventory maps and spatial statistical techniques (i.e., geographically-weighted regression) were employed to quantify the factors most influential in sinkhole development. With those results, the susceptibility of every area within Dougherty County to future sinkhole formation was identified. The results of this applied science project will enable the PDS and SGWRTF to make informed decisions on current and future land use, safe infrastructure development, and sustainable water resource management.

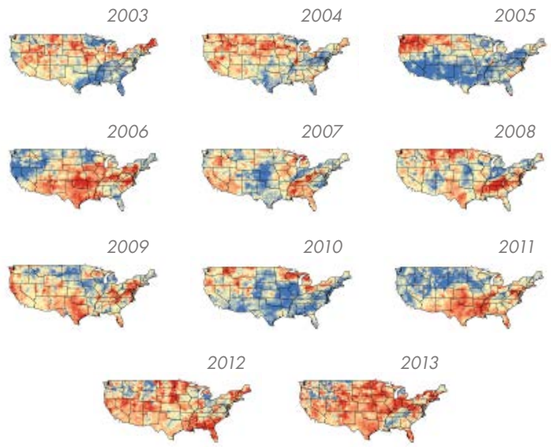
ALASKA DISASTERS — Utilizing NASA Earth Observations to Identify Oil Spills and Natural Oil Seeps off Coastal Alaska

NASA Langley Research Center

Team – Will Manion (Project Lead), Amy Ferguson, Jordan Vaa, Kristen Noviello, Katelynn Quinn, Nicole MacDonald
Partners – U.S. Coast Guard Auxiliary University Programs (USCG AUP), U.S. Coast Guard, NOAA Environmental Response Management Application (ERMA)
Earth observations – Aqua/Terra MODIS, Landsat 8 OLI, Sentinel-1



Sea ice is rapidly decreasing in the Arctic, encouraging a surge in maritime transportation and energy exploration in the region. This increase in traffic, combined with challenges unique to an Arctic environment, escalates the risk of an oil spill. In addition to human activity, a significant amount of oil enters the marine environment through natural oil seeps. The United States Coast Guard (USCG) is the lead response agency for oil spills in U.S. coastal waters. Ancillary responsibilities include monitoring natural oil seeps in order to rule out anthropogenic sources. Complexities inherent to an Arctic oil spill—ice-infested waters, strong currents, cloud cover, and extended darkness—require a combination of sensors operating across the electromagnetic spectrum to accurately portray the incident. NASA DEVELOP partnered with the USCG Auxiliary University Program to create a Python-based tool that automates access to optical and radar imagery. The project incorporated optical data from the NASA Earth Observing Systems—Aqua, Terra and Landsat 8—and radar data from the European Space Agency platform, Sentinel-1. Additionally, the study constructed a natural oil seeps map using ArcGIS 10 by spatially enabling data discovered in historical literature. The resultant dataset was injected into the interactive Arctic Emergency Response Management Application to facilitate fast visualization and coordination for emergency responders. These products will be used by the USCG to improve strategic oil spill response planning for the northern coast of Alaska.

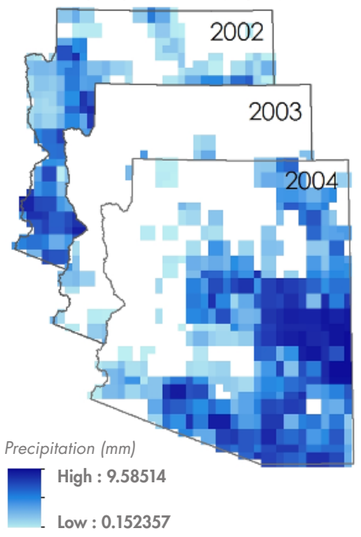


U.S. DISASTERS — Using GRACE-Derived Water and Moisture Products as a Predictive Tool for Fire Response in the Contiguous United States

NASA Jet Propulsion Laboratory

Team – Brittany Zajic (Project Lead), Daniel Jensen, Nick Rousseau
Partners – USDA Forest Service Remote Sensing Applications Center (RSAC), NASA Terrestrial Hydrology Program at Goddard Space Flight Center
Earth observations – GRACE, Terra MODIS

Understanding the relationship between wildfire activity and soil moisture in the United States has been difficult to assess, with limited ability to determine areas that are at high risk. This limitation is largely due to complex environmental factors at play, especially as they relate to alternating periods of wet and dry conditions, and the lack of remotely-sensed products. Recent drought conditions and accompanying low Fuel Moisture Content (FMC) have led to wildfire outbreaks causing economic loss, property damage, and environmental degradation. Thus, developing a programmed toolset to assess the relationship between soil moisture, which contributes greatly to FMC and fire severity, can establish the framework for determining overall wildfire risk. To evaluate these parameters, we used data assimilated from the Gravity Recovery and Climate Experiment (GRACE) and data from the Fire Program Analysis Fire-Occurrence database (FPA FOD) to determine the extent soil moisture affects fire activity. Through these datasets, we produced correlation and regression maps at a coarse resolution of 0.25 degrees for the contiguous United States. These fire-risk products and toolsets proved the viability of this methodology, allowing for the future incorporation of more GRACE-derived water parameters, MODIS vegetation indices, and other environmental datasets to refine the algorithm for fire risk. Additionally, they will allow the Tactical Fire Remote Sensing Advisory Committee (TFRSAC) and the USDA Forest Service Remote Sensing Applications Center (RSAC) to assess national-scale fire management and provide responders with a predictive tool to better employ early decision-support to high risk areas during regions' respective fire season(s).

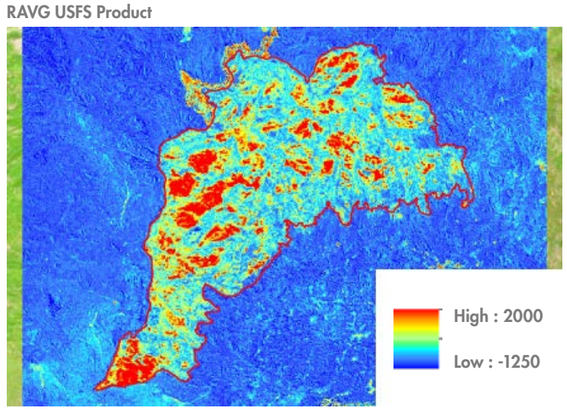


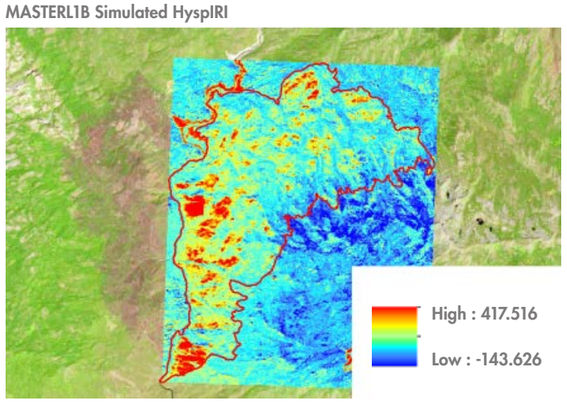
SOUTHWEST U.S. DISASTERS — Incorporating CDRs and MODIS to Create a Predictive Model of Post-Burnout Vegetation Regrowth in Relation to Flood Risk

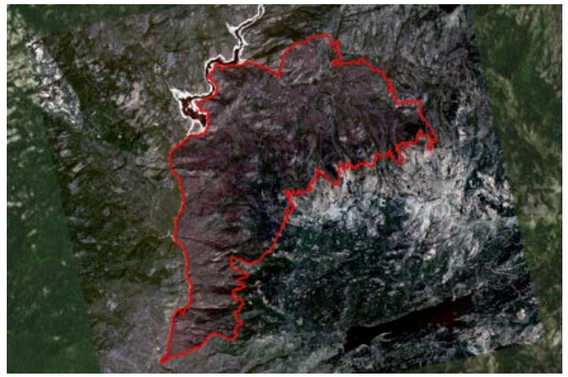
NOAA National Centers for Environmental Information

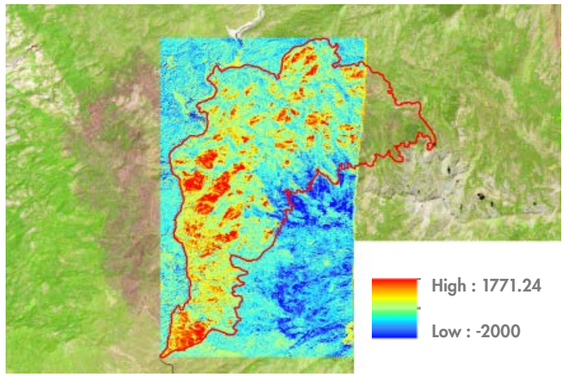
Team – Jason Zylberman (Project Lead), Jennifer Holder, Lance Watkins
Partners – Climate Assessment for the Southwest (CLIMAS), Western Regional Climate Center (WRCC)
Earth observations – Terra ASTER/MODIS, AVHRR, PERSIANN-CDR, CMORPH-CDR

This study investigated the relationship between the vegetation regrowth process and flooding following wildfire events in Arizona within the Lower Colorado River Basin. Extensive studies have been conducted on post-burnout rainfall-run-off relationships or post-burnout vegetation regeneration, but few establish a relationship between both processes. In this study, Moderate Resolution Imaging Spectroradiometer (MODIS) Normalized Difference Vegetation Index (NDVI) Earth observations were first used to create a surface indicating vegetation regrowth rate on a per-pixel basis following historical wildfire events. Next, historical flood events were identified in the NOAA PERSIANN precipitation Climate Data Records to establish precipitation trends associated with increased post-wildfire flooding risk. The relationships between precipitation anomalies, time since the fire, and vegetation regrowth were then used to predict flooding. By utilizing remotely-sensed vegetation and precipitation data in a study area with limited in situ data, this analysis developed an additional long-term predictive tool for managing future post-fire hazards.







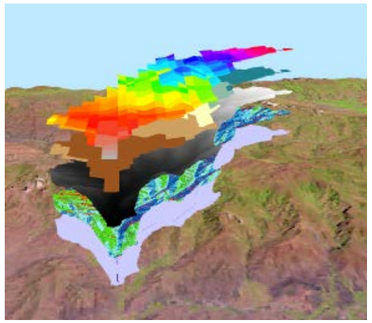


SOUTHERN CALIFORNIA DISASTERS — Assessing the Effectiveness of Simulated HyspIRI Data for Use in USDA Forest Service Post-Fire Vegetation Assessment and Decision Support

NASA Stennis Space Center

Team – Heather Nicholson (Project Lead), Amber Todoroff, Madeline LeBoeuf
Partners – USDA Forest Service Remote Sensing Applications Center (RSAC), USDA Forest Service Eastern Forest Environmental Threat Assessment Center (EFETAC), USDA Forest Service Rocky Mountain Research Station, Missoula Fire Sciences Laboratory, NASA HyspIRI Science Team
Earth observations – ER-2 AVIRIS/MASTER (simulated HyspIRI), Landsat 8 OLI, Landsat 5 TM

The USDA Forest Service has multiple programs in place which monitor post-fire burn severity. These programs primarily utilize Landsat imagery to produce burn severity indices which provide widely-used wildfire damage assessment tools to decision makers. When the Hyperspectral Infrared Imager (HyspIRI) is launched, its hyperspectral resolution will support new methods for assessing natural disaster impacts on ecosystems, including wildfire damage to forests. Since it is critical to evaluate and understand the capabilities and limitations of this satellite prior to its proposed launch date in 2022, NASA conducted an airborne campaign to simulate HyspIRI data starting in 2013 and continuing into 2015. HyspIRI data were simulated from co-located Airborne Visible/ Infrared Imaging Spectrometer and Master/ Aster Simulator (MASTER) sensors onboard a NASA ER-2 aircraft. A NASA DEVELOP project completed in the summer of 2014 qualitatively compared burn indices calculated using simulated HyspIRI data to those produced using Landsat. This project expanded upon those efforts using simulated HyspIRI data to study three southern California fires from 2013 and 2014: Aspen, French, and King. Burn severity indices were calculated from the data and the results were quantitatively compared to the USFS products currently in use. The final results from this project indicate how HyspIRI data may be used in the future to enhance assessment of fire-damaged areas and provide additional monitoring tools for decision support to agencies such as the USDA Forest Service.resource management and regional cooperation.



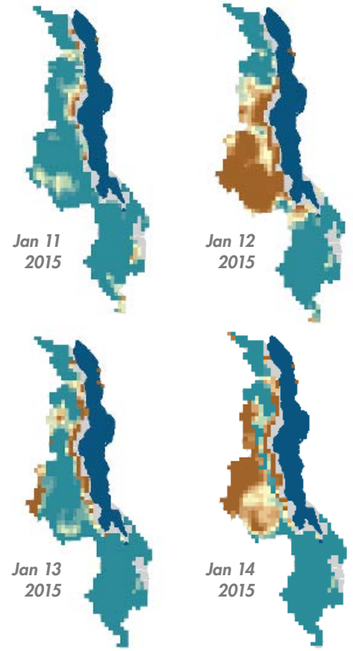
Coupled Routing and Excess Storage (CREST) data layers use inputs from NASA Earth observations to analyze seasonal flood patterns

PERU DISASTERS — Utilizing NASA Earth Observations to Develop the Tools for Flood Risk Mitigation for the Ochape Sub-Basin in the La Libertad Region of Peru

Wise County and City of Norton Clerk of Court's Office

Team – William Wilson (Project Lead), Grant Bloomer, Allison Daniel, Anthony Donzella, Josh Hammes
Partners – Water For People, Instituto Nacional de Defensa Civil del Peru (INDECI)
Earth observations – Landsat 8 OLI/TIRS, SRTM, TRMM PR, Terra MODIS

In recent years, natural disasters have afflicted the rural regions of Peru. Large flooding events in 2008, 2013, and 2014 disrupted central highlands districts, including the Cascas district of the Gran Chimu province about 110 km inland from the coastal city of Trujillo. The primary study area was the Ochape river sub-basin near the city of Cascas, the capital of the Gran Chimu province. In partnership with Water For People and the Instituto Nacional de Defensa Civil Del Peru (INDECI), this project created resources and tools necessary for flood risk assessment projects in the Cascas district of Peru. NASA Earth observations were used as inputs in the Coupled Routing and Excess Storage (CREST) Distributed Hydrological Model, which was developed by the University of Oklahoma in collaboration with NASA SERVIR. These inputs include Digital Elevation Models (DEM) and related data from the HydroSHEDS portfolio of NASA's Shuttle Radar Topography Mission (SRTM), rainfall data collected by Tropical Rainfall Measuring Mission (TRMM), and Landsat 8 imagery. All final maps, models, datasets, and tutorials developed in this project will enable Water For People and the local government to be more equipped in analyzing seasonal flood patterns.

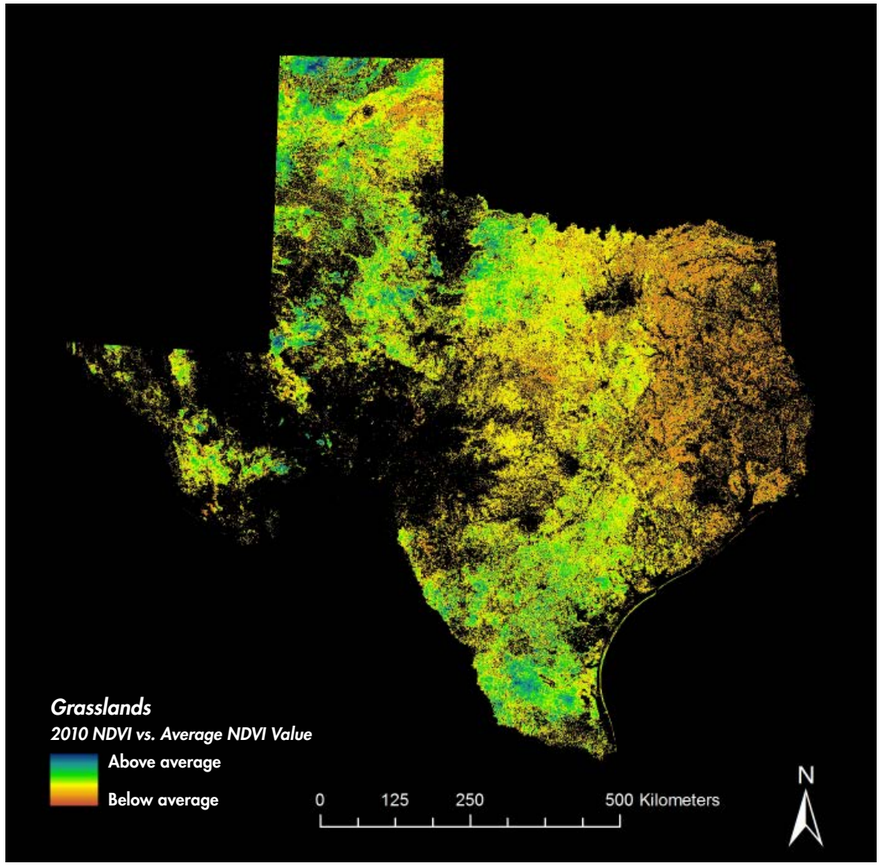


MALAWI DISASTERS — Applications of Flood Definitions and NASA Earth Observations to Create a Flood Forecasting Methodology

International Research Institute for Climate and Society

Team – Andrew Kruczkiewicz (Project Lead), Helen Cen, Brigitte Moneymaker
Partners – Red Cross/Red Crescent Climate Centre (RCRCCC), Malawi Red Cross Society
Earth observations – Aqua/Terra MODIS, TerraSAR-X, RADARSAT 1 & 2, TRMM PR/TMI/VIRS, Aqua AMSR-E, DMSP SSM-I, Aqua AMSU-A, EUMETSAT METOP ASCAT

The African country of Malawi experiences a strong seasonal rainy season stretching from October to April, which provides about 95% of its annual precipitation. In addition to this high seasonality, about 20% of Malawi's land cover is comprised of surface water from Lake Malawi, one of the Great African Lakes. These unique features contribute to the country's increased vulnerability to riverine floods and flash floods. In January 2015, extended periods of extreme rainfall caused a series of flood events throughout Malawi, which resulted in the displacement of over 230,000 residents and caused 276 fatalities. In order for local authorities and humanitarian agencies to provide post-disaster relief, these organizations often rely on remotely-sensed satellite data to evaluate initial disaster impact and design response programs. In partnership with the Malawi Red Cross, this project aimed to expand on the findings from previous research in Spring 2015 by first comparing ground-truth data (locations of shelter site of internally displaced people (IDPs) and origins of IDPs) with previous term data and second, by integrating European Space Agency (ESA) remotely sensed data to explore the potential predictive capabilities of soil moisture for flash flood detection. In addition to data from NASA sensors (MODIS, TRMM, SSM-I and AMSU-A data), this project incorporated ASCAT data from ESA. The results of this study will increase the ability to forecast and monitor flood events, benefiting organizations involved with disaster relief efforts in Malawi and potentially allowing for more efficient response and allocation of emergency flood relief efforts.



TEXAS DISASTERS — Mapping and Analyzing Fuel Loads and Phenology in the Texas Grasslands

NASA Stennis Space Center

Team – Benjamin Beasley (Project Lead), Alex Holland, Kristen Kelehan
Partners – Texas Forest Service, USDA Forest Service ForWarn, USDA Forest Service Eastern Forest Environmental Threat Assessment Center (EFETAC)
Earth observations – Landsat 8 OLI, Terra MODIS

In recent years, the risk of severe wildfires has been increasing due to weather phenomena such as sequences of wet and drought years and recent urban expansion into wilderness areas that are vulnerable to wildfire. The Texas Forest Service is tasked with estimating and evaluating potential fire risk in order to manage and allocate resources for the prevention and containment of possible wildfires across the varied and dynamic Texas landscape. Some of the main components for assessing fire risk is understanding vegetative fuel types and fuel loads. NASA Earth Observations provide a platform for evaluating wildfire fuel across a large temporal and spatial scales. MODIS and Landsat OLI were used to calculate vegetation indices such as NDVI and EVI and produce fuel type and fuel load maps. The relative strengths of two satellite sensors were combined so that the temporal advantages of MODIS were applied to Landsat data, and the spatial advantages of Landsat were applied to MODIS data. This technique resulted in fuel maps that are more current and updatable than the products derived only from Landsat data. Fuel maps were created for the 2010–2011 fire season, which saw some of the worst wildfires in recent history, and for the 2014–2015 season to provide a current assessment of wildfire fuels. The Texas Forest Service will utilize these products in order to better understand and evaluate wildfire risks throughout the state.

ECOLOGICAL FORECASTING

Overview

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

Portfolio

p. 20 **Ethiopia Eco** Mapping Fire History for Habitat Conservation in Ethiopia's Bale Mountains Using a Time Series of Landsat Data — *USGS-CSU*

p. 21 **North Carolina Eco** Evaluating the Application of NASA Earth Observations to Rapidly Detect Change in Wetland Types at a Regional Scale — *LaRC*

p. 21 **Southeast U.S. Eco** Utilizing NASA Earth Observations and Proximal Remote Sensing to Map the Spatio-Temporal Distribution of *Hydrilla verticillata* — *UGA*

p. 22 **Maryland Eco** Utilizing NASA Earth Observations to Monitor and Strengthen the Survivorship of Maryland's Sea Turtles — *GSFC*

p. 22 **Texas–Arizona Eco** Utilizing NASA Earth Observations to Monitor and Manage Ocelot Habitat Loss — *MSFC*

p. 23 **Mississippi Eco** Using NASA Earth Observations to Locate Potential Habitat for the Dusky Gopher Frog — *SSC*

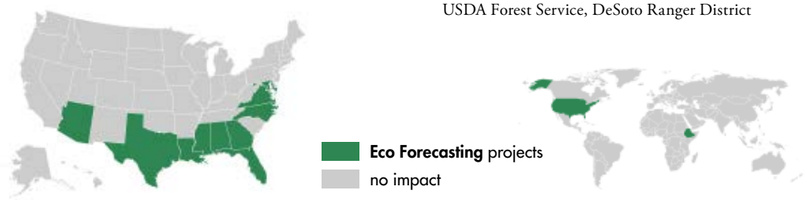
p. 23 **Ocmulgee Eco II** Utilizing NASA's Earth Observations for Forecasting Land Use Change and Wildlife Disturbances along the Ocmulgee River Corridor — *UGA*

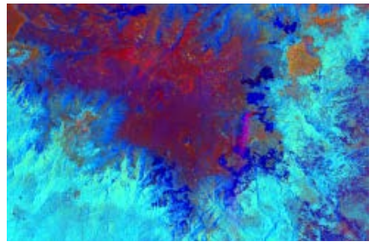
Partners

Albemarle-Pamlico National Estuary partnership (APNEP)
Caesar Kleberg Wildlife Research Institute at Texas A&M University–Kingsville
Colorado State University, Natural Resource Ecology Laboratory
East Wildlife Foundation
Georgia Department of Natural Resources
Georgia Power
Henry County Water Authority
J.W. Jones Ecological Research Center
Maryland Department of Natural Resources, Marine Mammal and Sea Turtle Stranding Program
National Oceanic and Atmospheric Association (NOAA)
North Carolina Department of Environmental and Natural Resources (NCDENR)
Pittsburg Zoo & PPG Aquarium
Secretaria de Medio Ambiente y Rescusos Naturales (SEMARNAT)
South Texas Refuge Complex
Texas Department of Transportation
The Denver Zoo
The Murulle Foundation
The Nature Conservancy
US Army Corps of Engineers
US Fish and Wildlife Service
USDA Forest Service, DeSoto Ranger District

Sensors

Aqua/Terra MODIS
Landsat 1–3 MSS
Landsat 5 TM
Landsat 7 ETM+
Landsat 8 OLI
SeaStar SeaWiFS
SRTM
Terra ASTER
WorldView 2





3-band tasseled cap composite of Landsat TM scene (03/09/2000) of the Bale Mountains. Burned areas (dark blue) and smoke (pink) are visible near image center.

ETHIOPIA ECO — Mapping Fire History for Habitat Conservation in Ethiopia's Bale Mountains Using a Time Series of Landsat Data

USGS at Colorado State University

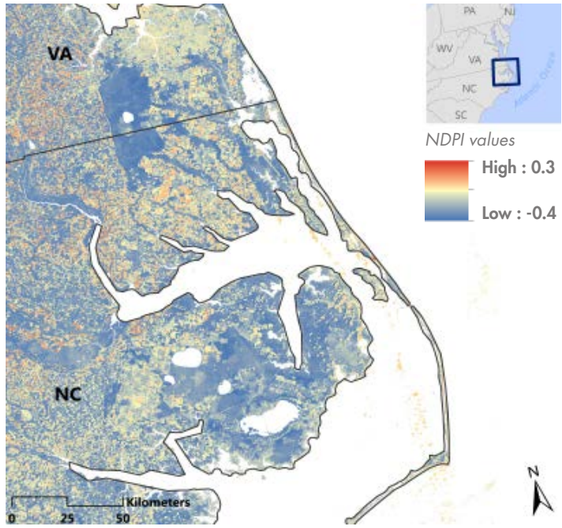
Team – Stephen Chignell (Project Lead), Chandra Fowler, Kelly Hopping, Darrin Schulte
Partners – The Murulle Foundation; Colorado State University, Natural Resource Ecology Laboratory
Earth observations – Landsat 1–3 MSS, Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI

The Bale-Arsi massif of south-central Ethiopia comprises one of the largest and least studied mountain systems in Africa. An internationally recognized biodiversity hotspot, the region is home to Bale Mountains National Park and the Sanetti Plateau, which provide critical alpine habitat for numerous endemic and endangered species such as the Mountain Nyala. Ethiopian agro-pastoralists in the region practice intentional burning to clear land for grazing and planting; however, pressures related to climate change and increasing populations have made understanding the frequency and extent of burning a top data need for conservationists and park managers seeking to balance conservation goals with the needs of local communities. We quantified historical fire occurrence and extent in the unique, high-altitude Ericaceous shrublands of Bale, using 42 years (1973–2015) of Landsat data. Multispectral images were spatially and spectrally linked within the LandsatLinkr R package, masked for clouds using a 30 m Shuttle Radar Topography Mission (SRTM) digital elevation model, and subsequently analyzed using the LandTrendr disturbance algorithm. The resulting fire extents were validated using the Moderate Resolution Imaging Spectroradiometer (MODIS) Burned Area product, as well as ancillary field records compiled from the literature. Maps and spatial data of fire date and extent were disseminated to project partners working in Bale. These will enable targeted conservation efforts in the park, and inform management approaches that ensure the preservation of the region's natural resources and the social-ecological systems they support.

NORTH CAROLINA ECO — Evaluating the Application of NASA Earth Observations to Rapidly Detect Change in Wetland Types at a Regional Scale

NASA Langley Research Center

Team – Zand Bakhtiari (Project Lead), Stephen Zimmerman, Kayla Patel, Brad Gregory
Partners – Albemarle-Pamlico National Estuary partnership (APNEP), National Oceanic and Atmospheric Association (NOAA), North Carolina Department of Environmental and Natural Resources (NCDENR)
Earth observations – Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI

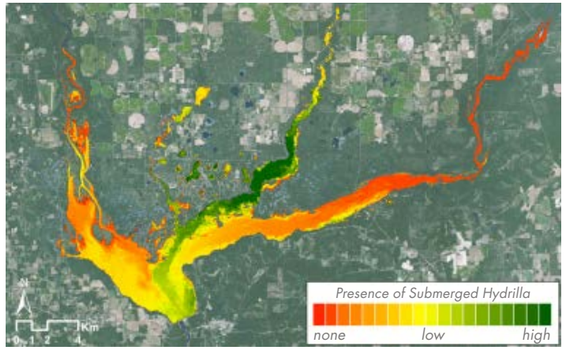


As a result of their sensitivity to sea level rise, wetlands are one of the most vulnerable ecosystems to climate change. In addition, wetland extents have diminished over time due to population increases and associated land change patterns. This project, partnered with the Albemarle-Pamlico National Estuary Partnership (APNEP), sought to delineate wetland extent within the Albemarle-Pamlico watershed from 2000 to 2015 using NASA's Landsat 5 Thematic mapper(TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI). Four images (representing spring, summer, fall, and winter) were collected for each year from 2000 to 2015. Multiple images were used for each year to account for tidal changes and to minimize the noise produced by clouds. After pre-processing the images, indices that measure water extent and wetland health were calculated for each image. A Normalized Difference Water Index was used to delineate shoreline. A wetland health index that ratios the near infrared and short wave infrared bands, and a Normalized Difference Pigment Index were used to assess wetland health. From these indices, wetland extent and relative health were measured more rapidly than contemporary classification methods. A tutorial was provided to APNEP to support the organization in implementing policies toward wetland monitoring, protection, and restoration.

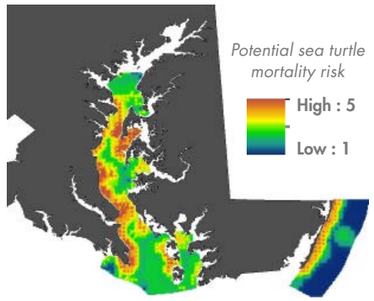
SOUTHEAST U.S. ECO — Utilizing NASA Earth Observations and Proximal Remote Sensing to Map the Spatio-Temporal Distribution of *Hydrilla verticillata*

University of Georgia

Team – Shuvankar Ghosh (Project Lead), Peter Hawman (Co-Project Lead), Wuyang Cai, Elizabeth Dyer, Pradeep Kumar Ragu Chanthar
Partners – J.W. Jones Ecological Research Center, Henry County Water Authority, Georgia Power
Earth observation – Landsat 8 OLI



Hydrilla verticillata is an invasive aquatic plant that has become a serious problem in Southeastern United States, especially impacting vegetation and water quality. Traditionally, hydrilla infestation has been tackled using a combination of field-based physical, chemical and biological methods which are often costly. Rapid and accurate spatio-temporal estimates of hydrilla density and distribution are needed for better monitoring and management of this invasive plant. This project demonstrated an innovative approach using Landsat 8 OLI data to study the spread of this invasive aquatic plant in inland waters. NASA Landsat 8 Operational Land Imager (OLI) imagery in combination with in situ data was used to map hydrilla density and distribution in four lakes across Georgia and Florida. Performances of Visible Atmospherically Resistant Index (VARI) and Green Normalized Difference Vegetation Index (GNDVI) were analyzed for indications of hydrilla density and distribution, using a combination of statistical techniques, such as coefficient of determination (R^2), percent normalized root mean square error (%RMSE), and residual trends. The resulting detection tool for monitoring hydrilla distribution was delivered to Georgia Power, the J. W. Jones Ecological Research Center, and the Henry County Water Authority for use in water quality restoration decision-making. This tool will be an efficient alternative to otherwise costly measures, and facilitate adaptive plant management. production, and see how those regions may move with forecasted climate change.

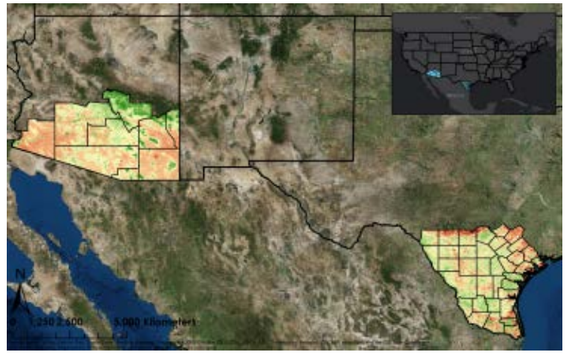


MARYLAND ECO — Utilizing NASA Earth Observations to Monitor and Strengthen the Survivorship of Maryland's Sea Turtles

NASA Goddard Space Flight Center

Team – Christopher Long (Project Lead), Kiersten Newtoff, Erica Scaduto
Partner – Maryland Department of Natural Resources, Marine Mammal and Sea Turtle Stranding Program
Earth observations – Aqua/Terra MODIS, SeaStar SeaWiFS, Landsat 8 OLI, WorldView 2

Maryland experiences dozens of sea turtle strandings every year on both the Atlantic and Chesapeake Bay coasts. The majority of these strandings are juvenile loggerhead sea turtles (Caretta caretta) that wash onshore during the late spring to early fall. Although some strandings are attributable to anthropogenic recreational activities, such as fishing and boating, most of the strandings lack a clear cause of death. Changes in sea surface temperature, algal bloom activity, and weather events can all affect the survivorship of sea turtles. Here, we analyzed correlations in loggerhead strandings with sea surface temperature and chlorophyll-a measured remotely by the Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) sensor, the SeaWIFS instrument onboard OrbView-2, and the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi National Polar-orbiting Partnership (NPP) satellite to understand the environmental variables affecting survivorship since 1991. The project also identified potential nesting site locations since this life cycle stage is the most sensitive. Nesting activity is limited in Maryland, but modeled climate change indicates warming along the Atlantic coastline – which will push the nesting range of loggerheads northward. Distance from human infrastructure, beach width, and beach slope were used to determine the greatest likelihood of future nesting under different climate and sea level rise scenarios using the Community Climate System Model. Findings will be used by the Maryland Department of Natural Resources to react faster and efficiently to future strandings and to conserve potential nesting site locations.



NDVI
Low : -0.8 — High: 0.9

TEXAS–ARIZONA ECO — Utilizing NASA Earth Observations to Monitor and Manage Ocelot Habitat Loss

NASA Marshall Space Flight Center at NSSTC

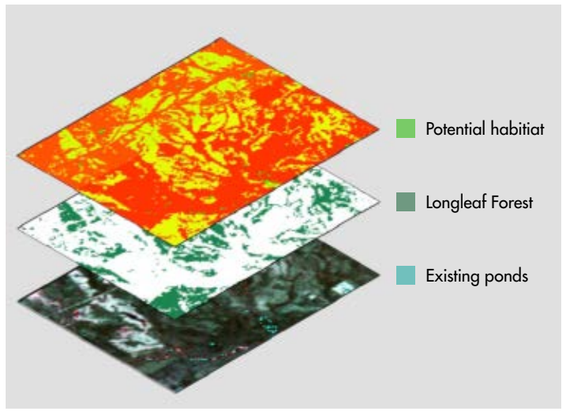
Team – Daryl Ann Winstead (Project Lead), Kaushik Narasimhan, Christina Fischer, Amberle Keith
Partners – Pittsburg Zoo & PPG Aquarium, Caesar Kleberg Wildlife Research Institute at Texas A&M University–Kingsville, The Denver Zoo, South Texas Refuge Complex, Texas Department of Transportatio, Secretaria de Medio Ambiente y Rescusos Naturales (SEMARNAT)
Earth observations – Landsat 8 OLI, Landsat 5 TM, Terra MODIS/ASTER

Although ocelot (*Leopardus pardalis*) habitat is found throughout Central America, portions of South America, and the United States, the species is currently listed as endangered with less than 100 remaining in the United States. This cat requires a minimum home range of 6.5 square kilometers, which aids in deadly interactions with humans on roadways. Many conservation efforts have been attempted, from ocelot translocation to habitat restoration. In this project, a remote sensing approach was developed, using NASA Earth-observing sensors. Landsat 8 Operational Land Imager (OLI) and Landsat 5 Thematic Mapper (TM) imagery were used to create supervised land cover classifications for 1996, 2005, and 2014 during January through March to assess land use and cover over time. Surface reflectance imagery from Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) were then used to derive Normalized Difference Vegetation Index (NDVI values) to verify the results from the land cover classification layer. The verified land cover classification was then used with in situ data in the Princeton Maximum Entropy model to identify suitable ocelot habitat. A proximity risk map to roads and urban areas was created using multiband buffer zones over this habitat. The products were delivered to the Pittsburgh Zoo & PPG Aquarium, Caesar Kleberg Wildlife Research Institute, Denver Zoo, Texas Department of Transportation, South Texas Refuge Complex, and Secretaria de Medio Ambiente y Rescusos Naturales. The use of GIS and remote sensing will greatly aid the project partner's decision-making process in directing conservation efforts for this endangered species.

MISSISSIPPI ECO — Using NASA Earth Observations to Locate Potential Habitat for the Dusky Gopher Frog

NASA Stennis Space Center

Team – Ross Reahard (Project Lead), Rudy Bartels, James Brooke, Meredith Williams
Partners – The Nature Conservancy; USDA Forest Service, DeSoto Ranger District; US Fish and Wildlife Service; US Army Corps of Engineers
Earth observations – Landsat 8 OLI, Landsat 5 TM, Terra ASTER, SRTM

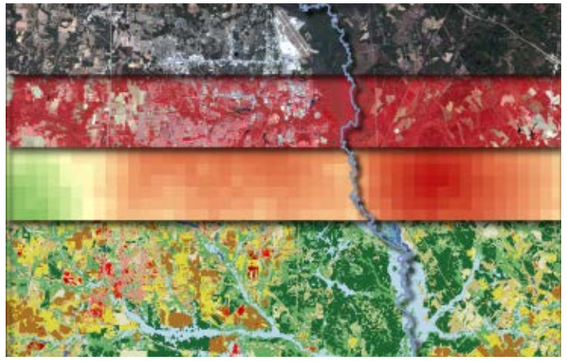


The dusky gopher frog (DGF), *Lithobates sevosus*, is currently found in only four ponds in south Mississippi. This small, wild population is threatened by high risk of inbreeding depression due to genetic isolation, loss of habitat due to land development, wildfire suppression, and runoff from surrounding roadways. Historically, these frogs inhabited longleaf pine ecosystems and utilized burrows from the gopher tortoise (*Gopherus polyphemus*), which is also endangered. In response, this project used NASA Earth observations to locate potential habitat for the DGF. Landsat 8 OLI was used to calculate vegetation indices and produce updated land cover classifications. ASTER imagery and Landsat 5 data were also used to calculate vegetation indices and water quality indices for the study area. NASA Earth observations were utilized to identify ponds, canopy cover, proximity to roadways, proximity to developed land, proximity to other bodies of water, appropriate pond hydrology over the course of the year, and emergent and submerged vegetation. NAIP aerial data were assessed for ability to detect ponds smaller than those detectable at the Landsat scale. This project will augment current decision-making practices regarding where relocation and reintroduction ponds for the dusky gopher frog should be established in order to aid in monitoring, protection, and restoration of this critically endangered species. Using this information, partnering organizations will be able to identify and map areas with the ideal land cover, water quality, and elevation characteristics for DGF habitation.

OCMULGEE ECO II — Utilizing NASA's Earth Observations for Forecasting Land Use Change and Wildlife Disturbances along the Ocmulgee River Corridor

University of Georgia

Team – Christopher Cameron (Project Lead), Andrew Herring, Ayn Remillard, Zhan Shi
Partner – Georgia Department of Natural Resources
Earth observations – Landsat 8 OLI, Terra ASTER



The Ocmulgee River south of Macon as seen across Landsat 8 true color, near infrared, ecological heat map, and 2014 land cover classification.

The Ocmulgee River corridor is home to unique species such as Atlantic sturgeon, short nosed sturgeon, black bear, and millions of migratory birds. It also holds a rich archeological record of Native American settlement. Over the years, this area has experienced increasing urbanization pressure. The NASA DEVELOP Ocmulgee River Water Resources and Ecological Forecasting team partnered with the Georgia Department of Natural Resources (GA DNR) to conduct a project focused on conserving the Ocmulgee River corridor. The goal of this project was to analyze land cover trends over the past 15 years using National Land Cover Dataset (NLCD) classifications and recent Landsat 8 images to predict future changes within the Ocmulgee River valley. With this goal in mind, a current land cover map was created and the team performed a time-series analysis. Threatened and endangered species habitats and hydrologic characteristics were overlaid with the classification maps to identify areas of concern. Using the results of this project, the GA DNR will be able to prioritize conservation of high risk areas and identify areas of future concern.

HEALTH & AIR QUALITY

Overview

DEVELOP's Health and Air Quality projects utilize satellite and airborne Earth observations, model products, and scientific findings to support air quality and public health management and policy making. This summer, DEVELOP's Health and Air Quality projects partnered with local and state governments, and non-governmental organizations (NGOs) to address topics like infectious disease risk mapping and air quality monitoring to improve global health.

Portfolio

p. 24 **Alto Orinoco Health & AQ** Utilizing NASA Earth Observations to Locate Yanomami Villages in the Alto Orinoco Municipality for Targeted Eradication of River Blindness Disease — *GSFC / MSFC / WC*

p. 25 **Arizona Health & AQ** Enhancing Extreme Heat Health-Related Intervention and Preparedness Activities Using Remote Sensing Analysis of Daily Surface Temperature Variation between Extreme Heat Days — *LaRC*

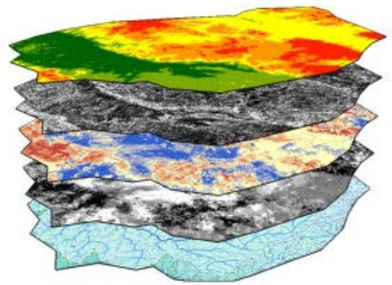
p. 25 **Los Angeles Health & AQ** Identifying Urban Emission Patterns in Los Angeles — *JPL*

Partners

Arizona Department of Health Services (ADHS)
Arizona State University, Center for Policy Informatics
Arizona State University, Environmental Remote Sensing and Informatics Lab
California Air Resources Board (CARB)
The Carter Center
The University of Minnesota

Sensors

Aqua MODIS
CLARS
GeoEye 1–2
GOSAT
IKONOS
Landsat 8 OLI/TIRS
QuickBird
SRTM
Terra ASTER
Worldview 1–3



Data types are evaluated using a Fuzzy Membership technique to create a habitat suitability model for the Yanomami people.

ALTO ORINOCO HEALTH & AQ — Utilizing NASA Earth Observations to Locate Yanomami Villages in the Alto Orinoco Municipality for Targeted Eradication of River Blindness Disease

NASA Goddard Space Flight Center / NASA Marshall Space Flight Center at NSSTC / Wise County and City of Norton Clerk of Court's Office

Team – Amanda Rumsey (Co-Lead), Kyle Sowder, Timothy Larson, Sara Amirazodi (Co-Lead), Rajkishan Rajappan (Co-Lead), Zachary Tate, Annabel White
Partners – The Carter Center, The University of Minnesota
Earth observations – Landsat 8 OLI/TIRS, Terra ASTER, SRTM, Worldview 1–3, IKONOS, GeoEye 1–2, QuickBird

Onchocerciasis, or River Blindness, is a treatable disease caused by the vector-borne parasite, *Onchocerca volvulus*. The parasite is transmitted through bites of infected black flies from the genus Simulium. Once inside the human host, *O. volvulus* migrate to the skin, various organs, and eyes, causing debilitating itching and rashes, disfigurement, visual impairment, and complete blindness. The Alto Orinoco Municipality of Venezuela is the last remaining area for active transmission of onchocerciasis in the Americas. Yanomami tribes occupy the Alto Orinoco Municipality in secluded rainforest villages and migrate frequently due to shifting cultivation, flooding, and food shortages. The remote locations of the Yanomami villages present a unique set of challenges to health workers when distributing regular treatments, collecting data, and locating groups of nomadic people whose survival depends on relocating regularly and living in isolation. The NASA DEVELOP team analyzed data from NASA's Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) and Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) to identify and map suspected locations of the Yanomami villages from 2005 to 2015. Spectral analysis, cloud masking, and classification techniques along with Digital Globe high-resolution data were utilized to locate villages. A suitability model was also created with Landsat 8 OLI/TIRS and Shuttle Radar Topography Mission (SRTM) data. Ultimately, this project assisted The Carter Center River Blindness Elimination Program in targeting its efforts to eliminate onchocerciasis in the Americas by the end of 2015.

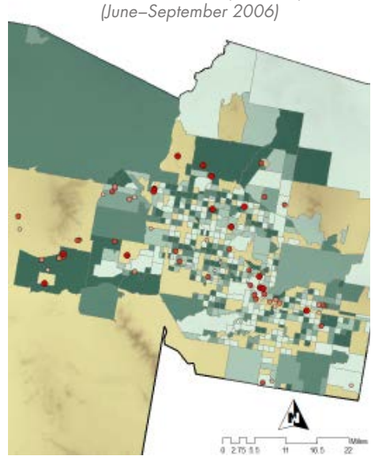
ARIZONA HEALTH & AQ — Enhancing Extreme Heat Health-Related Intervention and Preparedness Activities Using Remote Sensing Analysis of Daily Surface Temperature Variation between Extreme Heat Days

NASA Langley Research Center

Team – Amy Stuyvesant (Project Lead), Geordi Alm, Rocky Garcia, Emma Baghel, April Rascon, Bernardo Gracia
Partners – Arizona Department of Health Services (ADHS); Arizona State University, Environmental Remote Sensing and Informatics Lab; Arizona State University, Center for Policy Informatics
Earth observations – Landsat 8 OLI/TIRS, Aqua MODIS, Terra ASTER

Extreme heat causes more human fatalities in the United States than any other natural disaster, elevating the concern of heat-related mortality. Maricopa County, Arizona is specifically known for its high heat index and is the leading megapolitan area in the U.S. for population growth and urbanization. As Phoenix expands, the increase in urban strictures raises nighttime temperatures and induces a positive feedback loop, creating an urban heat island (UHI) effect. Individuals at higher risk are unequally distributed, leaving the poor, homeless, non-native English speakers, elderly, and socially isolated vulnerable to heat events. While this is a devastating incidence, it can be prevented. The Arizona Department of Health Services and the Phoenix Heat Relief Network, among others, are working to create more effectively placed cooling centers and heat warning systems to aid those with the highest exposure. Using NASA Earth observation technology from Landsat 8, Aqua (MODIS), and Terra (ASTER) satellites (sensors) the daily spatial and temperature variability within the UHI was quantified over the summer seasons of 2005–2014. A series of One-way Analysis of Variance revealed significant differences between daily surface temperature averages of the hottest 30% of census tracts within a single season. Visual analyses displayed shifts of where and how consistently the top 30% occur. These results provided detailed information regarding nuances within the UHI effect and will allow pertinent recommendations regarding the health department's adaptive capacity. They also hold essential components for future policy regarding appropriate locations for cooling centers and efficient warning systems.

Consistency of daily top 30% hottest census tracts with survey response of no A/C use due to cost in Maricopa County (June–September 2006)

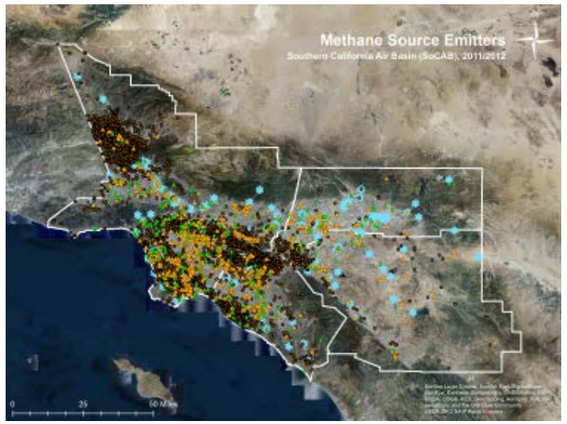


LOS ANGELES HEALTH & AQ — Identifying Urban Emission Patterns in Los Angeles

NASA Jet Propulsion Laboratory

Team – Talha Rafiq (Project Lead), Isis Frausto-Vicencio, Valerie Carranza
Partner – California Air Resources Board (CARB)
Earth observations – CLARS, GOSAT

Combining greenhouse gas (GHG) datasets with GIS spatial modeling is a viable method for analyzing the distribution of GHG emissions. Understanding the spatial dynamics of GHG emissions is important for global climate modeling and forecasting, especially as it relates to predicting the effects of global warming and the development of state and federal policies. Our research presented a spatial model of methane (CH_4) emissions in the Southern California Air Basin. Point sources of CH_4 emissions were established through the development of a geospatial database. We estimated CH_4 emission factors using a combination of the GHG inventory developed by the California Air Resources Board (CARB) and other statistical methods derived from previous GHG studies to tabulate these spatial datasets in order to create a raster-based visualization of CH_4 emissions. Our spatial map of CH_4 emissions illustrated the potential of spatial modeling for accurately depicting GHG emissions in a megacity, such as greater Los Angeles. This data provided a baseline against which measurements collected by NASA Jet Propulsion Laboratory's Earth Science Division, chiefly the Megacities Carbon Project, can be evaluated. The identification and quantification of dominant source types and locations of CH_4 were also employed by CARB to develop effective GHG reduction policies aimed to satisfy the requirements enforced by AB 32, the California Global Warming Solutions Act of 2006.



WATER RESOURCES

Overview

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

Portfolio

p. 27 **Mexico Water Resources** A Geospatial Evaluation of Drivers, Occurrences, and Distribution of Hypoxic Events within the Grijalva–Usumacinta River Delta System and the Southern Coast of the Gulf of Mexico — *ARC*

p. 27 **Virginia Water Resources** Utilizing NASA Earth Observations to Monitor the Extent of Harmful Algal Blooms in Chesapeake Bay Watershed — *PHB*

p. 28 **Colorado Water Resources II** Utilizing NASA Earth Observations to Identify Locations for Sedimentation Mitigation in the Ralston Creek Watershed Following the September 2013 Colorado Floods — *LaRC*

p. 29 **Texas Water Resources** Utilizing NASA Earth Observations to Monitor Drought Severity in Texas for Wildfire Mitigation Support — *LaRC*

p. 29 **New Mexico Water Resources** Delivering Automated Evapotranspiration Data to the New Mexico Office of the State Engineer for Enhanced Water Resource Decision Making — *JPL*

p. 30 **Sierra Nevada Water Resources** Quantifying the Effects of Wildfire Severity on Snow Water Equivalent in the Sierra Nevada — *ARC*

p. 30 **Pacific Water Resources** Using NOAA CDRs and Satellite Data to Connect Phases of the El Niño Southern Oscillation with Precipitation across Hawaii and the U.S. Affiliated Pacific Islands — *NCEI*

p. 31 **Costa Rica Water Resources** Utilizing NASA Earth Observations to Develop a Comprehensive Water Budget for the Arenal-Tempisque Watershed of Costa Rica — *UGA*

p. 31 **Coastal Texas Water Resources** Utilizing NASA Earth Observations to Assess Estuary Health and Enhance Management of Water Resources in Coastal Texas through Land Cover and Precipitation Mapping — *MCHD*

Partners

Centro del Cambio Global y la Sustentabilidad en el Sureste (CCGSS)
Centro Nacional de Datos Oceanográficos (CENDO)
Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO)
Consorcio de Instituciones de Investigación Marina del Golfo de México y del Caribe (CIIMar-GoMC)
Costa Rica's National Service of Underground Water, Irrigation, and Drainage (SENARA)
Costa Rican Embassy to the United States
Denver Water
ERT Inc.
National Park Service
New Mexico Office of the State Engineer
NOAA, Regional Climate Services Director
Old Dominion University (ODU) Department of Biological Sciences
Pacific ENSO Applications Climate (PEAC) Center
Secretaría de Marina (SEMAR)
Texas Forest Service
Universidad Autónoma de Baja California (UABC)
Universidad Juarez Autónoma De Tabasco (UJAT)
University of Georgia, Costa Rica Campus
USDA Forest Service
Virginia Department of Environmental Quality (DEQ)
Virginia Governor's Office Deputy Secretary of Natural Resources for the
Virginia Institute of Marine Science (VIMS)

Sensors

Aqua/Terra MODIS
GRACE
Landsat 4-5 TM
Landsat 7 ETM+
Landsat 8 OLI/TIRS
PERSIANN CDR
SRTM
Terra ASTER
TRMM PR

MEXICO WATER RESOURCES — A Geospatial Evaluation of Drivers, Occurrences, and Distribution of Hypoxic Events within the Grijalva–Usumacinta River Delta System and the Southern Coast of the Gulf of Mexico

NASA Ames Research Center

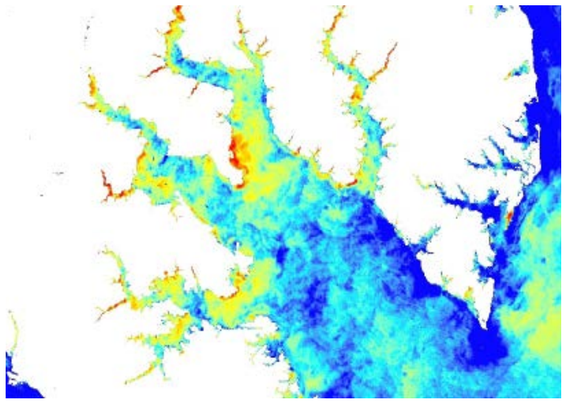
Team – Rebecca Chapman (Project Lead), Irma Caraballo Álvarez, Åse Mitchell, Alannah Johansen, Mackenzie Taggart, Bridget Smith
Partners – Consorcio de Instituciones de Investigación Marina del Golfo de México y del Caribe (CIIMar-GoMC), Centro del Cambio Global y la Sustentabilidad en el Sureste (CCGSS), Centro Nacional de Datos Oceanográficos (CENDO), Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), Universidad Autónoma de Baja California (UABC), Universidad Juarez Autónoma De Tabasco (UJAT), Secretaría de Marina (SEMAR)
Earth observations – Landsat 8 OLI, Aqua MODIS

Monitoring and analyzing harmful algal blooms (HABs) and hypoxic events in the southern coastal areas of the Gulf of Mexico (GoM) is important for watershed management and mitigation of environmental degradation. This study uncovered trends and dynamic characteristics of chlorophyll-a (Chl) concentration, sea surface temperature (SST), colored dissolved organic matter index (CDOM), and photosynthetically available radiation (PAR); as evident in 8-day standard mapped image (SMI) products from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on the Aqua platform from 2002–2015 using Clark Labs' TerrSet Earth Trends Modeler (ETM). Additionally, sediment and nutrient loading values of the Grijalva-Usumacinta watershed were modeled using the Soil and Water Assessment Tool (SWAT) within ArcGIS. Normalized Difference Turbidity Index (NDTI) and Floating Algae Index (FAI) were generated using Landsat 8 Operational Land Imager (OLI) scenes for 2014–2015. Results will assist local environmental and health authorities in revising water quality standards and mitigating the impacts of future HABs and hypoxic events in the region.locations for cooling centers and efficient warning systems.

VIRGINIA WATER RESOURCES — Utilizing NASA Earth Observations to Monitor the Extent of Harmful Algal Blooms in Chesapeake Bay Watershed

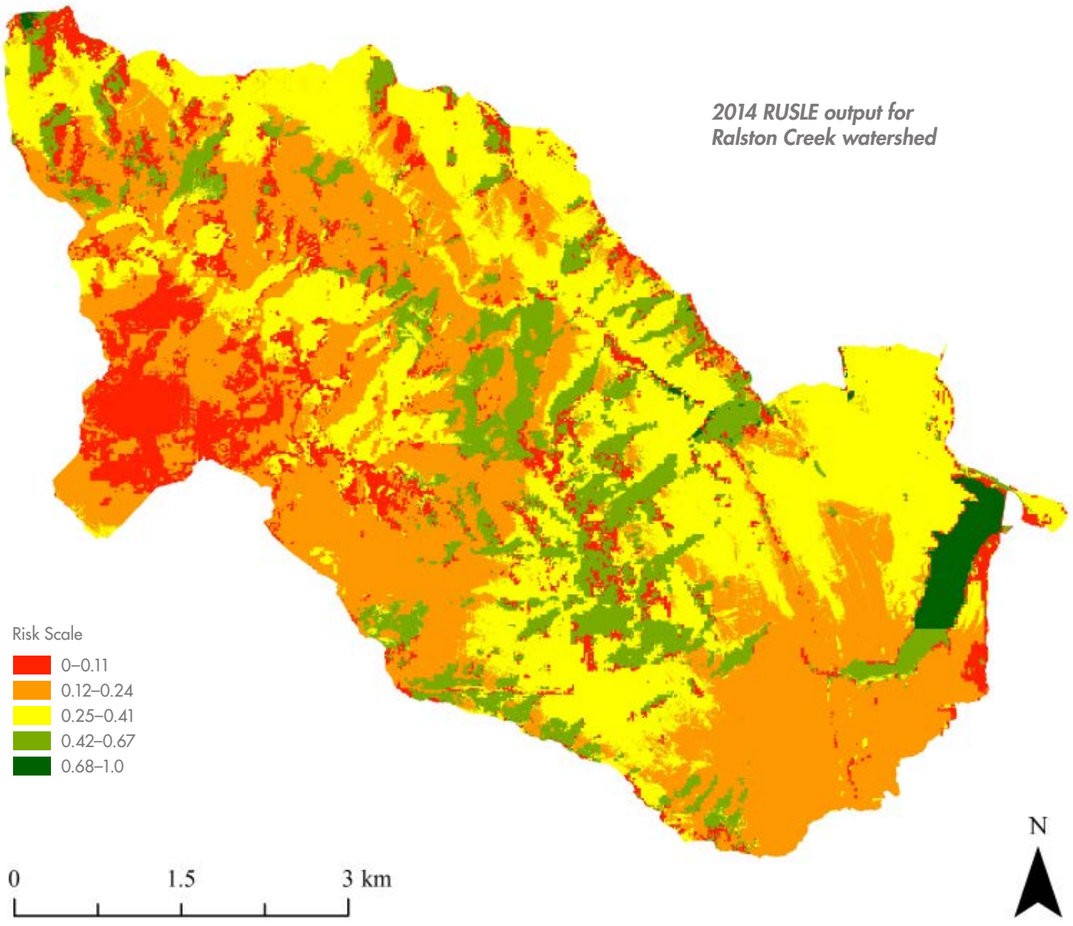
Patrick Henry Building

Team – Cassandra Morgan (Project Lead), Sara Lubkin
Partners – Virginia Institute of Marine Science (VIMS), Virginia Department of Environmental Quality (DEQ), Old Dominion University (ODU) Department of Biological Sciences, Virginia Governor's Office Deputy Secretary of Natural Resources for the Chesapeake Bay
Earth observations – Aqua MODIS, Landsat 8 OLI, Landsat 7 ETM+



MODIS imagery displaying changes in chlorophyll levels in the Chesapeake Bay

Harmful algal bloom (HAB) species such as Alexandrium monilatum and Cochlodinium polykroides have had an increasing ecological impact on the Chesapeake Bay Watershed where they disrupt water chemistry, kill fish, and cause human illness. In Virginia, scientists from Virginia Institute of Marine Science (VIMS) and Old Dominion University (ODU) monitor HABs and their effect on water quality; however, these groups lack a method to monitor HABs in real time. This limits the ability to document associated water quality conditions and predict future blooms. Band reflectance values from Landsat 8 Surface Reflectance data obtained from USGS Earth Explorer and Moderate Resolution Imaging Spectroradiometer (MODIS) imagery collected from NOAA CoastWatch were cross-calibrated to create a regression model that calculated concentrations of chlorophyll. Calculations were verified with in situ measurements from the Virginia Estuarine and Coastal Observing System. Imagery produced with the Chlorophyll-a calculation model will allow VIMS and ODU scientists to assess the timing, magnitude, duration and frequency of HABs in Virginia's Chesapeake watershed and to predict the environmental and water quality conditions that favor bloom development.



2014 RUSLE output for Ralston Creek watershed

COLORADO WATER RESOURCES II — Utilizing NASA Earth Observations to Identify Locations for Sedimentation Mitigation in the Ralston Creek Watershed Following the September 2013 Colorado Floods

NASA Langley Research Center

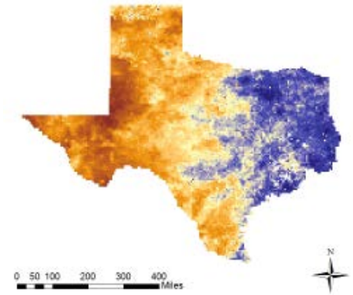
Team – Tyler M. Rhodes (Project Lead), Amy Phillips, Romina Gotzmann, Rebekke Muench, Jared Ryks
Partner – Denver Water
Earth observation – Landsat-8 OLI/TIRS

The September 2013 flooding in Denver, CO, characterized as a "one in 1,000" rainfall event, resulted in excessive runoff and sedimentation, which altered surrounding watershed structure and hydrology. This flooding event and the uncharacteristic weather in spring 2015 prompted a study by the NASA DEVELOP team to address community concerns regarding water quality. DEVELOP worked with Denver Water, the city's primary water supplier, to determine erosion mitigation sites in the Ralston Creek Watershed using the Revised Universal Soil Loss Equation (RUSLE). This model combines rainfall, slope, land cover, and conservation practices to predict soil loss. This research integrated land cover maps derived from NASA's Landsat 8 with a high resolution airborne LiDAR digital elevation model, which provided Denver Water with a fine scale map detailing potential mitigation sites. Mitigation sites were determined based on RUSLE outputs and accessibility.

TEXAS WATER RESOURCES — Utilizing NASA Earth Observations to Monitor Drought Severity in Texas for Wildfire Mitigation Support

NASA Langley Research Center

Team – Megan Buzanowicz (Project Lead), Laura Lykens, Zacary Richards, Jeff Close
Partner – Texas Forest Service
Earth observations – Aqua/Terra MODIS



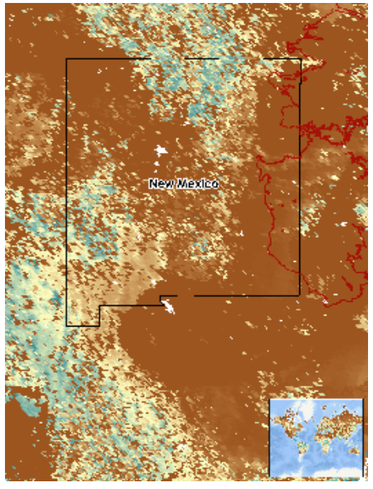
Drought Severity Index for Texas (June 2011)

The 2011 wildfire season was one of the most destructive wildfire seasons in Texas history. The combination of a wet 2010 growing season, which allowed vegetation to prosper, followed by an extremely dry year in 2011 provided the worst case scenario for wildfires. The purpose of this project was to expand upon a drought severity index (DSI) created during the summer 2013 Great Plains Agriculture project. A risk map of potential wildfire areas that contain dry fuels was also created; specifically, how dry the fuels are. To accomplish this, data that measure specific factors contributing to drought conditions and dry vegetation were acquired, including land surface temperature and the Normalized Difference Vegetation Index (NDVI) from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument onboard the Aqua and Terra satellites, precipitation from the Multi-Sensor Precipitation Estimate (MPE), and soil moisture from the North American Land Data Assimilation System (NLDAS). Data for these four factors were compiled through ArcGIS in order to assemble a risk map. The accuracy of the DSI was correlated to live fuel moisture data supplied by the Texas Forest Service (TFS). Methods and results produced for determining drought conditions were presented to the TFS for future use throughout the state; the benefit of which was a high-resolution drought index that can be easily constructed with little cost to the end-user.

NEW MEXICO WATER RESOURCES — Delivering Automated Evapotranspiration Data to the New Mexico Office of the State Engineer for Enhanced Water Resource Decision Making

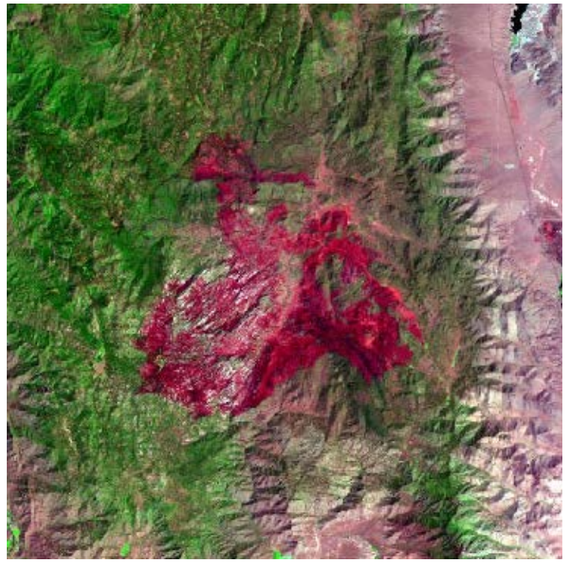
NASA Jet Propulsion Laboratory

Team – Sol Kim (Project Lead), Agustin Muniz, Trevor McDonald
Partner – New Mexico Office of the State Engineer
Earth observations – Terra/Aqua MODIS



June 1, 2004 Evapotranspiration (mm/day)

As New Mexico is experiencing some of the most severe drought in the US, equipping water resource management with evapotranspiration data becomes increasingly vital. Knowledge of rangeland conditions is necessary for decisions regarding cattle management, emergency response for rapid rangeland and farmland deterioration, fire management risk decisions, and determining drought severity. New Mexico land managers and decision-makers currently assess rangeland conditions using spatially-limited in situ spot checks which provides limited information. Additionally, weekly Normalized Difference Vegetation Index (NDVI) and evapotranspiration products for New Mexico counties are not widely distributed nor easily accessible. By providing an automated, streamlined, non-proprietary evapotranspiration product to the New Mexico Office of the State Engineer, New Mexico decision makers will have easy access to critical evapotranspiration data which will drive water resource decision making and drought assessment. To create the evapotranspiration product, we utilized the MODIS sensors on NASA's satellites Aqua and Terra to retrieve several six MODIS land and four MODIS atmosphere datasets.conditions and moisture thresholds.



The 2000 Manter fire in Tulare County, CA. Landsat bands 7, 4, and 3 are used to highlight the burn scar in red.

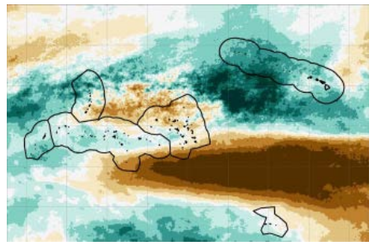
SIERRA NEVADA WATER RESOURCES — Quantifying the Effects of Wildfire Severity on Snow Water Equivalent in the Sierra Nevada

NASA Ames Research Center

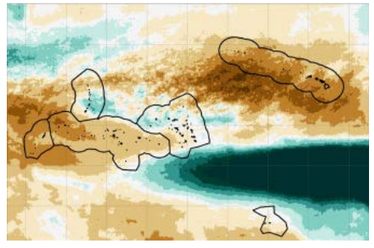
Team – Sean Cunningham (Project Lead), Justin Anzelc, Vishal Arya, Nolan Cate, Clayton Sodergren
Partners – USDA Forest Service, National Park Service
Earth observations – Landsat 4–5 TM, Landsat 7 ETM+, Landsat 8 OLI, SRTM

Snowpack in the Sierra Nevada is a crucial component of the California water supply. Climate change effects on forest ecosystems in this region have reduced snowpack resulting in earlier snowmelt. Wildfire frequency and severity in the Sierra Nevada have also increased, due to climate change-induced warmer temperatures, drought, and a legacy of fire suppression policies leading to increased fuel loads beyond their range of historic variability. These combined factors have the potential to severely impact California's water supply. However, the effects of wildfire severity on snowpack have not been geospatially quantified. This study used NASA Earth observations, modeled climate data, and automated classification of Landsat imagery, to quantify the effect of low, moderate, and high severity wildfire on snowpack and snow water equivalent (SWE) in the Sierra Nevada. Results indicate a moderate to strong correlation of rapid deceases in snowpack and SWE in areas of moderate to high severity burns. This information will assist in decision and policy making related to management of forest ecosystems and water resources within the Sierra Nevada.

Moderate-Strong La Niña – DJF Year (+1)



Moderate-Strong El Niño – DJF Year (+1)



Precipitation Change (%)

-100 -80 -60 -40 -20 -5 +5 +20 +40 +60 +80 +100

PACIFIC WATER RESOURCES — Using NOAA CDRs and Satellite Data to Connect Phases of the El Niño Southern Oscillation with Precipitation across Hawaii and the U.S. Affiliated Pacific Islands

NOAA National Centers for Environmental Information

Team – Jessica Sutton (Project Lead), Nicolas Luchetti, Ethan Wright
Partners – ERT Inc.; NOAA, Regional Climate Services Director; Pacific ENSO Applications Climate (PEAC) Center
Earth observation – PERSIANN CDR

The United States Affiliated Pacific Islands (USAPI) are highly susceptible to extreme precipitation events such as drought and flooding, which directly affect their freshwater availability. Precipitation distribution differs by sub-region, and is predominantly influenced by phases of the El Niño Southern Oscillation (ENSO). Forecasters currently rely on ENSO climatologies from sparse in situ station data to inform their precipitation outlooks. This project provided an updated ENSO-based climatology of long-term precipitation patterns for each USAPI Exclusive Economic Zone (EEZ) using the NOAA PERSIANN Climate Data Record (CDR). This data provided a 30-year record (1984–2015) of daily precipitation at 0.25° resolution, which was used to calculate monthly, seasonal, and yearly precipitation. Results indicated that while the PERSIANN precipitation accurately described the monthly, seasonal, and annual trends, it under-predicted the precipitation on the islands. Additionally, maps showing percent departure from normal (30 year average) were made for each three month season based on the Oceanic Niño Index (ONI) for five ENSO phases (moderate-strong El Niño and La Niña, weak El Niño and La Niña, and neutral). Local weather service offices plan on using these results and maps to better understand how the different ENSO phases influence precipitation patterns. conditions and moisture thresholds.

COSTA RICA WATER RESOURCES — Utilizing NASA Earth Observations to Develop a Comprehensive Water Budget for the Arenal-Tempisque Watershed of Costa Rica

University of Georgia

Team – Veronica Fay (Project Lead), Steve Padgett-Vasquez, Caren Remillard, Eduardo Rendon, Kamala Kanta Sahoo, Xuan Zhang
Partners – Costa Rica's National Service of Underground Water, Irrigation, and Drainage (SENARA); University of Georgia, Costa Rica Campus; Costa Rican Embassy to the United States
Earth observations – Landsat 8 OLI, Terra ASTER/MODIS

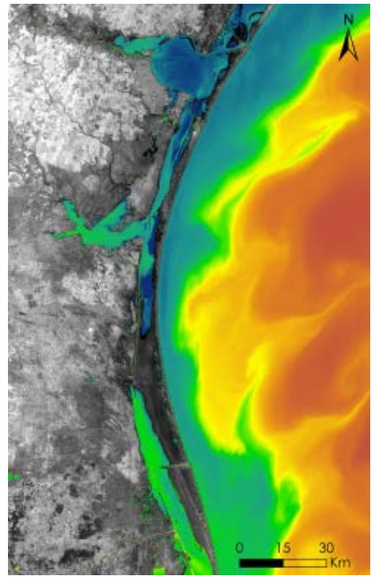
For the past three years, the Arenal-Tempisque Watershed has experienced drought conditions complicating water management and agricultural production. To facilitate a responsive water management decision-making process, the Costa Rica Water Resources team collaborated with Servicio Nacional de Aguas Subterráneas Riego y Avenamiento (SENARA), UGA Costa Rica, and the Costa Rican Embassy. The team created a model in the Soil and Water Assessment Tool (SWAT) modeling software for the Arenal-Tempisque Watershed using NASA Earth observations, ancillary data sources, and in situ data. The model's results were calibrated and validated through the use of the Soil and Water Assessment Tool- Calibration and Uncertainty Procedures software (SWAT-CUP). The evapotranspiration data (MOD16) from Terra's Moderate Resolution Imaging Spectroradiometer (MODIS) sensor were used to offer another source of continuous data to supplement the SWAT model's outputs. Additionally, the project partners were provided with a tutorial that will enable the SWAT model's hydrological outputs to be calibrated and validated for different future scenarios. The results obtained from the SWAT model and the MOD16 data provided greater insight into the region's hydrologic processes, which allowed for the development of a water resource inventory for the study area. Upon receiving the hydrological data and tools, SENARA will be able to replicate the project's methods to continuously update their water budget; this will allow them to make a more efficient water management plan, benefitting the local inhabitants and stakeholders.

COASTAL TEXAS WATER RESOURCES — Utilizing NASA Earth Observations to Assess Estuary Health and Enhance Management of Water Resources in Coastal Texas through Land Cover and Precipitation Mapping

Mobile County Health Department

Team – Elaina Gonsoroski (Co-Team Lead), Tyler Lynn (Co-Team Lead), Georgina Crepps, Rodrigo Pereira da Silva, Ryan Schick
Partner – National Park Service
Earth observations – Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI/TIRS, GRACE, TRMM PR

This project partnered with the National Park Service (NPS) to help analyze the correlation between mesquite trees and the salinity of the Laguna Madre of Padre Island National Seashore. The lagoon is a hypersaline estuary; however, there is historical evidence that this was not always the case. It is hypothesized that the increase in the number of honey mesquite trees (*Prosopis grandulosa var. glandulosa*) in the area has contributed to the Laguna Madre's increased salinity by decreasing the groundwater inflow to the lagoon. These mesquite trees have long taproots capable of extracting significant amounts of groundwater. This project utilized Earth observation data in ERDAS IMAGINE and ArcGIS software to create map time series and analyze the data. Landsat 5, 7, and 8 data were used to create land use/land cover (LULC) maps in order to analyze the change in the occurrence of mesquite trees over time. Thermal maps of the lagoon were generated using Landsat 5, 7, and 8 data to understand changes in groundwater inflow. In addition, TRMM and GRACE derived changes in root zone soil moisture content data were compared over the study period. By investigating the suspected positive correlation between the mesquite trees and the salinity of the Laguna Madre, the NPS can improve future land management practices.



Surface temperature (°C)

Low : 3.93096 High: 22.0588

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Wise County and City of Norton Clerk of Court's Office
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Sahakait Benyasut
Jakub Blach
Grant Bloomer
Allison Daniel
Anthony Donzella
Joshua Hammes
Rajkishan Rajappan
Zachary Tate
Thanapat Vichienlux
Atipat Wattanuntachai
Annabel White
William Wilson

International Centre for Integrated Mountain Development
Binu Maharjan
Amanda Schochet
Kanti Sen Ojha
Ang Sherpa

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

Get involved as a **DEVELOPer**

DEVELOP runs three application periods per year—spring, summer and fall. Anyone 18 and over who is interested in pursuing experience in the Earth sciences and remote sensing, including currently enrolled college students, recent graduates, early career professionals, transitioning career professionals, and active & recently transitioned U.S. military service members, is eligible to apply. Participants from all education levels and backgrounds are welcome to apply. DEVELOP offers both paid and volunteer opportunities.

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

- **U.S. Citizens –** eligible to apply to all DEVELOP locations in the United States.
- **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. Acceptances for foreign nationals are conditional upon proof of a valid visa, I-20 form, and an approved CPT/OPT that will allows legal employment within the United States. Applicants who do not meet these requirements are not eligible to participate.

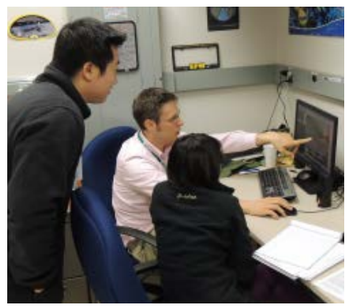
Get involved as a **Project Partner**

Any organization that is making decisions related to environmental concerns and is interested in incorporating NASA Earth observations into that decision-making process is welcome to contact DEVELOP to discuss potential collaborations.

A project request form can be found on the DEVELOP website on the Partner page at **http://develop.larc.nasa.gov/partners.html**. Please visit the website for more information on partnering with DEVELOP and contact information.

Get involved as an **Advisor**

A broad spectrum of advising supports DEVELOP projects, ranging from remote sensing experts to specialists relating to 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**.



DEVELOP
National Program

National Aeronautics and
Space Administration

http://develop.larc.nasa.gov

NP-2015-07-638-LaRC