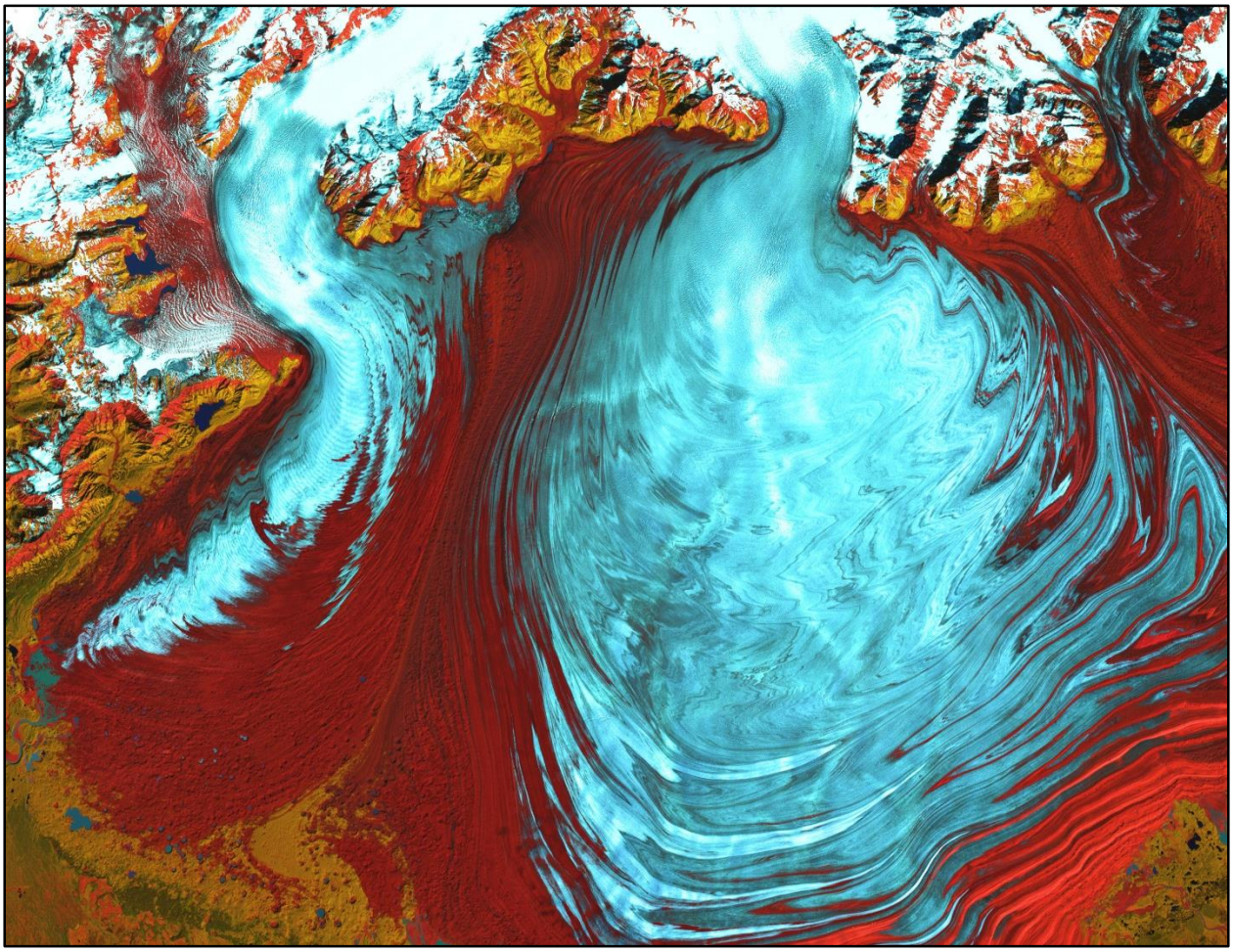
DEVELOP National Program

Water Resources Project Proposals

Summer 2015



Proposals Snapshot

1. Mexico Water Resources: A Geospatial Evaluation of Drivers, Occurrences, and Distribution of Hypoxic Events within the Grijalva-Usumancita River Delta System and the Southern Coast of the Gulf of Mexico (Ames)
Objective: Use NASA Earth observations to assess the drivers leading to hypoxic events in the Grijalva-Usumacinta delta system and detect hypoxia occurrences and distribution off the southern coast of the Gulf of Mexico.

2. Sierra Nevada Water Resources: Understanding the Effects of Wildfire Severity in Relation to Snowpack in the Sierra Nevada (Ames)
Objective: Investigate changes in snowpack in specific areas where wildfire is managed for resource benefit and areas where wildfire has been suppressed and subjected to large high-severity burns. Quantifying these changes will enable the USDA Forest Service and other forest managers to better understand the effects of wildfire to snowmelt timing during spring and summer months.

3. New Mexico Water Resources: Investigating Rangeland Conditions in New Mexico Using MODIS-Derived Evapotranspiration Products (JPL)
Objective: Automate MODIS data acquisition for, and to streamline evapotranspiration product generation and delivery to, the New Mexico Office of the State Engineer. These products will then be disseminated to decision-makers in the ranching, drought assessment and fire-response communities in the Eastern Plains Region of New Mexico through an easily accessed online interface.

4. Colorado Water Resources II: Utilizing NASA Earth Observations to Identify Changes in Contaminate Sources after the Colorado Floods of September 2013 (Langley)
Objective: Identify any changes in contaminant sources, such as organic carbons, nitrates, phosphates, and uranium, as a result of the 2013 Colorado flood event.

5. Texas Water Resources: Utilizing NASA Earth Observations to Monitor Drought Severity in Texas for Wildfire Mitigation Support (Langley)
Objective: Monitor drought severity in Texas and support the Texas Forest Service to use the previously developed Drought Severity Index. This project will be conducted in parallel with the Stennis DEVELOP Texas Disasters project which will focus on fuel type and loading monitoring.

6. 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)
Objective: Conduct a land cover classification and precipitation analysis of Laguna Madre in Padre Island National Seashore to analyze the suspected correlation between the increase in mesquite trees in the area and the increase in salinity of the lagoon.

7. Pacific Water Resources: Using NOAA CDRs and Satellite Data to Connect Atmospheric Teleconnections with Precipitation across Hawaii and the U.S. Affiliated Pacific Islands (USAPI) (NCDC)
Objective: Examine the influence of specific phases of the El Niño Southern Oscillation (ENSO) on long-term precipitation averages for the Exclusive Economic Zones (EEZ's) encompassing American Samoa, Guam, the Republic of the Marshall Islands (RMI), the Federated States of Micronesia (FSM), the Commonwealth of the Northern Mariana Islands (CNMI), the Republic of Palau, and Hawaii. The goal is to identify long-term rainfall patterns during specific phases of ENSO for each of the USAPI.

8. Costa Rica Water Resources II: Utilizing NASA Earth Observations to Develop a Comprehensive Water Budget for the Arenal-Tempisque Irrigation District of Costa Rica (UGA)
Objective: Provide Costa Rica's National Service of Underground Water, Irrigation, and Drainage with datasets and tools derived from NASA Earth observations to help guide their decision-making process throughout their water resource management plan in the Arenal-Tempisque Irrigation District.

9. Virginia Water Resources: Monitoring Harmful Algal Blooms through NASA Earth Observations in the James River for Improved Water Management (PHB)
Objective: Explore the use of Floating Algal Index (FAI) and Normalized Difference Turbidity Index (NDTI) to augment current water quality monitoring practices in the James River.

Partners Snapshot

Local Partners

- Denver Water (Partner/End-User, POC: Linda Rosales (Water Quality Specialist), Diego Portillo (GIS Specialist), and Sheila Pelczarksi (Remote Sensing Specialist))

State Partners

- New Mexico Office of the State Engineer (NMOSE) (End-User/Boundary Organization, POC: John W. Longworth, P.E., Chief of Water Use and Conservation Bureau)
- Texas Forest Service (Boundary Organization and End-User, POC: Curt Stripling, GIS Systems Coordinator; Tom Spencer, Department Head – Predictive Services)
- Virginia Department of Environmental Quality (VDH) (End-User, POC: Arthur Butt, Office of Water Monitoring and Assessment)
- Virginia HAB Task Force

Federal Partners

- USDA Forest Service (End-User, POC: Dr. Marc Meyer, USDA Forest Service Southern Sierra Nevada Province Ecologist)
- National Park Service (End-User, POC: Jim Roche, Yosemite National Park Hydrologist)
- National Park Service (End-user & Collaborator, POC: Joe Meiman, Hydrologist)
- NOAA Regional Climate Services Director (RCSD) (Partner, POC: John Marra, Pacific Regional Director)
- NWS Pacific ENSO Application Center (PEAC) (Boundary Organization, POC: Carl Noblitt, NOAA Corp Communication Officer)

International Partner

- Consorcio de Instituciones de Investigación Marina del Golfo de México y del Caribe (CiiMar-GoMC) (End-User, POCs: Dr. Porfirio Alvarez Torres, Executive Secretary and Dr. José Manuel Piña Gutiérrez, President of CiiMar-GoMC and Rector of the University Juarez Tabasco)
- Centro del Cambio Global y la Sustentabilidad en el Sureste (CCGSS) (End-User, POC: Dr. Mariana Elvira Callejas Jiménez, Research Scientist)
- Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) (Collaborator, End-User, POCs: Dr. Rainer Ressl, General Director of Geomathics and Dr. Sergio Cerdeira,Marine Monitoring Coordinator)
- Centro Nacional de Datos Oceanograficos (CENDO) (End-User, POC: Dr. Carlos Torres, Director)
- Universidad Autónoma de Baja California (UABC) (Collaborator, POC: Dr. Eduardo Santamaria del Angel, Professor and Researcher)
- Universidad Juarez Autonoma De Tabasco (UJAT) (Collaborator, POC: Rosa Martha Padron) Biological Sciences Director)
- Secretaría de Marina (SEMAR) (Collaborator, POC: Captain Joel Pensamiento, Data Management Subdirector)

- SENARA (End-User/Boundary Organization, POC: Javier Artiñano Guzmán, Agronomist for the Arenal-Tempisque Irrigation District)
- University of Georgia Costa Rica (Partner, POC: Dr. Quint Newcomer, Director of the University of Georgia Costa Rica Campus)
- Costa Rican Embassy to the United States (Partner, POC: HE Ambassador Roman Macaya and Alejandra Solano, Minister Counselor)

Private Company Partners

- ERT, Inc. (Partner, POC: Michael Kruk, Pacific Water Resources Product Development Lead)

Academia

- Virginia Institute of Marine Science (VIMS) (Collaborator, POC: Dr. Juliette Smith, Aquatic Health Science Lab)

Letters of Support

- ARC Sierra Nevada Water Resources – USDA Forest Service, Marc Meyer, USDA Forest Service Southern Sierra Nevada Province Ecologist
- JPL New Mexico Water Resources – New Mexico Interstate Stream Commission, Amy Hass, Acting Director
- LaRC Texas Water Resources – Texas Forest Service, Curt Stripling & Tom Spencer
- MCHD Coastal Texas Water Resources – National Park Service, Joe Meiman, Hydrologist
- UGA Costa Rica Water Resources – Arenal-Tempisque Irrigation District, Javier Artiñano Guzmán, Agronomist for the Arenal-Tempisque Irrigation District
- UGA Costa Rica Water Resources – Costa Rican Embassy to the US, HE Ambassador Roman Macaya

Project Proposals

1. Mexico Water Resources (Ames)

A Geospatial Evaluation of Drivers, Occurrences, and Distribution of Hypoxic Events within the Grijalva-Usumancita River Delta System and the Southern Coast of the Gulf of Mexico

Objective:

The project will use NASA Earth observations to assess the drivers leading to hypoxic events in the Grijalva-Usumacinta delta system and detect hypoxia occurrences and distribution off the southern coast of the Gulf of Mexico.

Community Concern:

The influx of nitrogen and phosphorus to marine environments worldwide has increased as a result of increasing intensive agricultural and industrial activities, as well as population growth. Excessive nutrient water enrichment is characterized by two main symptoms: the decrease of water oxygen (hypoxia) and the explosive proliferation of noxious algae (Harmful Algae Blooms), which can destroy aquatic life in affected areas. Hypoxia is an environmental phenomenon where the oxygen concentration in the water column decreases to levels that no longer can support living aquatic organisms. A total of 415 areas worldwide are affected by hypoxia (Diaz and Rosenberg, 2008), with high profile cases occurring within the dead zone in the northern Gulf of Mexico. However, the multi-level impact of increased nutrient inputs and increases of hypoxia events are unknown.

Hypoxia in the southern Gulf of Mexico (GoM) is mainly assumed to occur in lagoons through excess organic loading and overgrowth of algae. This natural process is related to respiration rates exceeding oxygen supply from the atmosphere or wind-driven mixing. Recent observations by Signoret et al. (ECSS 2006) have evidenced hypoxic events in the coastal region of the Grijalva-Usumacinta (GU) river delta. This river system represents the second most important freshwater inflow entering the Gulf of Mexico, just after the Mississippi river. Furthermore, despite the fact of the Grijalva-Usumancita basin systems great importance and influence on the GoM ecology, information available for the system influence on the southern GoM is limited.

Additionally, algal blooms are natural phenomena consisting of the rapid growth of phytoplankton populations. Several blooms have negative ecological or public health effects due to toxin production and the removal of oxygen from the water column, thus are related to hypoxic events. In recent years, such Harmful Algal blooms (HABs) have been linked to human illness, economic loss from decreased fishing, and ecological damage related to marine mortality as well as eutrophication.

Partner Organizations:

Consorcio de Instituciones de Investigación Marina del Golfo de México y del Caribe (CiiMar-GoMC) (End-User, POCs: Dr. Porfirio Alvarez Torres, Executive Secretary and Dr. José Manuel Piña Gutiérrez, President of CiiMar-GoMC and Rector of the University Juarez Tabasco)

Centro del Cambio Global y la Sustentabilidad en el Sureste (CCGSS) (End-User, POC: Dr. Mariana Elvira Callejas Jiménez, Research Scientist)

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Secretaría de Marina (SEMAR) (Collaborator, POC: Captain Joel Pensamiento, Data Management Subdirector)

Initial contact between representatives of the Mexican Embassy and DEVELOP came about through the Global Earth Observation System of Systems (GEOSS) in the Americas meeting at NASA Headquarters in August 2014. Discussions from there led to a strong project collaboration interest from the Mexican Embassy via CiiMar-GoMC who submitted multiple project ideas and joined a follow-up meeting at NASA Headquarters to flesh out final details – those conversations produced the current proposal. The DEVELOP Ames office was contacted and agreed to conduct the project based on their unique background in the study region and community concern.

Decision Making Process:
Results from this study will assist GoM economic, environmental, fishing, tourism, and health authorities in mitigating and managing the impact of future HABs and hypoxic events. The Grijalva-Usumacinta basin extends to the coastal states of Tabasco, Campeche, and Chiapas. However, the wealth of this ecosystem's resources renders this location susceptible to exploitation and economic development. Hypoxic events are of importance to managers to set minimum legal levels of dissolved oxygen concentration. These efforts protect biodiversity and/or support fisheries that would be significantly affected in cases where concentrations fall below threshold, thus interrupting essential ecosystem functions and services.

UJAT-CONABIO-UABC-CCGSS and CIIMAR have been in collaboration to promote HABs and Hypoxia monitoring and research in the Southern GoM Region. They have had several workshops on HABs and Hypoxia involving the states of Tamaulipas, Veracruz, Tabasco, Campeche, Yucatán, and Quintana Roo to assess the most current HABs monitoring techniques.

Considering the oceanographic features of the GoM, they have collaborated with the Gulf of Mexico Large Marine Ecosystem Binational Program (MEX US) closely with US entities, such as the EPA Gulf of Mexico Program, the Gulf of Mexico Coastal and Ocean Observing System Regional Association (GCOOS), and the Gulf of Mexico Alliance (GOMA) to foster a regional wide HABs Integrated System to support understanding of HABs and hypoxia phenomena.

The Federal Ministry of Health, through its directorship on Sanitary Risks Protection, is responsible for monitoring and timely detection of HABs in their geographic jurisdiction. They obtain water samples and fish or mollusks throughout the region. The Public Health State Labs then receives these samples to identify and count the number of species and toxic cells of harmful blooms. The results are generated and sent to the Federal Commission of Sanitary Risk Protection.

Additionally, all coastal states have leaders researching red tide events while supporting the identification and assessment of results. The the Ministry of Health in these states are authorized spokespeople to inform the public pre-contingency or contingency plans to mitigate or adapt to the presence of HABs, in the interest of public health.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 5	Thematic Mapper (TM)	Floating Algal Index (FAI), Normalized Turbidity Index (NDTI), Land Cover
Landsat 7	Enhanced Thematic Mapper Plus (ETM+)	Floating Algal Index (FAI), Normalized Turbidity Index (NDTI), Land Cover

Landsat 8	Operational Land Imager (OLI)	Floating Algal Index (FAI), Normalized Turbidity Index (NDTI), Phycocyanin Index, I Land Cover
Aqua/Terra	Moderate Resolution Imaging Spectroradiometer (MODIS), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)	Chlorophyll A (Chl), Remote Sensing Reflectance (Rrs), Sea Surface Temperature (SST), Photosynthetically Available Radiation (PAR), colored dissolved organic matter (CDOM)
Suomi NPP	Visible Infrared Imaging Radiometer Suite (VIIRS)	Sea surface temperature (SST), Land surface temperature (LST), Ocean color, Chlorophyll A (Chl)
OSTM/Jason 2	Poseidon-3	Altimetry, Ocean Topography

NASA Earth Observations Highlighted:
Landsat 5, 7, and 8 will be used to derive FAI and NDTI, and land cover for the study region. Aqua and Terra will be used to delineate Chl, Rrs, SST, CDOM, and PAR. Suomi NPP will be used for SST, LST, and ocean color. Lastly, OSTM/Jason 2 will provide information regarding water levels and topography. All these variables can be used as potential indicators of hypoxia presence and absence.

Ancillary Datasets:
- There is potential for our partners to collet water-leaving radiance data with a GER 1500 spectroradiometer at the stations which will eventually be converted into remote sensing reflectance. Additionally, data on chlorophyll concentration and total suspended sediments will also be collected and use for calibration/validation of the imagery
- High resolution ocean imagery - SPOT 7 Panchromatic
- Chl, SST, Turbidity, dissolved oxygen and CDOM- Buoy Holbox-México
- Chl, Rrs, SST, PAR- Sea-viewing Wide Field-of-view Sensor (SeaWiFs)
- Projected temperature and precipitation- Coupled Model Intercomparison Project Phase 5 (CIMIP 5)

Models:
- Marine Geospatial Ecology Toolbox- Random Forests (POC: Andrew Nguyen, DEVELOP National Program)
- TerrSet-Land Change Modeler (POC: James Toledano, Clark Labs/ Clark University and Andrew Nguyen, DEVELOP National Program)
- TerrSet-Habitat and Biodiversity Modeler (POC: James Toledano, Clark Labs/ Clark University and Andrew Nguyen, DEVELOP National Program)
- Soil and Water Analysis Tool (SWAT) (POC: Chase Mueller, Bay Area Environmental Research Institute [BAERI])

Decision Support Tools & Analyses:

Proposed End Products	Decision to be Impacted	Current Partner Tool/Method
Time Series of Floating Algal Index (FAI), Difference Turbidity Index (NDTI), and Phycocyanin intensity index	Display historical and current compounds that may lead to Hypoxia and HAB events	Field surveys
Hypoxia Suitability Model	Spatially display the historical and current proximities and extent of	N/A

	hypoxia	
Modeled nitrogen, Phosphorus, and sediment load	Measure historical and projected Grijalva-Usumacinta watershed deposition	Buoy Station Data and Field surveys
Statistical analysis of Hypoxia contributors	Determine the main drivers leading to hypoxic events	Field surveys

FAI/NDTI/PII Time Series – The time series will enable a historical visual representation of the known potential indicators of hypoxia occurrences. Hypoxic events are followed by excessive floating algal blooms and high levels of the pigment Phycocyanin. Additionally, turbidity from the Grijalva-Usumacinta watershed has been identified as a driver for these events.

Hypoxia Suitability Model – This suitability model will enable GoM marine researchers to determine areas of potential hypoxia suitability according to the most up-to-date observations (remotely sensed and *in situ*). The team will test the model during several historical time steps and validate the model using areas of known hypoxic sites.

Nitrogen, Phosphorus, Sediment Load Model – This product will use the SWAT model to measure nitrogen, phosphorus, and sediment load from the Grijalva-Usumacinta watershed. These variables are known contributors to hypoxic events.

Statistical Analysis – This product will consist of a list of known drivers and their respective statistical significances for contributing to hypoxic events. This will allow the end-users to better understand the drivers causing hypoxia and therefore put forth enhanced prevention and mitigation efforts.

Project Details:
National Application Area Addressed: Water Resources
Source of Project Idea: Connection was initiated by Jamie Favors (DEVELOP National Program Deputy Lead) with CiiMar-GoMC affiliates via the Mexican Embassy. CiiMar-GoMC produced three initial proposal ideas. ARC DEVELOP chose one and further developed the idea into two objectives after collaborator approval.

Advisors: Dr. Juan Torres-Perez (Bay Area Environmental Research Institute), Dr. Porfirio Alvarez Torres (CiiMar-GoMC), and Dr. Mariana Elvira Callejas Jiménez (CCGSS)
Participants Requested: 4

Project Timeline: 2 Terms: 2015 Summer (Start) to 2016 Fall (Completion)
Study Location: Grijalva Usumacinta watershed and the southern Gulf of Mexico, MX
Period being Studied: 1995 - Present

Multi-Term Objectives:
- **Term 1 (Proposed Term)** – The team will derive FAI and NDTI, from Landsat to located areas of historical hypoxia spread. The team will also process other hypoxia contributors such as Chl and SST. These variables will be used as inputs into a suitability model to reveal areas of potential hypoxia spread. This term will also begin running the SWAT model derive modeled nitrogen, phosphorus, and sediment load.
- **Term 2** – This term will continue to calibrate the SWAT model to better understand the amount of hypoxic contributors deposited from the Grijalva-Usumacinta watershed. The model will also be calibrated to model future deposition.

Notes: The GoM is heavily influenced by two major watershed systems: the Mississippi River flowing into the northern Gulf, and the Grijalva-Usumacinta system discharging into the southern region of GoM. To date, there are many published studies on hypoxic events concerning the Mississippi River and the Northern GoM; however, there are no published studies related to the Grijalva-Usumacinta and the Southern GoM. Additionally, the information available for these events is limited. Furthermore, the Grijalva-Usumacinta basin system has a great importance to Mexico due to its agricultural production, land use change, deforestation, water diversion, and other human activities. Intensive use of this basin is one of the causes hypoxia in GoM southern coastal areas.

The potential impacts of worsening hypoxic conditions are evident, according to observations in other systems (e.g., N. Gulf of Mexico, Baltic and Black Seas) where it has caused declines of ecologically and commercially important species. Future understanding of biogeochemical responses to hypoxia must be established in the context of global climate change and other human influences such as damming, over-fishing, pollution, disease, habitat loss, and species invasions.

2. Sierra Nevada Water Resources (Ames)

Understanding the Effects of Wildfire Severity in Relation to Snowpack in the Sierra Nevada

Objective:

This project will look at the changes in snowpack in specific areas where wildfire is managed for resource benefit and areas where wildfire has been suppressed and subjected to large high-severity burns. Quantifying these changes will enable the USDA Forest Service and other forest managers to better understand the effects of wildfire to snowmelt timing during spring and summer months.

Community Concern:

Wildfire has become an increasing concern in the Sierra Nevada and has gained more widespread attention since the catastrophic 2013 Rim Fire in Stanislaus National Forest and sections of Yosemite National Park. These large high-severity fires are usually the result of areas subjected to fire suppression. There are also increasing concerns over water availability and the snowmelt timing during the spring and summer months in California. In order to better manage future water availability, the USDA Forest Service (USFS) and National Park Service (NPS) seek a greater understanding in how wildfire severity, in fire suppressed and non-suppressed areas, are related to snowpack availability and snowmelt timing in the Sierra Nevada.

Partner Organizations:

USDA Forest Service (End-User, POC: Dr. Marc Meyer, USDA Forest Service Southern Sierra Nevada Province Ecologist)
National Park Service (End-User, POC: Jim Roche, Yosemite National Park Hydrologist)

According to Dr. Meyer, there is little to no research regarding how wildfire affects the melting period of snowpack in the Sierra Nevada. Currently, the USFS and NPS have managed wildfires for resource benefits within several experimental forest landscapes to better understand natural fire regimes and their potential benefits for resource management. These resources also include snowpack deposited on these areas to eventually be used for recharging water bodies and aquifers, along with replenishing plant and animal ecosystems during the spring and summer months. Additional experimental forest landscapes have ecological and human benefits. Thus, this project's end-users will use the results to strengthen their understanding of natural fire regimes with the potential to invest in and preserve similar areas. The end-users will also benefit from a comparative analysis of solar radiation emitted from several different burn areas with various

levels of severity to better account for quantifying runoff from the Sierra Nevada. A tools package will also be created to easily update project results with future remote sensing data. Lastly, all processed data will be updated in the USFS Region 5 Sierra Nevada Decision Support System for ease of public data access. A formal hand-off presentation will be held during the annual Southern Sierra Fire and Hydroclimate Workshop in Yosemite, CA or other related conferences within the southern Sierra network.

Letters of Support: USDA Forest Service, Marc Meyer, USDA Forest Service Southern Sierra Nevada Province Ecologist

Decision Making Process:

The USFS, in accordance with its Technical Report PSW-GTR-220, plans to integrate practices to understand forest conditions that may help increase forest resilience to changes in climate and climate-related processes, such as fire and beetle infestation. A proposed method for accomplishing these goals is to create variation in stem density and fuel loads in dense forests (e.g., structural heterogeneity) and attempt to reverse years of fire suppression in strategic areas. This will limit the extent and severity of drought stress and high-severity fire. NPS and USFS have experimented with the use of wildfires for resource objectives in "restored" fire-suppressed forest landscapes. In the Sierra Nevada, areas such as Sugar Loaf Creek Basin and Illilouette Creek Basin are examples of case studies where predominantly low to medium severity fires benefit natural resources (e.g., reduced fuel loading, enhanced watershed function, seed dispersal, etc.). These areas are managed to burn under natural fire regime conditions with minimal fire suppression efforts. This decreases the density of such forest stands while enabling natural revegetation cycles (e.g., tree regeneration, shrub recruitment and sprouting) to take place. This allows faster regeneration periods which may contribute to healthier watersheds, ecosystems, and extended periods of snowmelt and runoff timing. In contrast, larger and high-severity fires such as the Chips Fire or Rim Fire represent areas of fire suppression. These burned landscapes may have slower revegetation or recovery periods resulting in soil degradation which may negatively affect watershed functions (e.g., water quality, faster snowmelt and runoff timing, infiltration, permeability, etc.). Larger fires compounded by burn severity leave scars and open landscapes that may be more susceptible to direct insolation and other natural elements which could inhibit snowpack retainment. Currently, there is little to no quantifiable understanding of the effects these different types of fires have on snowpack and the behavior of snowmelt during the spring and summer months. This project showcases these differences to assist the USFS in planning for future allocations of natural fire regime areas in order to increase overall forest health and decrease wildfire severity. Understanding snowpack and snowmelt behavior over previously burned areas will create an additional variable to consider when assessing water runoff from the Sierra Nevada.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Aqua & Terra	Moderate Resolution Imaging Spectroradiometer (MODIS)	Snow cover, Land Surface Temperature (LST), Land Surface Reflectance, Burn Area
Landsat 5 & 8	Thematic Mapper(TM) and Operational land Imager (OLI)	NDVI, Normalized Difference Moisture Index (NDMI), True color images
Suomi NPP	Visible Infrared Imaging Radiometer Suite (VIIRS)	NDVI , Active fire products

NASA Earth Observations to be Highlighted:

It is believed that the amount of precipitation, snow water equivalent, snowpack, soil moisture content, and surface temperature in the Sierra Nevada are directly correlated with forest disturbance, specifically forest fires. MODIS will give a general outline of snow cover in the Sierra Nevada and will be used to validate snow water equivalent estimates. Burn areas, Land Surface Reflectance, and Land Surface Temperature products will also be used to analyze pre and post burn landscapes. Landsat 5 TM and Landsat 8 OLI will be used to measure forest health. VIIRS data will also be used to measure forest health and fire activity. These data sets will be collected for a 30 year period of time, roughly from 1984 to 2014.

Ancillary Datasets:

- Land Cover products (1990, 2001, 2006), National Land Cover Dataset (NLCD)
- National Park and National Forest Boundaries Shapefile, National Park Service
- Ariel Detection Survey (ADS) (1974-2014), USDA Forest Service Forest Disturbance
- Snow water equivalent (2004-2014), Snow Data Assimilation System (SNODAS)
- Fire Extent, Fire Severity and Fire Ignition Points (1990-2014), Monitoring Trends in Burn Severity (MTBS)
- Historical and forecasted Actual evapotranspiration, Climatic water deficit, Excess water, Max temperature, Min temperature, Potential Evapotranspiration (PET), Runoff, Snowfall, Snowmelt, Snowpack, Soil water storage, and Total precipitation, California Basin Characterization Model (BCM) products (1995-2025)
    - Note: All BCM products are past, current, and future estimates based on the Parameter-elevation Regressions on Independent Slopes Model (PRISM) and downscaled CIMP5 RCP 2.6, 4.5, 6, and 8.5
- Existing Vegetation Type (EVT), Existing Vegetation Cover (EVC), and Canopy Cover (CC), LANDFIRE data products

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Time Series Frequency Analysis	Provides better understanding of the relationship between fire variables (severity, extent) and timing of snowmelt for watershed management	N/A
Regression analysis	Provides better understanding of the relationship between fire variables (severity, extent) and timing of snowmelt for watershed management	N/A
Comparative analysis of solar radiation	Provides better understanding of the effects of the total amount of solar radiation energy received on pre and post burn surface areas and related to retained snow pack	N/A
Pre/Post Burn Snowmelt Analysis Package	Enables updating of analysis for future monitoring and to account for future data obtained by remote sensing	N/A

Time Series Frequency Analysis – Correlations will enable our end-user to understand the potential benefits of areas subjected to natural fire regimes. This will enable more support to preserve and invest into these types of areas for better management of natural resources.

Regression Analysis – A regression analysis will be performed for the percent of watershed burned at high severity (independent variable) versus average and peak snowmelt timing, such as runoff (dependent variable). This will provide more support to preserve and invest into these natural fire regime areas for better management of natural resources. This secondary analysis will help cross check our results for the time series correlations.

Comparative Analysis of Solar Radiation – Insolation and surface reflectance values will be compared across pre and post burned areas by severity levels and retained snow pack. This analysis will provide quantifiable support for understanding the timing of snowmelt within high severity fires when compared to medium to lower severity fires. Therefore, this will further support the preservation and investment into natural fire regime areas and will create an additional variable to consider when assessing water runoff from the Sierra Nevada.

Pre/Post Burn Snowmelt Analysis Package – The tools and models created by this project will allow our partners to update this analysis with future EO data. This enables consistent monitoring of Sierra Nevada water resources within burn areas using the most current NASA EO products.

Project Details:
National Application Areas Addressed: Ecological Forecasting, Climate, Water Resources
Source of Project Idea: Marc Meyer, USDA Forest Service Southern Sierra Nevada Province Ecologist, has been a past end-user and collaborator with DEVELOP for two projects.

Advisors: Dr. Juan Torres-Perez (NASA Ames Research Center/Bay Area Environmental Research Institute), Marc Meyer (USDA Forest Service)
Participants Requested: 5

Project Timeline: 1 Term: 2015 Summer
Study Location: Sierra Nevada, CA
Period being studied: 1995-2025

Previous Related DEVELOP Work:
Summer 2013 (ARC) - Sierra Nevada Water Resources: *Impacts of Snow Water Equivalent on Wildfire in the Sierra Nevada*

Fall 2013 to Summer 2014 (ARC) - Sierra Nevada Ecological Forecasting: *Implementing a Web-Based Decision Support System to Spatially and Statistically Analyze Ecological Conditions of the Sierra Nevada*

Notes: This project will complement ongoing efforts to better understand natural or restored fire regimes and their potential beneficial effects on natural resources. The USFS manages these resources for ecological and human benefits. Resource management techniques employed by our end-users, in regards to fire adaptation, are incorporating climate change and decades of fire suppression data. In order for our end-users to move forward with creating and preserving more natural fire regimes areas, they require projects to help support natural resources benefits from these types of areas. Our project addresses this support by better understanding the revegetation of burned areas and its effects in water resources within the Sierra Nevada. It will also create tools that will allow future monitoring using NASA Earth observations. There is also potential to incorporate the data into a Sierra Nevada web mapping application created by DEVELOPers to make it more accessible for forest manager. Additionally, a similar DEVELOP project was conducted in summer 2013 analyzing the impacts of snow water equivalent to wildfire. This project completes the cycle that geospatially assess the relationship between fire and snow in the Sierra Nevada.

3. New Mexico Water Resources (JPL)

Investigating Rangeland Conditions in New Mexico Using MODIS-Derived Evapotranspiration Products

Objective:
The goal of this project is to automate MODIS data acquisition for, and to streamline evapotranspiration product generation and delivery to, the New Mexico Office of the State Engineer. These products will then be disseminated to decision-makers in the ranching, drought assessment and fire-response communities in the Eastern Plains Region of New Mexico through an easily accessed online interface.

Community Concern:
The eastern portion of New Mexico has suffered consistent drought conditions throughout the last decade, negatively impacting agriculture, ranching, and the gas and oil industries. These conditions are expected to continue and possibly to worsen due to climate change in the coming century, putting further stress on an already strained water community. Decision makers such as agricultural producers, ranchers, fuel producers, emergency assistance organizations and fire responders need tools that facilitate accurate and timely rangeland condition assessments to help guide water use and land use decisions. Evapotranspiration (ET) products can provide important information about water use efficiency and vegetation conditions in rangeland and farmland. ET is measureable on the ground over small areas, but is complicated to measure via remote sensing on the scale needed for land and water management in this region. There is a need for remotely-sensed products that are easily accessible and provide ET information in a friendly format. Such tools could aid decision makers in land use and irrigation decisions, assist land managers applying for national governmental assistance programs, and possibly provide lead-time to fire managers on potential grassland fire conditions.

End-Users/Partners/Boundary Organizations:
New Mexico Office of the State Engineer (NMOSE) (End-User/Boundary Organization, POC: John W. Longworth, P.E., Chief of Water Use and Conservation Bureau)

Contact among John Longworth of NMOSE, Dr. Fisher of JPL, and DEVELOP has been established through email communication and telecons. After a few brainstorming sessions, a project has been chosen that will address the immediate needs of the NM Great Plains community by producing near-real-time ET visualizations from MODIS data. These data products will be distributed to the ranching community and other decision-makers within NM by NMOSE.

Letters of Support: New Mexico Interstate Stream Commission, Amy Hass, Acting Director

Decision Making Process:
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 give useful, but limited, information. Additionally, weekly NDVI products for New Mexico counties are generated by the New Mexico Department of Agriculture from data supplied through the USDA Forest Service. However, this information is not widely distributed nor easily accessible. Some ET products are generated with the Mapping EvapoTranspiration at high Resolution with Internalized Calibration (METRIC) method and Landsat data. The low temporal resolution and large file size of Landsat scenes and the proprietary nature of METRIC obstruct the flow of products from this process.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Aqua & Terra	MODIS	Evapotranspiration – MOD16

NASA Earth Observations to be Highlighted:

Dr. Joshua Fisher of NASA-JPL has devised and published a method to create ET products in near-real-time using MODIS data. This method has advantages in temporal resolution and coverage over Landsat-based methods such as METRIC. Streamlining the production of easily accessible, operational, and digestible ET products using this method will empower rangeland decision makers in eastern New Mexico.

Models:
PT-JPL ET method (POC: Dr. Joshua Fisher, JPL)

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
ET-Based Rangeland Health Maps	Land use and water use decisions	Spatially-limited spot checks, METRIC method
ET Product Access Interface	Land use and water use decisions	None

ET-Based Rangeland Health Maps – MODIS data and the PT-JPL ET method will be used to generate rangeland health maps for the plains region of New Mexico. The methodology will be transferred to NMOSE so that map creation will continue after the conclusion of the project.

ET Product Access Interface – A data pipeline will be established allowing the NMOSE to access MODIS data and data products quickly and efficiently, as well as to disseminate them to decision-makers. This pipeline will be accessible through the website of the New Mexico State Climatologist.

Project Details:
National Application Areas Addressed: Water Resources, Agriculture
Source of Project Idea: This project arose out of communications initiated at the Western States Water Council's Water Management Workshop, Special Remote Sensing Science Session, at the Jet Propulsion Laboratory in August 2014. At this meeting Dr. Fisher presented the results of his work on MODIS evapotranspiration calculations. Mr. Longworth of NMOSE became interested in learning more about this approach to help potentially address several NM water resources questions. The DEVELOP Center Lead also attended the meeting and introduced Mr. Longworth to DEVELOP. In subsequent communication via email and telecons, several ideas were vetted regarding potential project ideas. The idea of having a reliable, fast and cheap ET visualization product via the method that Dr. Fisher had presented led to the proposed collaboration among DEVELOP, Dr. Fisher, and NMOSE.

Advisors: Dr. Joshua Fisher (JPL)
# of Participants Requested: 3

Project Timeline: 2 Terms: 2105 Summer to 2105 Fall
Study Location: Plains region, New Mexico
Period being Studied: 2000 to Present

Previous Related DEVELOP Work:
Peru Water Resources: Integrating NASA Earth Observations into Water Resource Planning and Management in Peru's La Libertad Region - Summer 2014 (NASA Langley Research Center)

Coastal Mid-Atlantic Water Resources: Developing a Water Budget Using Evapotranspiration Measured with the METRIC Model and Groundwater Storage Data in the Coastal Plain of

Maryland, Virginia, and North Carolina - Summer 2014 – Spring 2015 (NASA Langley Research Center)

Multi-Term Objectives:

Term 1 (Proposed Term) – This term focuses on transitioning the research-mode processing workflow to an operational-mode workflow. During the term, participants learn how to produce the ET product, and develop code for near-real-time automated data downloading and processing within JPL's supercomputing environment via the JPL Climate Center. Software release protocols are initiated with NASA/JPL export control guidelines. FTP access to the ET products is established.

- **Term 2** – This term focuses on creating public access to the products and creating meaningful products that best suit the needs of local users. An initial outflow is constructed from the Climate Center to a website hosted by the New Mexico State Climatologist. A simple website is created displaying the maps. Participants work closely with the Office of the State Engineer to determine what standardized form for the product is most useful and most easily understandable by the community. The results are presented to local decision-makers.

Notes:

This is a stand-alone project that will not otherwise be implemented. Although the methodology has been validated and published, the product was built for science as part of a research project, and not yet applied for the benefit of a community. It is hoped that this project will lay the foundation for a ROSES proposal for ongoing support of the product's application in NM and eventual complete transference to the New Mexico Office of the State Engineer.

Reference:

Joshua B. Fisher, Kevin P. Tu, Dennis D. Baldocchi, Global estimates of the land–atmosphere water flux based on monthly AVHRR and ISLSCP-II data, validated at 16 FLUXNET sites, Remote Sensing of Environment, Volume 112, Issue 3, 18 March 2008, Pages 901-919, ISSN 0034-4257, http://dx.doi.org/10.1016/j.rse.2007.06.025.
(http://www.sciencedirect.com/science/article/pii/S0034425707003938)

4. Colorado Water Resources II (Langley)

Utilizing NASA Earth Observations to Identify Changes in Contaminate Sources after the Colorado Floods of September 2013

Objective:

The objective of this project is to identify any changes in contaminant sources, such as organic carbons, nitrates, phosphates, and uranium, as a result of the 2013 Colorado flood event.

Community Concern:

Denver Water is a water utility responsible for supplying quality water to over 1.3 million people in the city of Denver, Colorado and surrounding suburbs. With most of the water being fed by mountain snowmelt washing into numerous rivers, source contaminants within the watersheds are a major concern. Identifying these source contaminants using NASA Earth observations, and producing site-suitability maps for water quality sampling sites, can improve the efficiency of watershed monitoring for Denver Water and support its mission to provide high-quality water using a resilient and reliable system.

End-Users/Partners/Boundary Organizations:

Denver Water (Partner/End-User, POC: Linda Rosales (Water Quality Specialist), Diego Portillo (GIS Specialist), and Sheila Pelczarksi (Remote Sensing Specialist))

Collaboration with Denver Water began following an introduction to DEVELOP by Dr. Christine Lee (ASP) during the summer of 2014 when the organization proposed potential project ideas to DEVELOP's NPO and the Langley node. Through communication with the partner/end-user, the project team will seek to identify point contamination sources and produce site suitability maps for water quality sample sites within the primary watersheds that feed into the Denver Water system (South Platte River, Blue River, Williams Fork River, and Fraser River watersheds). This will allow for Denver Water to enhance their monitoring efforts in order to provide the city with clean water.

Decision Making Process:

Denver Water has approximately 60 designated sampling sites in their watershed monitoring program. They primarily use locations along the major streams providing water to the three terminal storage reservoirs that feed their water treatment plants. Sampling sites are chosen to capture potential impacts to water quality, whether that is from the entrance of a tributary, passage into or out of a reservoir, the presence of a town or wastewater treatment plant, or proximity to a diversion structure. The site selection process has not used data from remote sensing imagery. Denver Water expects addition of this data will enable further refinement of their site selection by adding information on the locations of burn areas, pine beetle kill, erosion, and other factors they aren't currently able to effectively include in their decision making process.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 7	ETM+	Land Use/Land Cover
Landsat 8	OLI/TIRS	Land Use/Land Cover

NASA Earth Observations to be Highlighted:

Landsat 7 and 8 will provide the end-users with the necessary up to date land cover classifications that will help determine suitable locations for water quality sampling sites within the watershed. This method of determining locations will help reduce costs and ensure adequate coverage of water quality monitoring stations, as well as be replicable into the future. Landsat 8's coastal band will be useful for more accurate detection of inland water bodies, especially shallow or turbulent areas.

Ancillary Datasets:

- Locations of current sampling sites provided by partner
- National Land Cover Dataset – USGS
- Cropland Data Layer – USDA

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Land Cover Classification Change Map	Determination of current infrastructure and potential contaminate sources	Field Surveys
Water Sampling Site Suitability Change Map	Selection of optimal locations for water quality sampling sites	Field Surveys

Land Cover Classification Change Map – Combination of the National Land Cover Dataset and the Cropland data layer used in conjunction with Landsat 8. Landsat 8 will provide currently Land Cover classification while NLCD and CDL will provide past Land Cover classification.

Water Sampling Site Suitability Change Map – Data from the land cover classification map and information from partners will be used to develop a weighted algorithm which will identify areas optimal for the placement of water quality sampling sites with the current data. Comparing that to historic data from before 2013 (created by term 1) will provide a change map.

Project Details:
National Application Areas Addressed: Water Resources, Disasters
Source of Project Idea: Dr. Christine Lee gathered pilot project ideas at 2014 Water Resources meetings and then connected interested organizations with DEVELOP. The project idea was proposed by representatives of Denver Water as an area where using NASA Earth observations would enhance their decision-making process.

Advisor: Dr. Kenton Ross (NASA DEVELOP National Program)
# of Participants Requested: 4

Project Timeline: 2 terms – 2015 Spring and Summer
Study Location: Denver, Colorado
Period being Studied: Pre-September 10, 2013 – Post-September 15, 2013

Previous Related DEVELOP Work:
Colorado Water Resources: Utilizing NASA Earth Observations to Identify Water Quality Sampling Sites in Denver, Colorado - Spring 2015 (Langley)

Colorado Water Resources: Utilizing Landsat 8 to Assess Impacts of the Historic 2013 Flooding in Colorado's Northern Front Range - Fall 2013 (Fort Collins)

Multi-Term Objectives:
- **Term 1** – Created site suitability maps for the placement of water quality sampling sites using NASA Earth observations to support Denver Water's mission in providing high quality water to the population of Denver.
- **Term 2 (Proposed Term)** – Identify the change in potential contaminate sources, site suitability maps, and infrastructure in the Ralston Reservoir as a result of the September 2013 Colorado flood event.

5. Texas Water Resources (Langley)

Utilizing NASA Earth Observations to Monitor Drought Severity in Texas for Wildfire Mitigation Support

Objective:
This project will monitor drought severity in Texas and support the Texas Forest Service to use the previously developed Drought Severity Index. This project will be conducted in parallel with the Stennis DEVELOP Texas Disasters project which will focus on fuel type and loading monitoring.

Community Concern:
The Texas Forest Service (TFS) is the incident management agency for state emergencies in Texas, including wildfires. Wildfires pose a constant risk for many regions across Texas, burning several thousand acres each year. For example, in 2013, there were 7,598 fires reported, which burned 45,963 acres. The ability to accurately monitor drought conditions is vital to forecasting wildfire risk, especially in the grassland regions where fires often spread rapidly. Using meteorological drought severity indices like the Keetch-Byram Drought Index (KBDI) and remote sensing indices like the Drought Severity Index with inputs from NASA Earth observations can offer a continuous spatial coverage of drought conditions. With more information about the spatial

coverage of drought conditions, decision makers at the Texas Forest Service can better allocate resources to mitigate the spread of wildfires when they occur.

End-Users/Partners/Boundary Organizations:
Texas Forest Service (Boundary Organization and End-User, POC: Curt Stripling, GIS Systems Coordinator; Tom Spencer, Department Head – Predictive Services)

DEVELOP partnered with the TFS in 2011 and recently reached out to re-open lines of communication regarding that project. In recent conversations, the TFS expressed interest in drought monitoring in order to predict wildfire behavior. Transition of results will occur through email and virtual presentation. Partners will implement the results by including them as part of their decision making process to prepare for potential wildfire risk in the region.

Letters of Support: Texas Forest Service, Curt Stripling and Tom Spencer

Decision Making Process:
Currently, the partners use products from the LANDFIRE Program and the National Predictive Services Unit which uses the Palmer Drought Severity Index, Climate Prediction Center Soil Moisture Model, USGS Weekly Streamflow, Standardized Precipitation Indicator, and objective indicator blends to classify the drought severity. The partners also use KBDI (Keetch-Byram Drought Index), which have inputs from NOAA NEXRAD. Another effort at Texas A&M is using AVHRR with NEXRAD to determine drought locations and severity. The LANDFIRE Program is designed to help the Texas Forest Service support fire planning, analysis, and budgeting to evaluate fire management alternatives. The Texas Forest Service also using LANDFIRE to supplement strategic and tactical planning for fire operations.

Earth Observations:

Platform	Sensor	Geophysical Parameter
GPM	Dual-Frequency Precipitation Radar (DPI)	Precipitation
Aqua & Terra	MODIS	LST, NDVI
GRACE		Ground Water
SMAP		Soil Moisture

NASA Earth Observations to be Highlighted:
GPM data will be used to calculate the drought indices over a large spatial area, filling in the gaps between ground-based stations. MODIS will offer similar capabilities for land surface temperature. MODIS will also provide the estimation of vegetative health through Normalized Difference Vegetation Index (NDVI). GRACE will be incorporated to identify fluctuations in ground water recharge. SMAP data, if available, will be used to highlight soil moisture available to the grasslands, where wildfires spread most rapidly.

Ancillary Datasets:
- NOAA Multisensory Precipitation Estimate (MPE) – Precipitation data prior to GPM launch

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Drought Severity Index Maps	Where the Texas Forest Service will allocate resources in preparation for wildfires	LANDFIRE
Soil Moisture Maps	Where the Texas Forest Service will allocate resources in preparation for wildfires	*In situ* measurements
Ground Water Anomalies	Where the Texas Forest Service will allocate	*In situ*

Maps	resources in preparation for wildfires	measurements

Drought Severity Index Maps – Using data from GPM and MODIS, the Drought Severity Index provides estimation of water stress to vegetation.

Soil Moisture Maps – Created using data form the newly launched SMAP, maps that show available soil moisture in the upper-most portion of the soil will give a good indication of the water available for grasslands.

Ground Water Anomalies Maps – The ground water maps will be created using GRACE, and will show where ground water is depleted during droughts, or where ground water storage is being recharged.

Project Details:
National Application Areas Addressed: Water Resources, Disasters
Source of Project Idea: This project idea came from the Texas Forest Service through communication with the DEVELOP National Program Office.

Advisor: Dr. Kenton Ross, DEVELOP National Program
# of Participants Requested: 4

Project Timeline: 2 Terms: 2015 Summer to 2015 Fall
Study Location: Texas
Period being Studied: 2010 - 2015

Previous Related DEVELOP Work:
California Disasters: A New Method for Providing Near-Real-Time Active-Fire and Post-Burn Support to Fire Responders Using Data Products Derived from NASA's UAVSAR - Spring 2015 (JPL)

Great Plains Agriculture I, II, III: Utilizing NASA Earth Observations to Monitor Drought Conditions for Enhancement of Rangeland Management - Summer 2013, Spring 2014, Summer 2014 (LaRC)

Multi-Term Objectives:
- **Term 1 (Proposed Term)** – The first term will focus on adapting the Drought Severity Index to Texas using GPM and MODIS data. SMAP will be explored for future inclusion.
- **Term 2** – The second term of the project will focus on using SMAP along with the Drought Severity Index from the first term to highlight drought areas and drought severity in the region. This term will also include hand-off of results and methodologies to the project partners.

6. Coastal Texas Water Resources (Mobile)

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

Objective:
To conduct a land cover classification and precipitation analysis of Laguna Madre in Padre Island National Seashore to analyze the suspected correlation between the increase in mesquite trees in the area and the increase in salinity of the lagoon.

Community Concern:
Laguna Madre of Padre Island National Seashore is a hypersaline estuary (salinity is higher than the adjacent marine environment). There is compelling historical evidence dating from pre-

European settlement of the region that the Laguna Madre was not always hypersaline, thus the original ecosystem of the lagoon was dramatically altered at some point in time. A National Park Service hydrologist hypothesizes that this is in part due to the increase of mesquite trees in the area, which have replaced local grasses. The trees have long taproots that extract large quantities of groundwater that previously reached the Laguna Madre via groundwater discharge, thus decreasing salinity. Artesian wells once common upslope of the Laguna Madre have ceased to flow over the past decades, likely matched by a decrease of groundwater discharge in the estuary. This situation poses an interesting management challenge. The mesquite tree, the suspected culprit of the changing hydrology, is also a native plant. Furthermore, the increased tree coverage has occurred on privately-owned, undeveloped land around the lagoon. This concern presents the complexities of managing native plants, and the interconnectivity between private and public land management.

End-Users/Partners/Boundary Organizations:
National Park Service (End-user & Collaborator, POC: Joe Meiman, Hydrologist)

Contact with the partner began in October 2014 via email and has since progressed to a teleconference discussing the project ideas in greater detail. Communication has been with Joe Meiman, hydrologist for several national parks in the southern US. While the intent of the initial email was to gauge interest in project ideas, Joe responded back with a clear project idea of testing the hypothesis that the increase in mesquite trees in the area surrounding Laguna Madre in the Padre Island National Seashore was decreasing groundwater flow into the lagoon and causing the increase in salinity of the estuary. Due to the distance between the team and the partner, the transition of support tools will likely be sent through email with a video conference presentation and discussion of results. The results of this project are meant to provide insight into this situation and lay the basis for future management plans.

Letters of Support: National Park Service, Joe Meiman, Hydrologist

Decision Making Process:
As part of the Padre Island National Seashore, the Laguna Madre falls under federal land management. The water quality (e.g. temperature, pH levels, turbidity, salinity, etc.) and nutrient levels of the lagoon are currently monitored with *in situ* data collection. Our partner mentioned that the park has some lidar data processed by the USGS in Tampa to monitor coastal morphology and vegetation. This data is from 2005-2008 from the Texas Natural Resources Information System and would be available to the team. Currently, the relationship between the mesquite trees, groundwater, and the lagoon is not studied in a systematic manner. Furthermore, as the mesquite trees are primarily on private land, the proposed analysis would serve as a foundation for decision-making in regards to how the national park worked with its partners in Texas for land management purposes. According to Meiman, "This project will serve to lay the data foundation to determine if connections exist between changes in natural land over and estuarine ecology. If eventually found to have merit, profound changes in land cover management could positively affect both agriculture and ecology."

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 8	TIRS & OLI	Thermal bands, land cover
Landsat 7	ETM+	Land cover
GRACE	ACC/SCA/KBR	Equivalent water thickness, groundwater
TRMM	Precipitation Radar	Rainfall accumulation
Terra	ASTER	Thermal bands

NASA Earth Observations to be Highlighted:
A key component of this analysis is change over time (in groundwater, in the mesquite tree population, and in the salinity of the lagoon). Data will be used to determine if fresh groundwater is being discharged in the bottom of the shallow (<1m) estuary. Landsat 8 data will provide insights into the changes in coverage of the mesquite trees in the area. In addition, GRACE data will provide a broad overview of the larger region of how the groundwater has changed over time. TRMM precipitation data will be compared with lagoon salinity data to examine the relationship between rainfall and the salinity of the estuary. While thermal mapping may provide insightful information regarding water and land resources, one challenge is often that of spatial resolution. Thus, its use for mapping the Laguna Madre illustrates its feasibility for mapping smaller water bodies. The thermal data will be acquired for winter months, as this will provide the highest contrast between the warmer, lighter, fresh groundwater and the cooler, dense saline water of the estuary.

Ancillary Datasets:

- *In situ* and historic water temperature and salinity data
- Texas Natural Resources Information System – (Experimental Advanced Airborne Research Lidar) EAARL sensor Oct 2005 Bare Earth lidar & 2006/ 2008 DEMs

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Precipitation Analysis	Whether changes in land management are needed if increase in mesquite trees correlates with decrease in groundwater and increase in estuary salinity (and not only/primarily precipitation)	None
LULC Map Time Series	Whether changes in land management are needed if increase in mesquite trees correlates with decrease in groundwater and increase in estuary salinity	NPS Inventory and Monitoring Network annual vegetative monitoring within park boundaries
Groundwater Map Time Series	Whether changes in groundwater inflow to lagoon can be identified and need to be addressed through changes in land management practices	No current groundwater monitoring within park boundaries
Thermal Map of Lagoon	Whether changes in groundwater inflow to lagoon can be identified and need to be addressed through changes in land management practices	Water quality *in situ* measurements

Precipitation Analysis – TRMM data will be used to identify how precipitation relates to the changes in lagoon salinity.

LULC Map Time Series – Landsat 8 OLI and Landsat 7 ETM+ data will be used to create LULC maps specifically focused on mapping the extent of mesquite trees in the area.

Groundwater Map Time Series – GRACE data will be used to illustrate groundwater presence at a broad scale through equivalent water thickness.

Thermal Map of Lagoon – Landsat 8 TIRS data will be used to create thermal maps of the lagoon to identify cooler areas indicative of cooler groundwater entering the lagoon.

Project Details:
National Application Area Addressed: Water Resources
Source of Project Idea: Joe Meiman, NPS expressed interest a project using NASA Earth observations to study one of the parks he manages as a hydrologist near Corpus Christi, Texas. He had a fairly well-developed project idea and hypothesis already and through a teleconference worked with the DEVELOP Mobile team to define this project.

Advisor: Joe Spruce (Stennis Space Center)
# of Participants Requested: 4-5

Project Timeline: 1 Term: 2015 Summer
Study Location: Padre Island National Seashore, Texas
Period being Studied: January 2000 – January 2015

Previous Related DEVELOP Work:
Padre Island Ecological Forecasting: Utilizing NASA EOS, European Remote-Sensing Satellites 1 and 2 (ERS-1&2), and Environmental Satellite (ENVISAT) to Create a Methodology for Monitoring Marine Debris Dispersal to Coastal Areas by Examining the Gulf of Mexico Loop Current and Associated Circulation Patterns - Summer 2011 (Stennis Space Center)

7. Pacific Water Resources (NCDC)

Using NOAA CDRs and Satellite Data to Connect Atmospheric Teleconnections with Precipitation across Hawaii and the U.S. Affiliated Pacific Islands (USAPI)

Objective:
This project aims to examine the influence of specific phases of the El Niño Southern Oscillation (ENSO) on long-term precipitation averages for the Exclusive Economic Zones (EEZ's) encompassing American Samoa, Guam, the Republic of the Marshall Islands (RMI), the Federated States of Micronesia (FSM), the Commonwealth of the Northern Mariana Islands (CNMI), the Republic of Palau, and Hawaii. The goal is to identify long-term rainfall patterns during specific phases of ENSO for each of the USAPI.

Community Concern:
Leaders and decision makers in Pacific Island nations have strived to increase their scientific and technical capacity relating to climate change and climate impacts. Working closely with a variety of US agencies including the National Oceanic and Atmospheric Administration (NOAA), the U.S. Agency for International Development (USAID), and several other international agencies, decision makers have enhanced their understanding of climate variability and its impacts. An important concern for these nations is to understand how ENSO affects their freshwater resource availability, as water resources for these nations are almost entirely dependent upon precipitation. Efforts by the USAID/NOAA Pacific Small Island Developing States (PSIDS) Project have helped provide more scientific tools to understand and prepare for the effects of ENSO. However, there is much more work to be done. This proposed project would aid in these efforts to enhance decision-makers' toolboxes to be more prepared for the impacts from ENSO.

End-Users/Partners/Boundary Organizations:
ERT (Partner, POC: Michael Kruk, Pacific Water Resources Product Development Lead)
Regional Climate Services Director (RCSD) (Partner, POC: John Marra, Pacific Regional Director)
Pacific ENSO Application Center (PEAC) (Boundary Organization, POC: Carl Noblitt, NOAA Corp Communication Officer)

ERT and DEVELOP NCDC met to discuss the project proposal, applicable data sources, community concerns, and end-user benefits. Since then, DEVELOP has explored different data sources and maintained contact with ERT. The results and decision support tools will be transitioned to Weather Station Offices for each USAPI and Hawaii, a total of eight end-users, virtually through PEAC. The results of this project will contribute to the ongoing efforts of USAID and NOAA to enhance the capacity for adaptation to climate change and variability for developing Pacific Island Nations and Hawaii.

Decision Making Process:
As mentioned previously, the results of this project will help increase local decision makers' understanding of the impact ENSO has on precipitation occurring in the region. With the exception of a few historical ENSO events, decision makers in this region do not have a historical context to frame and understand the influence of ENSO on precipitation. This limits their ability to adequately prepare for extreme events like flooding or drought. The end products will provide the missing historical context of how the likelihood of precipitation changes within seven specific ENSO phases, defined using Oceanic Niño Index (ONI) 3.4 Index. These seven phases are strong negative (< -1.5), moderate negative (-1.5 to -1.0), weak negative (-1.0 to -0.5), neutral (-0.5 to 0.5), weak positive (0.5 to 1.0), moderate positive (1.0 to 1.5), and strong positive (>= 1.5). By understanding the relationship established in this project, end-users will be able to look at existing forecasted ENSO values and have a better understanding of the likelihood of precipitation or drought occurring in their region.

Earth Observations:

Platform	Sensor	Geophysical Parameter
PERSIANN CDR	GridSat-B1 IR Window Channel	Precipitation Estimation

Earth Observations to be Highlighted:
The primary dataset will be NOAA PERSIANN Climate Data Record (CDR). This dataset provides daily precipitation estimates from 1983 to present. In addition to PERSIANN CDR the CMORPH Climate Data Record will be used for precipitation estimates if time permits. CMORPH CDR has a spatial resolution of 8km with a temporal resolution of 30 minutes.

Ancillary Datasets:
Monthly Oceanic Niño Index (ONI), from the NOAA Climate Prediction Center (CPC) will also be incorporated to identify the different phases of ENSO.

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Climatology Maps	Enhance water resource management by providing quantitative information on how ENSO impacts seasonal precipitation in the region.	Outside historical records associated with a few major ENSO events our end users do not have an established climatology for precipitation throughout the various phases of ENSO.
Anomalous Wet and Dry Maps	This product will provide a statistically analysis of the likelihood of anomalous dry or wet days throughout the study area. Useful threshold values will be identified in order to	End-users currently don't have a way to assess which ENSO phases will lead to more or less precipitation. They are only provided ENSO outlooks by NOAA CPC but these products don't

	help the end-user better understand which ENSO index value will impact their area of concern.	provide quantitative information on the influence of specific phases of ENSO on precipitation.

Climatology Maps – This end product will be a set of maps which will display the monthly, seasonal, and annual precipitation climatology for each ENSO phase. The climatology will establish "normal" precipitation totals for the given time period from which anomalous precipitation can be derived. The PERSIANN-CDR will be utilized to create the climatology and calculate anomalous precipitation. The ONI index will be used to estimate the phase of ENSO. Time permits, the CMORPH-CDR will be used to calculate the anomalous precipitation throughout its record of length.

Anomalous Wet and Dry Maps – This end product will identify the likelihood of precipitation anomalously wet and anomalously dry periods occurring with each phase of ENSO. The PERSIANN-CDR will be utilized for precipitation estimates and the ONI index will be used to estimate the phase of ENSO.

Project Details:
National Application Areas Addressed: Water Resources, Climate
Source of Project Idea: This idea came from existing work lead by Michael Kruk (ERT, Inc.) and John Marra (NOAA NCDC Regional Climate Services Director, Pacific Region). They expressed interest in a DEVELOP project after seeing a presentation on the fall 2014 Southwest Climate Presentation.

Advisors: Michael Kruk (Pacific Water Resources Product Development Lead), John Marra (NOAA Regional Climate Services Director, Pacific Region)
# of Participants Requested: 3

Project Timeline: 1 Term: 2015 Summer
Study Location: Commonwealth of the Northern Mariana Islands, Republic of the Marshall Islands, American Samoa, Federated States of Micronesia, and Hawaii
Period being Studied: Boreal Summer: May – September, Boreal Winter: October – April, years studied will be from 1983 to 2013

Notes: This project proposal has received interest from the Pacific Region RCSD, as well as other RCSDs throughout the country. The role of RCSDs is to support the development and delivery of a wide range of place-based climate science and information products and services to help people in their decision-making process. The RCSDs are a great resource to reach out and engage end-users. This is an opportunity for DEVELOP to work with the RCSDs to reach a broader base of end users and increase our focus on environmental and climate related issues.

8. Costa Rica Water Resources II (UGA)

Utilizing NASA Earth Observations to Develop a Comprehensive Water Budget for the Arenal-Tempisque Irrigation District of Costa Rica

Objective:
The overall goal of the project is to provide Costa Rica's National Service of Underground Water, Irrigation, and Drainage (Servicio Nacional de Aguas Subterráneas Riego y Avenamiento, SENARA) with datasets and tools derived from NASA Earth observations to help guide their

decision-making process throughout their water resource management plan in the Arenal-Tempisque Irrigation District.

Community Concern:
Costa Rica's National Service of Underground Water, Irrigation, and Drainage (Servicio Nacional de Aguas Subterráneas Riego y Avenamiento, SENARA) is responsible for water management and helps coordinate water usage with the agricultural and environmental agencies. For the last three consecutive years, the Arenal-Tempisque Irrigation District has experienced drought conditions making water management more difficult and adversely affecting the agriculture in the area. Discussions between SENARA and DEVELOP have concluded that incorporating NASA Earth observations into their decision-making process will help increase efficient water management as it will allow more continuous data than currently utilized. Successful implementation will have cascading benefits to local stakeholders, the agriculture industry, and environmental agencies. Upon completion of this project, SENARA will replicate the methodology in other irrigation districts in the country.

End-Users/Partners/Boundary Organizations:
SENARA (End-User/Boundary Organization, POC: Javier Artiñano Guzmán, Agronomist for the Arenal-Tempisque Irrigation District)
University of Georgia Costa Rica (Partner, POC: Dr. Quint Newcomer, Director of the University of Georgia Costa Rica Campus)
Costa Rican Embassy to the United States (Partner, POC: HE Ambassador Roman Macaya and Alejandra Solano, Minister Counselor)

There has been active communication between DEVELOP and the Costa Rican Embassy since the GEOSS of the Americas event at NASA HQ in August 2014. Since mid-November, there has been continued communication with Javier Artiñano Guzmán, the project's main end-user at SENARA. Through those conversations, SENARA expressed specific interested in deriving components of a water budget through remote sensing and in calculating evapotranspiration. Once the project is completed, SENARA will implement the methodology in other irrigation districts. Javier and two students from Costa Rica's Earth University will provide on-the-ground support for this project. University of Georgia (UGA) Costa Rica will facilitate the data transfer.

Letters of Support: Javier Artiñano Guzmán, Agronomist for the Arenal-Tempisque Irrigation District

Decision Making Process:
SENARA is responsible for water management and helps coordinate water usage with the agricultural and environmental agencies of Costa Rica. In an effort to increase efficiency in water usage, SENARA has begun to incorporate GIS into their decision support tools. Even though remote sensing is not currently being used, SENARA is aware of and interested in incorporating NASA Earth observations into their decision support tools. SENARA currently calculates certain parameters using *in situ* measurements and NASA Earth observations will allow more data over continuous areas. Their field measurements will help validate derived models.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Landsat 5,7, & 8	MSS, ETM+, OLI/TIRS	Evapotranspiration
Aqua & Terra	MODIS	Evapotranspiration
Terra	ASTER	DEM
TRMM	PR	Historical Precipitation

NASA Earth Observations to be highlighted:
Landsat 8 data will be used to derive evapotranspiration through use of the METRIC (Mapping EvapoTranspiration at high Resolution with Internalized Calibration) model, as well as to compare with land cover datasets to determine evapotranspiration by land cover type. Landsat 8 and MODIS will provide land cover as required. Precipitation measurements will be derived from TRMM data to supplement *in situ* measurements. MODIS data will also be analyzed for possible contributions to the water balance.

Ancillary Datasets:

- SENARA will provide *in situ* data in the form of survey data, stream gauge data, and calculated evapotranspiration values for some irrigation fields; data will validate models
- Costa Rica Digital Atlas – geospatial datasets that include watersheds, roads, political boundaries, and census data
- Digital Soil Map from the Food and Agriculture Organization of the UN (FAO)'s

Models:
The Soil and Water Assessment Tool (SWAT) Model (http://swat.tamu.edu/)
(POC: Jeff Arnold, USDA Agricultural Research Service (USDA-ARS))
Mapping Evapotranspiration with high Resolution and Internalized Calibration (METRIC) (POC: Dr. Richard Allen, University of Idaho)

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Watershed and Sub-Basin Delineation	Increase efficient water management through water budget monitoring and allocation	2008 Digital Atlas of Costa Rica
Precipitation Measurement	Increase efficient water management through water budget monitoring and allocation	Stream gages in some areas
Evapotranspiration	Increase efficient water management through water budget monitoring and allocation	Limited field data

Watershed & Sub-Basin Delineation – The Soil and Water resources Assessment Tool (SWAT) Model will enable the end-user to study the hydrological processes in addition to developing a water resource inventory for the study area. The current geospatial data utilized have not been updated since 2008 and SWAT can help update those files.

Precipitation Measurements – TRMM will be utilized to acquire precipitation measurements for an extended coverage beyond gages in the field.

Evapotranspiration – The Python script based on the principles of the Mapping Evapotranspiration at high Resolution with Internalized Calibration (METRIC) model will map and quantify evapotranspiration mechanisms in the study area.

Project Details:
National Application Area Addressed: Water Resources
Source of Project Idea: Initial exploration of potential projects arose from a follow up meeting with the Costa Rican Embassy after the GEOSS of the America closeout at NASA HQ in August of 2014. Jamie Favors and Steve Padgett Vasquez discussed potential project ideas with representatives and the Ambassador of Costa Rica to the US. During a research field trip to

Costa Rica, Steve Padgett Vasquez and Dr. Quint Newcomer met with potential project partners.

Advisors: Dr. Marguerite Madden (University of Georgia), Dr. Kenton Ross (DEVELOP NPO), Dr. Quint Newcomer (University of Georgia), Steve Padgett Vasquez (University of Georgia)
# of Participants Requested: 5

Project Timeline: 2 Terms: 2015 Spring to 2015 Summer
Study Location: Guanacaste, Costa Rica
Period being Studied: January 2000 to July 2015

Previous Related DEVELOP Work:
Peru Water Resources (I and II): Utilizing NASA Earth Observations to Develop a Comprehensive Water Budget for La Libertad Region in Peru - Summer 2014 (LaRC) and Fall 2014 (WC)

Coastal Mid-Atlantic Water Resources (I, II and III): NASA Earth Observations and Unmanned Autonomous System Inputs for Estimating Water Balance in Coastal Virginia, Maryland and North Carolina - Summer 2014,Fall 2014, and Spring 2015 (LaRC)

Multi-Term Objectives:

- **Term 1**– The main objective of this term is setting up a model based on the SWAT to enable the end-user to study the hydrological processes as well as to develop a water resource inventory for the study area. The main project partner will have a team in Costa Rica for support consisting of a representative from SENARA, Javier Artiñano Guzmán, and two students from Earth University.
- **Term 2 (Proposed Term)** – The main objective of the second term is scripting the Mapping Evapotranspiration at high Resolution with Internalized Calibration (METRIC) model. The script will lead to a user-friendly tool that will be used to quantify and map the evapotranspiration. At the completion of the term, SENARA will have all the components to create a water budget for the Arenal-Tempisque Irrigation district. SENARA will continue to provide a team to help support the DEVELOP team.

Notes: During the Summer 2015 Term, we hope a team at LaRC can support this project by working on the METRIC code under the supervision of Dr. Kenton Ross, facilitating the applicability of the code to the proposed study area.

9. Virginia Water Resources (PHB)

Monitoring Harmful Algal Blooms through NASA Earth Observations in the James River for Improved Water Management

Objective:
This project will focus on the application of NASA Earth observations in Virginia's Chesapeake Bay and the James River to enhance coastal managers with new remote sensing tools. Harmful algal blooms will be monitored through satellite remote sensing to augment *in situ* and UAS monitoring activities, and provide another data point for coastal management.

Community Concern:
Virginia has 7,213 miles of shoreline in the tidal portions and tributaries of the Chesapeake Bay and 2,775 miles of inland bays and lagoons along the Atlantic Ocean. Harmful algal blooms are a major concern for coastal managers, local governments, and the Governor's Office.

End-Users/Partners/Boundary Organizations:

Virginia Institute of Marine Science (VIMS) (Collaborator, POC: Dr. Juliette Smith, Aquatic Health Science Lab)
Virginia Department of Environmental Quality (VDH) (End-User, POC: Arthur Butt, Office of Water Monitoring and Assessment)
Virginia HAB Task Force

Recent meetings have taken place at VIMS with Dr. Kenton Ross, DEVELOP Lead Science Advisor, participating. These meetings focused discussion on ways to engage. Through DEVELOP's connections in the Governor's Office, communication with the Department of Environmental Quality has taken place.

Decision Making Process:

Currently the VDH hosts an algal bloom surveillance map which is based on a network of water quality sampling stations and reports called in to a HAB Hotline. This is a product of Virginia's Harmful Algal Bloom Response Plan and the Virginia HAB Task Force, who has a 24-7 response capability.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Aqua	MODIS	Turbidity, Chlorophyll-a, water color, surface water temperature, turbidity
Landsat 8	OLI	Sediment deposition, water color, true color images, surface water temp, floating algal index, normalized difference turbidity index, land cover
Suomi NPP	VIIRS	Ocean color, sea surface temperature

NASA Earth Observations to be Highlighted:

HABs can be detected and deciphered from surrounding water containing different phytoplankton functional types using OLI, MODIS, and VIIRS to detect spectral, surface water temperature, near shore sediment, chlorophyll concentration, and true color images that are indicators of algal growth. Floating Algal Index (FAI) and Normalized Difference Turbidity Index (NDTI), which will be derived from Landsat 8 indicate the presence of suspended or floating particles that can include algae, sediment, and nutrient concentrations that can lead to the proliferation of HAB events.

Ancillary Datasets:

- UAS and in situ water quality datasets
- HABs reports

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Results of Floating Algal Index (FAI) & Normalized Difference Turbidity Index (NDTI)	These indices display compounds that may lead to HAB events	N/A
HABs Time Series	Historical understanding of HAB events indicators will assist in predicting future events and influence agricultural policy decisions	N/A

FAI & NDTI – these will be measured with a combination of in-situ data and remotely sensed data to provide accurate remotely sensed water quality indices.

Time Series – this series will provide a visual means of monitoring HAB events in Virginia water bodies over time, and will be compiled of the past five years of data.

Project Details:
National Application Areas Addressed: Water Resources, Ecological Forecasting
Source of Project Idea: Discussions with VIMS.

Advisor: Dr. Kenton Ross
# of Participants Requested: 4

Project Timeline: 1 Term: Summer 2015
Study Location: Virginia (Chesapeake Bay, James River)
Period being Studied: 2010 – present

Previous Related DEVELOP Work:
Lake Erie Water Resource: Methodology Validation for Quantitative Analysis to Model Indicators of Harmful Algal Blooms in the Maumee River Watershed of Lake Erie (Ames, Spring 2015)

Notes:
Virginia HAB Plan - www.vdh.virginia.gov/epidemiology/dee/HABS/documents/factsheets/HabPlans_Final%20e.pdf
Virginia HAB Task Force - www.deq.state.va.us/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/VirginiaHarmfulAlgalBloomTaskForce.aspx
NOAA HABs - http://tidesandcurrents.noaa.gov/hab/resources.html#midalt
VIMS Sea Level Rise - http://www.vims.edu/newsandevents/topstories/slr_scenarios.php