DEVELOP National Program

Climate Project Proposals

Summer 2015

Proposal Snapshot

1. Navajo Nation Climate II: Assessing Climate Change Impacts on Ground Water Availability and Drought Vulnerability in the Navajo Nation Using NASA Earth Observations (Ames)
Objective: Assess impacts on water resource availability on the Navajo Nation (NN) with climate change using Earth observations (EO) and hydrological modeling techniques. A NN Standard Precipitation Index (SPI), a ground station placement suitability index, and modeled stream flow measurements will be created using various NASA EO water resource related products. Products created by this project will enhance drought monitoring, water infrastructure allocations, and enhance policy decisions regarding water quality.

Partners Snapshot

Tribal Partners

- Navajo Nation Department of Water Resources (NNDWR), Water Management Branch (End-user, POC: Jason John, Branch Director, Robert Kirk and Teresa Showa, Principal Hydrologists, and Maurice Upshaw, Geographic Information System Supervisor)
- Navajo Technical University (End-user, POC: Ramsey Seweingyawwa, Geospatial Engineering Technology Lab Lead)

Letters of Support

- Navajo Technical University, Ramsey Seweingyawma, Geospatial Engineering Technology Lead

Project Proposals

1. Navajo Nation Climate II (Ames)

Assessing Climate Change Impacts on Ground Water Availability and Drought Vulnerability in the Navajo Nation Using NASA Earth Observations

Objective:
This project aims to assess impacts on water resource availability on the Navajo Nation (NN) with climate change using Earth observations (EO) and hydrological modeling techniques. A NN Standard Precipitation Index (SPI), a ground station placement suitability index, and modeled stream flow measurements will be created using various NASA EO water resource related products. Products created by this project will enhance drought monitoring, water infrastructure allocations, and enhance policy decisions regarding water quality.

Community Concern:
Water is one of the most important resources for the NN and has implications to the successful management of many operations. Over 70,000 Navajo (roughly one-third of the Reservation population) do not have access to running water due to water rights and infrastructural issues. The projected climate change impacts on water resources include: declines in snowpack, more persistent and long-term droughts, decreases in late spring and summer streamflow due to changes in snowmelt timing, and decreases in water quality. In a recent report addressing the climate change and variability adaptation on the NN, water was deemed a "super sector" that has implications for all sectors of the NN including agriculture, forest management, energy, economic development, and human health.

Partner Organizations:
Navajo Nation Department of Water Resources (NNDWR), Water Management Branch (End-user, POC: Jason John, Branch Director, Robert Kirk and Teresa Showa, Principal Hydrologists, and Maurice Upshaw, Geographic Information System Supervisor)
Navajo Technical University (End-user, POC: Ramsey Seweingyawwa, Geospatial Engineering Technology Lab Lead)

Ames Research Center has been working with students from the United Tribes Technical College (UTTC) for many years through an internship for tribal students to use remote sensing for issues related to native lands. These internships have been successful in many aspects, to include GIS and remote sensing training, access to remote sensing products, and enhancing tribal- US government relations. However, there is a further need to better understand how to enhance collaboration with tribal communities and organizations, such as the NN. Before the first phase of the project, the team conducted an in-person meeting with representatives from NNDWR and Navajo Technical University to assess the current water infrastructure and the needs of the NN. Currently, the team is in close contact with these end-users through telecons and email threads to further assess project needs, expectations, and agreements. These details include developing a custom SPI for the NN, modeling runoff for the San Juan watershed, and creating a ground station placement suitability index. The benefits to the end-users will be an increased knowledge of current and future water resources and the ability to make informed decisions about how to improve the existing water supply infrastructure. An in-person handoff session will take place at the conclusion of the project. The handoff materials will be presented in the form of videos, data, maps, tools, and a set of tutorials for continued use of these methods on the Reservation.

Letters of Support: Navajo Technical University, Ramsey Seweingyawma, Geospatial Engineering Technology Lead

Decision Making Process:
Water supply adaptation strategies include: settling water rights from ongoing litigation/negotiations, identifying and developing alternative water sources, integrating surface water and groundwater management, and rehabilitating or developing additional storage capacity. The NNDWR Water Management Branch uses a six-month SPI to issue drought alerts, warnings and declarations, and to trigger drought responses. The agency also issues a monthly drought status report that includes national and regional precipitation along with temperature estimates, a 12-month drought outlook, a streamflow outlook, and a Palmer Drought Severity Index (PDSI) outlook.

The NNDWR heavily relies on the SPI, calculated by the Western Regional Climate Center (WRCC), because the in situ ground station network within the Nation does not provide the coverage of data needed to calculate Nation-specific SPI values. However, the WRCC uses state-based climate divisions which do not take the Navajo Nation's political boundaries into consideration. In addition, neither of these agencies currently obtains or processes NASA data for drought monitoring purposes. While the SPI integrates information provided by governmental organizations, specific management decisions can be improved with more accurate and longer-term climate projections through the use of EO and modeled datasets. Additionally, NN ground station networks are inefficient in terms of data reliability, coverage, and placement.

Earth Observations:

Platform	Sensor	Geophysical Parameter
Aqua & Terra	Moderate Resolution Imaging Spectroradiometer (MODIS)	Snow cover, Land cover type, Vegetation indices, Land surface temperature, Derived soil moisture
Aqua	Atmospheric Infrared Sounder (AIRS)	Atmospheric temperature and humidity, Precipitation
Landsat 5 & 8	Thematic Mapper (TM) and Operational Land Imager (OLI)	Land cover change and NDVI products
Suomi NPP	Visible Infrared Imaging Radiometer Suite (VIIRS)	Land surface temperature, Land surface type
GPM	GPM Microwave Imager (GMI) and the Dual-frequency Precipitation Radar (DPR)	Precipitation intensities and horizontal patterns
TRMM	Precipitation Radar (PR)	Rain rate and rain rate profile, Accumulated rain

NASA Earth Observations Highlighted:
The main objective of this project is to analyze historical water availability through the use of Earth observations and *in situ* data, and to predict future changes with climate change projections. Drought indicators will also be outlined using Global Precipitation Measurement (GPM) and Tropical Rainfall Measuring Mission (TRMM). Vegetation health will also be assessed as a drought indicator using Landsat 5 and 8, Aqua AIRS and MODIS, Terra MODIS, and Suomi National Polar-orbiting Partnership (NPP) VIIRS products.

Ancillary Datasets:
- Digital Elevation Model (DEM), National Elevation Dataset
- Hydrological Sub-Regions, National Hydrology Dataset (NHD), USGS
- Land Cover (1990, 2001, 2006), National Land Cover Data (NLCD) products
- Snow water equivalent (2004-2014), Snow Data Assimilation System (SNODAS)

- Duration and intensity of the long-term drought-inducing circulation patterns, Palmer Drought Severity Index (PDSI)
- Forecasted Precipitation, Forecasted Maximum Temperature, Forecasted Minimum Temperature (2010-2100), Coupled Model Intercomparison Project Phase 5 (CMIP5), NASA Earth Exchange (NEX) Downscaled Climate Projections (NEX_DCP30)
- Soil Moisture and Soil Temperature, NASA's North American Land Assimilation System (NLDAS-2) data
- Infrastructure (roads, irrigation areas, dams, political boundaries), lakes, rivers, wells, springs, dams, snowpack, precipitation, streamflow, Navajo Nation Department of Water Resources Products
- Historical Precipitation and Temperature, Parameter-elevation Relationships on Independent Slopes Model (PRISM)
- Historical Precipitation, US Climate Reference Network (USCRN)

Models:

- DEVELOP Drought Severity Index (Lance Watkins, DEVELOP National Program) will be used to measure areas of drought risk. It is based on the Scaled Drought Condition Index (SDCI) model C12 (Rhee, Im, & Carbone, 2010) and is optimized for arid regions.
- Soil and Water Assessment Tool (SWAT) (POC: Chase Mueller, BAERI) will be used to model watershed runoff and pollution.

Decision Support Tools & Analyses:

Proposed End Products	Decision Impacting	Current Partner Tool/Method
Navajo Nation Standard Precipitation Index tool	Ability to generate Navajo Nation specific SPI values for a chosen time period	Palmer Drought Severity Index, Drought Contingency Plan
Modeled Stream flow in the San Juan River Basin	Allow decision-makers to identify potential areas with water quality issues where additional monitoring can be undertaken or mitigation activities can be focused	None
Ground Station Suitability Index	Enable end-users the ability to decide the most cost effective and suitable areas for ground station placement	None

Navajo Nation Standard Precipitation Index – This tool calculates Standard Precipitation Index (SPI) values for a user-selected area within the study site, and supplies the geodatabase of historical climate information necessary to calculate these values. The tool and geodatabase uses TRMM and GPM observed precipitation data, along with PRISM historical precipitation modeled products. The product enhances the current use of the SPI and eases the process of extracting values indicative of drought monitoring. (Spring/Summer 2015)

Ground Station Suitability Index – This tool calculates the most suitable placement of in situ ground stations to measure snowpack, precipitation, and temperature. The product allows the NNDWR the ability to make the most cost effective decisions on ground station placement as they reorganize their ground station network. The index will be created using NASA EO data products to allow wider coverage and account for multiple variables. (Summer 2015)

Modeling Stream Flow in the San Juan River Basin – This product will use the SWAT model to assess the variability and trends in volumes and peaks of runoff, sediment yield, and pollution

(nitrogen and phosphorus) in the San Juan River Basin. The model outputs greatly influence ground water and surface reservoir recharge; therefore, analyzing these conditions will enhance water resource management. Drought indicators such as changes in plant species, high evapotranspiration, decline in rainfall, are delineated from remote sensing products. These indicators will be used to support this analysis. USGS gage measurements will be used to validate the model outputs. These results allow NN decision-makers to identify potential problem areas where additional monitoring can be undertaken or mitigation activities can be focused. (Summer 2015)

Project Details:

National Application Areas Addressed: Water Resources, Climate
Source of Project Idea: Previous DEVELOP mentor, Cindy Schmidt (NASA Ames), has been working with tribal groups for many years to use NASA EO to assist in a wide range of environmental issues on reservations. She has also been involved with the United Tribes Technical College in North Dakota to provide internship opportunities to native students interested in Environmental Science, Geography, and Remote Sensing.

Advisors: Dr. Juan Torres Perez (NASA Ames Research Center/Bay Area Environmental Research Institute) and Ramsey Seweingyawma (Navajo Technical University)
Participants Requested: 5

Project Timeline: 2 Terms: 2015 Spring to 2015 Summer
Study Location: The Navajo Nation, AZ, UT, NM
Period being Studied: 1901-2015

Multi-Term Objectives:

- **Term 1** – This term will focus on the historical and future assessment and analysis of water resources on the NN lands, using various EO and modeled data. These data will be clipped to hydrological basins overlapping the NN. The team will construct a modified SPI catered to NN watersheds that uses EO products such as TRMM and GPM precipitation measurements. This term will also focus heavily on partner engagement and logistics for the summer term. The team will be contacting partners, setting up regular meetings, and planning to work with a remote team of Navajo Technical University students.
- **Term 2 (Proposed Term)** – During this term, the project will focus using the SWAT Model to assess runoff, sediment yield, and pollution within the San Juan River Basin. These results will allow decision makers to identify areas that may hinder the Reservations ability to provide access to drinking water in this region of the NN. The team will also create a Ground station network suitability index based off of EO and spatially modeled products. The final stage of this project will also focus on a partner handoff and continued engagement with this community for anticipated future needs. Additionally, there will be a one or two Navajo student DEVELOPers who will work remotely with Ames DEVELOPers for the first half of the term. The Navajo team will then work in-person with the Ames team during the second half of the term at Ames Research Center.

Notes: This is a multi-term project that will address issues of climate change impacts on water resource availability in the agricultural, ecological, and social systems of the NN. This research will create a vital set of tools and data for water supply managers within the NNDWR, to support current and future water supply demands on the Reservation. The tools and products will also better serve the Navajo Technical University when conducting future water resources related projects.

The first term (spring 2015) of the project focused on assessing current and historical water resources within the study region using local DEVELOP participants. We have maintained collaboration with the Navajo Technical University to prepare for the second phase (summer 2015) of this project. During this second phase, one or two students from the university are expected to remotely participate in the DEVELOP program with two to three others located at Ames Research Center. The Navajo students will be in remote collaboration for the first five weeks of the term. They will then travel to Ames Research Center to continue working, in-person, with the rest of the team for the duration of the term. Ramsey Seweingyawma has been instrumental in mentoring and supporting the Navajo Tech students to allow a more subtle transition to and from the reservation. Funding for travel and housing have been established for the Navajo Tech DEVELOPers though outside funding sources by Ramsey Seweingyawma.

References and helpful websites:

Garfin, G. (2013), *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, Island Press.

Nania, J., K. Cozzetto, N. Gillett, S. Duren, A. Tapp, M. Eitner, and B. Baldwin (2014), *Considerations for Climate Change and Variability Adaptation on the Navajo Nation*, University of Colorado, Boulder, Boulder, CO.

Websites:
Navajo Nation Government
http://www.navajo-nsn.gov/govt.htm

Navajo Nation Department of Water Resources
http://www.frontiernet.net/~nndwr_wmb/