**NASA DEVELOP National Program**

**2019 Summer Project Proposal**

**North Carolina – NCEI**

**Kansas Agriculture & Food Security**

*Characterizing Soil Drydown Parameters for Drought Mitigation in Cropland and Rangeland of Kansas Using NASA Earth Observations*

**Project Overview**

***Project Synopsis*:** This project will work with the Kansas Office of the State Climatologist at Kansas State University for the goal of using NASA Earth observations to characterize the process of soil drydown in cropland and rangeland areas. Soil drydown represents the exponential decrease in soil moisture following a precipitation event, and the project partners are interested in modeling the rate of depletion in various empirically-measured precipitation and drought scenarios. Climate variable inputs into the soil drydown model will include vegetation indices from Suomi NPP VIIRS, precipitation from GPM IMERG, and soil moisture content from SMAP L-band enhanced with Sentinel-1 C-SAR data. The team will compare the output rates of soil drydown from the remote sensing products to output rates measured from *in situ* soil moisture conditions, which are not spatially comprehensive throughout the state. Using up-to-date drought conditions and projections, the project partners will be able to make data-informed recommendations to mitigate the impacts of soil moisture depletion for agricultural producers and cooperatives, as well as identify counties most susceptible to drydown.

***Community Concern:*** Kansas is one of the nation’s leading states in agricultural production. In 2016, the total agricultural exports of Kansas amounted to $4.5 billion, which was the 9th largest amount by state that year. For wheat, specifically, Kansas ranked second in exports by state in 2016. Drought conditions, including low rainfall, high temperatures, and vegetative stress, deplete soil moisture content and result in negative impacts on agricultural production. In the summer of 2018, the Governor’s Office declared ‘emergency drought’ status in nearly half of the state’s counties, and some farmers reported up to 25% less wheat output than the previous year.

***Source of Project Idea:*** The NOAA National Integrated Drought Information System (NIDIS) is working with the North Carolina node for project development in 2019. Through a call for project ideas, NIDIS connected the NC node leadership to researchers from the Office of the State Climatologist at Kansas State University. The researchers are interested in integrating Earth observation data into their soil monitoring practices for agricultural extension efforts throughout the state. Additionally, NIDIS is interested in developing applications for their set of drought indices in sectors like agriculture.

***National Application Areas Addressed:*** Agriculture & Food Security, Water Resources

***Study Location:*** KS

***Study Period:*** January 2015 – June 2019

***Advisor:*** Jessica Blunden, jessica.blunden@noaa.gov, NOAA National Centers for Environmental Information

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Kansas State University, Kansas Office of the State Climatologist** | Mary Knapp, Service Climatologist | End User | Yes |
| **Kansas Water Office** | Diane Knowles, Water Resource Planner | End User | No |
| **Kansas State University, Department of Agronomy** | Andres Patrignani, Assistant Professor of Soil Water Processes; Christopher Redmond, Assistant Scientist | Collaborator | No |
| **Desert Research Institute, Western Regional Climate Center** | Dan McEvoy, Assistant Professor of Climatology and Regional Climatologist | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The Kansas Water Office forms action teams like Governor’s Drought Response Team to work with the Kansas Office of the State Climatologist and to disseminate climate and weather information to agricultural producers and cooperatives. The Office monitors climate and weather data to report on developing drought conditions based on measurements of precipitation, humidity, land surface temperature, and soil moisture content derived from *in situ* stations. Based on the conditions and drivers of drought in individual counties, they make decisions on drought mitigation recommendations for the producers and cooperatives. The Kansas Office of the State Climatologist produces the Kansas Mesonet dataset, which their researchers use to make the drought recommendation decisions. The dataset includes 61 sites of *in situ* measurements, in which 41 measure soil moisture content in grasslands, leaving spatial data gaps at the sub-county scale for cropland and rangeland areas. These decisions include recommendations like the allocation of irrigation sources or adjustments to livestock grazing practices.

***End User’s Capacity to Use NASA Earth Observations:***

*Kansas State University, Kansas Office of the State Climatologist* – The Kansas Office of the State Climatologist houses researchers familiar with climate variables derived from both *in situ* stations and remote sensing products. They are familiar with the acquisition, manipulation, and processing of climate data, including soil moisture. Their current monitoring practices primarily rely on *in situ* measurements, but they have the technical capacity to use remote sensing products to model soil moisture conditions and changes.

*Kansas Water Office* – The Kansas Water Office works closely with researchers from academic institutions like Kansas State University. They collect and disseminate climate information related to drought that is produced from remote sensing data, so they have the understanding to interpret end-products based created with Earth observations.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Kansas State University, Department of Agronmy* – Kansas State University houses researchers in the Department of Agronomy who are familiar with collecting, analyzing, and model soil moisture data. They will support the modeling efforts of the NASA DEVELOP project team.

*Desert Research Institute, Western Regional Climate Center* – The Western Regional Climate Center has developed several datasets for measuring drought potential and conditions. This partner will serve as an advisor on the use and derivation of relevant drought metrics for the soil drydown model inputs.

***Dissemination by Boundary Organizations*:**

*Kansas State University, Kansas Office of the State Climatologist* – The Kansas Office of the State Climatologist works with the Kansas Water Office to inform the Governor’s Drought Response Team on developing drought conditions in the state. With the data on soil moisture drydown, the Kansas Office of the State Climatologist provides data to decide on relevant drought mitigation recommendations for agricultural producers and cooperatives throughout the state. This communication occurs through workshops and drought reports that occur weekly, quarterly and annually.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The Project Lead will serve as the main point of contact between the team and the partners during the term. The partners expect to participate in biweekly phone calls to communicate their needs and goals, as well as provide feedback on project progress.

***Transition Plan*:** At the end of the term, the team will communicate the project results to the partners through a Google Hangout video meeting and discuss next steps for the partners in using and applying the end products. The modeled output data will be shared through Google Drive for easy access from the partners.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Suomi NPP VIIRS** | Irradiance/Reflectance | The team will derive the Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) as soil drydown model inputs. |
| **GPM IMERG** | Precipitation | The team will use precipitation as a soil drydown model input and identify sequences of ‘no rainfall days’ in the period of record. |
| **SMAP/Sentinel-1 C-SAR enhanced** | Soil Moisture | The team will derive measurements of soil moisture content at a 1km resolution as an input into the soil drydown model. |

***Ancillary Datasets:***

Kansas Mesonet Soil Moisture – The team will use the *in situ* measurements of percent of saturation and volumetric water content at 5cm as an input into the drydown model and compare the output rates to those from the remote sensing inputs as a source of ‘truth.’

Evaporative Demand Drought Index (EDDI) – The team will use the data as measurements of meteorological and vegetative drought to serve as a model input representing drought condition. The data is derived from the NASA National Land Data Assimilation Systems (NLDAS-2).

***Software & Scripting:***

R – statistical analysis and data visualization

Python – statistical analysis and data visualization

Google Earth Engine – data acquisition and analysis, computation of vegetation indices

ESRI ArcMap – raster data processing and visualization, land cover classification

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Map Atlas of Soil Drydown under varying Drought Scenarios** | The Kansas Office of the State Climatologist will use the modeled outputs to measure soil drydown rates throughout the state under different drought scenarios. They will then be able to identify the counties with the most at-risk cropland and rangeland for soil moisture depletion given projected drought conditions. | The team will apply NDVI, LST, precipitation, and soil moisture measurements derived from the Earth observations to a soil drydown model indicated in existing literature and research. | N/A |
| **Correlation of EDDI (Drought Index) and Soil Moisture Drydown Outputs** | The Kansas Office of the State Climatologist will gain an understanding of how an early-warning drought index like EDDI correlates to soil moisture. The correlation will give them an idea of how EDDI can be used to indicate soil drydown vulnerability. | The team will correlate the EDDI measurements with soil drydown rates based on the modeled outputs. | N/A |

***End-User Benefit*:** Currently, the Kansas Water Office relies on data from the Kansas Office of the State Climatologist, which uses on 41 *in situ* stations to measure soil moisture in the 105 counties in the state, primarily measuring in grassland. With the end products, their teams and researchers will have spatially comprehensive and sub-county level data on soil drydown rates under various drought scenarios. The researchers will be able to identify the counties whose cropland and rangeland are expected to have the fastest rates of drydown and at what time scales the drydown occurs.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2019 Summer

***Related DEVELOP Work:***

2018 Summer (ID) – Idaho Water Resources: Estimating Soil Moisture in Semi-arid Sagebrush Steppe

Utilizing NASA Earth Observations

2016 Spring (ID) – Southeast Idaho Disasters II: Using Earth Observing Systems to Characterize Juniper Invasion and Assess Changes in Soil Moisture within Cheatgrass Dominated Sites Relative Wildfire Susceptibility in Eastern Idaho

**References:**

Hobbins, M. T., Wood, A., McEvoy, D. J., Huntington, J. L., Morton, C., Anderson, M., & Hain, C. (2016). The Evaporative Demand Drought Index. Part I: Linking drought evolution to variations in evaporative demand. *Journal of Hydrometeorology, 17*, 1745–1761. https://doi.org/10.1175/JHM-D-15-0121.1

McColl, K. A., Wang, W., Peng, B., Akbar, R., Short Gianotti, D. J., Lu, H., … Entekhabi, D.

(2017). Global characterization of surface soil moisture drydowns: Surface soil moisture drydown analysis. *Geophysical Research Letters*, *44*(8), 3682–3690. https://doi.org/10.1002/2017GL072819

McEvoy, D. J., Huntington, J. L., Hobbins, M. T., Wood, A., Morton, C., Anderson, M., & Hain, C. (2016). The Evaporative Demand Drought Index. Part II: CONUS-wide assessment against common drought indicators. *Journal of Hydrometeorology, 17*, 1763-1779. https://doi.org/10.1175/JHM-D-15-0122.1

Shellito, P. J., Small, E. E., Colliander, A., Bindlish, R., Cosh, M. H., Berg, A. A., … Walker, J. P. (2016).

SMAP soil moisture drying more rapid than observed in situ following rainfall events: SMAP soil moisture drying. *Geophysical Research Letters*, *43*(15), 8068–8075. https://doi.org/10.1002/2016GL069946