**NASA DEVELOP National Program**

**2020 Summer Project Proposal**

**North Carolina – NCEI**

**Montana Water Resources**

*Developing a Composite Drought Index Utilizing NASA Earth Observations for Drought Monitoring in Montana and the Upper Missouri River Basin*

**Project Overview**

***Project Synopsis*:** This project will create a Composite Drought Index (CDI) metric to enhance the drought monitoring efforts of the Montana Climate Office (MCO). Based on recommendations from the MCO, NOAA Regional Climate Services – Central Region, and the NOAA National Weather Service Missouri River Basin Forecast Center, the project team will optimize a weighting scheme of climate parameters that represent the seasonal drivers of drought for the state of Montana and other parts of the Upper Missouri River Basin. The parameters of the index will leverage precipitation, soil moisture, and vegetation indices derived from the GPM IMERG, Suomi NPP VIIRS, SMAP, and Terra MODIS missions. To assess the performance of the index, the team will cross-validate the outputs with historic dry and wet events in the state. The CDI will provide a composite value of wetness and dryness that the MCO can use to communicate drought risk to the public.

***Community Concern:*** Montana’s climate varies across the state from the Northern Plains landscape to the Rocky Mountain ranges. Drought events impact the resource availability and economic productivity of these environments. For example, in the summer of 2017, 65% of the state was categorized in a condition of extreme to exceptional drought, according to the U.S. Drought Monitor. Impacts of the 2017 droughts included degraded quality of wheat harvests in eastern Montana and dry conditions that exacerbated the spread of wildfires. The MCO has a particular interest in monitoring winter drought conditions, as local knowledge indicates that winter drought conditions can degrade moisture availability during the start of the growing season. A CDI that can be referenced in the context of historic wet and dry events can give the public a stronger understanding of current and antecedent drought conditions.

***Source of Project Idea:*** DEVELOP leadership at the North Carolina – NCEI location solicited project ideas through the Regional Drought Early Warning Coordinators of the NOAA National Integrated Drought Information System. The MCO, in conversation with NOAA Regional Climate Services, requested the project idea.

***National Application Area Addressed:*** Water Resources

***Study Location:*** MT, ND, SD

***Study Period:*** January 2000 – August 2020

***Advisors:*** Steve Ansari (NOAA National Centers for Environmental Information); Ronald Leeper (NOAA National Centers for Environmental Information, North Carolina Institute for Climate Studies)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Montana Climate Office** | Zachary Hoylman, Research Hydrologist; Kelsey Jensco, Montana State Climatologist | End User | Yes |
| **NOAA, Regional Climate Services, Central Region** | Doug Kluk, Regional Climate Services Director | Collaborator | No |
| **NOAA, National Weather Service, Missouri River Basin Forecast Center** | Kevin Low, Hydrologist | Collaborator | No |

***End User Overview***

***End User’s Current Decision-Making Process:***The MCO currently communicates drought information through its drought dashboard, which displays metrics representing different climate variables from *in situ*, modeled, and remote sensing sources. MCO uses this dashboard as a tool to provide early warnings for periods of excess wetness or dryness to stakeholders including agricultural produces, water resource managers, and ranchers. MCO is seeking to integrate these variables into a single index that can streamline drought early warning efforts.

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

*Montana Climate Office* – The MCO houses climate, hydrology, and agricultural specialists. These specialists have experience developing remote sensing data products, including vegetation indices based on NASA Earth observations. They are interested in testing the development of a new CDI product.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*NOAA, Regional Climate Services, Central Region* – NOAA Regional Climate Services of the Central Region will provide input into the weighting scheme of the index and help interpret the results of the validation based on its knowledge of climate in the region.

*NOAA, National Weather Service, Missouri River Basin Forecast Center* – The Missouri River Basin Forecast Center will provide input into the weighting scheme of the index and help interpret the results of the validation based on its knowledge of the hydrology of the region.

***Dissemination by Boundary Organizations*:**

*Montana Climate Office* – The goal of the project will be to integrate the CDI in the MCO’s drought dashboard. Through this dashboard, MCO will disseminate the project results to stakeholder groups through workshops and drought briefing events.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The DEVELOP team will plan to communicate with the partner organizations for planning methodology and feedback sessions via teleconference calls and video chat on a biweekly basis.

***Transition Plan*:** During the final week of the project, the DEVELOP team will hold a virtual hand-off meeting to review final results. This meeting will provide an overview of hand-off materials, including a tutorial for project methods and a discussion of the performance assessment. The hand-off will ensure that partners understand how to use the tutorial materials so that they can reproduce the methods and continue analysis beyond the scope of the project.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **GPM IMERG** | Precipitation | The team will compute precipitation accumulation and anomalies for the current day and previous month. |
| **Suomi NPP VIIRS** | Normalized Difference Vegetation Index (NDVI) | The team will compute NDVI to measure vegetation stress for the time period of interest |
| **Terra MODIS** | NDVI, Normalized Difference Snow Index (NDSI) | Terra MODIS will provide long-term NDVI and NDSI values to compute anomalies in these variables for the current day based on the past twenty years of normals. |
| **SMAP** | Surface and Root Zone Soil Moisture | The team will input the Surface and Root Zone Soil Moisture values into their weighting methods. |

***Ancillary Datasets:***

* NOAA National Centers for Environmental Prediction (NCEP) Real-Time Mesoscale Analysis (RTMA) – Extraction of daily max temperature, wind speeds, and dew point as input into the index.
* NOAA Snow Data Assimilation System (SNODAS) – use of Snow Water Equivalent (SWE) values to determine snow water availability during snow cover seasons
* USDA Soil Climate Analysis Network (SCAN) – The team will extract soil moisture values and anomalies for the current and past month. Some of these data points will be used as validation data to assess the Composite Drought Index performance of measuring historic wetness and dryness.
* USGS stream gauge data – The team will use stream gauge data to determine periods of excess wetness and dryness over the past twenty years.

***Software & Scripting:***

* ESRI ArcMap – map generation, raster analysis, land cover classification
* Google Earth Engine – data acquisition, classification
* R – data acquisition and analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **CDI Outputs & Computational Framework** | The framework will provide map outputs of during events of interest in the study period for reference, as well as the framework of calculation and lessons learned for the proof of concept of the CDI computation. | Current and antecedent climate conditions will be derived from anomalies of precipitation (GPM IMERG), NDVI (Suomi NPP VIIRS, Terra MODIS), NDSI (Terra MODIS), and soil moisture (SMAP). | N/A |
| **CDI Performance Assessment** | The performance assessment will highlight the optimal weighting scheme of the CDI that best reflects historic wet and dry periods. | Climate conditions derived from GPM IMERG, Suomi NPP VIIRS, Terra MODIS, and SMAP will be weighted into an index and validated against historic stream gauge data. | N/A |

***End User Benefit*:** The goal of this project is to create the framework of a CDI based on the climate considerations for the state of Montana. The MCO will be able to use this framework to further optimize the CDI and integrate the index into their existing drought indicators dashboard. The CDI will provide a single, objective value of relative wetness and dryness that will streamline drought early warning communication to stakeholder groups who might be unfamiliar with other drought monitoring tools.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2020 Fall

***Related DEVELOP Work:***

2018 Fall (NC) – Missouri River Basin Disasters: Utilizing NASA Earth Observations and NOAA Climate Data Records to Produce Climate Indicators of Rangeland Health and Wildfire

2020 Spring (MSFC) – Kenya Food Security & Agriculture II: Using NASA Earth Observations to Enhance Drought Warning Systems and Develop Capacity to Use the RHEAS Model in Kenya

**Notes & References:**

***Notes*:** This project will build upon the existing drought communication efforts of MCO via their Upper Missouri River Basin Drought Indicators Dashboard (<https://drought.climate.umt.edu/>).

***References:***

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