**NASA DEVELOP National Program**

**Fall 2015 Project Proposal**

NOAA National Centers for Environmental Information

**Missouri River Climate**

Utilizing NASA Earth Observations and NOAA Climate Data Records to Model Runoff in the Upper Missouri River Basin

**Objective:**To model long-term runoff in the Upper Missouri River Basin for improved understanding of the influence and variability precipitation and snow water equivalent have on runoff in the basin, as well as assess the feasibility of using NASA Earth observations and NOAA satellite data to estimate runoff.

**Community Concern:**  
As the NOAA Central Regional Climate Service Director, Doug Kluck disseminates applicable climate and environmental information to decision makers in his region. The Missouri River Basin contains the largest reservoir system (by storage) in the United States. The Missouri River Mainstem Reservoir System is comprised of six dams and reservoirs located along the mainstem of the Missouri River. The system is operated by the U.S. Army Corps of Engineers (USACE) under the guidance of the USACE’s Missouri River Basin Water Management (MRBWM) office in Omaha, Nebraska. The three uppermost reservoirs, Fort Peck, Garrison, and Oahe, are located in the upper Missouri River Basin and contain nearly 90 percent of the system’s 71.4 million acre-feet (MAF) of storage. The system is operated to meet eight purposes authorized by Congress: flood control, navigation, irrigation, recreation, hydropower generation, water supply, water quality control and fish and wildlife, which includes threatened and endangered species. In order to accurately estimate water availability, it is import to understand the factors that contribute to runoff. A few of these contributing factors include evapotranspiration, precipitation, soil moisture, and plains and mountain snowpack melt. While it is understood that these variables impact runoff they aren’t completely incorporated into runoff forecasts through typical means. This can affect the ability that MRBWM has to make accurate decisions regarding reservoir releases to best meet all of the competing authorized purposes.

**Partner Organizations:**

NOAA Regional Climate Services Director (RCSD) (Boundary Organization, POC: Doug Kluck, NOAA Regional Climate Services Director, Central Region [Central RCSD])

Global Science & Technology (GST) National Centers for Environmental Information (NCEI) (Collaborator, POC: DeWayne Cecil, Chief Climatologist and Program Manager)

Missouri River Basin Water Management (MRBWM) (End-User, POC: Kevin Grode, Reservoir Regulation Team Lead)

NWS Missouri Basin River Forecast Center (Potential End-User, POC: Kevin Low, River Forecaster)

Contact has been made with Doug Kluck (Central RCSD) and several of his associates who are interested in this project. They are interested in an end-product that can assist with forecasting runoff, especially long-term forecasts. Additional interests are in understanding how annual, seasonal and monthly changes in precipitation, evapotranspiration, and snow water equivalent can improve runoff forecasts. We have made initial contact with two potential end-users Kevin Low (NWS Missouri Basin River Forecast Center) and Kevin Grode (MRBWM). Kevin Grode provided more information on his work at MRBWM and concerns that could be addressed through a NASA DEVELOP term. The end product of this project will be a model for estimating runoff which will start to address these concerns, which will be handed off virtually. Our model would be an additional tool to help improve the decision-making process in regard to water availability in the Missouri River Basin.

**Decision Making Process:**  
The MRBWM office is comprised of a small team of hydraulic engineers, computer specialists, and a biologist who are responsible for producing Missouri River Basin runoff and reservoir regulation forecasts to regulate the system. The MRBWM team is also responsible for providing accurate information concerning how the regulation of the system will affect the public regarding basin runoff, river flow, and health for several key sectors which include flood control, fish and wildlife, irrigation, hydropower, recreation, navigation, and threatened and endangered species. The MRBWM office currently provides monthly reach runoff forecasts for as far out as a year. These forecasts provide information on expected runoff, which are used in reservoir models to determine how much water will be available for use. Estimating runoff is difficult, especially for forecasts that extend out beyond a few months. Any project which can provide a better understanding of how contributing variables, i.e. temperature, soil moisture, and snowpack, impact water runoff at this scale will be useful to the objectives of the MRBWM team.

**Earth Observations:**

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| **Platform** | **Sensor** | **Geophysical Parameter** |
| **CMORPH-CDR** | IR Band | Precipitation Estimate |
| **PERSIANN-CDR** | GridSat-B1 IR Window Channel | Precipitation Estimate |
| **SMMR, SSM/I, SSMIS** | K- and Ka-bands assimilated with station data | ESA GlobSnow Snow-Water Equivalent |
| **MODIS Global Evapotranspiration Project (MOD16)** |  | Evapotranspiriation |
| **GRACE Assimilated Data** |  | Surface Soil Moisture and Root Zone Soil Moisture |

**NASA Earth Observations Highlighted:**

This project will utilize several different NASA and NOAA based sensors. The CMORPH and PERSIANN Climate Data Records (CDRs) are data products produced at NOAA National Centers for Environmental Information. These products provide global precipitation estimates. The PERSIANN-CDR, has a spatial resolution of 0.25 degrees and a length of recording extending from 1983 to present, which will be useful in establishing a base climatology for yearly, seasonal, and monthly precipitation. The CMORPH-CDR has a finer spatial resolution, 4km, and is updated every 30 minutes, but has a smaller length of record, 1991 – present, which makes it more useful for near real-time monitoring. The ESA GlobSnow Snow-Water Equivalent data product would be used to estimate snow-water equivalent for our study area. Evapotranspiration estimates will come from the MODIS Global Evapotranspiration Project (MOD16). GRACE Assimilated Data soil moisture product is one of the few remote sensing based products used to estimate soil moisture, which might also be included in the model.

**Ancillary Datasets:**

Global Historical Climate Network (GHCN) Daily and GHCN Monthly precipitation data will be used to establish a larger precipitation climatology, if needed

NOAA in-situ water runoff data will be used to assess the model

**Decision Support Tools & Analyses:**

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| **Proposed End Products** | **Decision to be Impacted** | **Current Partner Tool/Method** |
| Runoff Estimation Model | This model will be a tool to better estimate the available water for irrigation for several needs including but not limited to, agriculture, preventative flood measures, and levees. This could also help state, tribal, and federal agencies plan better for ecosystem recovery efforts currently underway. Understanding available water resources would also help Corps better balance meeting the authorized purposes for a multi-purpose reservoir system. | They have existing models for estimating available water in their reservoirs. Additionally, reports are produced covering runoff estimates. The proposed model would improve current methods by modeling the key predictors that influence run-off. |
| Runoff Maps | These set of maps will show how runoff is predicted to change and how the relationship between each variable and runoff changes throughout the study area | Map produced at other agencies (i.e. NOAA or CPC) which depict the current and expected conditions of variables which impact runoff (i.e. precipitation forecast and drought severity index). These maps do not examine the relationship between these variables and run off. |

*Runoff Estimation Model* - This will be a model that estimates run-off associated with the Missouri River Basin in the Upper Missouri River Basin. Key predictors for the model include snow water equivalent, precipitation, evapotranspiration, and soil moisture. This model will help determine the statistical relationship between these predictors and runoff.

*Runoff Maps* – A set of maps show the results of the model at a yearly, seasonal, and monthly time scale. These maps will depict the modeled change in runoff and the relationship between runoff predictors and runoff.

**Project Details:**

**National Application Areas Addressed:** Climate, Water Resources, Agriculture

**Source of Project Idea:** This project came from a series of conversations between the NCEI Center Lead and Doug Kluck (Central RCSD), Kevin Grode (Missouri River Basin Water Management), Mark Svoboda (National Drought Mitigation Center), and Dr. Dennis Todey (South Dakota State Climatologist).

**Study Location:** Upper Missouri River Basin: South Dakota, North Dakota, and Wyoming

**Period being Studied:** January 1990 to January 2014

**Advisors:** Dr. DeWayne Cecil (GST/CDR), Doug Kluck (RCSD)

Participants Requested: 4

**Project Timeline:** 2 Terms: 2015 Fall to 2015 Spring

**Multi-Term Objectives:**

* **Term 1(Proposed Term)** – Land cover and land practices are big issues in the Missouri basin. For example, as more grassland has been tilled and planted runoff becomes more likely. A project that examines the correlation between runoff and land use change and then adapts the model created in this term to account for this relationship. End products would include graphs and map depicting the correlation of runoff with various types of land use cover types and a land use cover adjusted run off model.
* **Term 2** – refine land cover / land use change measurements and correlations with runoff. Validate runoff estimation model results. Create tutorials and transition package for end-users.

**Software & Scripting Requested:**

* ERDAS IMAGINE – land classification of Landsat imagery
* ArcGIS 10.3.1 – raster manipulation/analysis, image enhancement, METRIC Model, runoff model, & map creation
* R – statistical analysis