**NASA DEVELOP National Program**

NCEI - Asheville, NC

**Fall 2015**

**Short Title: Missouri River Climate**

**Subtitle:** Understanding Driver Variables of Runoff in the Missouri River Basin for Improved River System Management

**VPS Title:** Informed River Management: Trends in environmental drivers of river runoff from Earth Observations in the Missouri River Basin

**Project Team & Partners**

**Project Team:**

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**Advisors & Mentors:**

DeWayne Cecil (Global Science & Technology, National Centers for Environmental Information)

**Past or Other Contributors:**

Dennis Todey (South Dakota State University)

**Partner Organizations:**

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

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

**Project Details**

**Applied Sciences National Applications Addressed:** Climate, Water Resources, Agriculture

**Study Area:** Missouri River Basin: MT, ND, SD, WY, NE, KS, MO, CO, IA, MN

**Study Period:** Jan 1983 - Dec 2014

**Earth Observations & Parameters:**

PERSIANN CDR – Precipitation Estimation

CMORPH CDR – Precipitation

GRACE Assimilated Data – Surface Soil Moisture and Root Zone Soil Moisture

MODIS Global Evapotranspiration Project (MOD16) – Evapotranspiration

SMMR, SSM/I, SSMIS K- and Ka-bands assimilated with station data, ESA GlobSnow Snow-Water Equivalent

AMSR-E/Aqua Daily L3 Global Snow Water Equivalent EASE-Grids – Snow Water Equivalent

TRMM, PR – rainfall measurements

MEaSUREs – Snow Cover Extent

**Ancillary Datasets Utilized:**

* USGS National Land Cover Dataset (NLCD) – land cover
* NOAA Global Historical Climatology Network (GHCN) – *in situ* precipitation
* NOAA NCEP CPC Morphing Technique (CMORPH) – Precipitation Estimates
* NCEP North American Regional Reanalysis: NARR – air temperature
* USGS Water Data – *in situ* water runoff data
* NRCS Soil Climate Analysis Network (SCAN) – *in situ* soil moisture and temperature & snowpack characteristics

**Models Utilized:**

* NOAA Frost depth estimation from air temperature model
* CRREL Snow water equivalent estimation from CRREL

**Software Utilized:**

Dnppy – Python scripting

wget – Ftp download

R – Data processing, statistical analysis, graphing

ArcGIS – data visualization, raster manipulation/analysis, image enhancement & map creation of Aqua/Terra MODIS

TerrSet – time series extraction, seasonal trend analysis

Groovy – algorithm computation

Microsoft Excel – Simple graphing

Microsoft Word – word processing

Microsoft Powerpoint – presentation creation

**Project Overview**

**Objectives Overview:**

This project improves the understanding of runoff in the Missouri River Basin with a focus on the Northern Plains Region. It uses NASA Earth Observations validated with NOAA climate data to detect frost depth, soil moisture, and snowpack characteristics in the upper basin. It analyzes the trends in these environmental variables and compares them with trends in precipitation, evapotranspiration, and runoff.

**Abstract:**

The Missouri River flows through a semi-arid region causing highly variable discharge and impacts the livelihood of the residents of six states. The Missouri River Basin Water Management team under the Army Corps of Engineers make informed management decisions for controlled releases from the reservoirs in the Basin. These decisions have consequences for residents of the region and those who depend on the sustained flow of water. However, there is a vital need for improved understanding of the influence of terrestrial and climatic variables on trends in runoff to facilitate better forecasting by the Corps. Environmental variables such as frost depth, soil moisture, snowpack, and precipitation have an unquantified influence on river volume. In particular, coverage of the Northern Plains Region of the Basin on-the-ground monitoring sites is sparse, resulting in a data-poor region and incomplete understanding of the driver variables of runoff. This project uses satellite data from a broad selection of NASA Earth Observation satellites, such as GRACE and MODIS, selecting for long-term (greater than 30-year time series) to improve the understanding of trends for runoff driver variables. However, such a long term study is constrained to only those variables for which 30-year satellite records exist. NOAA’s Climate Research Data is used to validate the measurements of the NASA satellite sensors.

**Community Concerns**

* The U.S. Army Corps of Engineers and the Missouri River Basin Water Management (MRBWM) team need to understand the impact on runoff of certain variables in the Missouri River Basin, including climatic (ENSO, climate trends) and hydrologic variables (soil moisture, snow water equivalents, frost depth, and precipitation).
* MRBWM is especially interested in changing trends for these variables and how these will affect runoff in the future.
* The U.S. Army Corps of Engineers wants to incorporate new data variables, trends, and methods of prediction to increase the efficiency of Missouri River Basin runoff predictions. Better runoff predictions will yield more efficient and effective management of the MRBWM’s reservoir system.

**Current Management Practices & Policies**:

Missouri River Basin Water Management operates their reservoir system based on runoff predictions produced by the U.S. Army Corps of Engineers. The Corps produces a monthly forecast of the expected annual runoff each calendar year with improved forecasting updates for remaining months as the year progresses. This forecast takes into account present basin conditions, such as soil moisture and snowpack, as well as historical trends and long-range weather expectations. Each month, these runoff forecast estimates are used as input to a 3-week forecast, which forecasts reservoir inflows, releases, storage levels, and hydropower generation among other things. The Corps has access to a wealth of *in situ* data and utilize a regression analysis of the past thirty years for mountain snowpack runoff. However, there are several areas within the Upper Missouri River Basin that are relatively data poor regions. For example, although mountain snowpack runoff is well known, there is little available information for surface water storage and snow water equivalents within the plains region of the basin. Our study aims to improve the knowledge base of these little-known areas.

**Decision Support Tools & Benefits:**

|  |  |  |
| --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Benefit & Impact** |
| Historical trend analysis of requested variables: soil moisture, snow characteristics, and frost depth | Soil moisture - GRACE/SMAP/MEaSURESSnow characteristics - SMMR/SSM/I/MEaSURESFrost depth - MODIS | Calculations and written conclusions concerning historical trends in the study region provide useful information on little-known variables for future management |
| Correlational study | Data acquired from list above | Calculations and written conclusions overviewing a correlational study of our variables and stream runoff provide a better understanding of the area’s environmental relationships, improving the Corps’ ability to manage their watershed |
| Climatology graphics and interactive map | Data acquired from list above | Visualizations, both graphically and in an interactive map, of past trends aid Corps managers in planning for the future |

**Project Imagery**

 **[Insert image here]**

**Caption:** [Insert Caption Here. Max of 25 words.] Image Credit: [Insert project short title] Team.

**Image:** File Name (Please submit your image as a separate .jpeg as well as inserting it in this document)

**Software Release Requirements**

What category do the tools your project is creating fall within? [Category I to V]

If your decision support tools fall within Category IV, fill out this section:

**Software Title:** Insert here (ex. DEVELOP National Program Python Package)

**Software Abbreviation:** Insert here (ex. dnppy)

**Technical Point of Contact:**

Insert full name, permanent email, and node here. Also include whether employed through SSAI or Wise County. (Team member who knows the most about the software.)

**Brief Description of the Software:** Insert here (ex. The dnppy package will be used to functionalize common programming tasks in the geospatial community, specifically for working with NASA data products. It will include functions for processing satellite data and assist in structuring analysis to reduce the startup time for DEVELOP teams to learn programming and create tools for end users.)

**Type of Code:** *Executable Code* and/or *Source Code* (Select one or both)

**Will the software include any embedded computer databases?** *Yes* or *No* (Select one)

**Does the software use or call any open software or libraries?** *Open Source* and/or *Proprietary/Commercial* (Select one or both)

**List the software or libraries used, under what license they were obtained, and the URL for the license in the table below:**

|  |  |  |
| --- | --- | --- |
| **Name** | **License** | **License URL** |
| Ex. Arcpy module | Ex. group license through ArcGIS | http://www.esri.com/software/arcgis |
| Ex. Python | Ex. Open source license | http://opensource.org/licenses/Python-2.0 |
|  |  |  |

**Full Software Description and Plan**

**Introduction/Objective:**

What motivated the creation of this software, what problem does it address?

**Applications and Scope:**

Where and how will this software be used to influence decisions?

**Capabilities:**

What can it do better than what was previously available?

**Interfaces:**

How is one expected to use the software? For example, command line, GUI, script execution, etc.

**Assumptions, limitations, & Errors:**

What areas that the software could be improved upon in the future? This is where limitations of the theory, model, science, etc should be briefly documented. If the tools only work for a specific scenario, say so.

**Testing:**

What validation techniques and testing strategy will be used to build confidence in the software?