**NASA DEVELOP National Program**

NOAA National Centers for Environmental Information

**Fall 2015**

**Short Title: Missouri River Climate**

**Subtitle:** Using NASA and NOAA Satellite Observations to better understand Runoff in the Missouri River Basin for Improved River System Management and Decision Support.

**VPS Title:** The Run-off Run-down: Environmental Drivers in the Missouri River Basin

**Project Team & Partners**

**Project Team:**

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**Advisors & Mentors:**

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**Other Contributors:**

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**Partner Organizations:**

NOAA Regional Climate Services Director (RCSD) (End-User/Boundary Organization), POC: Doug Kluck

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

**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:** Sep 1979 - Dec 2014

**Earth Observations & Parameters:**

NOAA NCEI Precipitation Estimation from Remotely Sensed Information using an Artificial Neural Network (PERSIANN) Climate Data Record (CDR) – Precipitation Estimation

NOAA NCEP/NCEI CPC Morphing Technique (CMORPH) CDR – Precipitation Estimates

NASA Gravity Recovery and Climate Experiment (GRACE) Assimilated Data – Surface Soil Moisture and Root Zone Soil Moisture

Aqua, sensor MODIS – Evapotranspiration

Defense Meteorological Satellite Program (DMSP), sensors SMMR, SSM/I, SSMISESA GlobSnow – Snow Water Equivalent

NASA National Snow and Ice Data Center (NSIDC) AMSR-E/Aqua Daily L3 Global Snow Water Equivalent EASE-Grids – Snow Water Equivalent

TRMM, Precipitation Radar – Rainfall measurements

NASA NSIDC Making Earth System Data Records for Use in Research Environments (MEaSUREs) – Snow Cover Extent

**Ancillary Datasets Utilized:**

* USGS National Land Cover Dataset (NLCD) – Land cover
* NOAA NCEI Global Historical Climatology Network (GHCN) – *In situ* precipitation
* NOAA 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 NCEI Frost depth estimation from air temperature model
* U.S Army Corps of Engineers CRREL Snow water equivalent estimation from CRREL

**Software Utilized:**

Dnppy – Python scripting

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

**Project Overview**

**Objectives Overview:**

The overall objective of this project is to improve the understanding of water supply and runoff in the Northern Plains Region of the Missouri River Basin using NASA Earth observations and NOAA *in situ* and satellite Climate Data Records (CDRs). Long term analysis of frost depth, soil moisture, snowpack characteristics, precipitation, evapotranspiration, and runoff in the upper basin will also be conducted.

**Abstract:**

The Missouri River flows through a semi-arid region, causing highly variable discharge, which directly affects the livelihood of the residents of six states. The MRBWM Team, under the Army Corps of Engineers, makes informed management decisions for controlled releases from the reservoirs in the Basin. These decisions have consequences for residents and ecosystems within the region that depend on the sustained flow of water. Environmental variables such as frost depth, soil moisture, snowpack, and precipitation have an unquantified influence on river volume. In particular, the Northern Plains Region of the Basin is not adequately covered by on-the-ground monitoring sites, resulting in a data-poor region and an incomplete understanding of the driving variables of runoff. This project uses satellite data from a broad selection of NASA Earth observation satellites and NOAA Climate Data Records (CDRs) and *in situ* datasets, to improve the understanding of water availability and runoff. Satellite observations were validated using *in situ* observations from NOAA and USGS.

**Community Concerns**

* Being able to better understand runoff in the basin will enable the MRBWM and the U.S. Army Corps of Engineers to make informed water management decisions and potentially improve the quality of flood control, navigation, irrigation, recreation, hydropower generation, water supply, and water quality.
* There are many endangered species and communities in the Basin that depend on the availability of water from the reservoirs.
* The MRBWM’s runoff forecasts are used by basin stakeholders to make business decisions that are affected by reservoir releases. Stakeholders include hydropower providers, fisheries, farmers, and river transportation companies.

**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 inputs 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 utilizes 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.

**Decision Support Tools & Benefits:**

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| **End-Product** | **Earth Observations Used** | **Benefit & Impact** |
| Historical trend analysis of requested variables: soil moisture, snow characteristics, and frost depth | AMSR-E/SMAP/MEaSURES  SMMR/SSM/I/MEaSURES/ GOES | Calculations and written conclusions concerning historical trends in the study region provide useful information on little-known variables for future management. |
| Correlational study | AMSR-E/SMAP/MEaSURES  SMMR/SSM/I/MEaSURES/ GOES | 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 | AMSR-E/SMAP/MEaSURES  SMMR/SSM/I/MEaSURES/ GOES | 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**

This project’s software tools fall within category I. R, IDL, and ArcGIS codes are being used but only the results are handed-off to end-users.