**NASA DEVELOP National Program**

NOAA National Centers for Environmental Information - Asheville, NC

**Fall 2015**

**Short Title: Missouri River Climate**

**Subtitle:** Understanding Runoff in the Missouri River Basin using NASA and NOAA satellite observations for Improved River System Management and Decision Support

**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:**

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**Past or Other Contributors:**

Dennis Todey (South Dakota State University)

**Partner Organizations:**

NOAA Regional Climate Services Director (RCSD) (end-user), POC: Doug Kluck, NOAA NCEI 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:**

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

MODIS Global Evapotranspiration Project (MOD16) – Evapotranspiration

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

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:**

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 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. 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 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.
* Being able to better understand runoff in the basin will directly affect the quality of flood control, navigation, irrigation, recreation, hydropower generation, water supply, and water quality.

**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 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. Our study aims to improve the knowledge base of these data-sparse areas.

**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 | 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**

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**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)