Developing an integrated modeling framework for Rio Grande Basin water resource management

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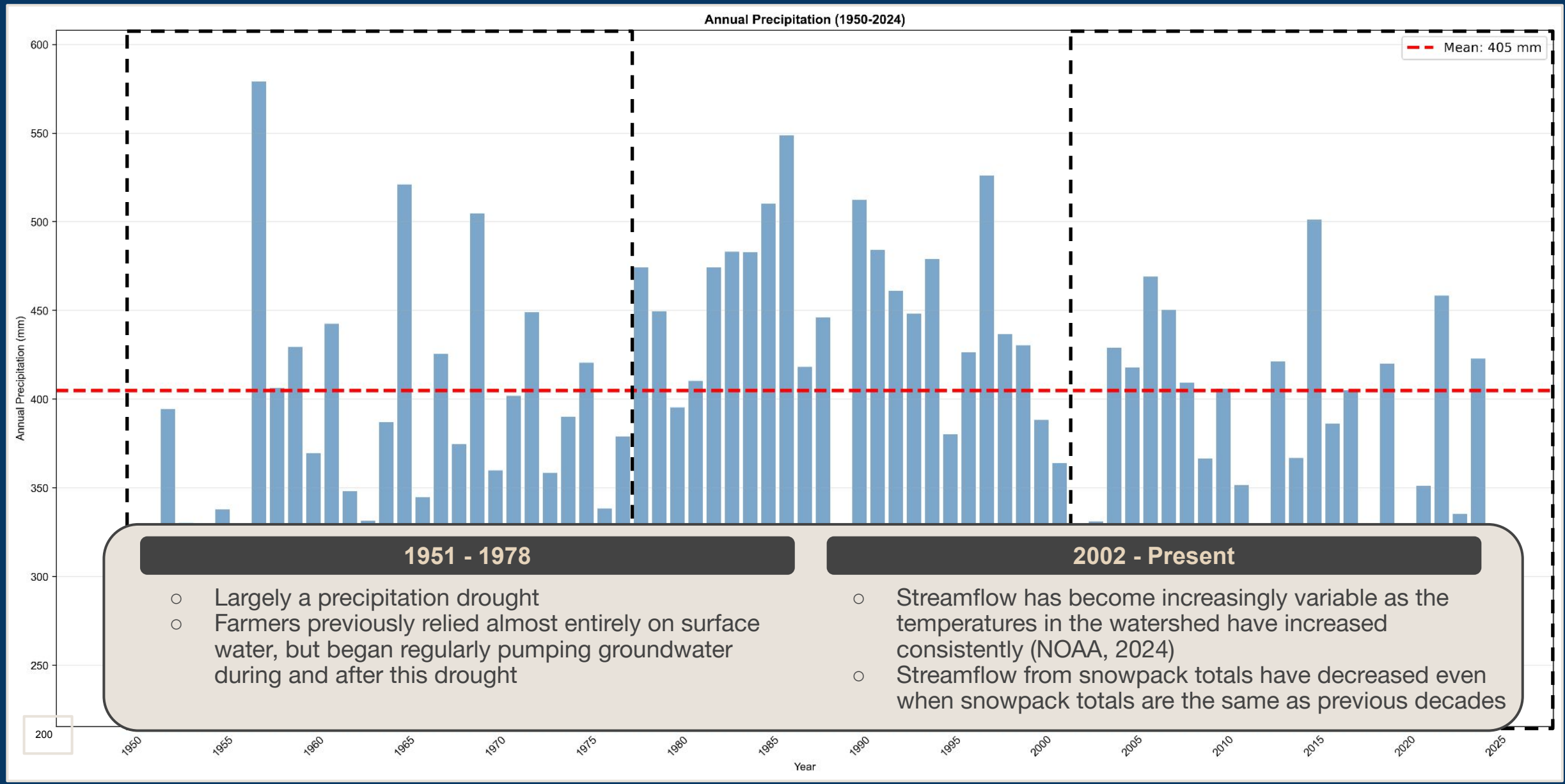
The Rio Grande Basin has experienced over 20 years of drought.



1951 - 1978

- Largely a precipitation drought
- Farmers previously relied almost entirely on surface water, but began regularly pumping groundwater during and after this drought

2002 - Present

- Streamflow has become increasingly variable as the temperatures in the watershed have increased consistently (NOAA, 2024)
- Streamflow from snowpack totals have decreased even when snowpack totals are the same as previous decades

Policy Context

Rio Grande Project

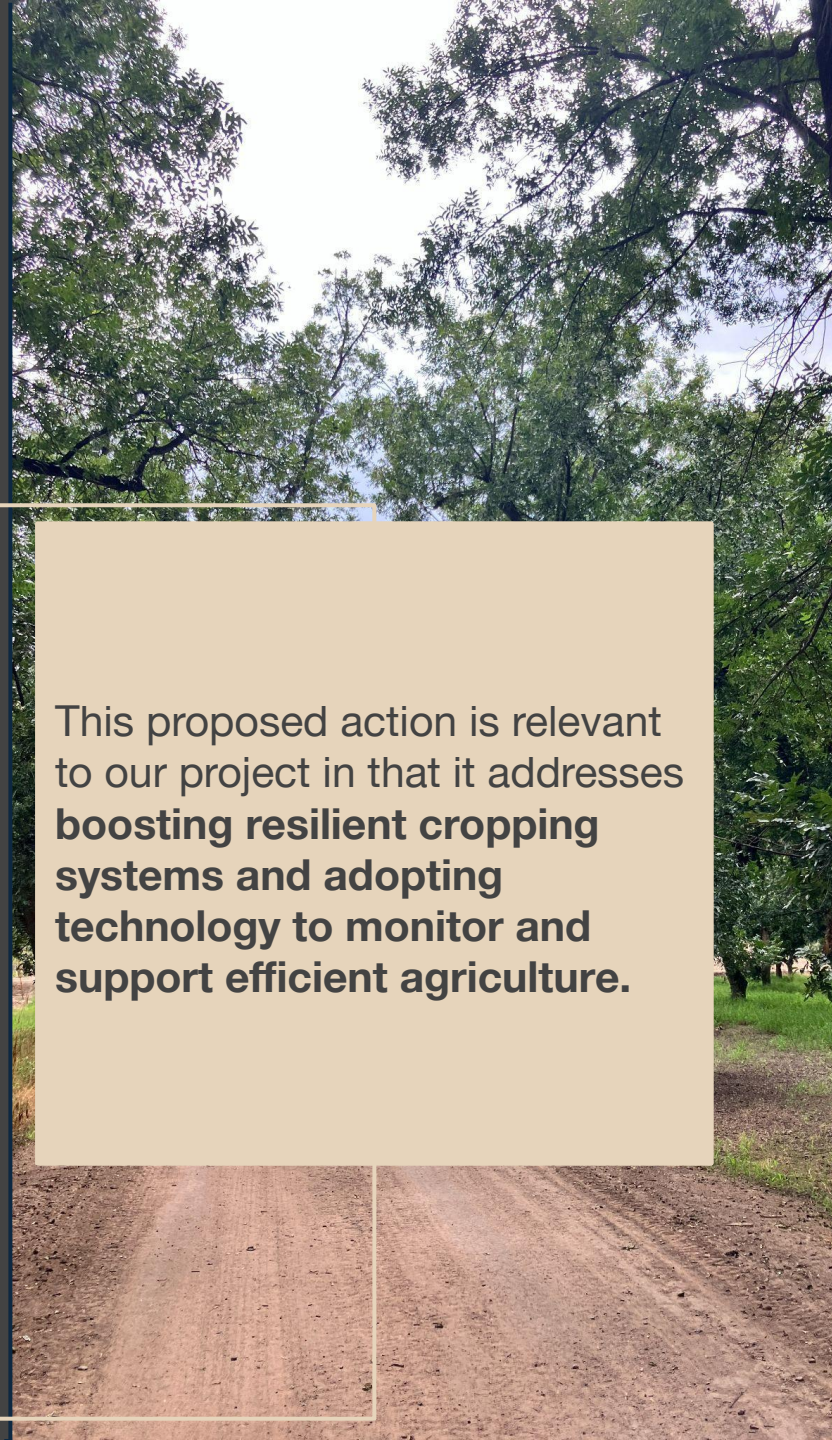
Federal Project started in 1916 led by the Bureau of Reclamation that includes New Mexico, Texas, and Mexico. It created a system of dams, miles of canals, hydroelectric plants, and drains to provide irrigation for over 178,000 acres of land [1]

Rio Grande Compact*

A 1938 interstate agreement between Colorado, New Mexico, and Texas to equitably apportion the waters of the Rio Grande River, using a debt and credit system to account for water between upstream and downstream users [2]

New Mexico 50 Year Water Plan

Action A2 under Water Conservation:
“Develop tools and policy incentives to expand water conservation and resilience in the agricultural sector through initiatives that increase producers’ voluntary adoption of high-efficiency irrigation technology (e.g., soil moisture sensors, remote controlled equipment, and application of satellite-based evapotranspiration data) and drought resilient, low water-demand crops.”



This proposed action is relevant to our project in that it addresses **boosting resilient cropping systems and adopting technology to monitor and support efficient agriculture.**

Objectives

The aim of this project is to further improve water allocation strategies in the Rio Grande River Basin by providing complementary surface water availability information to irrigation districts for effective decision-making.

This proposal aims to address two specific water resource management needs identified in the RG Basin assessment:

a) *Integrated Data/Information System and Modeling (4.1.2)*

b) *Improved water supply forecasts to support planning and farm management (4.2.3)*

Partners and Stakeholders

Decision-maker

J. Phillip King — Elephant Butte Irrigation District

Integration and Data Dissemination Team

Hatim Geli — New Mexico State University

Stacy Timmons — New Mexico Water Data Institute

Technical Team

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University of Alabama in Huntsville

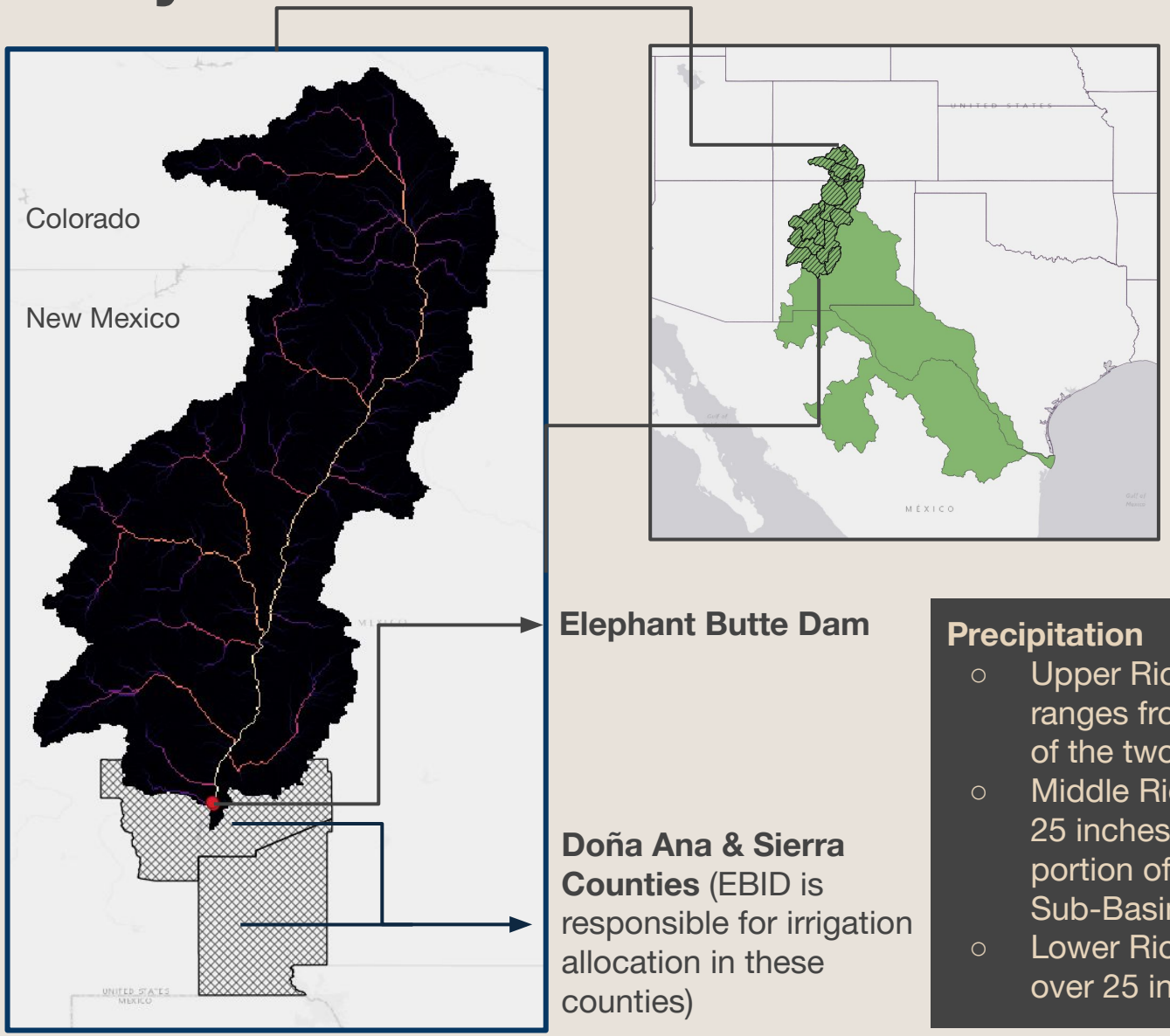
New Mexico State University

NASA SPoRT

New Mexico Data Initiative

Elephant Butte Irrigation District

Study Area



Elephant Butte Dam

Doña Ana & Sierra Counties (EBID is responsible for irrigation allocation in these counties)

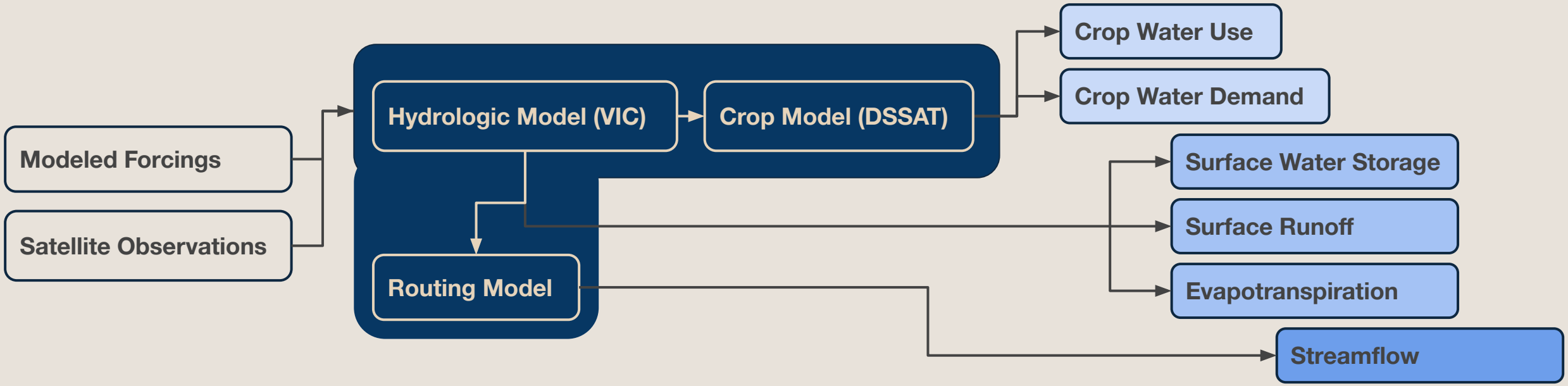
Precipitation

- Upper Rio Grande Basin: annual rainfall ranges from 9 inches in the upper portion of the two sub-basins to 15 inches
- Middle Rio Grande Sub-Basin: averages 25 inches of rain, as does the western portion of the Lower Rio Grande Sub-Basin.
- Lower Rio Grande Sub-Basin: receives over 25 inches of rainfall

Approach

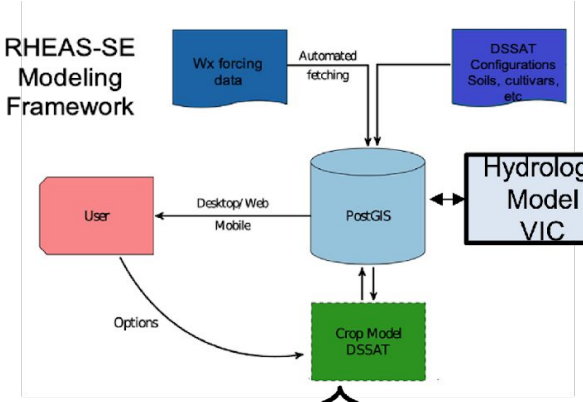
The aim of this project is to better assess surface water availability in the upper and middle Rio Grande Basin to support decision makers, especially irrigation districts.

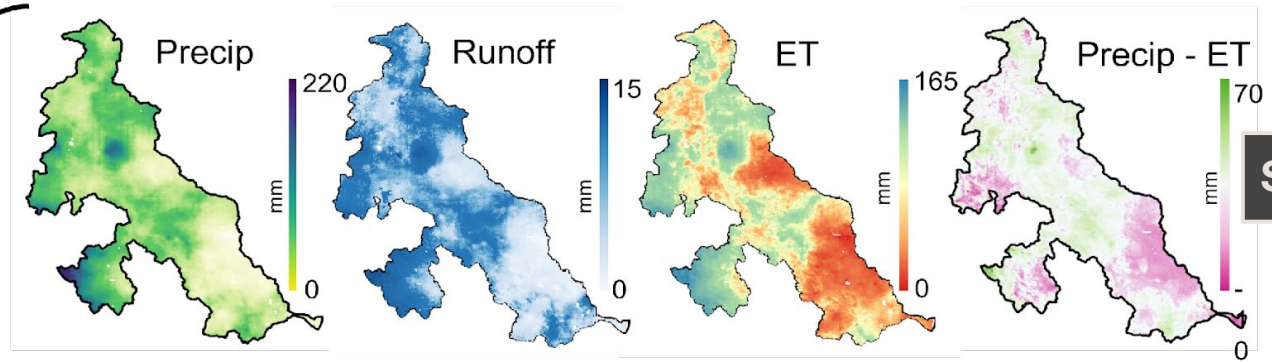
To do this, we are developing a special instance of a global modeling framework called Regional Hydrological Extremes Assessment System **(RHEAS)** tailored for the Rio Grande Basin.



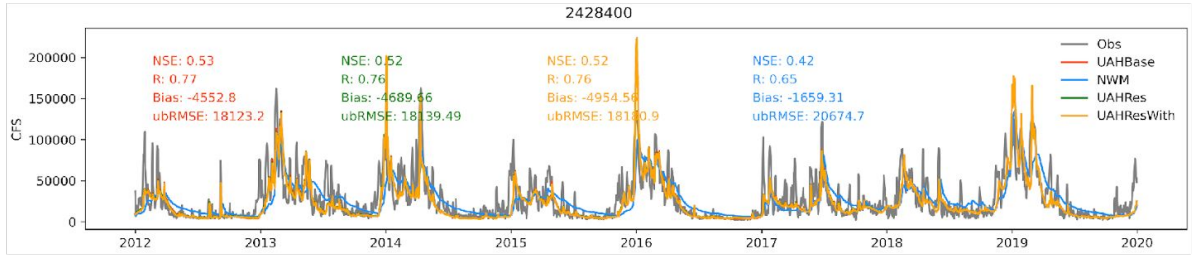
We are using several modeling tools and datasets that are directly or indirectly supported by NASA.
The *RHEAS* framework was developed by NASA JPL. Additionally we are using multiple model/satellite products to evaluate the mode performance including *NASA SPoRT LIS, SMAP, ALEXI ET , and OpenET.*

Integrated Modeling Framework Approach





STEP 1



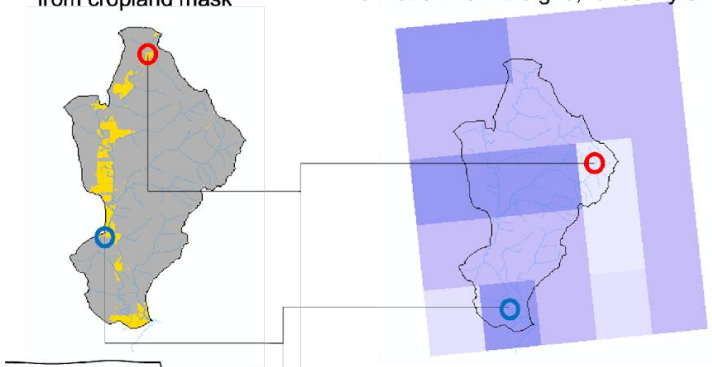
STEP 2

Surface Water Availability

The DSSAT Crop model is run stochastically over an AOI (HUC-12), sampling n times (# of ensembles chosen) over **weather** inputs, **soil,** and **cultivars** randomized over the area

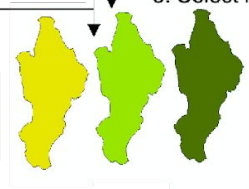
1. Randomly select soils from cropland mask

2. For each selected soils, select weather information from the grid, randomly chosen.



Cultivar - 1
Cultivar - 2
Cultivar - 3
…

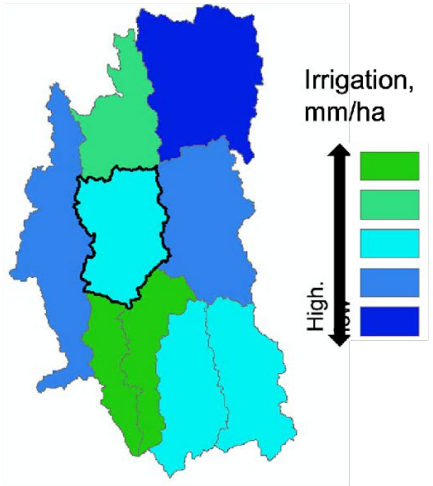
3. Select random cultivar from a curated list

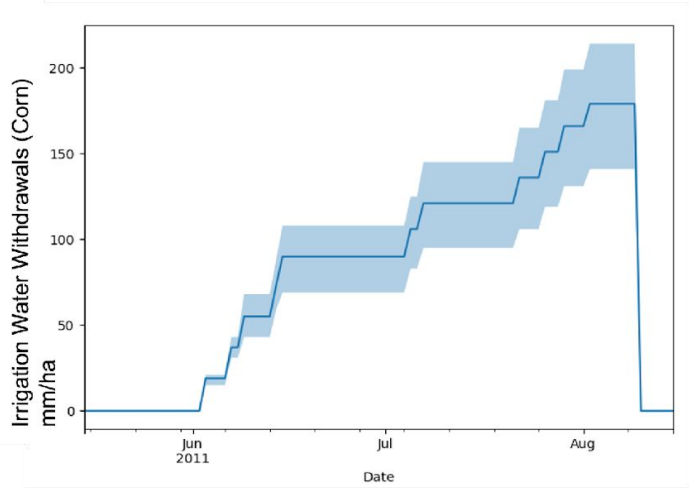


OUTPUT: n number of simulations (and associated stats) of yield, irrigation demand, etc.

STEP 3

Irrigation Demand Statistics @ HUC 12



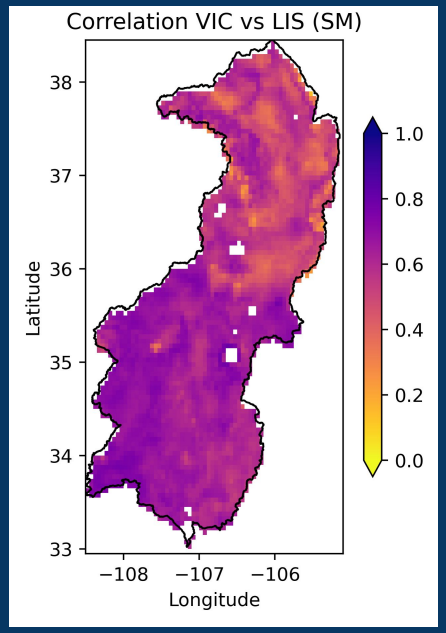


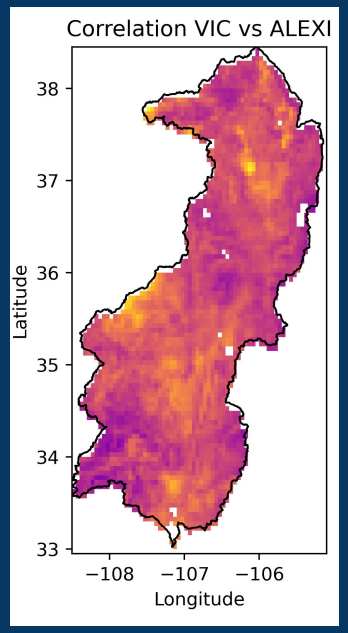
STEP 4

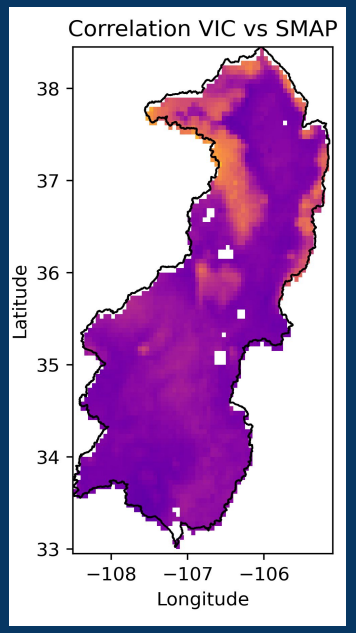
Preliminary Results
(Hydrology Model)

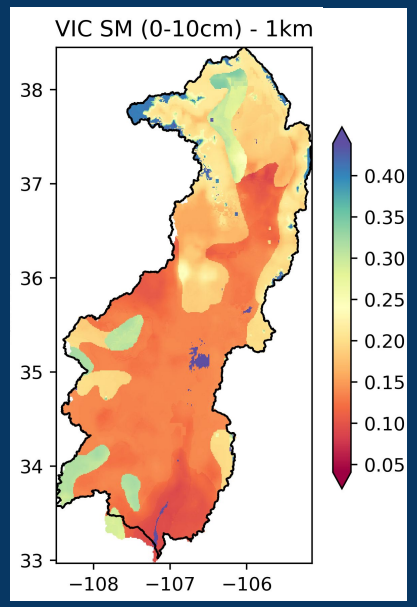
- VIC simulations at 5-km Resolution (2000-2023)
- All model evaluations are performed from 2015-2023

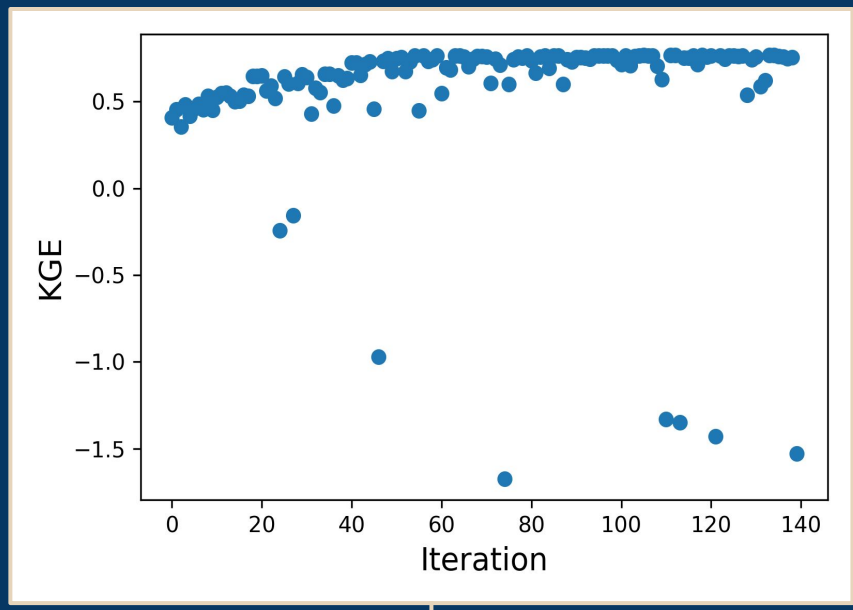
	Bias	RMSD	R
VIC/LIS (SM)	0.05	0.07	0.60
VIC/SMAP	-0.01	0.05	0.68
VIC/ALEXI	2.89	3.15	0.47







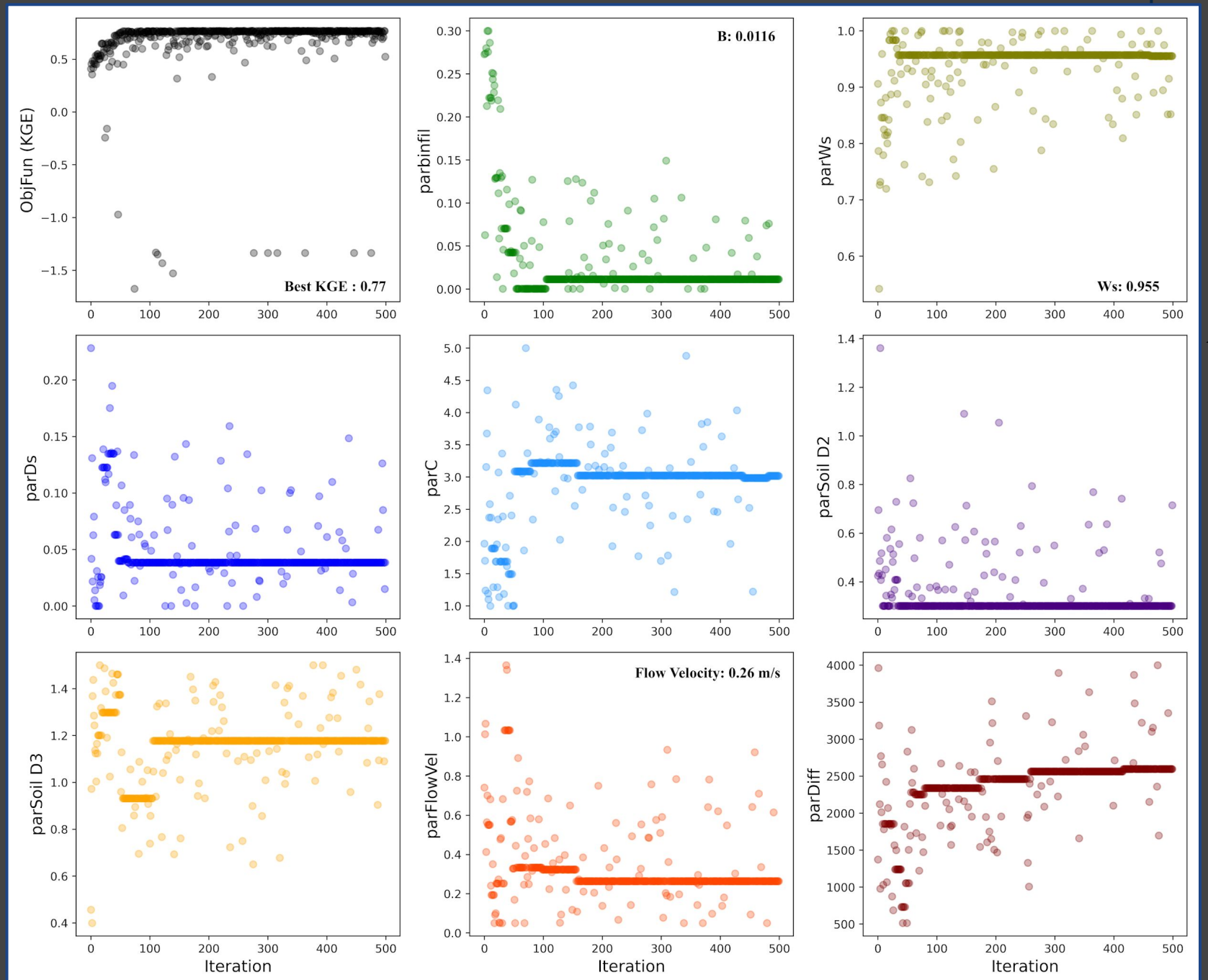




Next Steps:
Enhance the default model resolution from 5 km to 1 km by adding high resolution soil and vegetation parameters

Further calibrate the model to better simulate the streamflow

Preliminary Results



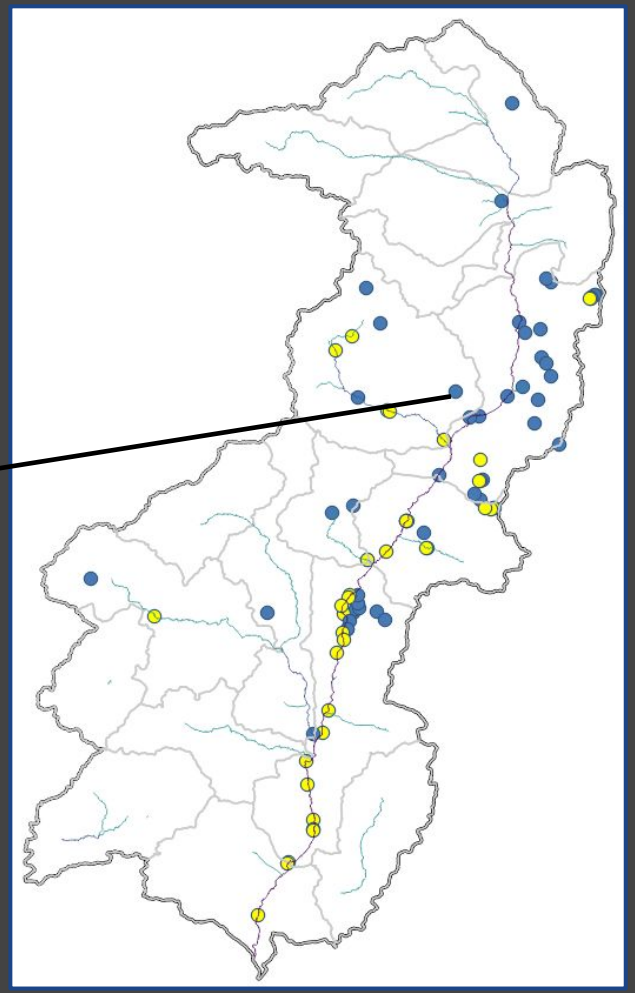
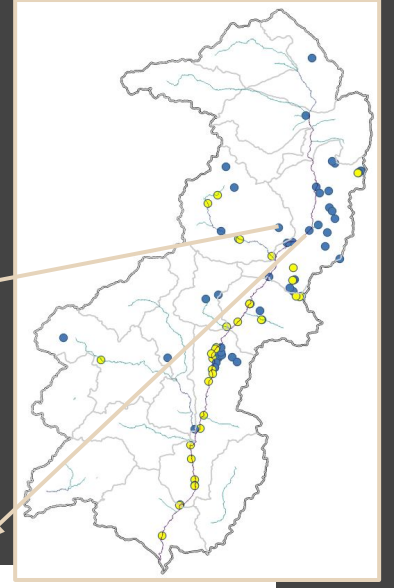


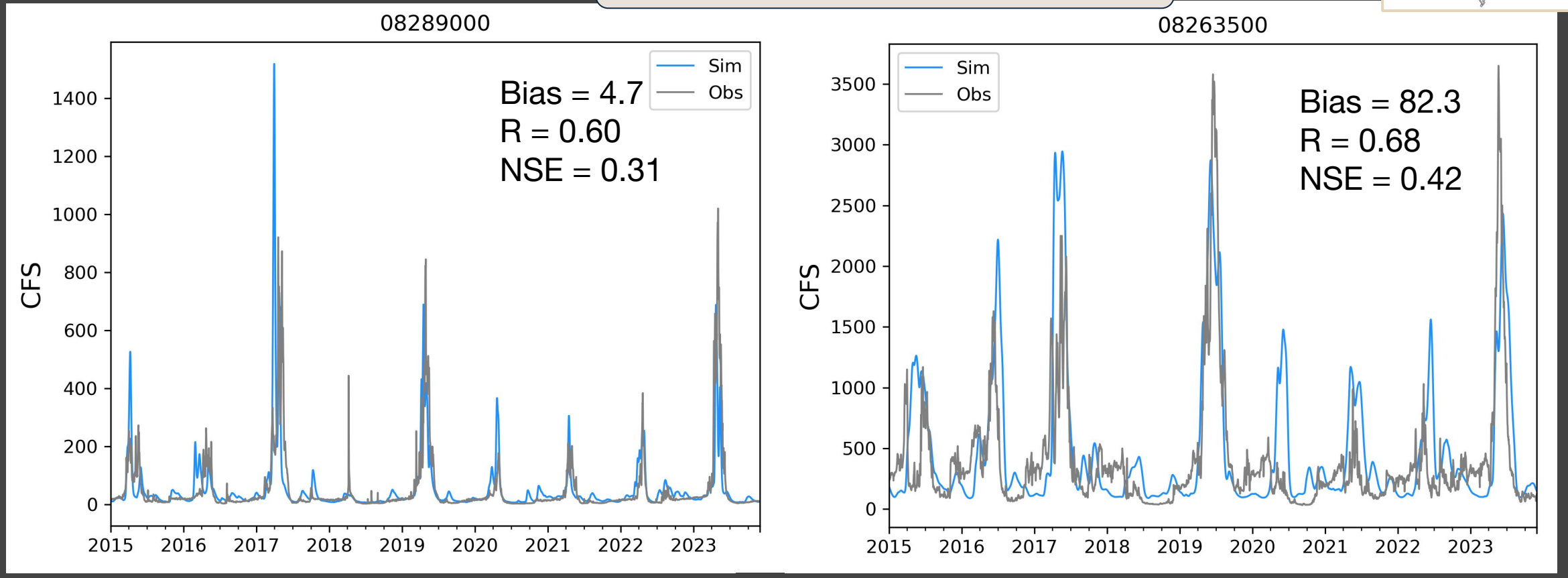
Figure shows the VIC parameter evolution with each calibration iteration for one of the calibration sites. The DDS calibration algorithm was used in this case.

Preliminary Results

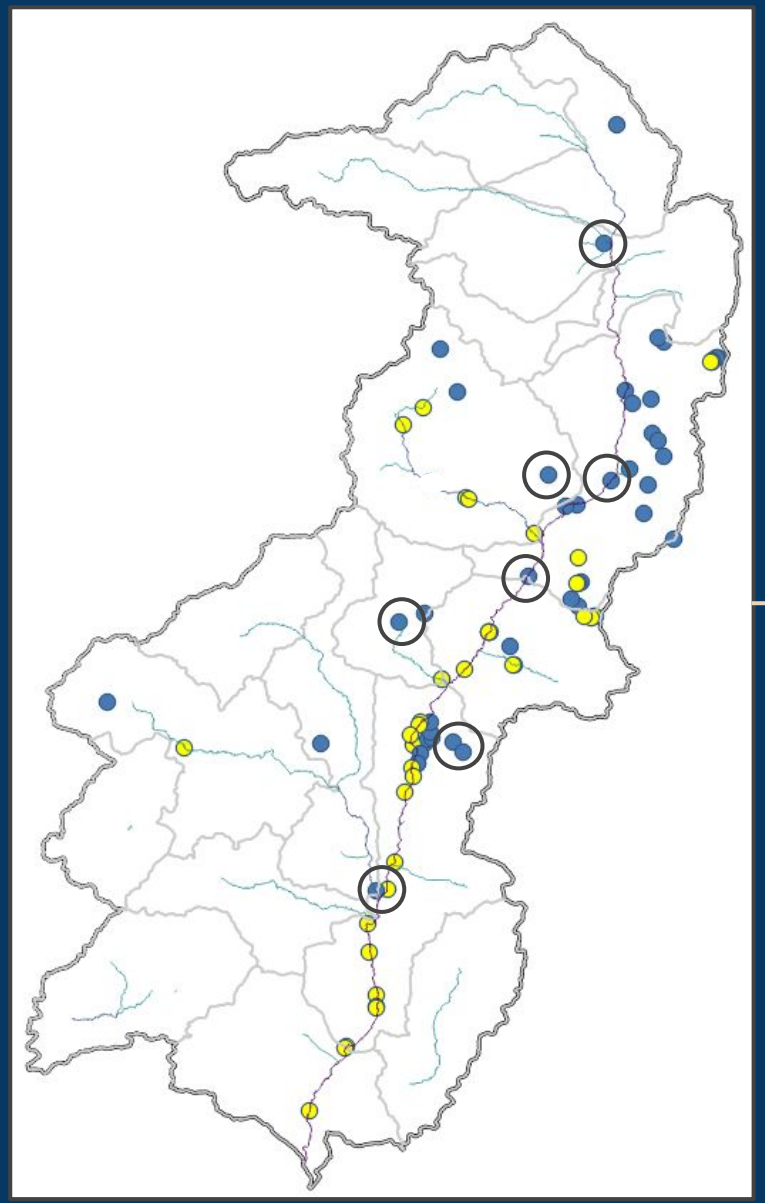
- Calibration was performed for site 08289000 (~1100 km^2) from 2005-2015
- Model evaluation was done from 2015-2023 at same and one independent site



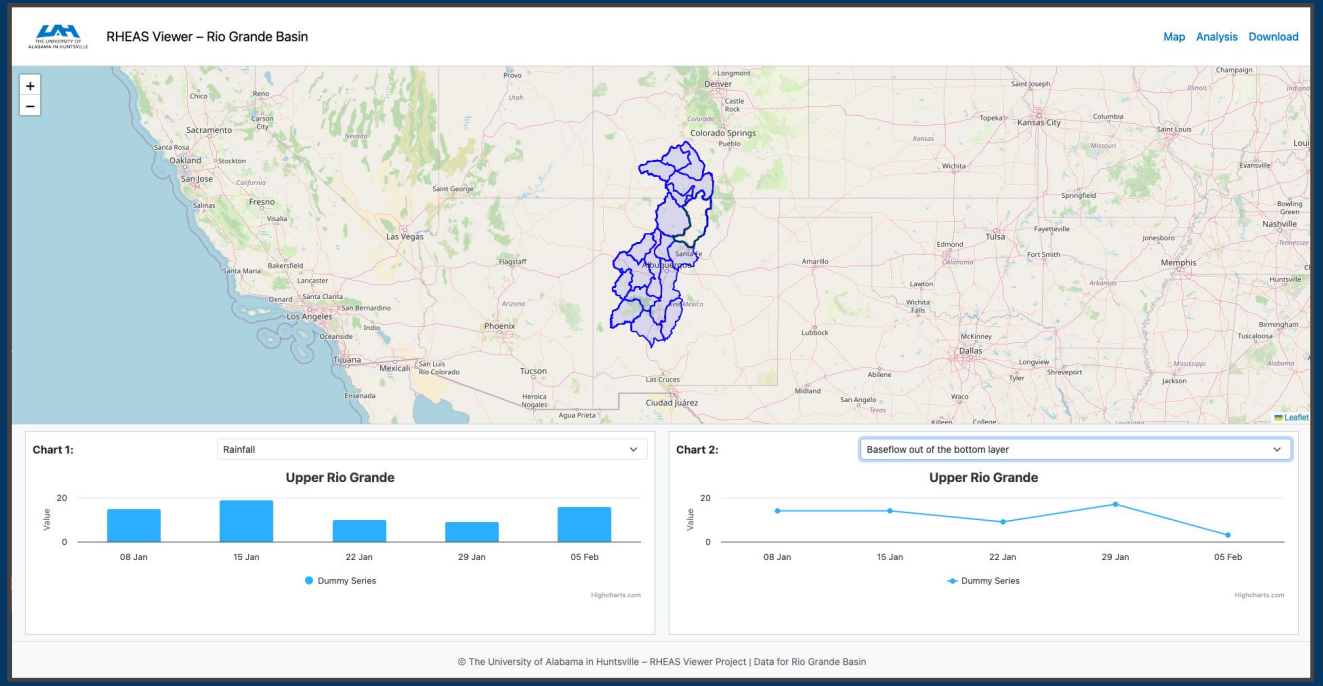
Calibrated 1km Model Simulations



Preliminary Results



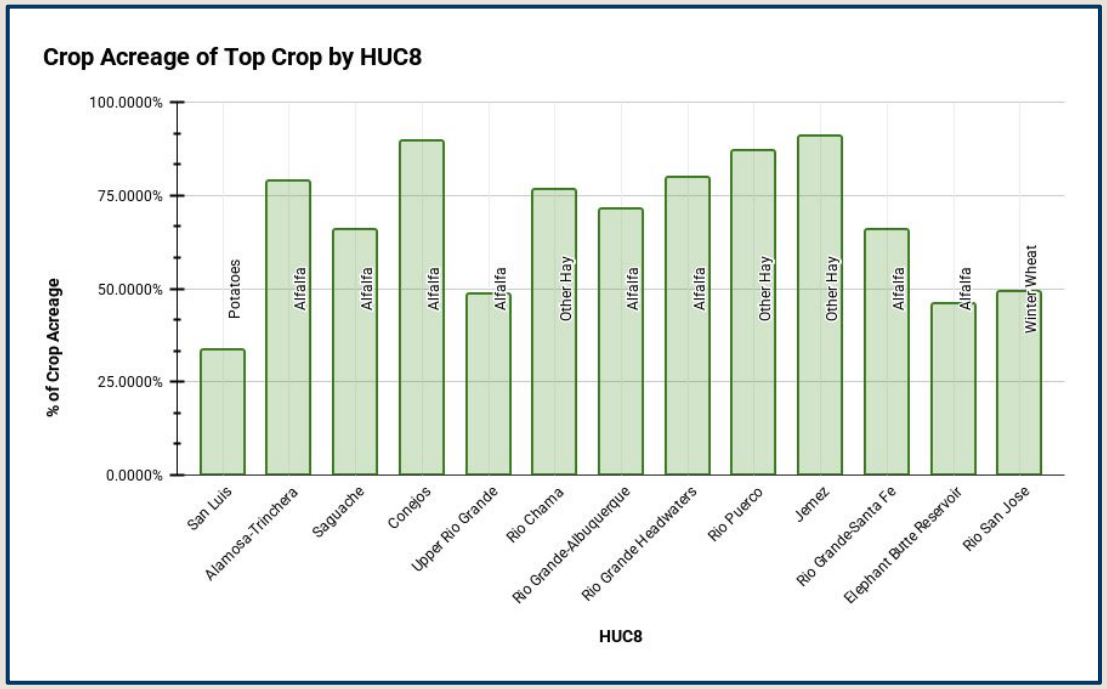
- Multi-site calibration
  - Identify parameter(s) value/range that might work optimally for the regional as a whole
  - Model evaluations
  - Integrating NLDAS3 forcing integration and test initial results



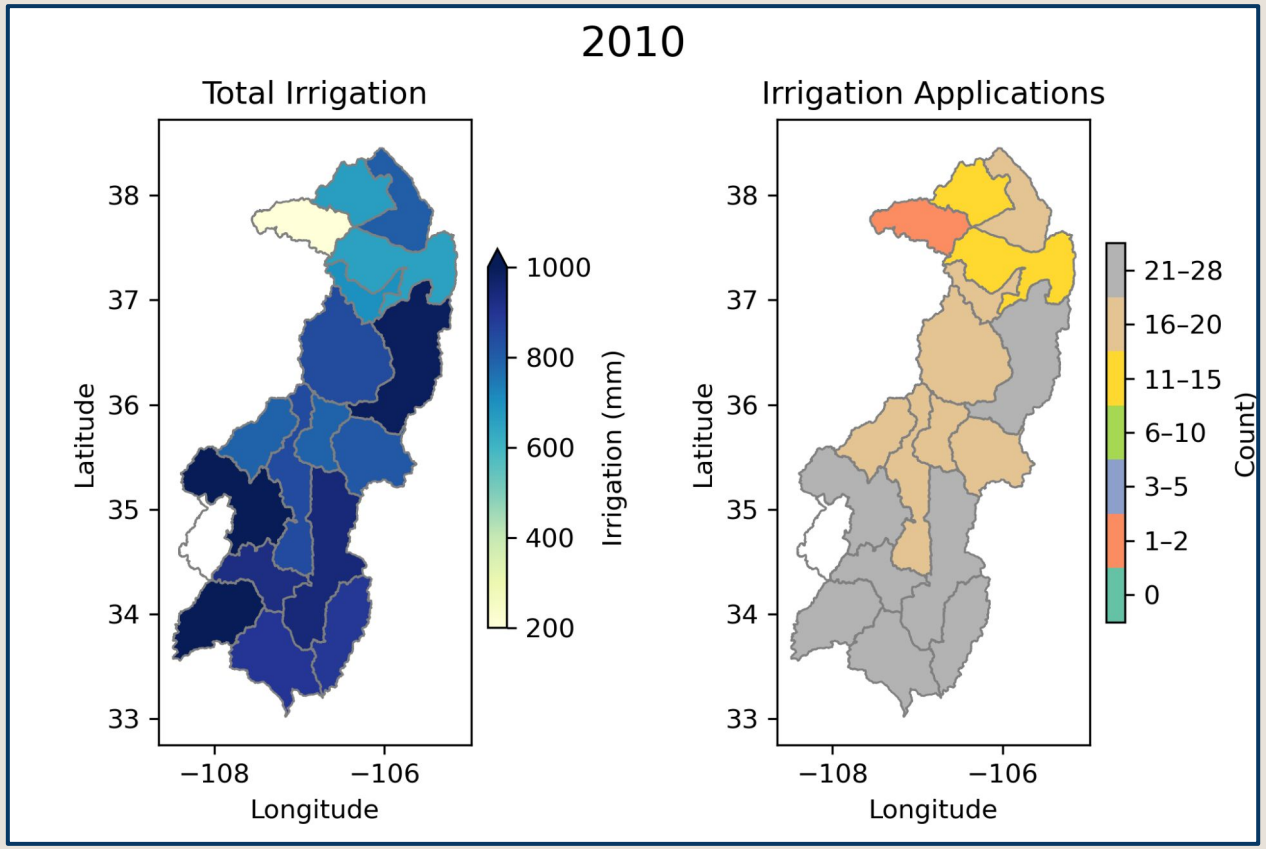
- Data visualization and dissemination tool development
- Model transition to NMSU and operational setup is largely complete after a workshop we held in August

Preliminary Results
(Crop Model)

Crop Irrigation Water Demand



"Other Hay/Non Alfalfa" class from the USDA's Cropland Data Layer has a similar irrigation demand as alfalfa. When combined, these crops comprise 56.9% of total agricultural land in the domain.



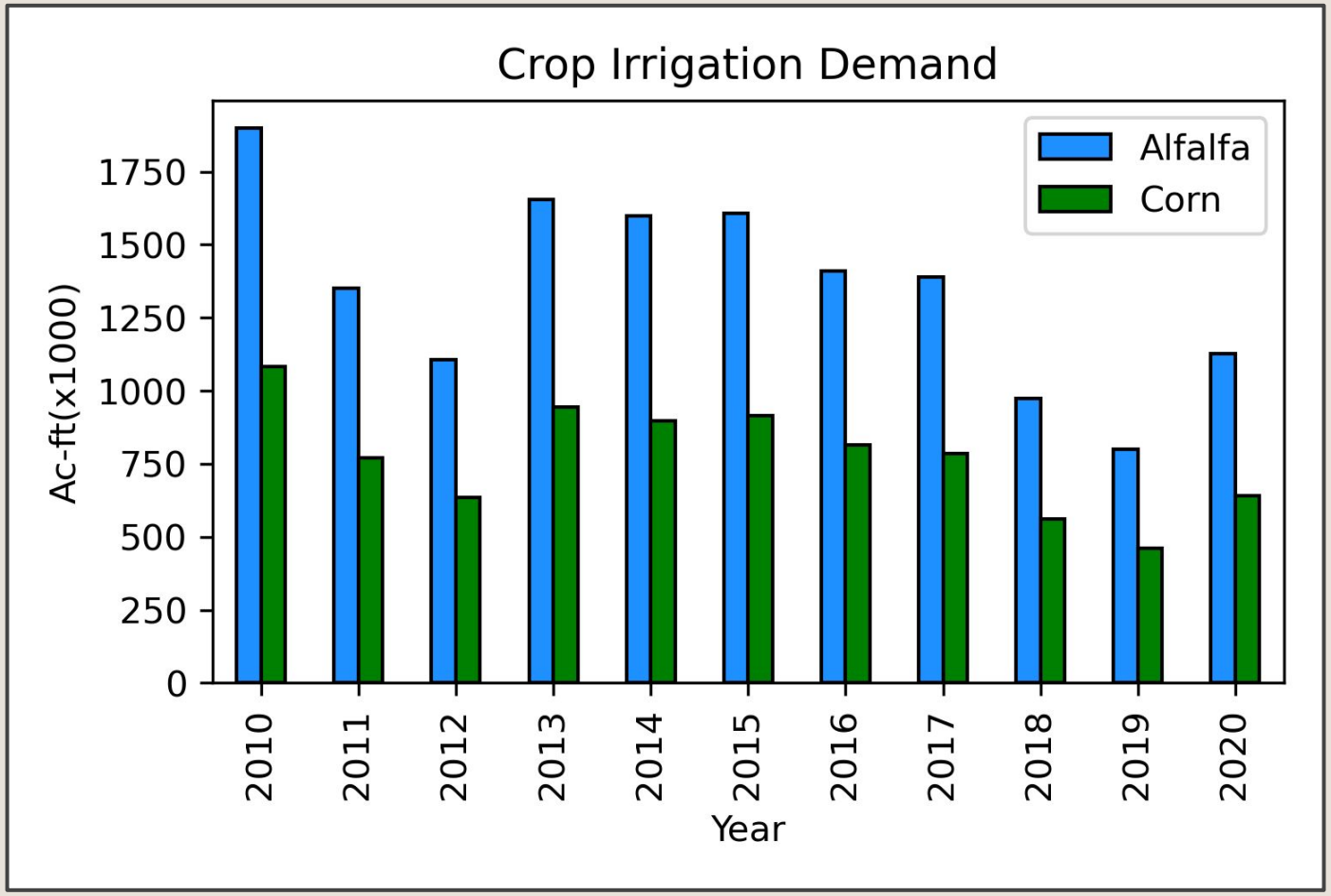
We are deriving irrigation demand from the crop model DSSAT within the RHEAS framework for corn, as a proxy. Future work will model irrigation demand for alfalfa in the region.

Preliminary Results

Alternate Scenarios:

- Nearly 40% less irrigation water demand when Alfalfa is replaced by drought resistant corn
- If half of Alfalfa is replaced with corn, it will require 30%(approx.) less water
- If we reduce the cropping area by 20%, water need will also go down by roughly that amount.
- If we reduce the crop area by 20% and replace Alfalfa with corn, water need can be reduced by more 50% compared to current condition.

Note: These scenarios are only meant to test model capabilities and cannot be taken as recommendation.

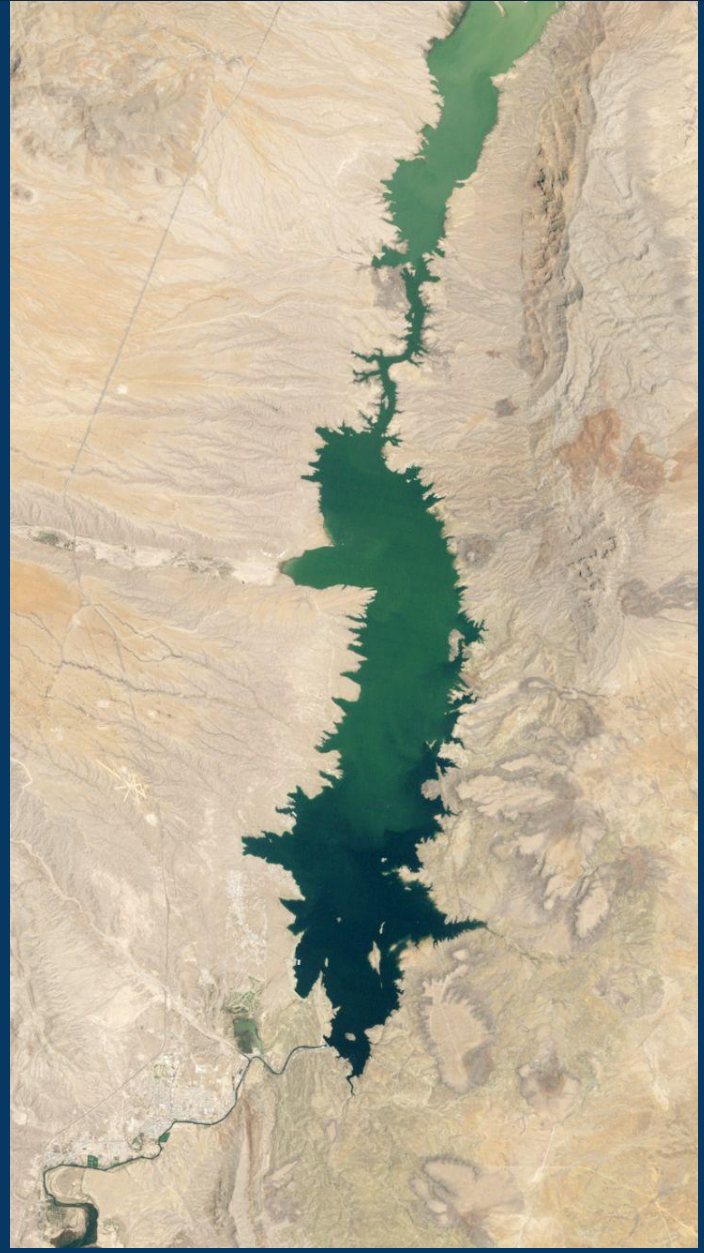


Next Steps

- Multi-site calibration
- Second Stakeholder meeting (~Nov)
- Short-term forecasts (15-day)
- Data visualization and dissemination tool development
- Continue working with EBID on model evaluation
- Develop pipelines for model data integration into EBID decision-making process

Potential Impacts:

- Establishing a physically-based sustainable modeling framework for cross-state allocation decisions
- Potential use of model results by state planning agencies
- Scaling the modeling framework outside of the initial domain



6/2/1994

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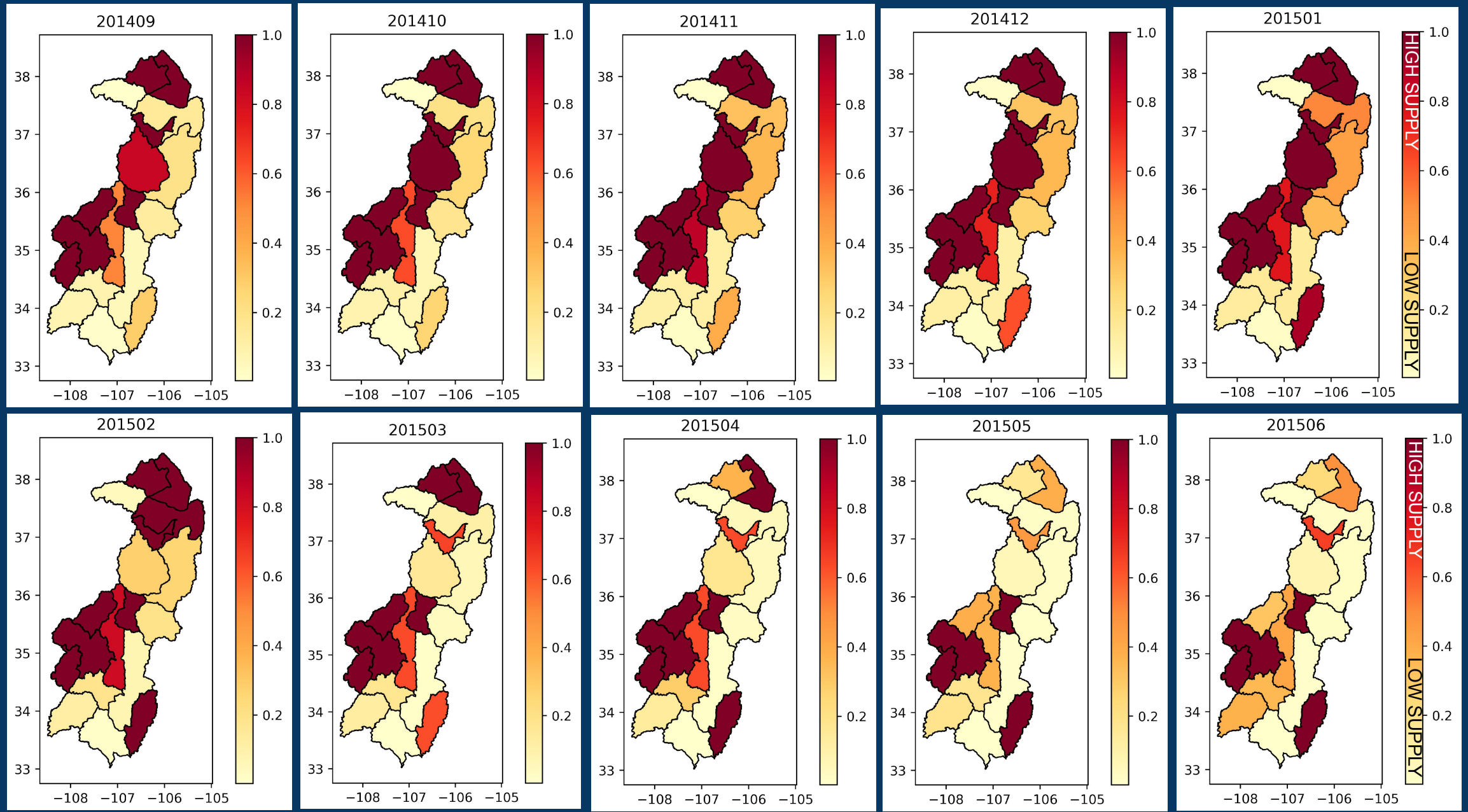
Image source: Landsat imagery (https://earthobservatory.nasa.gov/images/151549/on-this-day-in-2013-elephant-butte-reservoir)

Next Steps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201410
201411
201412
201501
201502
201503
201504
201505
201506
HIGH SUPPLY
LOW SUPPLY
38
37
36
35
34
33
−108
−107
−106
−105
1.0
0.8
0.6
0.4
0.2

Thank you for listening.

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