USGS National Water Use Models

Water Availability and Use Science Program

Rich Niswonger, USGS, 8/16/2022

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OPENET

Earth Resources Observation and Science (EROS) Center

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

USGS
science for a changing world

NASA

Google Earth Engine

DRI
Desert Research Institute

UNIVERSITY OF NORTH TEXAS 1890
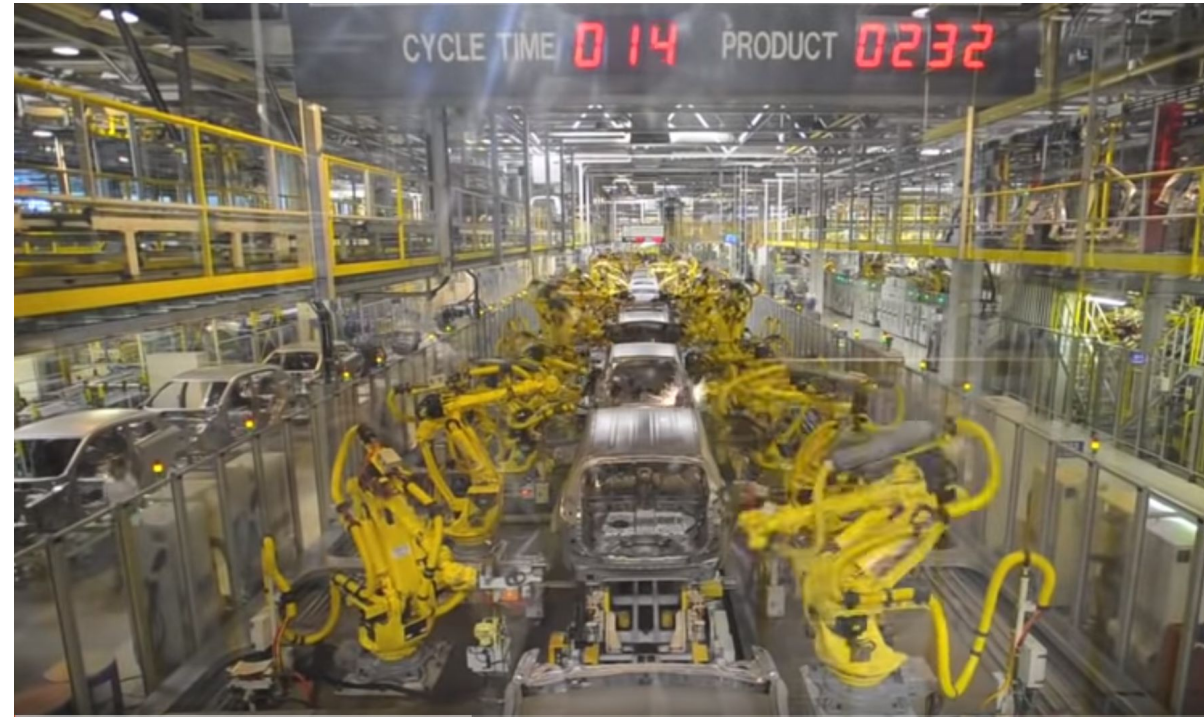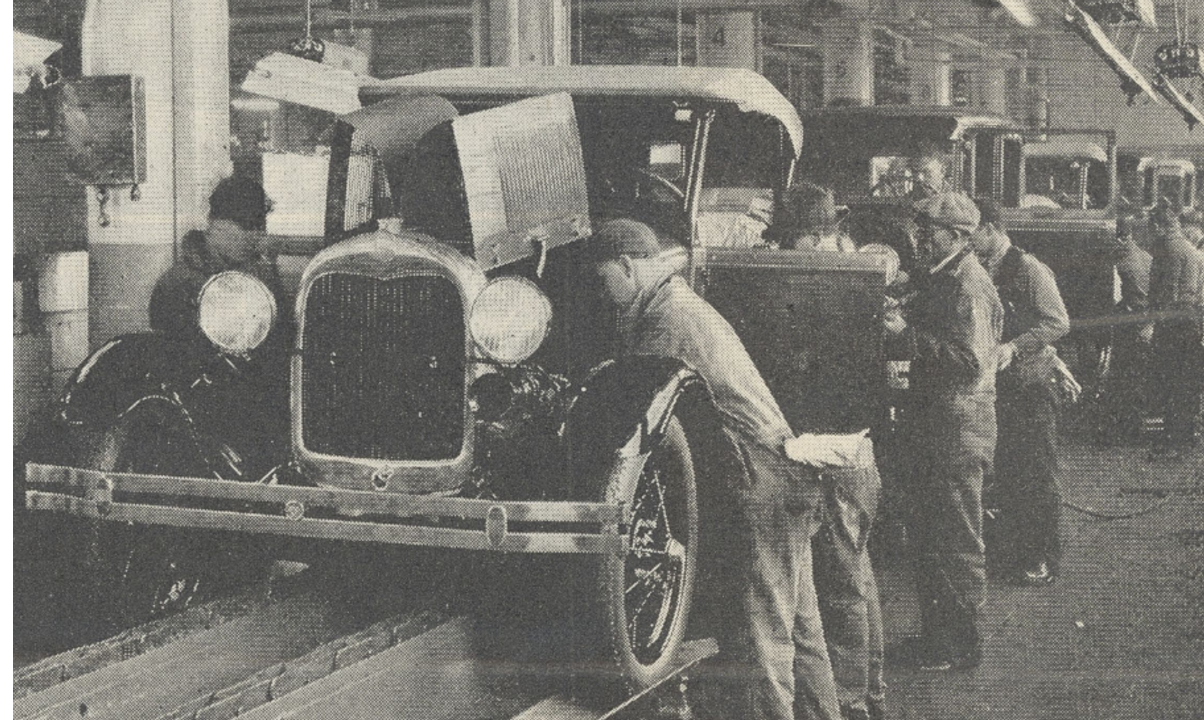
Estimating Irrigation Water Use—WY2000-2020 Reanalysis

Evapotranspiration (OpenET-SSEBop)

Hydrologic Model (NHM)

Irrigation Withdrawals (WUP)

**Constellation of Satellites
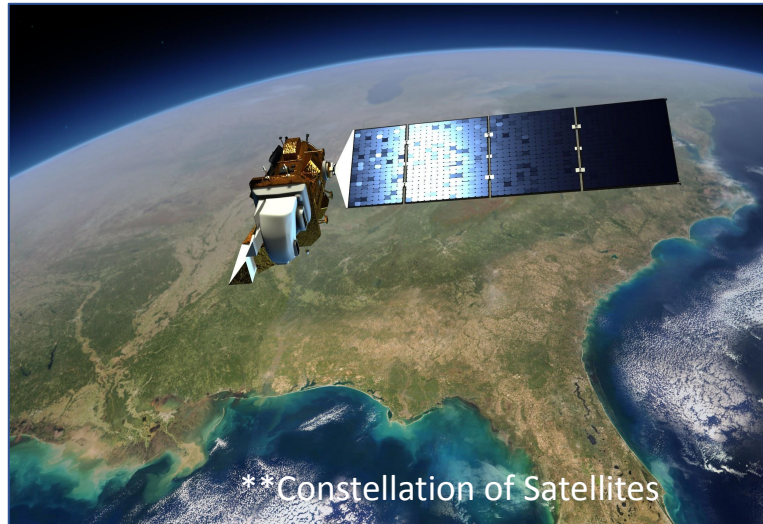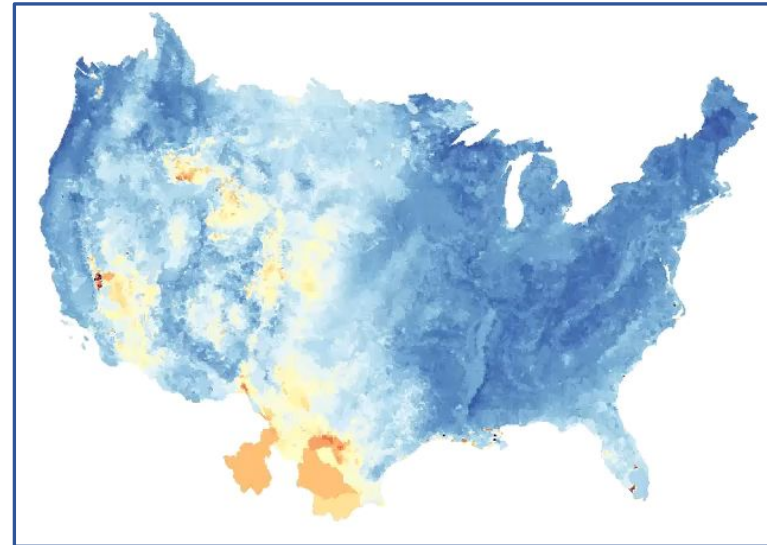
OpenET, a multiple agency collaboration, provides the computational resources and algorithms to provide evapotranspiration estimates (**irrigation *consumptive use***)
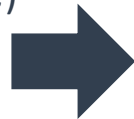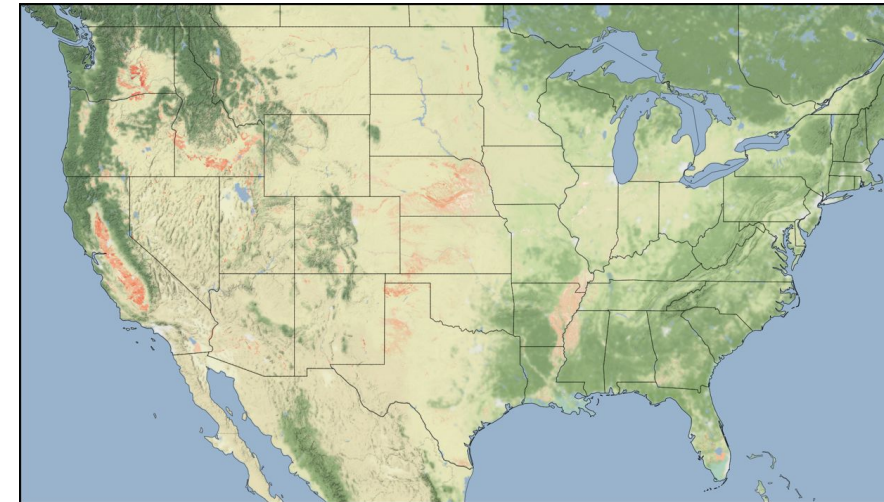
We use these estimates in our hydrologic modeling to determine amount of irrigation needed by crops.

Finally, we estimate groundwater and surface-water withdrawals by adding **conveyance and irrigation system efficiencies.**
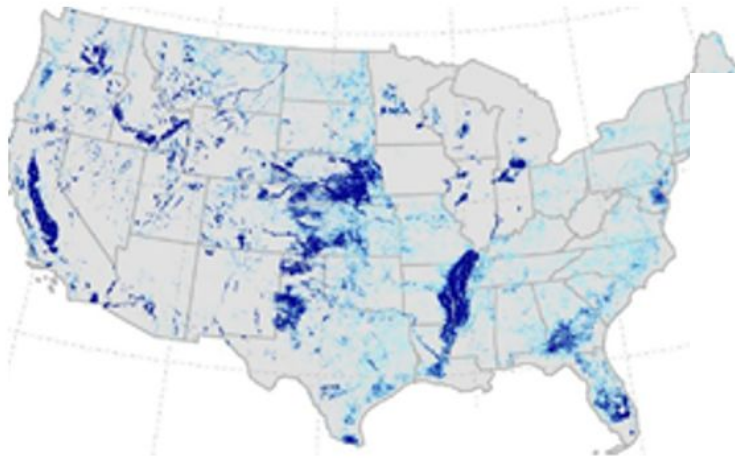
Estimating Irrigation Withdrawals

Effective precipitation—portion of crop consumption supplied by rain and snowmelt

Inefficiencies and return flows—water loss/gain during conveyance and application of irrigation
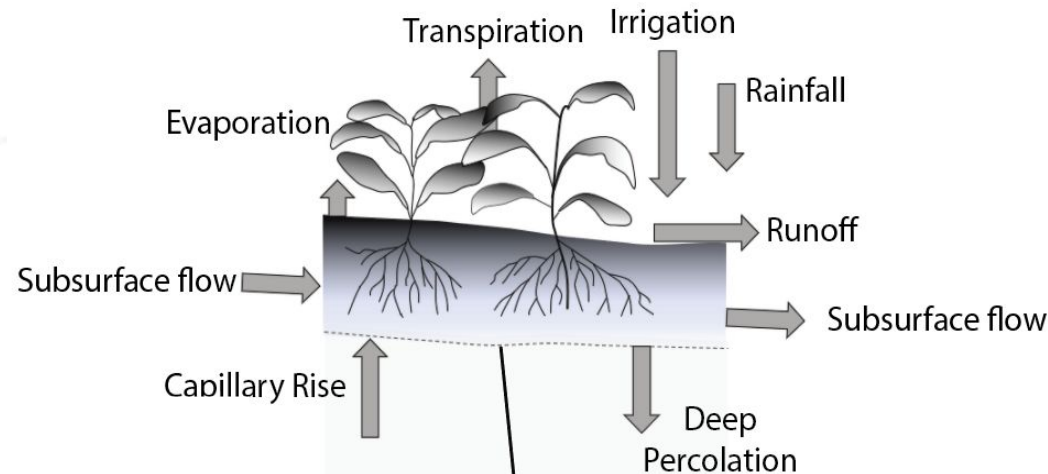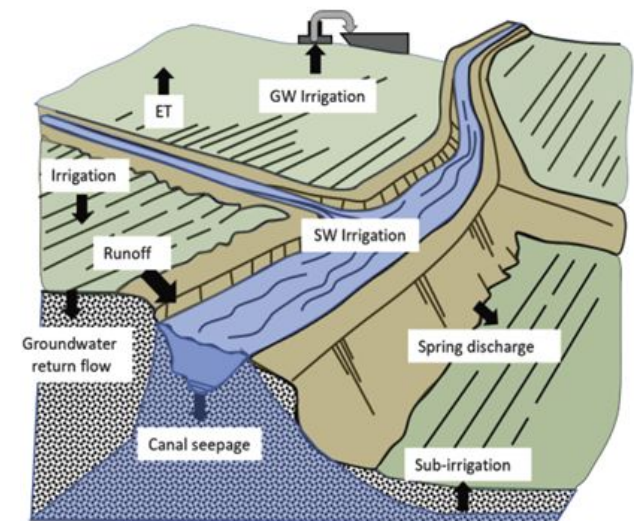
**Irrigated lands
(LANID)**

Xie, Yanhua, Tyler J. Lark, et al.
*ISPRS Journal of Photogrammetry
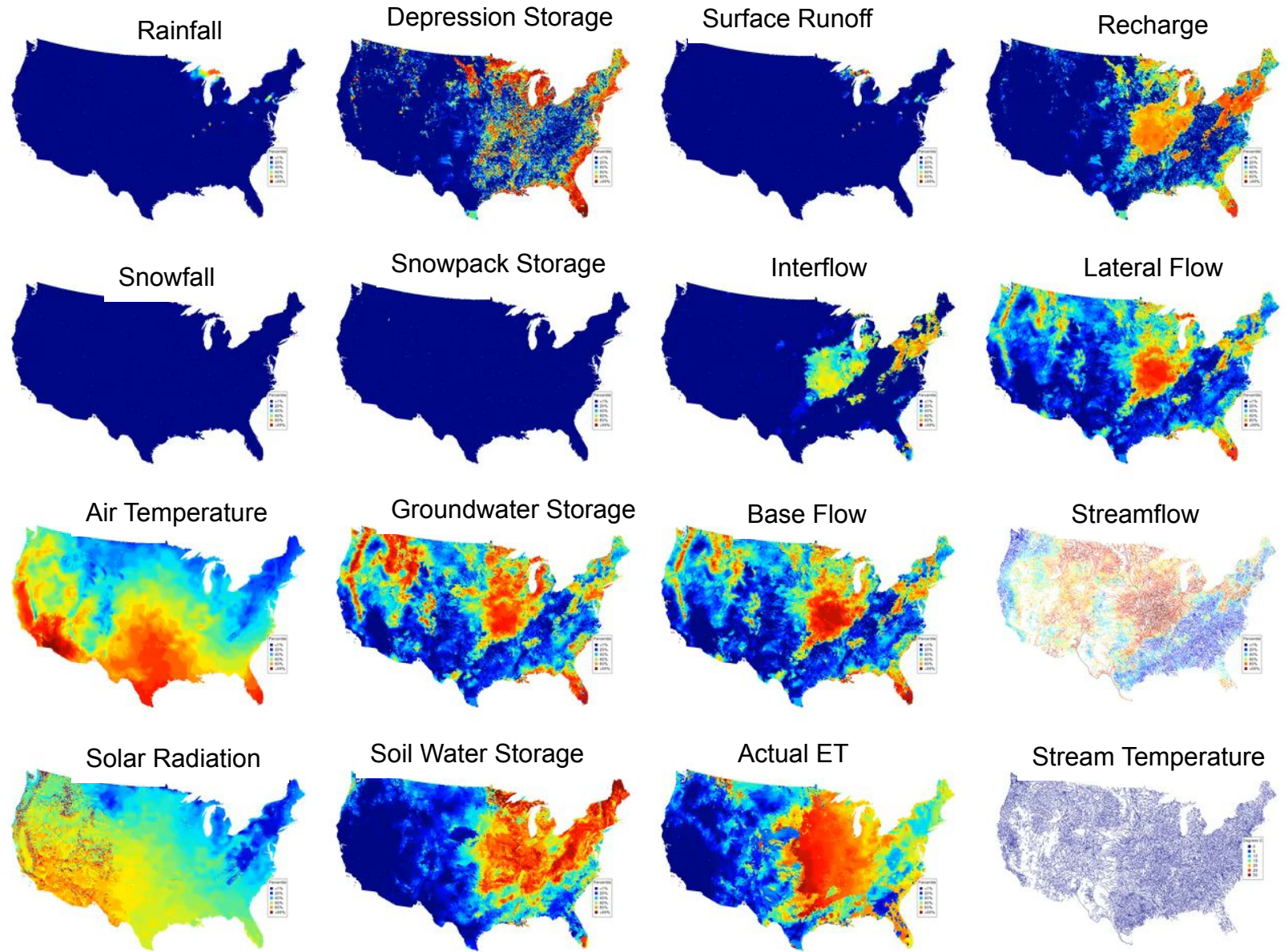and Remote Sensing* 155 (2019): 136-149.

**Soil-water balance
(NHM)**

**Water use efficiency
(hi-res imagery,
system mapping with
machine learning)**

- National Hydrologic Model (PRMS) used to determine irrigation water requirements

- Automatically includes affects of growing (and non-growing) season rain.

Irrigation deficit $(ET_{d,i})$:
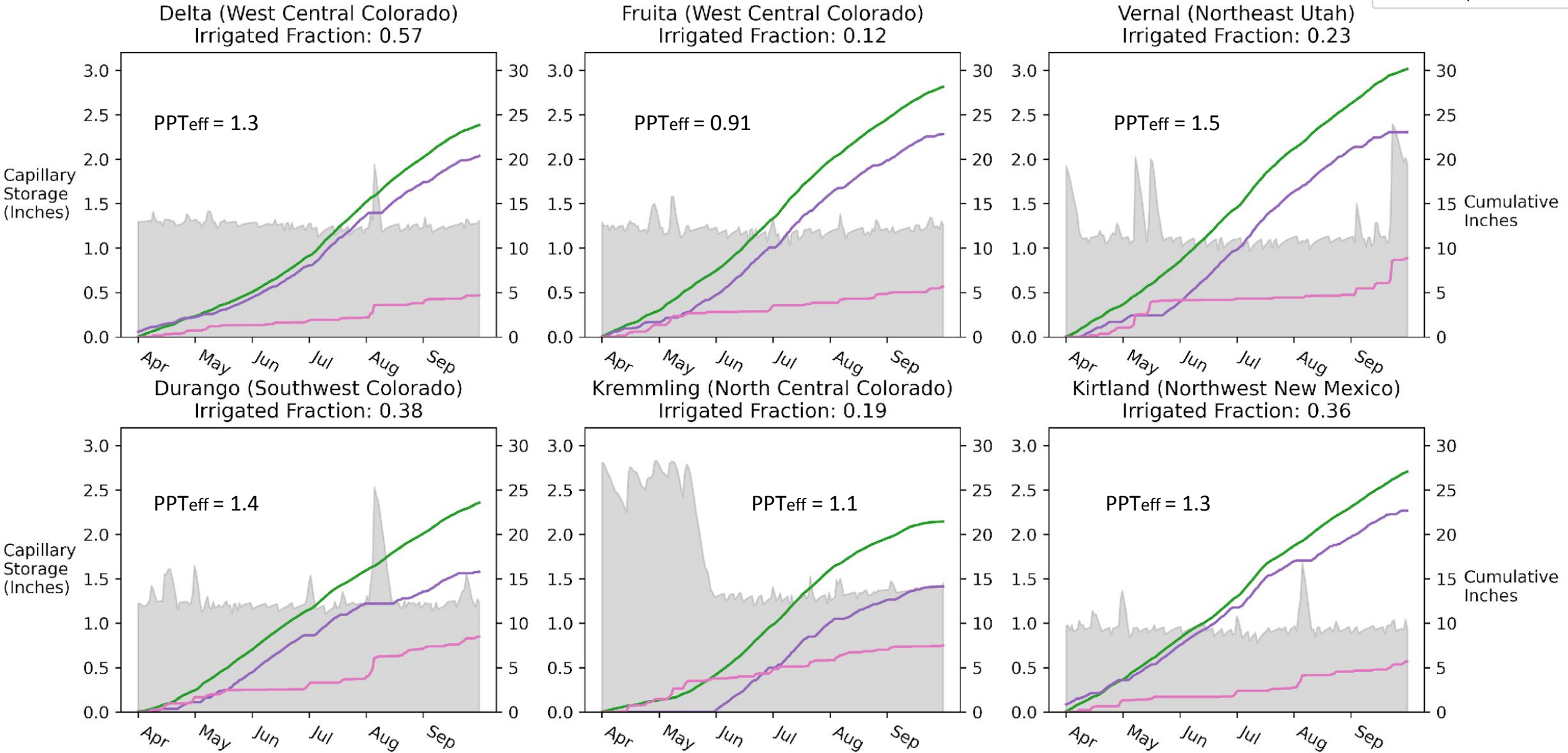
$$\min(ET_{d,i}) = ET_{a,HM,i} - ET_{a,SSEBop\_ET}$$

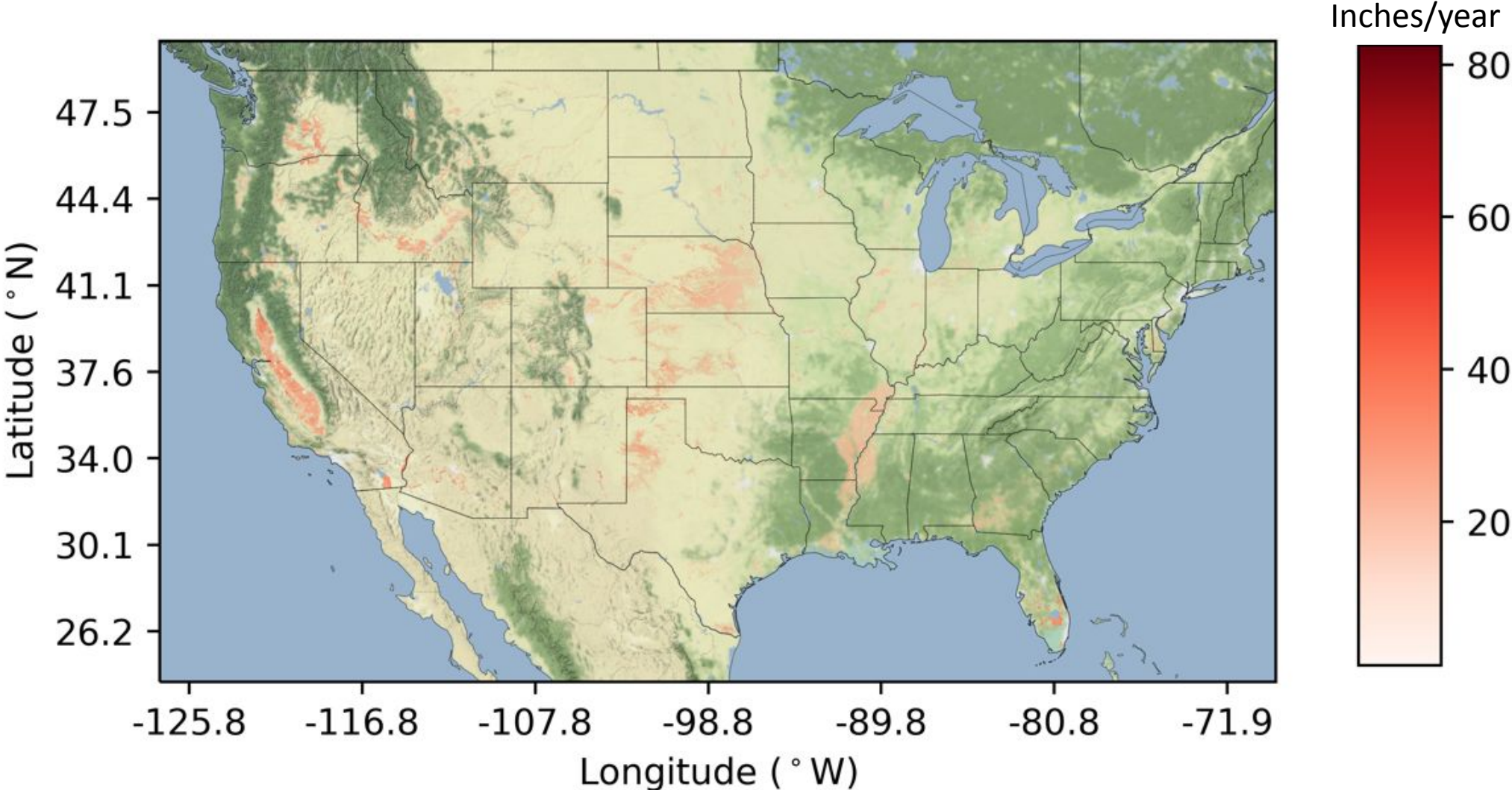↕ Model iteration

$$Q_{d,i+1} = Q_{d,i} + f(A_{irr}ET_d)$$

NHM-PRMS

# Upper Colorado Basin, Modeling of Effective Precipitation

Legend:
- Capillary Storage
- ETa (OpenET)
- ETa (NHM/PRMS)
- Applied Irrigation
- Precipitation

Delta (West Central Colorado)
Irrigated Fraction: 0.57
PPT_{eff} = 1.3

Fruita (West Central Colorado)
Irrigated Fraction: 0.12
PPT_{eff} = 0.91

Vernal (Northeast Utah)
Irrigated Fraction: 0.23
PPT_{eff} = 1.5

Durango (Southwest Colorado)
Irrigated Fraction: 0.38
PPT_{eff} = 1.4

Kremmling (North Central Colorado)
Irrigated Fraction: 0.19
PPT_{eff} = 1.1

Kirtland (Northwest New Mexico)
Irrigated Fraction: 0.36
PPT_{eff} = 1.3

Total Crop Consumption for Irrigated Lands, 2015 (Preliminary)

Water Application for Irrigated Lands (Preliminary)
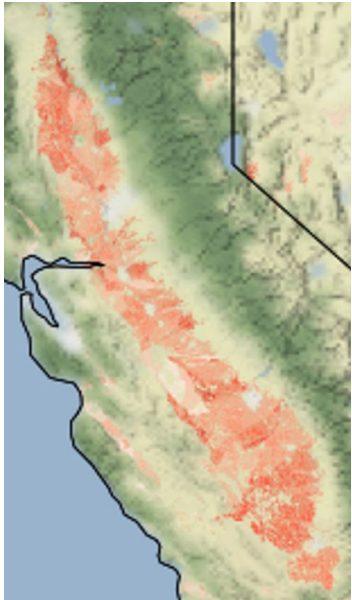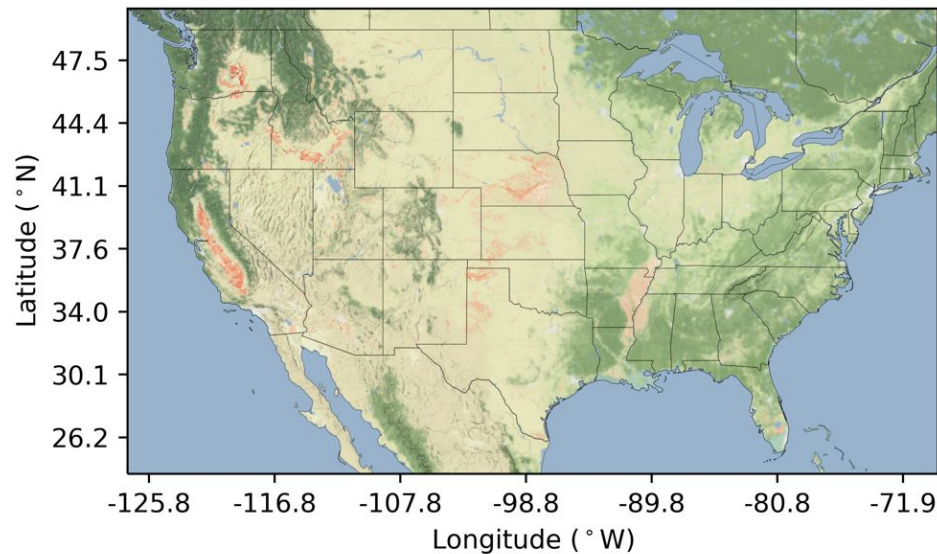

Central Valley, CA
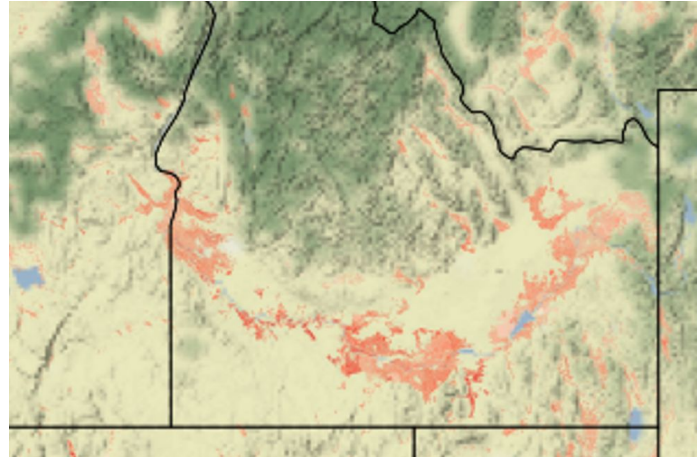
Snake River Plain, ID
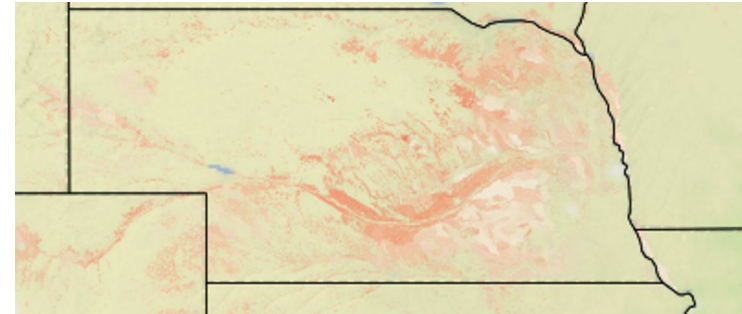
Platte River Basin, NE
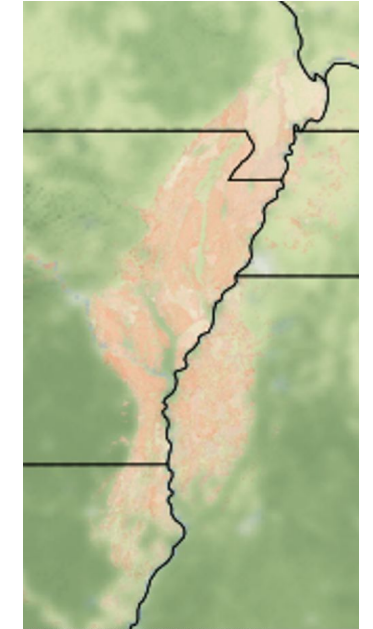
Mississippi Alluvial Plain
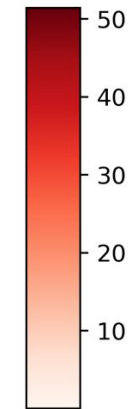
Inches per year, 2015

Public Supply Water Use

- Def: Public Water System in US Safe Drinking Water Act

  "an entity that provides water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year"

- Public supply is ~14% of total freshwater withdrawals in the US, 3rd largest withdrawal, surpassed by irrigation and thermoelectric

- Our goal is to produce estimates of daily public water use for the nation.

A Water Utility and It's Deliveries to Different Sectors

(CIIT) Non-Domestic Public Water Use
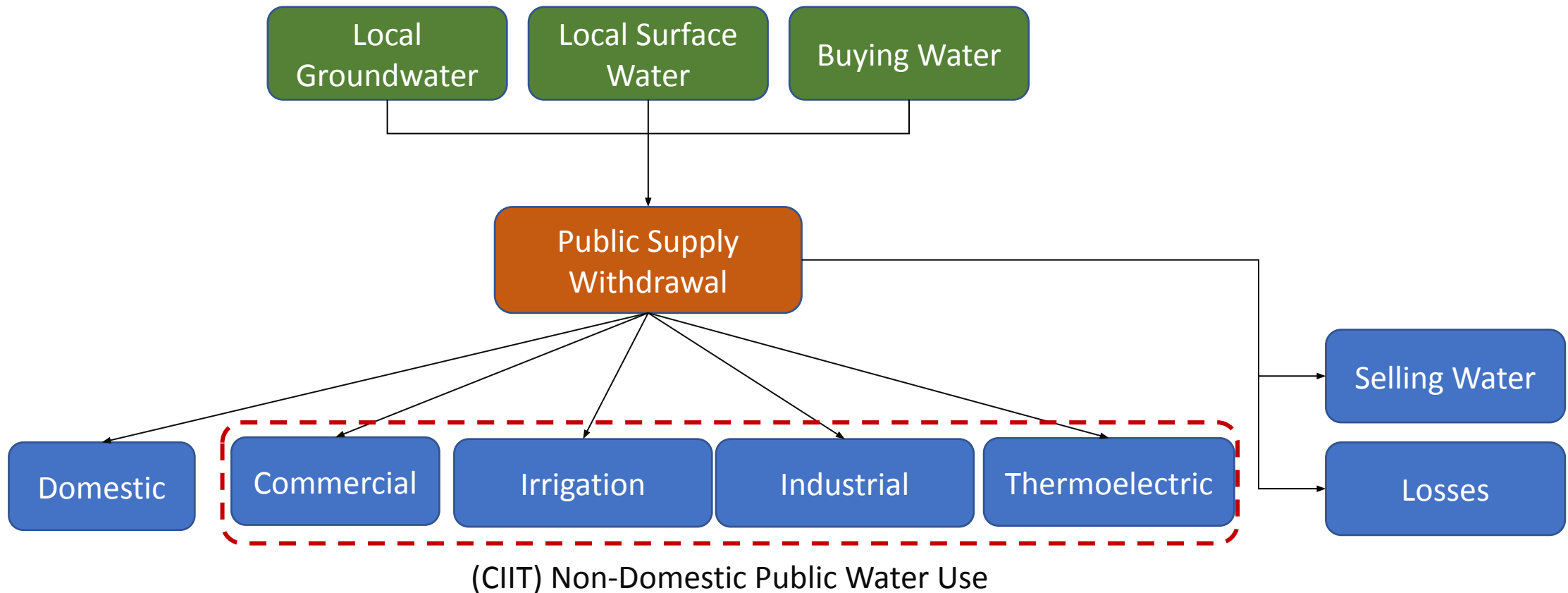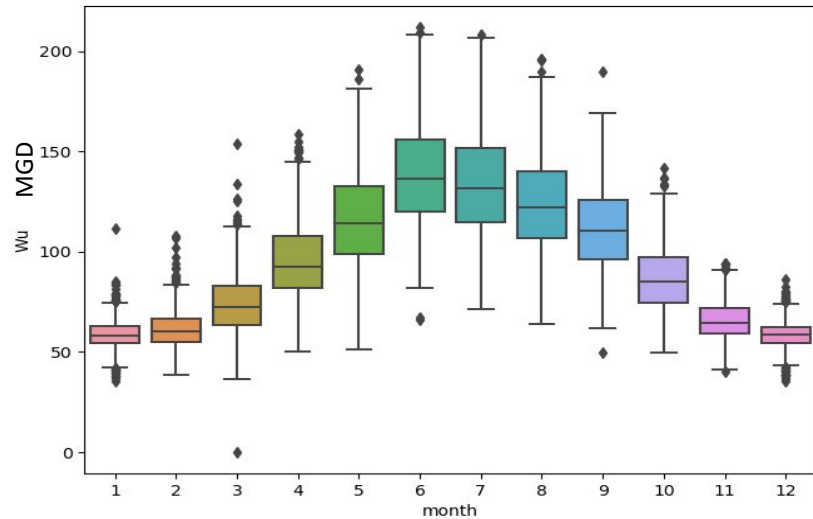
Water Use Machine Learning Model
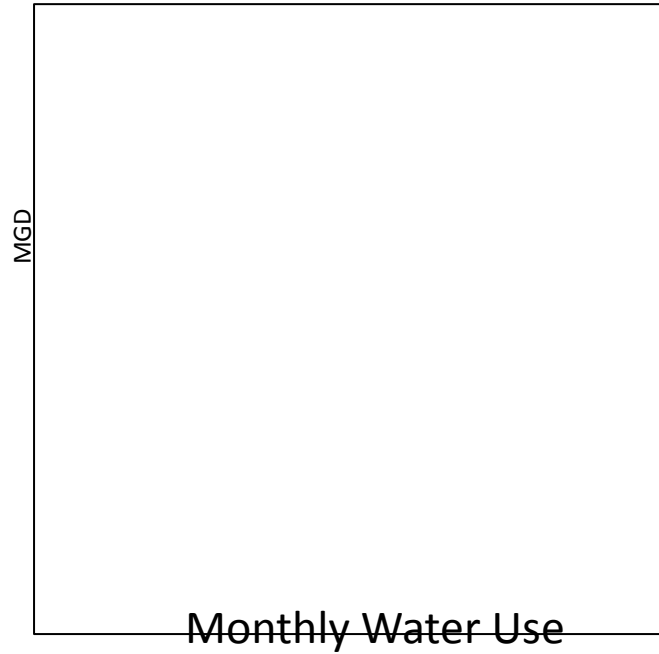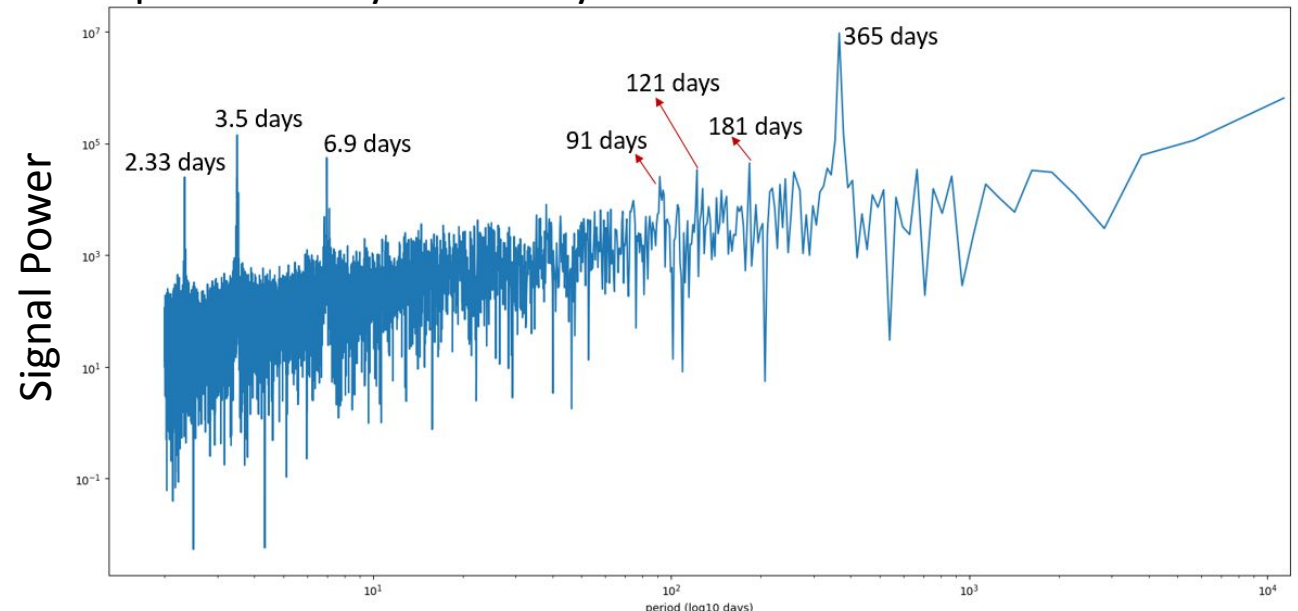

Historical Water use
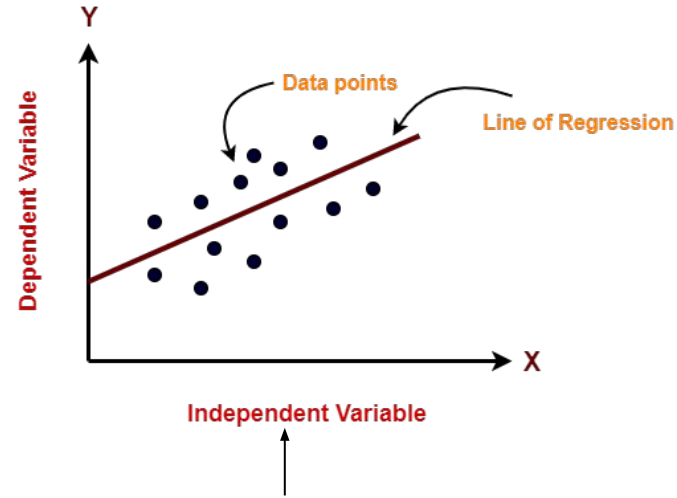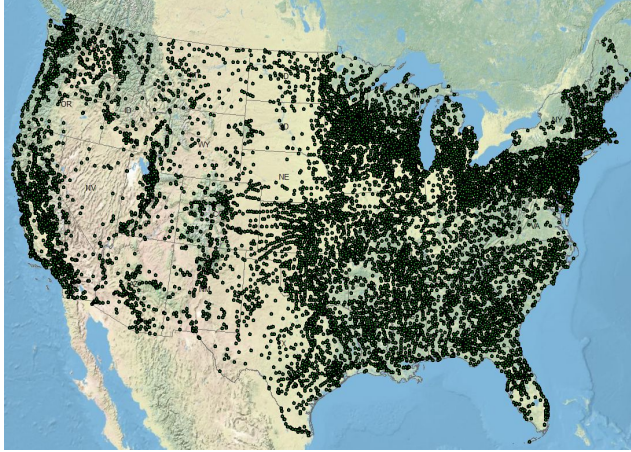
Climate, demographic and Socio-economic Data

Patterns in Water Use

Average Daily Water Use (0 : Monday)
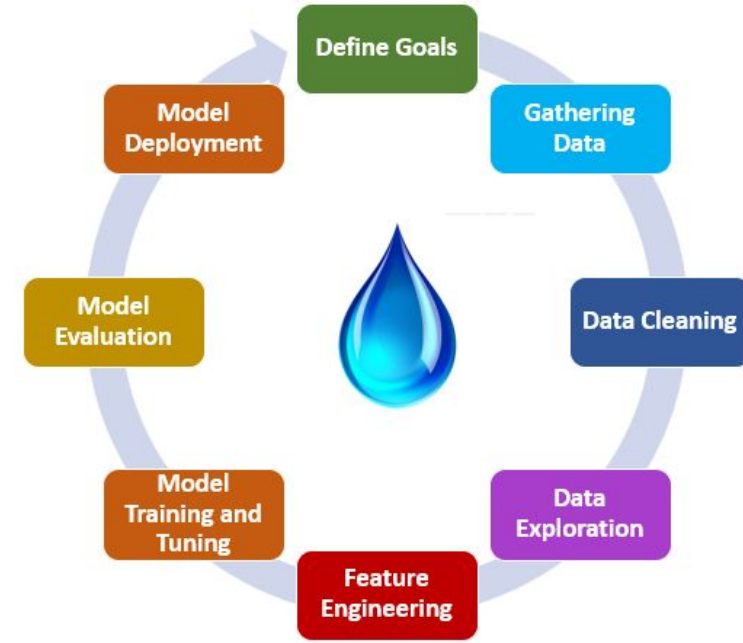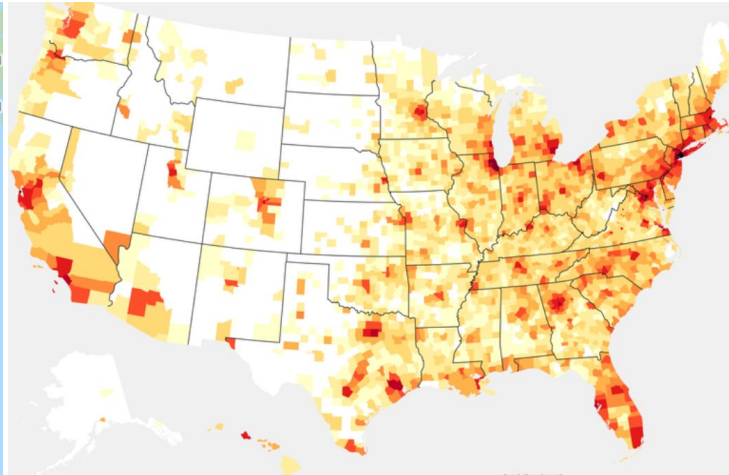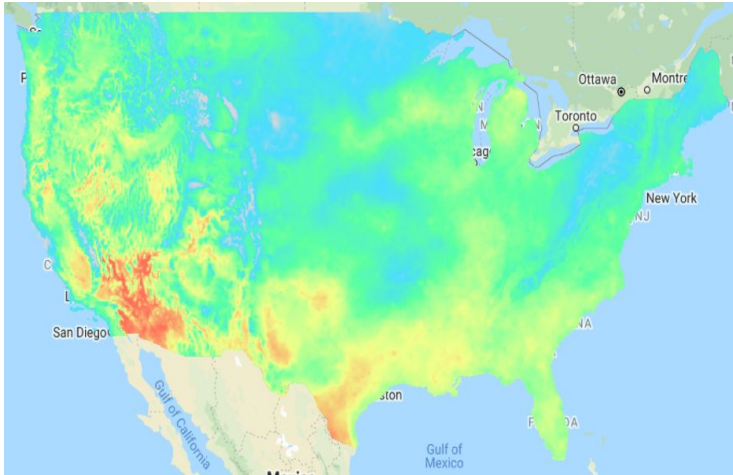
Monthly Water Use
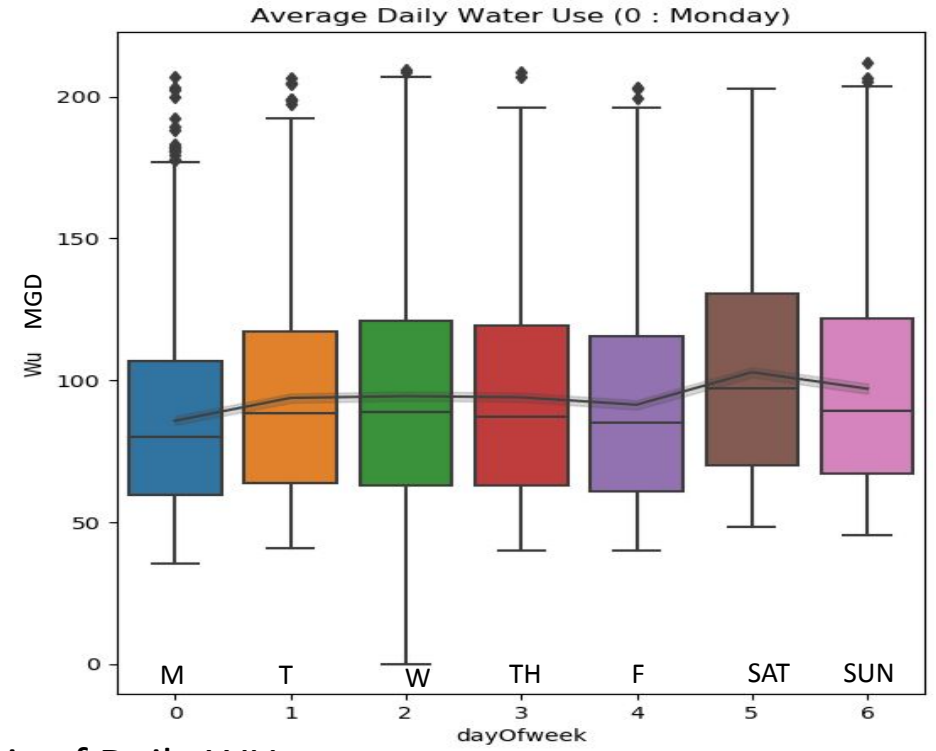
Spectral Analysis of Daily WU

365 days
121 days
3.5 days
181 days
6.9 days
91 days
2.33 days

National Water Use Machine Learning Model

Explanatory Variables

Water system Info
- ICITE Estimates (non-domestic water use)
- Water Exchange Data (selling and Buying)
- Land Use
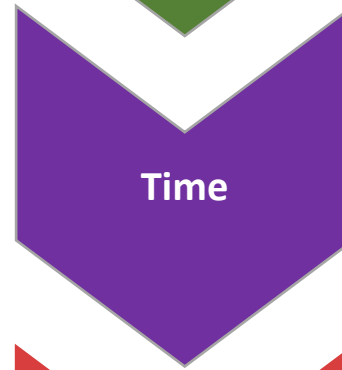
Time
- Date (month, year)
- Holidays
- Day of the week

Census
- Population
- Number Of Houses
- Infrastructure Age
- Population Density

Geography
- LAT/LON
- HUC2
- State and County
- Rural-Urban Continuum Codes

Climate
- Precipitation
- Maximum and Minimum Temperature
- Reference Evapotranspiration
- Koppen-Geiger Climate Classification

Socio-economic
- Income
- Individual and Businesses Tax return
- County GDP
- Gross Industry Production
- Number of Jobs and Unemployment
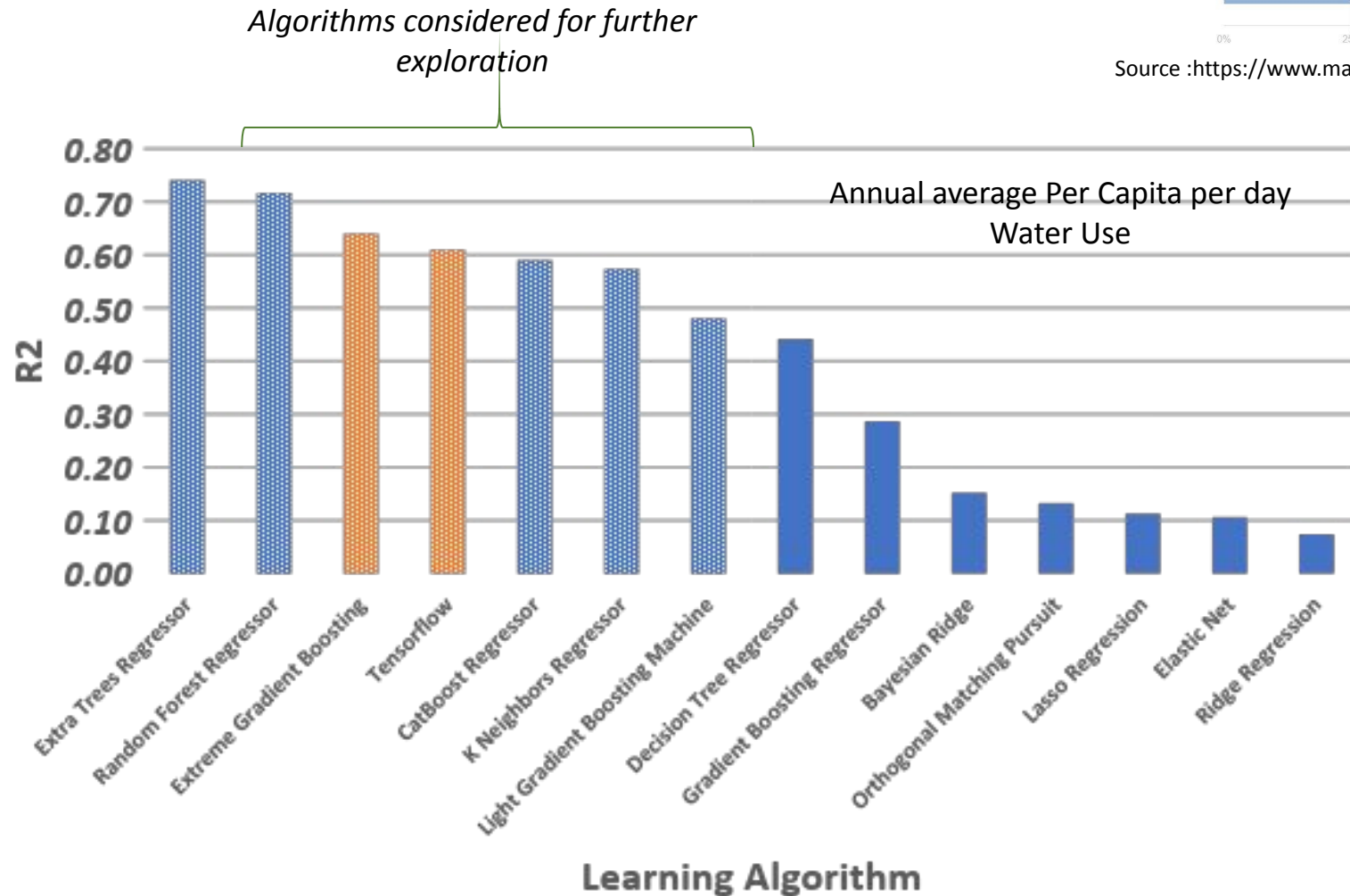- Poverty Index & Gini-index
- Education Level

Model Selection

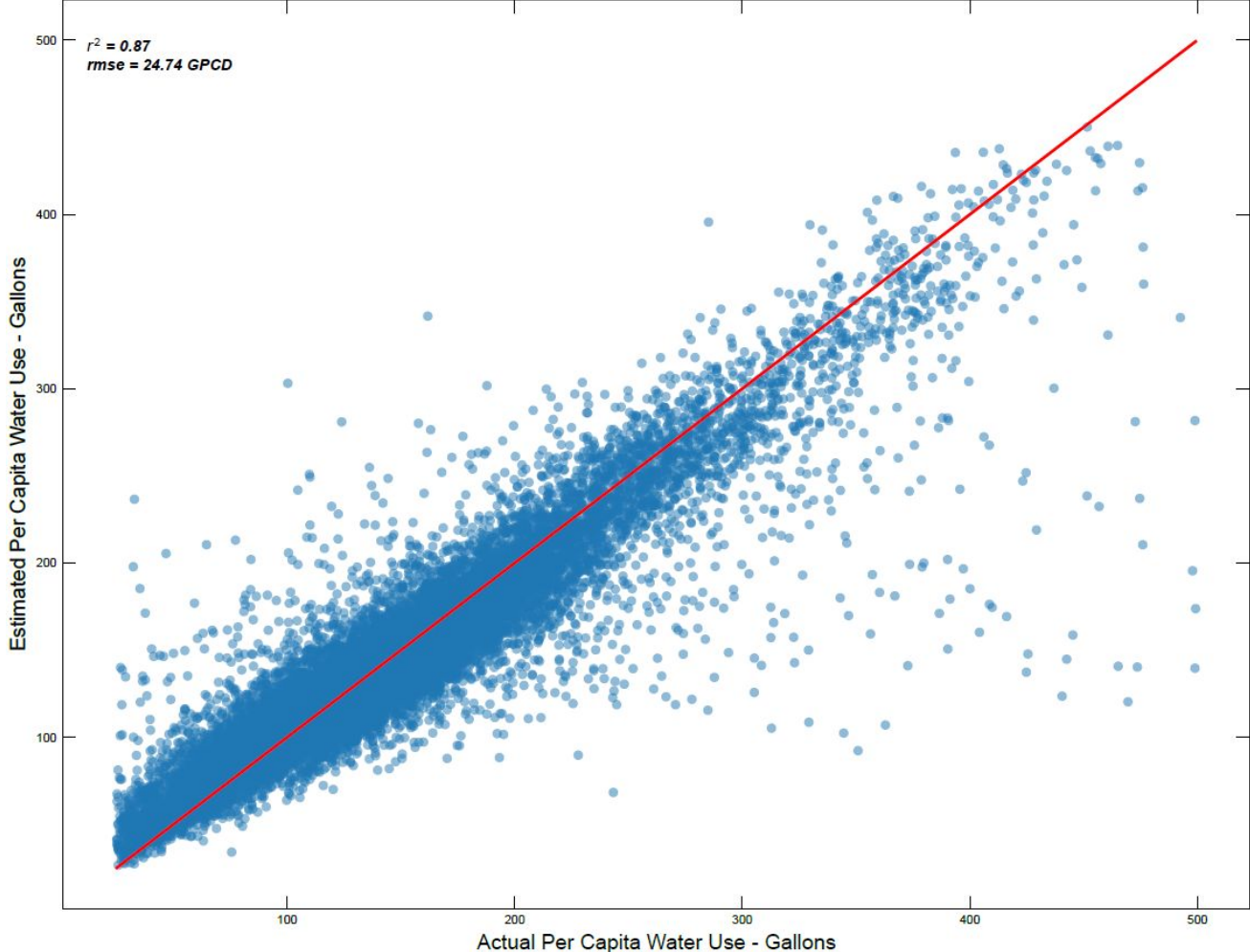**Initial Learning Algorithms Exploration**

4-fold validation (k=4)

Algorithms considered for further exploration
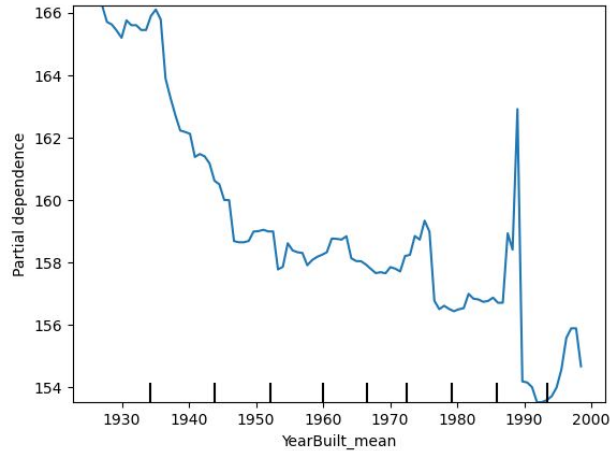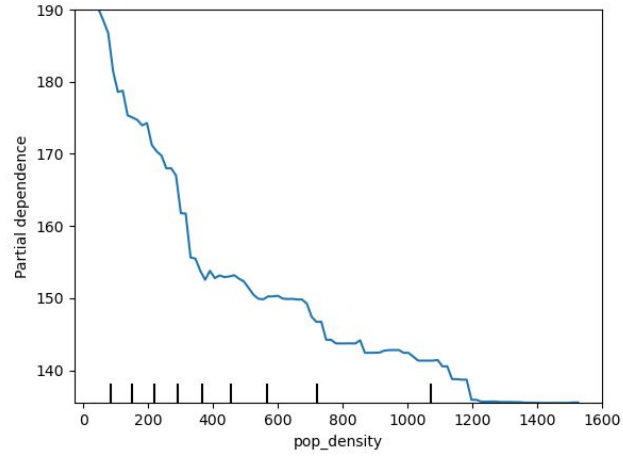
Annual average Per Capita per day Water Use

Model Validation

A. Scatter Plot for Annual Water Use

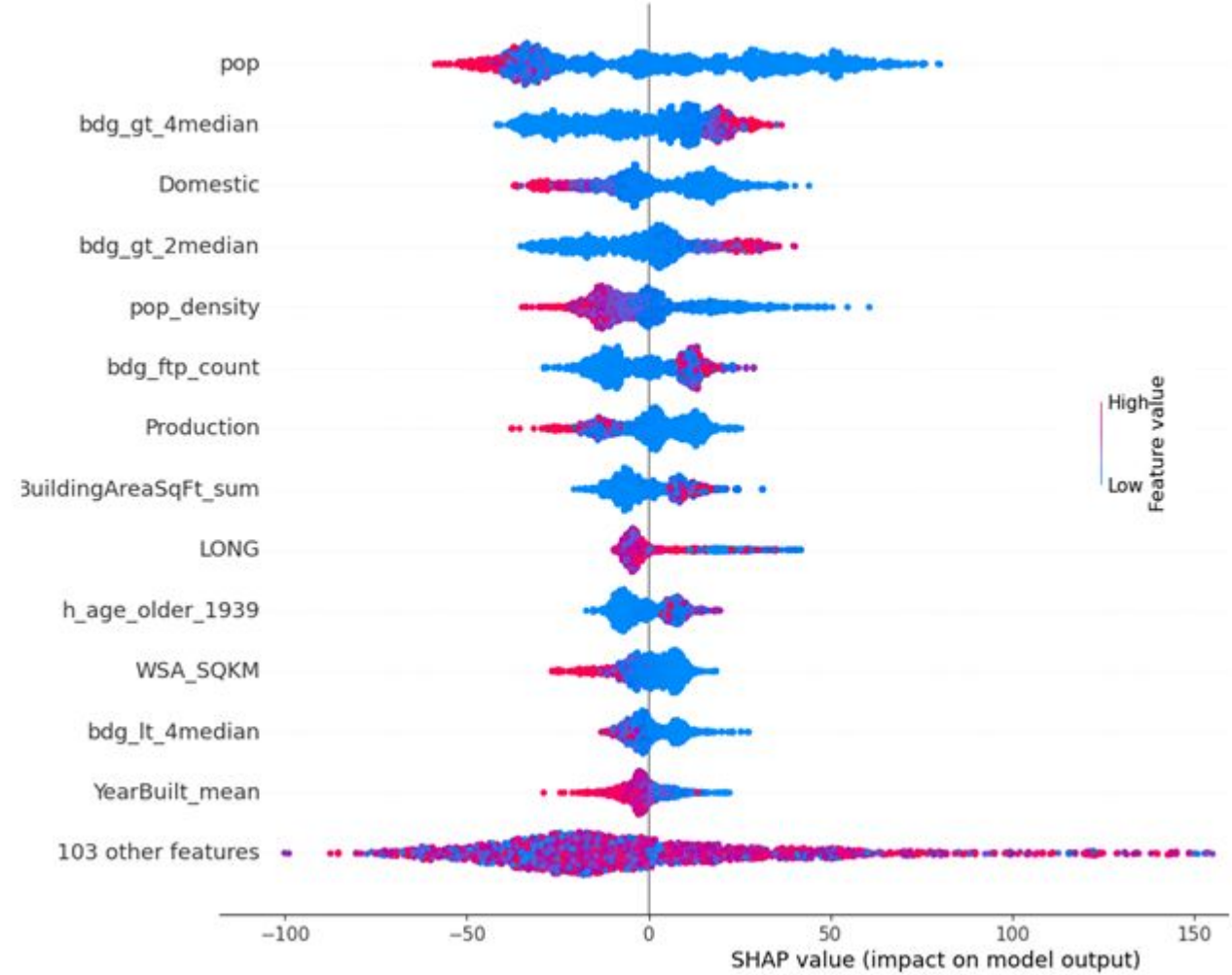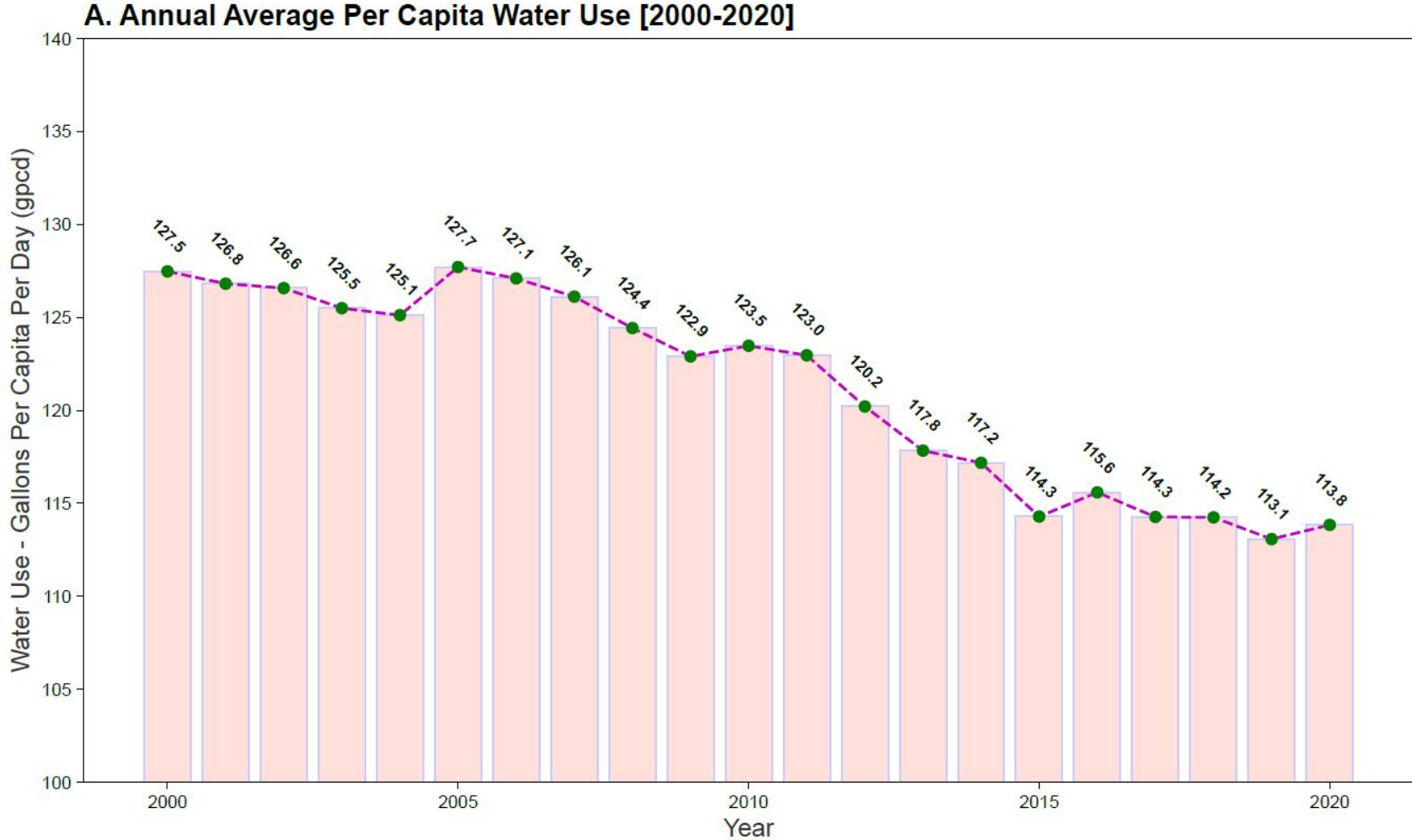# Explainable AI
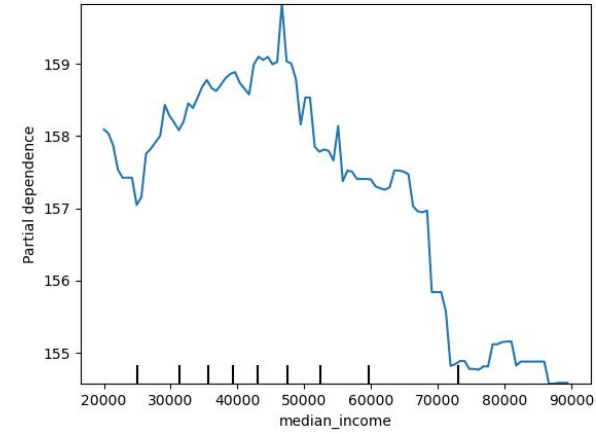
Partial Dependance Plots

SHAP Values for HUC2 = 2

National Per-Capita Public Supply water Use
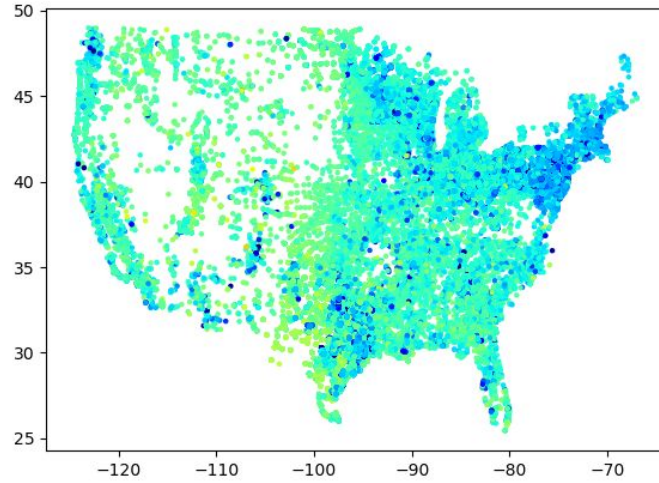

A. Annual Average Per Capita Water Use [2000-2020]

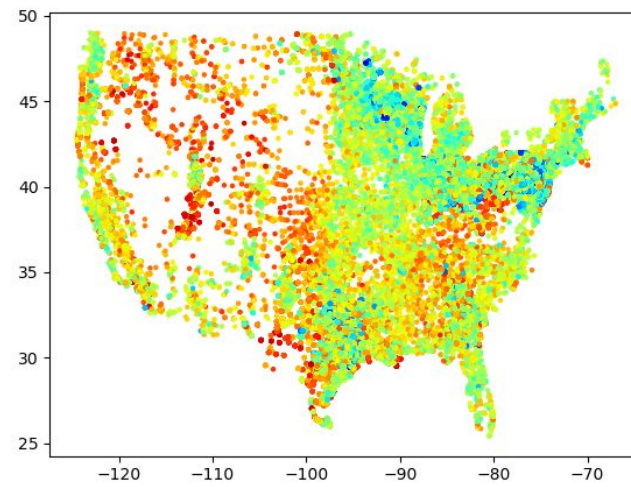A. Average Change of Per Capita by State in the Period 2000-2020
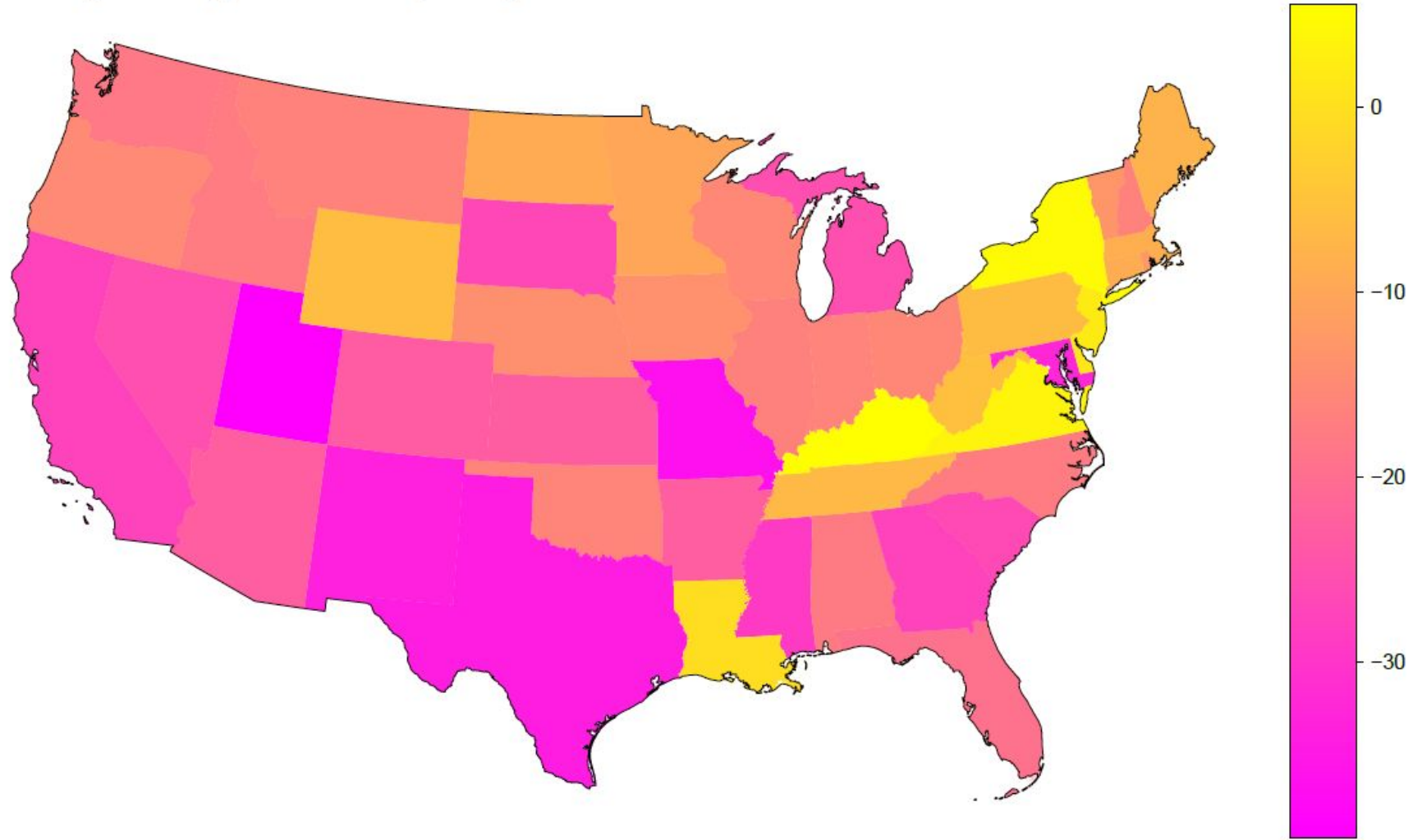
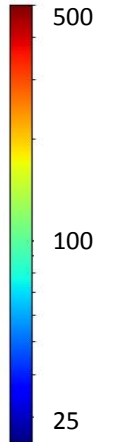# Uncertainty Quantification – Quantile Regression
Ongoing work

5th Percentile
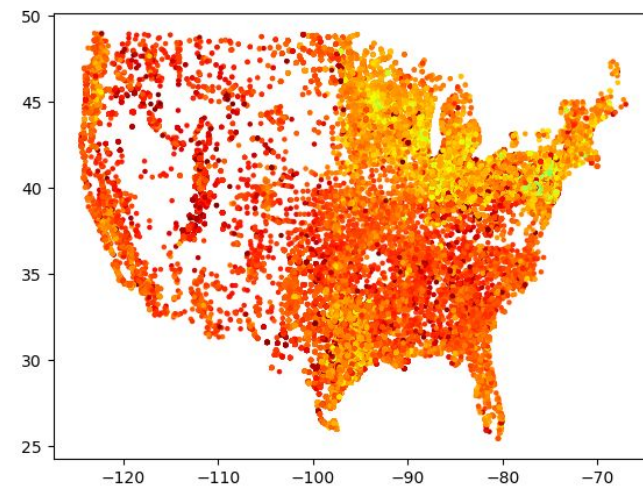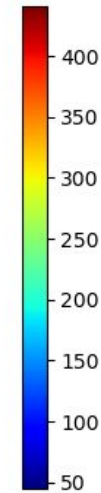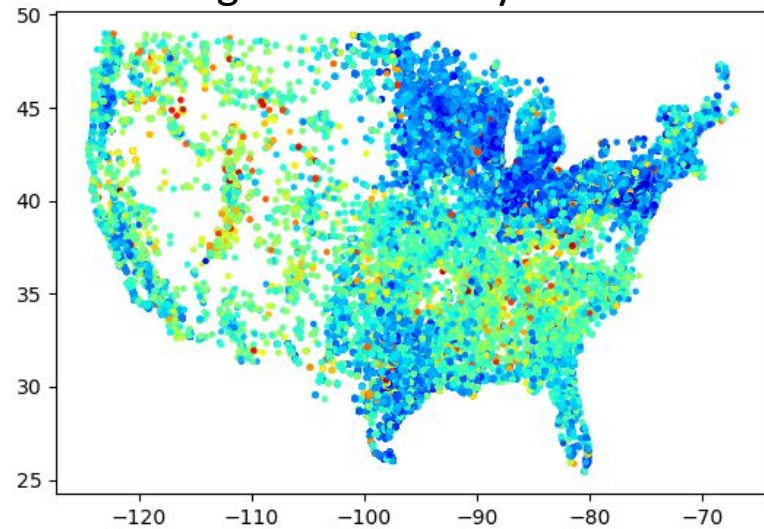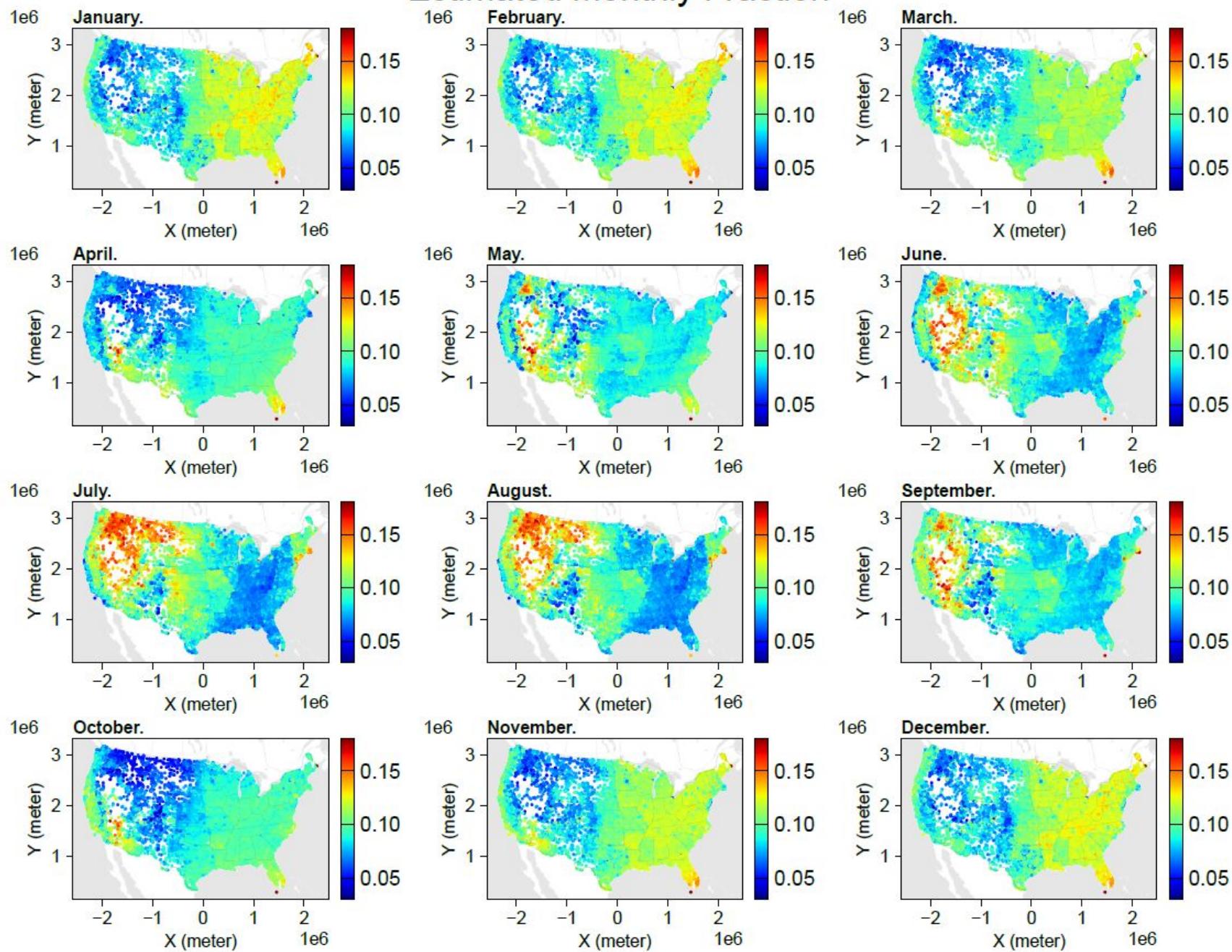
50th Percentile

95th Percentile

Range of variability 95th - 5th

Estimated Monthly Fraction

Thank You!