Analysis of California Residential Water Demand and Supply

Steve

2025-04-18

```
# Install required packages (uncomment if needed)
# install.packages("readr")
# install.packages("dplyr")
# install.packages("tidyr")
# install.packages("lubridate")
# install.packages("ggplot2")
# install.packages("corrplot")
# install.packages("ggcorrplot")

# Load required libraries
library(readr)
```

```
## Warning: package 'readr' was built under R version 4.4.3
```

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(tidyr)
library(lubridate)
```

```
##
## Attaching package: 'lubridate'

## The following objects are masked from 'package:base':
##
##     date, intersect, setdiff, union
```

```r
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 4.4.3
```

```r
library(corrplot)
```

```
## Warning: package 'corrplot' was built under R version 4.4.3
```

```
## corrplot 0.95 loaded
```

```r
# Load required packages
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 4.4.3
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v forcats 1.0.0     v stringr 1.5.1
## v purrr   1.0.2     v tibble  3.2.1
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```r
library(lubridate)

# 1. Read and Clean Data
df <- read.csv("C:/Users/HomePC/OneDrive/Desktop/CaRDS.csv", check.names = FALSE) %>%
  pivot_longer(
    cols = -c(PWSID, Variable),
    names_to = "Date",
    values_to = "Value"
  ) %>%
  mutate(Date = as.Date(Date)) %>%
  filter(!is.na(Value))  # Remove missing values
```

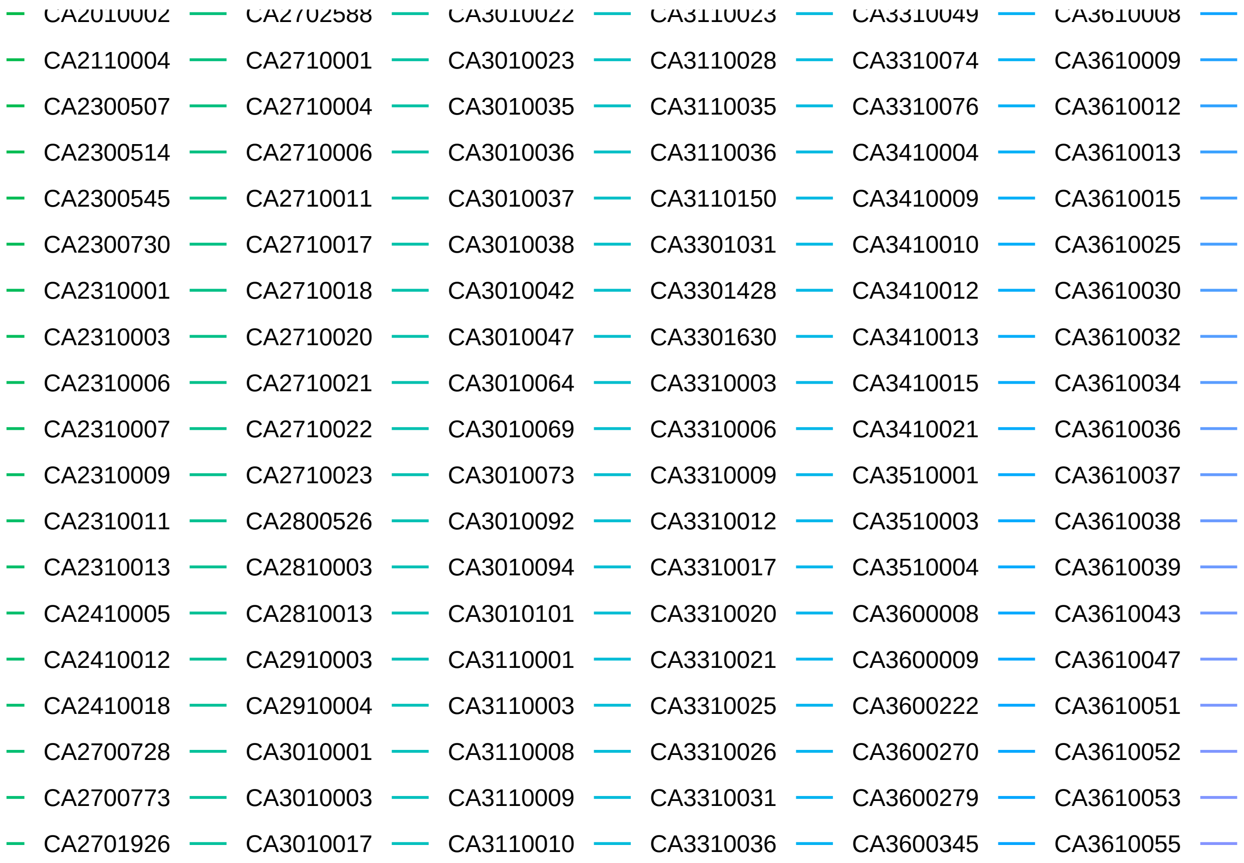
```r
# 2. Basic Exploration
# View structure
glimpse(df)
```

```
## Rows: 218,160
## Columns: 4
## $ PWSID    <chr> "CA0110005", "CA0110005", "CA0110005", "CA0110005", "CA011000~
## $ Variable <chr> "PDSI", "PDSI", "PDSI", "PDSI", "PDSI", "PDSI", "PDSI", "PDSI~
## $ Date     <date> 2013-01-01, 2013-02-01, 2013-03-01, 2013-04-01, 2013-05-01, ~
## $ Value    <dbl> -1.33, -2.02, -2.76, -3.23, -3.72, -4.14, -4.39, -4.31, -4.02~
```

```r
# Summary statistics
df %>%
  group_by(PWSID, Variable) %>%
  summarise(
    Mean = mean(Value, na.rm = TRUE),
    Median = median(Value, na.rm = TRUE),
    SD = sd(Value, na.rm = TRUE),
    .groups = "drop"
  )
```

```
## # A tibble: 2,020 x 5
##    PWSID     Variable          Mean        Median      SD
##    <chr>     <chr>            <dbl>         <dbl>   <dbl>
##  1 CA0110005 PDSI          -2.44e 0         -2.46 2.49e 0
##  2 CA0110005 demand         2.92e 9 2854036302    5.98e 8
##  3 CA0110005 precipitation  4.00e 1          6.24 6.38e 1
##  4 CA0110005 supply         5.00e 9 4891900000    1.03e 9
##  5 CA0110005 temperature    1.53e 1         15.2  2.64e 0
##  6 CA0110006 PDSI          -2.44e 0         -2.46 2.49e 0
##  7 CA0110006 demand         2.13e 8  227687086    8.86e 7
##  8 CA0110006 precipitation  3.48e 1          9.18 5.34e 1
##  9 CA0110006 supply         1.35e11  510466242    2.06e11
## 10 CA0110006 temperature    1.53e 1         15.4  3.56e 0
## # i 2,010 more rows
```

```
# 3. Time Series Visualization
# Plot PDSI over time
df %>%
  filter(Variable == "PDSI") %>%
  ggplot(aes(x = Date, y = Value, color = PWSID)) +
  geom_line() +
  labs(title = "PDSI Index Over Time", y = "PDSI") +
  theme_minimal()
```

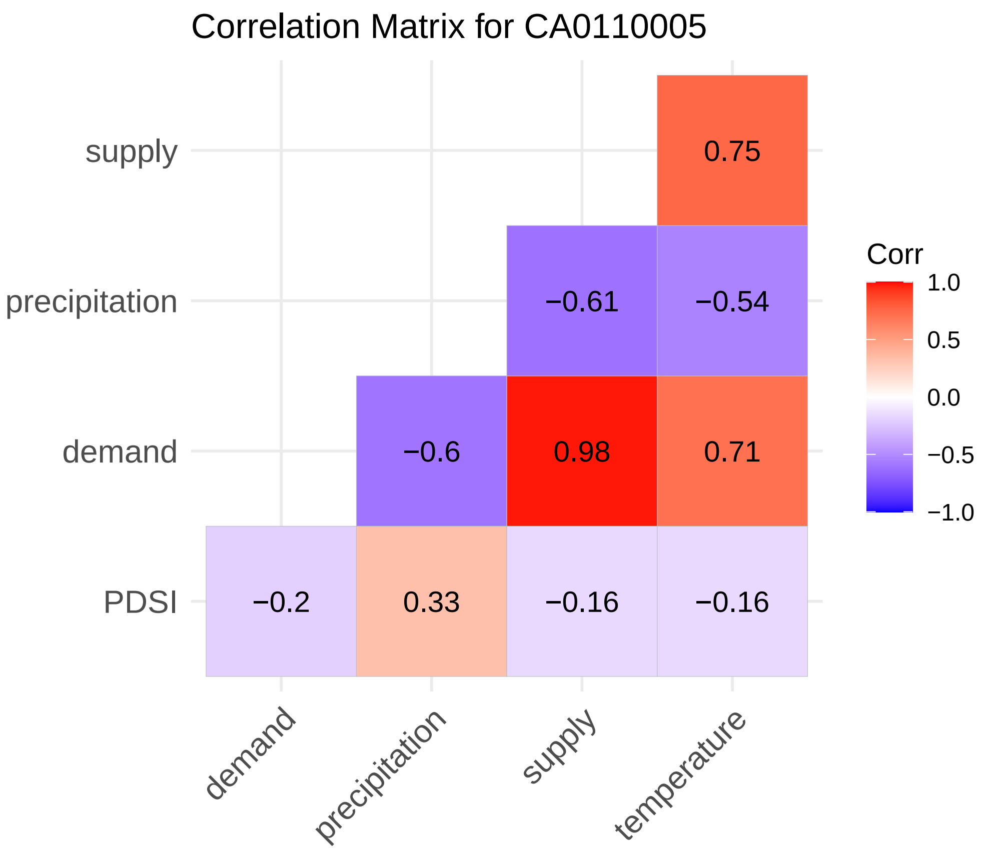


```r
# 4. Correlation Analysis for a single PWSID

library(ggcorrplot)
```

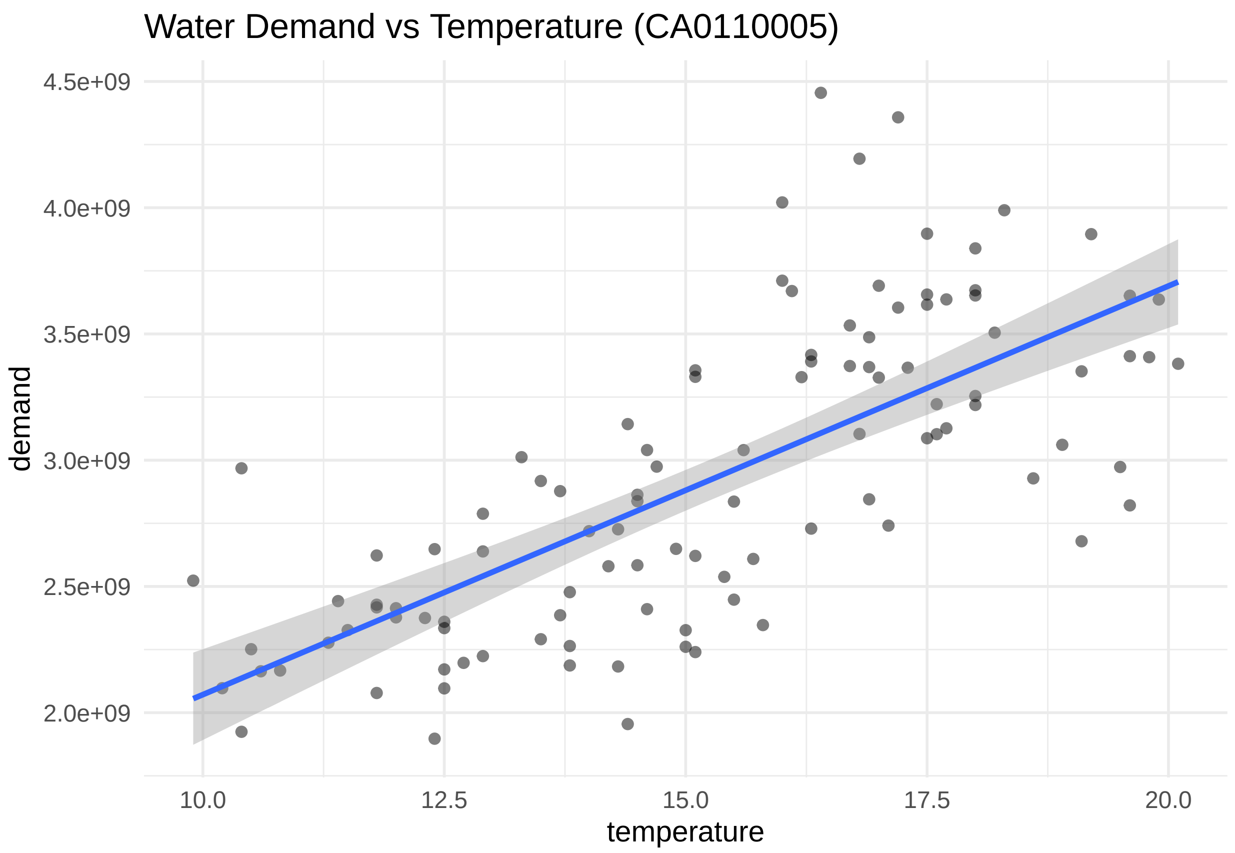
```
## Warning: package 'ggcorrplot' was built under R version 4.4.3
```

```r
df %>%
  filter(PWSID == "CA0110005") %>%
  select(-PWSID) %>%
  pivot_wider(names_from = Variable, values_from = Value) %>%
  select(-Date) %>%
  cor(use = "complete.obs") %>%
  ggcorrplot::ggcorrplot(
    type = "lower",
    lab = TRUE,
    title = "Correlation Matrix for CA0110005"
  )
```

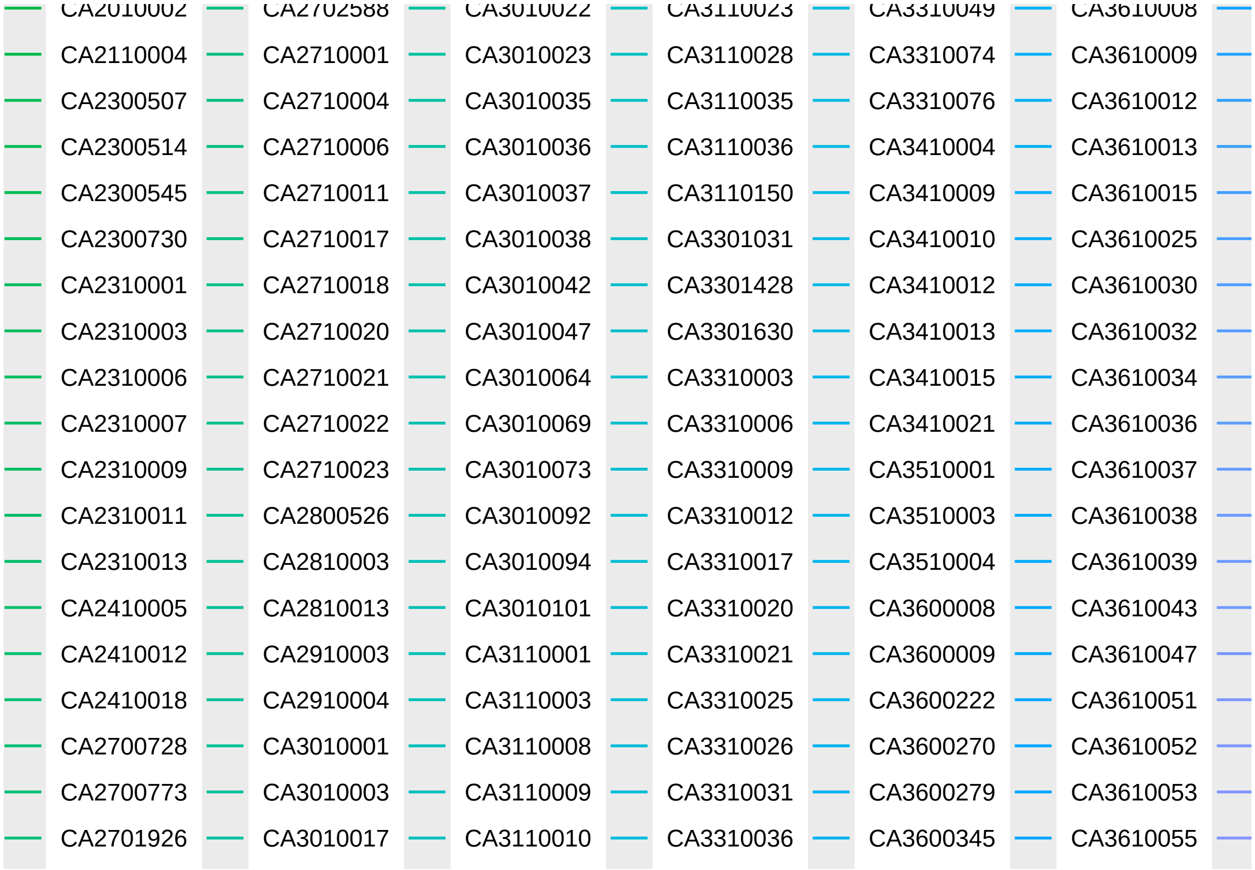


```
# 5. Demand vs Temperature Analysis
df %>%
  filter(PWSID == "CA0110005",
         Variable %in% c("demand", "temperature")) %>%
  pivot_wider(names_from = Variable, values_from = Value) %>%
  ggplot(aes(x = temperature, y = demand)) +
  geom_point(alpha = 0.5) +
  geom_smooth(method = "lm") +
  labs(title = "Water Demand vs Temperature (CA0110005)") +
  theme_minimal()
```

```
## 'geom_smooth()' using formula = 'y ~ x'
```



```r
# 6. Monthly Aggregations
# Average monthly demand across years
df %>%
  filter(Variable == "demand") %>%
  mutate(Month = month(Date, label = TRUE)) %>%
  group_by(PWSID, Month) %>%
  summarise(Avg_Demand = mean(Value, na.rm = TRUE), .groups = "drop") %>%
  ggplot(aes(x = Month, y = Avg_Demand, color = PWSID, group = PWSID)) +
  geom_line() +
  labs(title = "Seasonal Demand Patterns", y = "Average Demand")
```



```r
# 7. Annual Trends
# Annual precipitation trends
df %>%
  filter(Variable == "precipitation") %>%
  mutate(Year = year(Date)) %>%
  group_by(PWSID, Year) %>%
  summarise(Total_Precipitation = sum(Value, na.rm = TRUE), .groups = "drop") %>%
  ggplot(aes(x = Year, y = Total_Precipitation, color = PWSID)) +
  geom_line() +
  geom_point() +
  labs(title = "Annual Precipitation Trends", y = "Total Precipitation")
```

CA2010002
CA2110004
CA2300507
CA2300514
CA2300545
CA2300730
CA2310001
CA2310003
CA2310006
CA2310007
CA2310009
CA2310011
CA2310013
CA2410005
CA2410012
CA2410018
CA2700728
CA2700773
CA2701926
CA2702588
CA2710001
CA2710004
CA2710006
CA2710011
CA2710017
CA2710018
CA2710020
CA2710021
CA2710022
CA2710023
CA2800526
CA2810003
CA2810013
CA2910003
CA2910004
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CA3010023
CA3010035
CA3010036
CA3010037
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CA3010101
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