

This presentation premiered at WaterSmart Innovations

watersmartinnovations.com



Coping with drought: Investigating media impact on water consumption

Kim Quesnel, Patricia Gonzales,
Nick Roby, and Newsha Ajami

Stanford University

WaterSmart Innovations Conference

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Outline

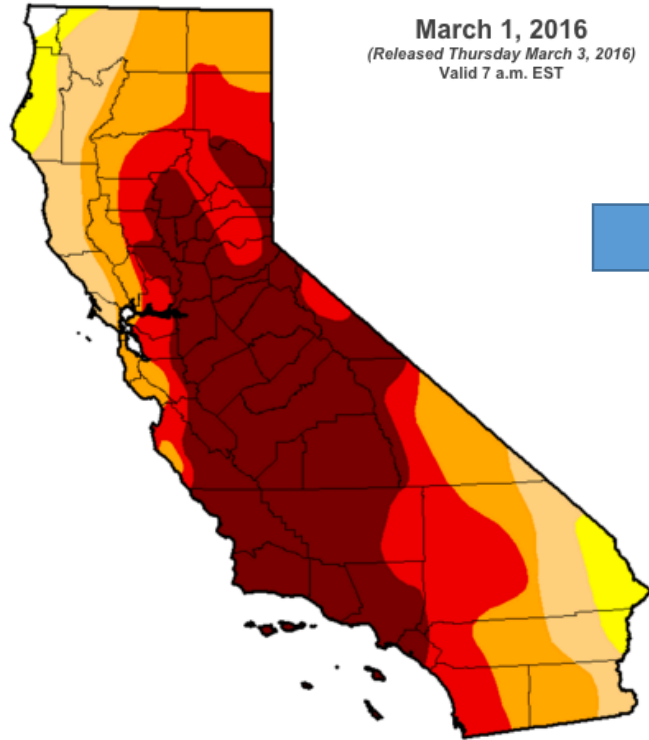
- Background and motivation
- Examining media coverage
- Modeling SFR water use
- Water use trends using smart meter data
- Implications



Background and Motivation

Motivation: California Drought

U.S. Drought Monitor California



Many utilities have seen unexplained decreased urban water consumption during current drought. Why?

Our Hypothesis:

Change in water supply landscape
→ political action
→ media coverage
→ change in water use behavior



THE WALL STREET JOURNAL.

**California Orders Unprecedented, Mandatory
Water Cuts**

Sierra Nevada snowpack levels fall to record low

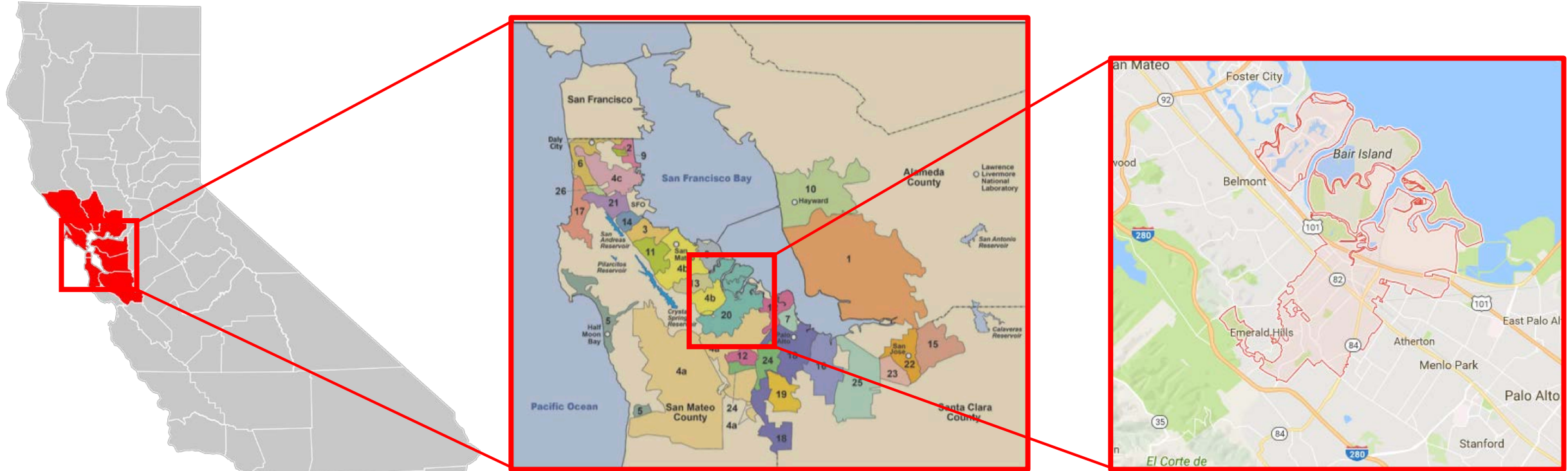
THE SACRAMENTO BEE

**Jerry Brown declares California drought
emergency, urges 20 percent cut in water use**

Los Angeles Times

**How bad is the drought? Here are some
sobering answers.**

Study Areas



1. Bay Area Water Supply and Conservation Agency (BAWSCA)

2. Redwood City (RWC)



Research Questions

BAWSCA

- How is media/political action related to water use changes throughout BAWSCA?
- How have different service areas with diverse populations reacted?

Redwood City

- How have customers responded to media at a fine temporal and spatial scale?
- How has AMI changed water use behavior in Redwood City?





Examining Media Coverage

Media Data Collection

- Developed web-scraping algorithm using Python and Google Custom Search Engine API to determine the number of newspaper articles about the “California Drought”
- Validated results using ProQuest proprietary database for select news sources

Top Nationwide Newspapers

- Wall Street Journal
- New York Times
- USA Today

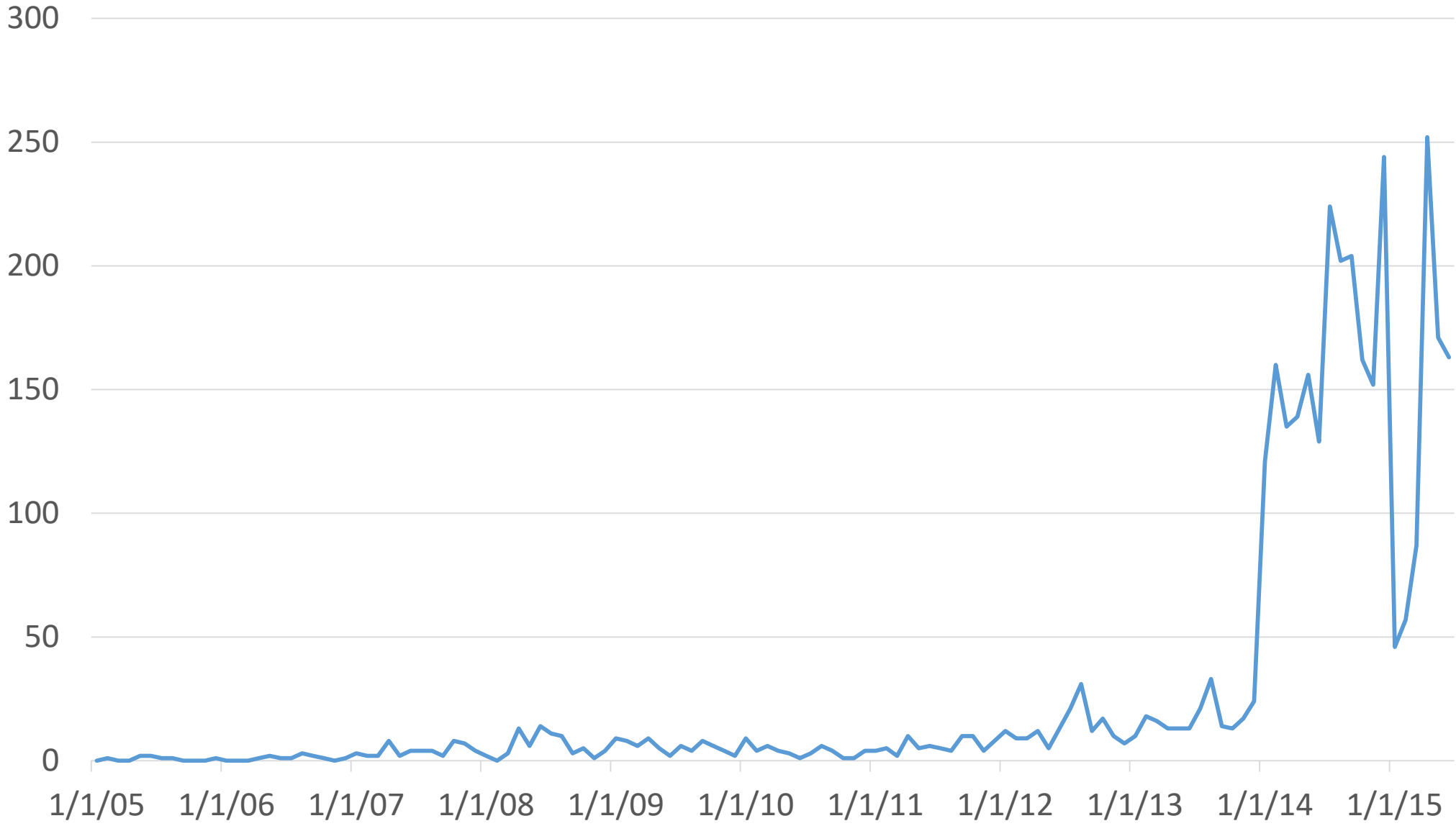
Top California Newspapers

- Los Angeles Times
- ~~San Jose Mercury News~~
- Sacramento Bee
- Orange County Register
- San Diego Union-Tribune
- San Francisco Chronicle (SF Gate)
- ~~Contra Costa Times~~



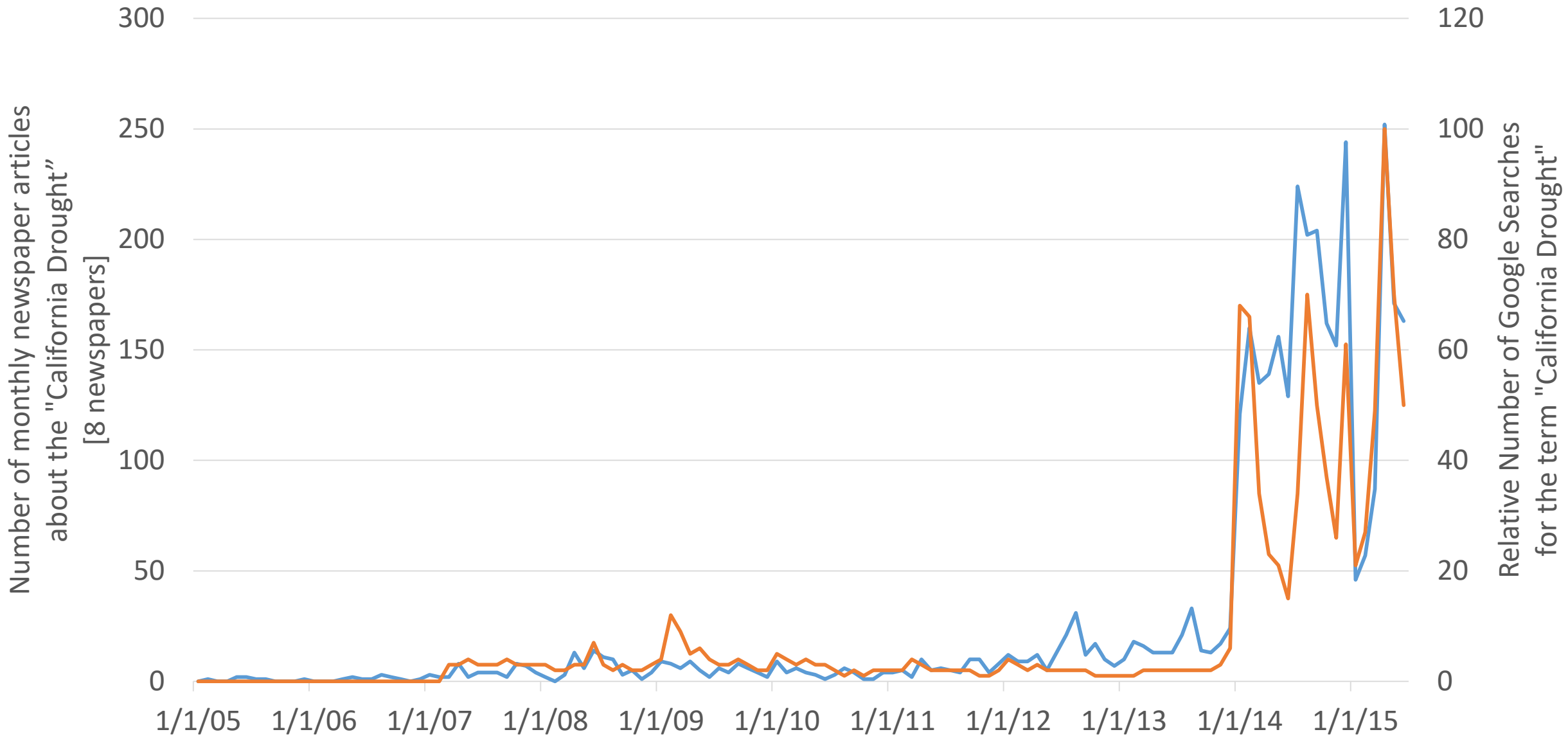
Number of monthly newspaper articles
about the "California Drought"

[8 newspapers]

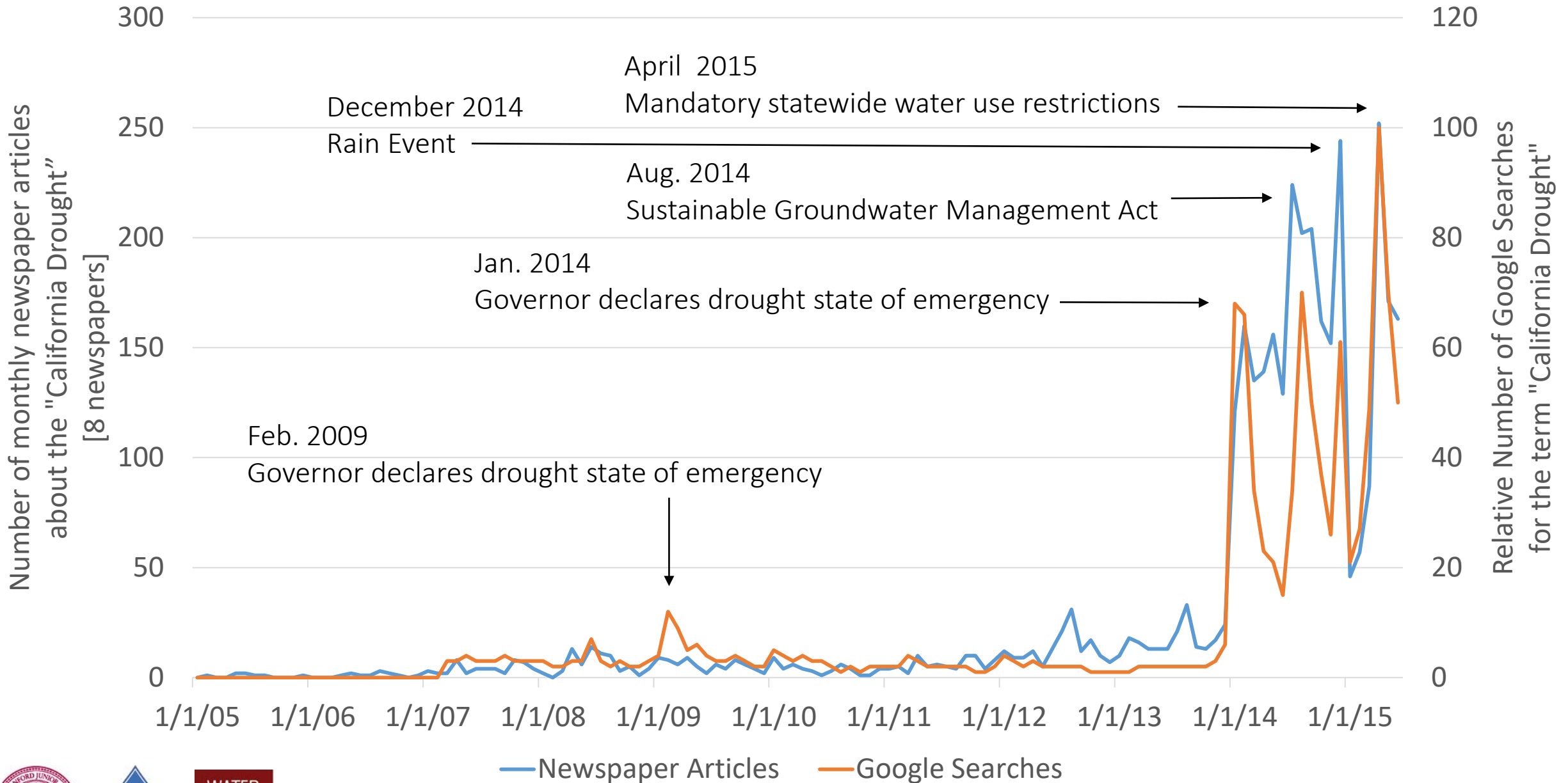


— Newspaper Articles





— Newspaper Articles — Google Searches



An aerial photograph of a coastal region, likely the San Francisco Bay Area. The image shows a complex network of waterways, including a large bay and several smaller channels. The water is a deep blue, and the surrounding land is a mix of green fields, brownish mudflats, and developed areas. In the foreground, there are several large industrial or commercial buildings, parking lots, and a multi-lane highway. In the background, a city skyline is visible across the water. A semi-transparent white banner is overlaid across the middle of the image, containing the text "Modeling SFR Water Use in BAWSCA".

Modeling SFR Water Use in BAWSCA

Data Collection

1. Water Use
2. Climate
3. Price
4. Unemployment
5. Demographics
6. Media



Data Collection

1. Water Use
2. Climate
3. Price
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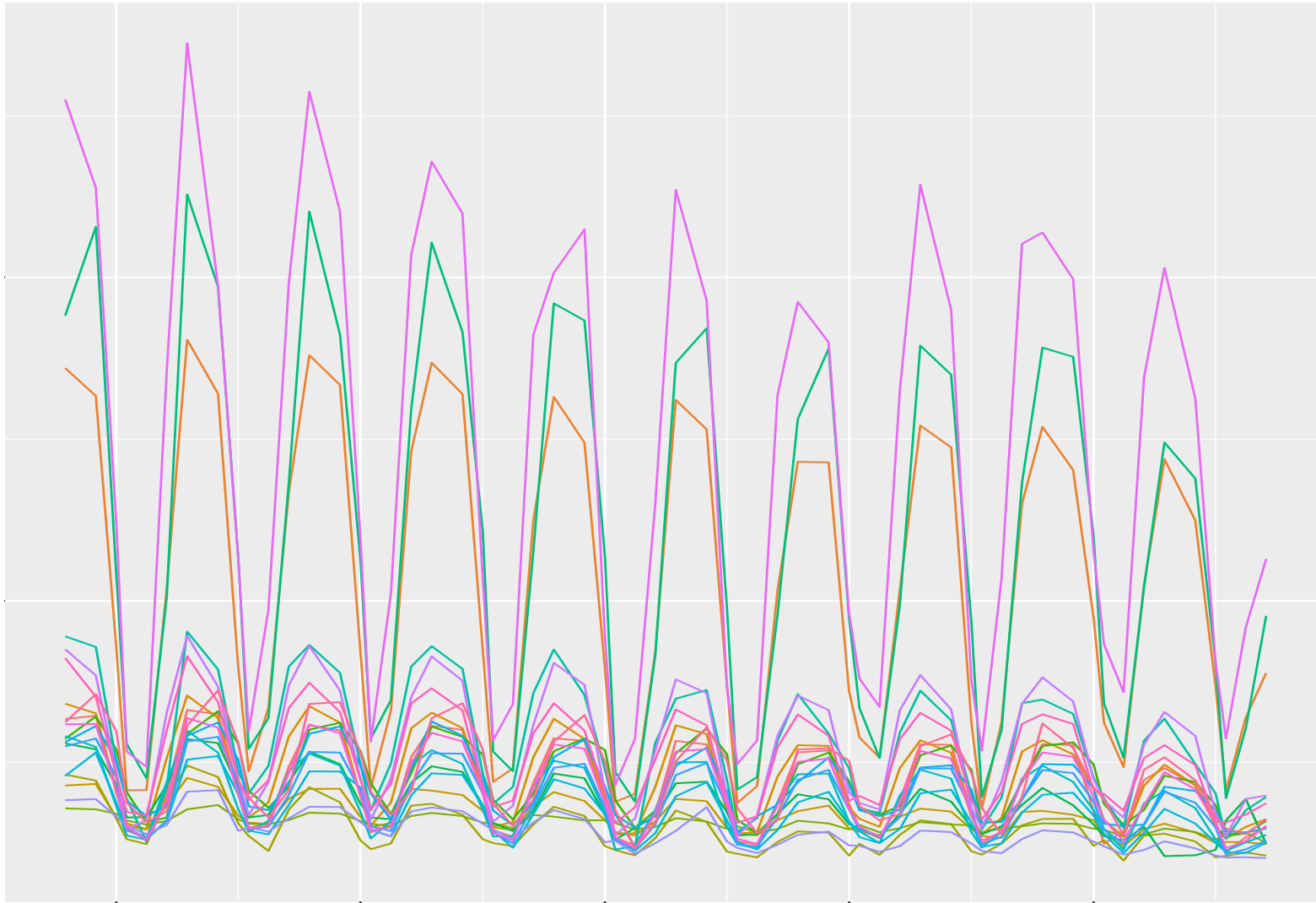
Data Collection

1. Water Use

- Bi-monthly, agency-level water use, normalized by number of accounts
- July 1, 2005- June 30, 2015
- 20/28 BAWSCA member agencies



Average Bimonthly SFR Water Use



Sunnyvale^a

Data Collection

1. Water Use
- 2. Climate**
3. Price
4. Unemployment
5. Demographics
6. Media



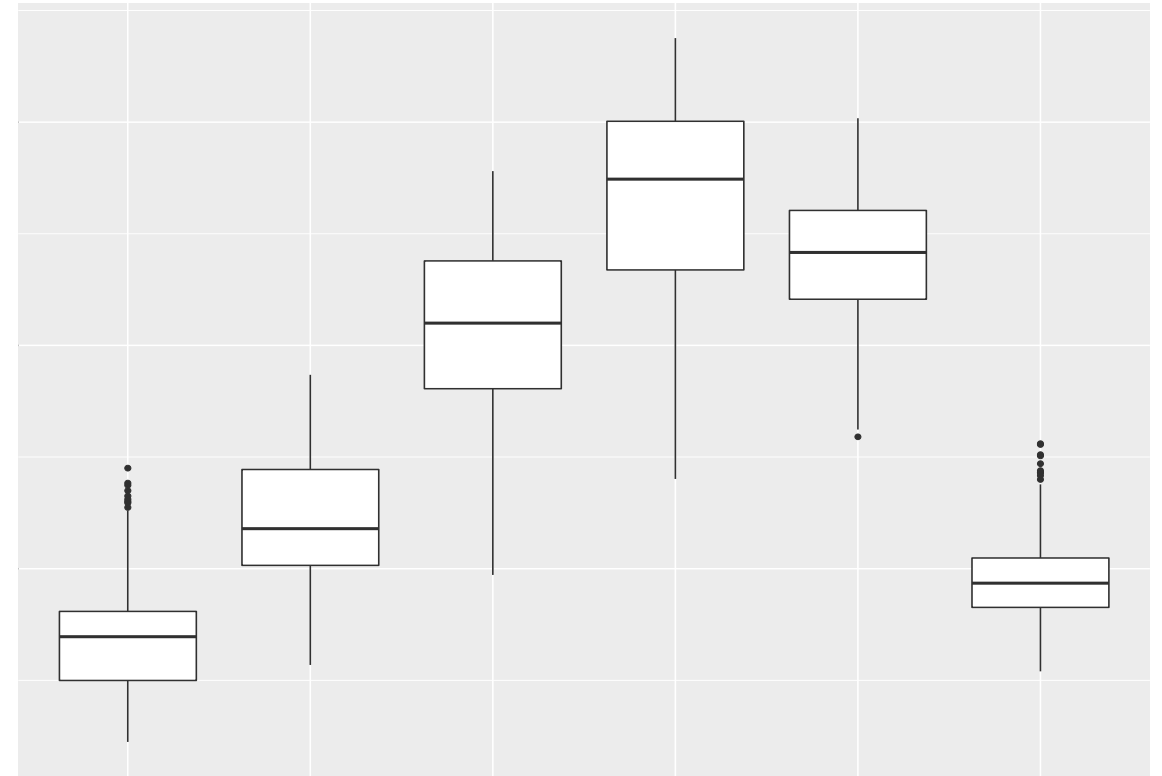
Data Collection

1. Water Use

2. Climate

- Monthly spatially-explicit temperature and precipitation from Oregon State PRISM database
- Used ArcGIS to calculate average monthly temperature and cumulative precipitation for each agency

ity and Variability in BAWSCA Agencies
2005–2015



Data Collection

1. Water Use
2. Climate
- 3. Price**
4. Unemployment
5. Demographics
6. Media



Data Collection

1. Water Use

2. Climate

3. Price

- Calculated the average price per CCF for an SFR customer each year (Average bill divided by average water use in CCF)
- Adjusted to 2015\$ using the monthly Consumer Price Index
- Price ranges between \$2.16/CCF to \$12.42/CCF



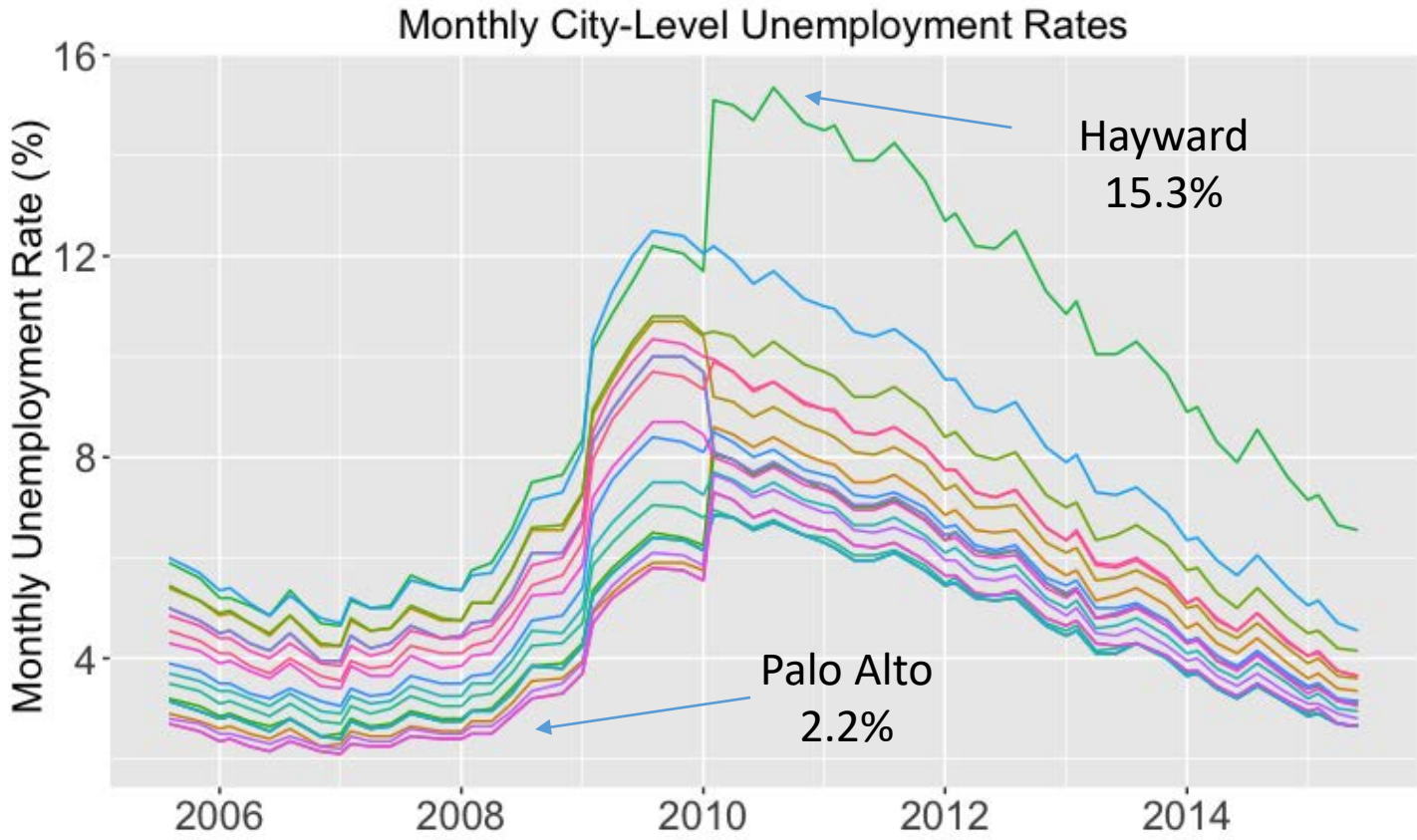
Data Collection

1. Water Use
2. Climate
3. Price
- 4. Unemployment**
5. Demographics
6. Media



Data Collection

- 1. Water Use
- 2. Climate
- 3. Price
- 4. Unemployment
 - Monthly city-level unemployment from the Bureau of Labor Statistics
 - 14/20 cities (agencies) reported, remaining 6 assigned representative cities as a proxy



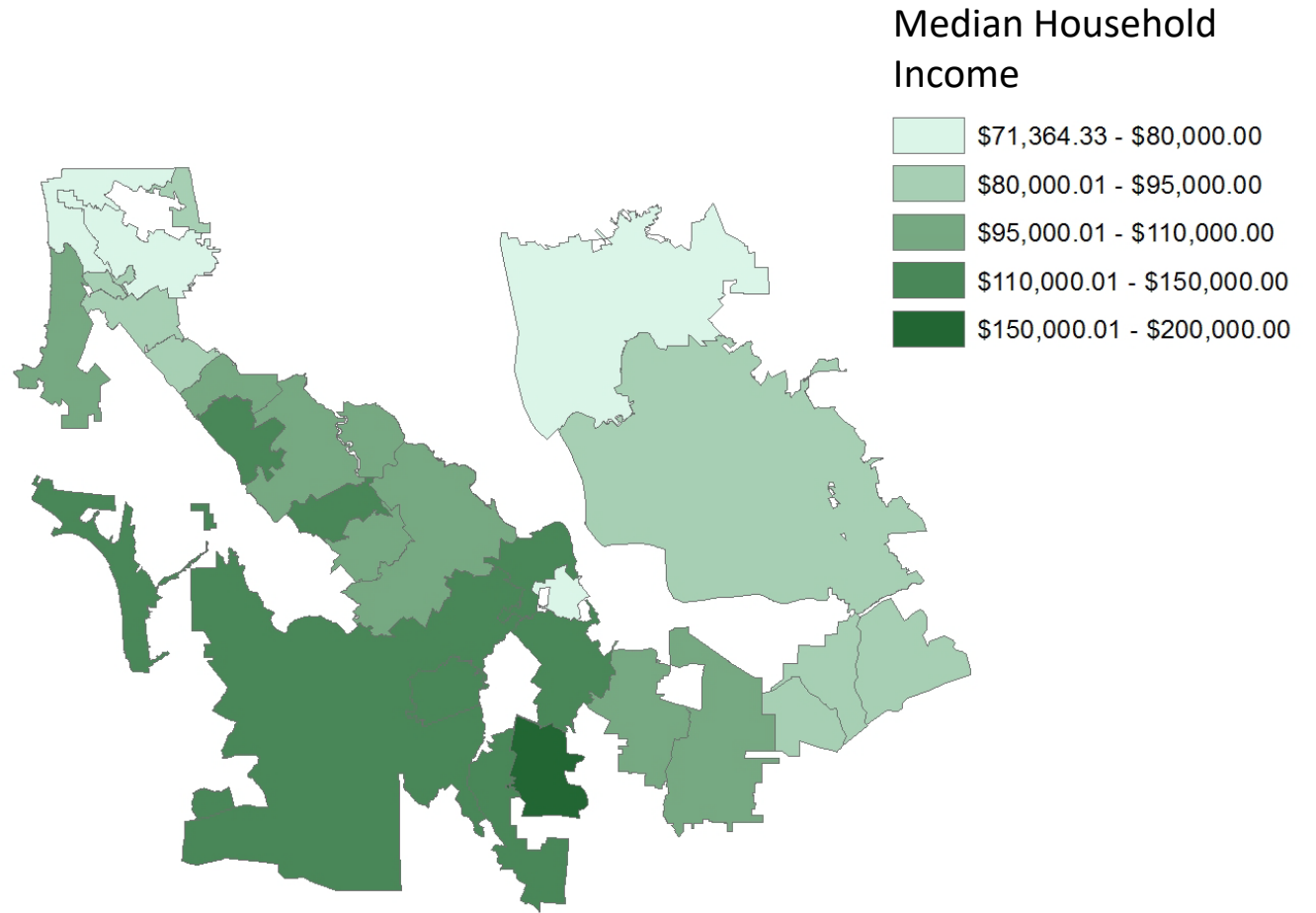
Data Collection

1. Water Use
2. Climate
3. Price
4. Unemployment
- 5. Demographics**
6. Media



Data Collection

1. Water Use
2. Climate
3. Price
4. Unemployment
5. Demographics
 - 2010 Census data at the Census block-group level aggregated to each agency



Data Collection

1. Water Use
2. Climate
3. Price
4. Unemployment
5. Demographics
6. **Media**



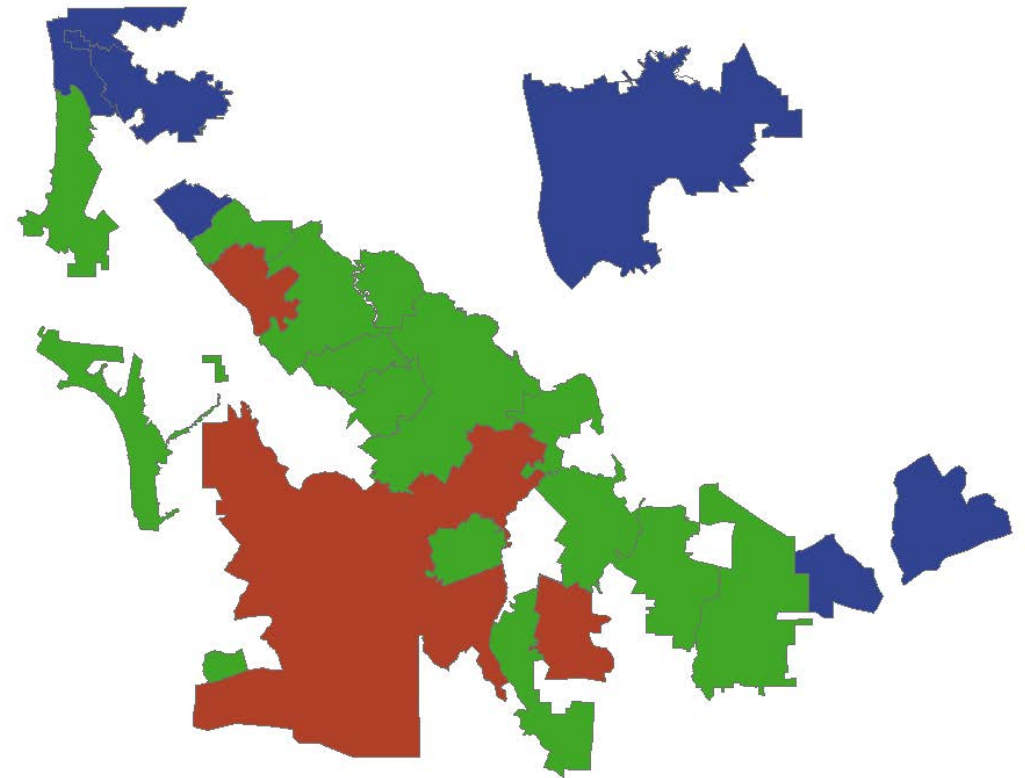
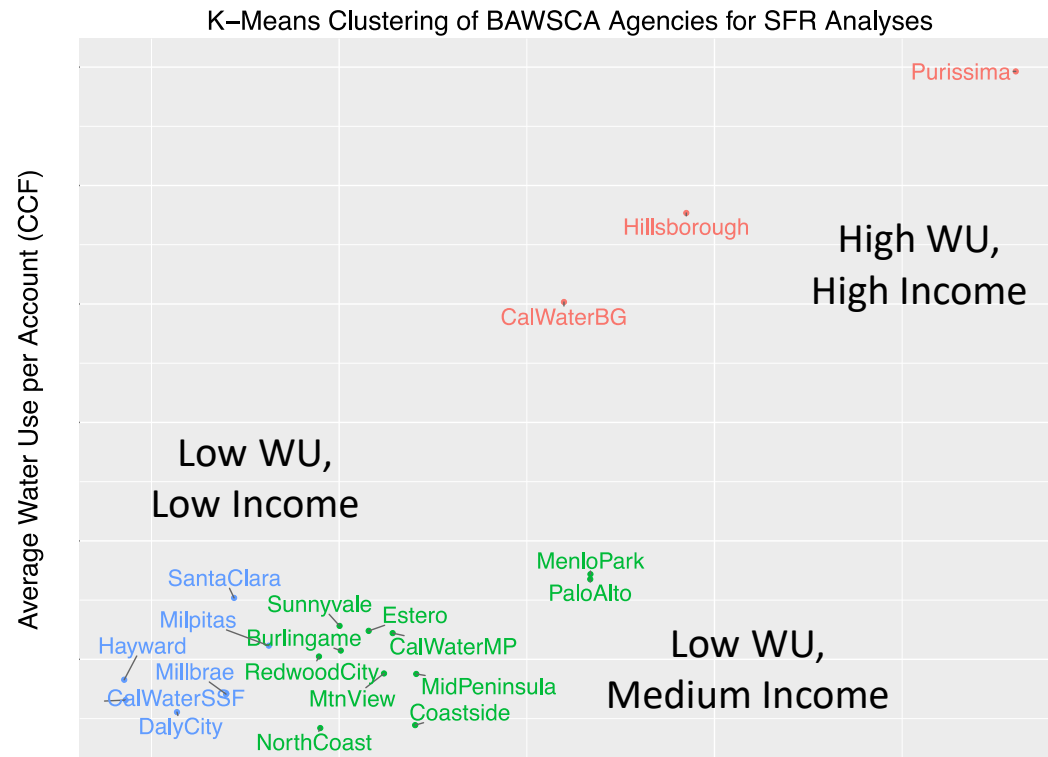
Modeling Methodology

- OLS Regression to model bimonthly SFR water use across 20 BAWSCA agencies
- Temperature accounts for seasonality and warrants linear model
- Two modeling approaches:
 1. Pooled model for all agencies
 2. Clustered models based on income and water use

$$\begin{aligned} & \ln(WU_{SFR}) \\ &= \beta_0 + \beta_1 Temp + \beta_2 Precip + \beta_3 Price \\ &+ \beta_4 Unemployment + \beta_5 Income + \beta_6 Media \end{aligned}$$



Modeling SFR Water Use: Cluster Analysis



Modeling SFR Water Use

- Similar or better model performance (R^2 , RMSE, and MAPE) for clusters than pooled model
- Variance in water consumption in each cluster can be partially explained by media: for every 100 articles, we can expect water use to decrease by ~10%

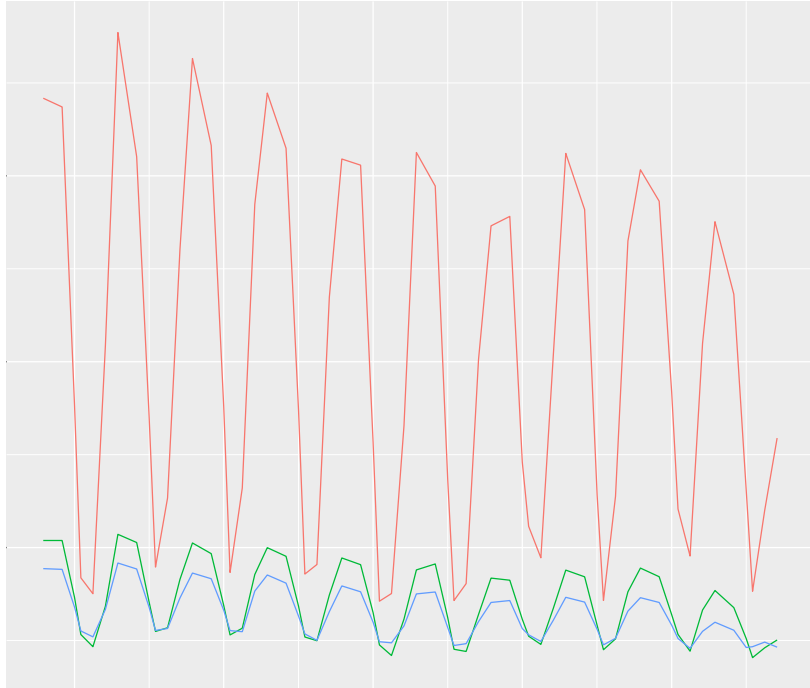


Note:

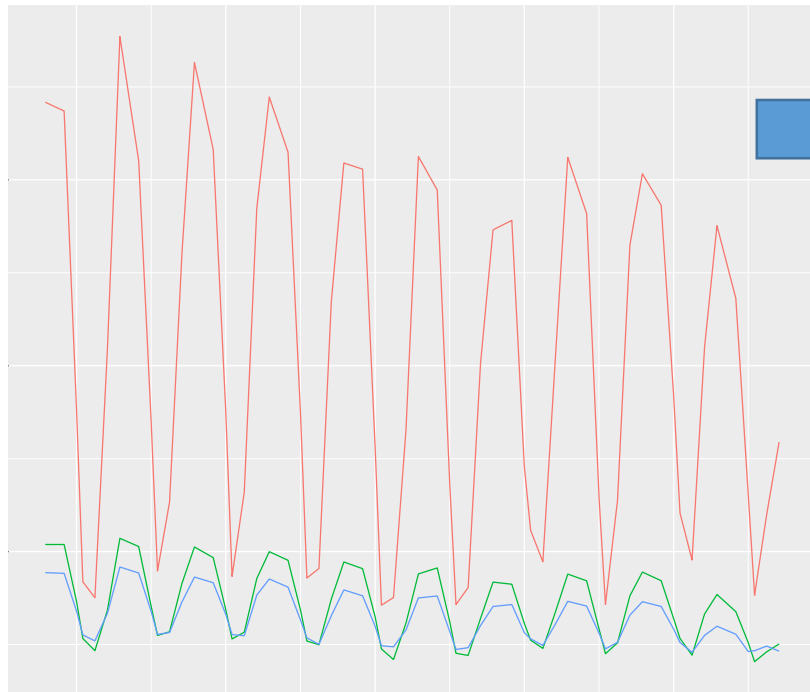
72*** (df = 6; 173)

* p<0.1; ** p<0.05; *** p<0.01

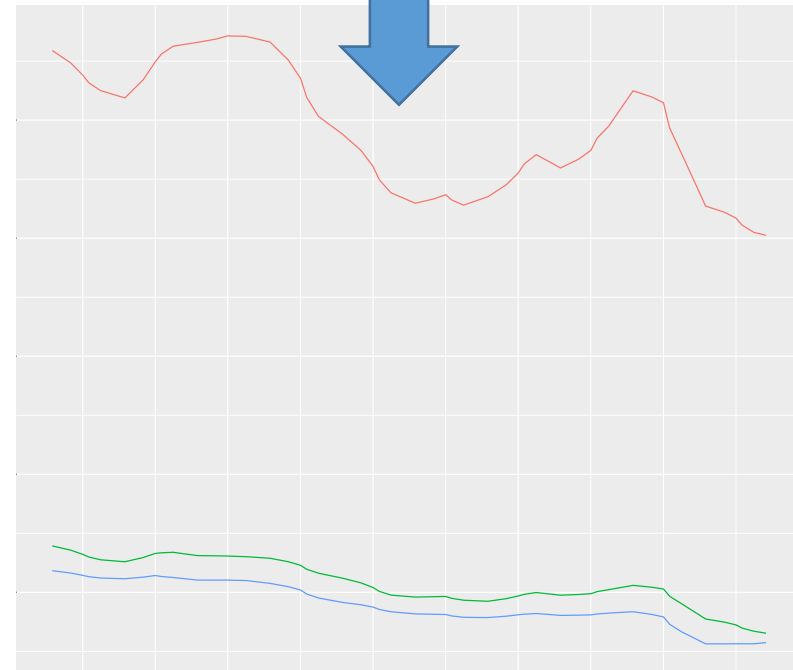
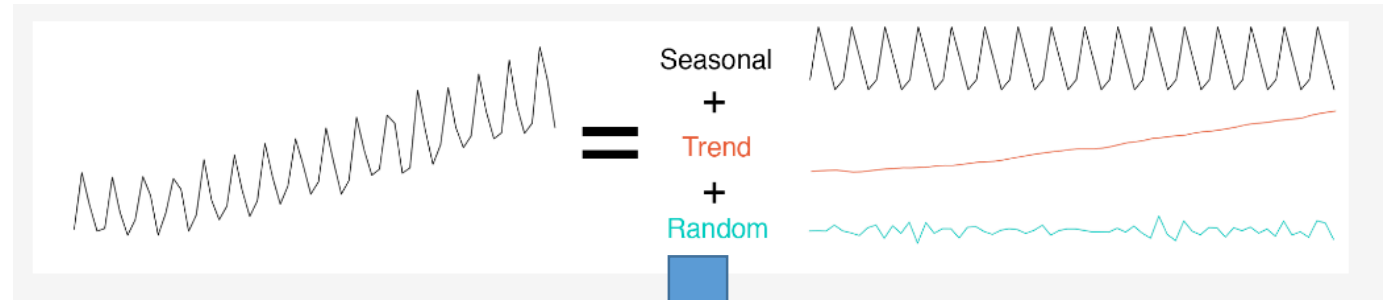
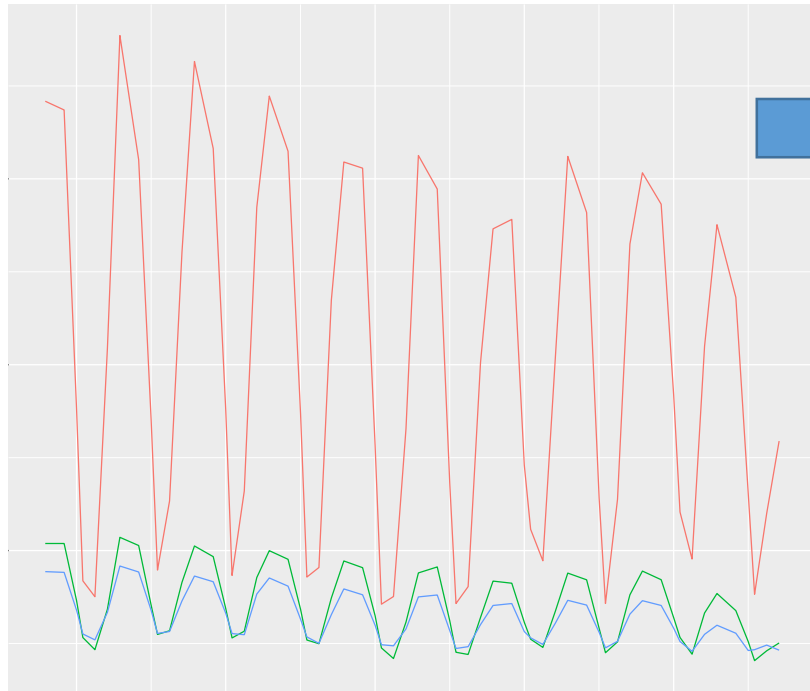
Examining SFR Water Use Trends



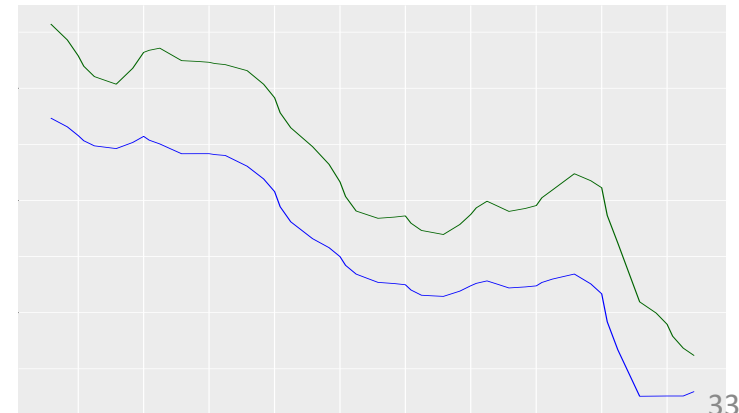
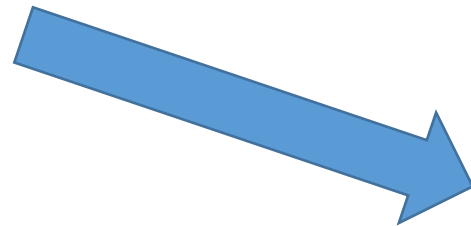
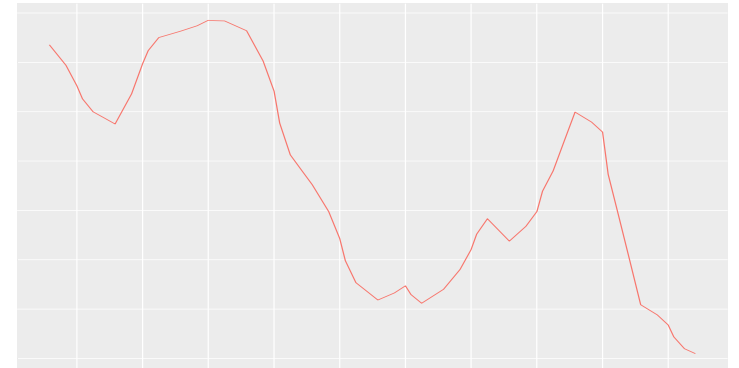
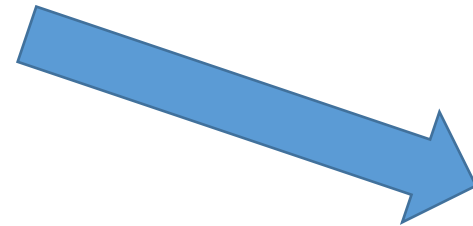
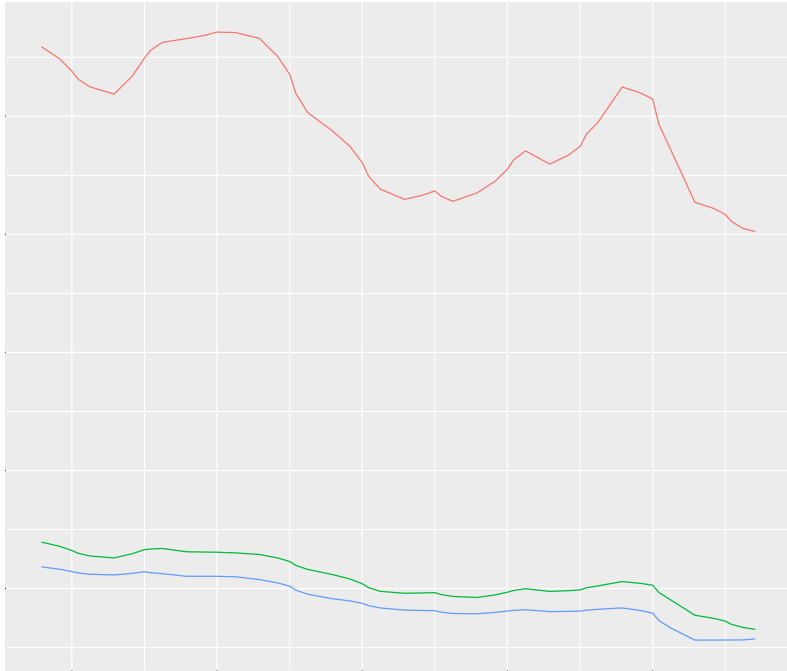
Examining SFR Water Use Trends



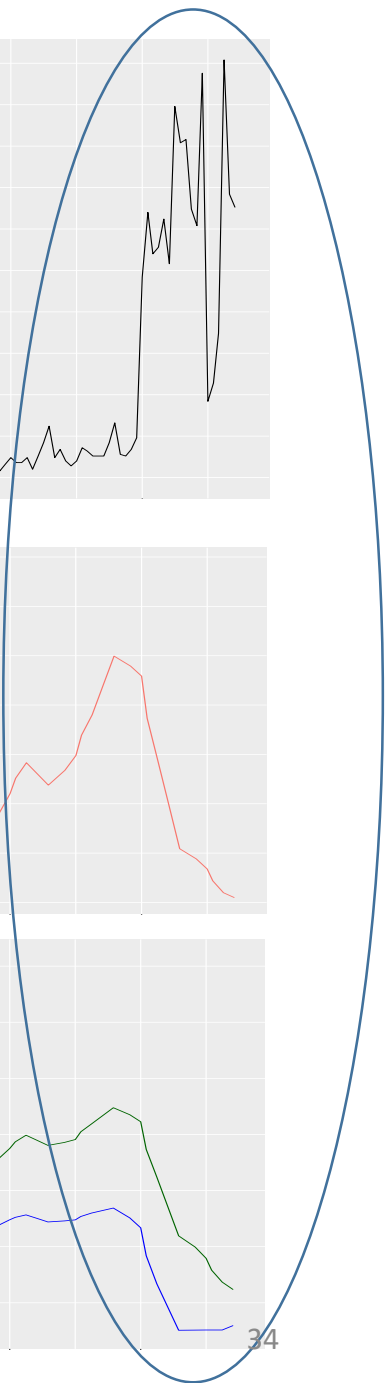
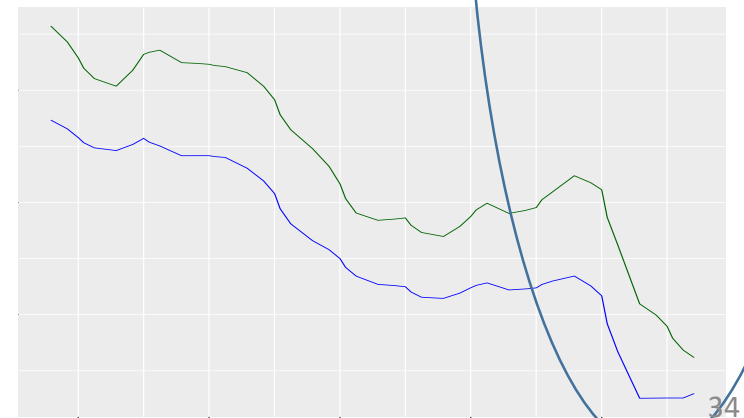
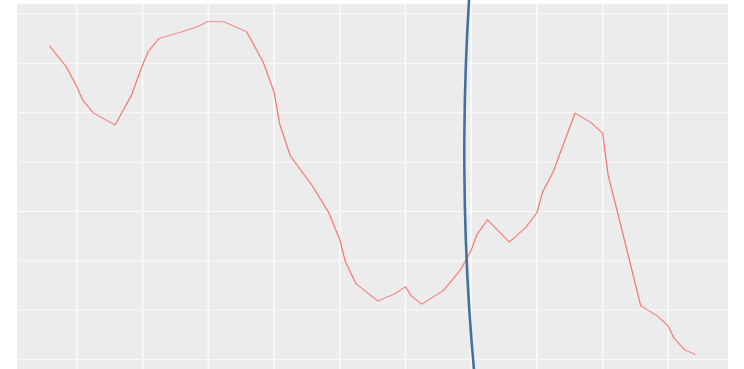
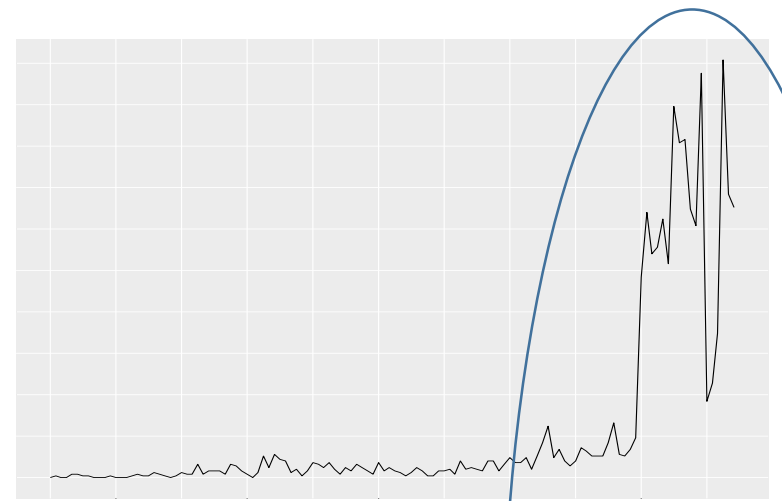
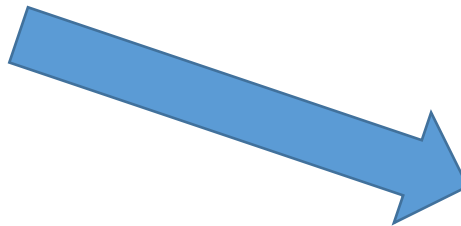
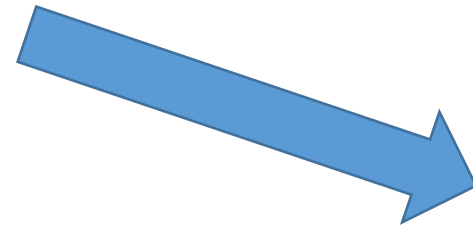
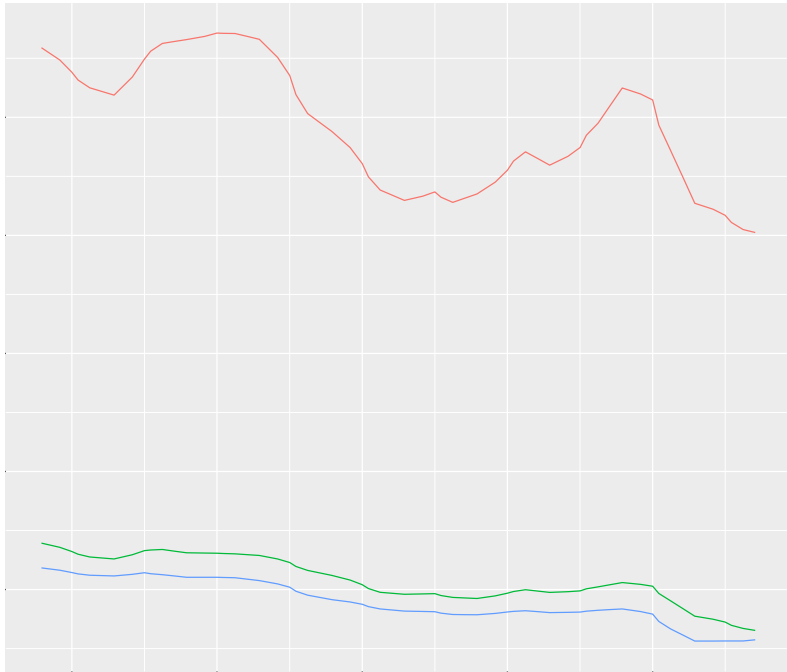
Examining SFR Water Use Trends



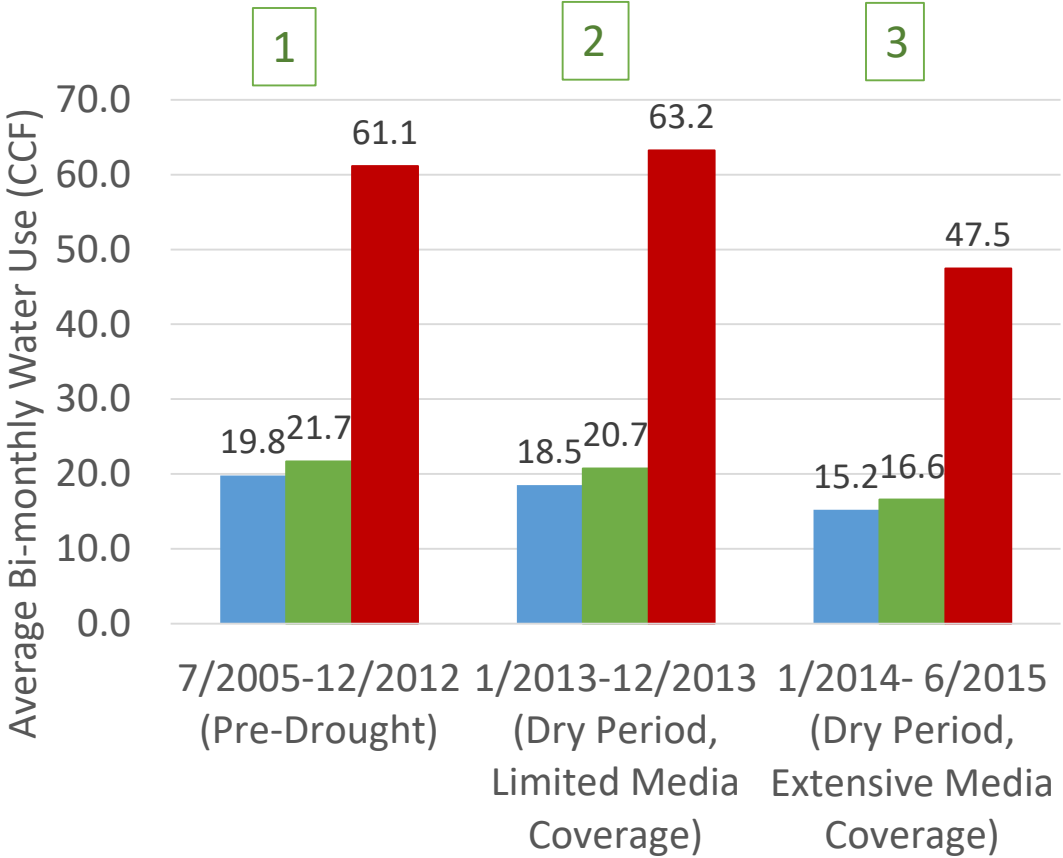
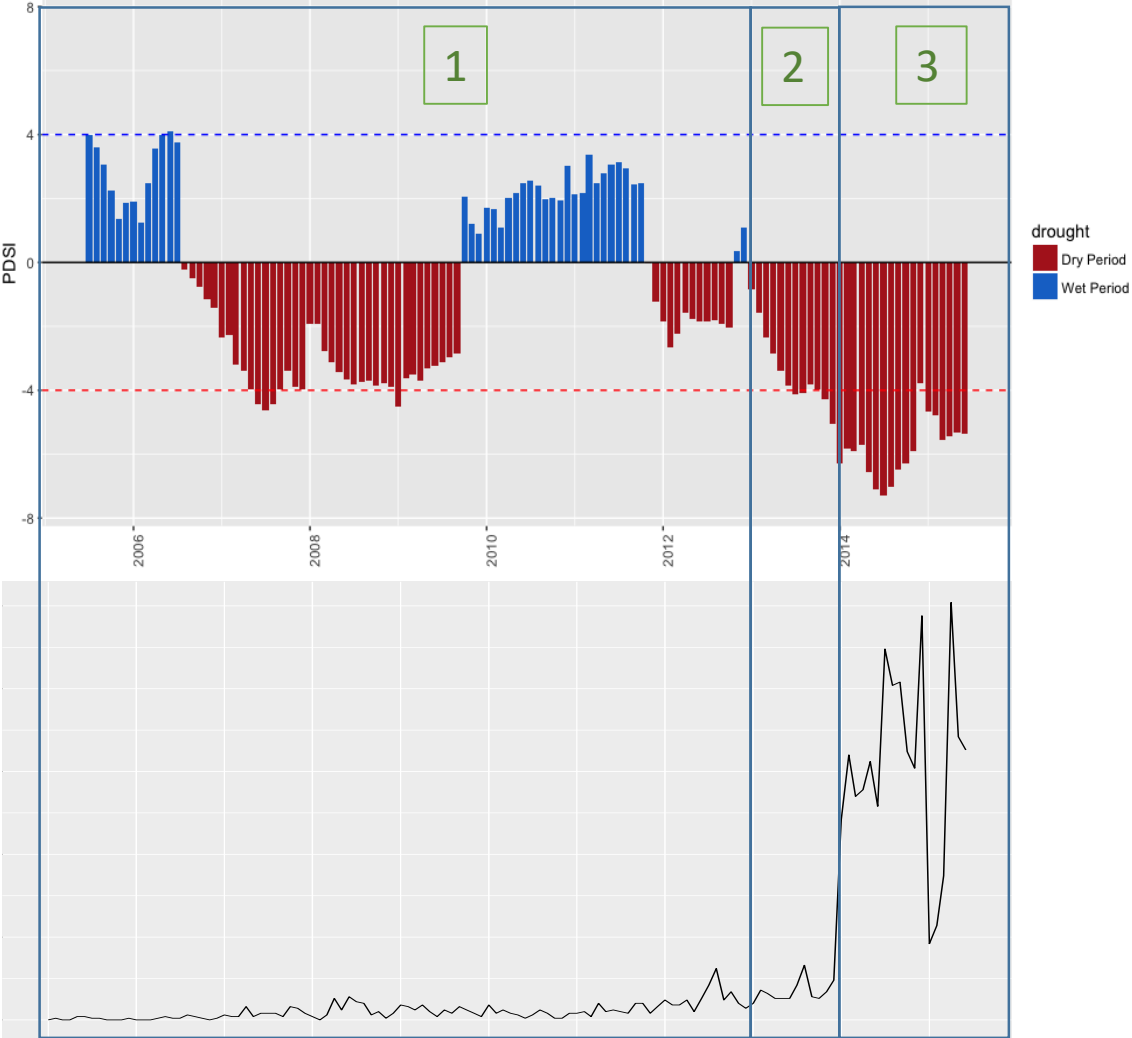
SFR Water Use Trends



SFR Water Use Trends



Examining SFR Water Use Trends



- Cluster 1: Low WU/Low Income
- Cluster 2: Low WU/Med Income
- Cluster 3: High WU/High Income

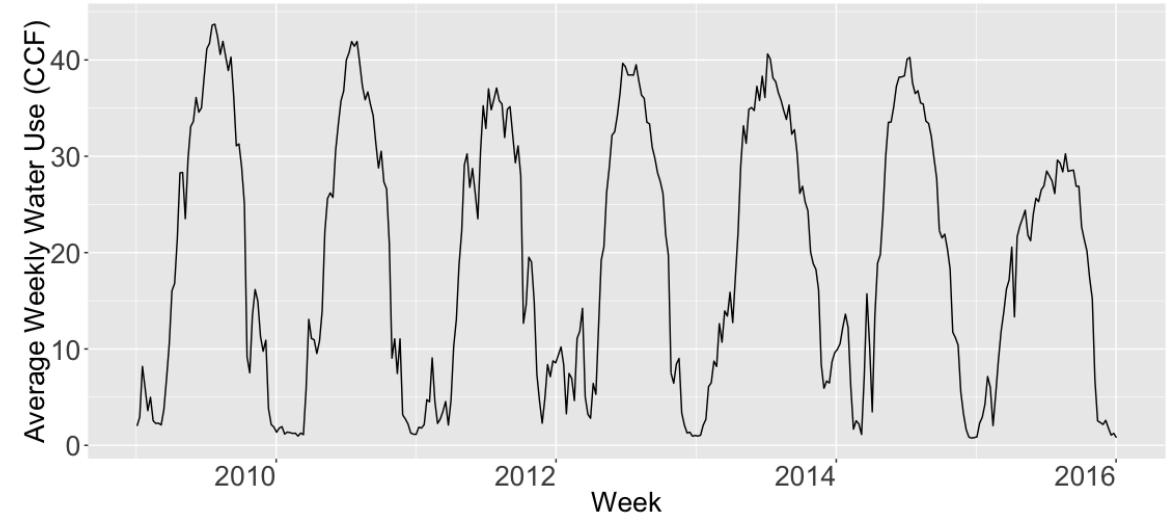
A photograph showing a row of smart water meters installed on a wall. The meters are grey and labeled "SmartMeter". They are connected to a network of pipes and valves. A semi-transparent white text box is overlaid in the center of the image, containing the text "AMI Water Use in Redwood City".

AMI Water Use in Redwood City

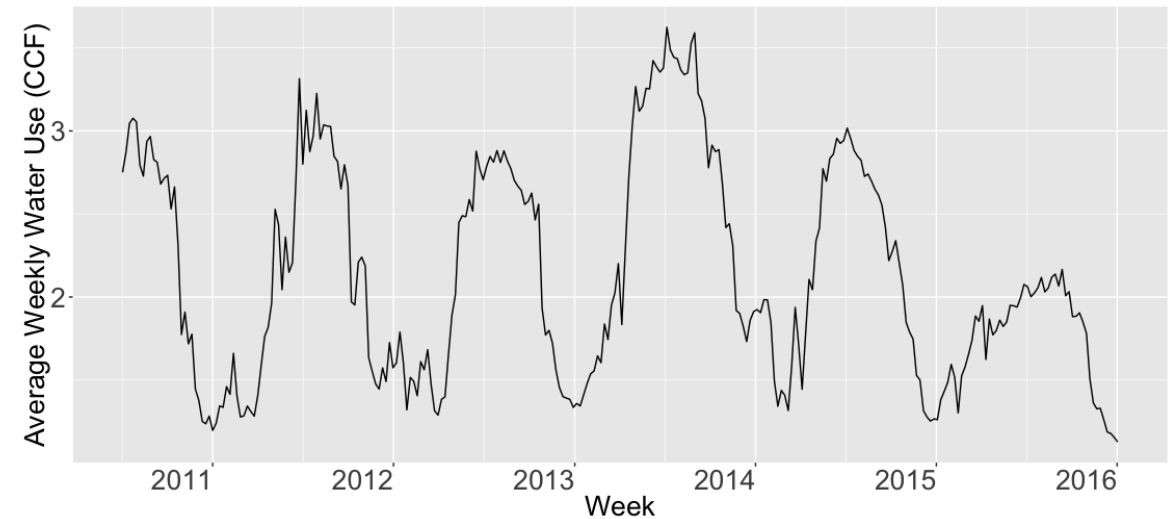
Redwood City

- Daily, customer-level water use from AMI, aggregated to weekly
- Sectors:
 - Commercial Irrigation (COMM-IRR)
January 1, 2009- Dec 31, 2015
 - Single Family Residential (SFR)
July 1, 2010- Dec 31, 2015
- Water use highly seasonal, especially for outdoor water use
- Apply additive seasonal decomposition to find trends and patterns in water use at a fine temporal scale

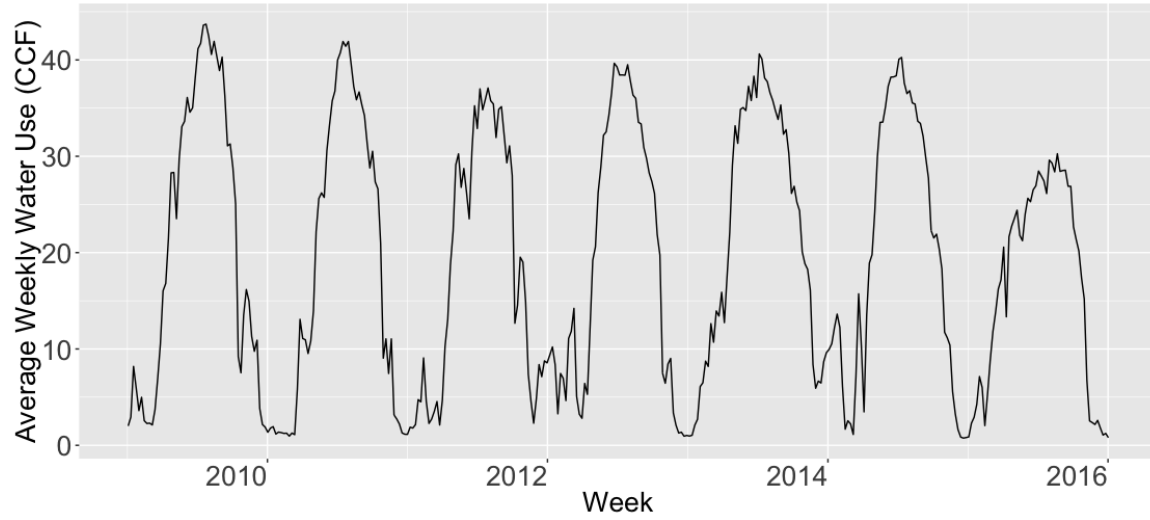
RWC Average Weekly Water Use
COMM-IRR Accounts with AMI



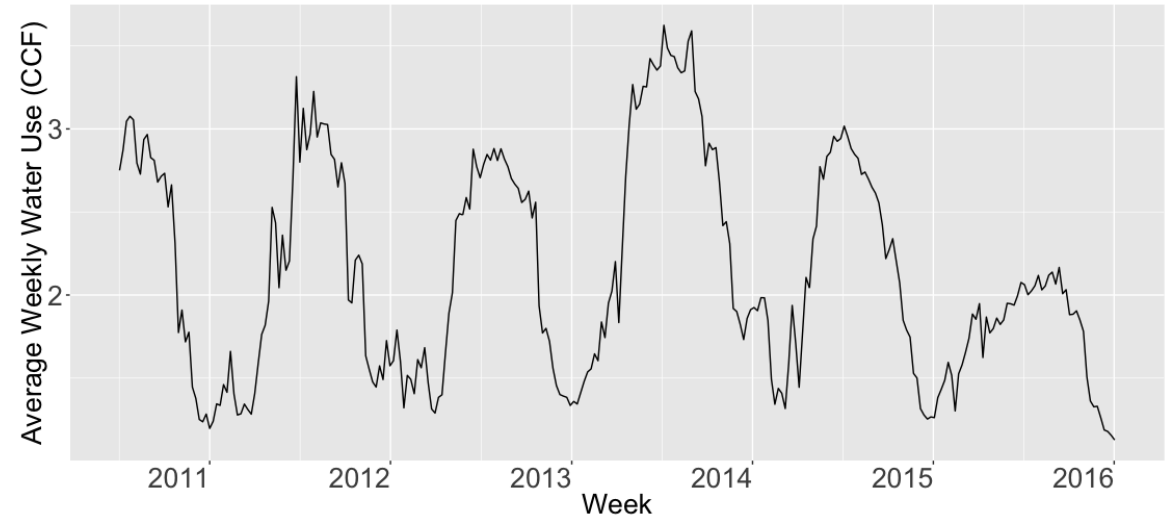
RWC Average Weekly Water Use
SFR Accounts with AMI



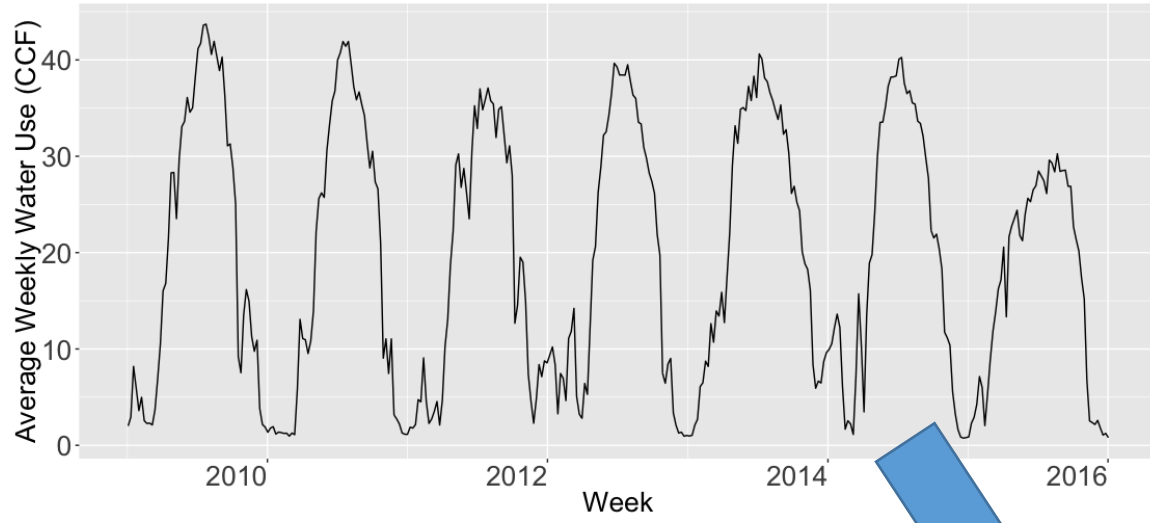
RWC Average Weekly Water Use
COMM-IRR Accounts with AMI



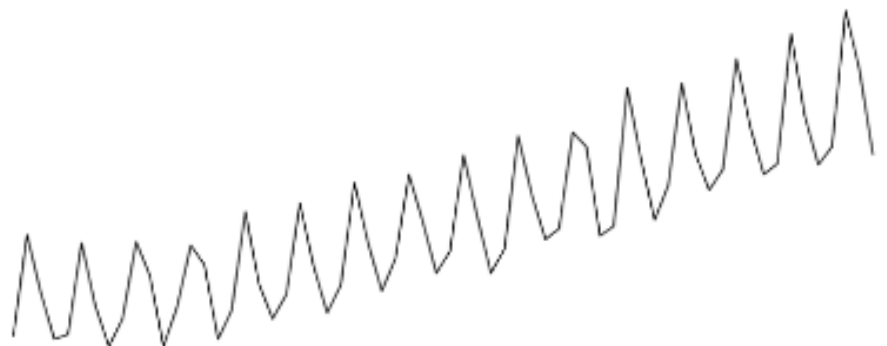
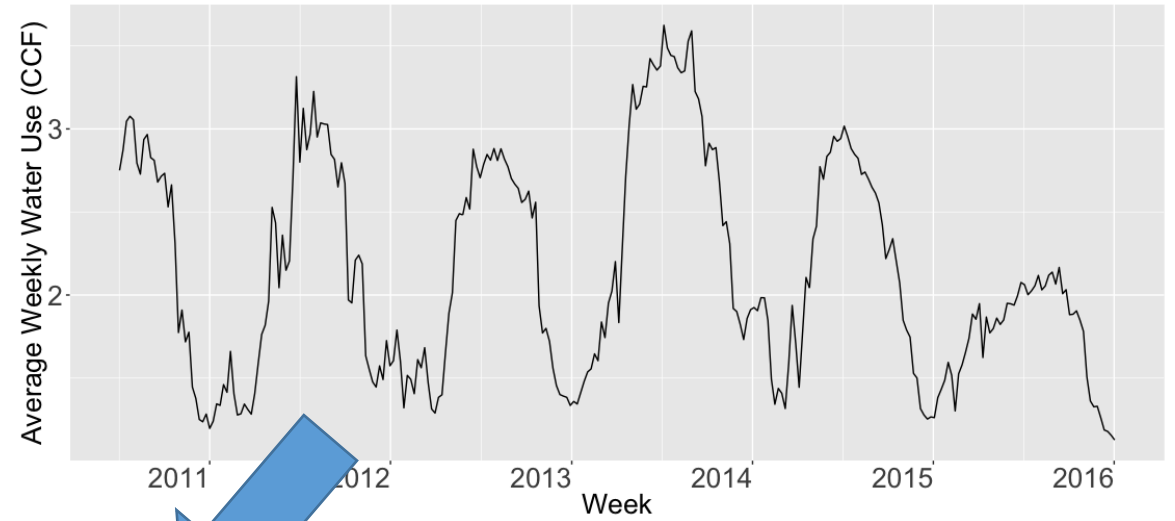
RWC Average Weekly Water Use
SFR Accounts with AMI



RWC Average Weekly Water Use
COMM-IRR Accounts with AMI



RWC Average Weekly Water Use
SFR Accounts with AMI



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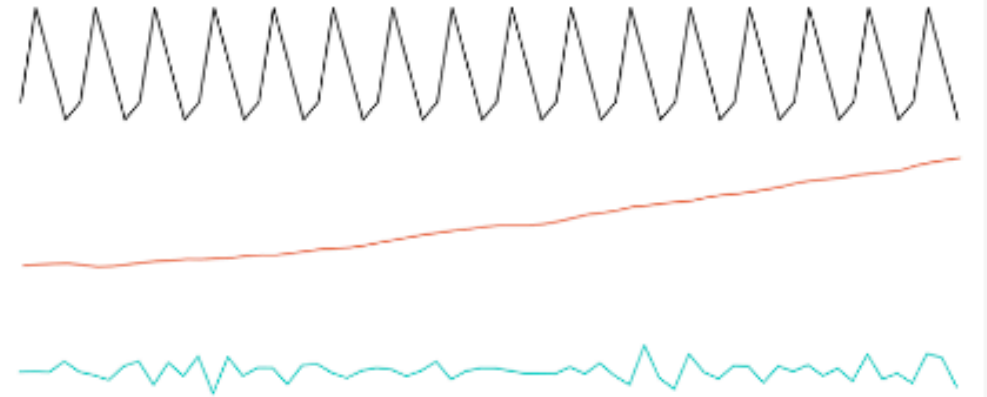
Seasonal

+

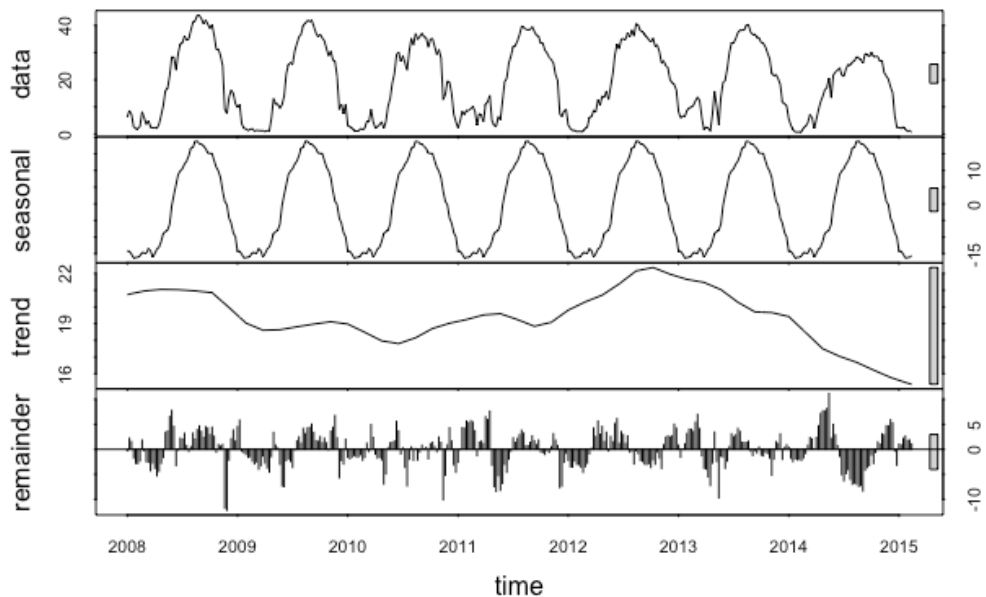
Trend

+

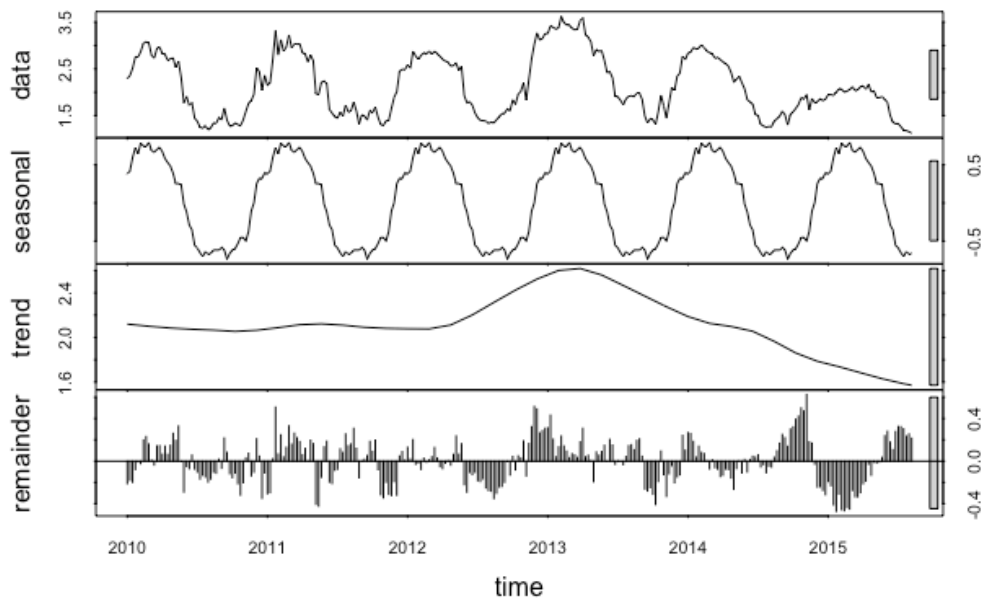
Random



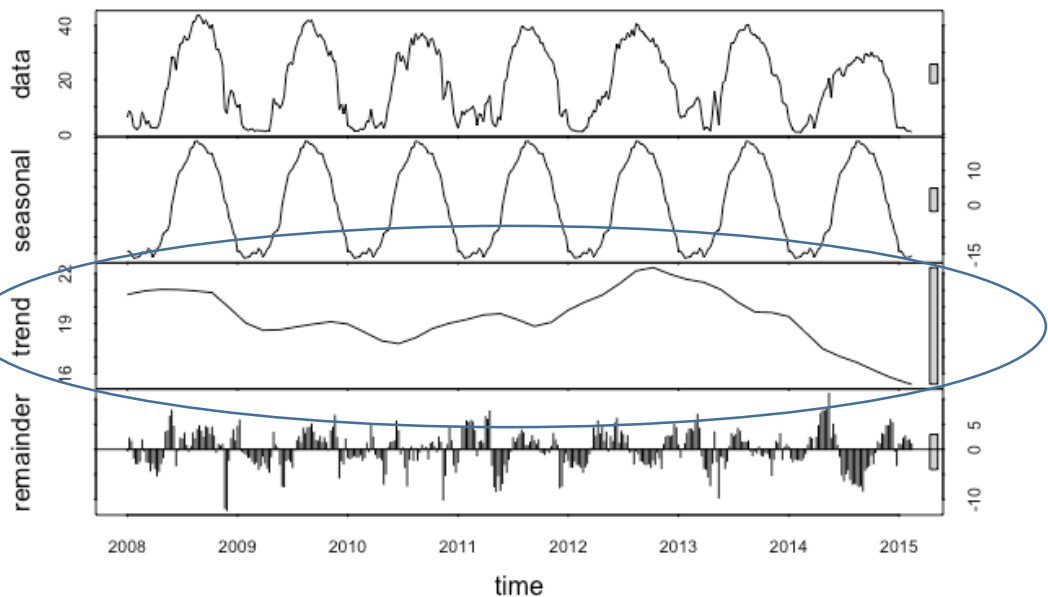
Seasonal Decomposition for RWC Commercial Irrigation



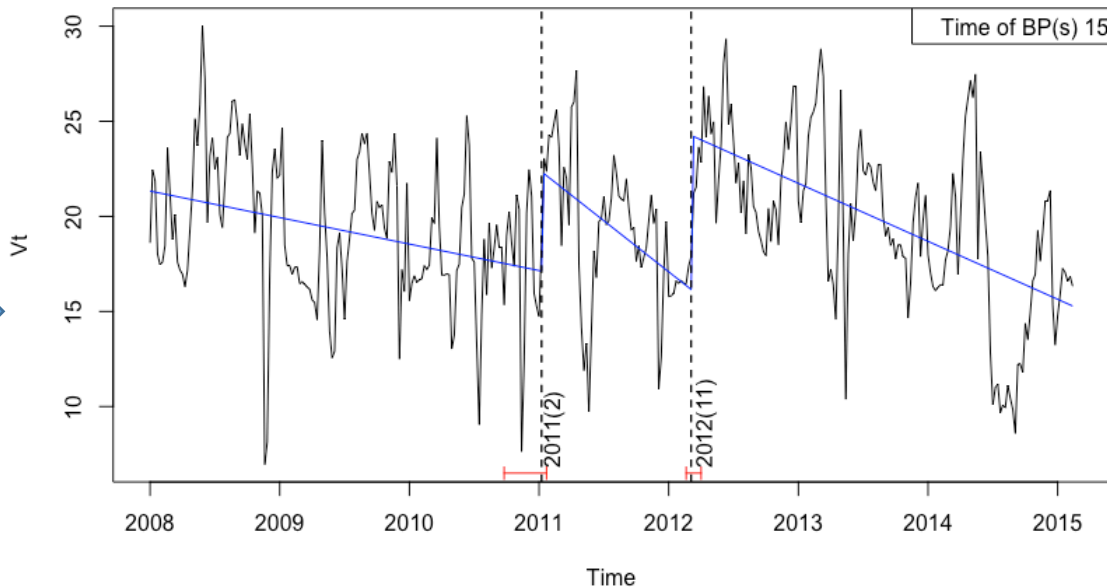
Seasonal Decomposition for RWC Single Family Residential



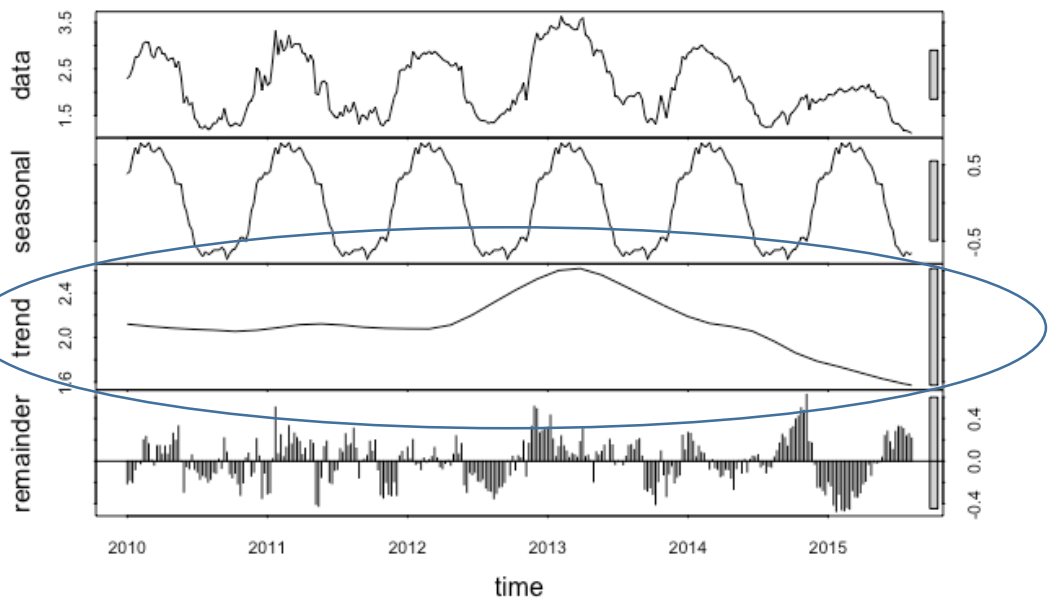
Seasonal Decomposition for RWC Commercial Irrigation



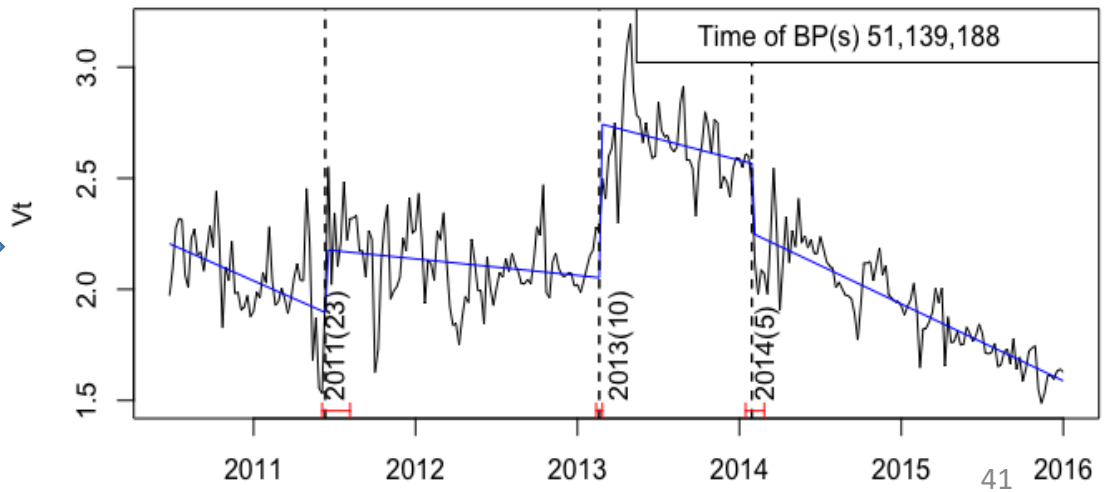
RWC Commercial-Irrigation Water Consumption Breaks For Additive Season and Trend (BFAST) Trend Breakpoints



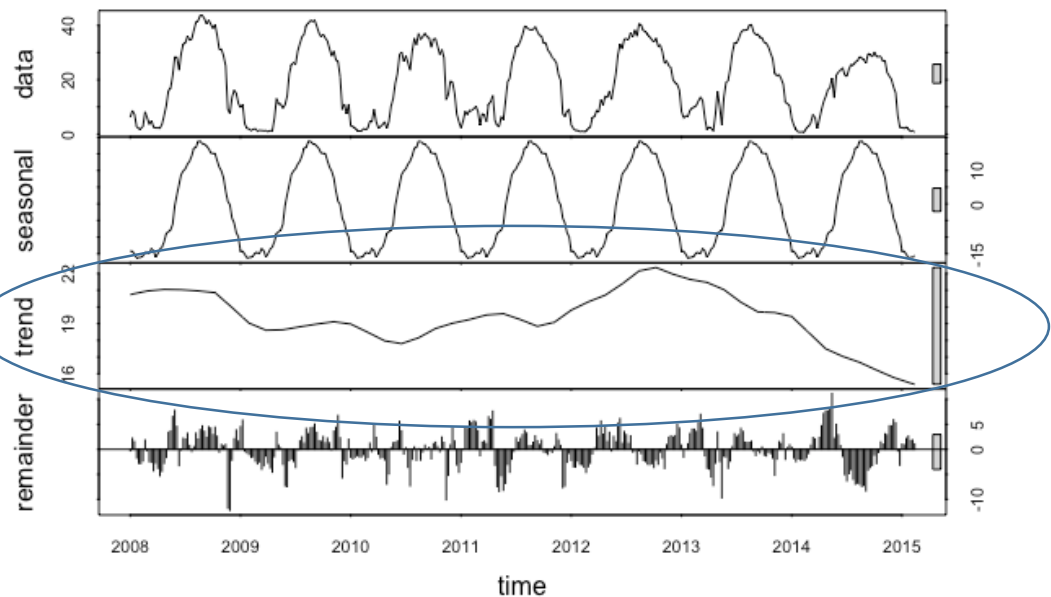
Seasonal Decomposition for RWC Single Family Residential



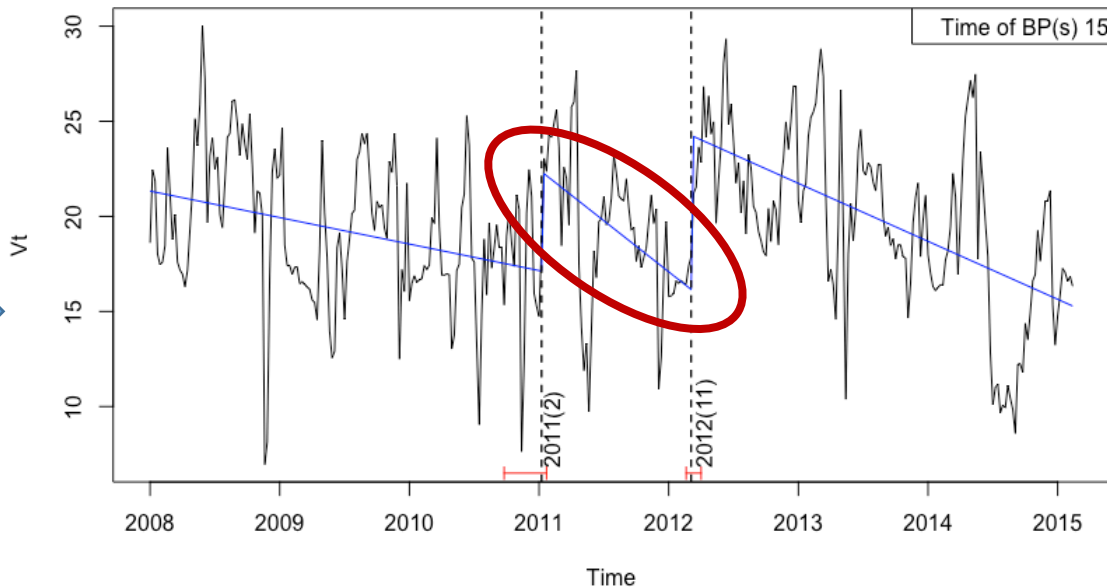
RWC Single Family Residential Water Consumption Breaks For Additive Season and Trend (BFAST) Trend Breakpoints



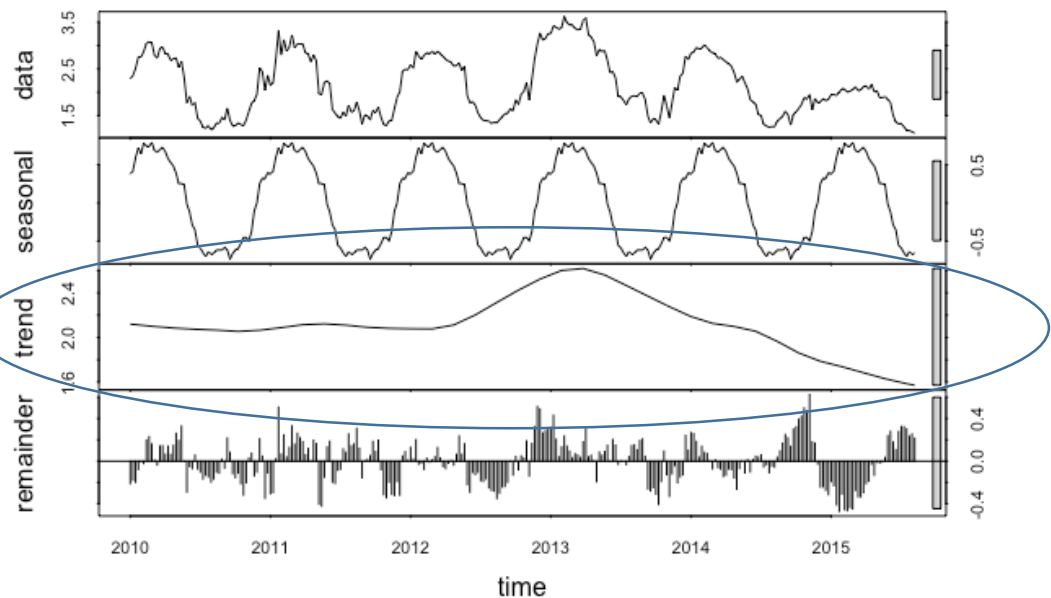
Seasonal Decomposition for RWC Commercial Irrigation



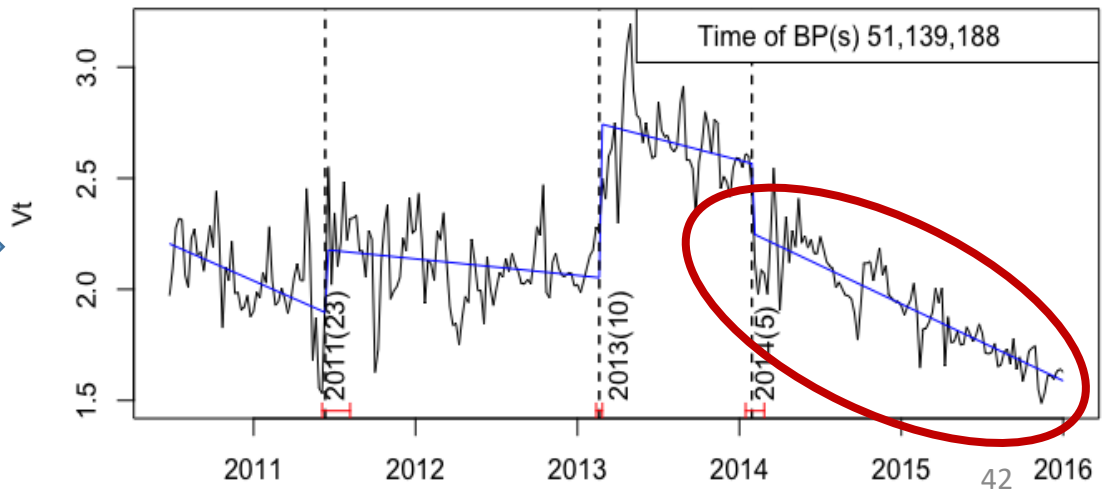
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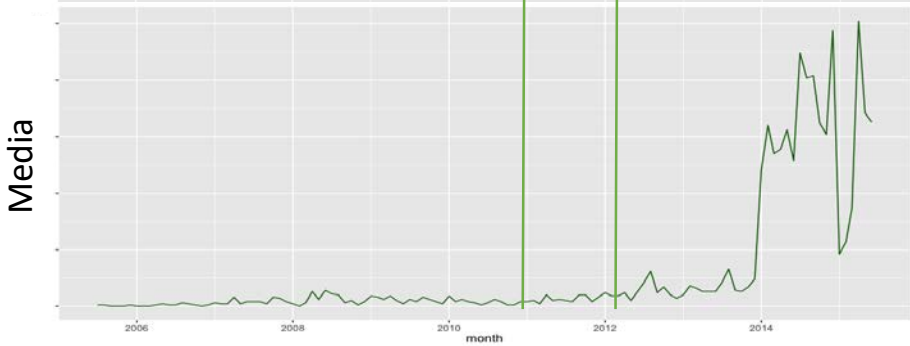
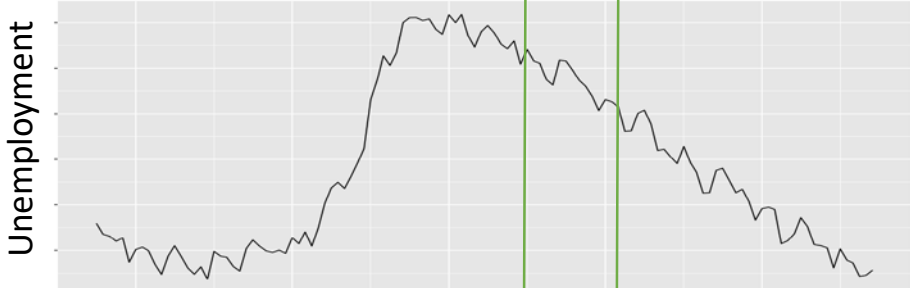
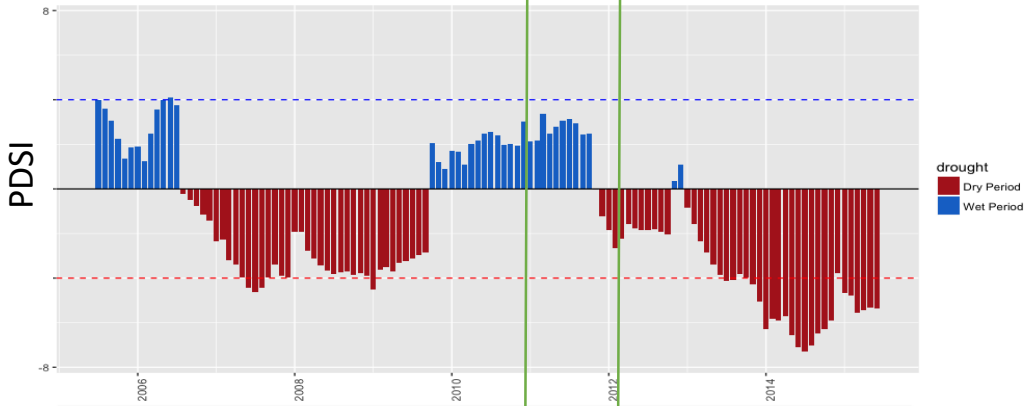
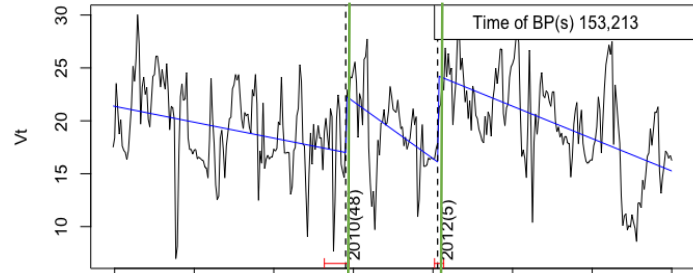
Seasonal Decomposition for RWC Single Family Residential



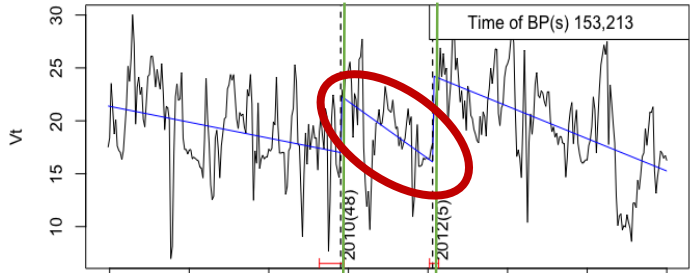
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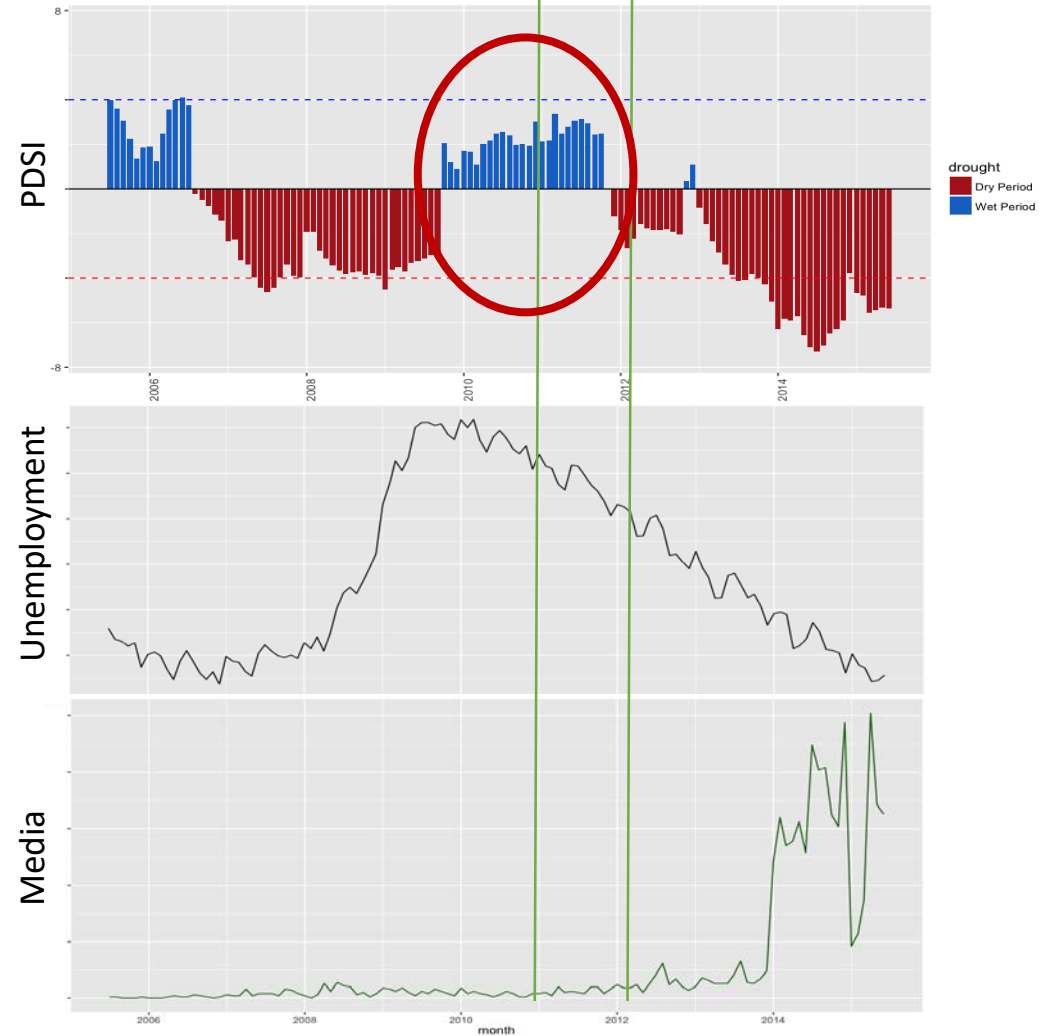
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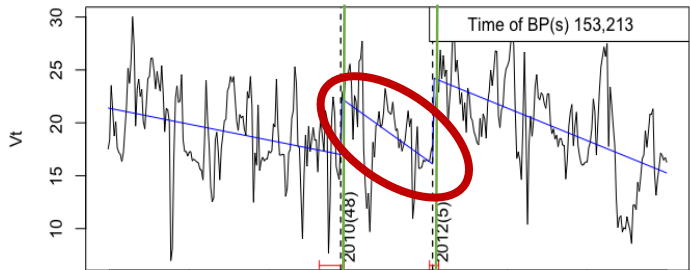
RWC Commercial-Irrigation Water Consumption
Breaks For Additive Season and Trend (BFAST) Trend Breakpoints



Period of greatest decrease in COMM-IRR water use occurred at tail end of wet period

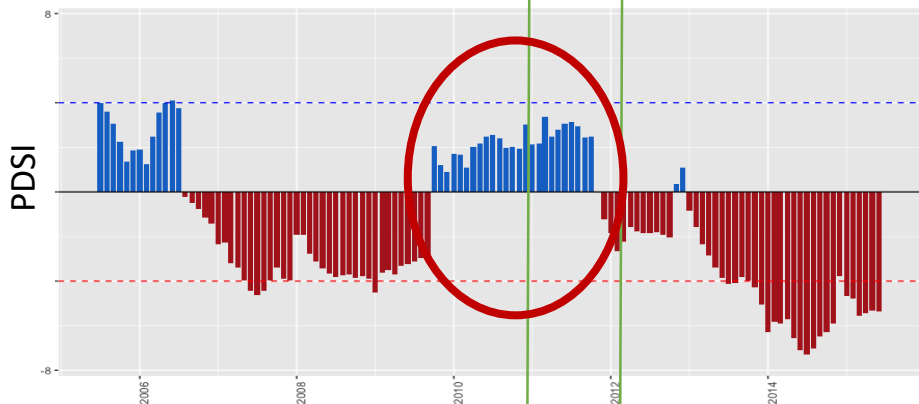
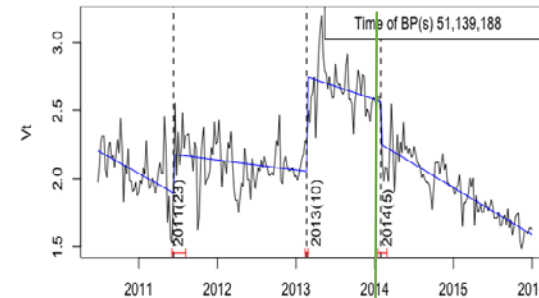


RWC Commercial-Irrigation Water Consumption
Breaks For Additive Season and Trend (BFAST) Trend Breakpoints

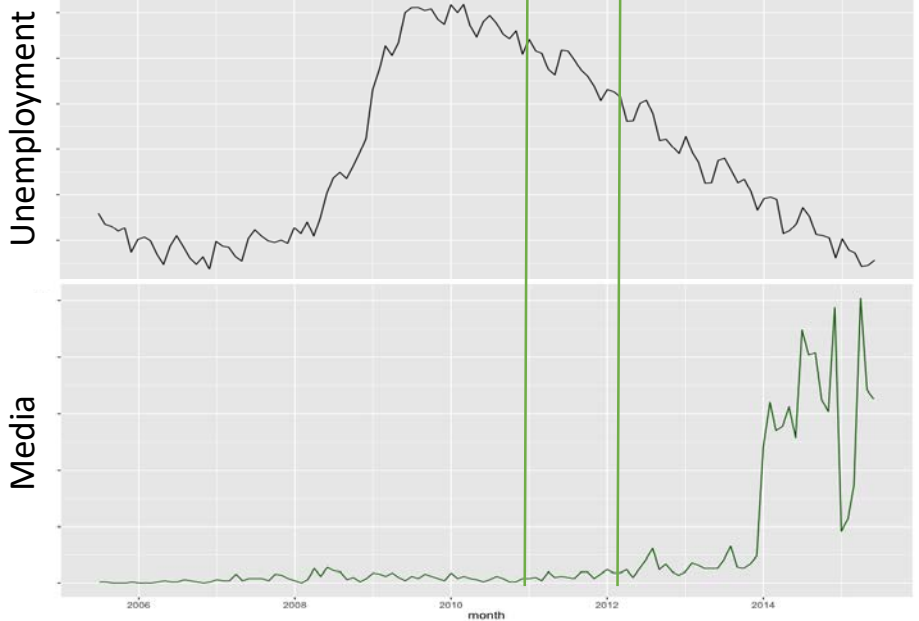


Period of greatest decrease in COMM-IRR water use occurred at tail end of wet period

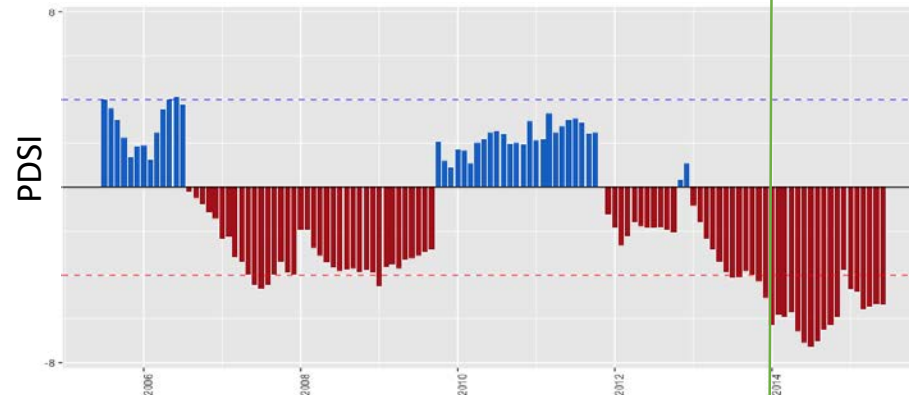
RWC Single Family Residential Water Consumption
Breaks For Additive Season and Trend (BFAST) Trend Breakpoints



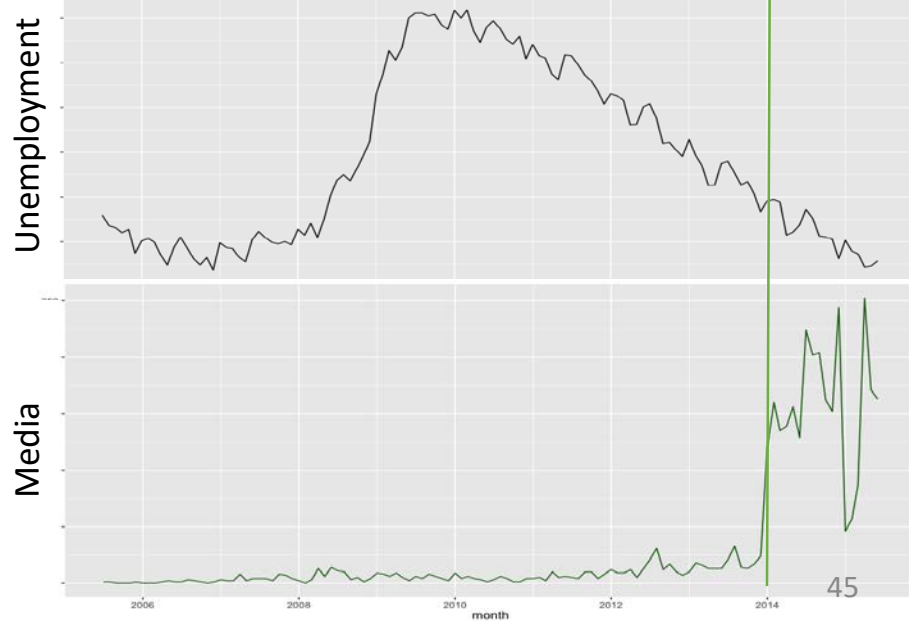
drought
■ Dry Period
■ Wet Period



Media

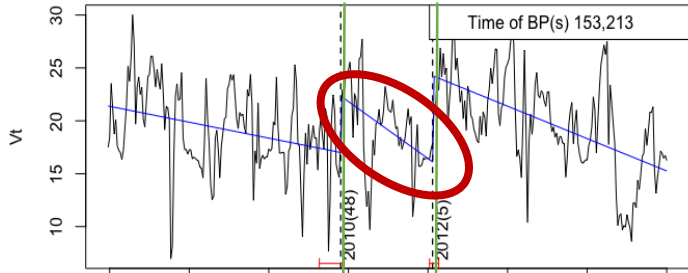


drought
■ Dry Period
■ Wet Period



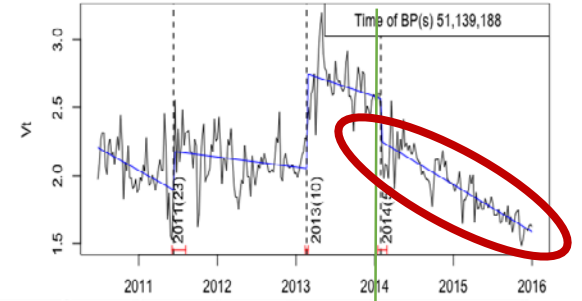
Media

RWC Commercial-Irrigation Water Consumption
Breaks For Additive Season and Trend (BFAST) Trend Breakpoints

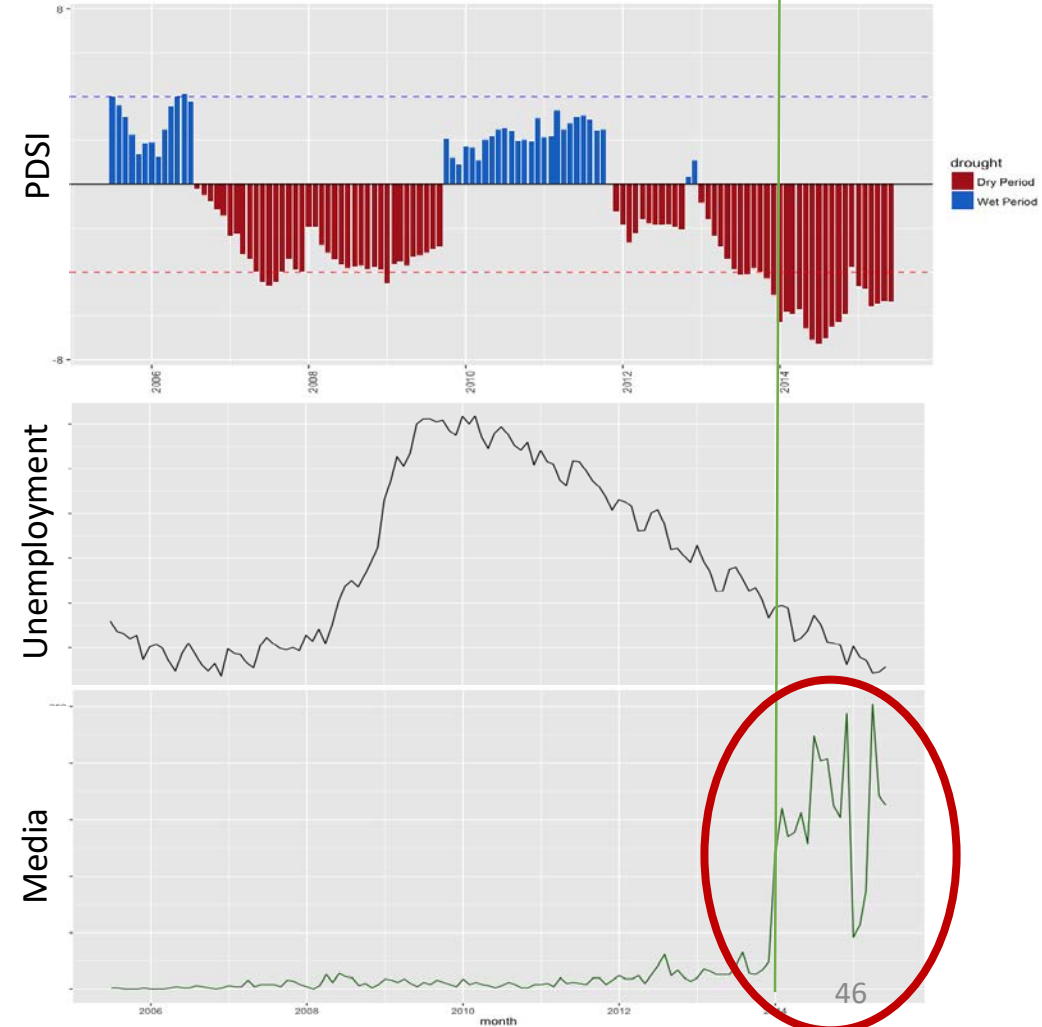
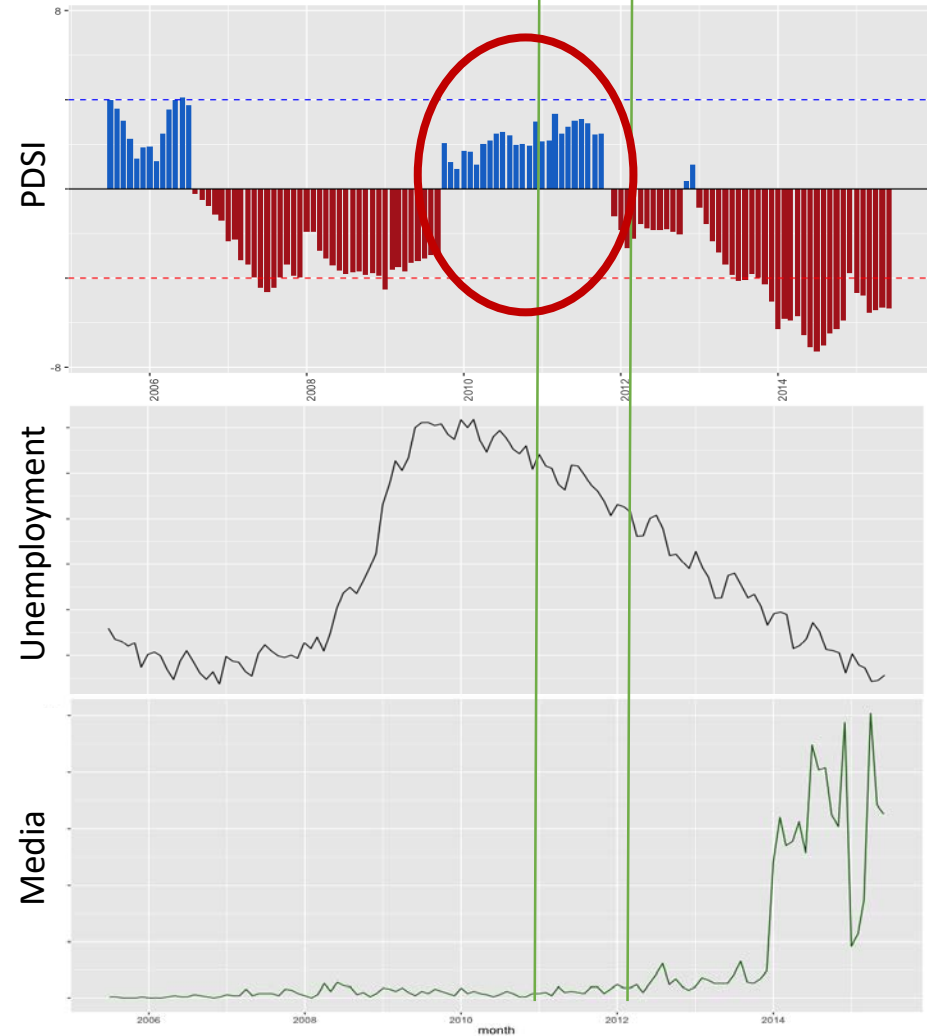


Period of greatest decrease in COMM-IRR water use occurred at tail end of wet period

RWC Single Family Residential Water Consumption
Breaks For Additive Season and Trend (BFAST) Trend Breakpoints



Period of greatest decrease in SFR water use started when media coverage began





Implications

Implications

- During drought, change in water supply landscape AND water use behavior
- Media can explain some variance in water use, especially for high income, high water users
- Demographic profiles of water agencies can be used to better understand water use behavior
- Smart meters can enable deeper understanding of water use at finer spatial and temporal scales





Thank you

Kim Quesnel kquesnel@stanford.edu

Patricia Gonzales patgonza@stanford.edu

Newsha Ajami newsha@stanford.edu

