

# What Does the Water Balance Data Reveal About Changes in California Water Resources?

CWEMF 17 April 2023

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## SAN DIEGO SUPERCOMPUTER CENTER

A National Laboratory for Computational Science and Engineering  
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# Outline

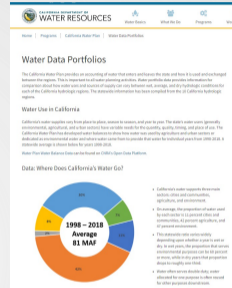
- ① Acknowledgements
- ② Introduction
- ③ Results
- ④ Summary and Conclusions

# Acknowledgements

- 1 Originally (~2015, 2 years)
  - 1 Funded by US EPA grant, through Western States Water Council (WSWC) and CDWR,
  - 2 Led by Sara Larsen (WSWC, now Upper Colorado River Commission)
  - 3 To integrate CDWR water balance data with the regional and federal data systems (+ other western states, WADE)
- 2 Subsequent funding by CDWR with engagement of:
  - 1 Regional offices of the Water Balance Team led by Tito Cervantes with collaboration of Todd Hillaire (ret.)
  - 2 HQ support by Gary Darling (ret.), Kamyar Guivetchi, Abdul Khan and Lew Moeller
- 3 Research collaborators at Scripps Institution of Oceanography, UC San Diego
  - Dan Cayan, Tom Corringham and Laurel Dehaan were supported by the California and Nevada Applications Program via the NOAA RISA (Climate Adaptation Partnerships Program)

## Where can I get the data?

- <https://water.ca.gov/Programs/California-Water-Plan/Water-Portfolios>



- <https://data.cnra.ca.gov/dataset/water-plan-water-balance-data>

**Water Plan Water Balance Data**

Department of Water Resources California Water Plan program completes applied, net, and depletion water balances for California. Water balances are simplified water budgets for a water user based on analysis of developed and undeveloped water supplies, water uses by sector, water needs, operational characteristics for an area, and other variables. California's water balances include surface water, groundwater, treated and recycled water. Balances can be used for a range of analyses including agricultural water management, urban water management, and water supply planning. Water balance results show annual water use applied to water users in their use equity supply. Recent data provided includes water uses and supplies for 1975-2020 (2019 is Drafted) Region Unit by County (SACCS), Planning Area (PA), Hydrologic Region (HR), and Statistical Region (SR). Calculation and aggregation equations for applied, net, and depletion water balances are included in the Standard Operating Procedures (SOPs) for data management and analysis. Metadata are provided in a .csv file which can be opened by any web browser. Zipped data files are in .CSV format. A data verification for each summary table is included for each year in .PDF format.

The California Water Plan Update 2019 Water Balance Supporting Document includes water use and supply discussion, graphics, and links to key and known of water use and supply data for 1998-2015, and related information. There is also a larger Water Balance Fact Sheet available. California Water Plan Update 2020 is underway. Data for 1975-2019, 2019, and 2020 are available here.

**Data and Resources**

- California Water Plan Update 2019 Supporting Document for Water
- California Water Plan Update 2019 Water Balance Fact Sheet
- Water Balance Standard Operating Procedures (SOPs)
- Water Balance Standard Operating Procedures (SOPs)
- California Water Plan Update 2019 Water Balance Fact Sheet - 1 page
- Water Balance Data for water years 1975-2020 (2019 is Drafted)
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Summary of Manuscript Now in Review at San  
Francisco Estuary and Watershed Science (SFEWS)

*Spatial Patterns of Water Supply and Use in California*

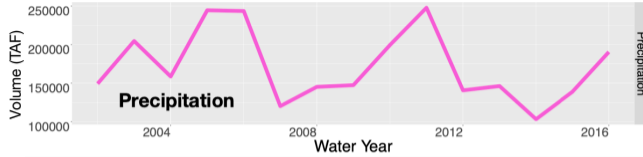
JOHN HELLY<sup>1,2</sup>, DAN CAYAN<sup>1</sup>, JENNIFER STRICKLIN<sup>3</sup>, AND LAUREL DEHAAN<sup>1</sup>

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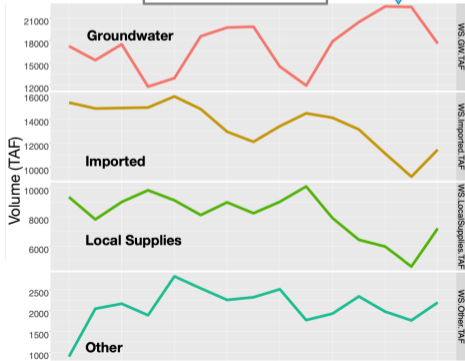
## Climate and Weather



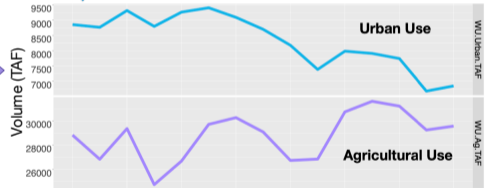
Developed Water Supply (4)

Water Balance Variables (6)

Water Use (2)



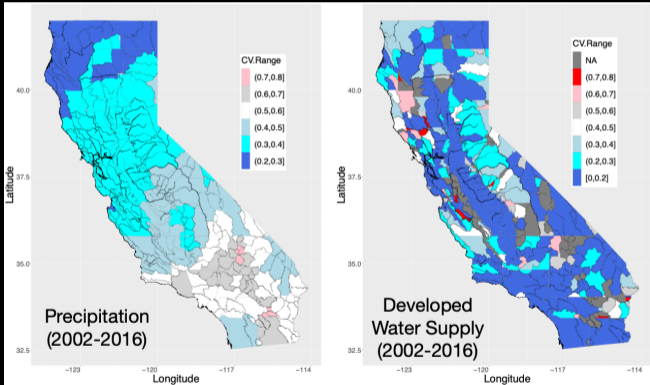
Regulatory Policy



## California's Water Balance

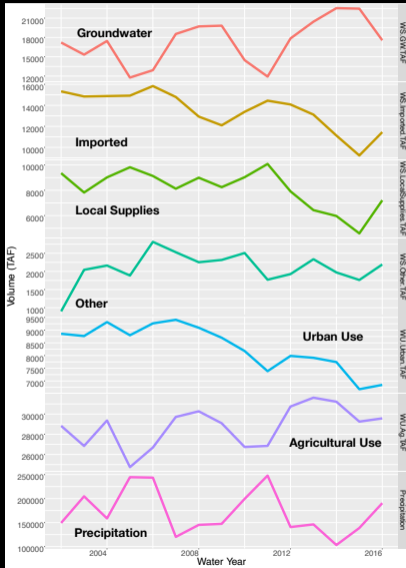
- Time-varying System Driven by Climate and Weather
- Constrained by Infrastructure and Policy

# Spatial Variability of Precipitation and Developed Water Supply



- 1 Each spatial polygon is a DAUCO: finest-grained management partitioning by CDWR
- 2 Variability of precipitation is *partially* dampened from water supply by infrastructure

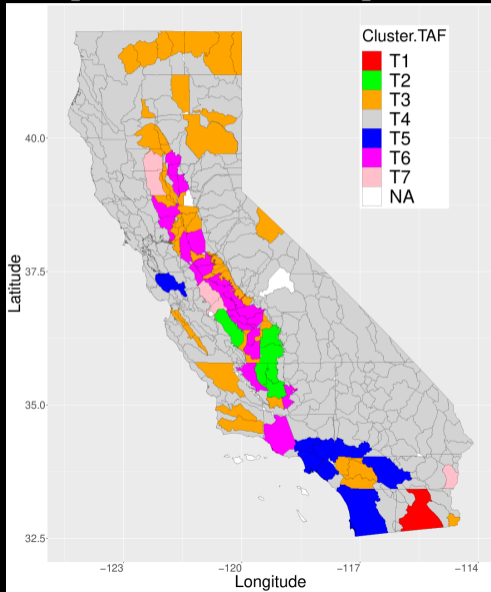
# California's Changing Water Balance 2002-2016



- 1 Six (6) water balance variables + precipitation
- 2 State-wide summary totals as time-series showing
  - 1 Trends and periodicities
  - 2 Lagged and inverse relationships
- 3 Wanted to look at this at finer-grained spatial scale
- 4 Used Cluster-Analysis and Principal Components Analysis (PCA)
- 5 Using DAUCO-level data



# Spatial Units Grouped into Clusters Using Water Balance Variables (6)



- 1 Each *Spatial Unit (polygon)* is a DAUCO (DAU/COunty)
- 2 Clusters based on DAUCO **Water Balance Profiles** → (T1-T7)
- 3 Each cluster has characteristic mean **Water Balance Profile** based membership
- 4 Notably:
  - 1 Most of California in cluster T4
  - 2 Imperial DAUCO in T1 alone

# Example of a Water Balance Profile for One DAUCO

**Table 2:** Water Balance Profile Example for DAUCO 00125: Lost River, Modoc County, Upper Klamath Hydrologic Region

	Variable					
	WS.GW.TAF	WS.Imported.TAF	WS.LocalSupplies.TAF	WS.Other.TAF	WU.Urban.TAF	WU.Ag.TAF
2002	8.7	82.5	15.3	18.4	0.3	107.8
2003	6.1	62.7	15.3	10.0	0.3	79.6
2004	6.5	91.8	7.6	1.8	0.3	86.4
2005	5.9	70.0	11.4	1.3	0.3	74.2
2006	8.2	68.3	15.3	30.3	0.2	106.3
2007	9.3	86.5	11.4	21.2	0.2	110.6
2008	8.0	90.0	7.6	21.2	0.3	109.5
2009	8.2	95.7	11.4	17.9	0.2	115.0
2010	8.3	48.3	15.3	42.1	0.2	99.9
2011	12.9	67.8	0.7	34.9	0.2	96.7
2012	19.6	74.8	0.7	36.0	0.2	111.5
2013	13.6	58.5	0.7	30.8	0.2	88.8
2014	13.6	54.1	1.2	24.7	0.1	79.6
2015	12.5	52.8	1.2	23.4	0.2	76.3
2016	15.8	88.8	1.2	0.0	0.1	90.1

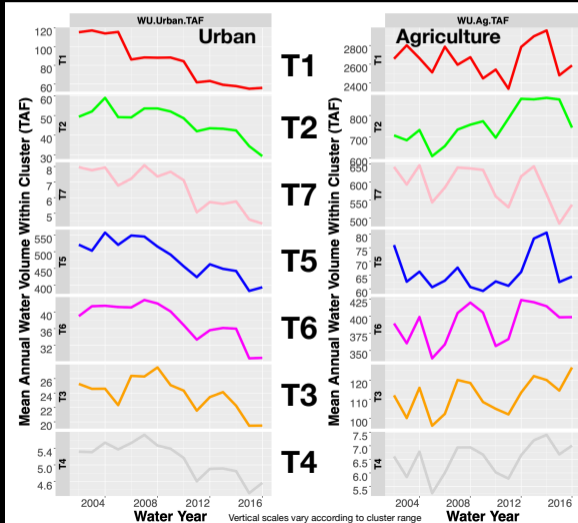
# Clusters (T1-7) Described By Their Mean Water Balance Profiles

**Table 5:** Number of DAUCOs in each volumetric cluster (TAF) with profiles summarized by water supply and use patterns.

## Cluster Membership

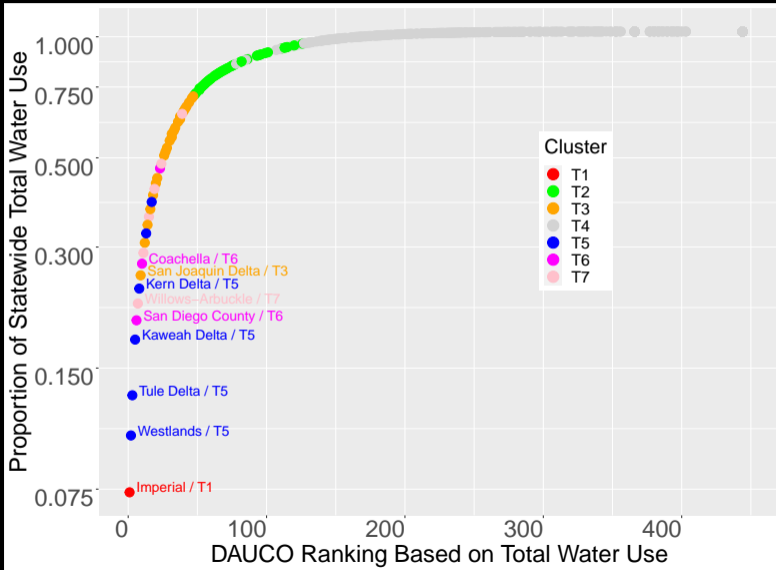
T1	T2	T3	T4	T5	T6	T7	Water Use	Water Supply
1							Imperial DAUCO only. Agriculture (97%), Urban (3%)	Imported water (94%).
	6						Mostly agricultural (94%).	Mixed (GW 60%)
		56					Mostly agriculture (84%).	Mixed (GW 50%)
			375				Split between urban (45%) and agricultural (55%).	Mixed (GW 44%)
				8			Mostly urban (83%)	Mixed (Imported 50%)
					24		Mostly agriculture (91%)	Mixed (GW 47%)
						5	Mostly agriculture (99%)	Mostly imported (73%)

# Clusters Reveal Patterns and Changes in Urban and Agricultural Water Use Over Time



- 1 **Urban:** (T1-7) show declines in water use with similar periodic features superimposed
- 2 **Agriculture:** More varied
  - 1 (T2,T3,T4,T6) show increasing water use
  - 2 (T1,T5) show decreases followed by abrupt large increases then return
  - 3 (T7) shows decline punctuated by abrupt increases

# A Few DAUCOs Use Most of California's Water



# Methods Summary and Comparison: Cluster Analysis and Principal Components Analysis

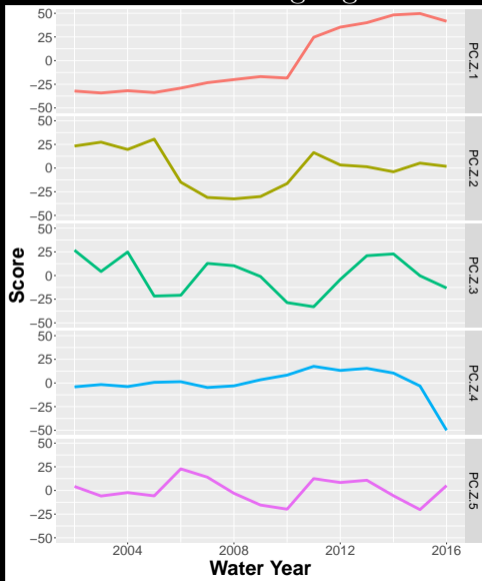
## 1 Cluster Analysis

- 1 reveals how similar or different DAUCOs are based on water balance profiles (i.e., behavior)
- 2 using a multi-variate distance metric to build clusters (k-means)
- 3 annual observations are repeated measures for each DAUCO

## 2 Principal Component Analysis (PCA)

- 1 reveals **statewide signals** in the DAUCO-level data ranked by importance (% variance) by
- 2 transforming water balance profiles into new variables (i.e., principal components)
- 3 generates time-series for each principal component

## Extracting Signals from Variability in Water Balance Profiles



- Input:** Annual Water Balance Profile for each DAUCO for 15 years
  - 2850 variables (6 variables x 475 DAUCOs) with 15 observations (2002-2016)
- Output:** Orthogonal (independent) variables: PC1-5
  - (PC1-3) = 66% variance
  - (PC1-5) = 80% variance
- Independent variables may have better diagnostic and predictive power as time-series lengthens

## Summary (of Manuscript)

- ① California water supply and use varies inter-annually in response to precipitation and regulatory policy (including land-use)
- ② Statewide, annual water supply components vary (19%) but DAUCO-level variability is much greater (254%)
- ③ Local precipitation is important in some areas but groundwater and imported water most important statewide
- ④ Agricultural water use consumes  $\sim 78\%$  of water supply: due to few DAUCOs
- ⑤ Urban water use is ubiquitous across California



## Conclusions

- ① Clusters, based on DAUCO water balance profiles, may provide more meaningful assessment units
  - ① Variability across DAUCOs reflects land-use differences over short distances (even adjacent DAUCOs) and variability in supply
  - ② Traditional regional analyses (i.e., hydrologic regions, planning areas) do not reflect variability at DAUCO-level
- ② Results emphasize value of DAUCO-level data but expose need for improvements
  - ① 2002-2016 are seven years behind present
  - ② 2017 missing (extreme wet year)
  - ③ 2018-2019 now available
  - ④ 2002-2016 + 2018-2019 still four years behind and incomplete
- ③ Need more, better and related data (e.g., socio-economic) to understand effects of climate, policy and land-use changes
  - ① higher-frequency (e.g., daily, weekly, monthly)
  - ② greater currency (e. g., near-realtime) and
  - ③ operationally meaningful scales of measurement (e.g., engineering and climate-related geophysical)

The End

See the paper for the full-story (when it appears)

*Spatial Patterns of Water Supply and Use in California*

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