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

CWEMF 17 April 2023

Jennifer Stricklin [1] and John Helly [2]

[1]California Department of Water Resources, Sacramento, California

[2]San Diego Supercomputer Center and Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California

SAN DIEGO SUPERCOMPUTER CENTER
A National Laboratory for Computational Science and Engineering
at the University of California, San Diego

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego

Outline

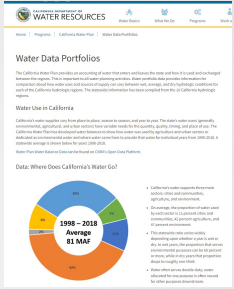
Acknowledgements

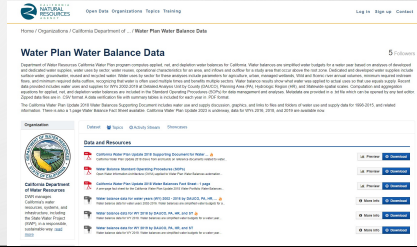
1. Originally (∼2015, 2 years)
   1. Funded by US EPA grant, through Western States Water Council (WSWC) and CDWR,
   2. Led by Sara Larsen (WSWC, now Upper Colorado River Commission)
   3. To integrate CDWR water balance data with the regional and federal data systems (+ other western states, WADE)
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





CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Summary of Manuscript Now in Review at San Francisco Estuary and Watershed Science (SFEWS)

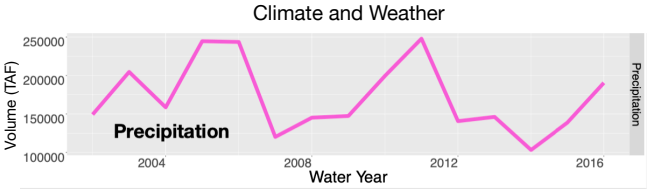
Spatial Patterns of Water Supply and Use in California

John Helly[1,2], Dan Cayan[1], Jennifer Stricklin[3], and Laurel DeHaan[1]

[1]*Climate, Atmospheric Science and Physical Oceanography, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA*

[2]*San Diego Supercomputer Center, University of California San Diego, La Jolla, CA, USA*

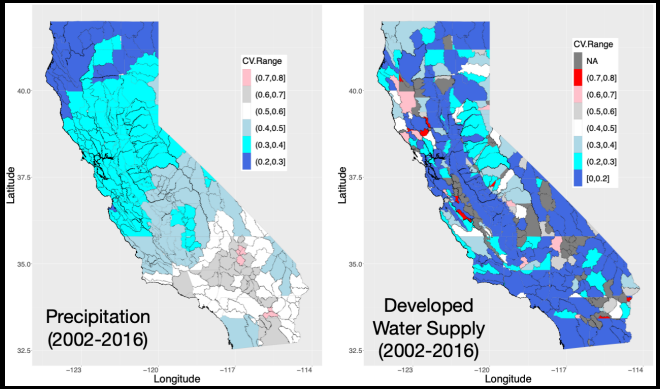
[3]*California Natural Resources Agency, Department of Water Resources, Sacramento, CA, USA*



California's Water Balance

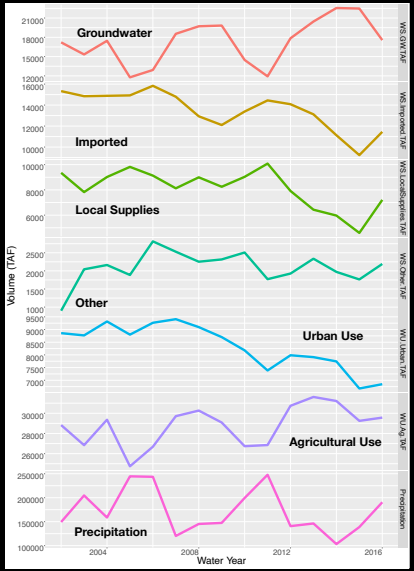
- Time-varying System Driven by Climate and Weather
- Constrained by Infrastructure and Policy

Spatial Variability of Precipitation and Developed Water Supply



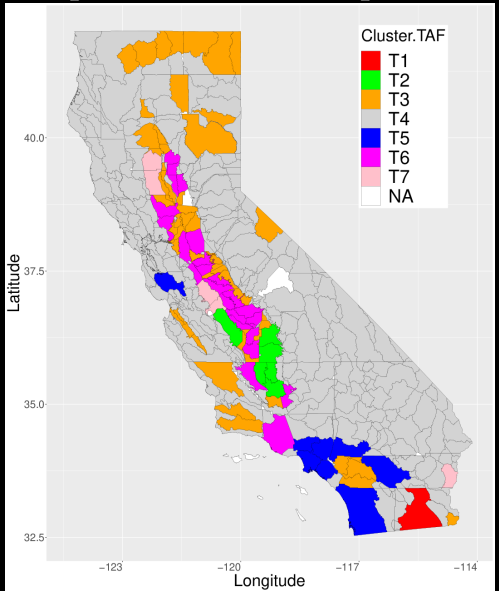
1. Each spatial polygon is a DAUCO: finest-grained management partitioning by CDWR
2. Variability of precipitation is *partially* dampened from water supply by infrastructure

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

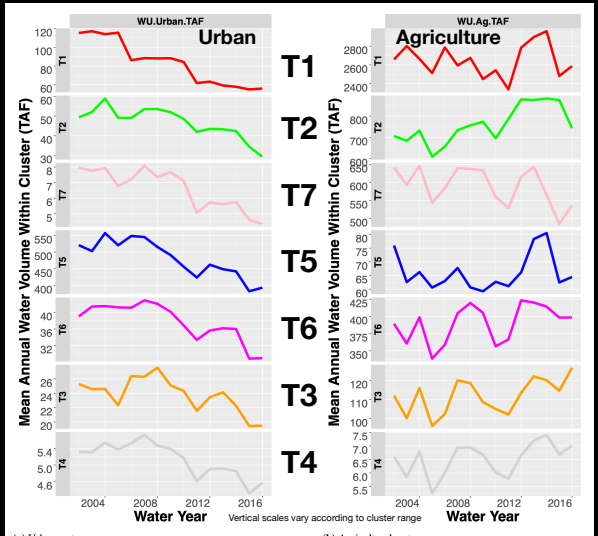
Variable	WS.GW.TAF	WS.Imported.TAF	WS.LocalSupplies.TAF	WS.Other.TAF	WU.Urban.TAF	WU.Ag.TAF
2002	8.7	82.5	15.3	18.4	0.3	107.8
2003	6.1	62.7	15.3	10.0	0.3	79.6
2004	6.5	91.8	7.6	1.8	0.3	86.4
2005	5.9	70.0	11.4	1.3	0.3	74.2
2006	8.2	68.3	15.3	30.3	0.2	106.3
2007	9.3	86.5	11.4	21.2	0.2	110.6
2008	8.0	90.0	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.

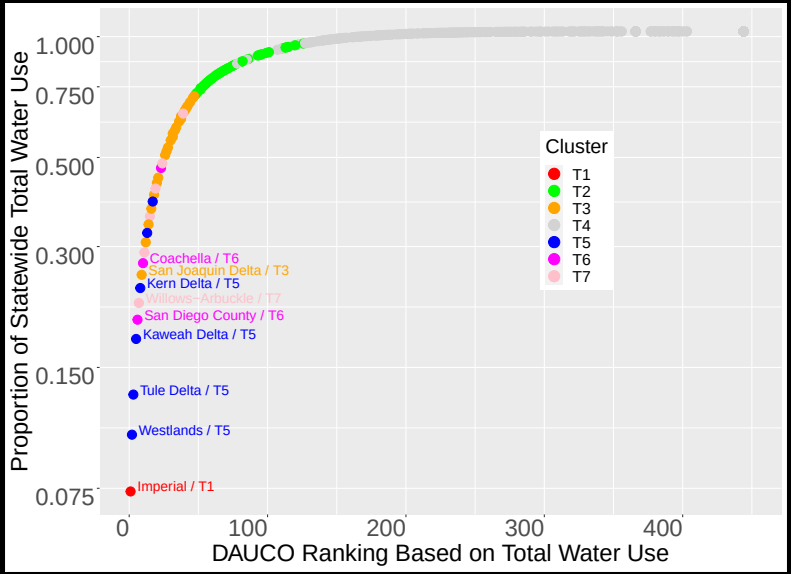
Cluster Membership								
T1	T2	T3	T4	T5	T6	T7	Water Use	Water Supply
1							Imperial DAUCO only. Agriculture (97%), Urban (3%)	Imported water (94%).
	6						Mostly agricultural (94%).	Mixed (GW 60%)
		56					Mostly agriculture (84%).	Mixed (GW 50%)
			375				Split between urban (45%) and agricultural (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

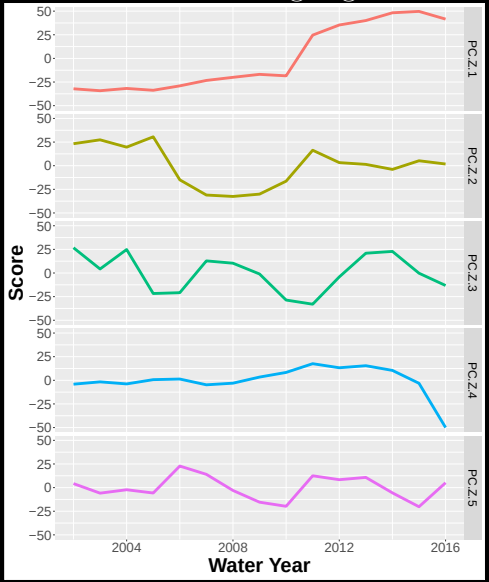
A Few DAUCOs Use Most of California's Water



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



1. Input: Annual Water Balance Profile for each DAUCO for 15 years
    1. 2850 variables (6 variables x 475 DAUCOs) with 15 observations (2002-2016)
2. Output: Orthogonal (independent) variables: PC1-5
    1. (PC1-3) = 66% variance
    2. (PC1-5) = 80% variance
3. 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 ∼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

John Helly[1,2], Dan Cayan[1], Jennifer Stricklin[3], and Laurel DeHaan[1]

[1]*Climate, Atmospheric Science and Physical Oceanography, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA*

[2]*San Diego Supercomputer Center, University of California San Diego, La Jolla, CA, USA*

[3]*California Natural Resources Agency, Department of Water Resources, Sacramento, CA, USA*