Scenarios of Drought

for California 4th Climate Change Assessment

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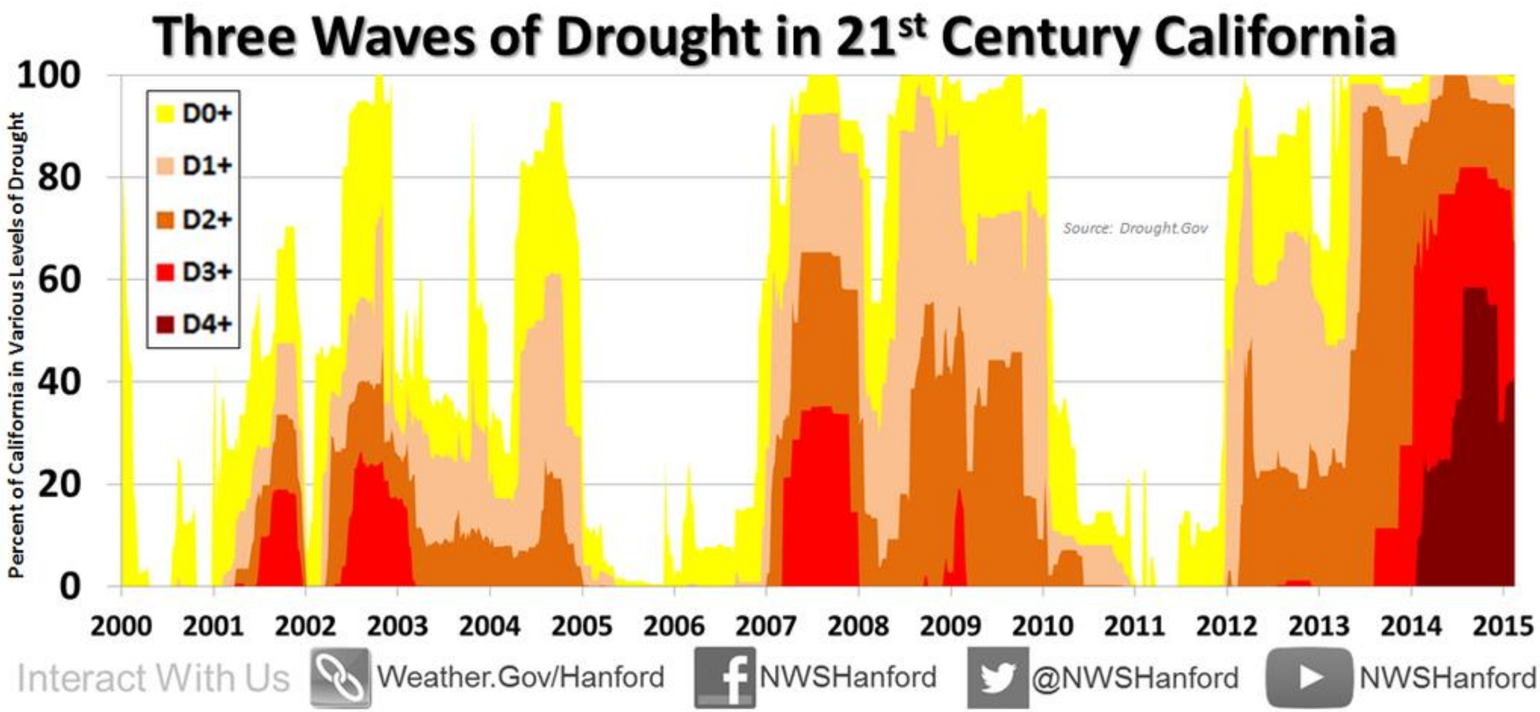
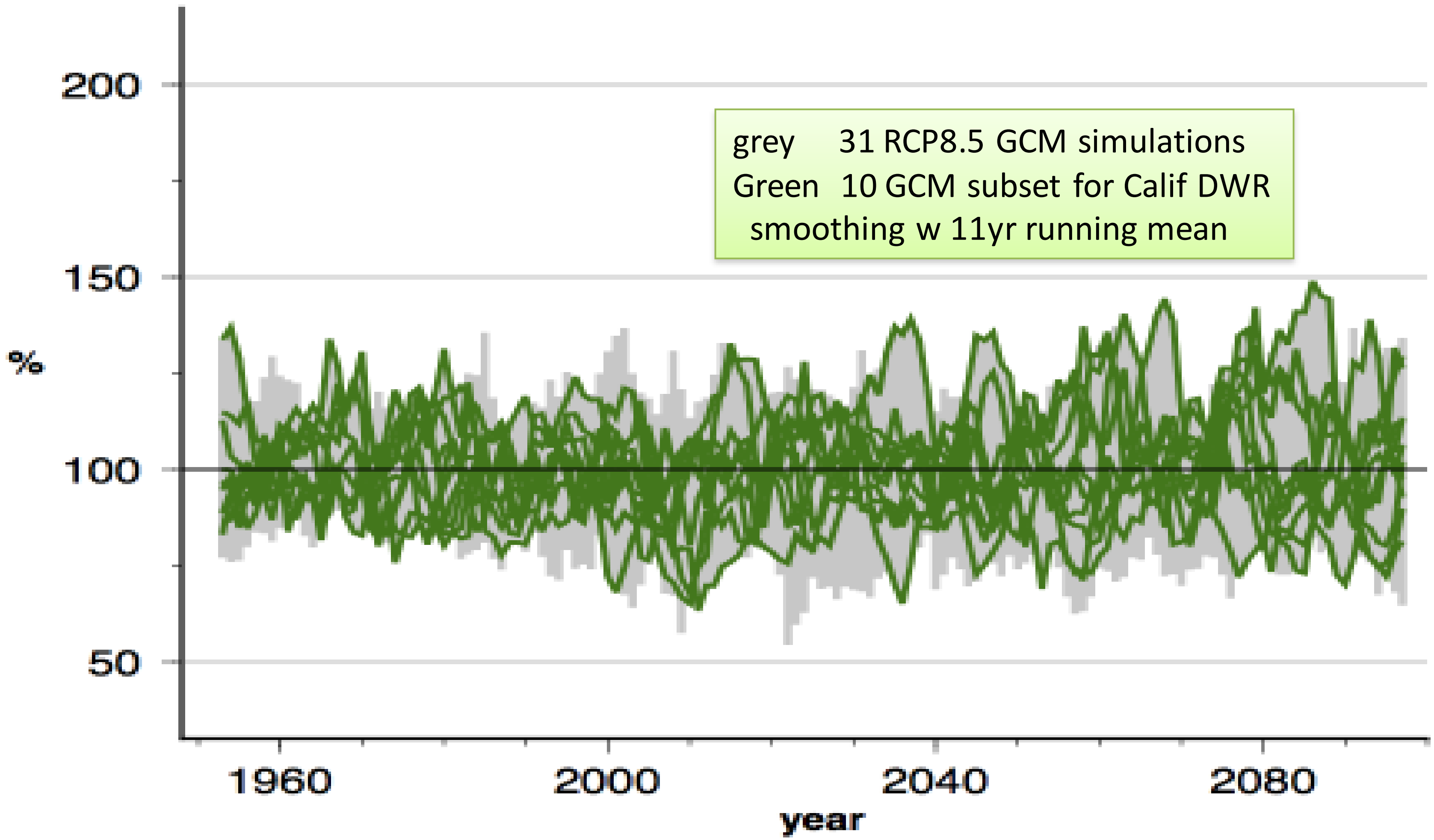


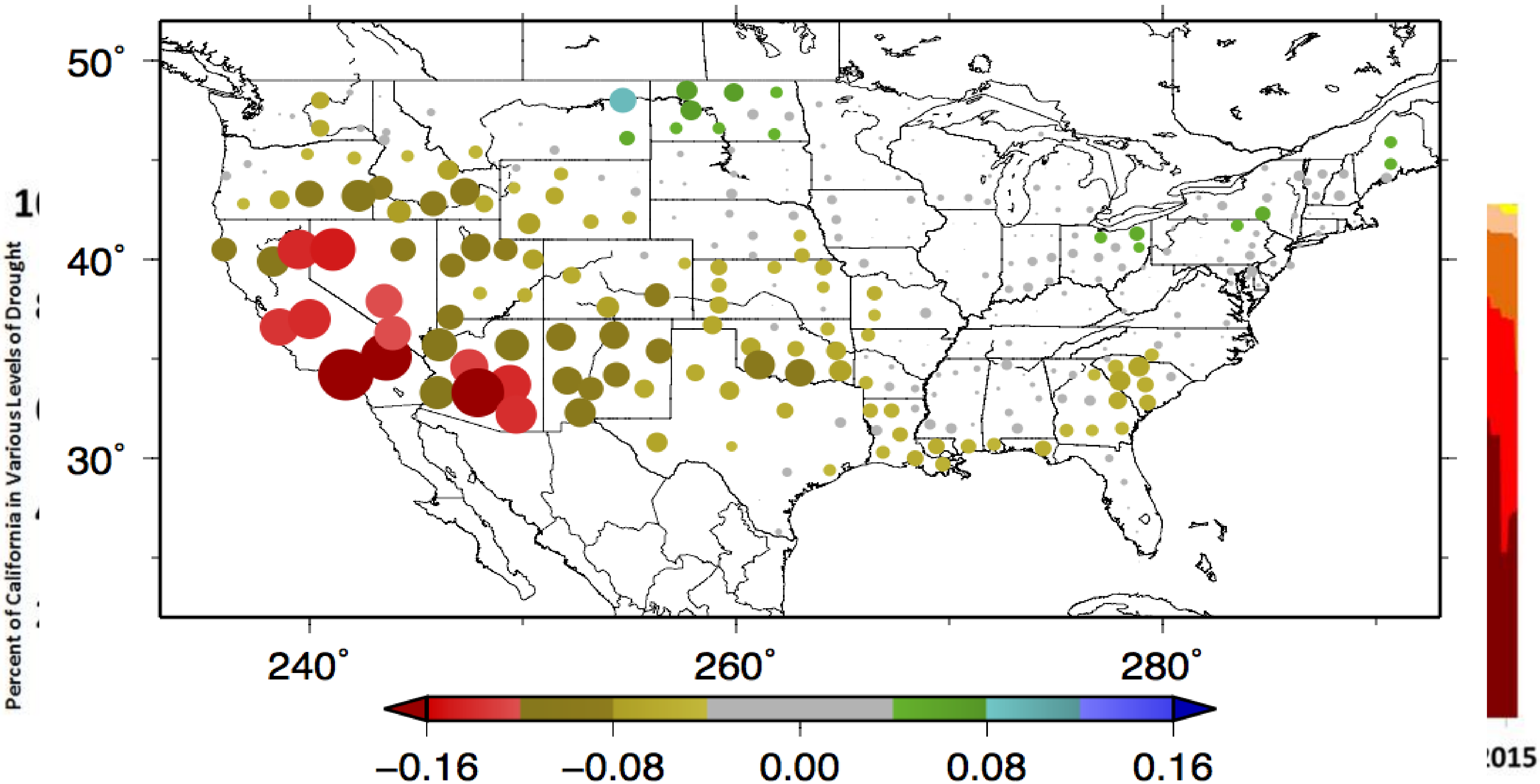
Within the swarm of CMIP5 GCMs there are dry spells of various intensity, duration

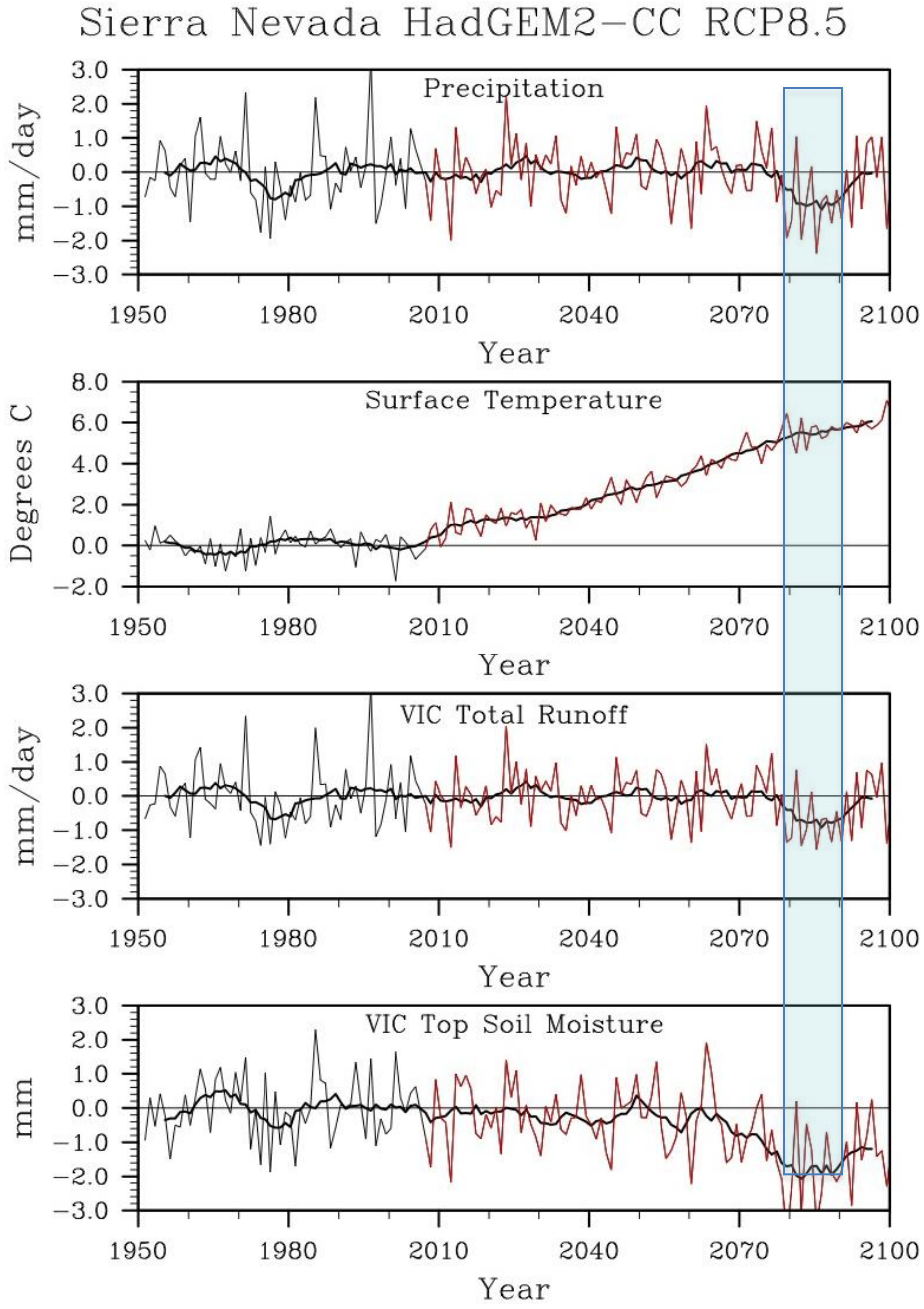


Drought often has a broad spatial footprint

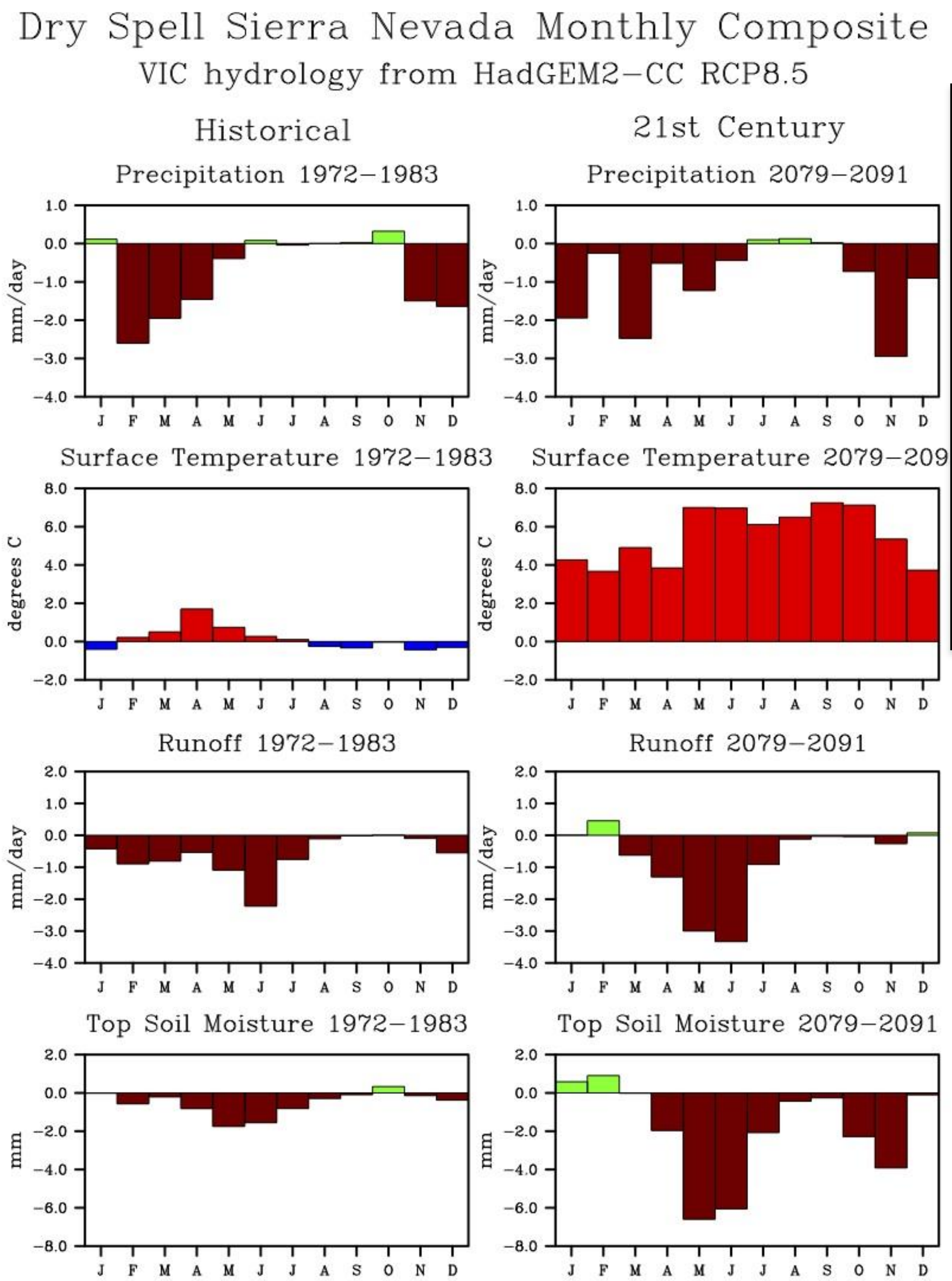
precip/clim wy 1998/99 – 2013/14

1980/81 – 2009/10 clim new clim div data





a warm, multi-year drought
HadGEM2-CC RCP8.5 projection
Sierra Nevada 2079-2091



Drought under climate warming compared to Drought during historical period

monthly averages
Sierra Nevada
2079-2091 vs. 1972-1983
HadGEM2-CC RCP8.5 projection

Soil moisture and runoff have amplified deficits under warmed climate

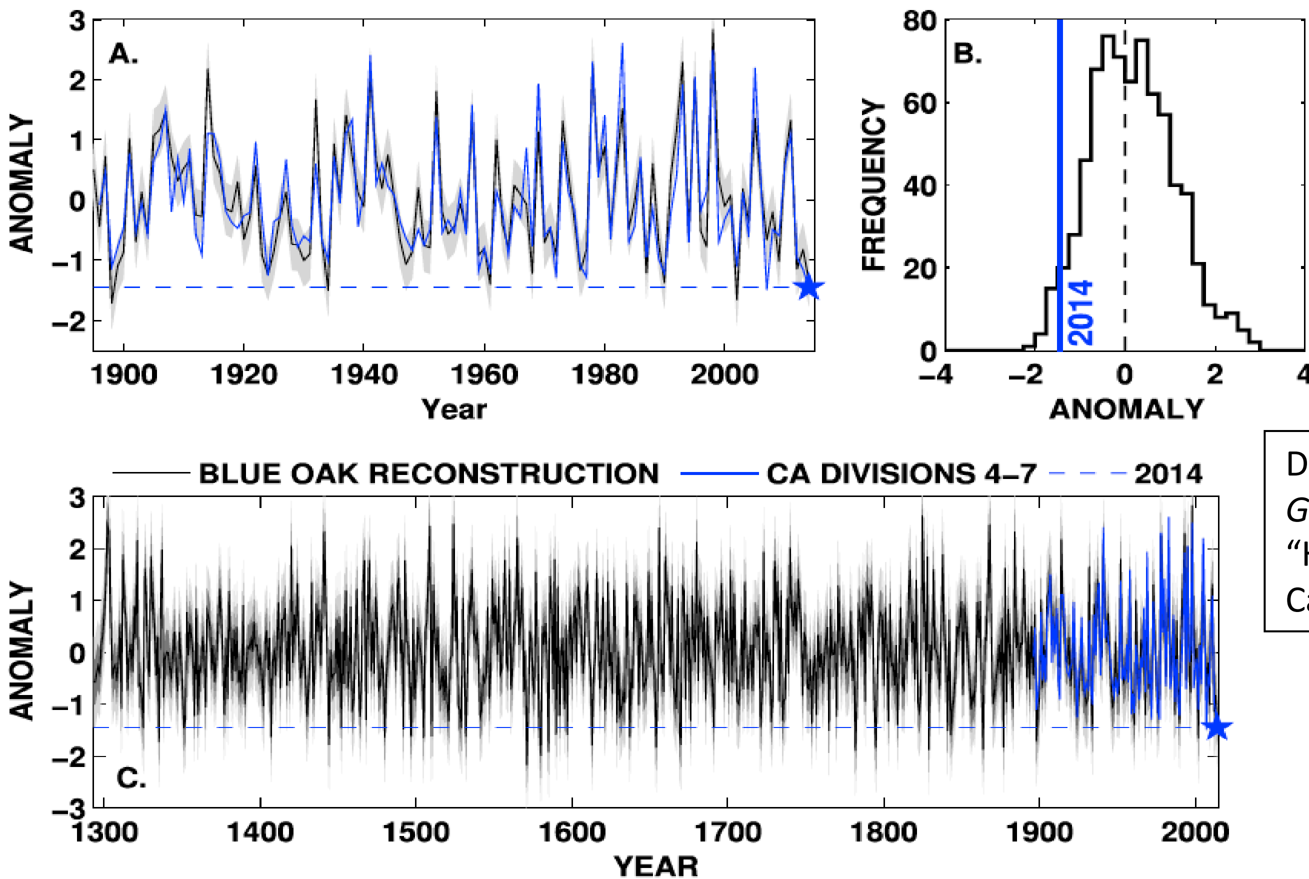
“State-of-the-art global climate models do not capture this characteristic of hydroclimate variability, suggesting that the models underestimate the risk of future persistent droughts.”

Projected changes in global rainfall patterns will likely alter water supplies and ecosystems in semiarid regions during the coming century. Instrumental and paleoclimate data indicate that natural hydroclimate fluctuations tend to be more energetic at low (multidecadal to multicentury) than at high (interannual) frequencies. State-of-the-art global climate models do not capture this characteristic of hydroclimate variability, suggesting that the models underestimate the risk of future persistent droughts. *Methods are developed here for assessing the risk of such events in the coming century using climate model projections as well as observational (paleoclimate) information*.

we also simulate hydroclimate as a process with underlying frequency characteristics that are described by a weak power-law relationship between frequency f and variance S(f), such that S(f) } f2b. Power spectra with higher values of b correspond to time series that exhibit more variance at lower frequencies.

Toby R. Ault, Julia E. Cole, Jonathan T. Overpeck, Gregory T. Pederson, and David M. Meko, 2014: Assessing the Risk of Persistent Drought Using Climate Model Simulations and Paleoclimate Data. J. Climate, 27, 7529–7549. doi: http://dx.doi.org/10.1175/JCLI-D-12-00282.1

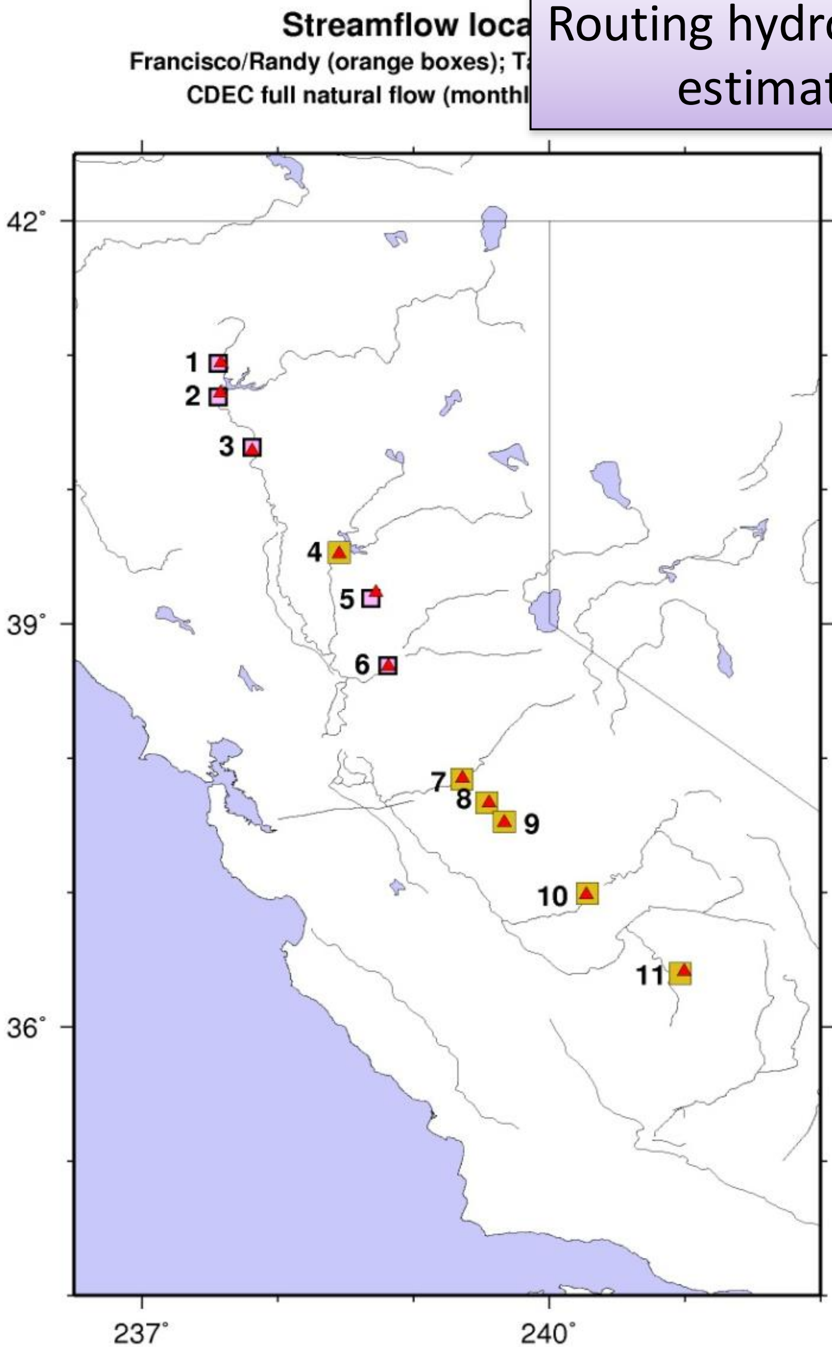
Tree ring records as hydroclimate proxies



Daniel Griffin and K Anchukaitis
Geophy Res letters 2014
"How unusual is the 2012-2014 California Drought?"

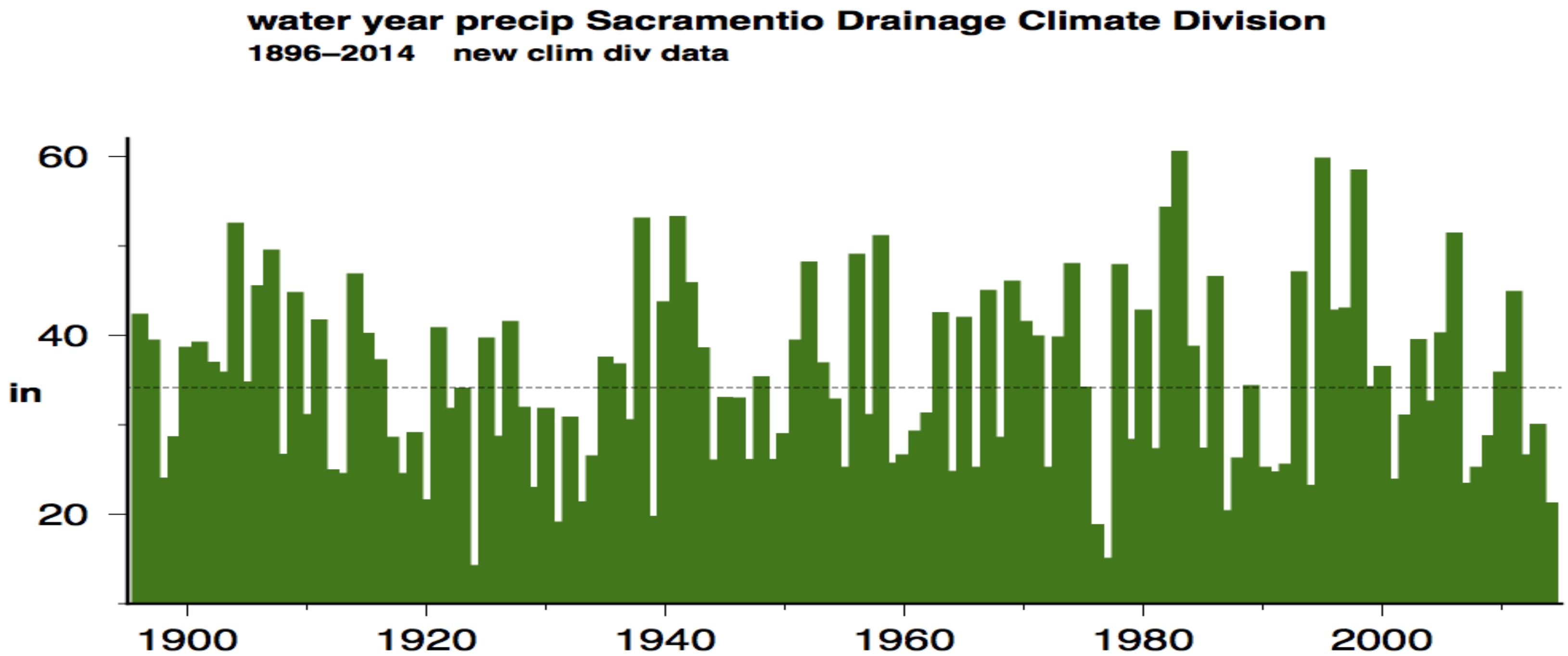
Figure 2. (a) Blue oak reconstructed (black line) and instrumental (blue line) October through June normalized mean precipitation anomalies from California NOAA Climate Divisions 4–7 [*Vose et al.*, 2014]. Uncertainty (1σ) calculated as the root-mean-squared error from the residual fit to the instrumental series shown as the shaded gray region. The dashed blue line and star indicate the 2014 value. (b) Distribution of the reconstructed October through June normalized mean precipitation anomalies for 1293–2014. The 2014 value is indicated by the blue line and labeled. (c) Long-term (1293 to 2014) reconstructed (black line) and instrumental (blue line) normalized precipitation anomalies. The dashed blue line and star indicate the 2014 value. Uncertainty on the reconstruction calculated as the root-mean-squared error from the residual fit to the instrumental series shown as light (2σ) and dark (1σ) shaded gray regions.

Routing hydrological model runoff will be implemented to estimate streamflow at selected gage locations



Stream flow site	USGS Gage number	USGS latitude	USGS longitude	CDEC drainage area (km^2)	VIC 12km grid area (km^2)	n cells	elevation (m)			
							median	mean	max	min
1	11342000	40.940	-122.416	1101	1440	10	1329	1348	1894	657
2	11370000	40.719	-122.420	16630	25200	175	1511	1468	2483	278
3	11377100	40.289	-122.186	23501	31968	222	1428	1309	2483	149
4	11407000	39.522	-121.547	9386	9360	65	1599	1491	2032	56
5	11418000	39.235	-121.273	2870	4320	30	1304	1281	2209	186
6	11446500	38.708	-121.156	4820	5472	38	1441	1385	2513	88
7	11302000	37.852	-120.637	2554	3456	24	1641	1569	2810	109
8	11289650	37.666	-120.441	3983	3456	24	1802	1762	3117	190
9	11270900	37.522	-120.331	2748	2592	18	1405	1578	3104	212
10	11251000	36.984	-119.723	4341	4320	30	2273	2104	3517	282
11	11208600	36.484	-118.835	886	2016	14	1358	1488	3132	210

How persistent are dry years?



Sequence of Dry, moderate, wet spells, Obs Sacramento Drainage 1895-2014

hmDDmmmmhmhhDhmhDDhhmDDmDhmmDhmhmDmDmDDmmmhDhhhmDmmDmDmmhmmDhmhDDmmhDhDhDhhhDhhm
DDhDhDhhmDhDDmDDDhDhhhhmmDmhmhhDDmmhDmD

Dry years have not repeated
Too often within the last 118 yrs

Transition frequencies year to year

	dry	mod	wet
dry	10	13	16
mod	16	12	11
wet	14	14	12

Synthetic Annual Precipitation Dry/Moderate/Heavy
Number of n year dry spells
10000 year simulation

length (n)	number dry spells
1	1549
2	488
3	153
4	57
5	13
6	8
7	0
8	1
9	0
10	0

Sequence of Dry, moderate, wet spellls, Synthetic 1st 400 years

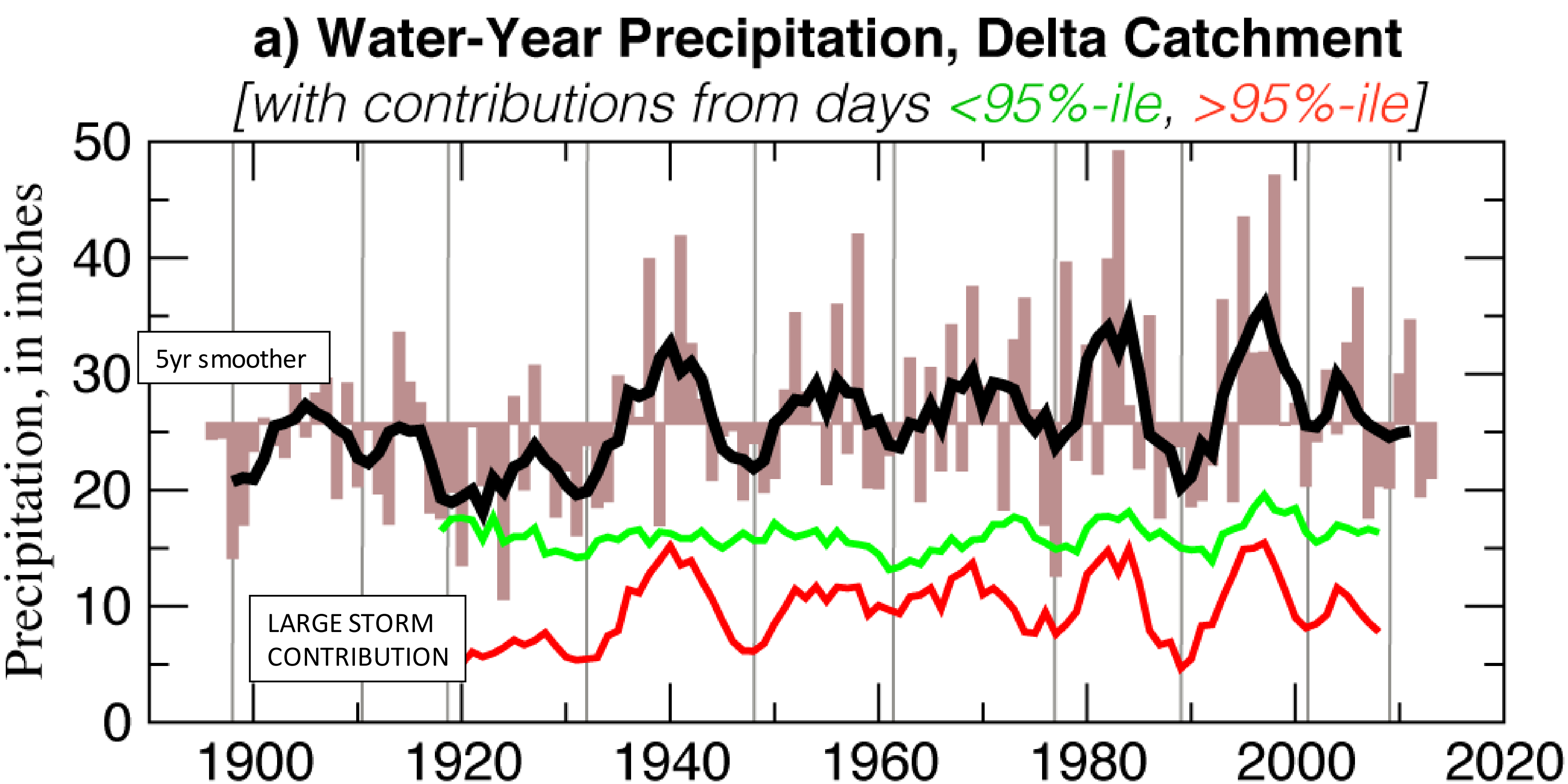
mDmDhhmDmDDhhmmhhDDhmhhDhmmDDhDmDmDDmhmDhDhmhhDmhhmmDmDmhhhDDDmhDDmhmDhhDmmmhDmm
hmDhDmhDmDmmhDhhmhmmhhhDmmhhhhDmDmhhhDhmmmhDDmDhmhhhDmDmhDDhDDhhmDDDDmhhmmDDmmhD
hmDmmmmmmDDhhhhmmmDmmDmhhhmDhmhhhDDhhDmmDmhDmDDhDDDmmDhmDhDDmhmDDmDhhDmhhmmDmDmh
hhDhDhhhDDmmDDDmhmDhDmDhDhDhDDDDmDmhhhmmDmDDmhhmmhDmDDhmmmhDmDhmDDhDmDmhDDmDmmhh
DmhhmhDmDDhhhDmDDmDhDhmhmmDmmhmhmmmDmDDmmhmhmhDDmDmhhDhmhhhDhDDmhDmDhmhDDmmmDhhD

Sequence of Dry, moderate, wet spells, Obs Sacramento Drainage 1895-2014

hmDDmmmmhmhhDhmhDDhhmDDmDhmmDhmhmDmDmDDmmmhDhhhmDmmDmDmmhmmDhmhDDmmhDhDhDhhhDhhm
DDhDhDhhmDhDDmDDDhDhhhhmmDmhmhhDDmmhDmD

a few large storms (or their absence)

account for a disproportionate amount of California's precipitation variability



Mike Dettinger

Dettinger and Cayan **Drought and the Delta—A Matter of Extremes**
accepted, San Francisco Estuary and Watershed Science, April 2014

Constructing Drought Scenarios, California 4th Assessment

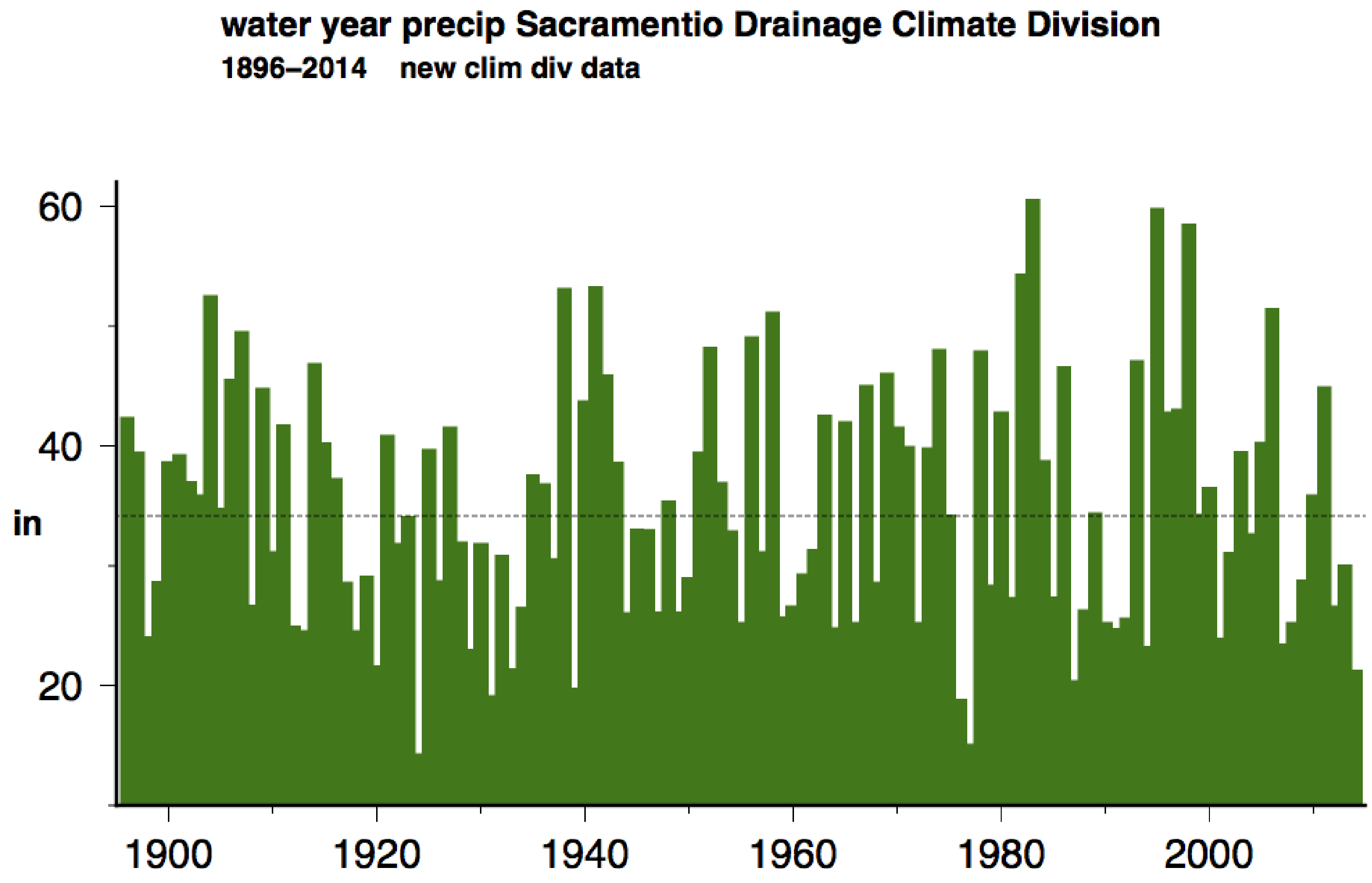
1. Climate model simulated guidance is crucial, because warming will increasingly will amplify dryness as climate change continues

2. GCMs may be deficient in multi-year variability, so observational (instrumental and proxy) guidance seems valuable

3. Sampling approaches to derive plausible dry spells could be useful

4. Frequency vs. Amplitude of precipitation changes are both important issues.

5. Event scale phenomena have been shown to be a major driver of dry (and wet) spells in California.


water year precip Sacramentio Drainage Climate Division
1896–2014 new clim div data
60
40
in
20
1900
1920
1940
1960
1980
2000