

NEW DROUGHTS DEMAND NEW METRICS

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THE NONSTATIONARITIES OF US DROUGHT THAT WE ARE (AND WILL BE) FACING ARE NOT JUST QUANTITATIVE/STATISTICAL CHALLENGES. INCREASINGLY, THEY ARE NONSTATIONARY CHANGES IN CHARACTER (MECHANISMS, ETC) AND IMPACTS OF US DROUGHTS.

Examples of “emerging” needs and questions:

- **Was the most recent set of storms enough to reverse antecedent precip deficits? How many MORE chances will there be to “fix” the precip deficits this year?**
[As resource managers play things closer to the edge, these questions become more urgent.]
- **What form did the precipitation (or *lack thereof*) come in? Rain vs snow?**
[Climate projections predict more precip as rainfall, and rain droughts impact differently than snow droughts.]
- **How is this precip drought playing out as function of altitude?**
[Orographic precip patterns vary from drought to drought, yielding significant resource-impact differences. Mountain communities have mental maps of surroundings that are based as much on topography as on map view, and we should present drought info both ways.]



- **How do the evaporative-demand surpluses compare (in pattern & magnitude) to precip deficits in a given drought?**

[As evaporative demands grow, evaporative-demand drought are increasingly “players” in drought impacts. Users need a more integrated (but still separable) depictions of drought status and outlook.]

- **How much worse (percentage-wise) is the streamflow-drought than the precipitation-drought situation?**

[Its long past time to start integrating precip AND streamflow (and more?) drought metrics on the same maps and tables. As evaporative demands grow, our traditional heuristics for interpreting the resource implications of precipitation drought will fail.]

...and so on.



My point today:

NONSTATIONARITIES OF DROUGHT THAT WE ARE (AND WILL BE) FACING ARE NOT **JUST** QUANTITATIVE/STATISTICAL CHALLENGES.

INCREASINGLY, DROUGHTS ARE **ALSO** NONSTATIONARY IN THEIR CHARACTER (MECHANISMS, ETC) AND IMPACTS.

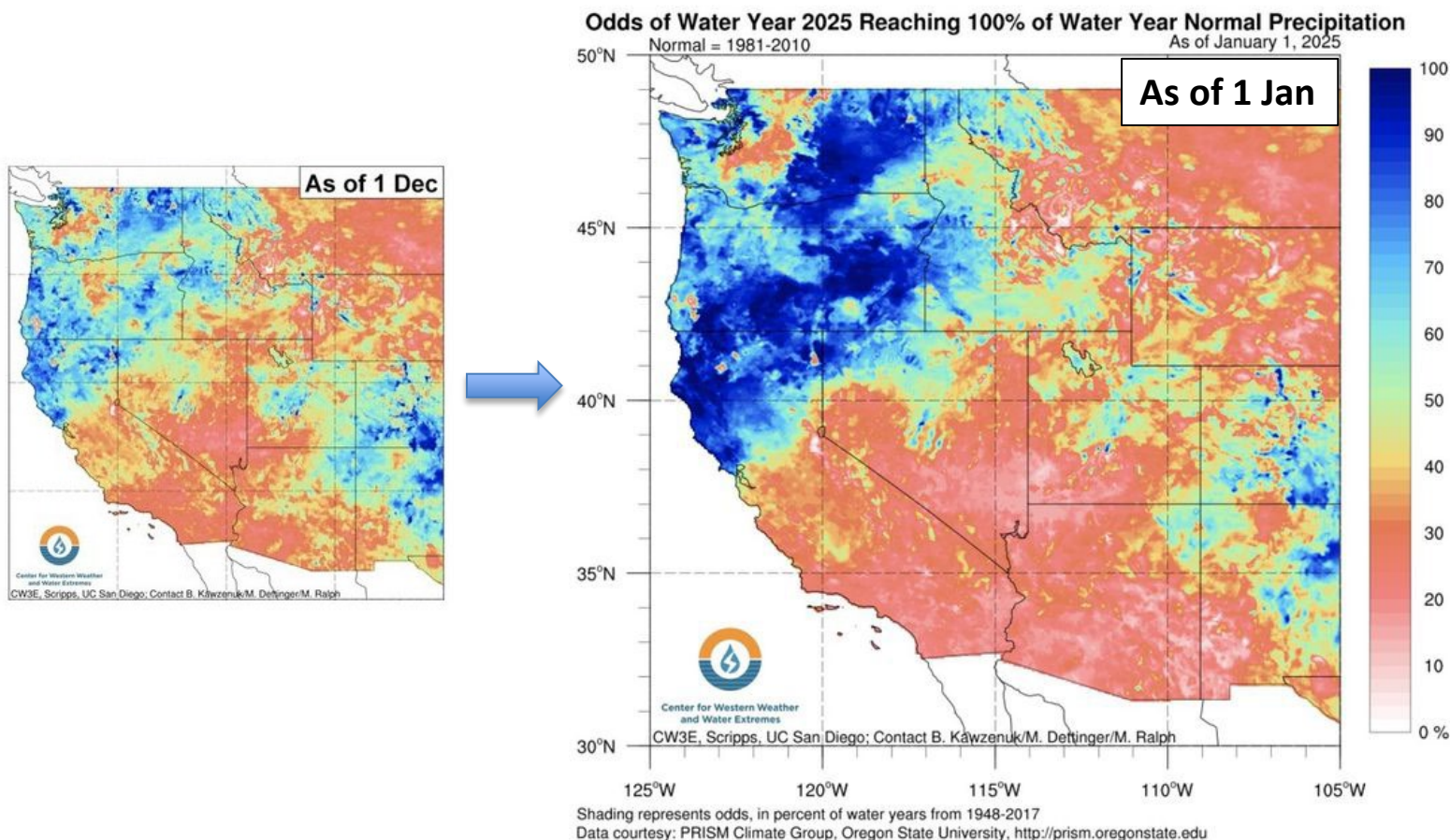
THE METRICS THAT WE FORECAST, TRACK & REPORT NEED AUGMENTATION TO ADDRESS EMERGING NEW FORMS OF DROUGHT & IMPACTS.



Some visualizations I use:

Historical data

**Was the most recent set of storms enough to reverse antecedent precip deficits?
How many MORE chances will there be to “fix” the precip deficits this year?**



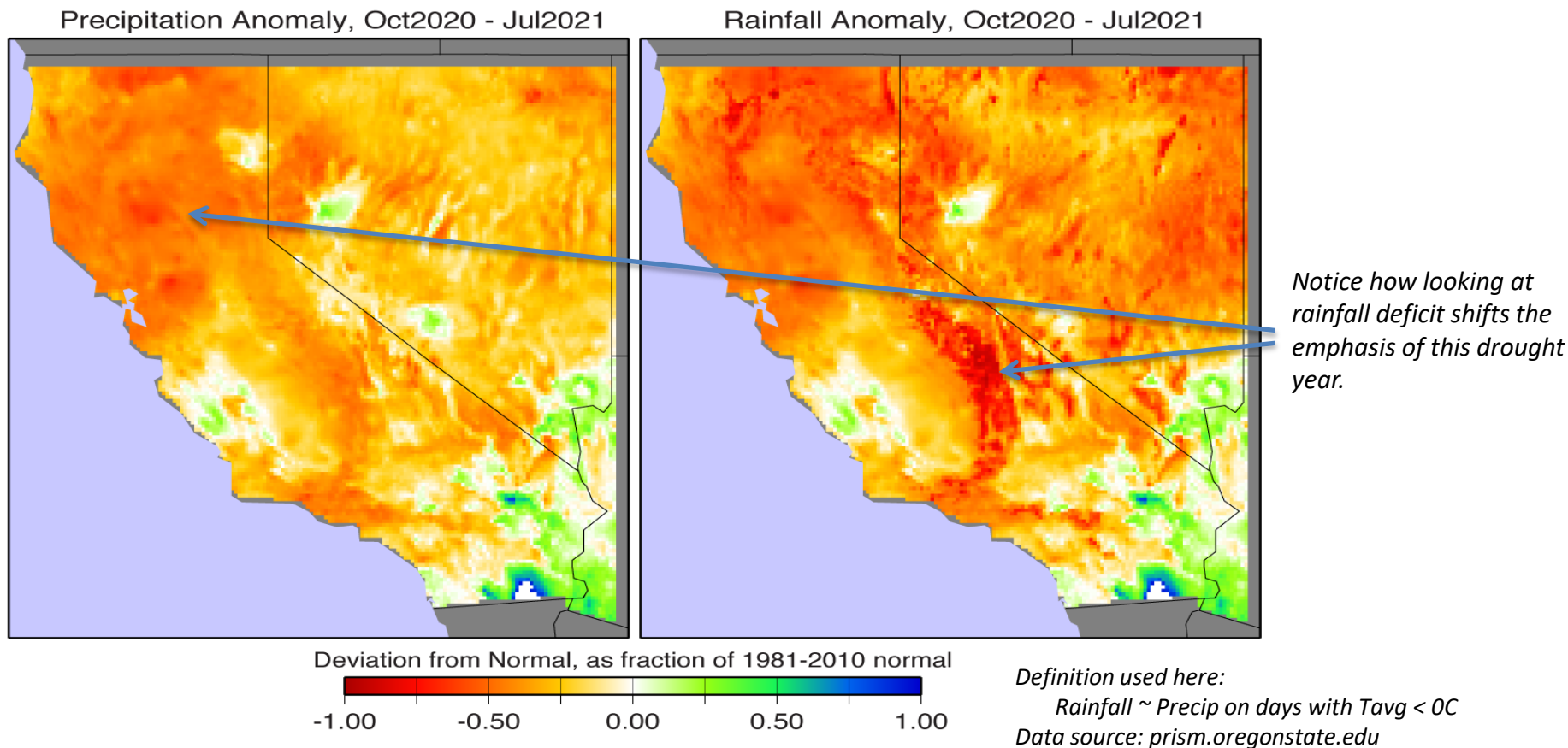
The steep divide between certainly-wet north & almost-certainly-dry south was intensified by December storms in northern California, and those same storms took odds of avoid precip drought from roughly even to ~90+% in that area. In the south, time is running out for important storms to arrive, using a recent 70 yrs worth of monthly precip records as fodder. For more examples/details and explanation of the calculations used here, see <https://cw3e.ucsd.edu/odds-of-normal-water-year-precipitation/>.



Some visualizations I use:

Historical data

What form did the precipitation (or *lack thereof*) come in? Rain vs snow?



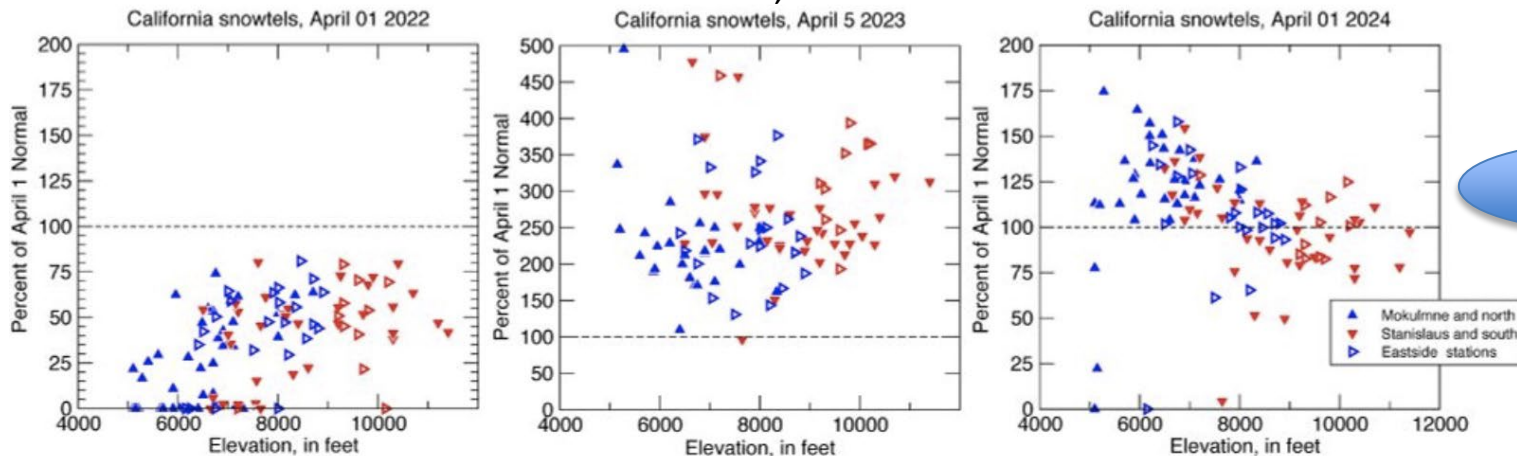
Here is how a particular recent drought year played out in terms of “was it a snow drought or a rain drought” (not a question that you hear much, admittedly) EXCEPT in its veiled forms “The drought isn’t THAT bad; so where is all the snow?” or “How did the wildfire-risk in the southern Sierra get so bad?”



Some visualizations I use:

How is this water yr (or drought) playing out as function of altitude?

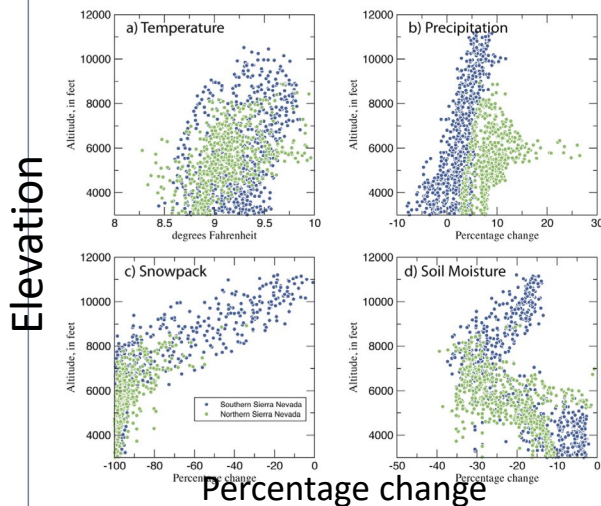
SWE vs Elevation, Sierra Nevada



Data source: cdec.water.ca.gov

Historical data

FIGURE 2.4



Climate
projections (cmip5)

From: Dettinger et al., 2018, *Fourth California Climate Assessment--Sierra Nevada Region Report: California's Fourth Climate Change Assessment report SUM-CCCA4-2018-00*, 94 p.

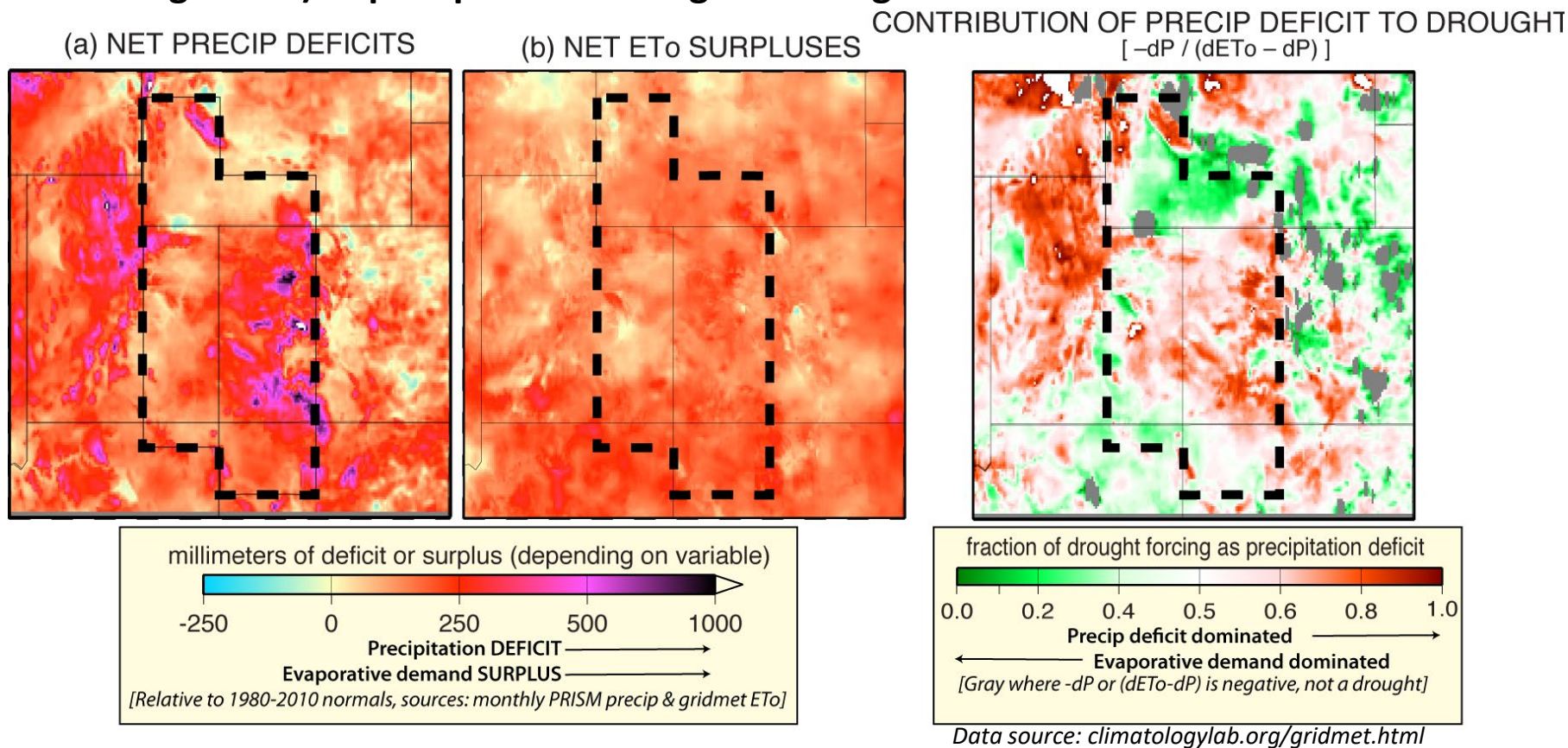
Average projected changes, by 2070-2099, in (a) annual temperatures, (b) annual precipitation, (c) April snow-water equivalents, and (d) June-September soil moisture as functions of elevation and subregion in the mountain range, from the 10-model ensemble of climate models responding to accelerating RCP8.5 greenhouse-gas emissions shown in Fig. 2.1c, 2.1f, 2.5d, and 2.7e, as degrees of warming (a) or percentage changes from 1961-1990 average conditions.



Some visualizations I use:

Historical data

How do the evaporative-demand surpluses compare (in pattern & magnitude) to precip deficits in a given drought?



- Over the **UCRB Oct2019-Aug2021**, the total volume of evaporative-demand surpluses is equal to 86% of the total precipitation deficit (panels a & b).
- Over the **UCRB Oct2019-Aug2021**, the surplus values are larger than or nearly equal to the precipitation deficits across 63% of the basin area (panel c)

→ Evaporative-demand surpluses have added to the past two-years of drought in amounts comparable to the more obvious precipitation deficits.

Used at Yampa R Rendezvous, Sept 2021



Some visualizations I use:

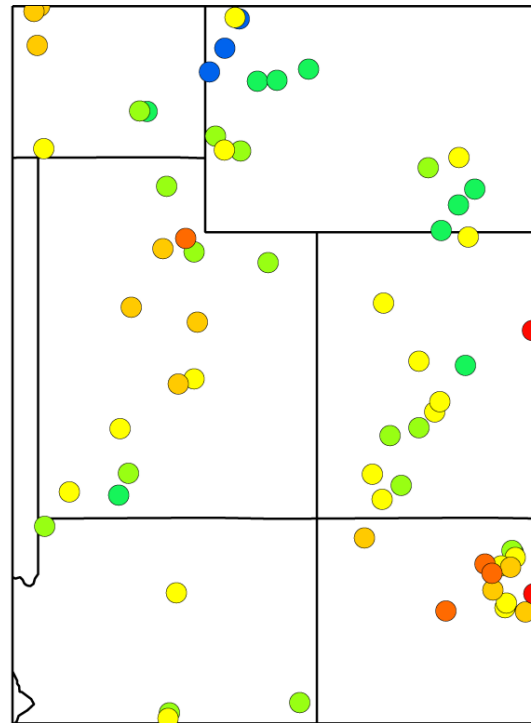
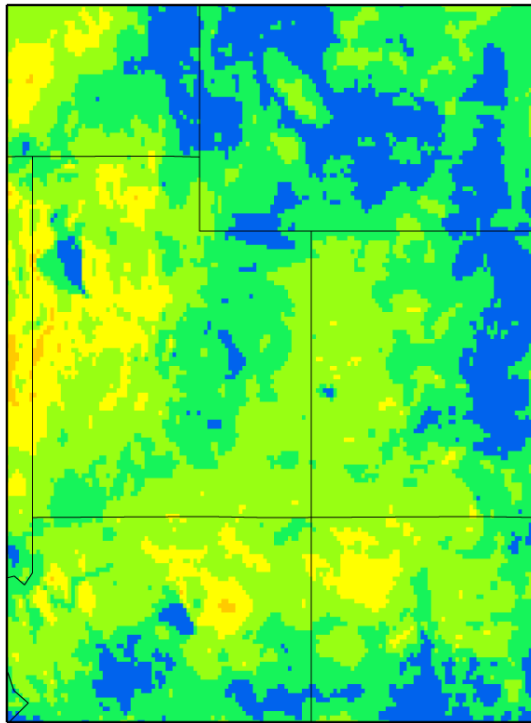
How much worse (percentage-wise) is the streamflow-drought than the precipitation-drought situation?

Historical data

PRECIPITATION DEFICITS
(PRISM OreState)

STREAMFLOW DEFICITS
(USGS HCDN gages)

1 Oct 1919 until 1 Sep 2021

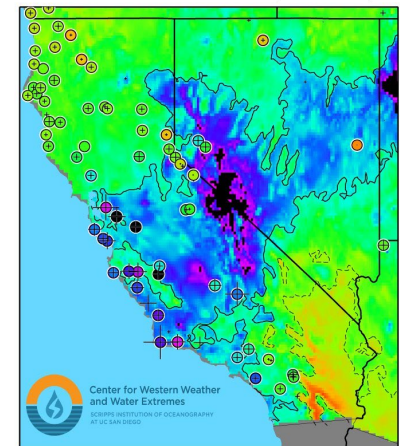


Normal Water-Years Worth of Missing Precip or Flow

-1.75 -1.50 -1.25 -1.00 -0.75 -0.50 -0.25 0.00

(normal = 1981-2010)

ACCUMULATED PRECIPITATION (shading) &
NATURAL STREAMFLOW VOLUMES (shaded dots)
from Dec 01 2022 thru Mar 31 2023, and
ANNUAL PEAK FLOW (scaled crosses)



0 50 100 150 200 250 300 350

as PERCENTAGE OF NORMAL 1981-2010 DEC-MAR TOTAL
PRECIPITATION OR STREAMFLOW (contours=100% & 200% normal precip)

0.5x 1x 2x 4x 6x

2023 PEAK FLOW / 1981-2010 AVERAGE PEAK FLOW
(2023 peak flow, as of March 31 2023)

[Data: PRISM PRECIPITATION & USGS HCDN STREAMGAGES]
Info: mddettinger at gmail.com

Not a drought yr, just included here as example of how three maps (precip, streamflow, & peak flows) can be integrated.

- On average, precipitation is ~half a (normal) year “behind” over past 2 years.
- On average, streamflow is about 0.8 years “behind”... that is, > half again as dry by this metric.



But, to reiterate, my point wasn't these specific examples...

My point is the more general observation that:

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INCREASINGLY, DROUGHTS ARE **ALSO 'NONSTATIONARY' IN CHARACTER (MECHANISMS, ETC) AND IMPACTS.**

THE METRICS THAT WE FORECAST, TRACK & REPORT NEED **AUGMENTATION TO ADDRESS & TRACK SPECIFIC NEWLY EMERGING FORMS OF DROUGHT & IMPACTS.**

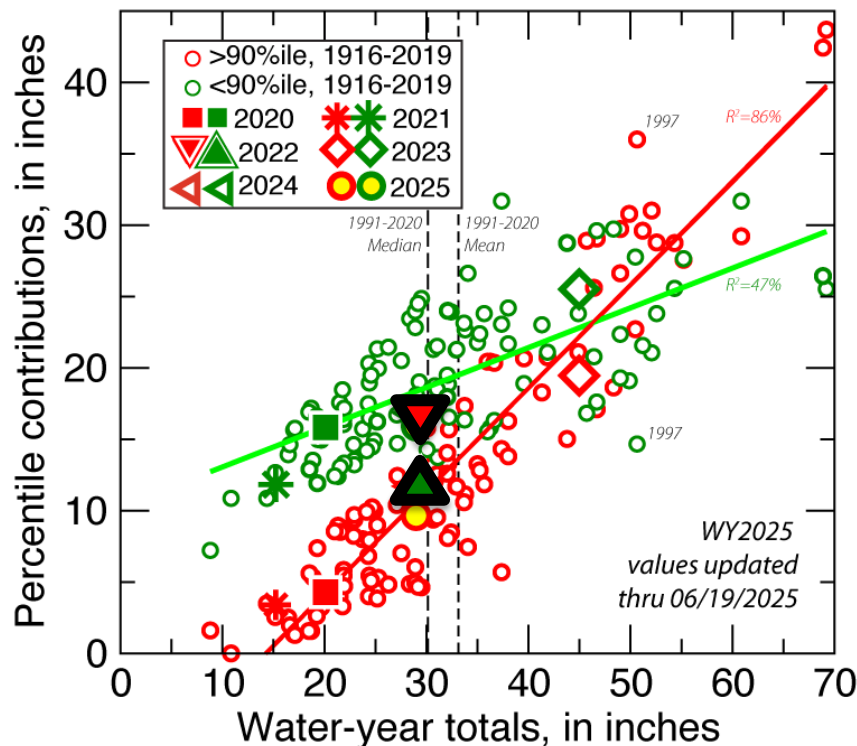
One more example (if there is time):

- **“Where” is the precip (or *lack thereof*) coming from? Big dangerous storms vs other storms?**

[Climate projections predict more of precip coming from big storms, and a drought caused by lack of a few BIG storms is hydrologically very different from a drought caused by lack of moderate to small storms.]

Tahoe City Precipitation, WY1916-2025

Total Precip vs **ABOVE/BELOW** 90th Percentile wet-day contributions



Notice that 2022 (vertical-pointing arrows)—a drought year—came from a completely different mix of “missing” precip. THIS is what we may expect to see more in coming decades.

[90th percentile threshold based on all recorded wet days from Oct 1949–Sept 1999; see Dettinger & Cayan 2014, & Dettinger 2016, San Francisco Estuary & Watershed Science; otherwise ask mddettinger@gmail.com]

Building on: Dettinger, M.D., and Cayan, D.R., 2014, Drought and the California Delta—A matter of extremes: San Francisco Estuary & Watershed Science, 12(2), 7 p. ; Dettinger, M.D., 2016, Historical and future relations between large storms and droughts in California: San Francisco Estuary and Watershed Science, 14(2), 21 p.