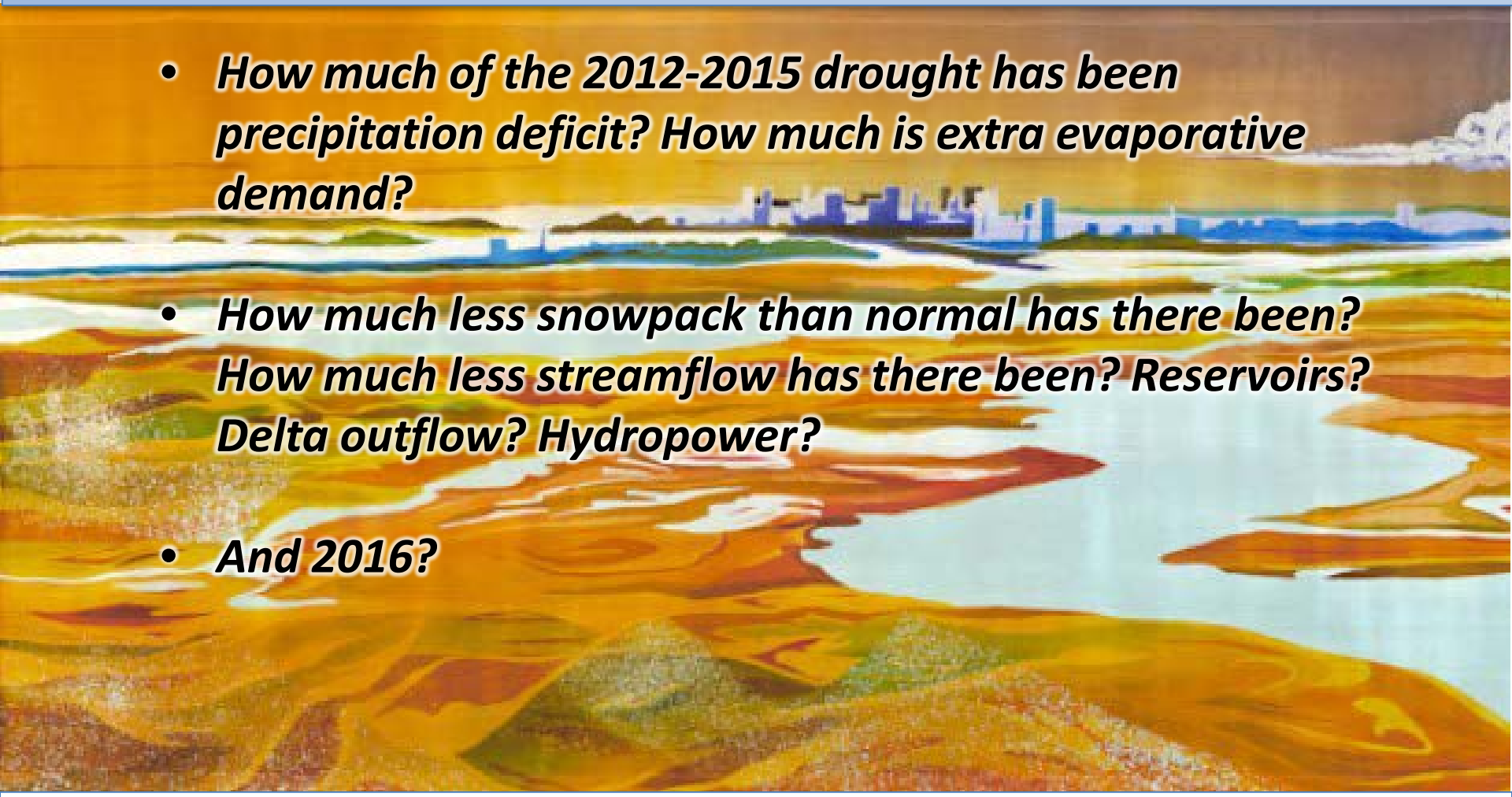
Decomposing this drought

Mike Dettinger, USGS



- ***How much of the 2012-2015 drought has been precipitation deficit? How much is extra evaporative demand?***
- ***How much less snowpack than normal has there been? How much less streamflow has there been? Reservoirs? Delta outflow? Hydropower?***
- ***And 2016?***

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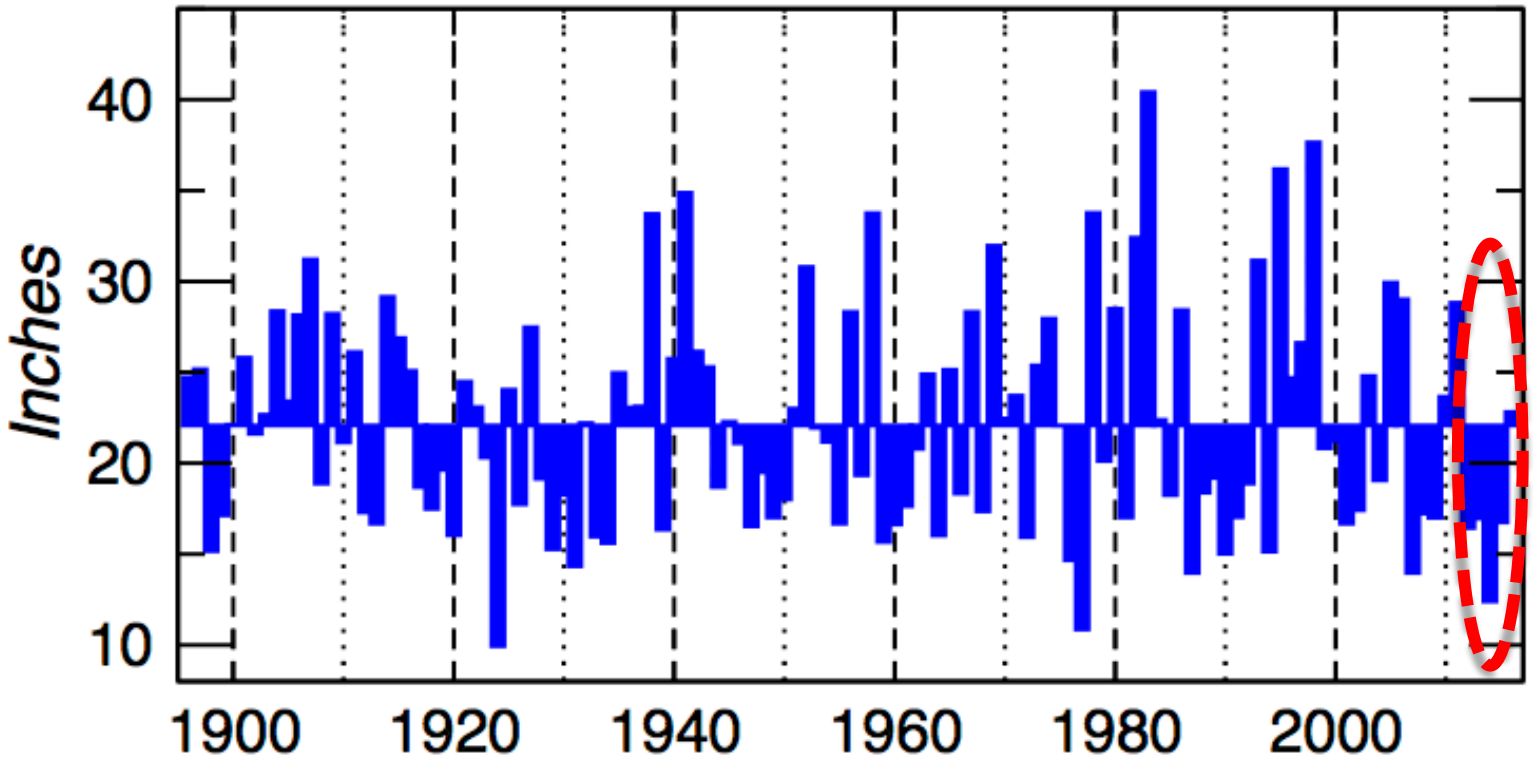
CNAP California-Nevada Climate Applications Program
A NOAA RISA team

Center for Western Weather and Water Extremes

California Statewide Water-Year Precipitation



Data source: NOAA/NCEI

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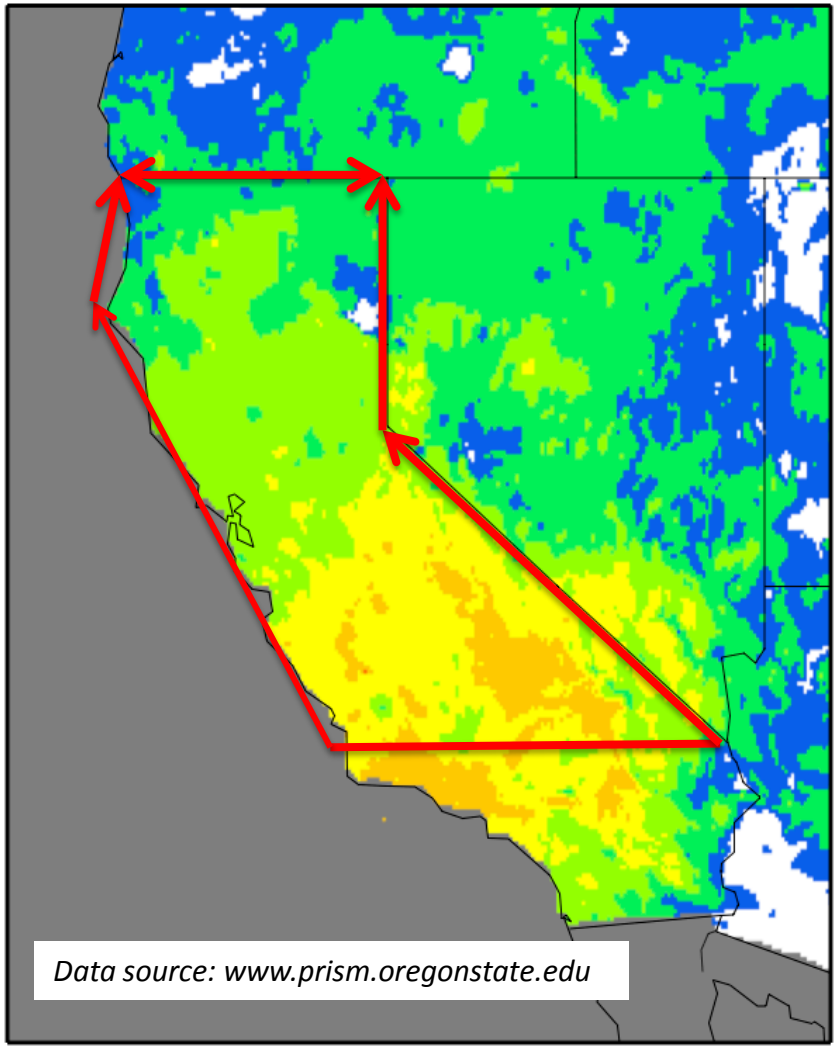
NET PRECIPITATION DEFICITS WY2012-2015

[in terms of PRISM 1981-2010 WY normals]



$\langle \delta Precip \rangle_{Delta}$ = -313 MAF

= -1.3 yr

Missing normal-years of precipitation

-4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.0

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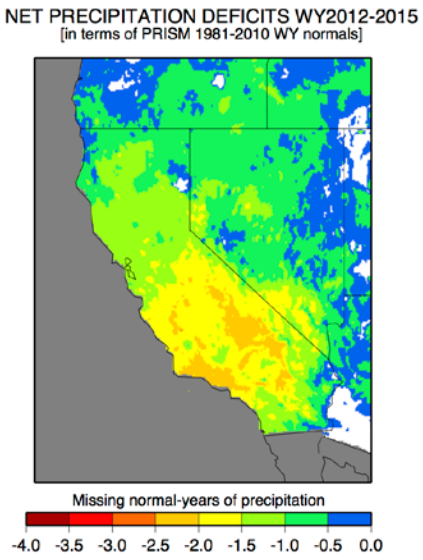
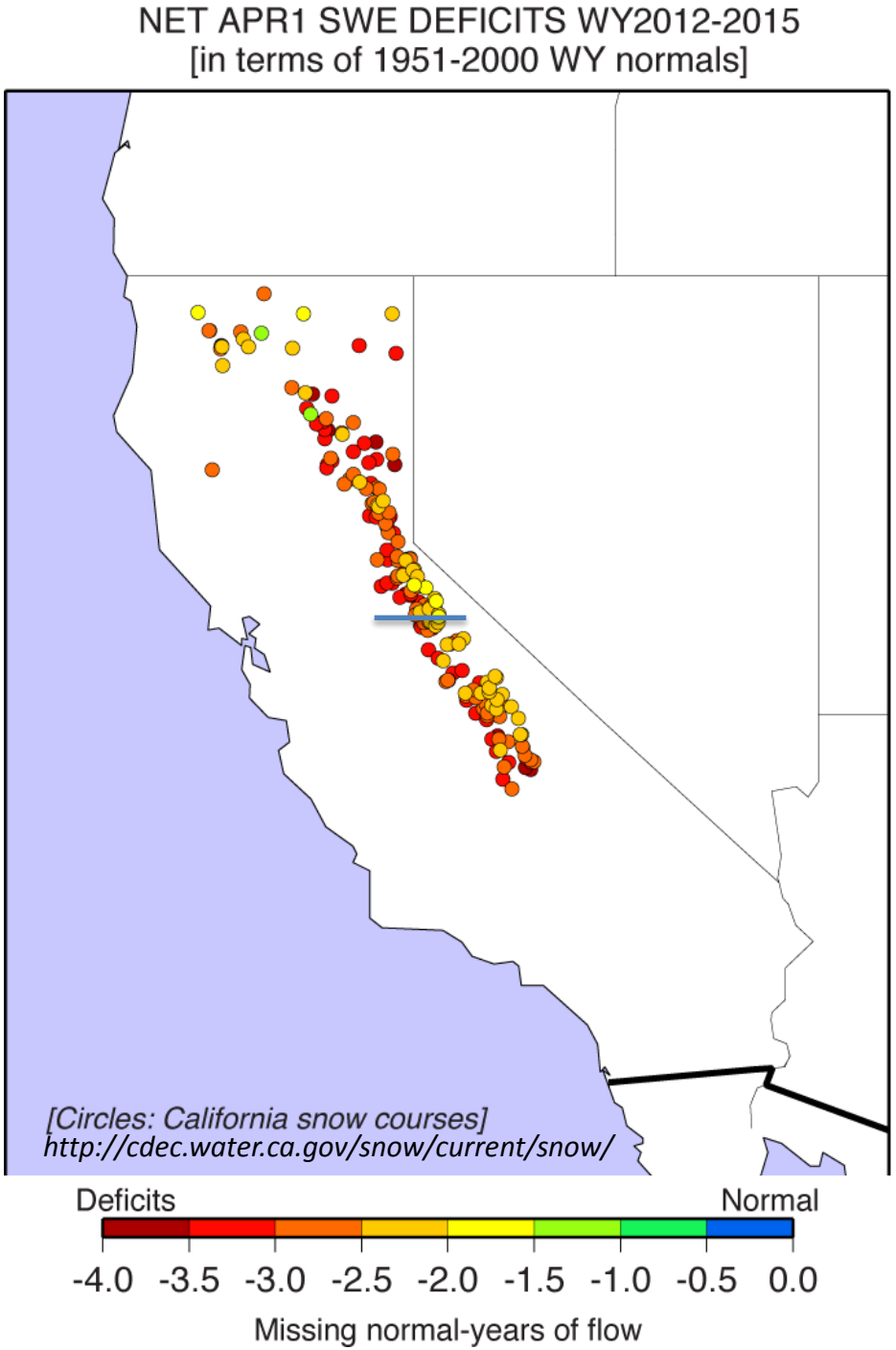
Using
California DWR
Snow Courses





<dSWE$_{Apr1}$> = -2.8 yr

[Margulis: <dSWE$_{peak}$> = -2.6 yr]

<dSWE$_{Apr1}$> = -47 MAF

[Margulis: <dSWE$_{peak}$> = -43 MAF]

<dPrecip>$_{Delta}$ = -1.3 yr
= -313 MAF

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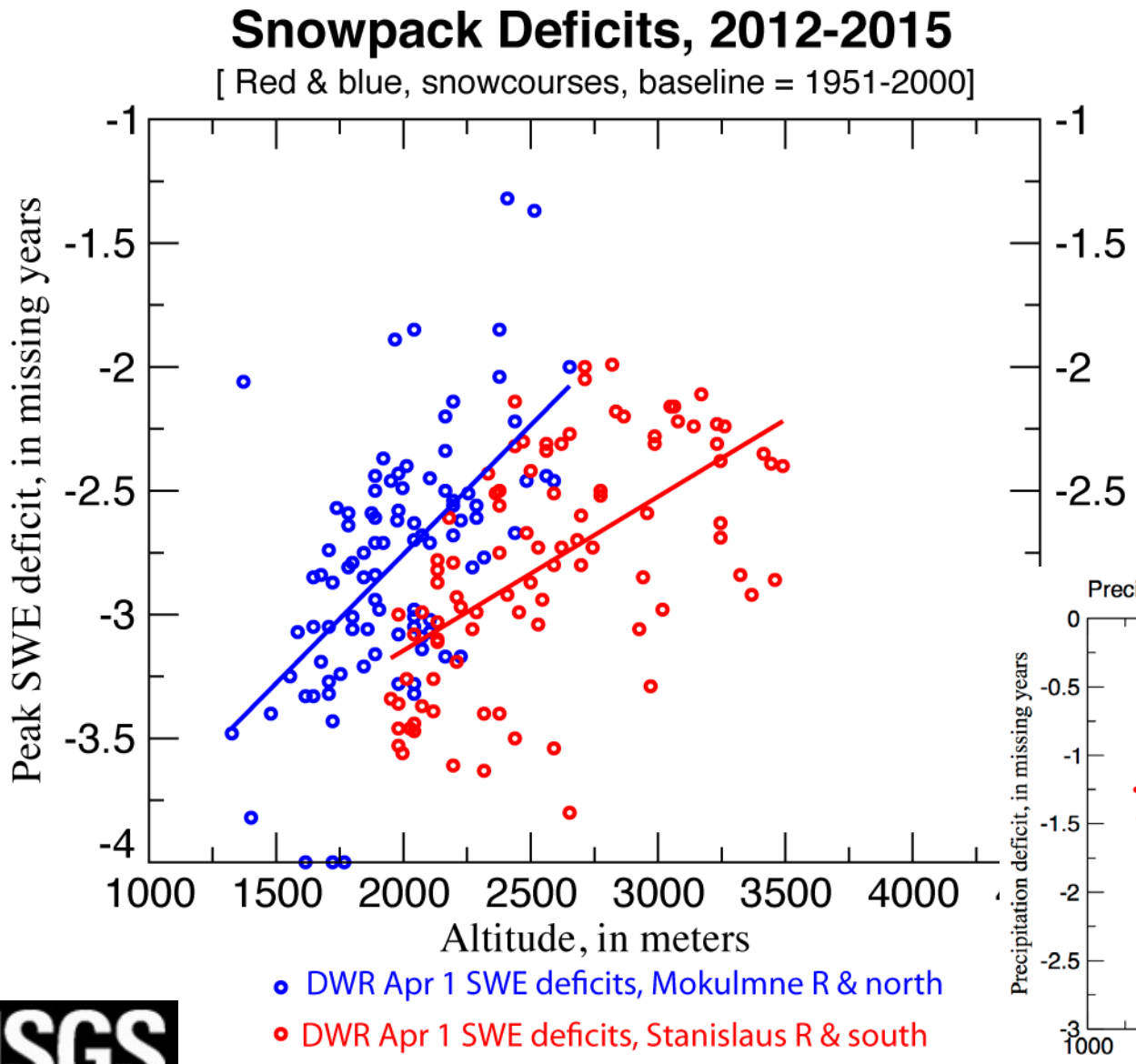
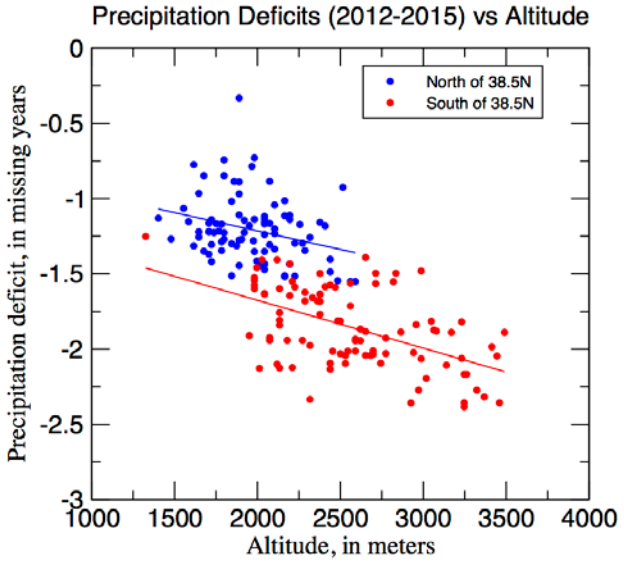
SWE deficits MUCH deficit-ier at lower altitudes





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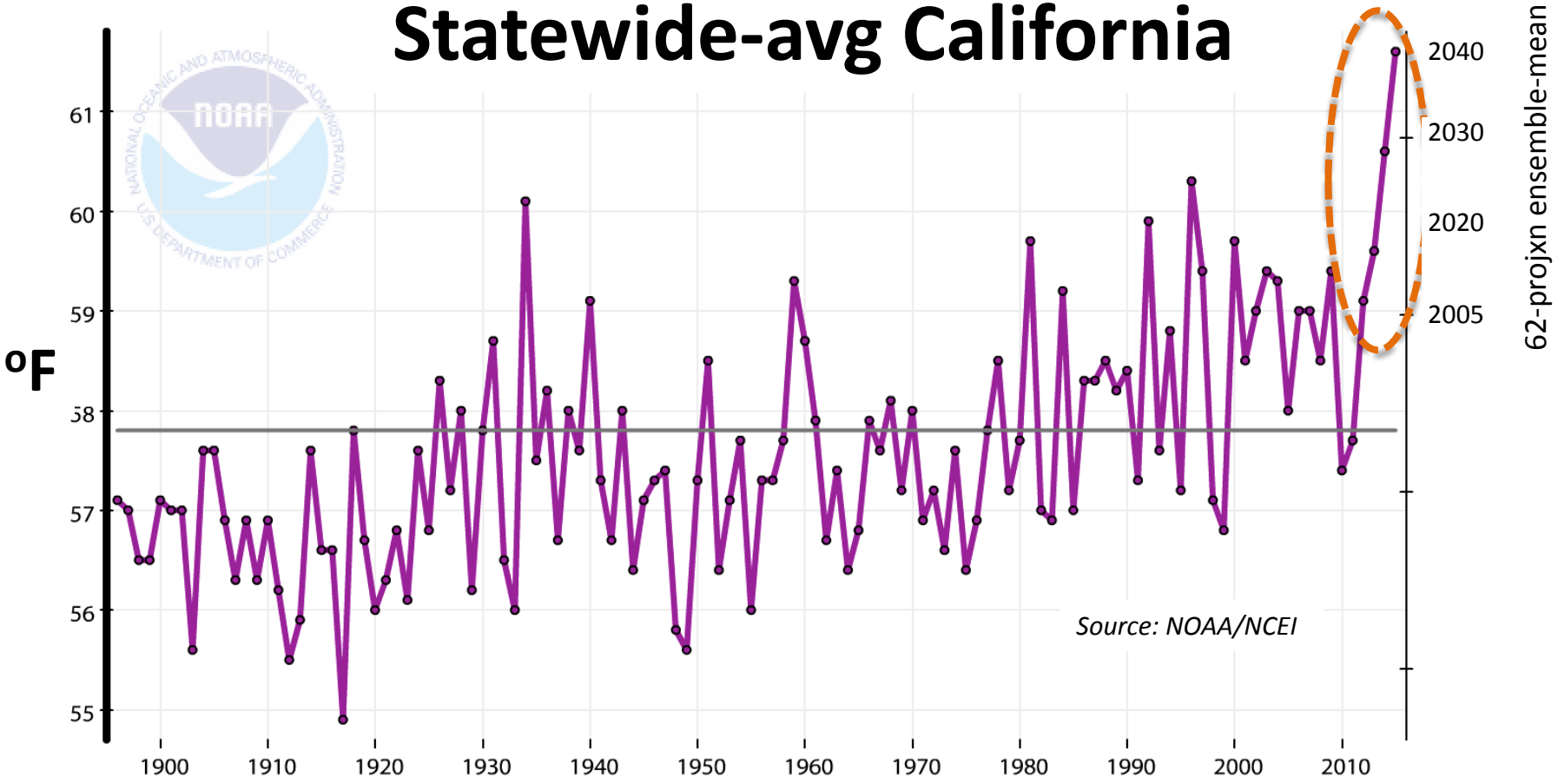
Water-year Temperatures Statewide-avg California



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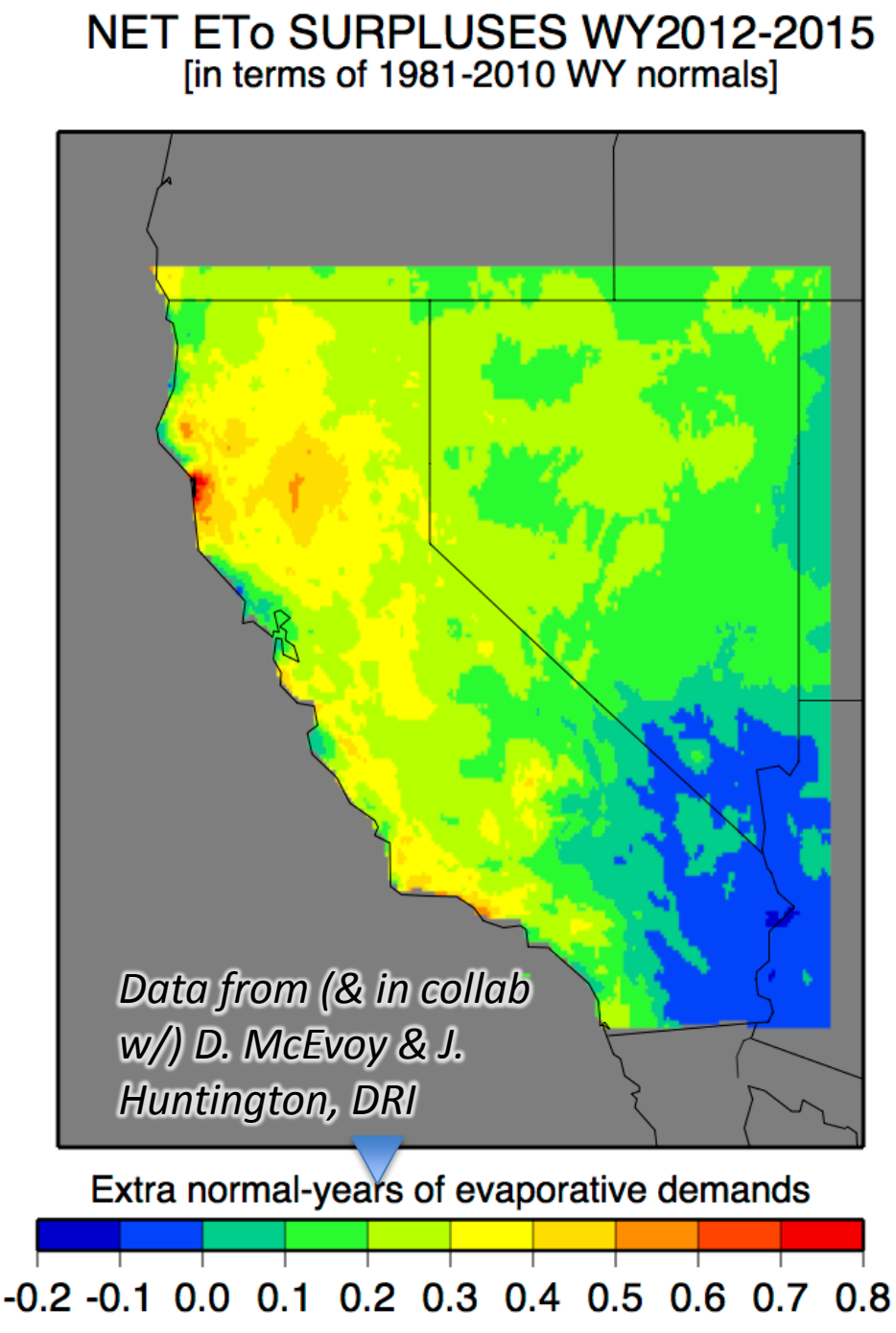
$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

- Net radiation
- Ground-heat flux
- Air temperature
- Vapor pressure
- Wind

<dPrecip>$_{Delta}$ = -313 MAF

<dETo>$_{Delta}$ = +123 MAF

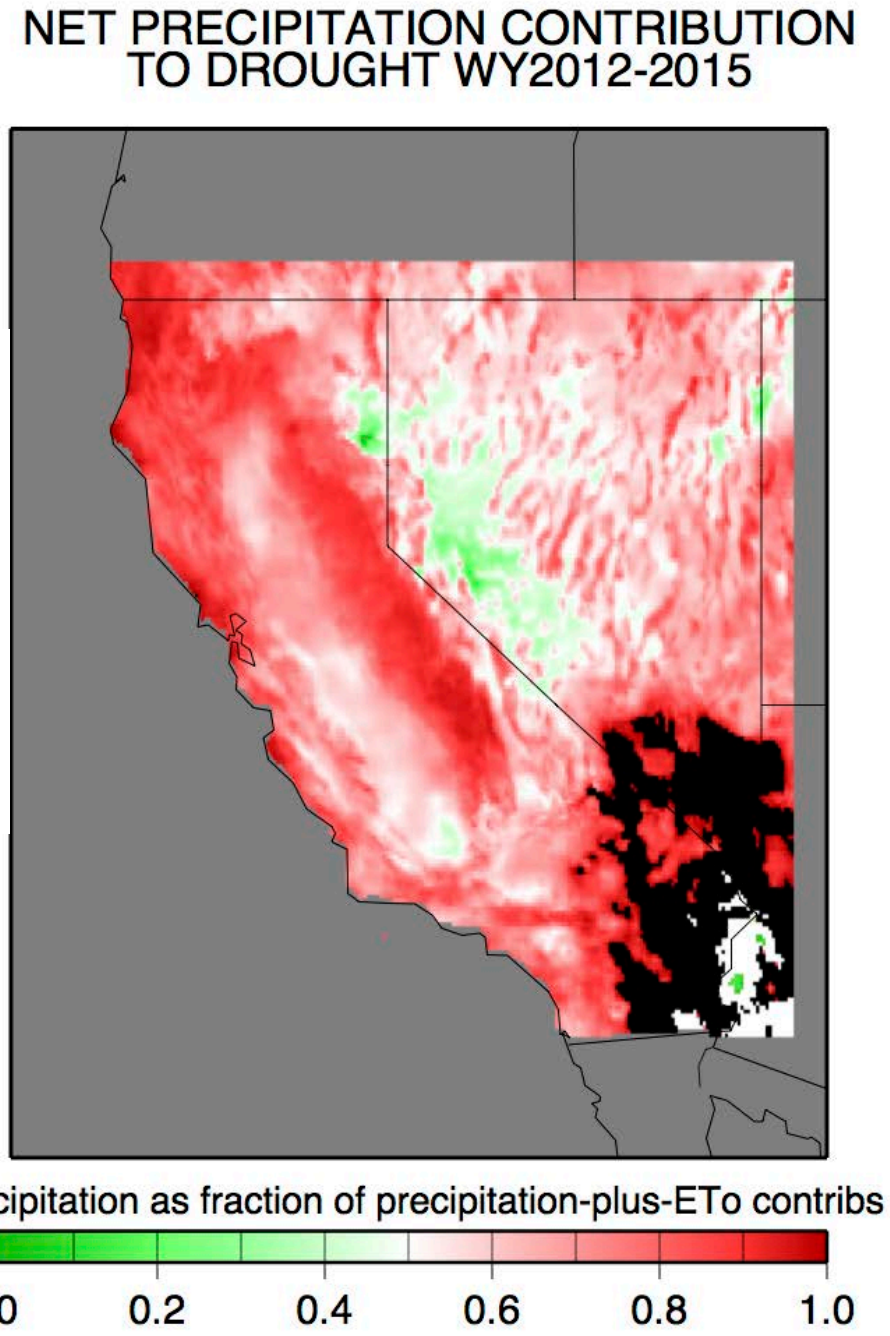


$\Delta P = \Sigma P - 4 * \langle P \rangle$

$\Delta ETo = \Sigma ET - 4 * \langle ET \rangle$

Mapped here:

$- \Delta P / (\Delta ETo - \Delta P)$



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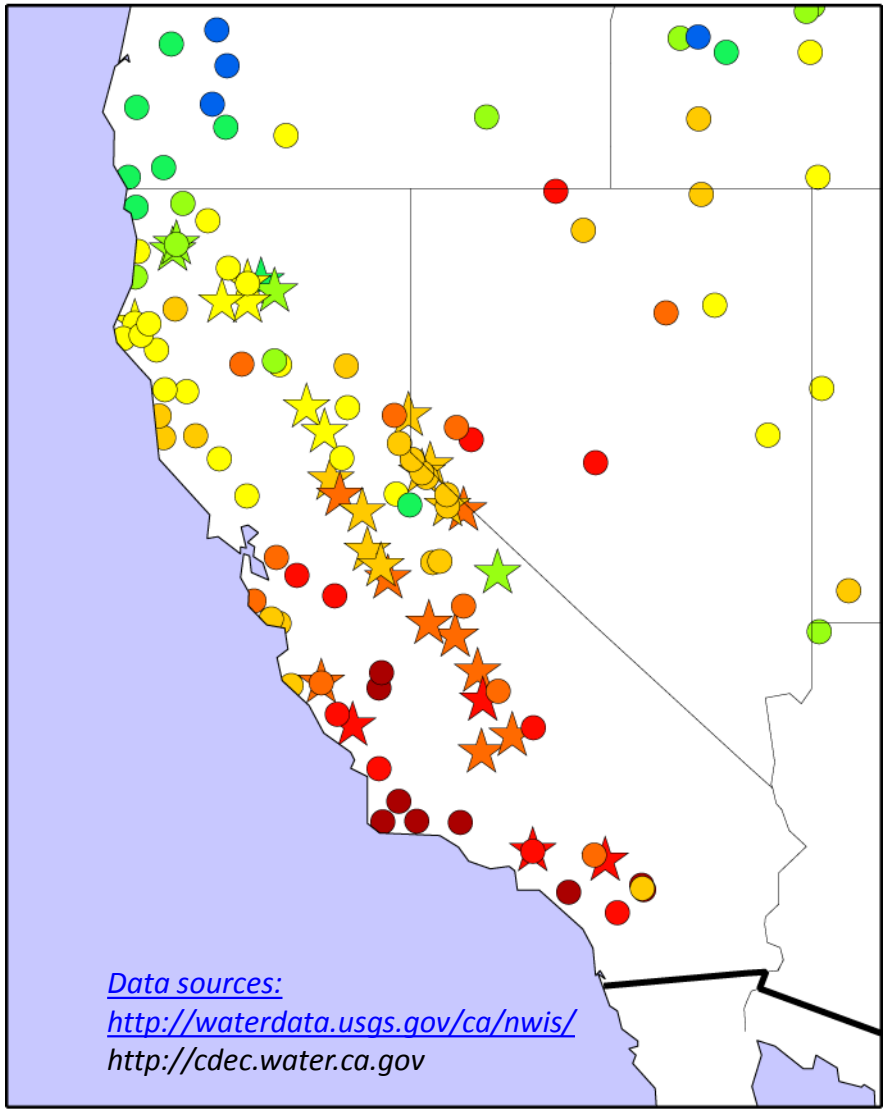
NET STREAMFLOW DEFICITS WY2012-2015
[in terms of 1961-2010 WY normals]



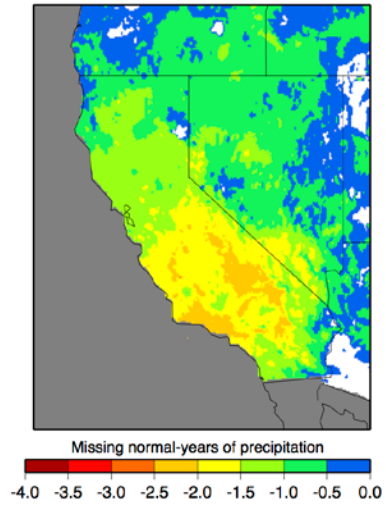
Deficits — Normal

-4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.0

Missing normal-years of flow

[Circles: HCDN gages; stars: reconstructed flows]

NET PRECIPITATION DEFICITS WY2012-2015
[in terms of PRISM 1981-2010 WY normals]



$\langle dPrecip \rangle_{Delta}$ = -313 MAF

= -1.3 yr

$\langle dSFlow \rangle_{Delta}$ = -90 MAF

(assuming total-normal = 57 MAF)

= -1.9 yr

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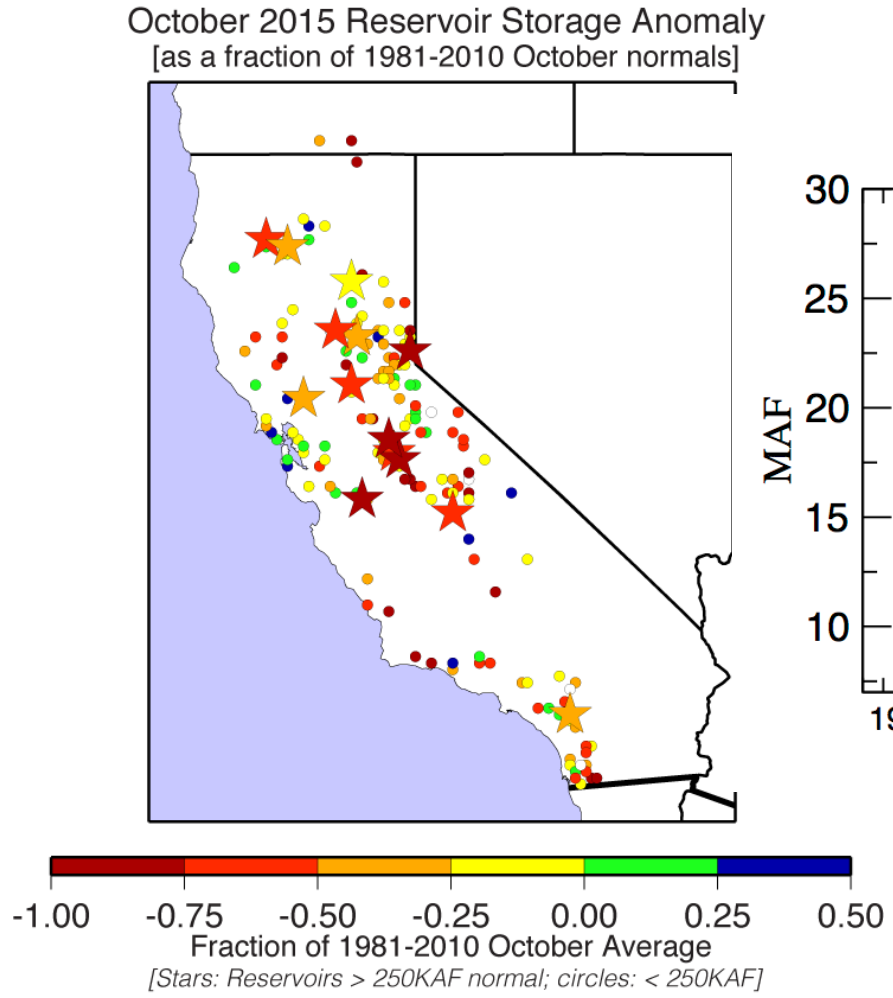
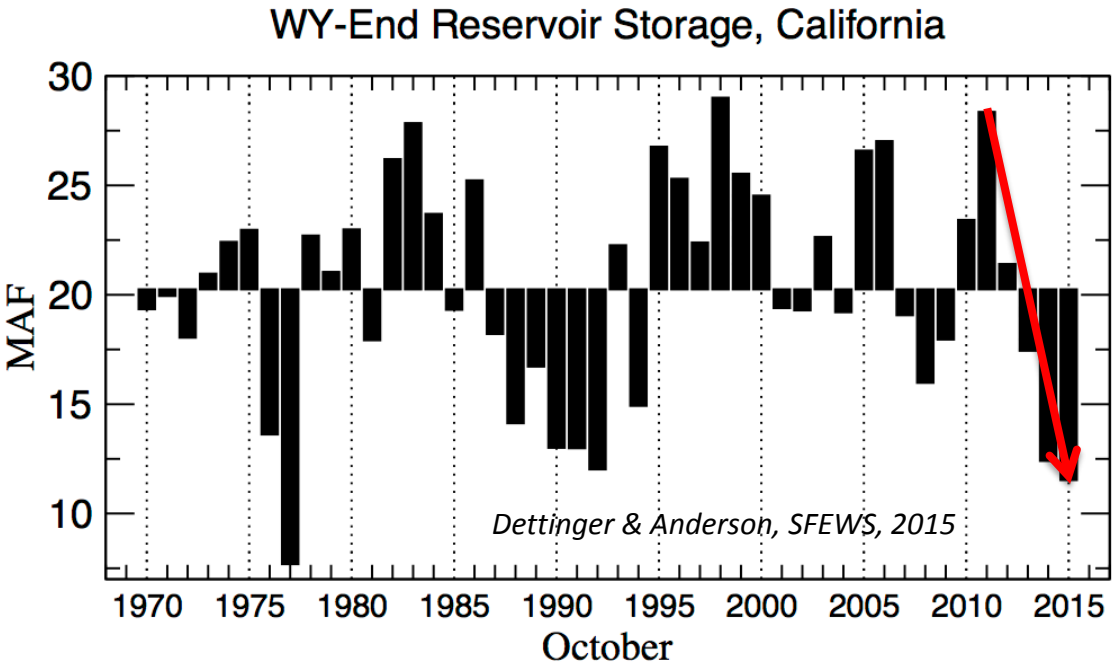
End of water year Reservoir Storage





<dPrecip>$_{state}$ = -273 MAF
= -1.3 yr

<dResvr>$_{state}$ = -17 MAF
= -0.9 yr

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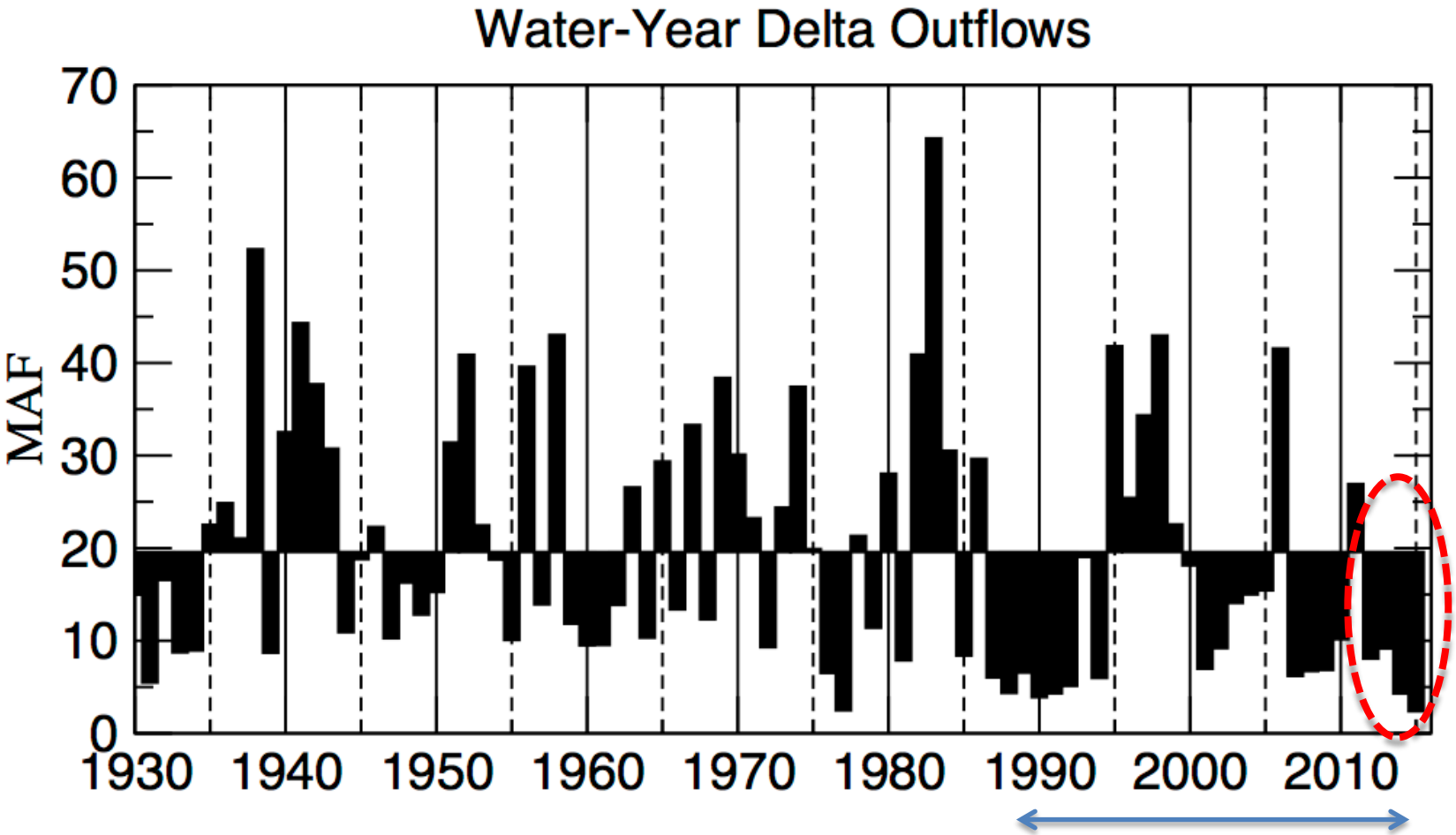
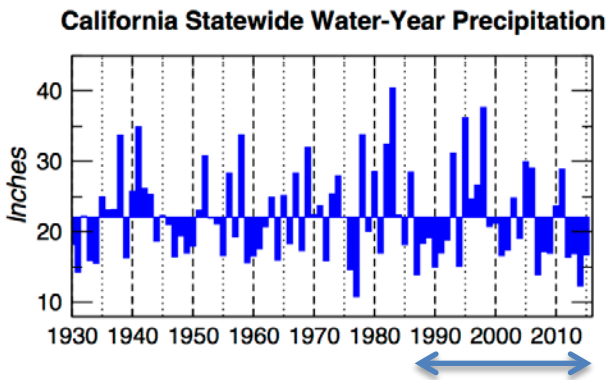
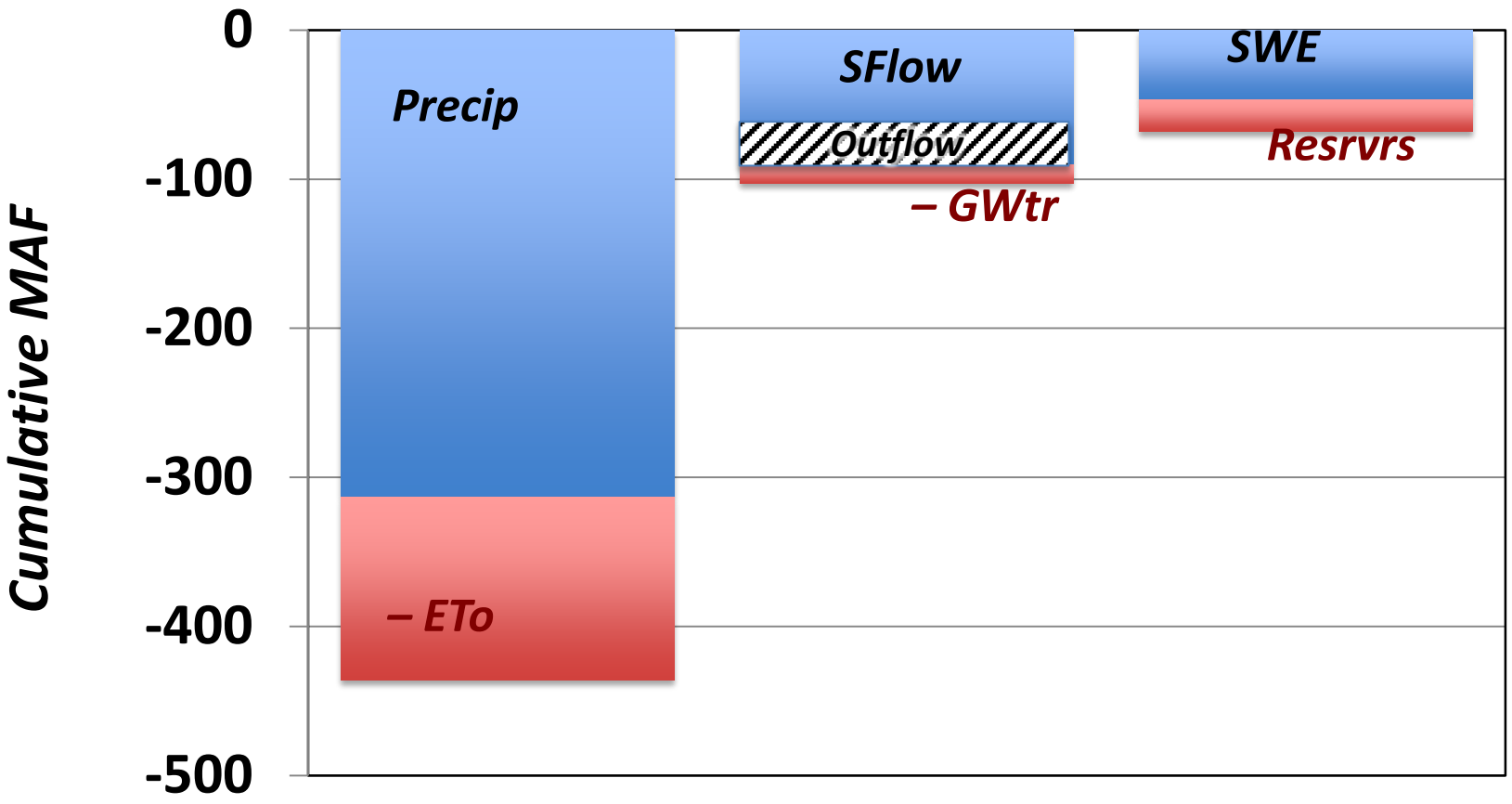




Although this drought has been hard on X2 and Delta outflows, we are in a new period when *outflow drought* (compared to earlier decades) is the normal situation for those outflows.

$\langle dOutFlow \rangle_{2012\text{-}2015}$ = -2.7 yr = -24 MAF

Accumulated Deficits, Delta-Totals, WY2012-2015



Caveat: Lots of apples & oranges here, but illustrative for comparing relative magnitudes of key deficits/surpluses pairs.

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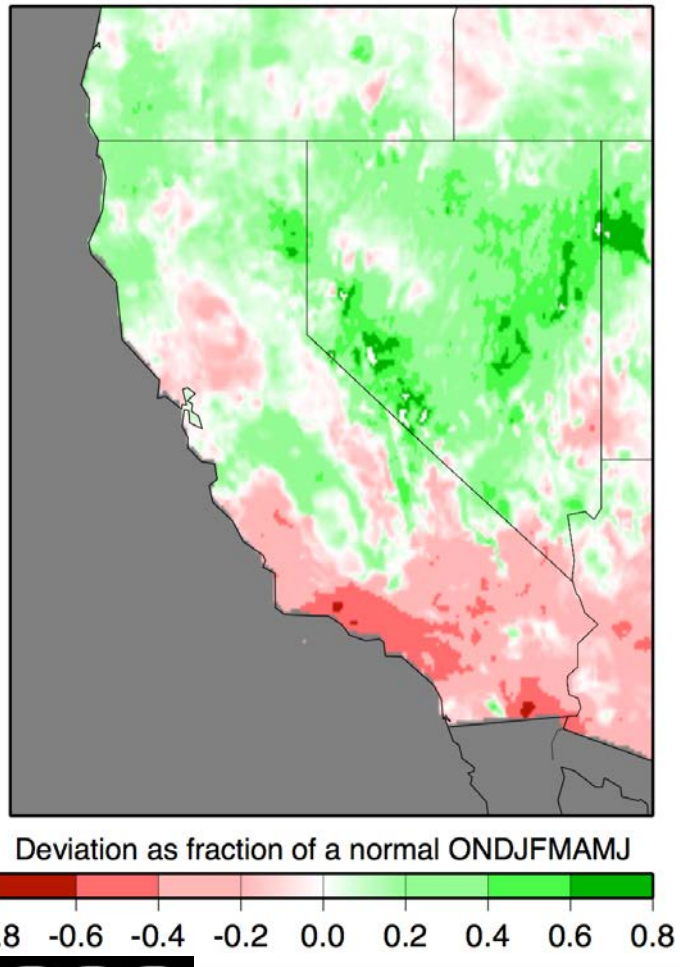
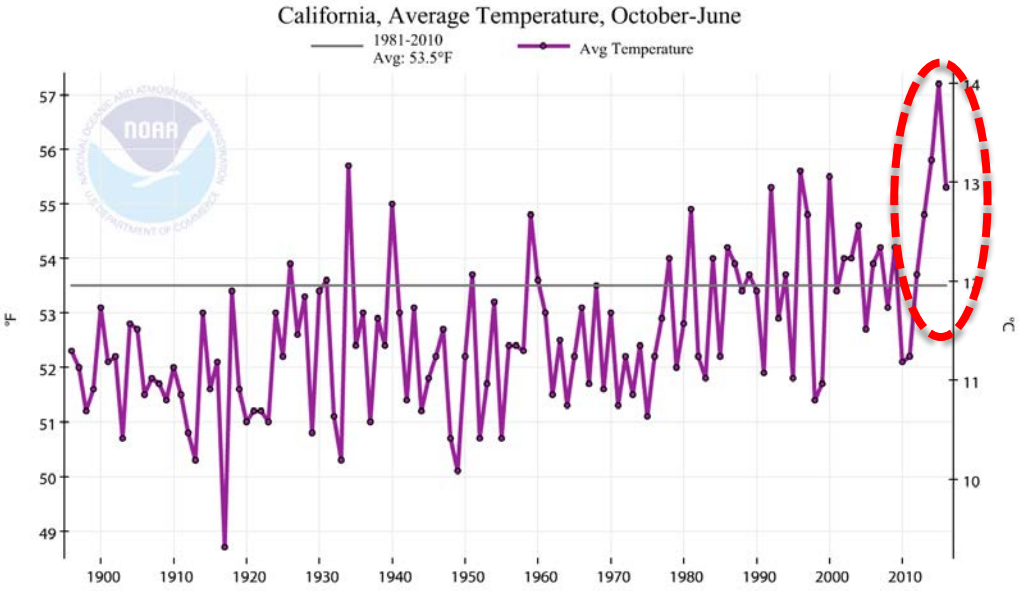
Turning to WY 2016…

PRECIPITATION ANOMALIES OCT2015-JUNE2016
[in terms of PRISM 1981-2010 ONDJFMAMJ normals]



STATE-AVG TEMPERATURES, OCT-JUNE



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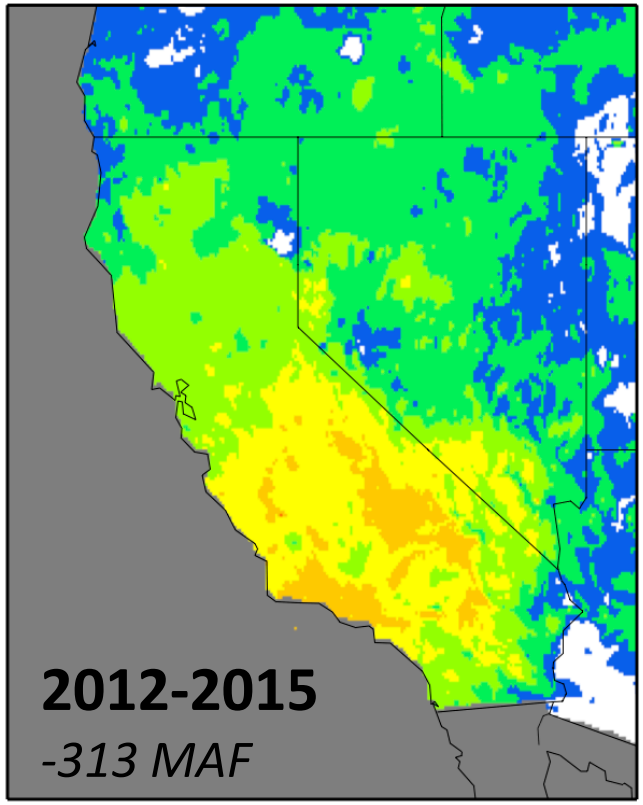
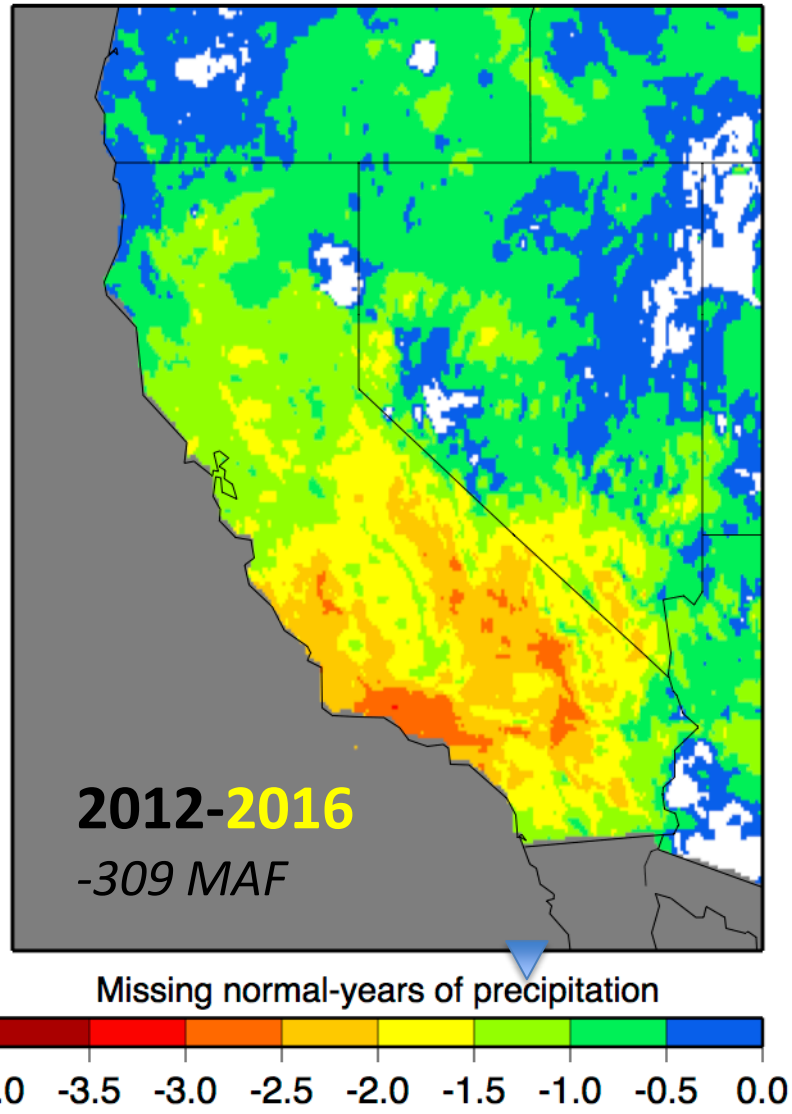
NET PRECIPITATION DEFICITS WY2012-2015
[in terms of PRISM 1981-2010 WY normals]



NET PRECIPITATION DEFICITS WY2012-2016
[in terms of PRISM 1981-2010 WY normals]



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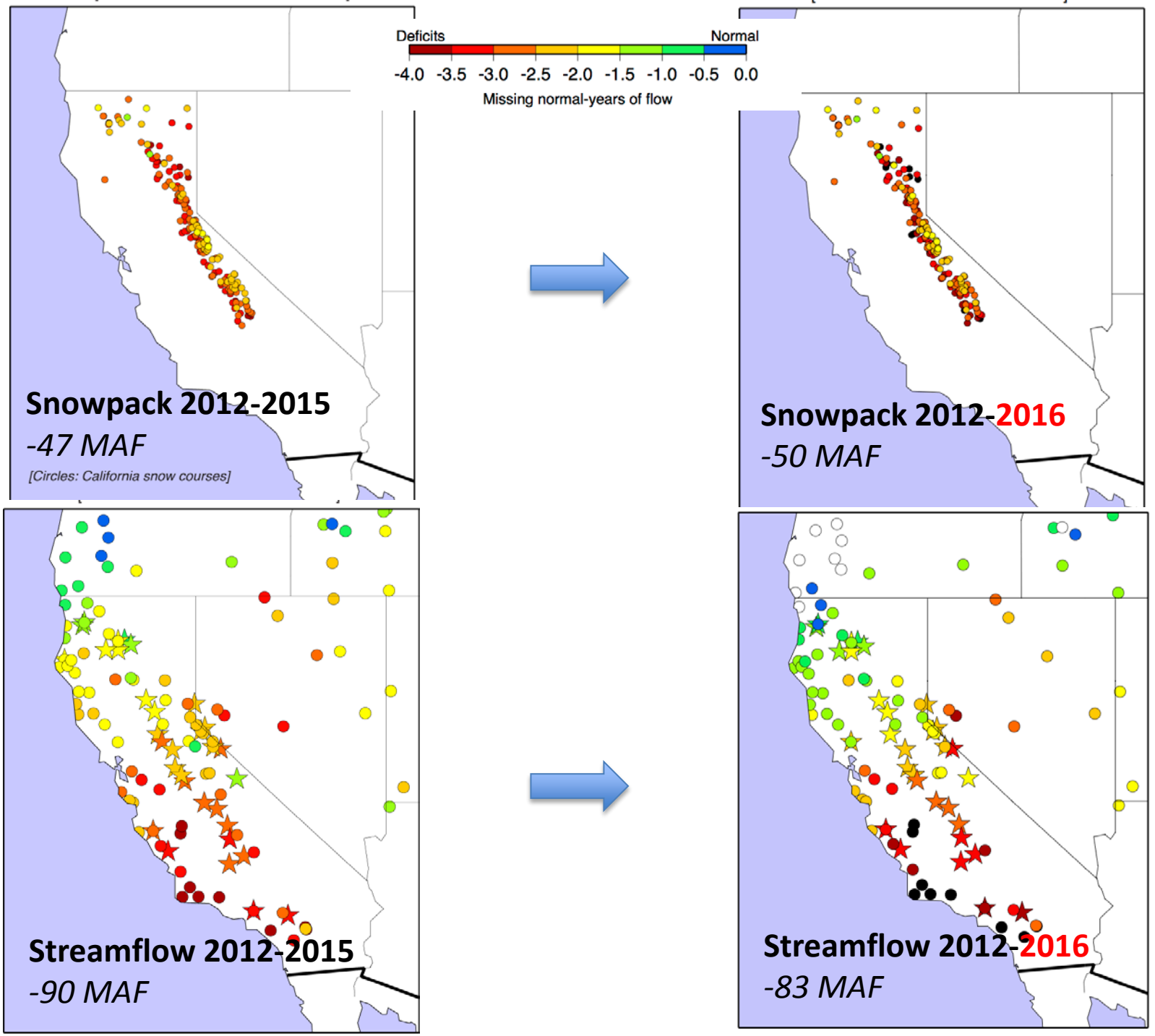
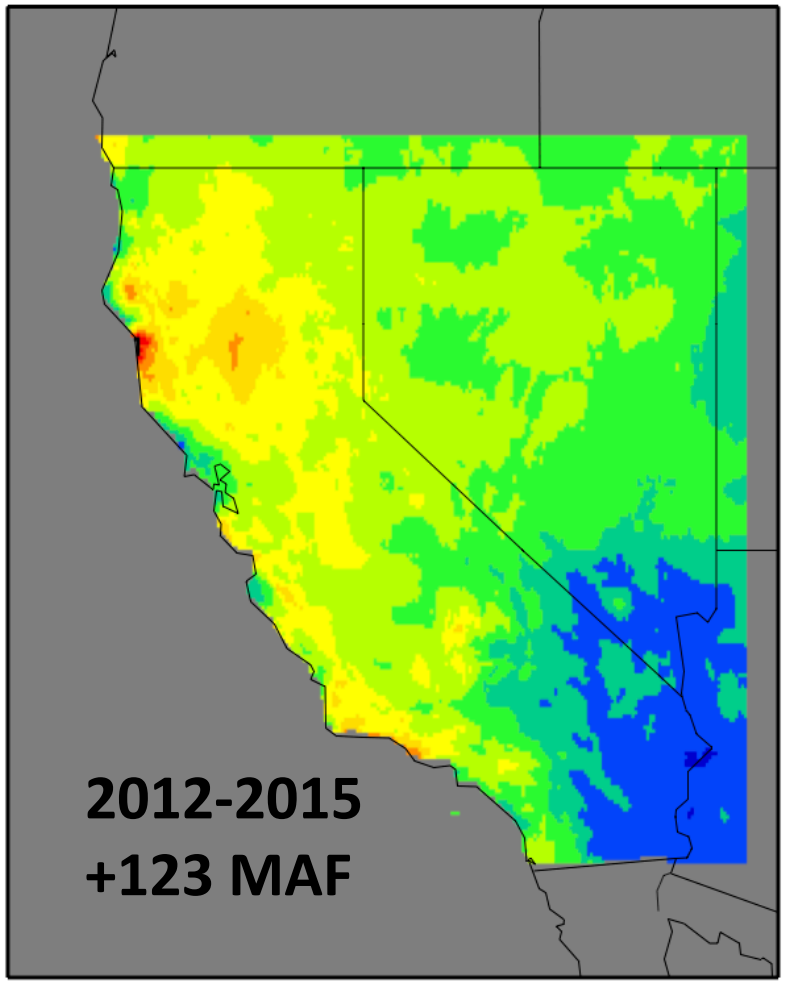
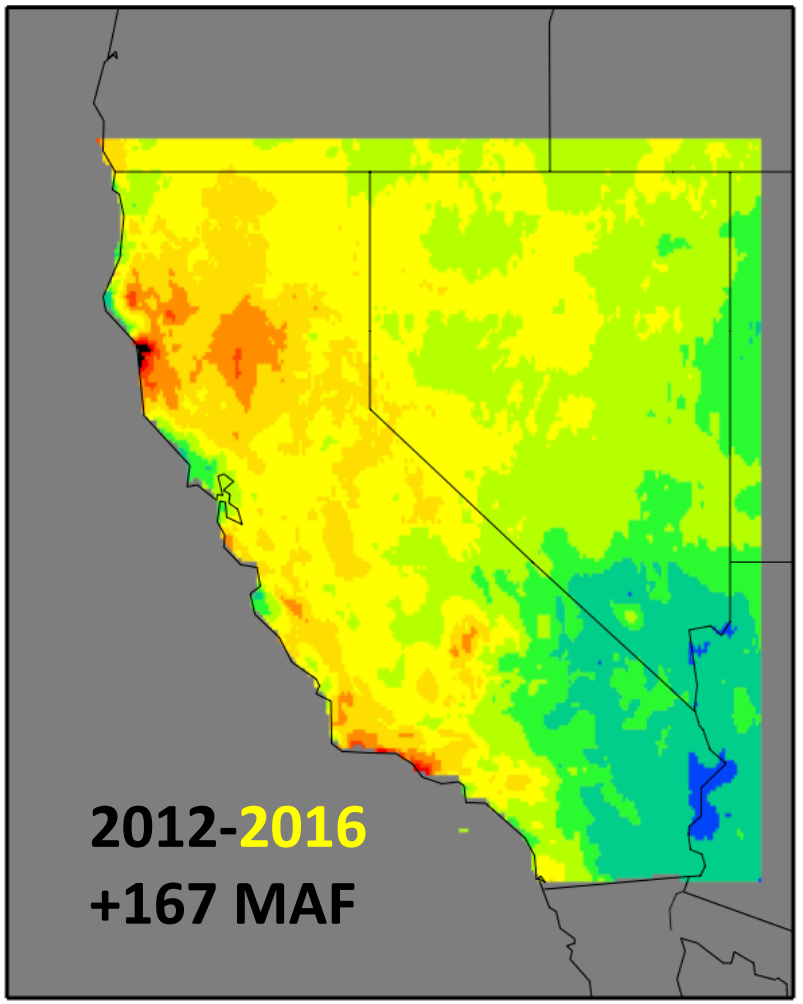

Deficits
Normal
-4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.0
Missing normal-years of flow
Snowpack 2012-2015
-47 MAF
[Circles: California snow courses]
Snowpack 2012-2016
-50 MAF
Streamflow 2012-2015
-90 MAF
Streamflow 2012-2016
-83 MAF

NET ETo SURPLUSES WY2012-2015
[in terms of 1981-2010 WY normals]



NET ETo SURPLUSES WY2012-July2016
[in terms of 1981-2010 WY normals]



Extra normal-years of evaporative demands

-0.2 -0.1 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8

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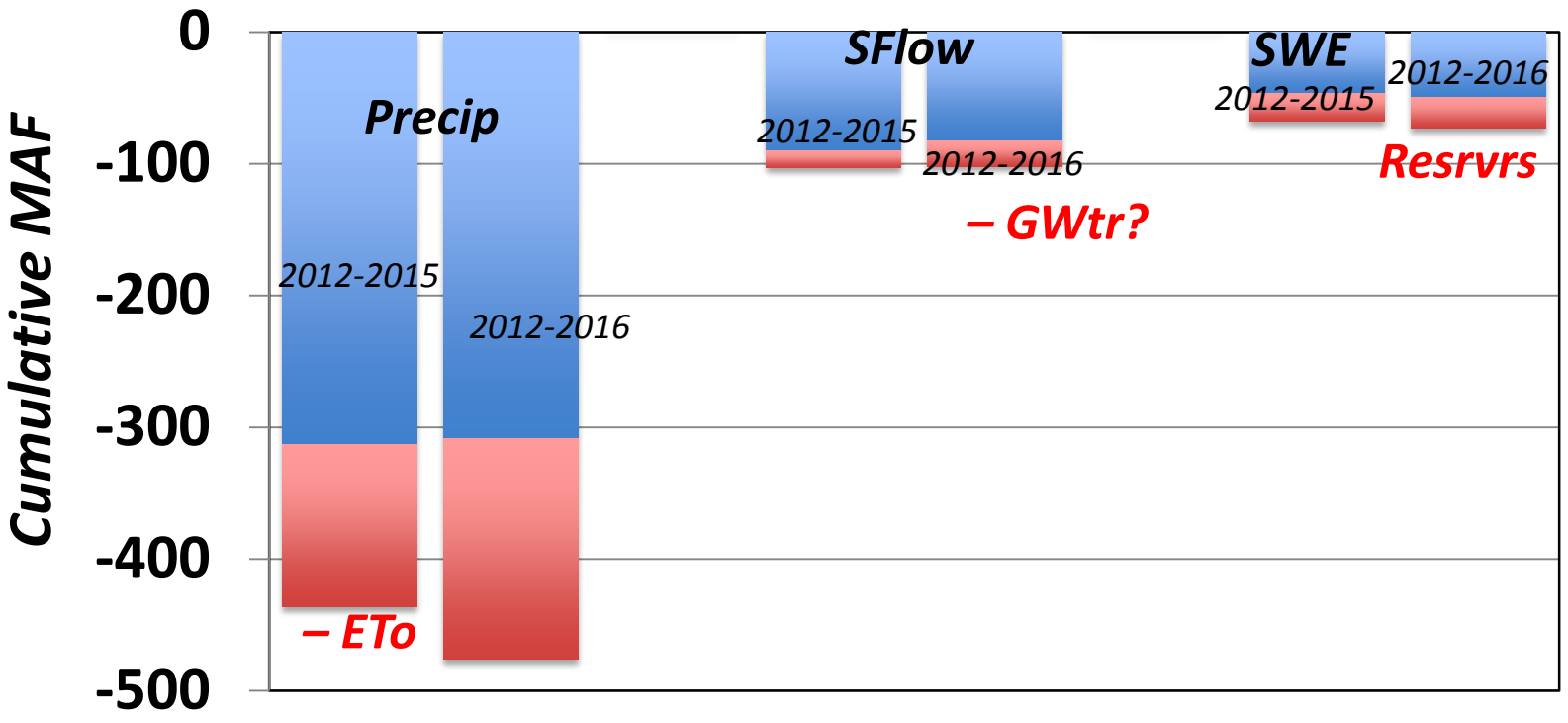
Data from (& in collab w/) D. McEvoy & J. Huntington, DRI

Comparisons of Accumulated Deficits, Delta-Totals, WY2012-2015 *vs* WY2012-2016



Caveat: Lots of apples & oranges here, but illustrative for comparing relative magnitudes of key deficits/surpluses pairs.

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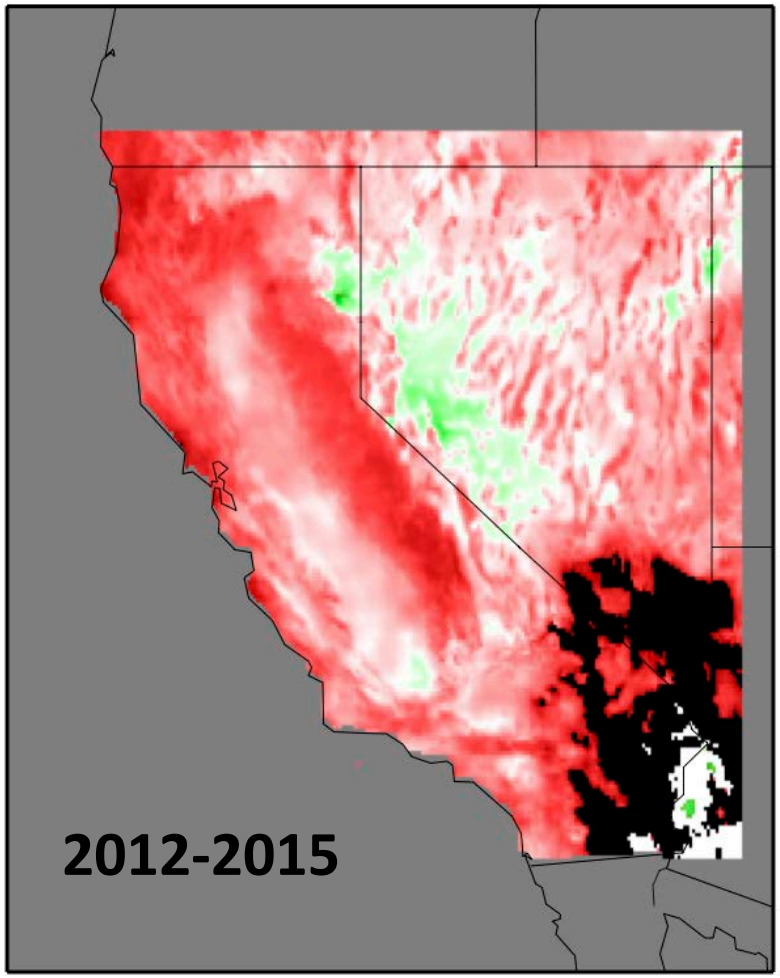
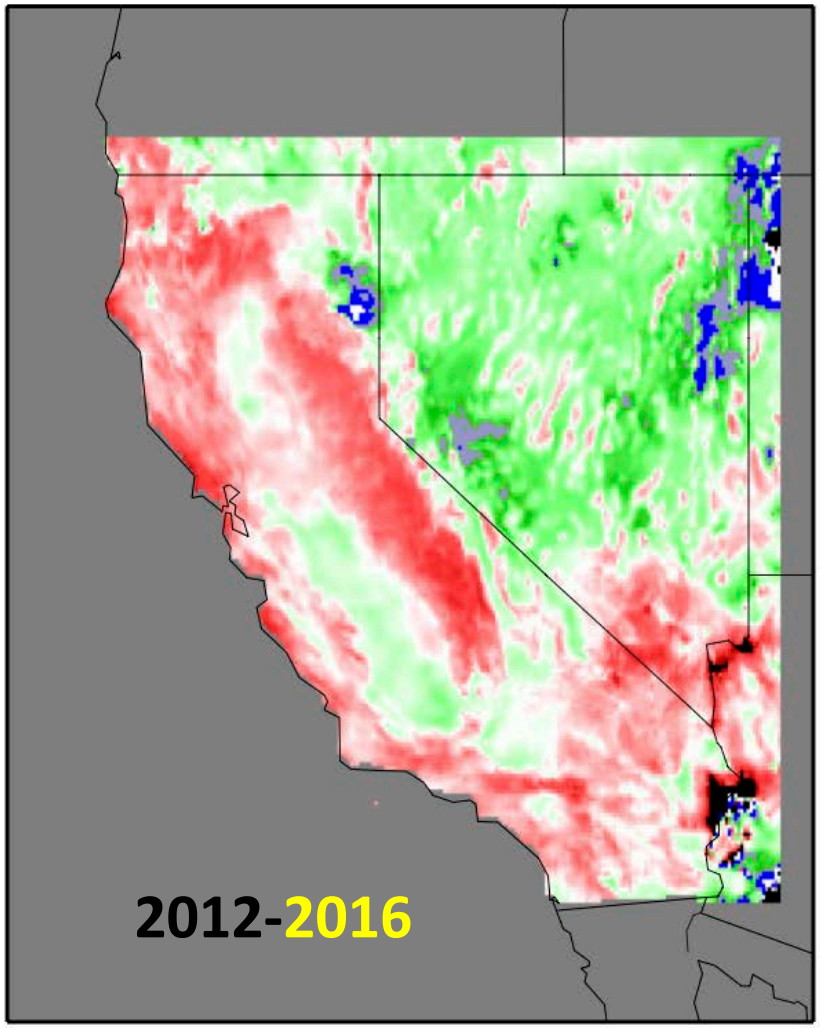
NET PRECIPITATION CONTRIBUTION TO DROUGHT WY2012-2015



NET PRECIPITATION CONTRIBUTION TO DROUGHT WY2012-July2016



Precipitation as fraction of precipitation-plus-ETo contribs

-1.0 -0.2 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

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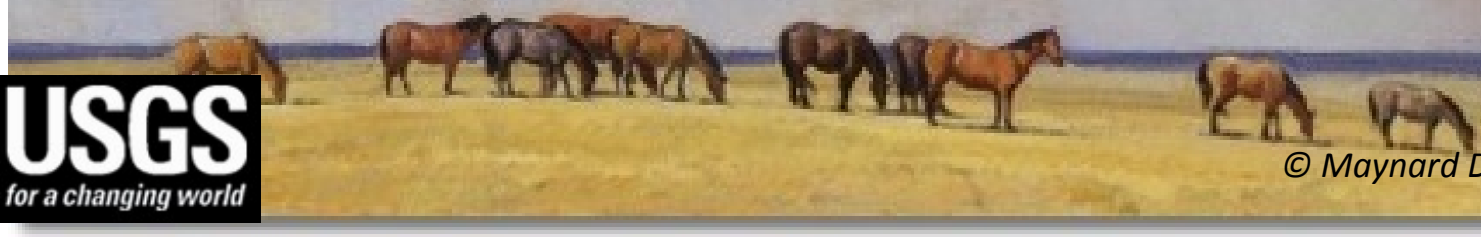
Eto data from (& in collab w/) D. McEvoy & J. Huntington, DRI

CONCLUSIONS

- In this drought, precipitation & temperature (ET) aspects have been vying with each other to determine drought severity in absolute (MAF) terms
- Drought deficits amplify in relative terms (missing yrs) as they pass into & thru the water system

- WY2016 was just wet enough to allow many deficits to hold their own, but continued warm temperatures have added considerably to this drought's "extra" evaporation demands.



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