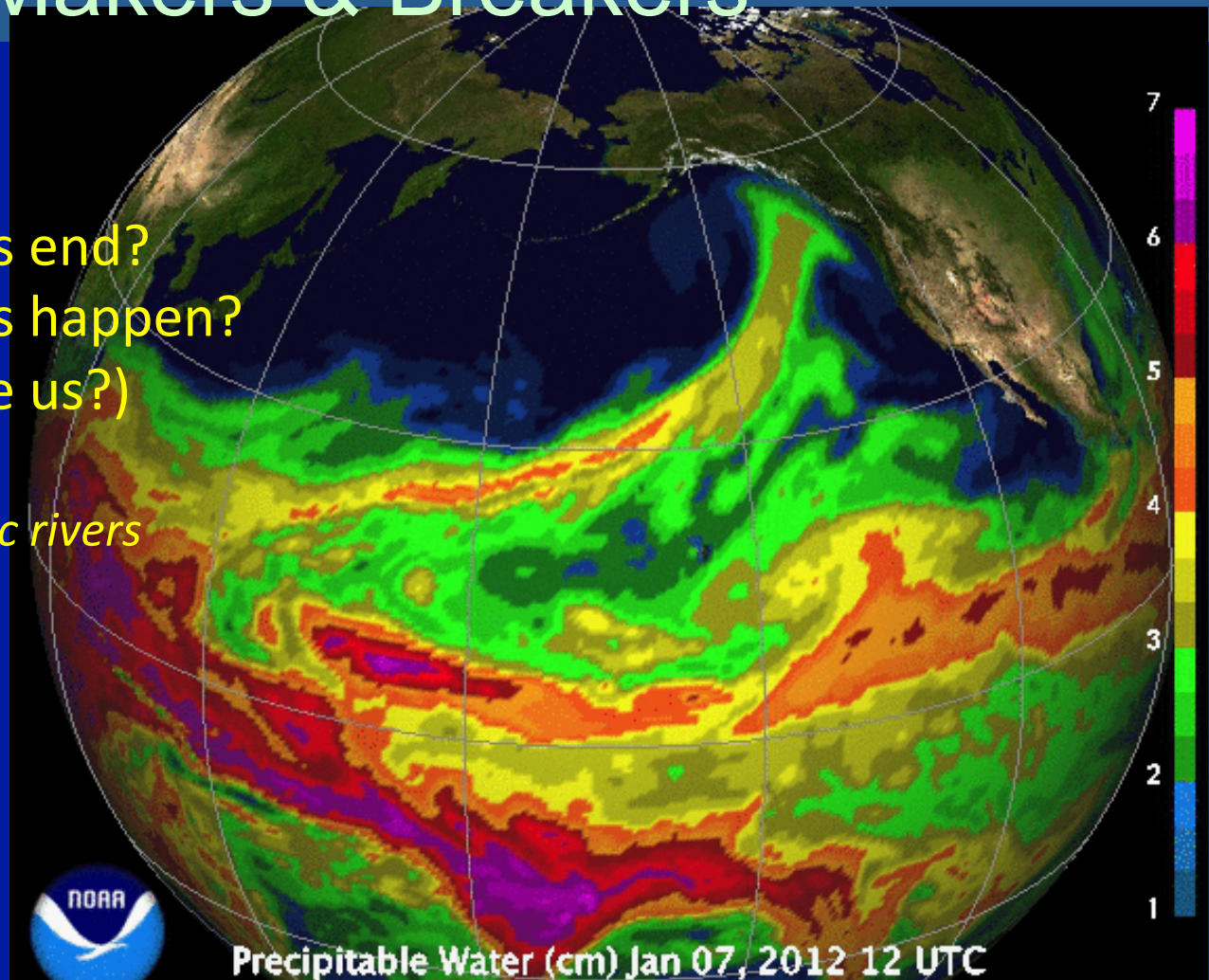


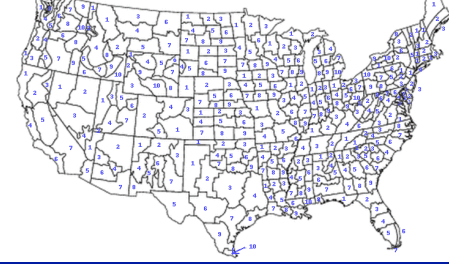
Atmospheric rivers as Drought Makers & Breakers

- How do droughts end?
- How do droughts happen?
- (Will El Nino save us?)

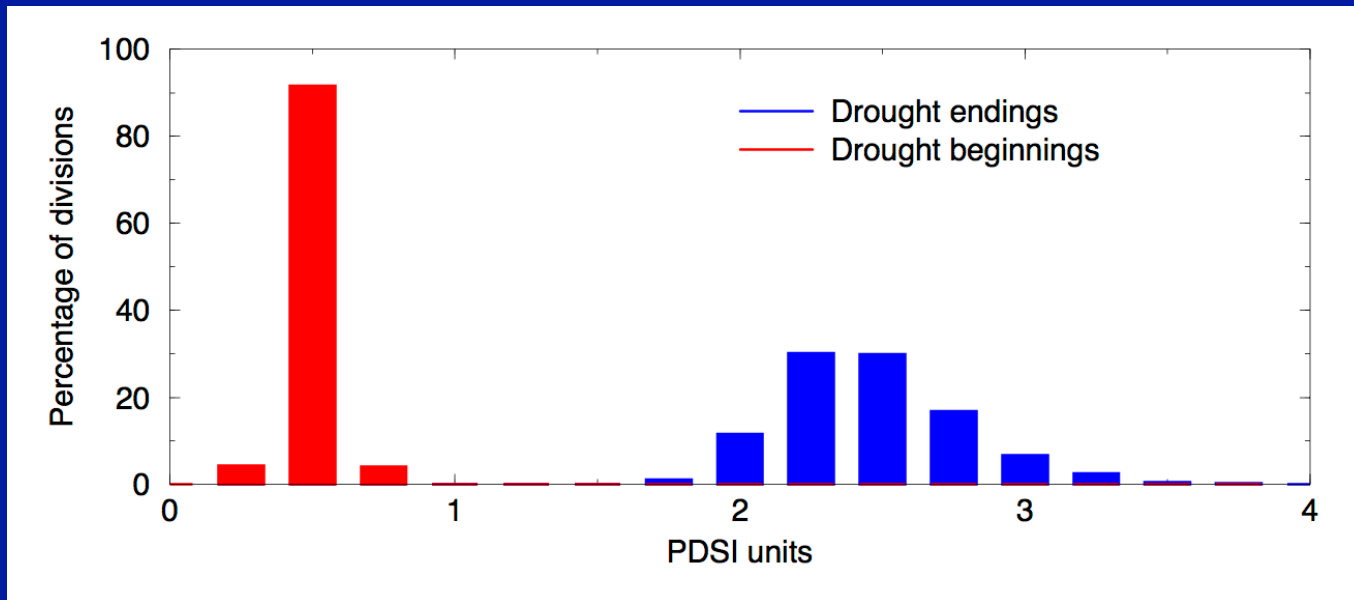
*...and what atmospheric rivers
have to do with all this.*



How droughts end...



Distributions of average PDSI steps across PDSI=-2 at 344 climate divisions, 1895-2010



PDSI Categories of Drought to Wet

Extreme
Drought
-4

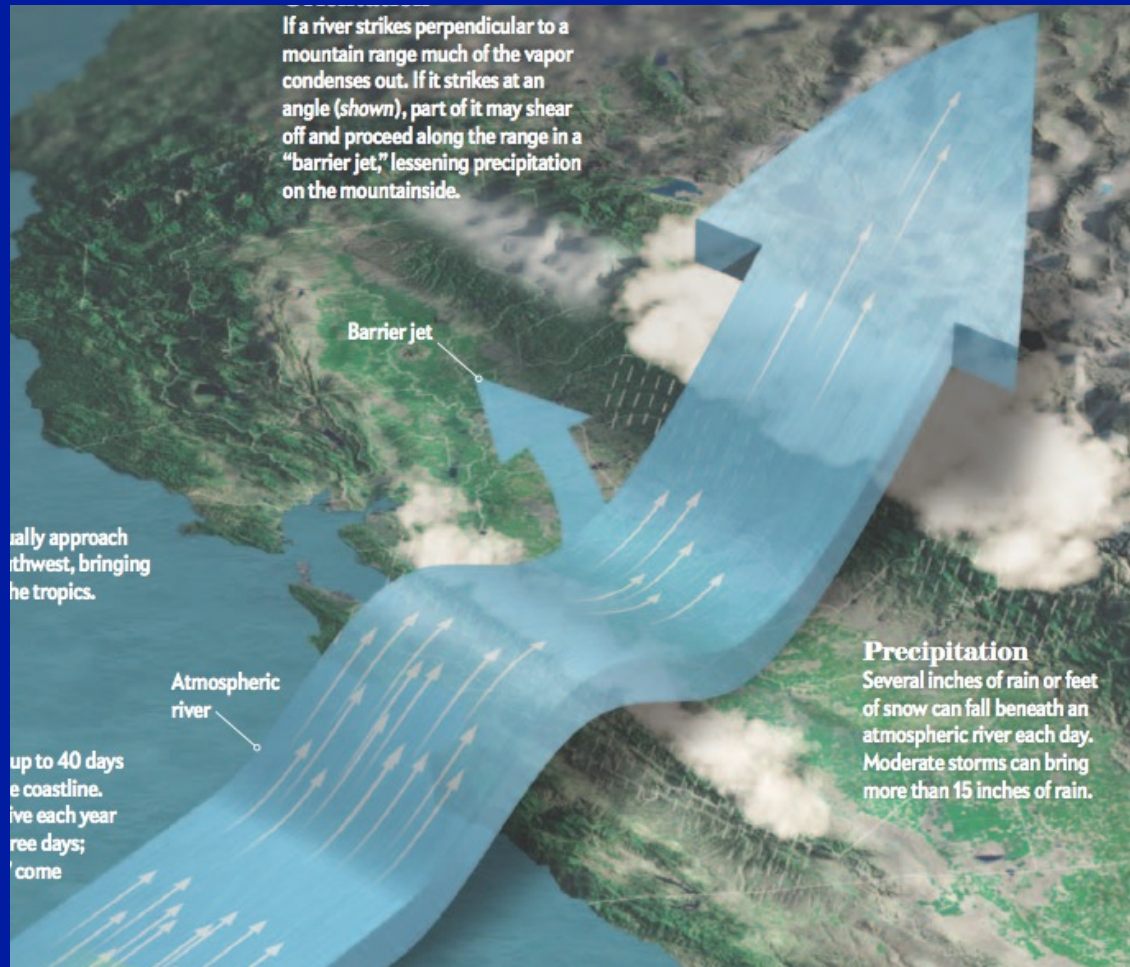
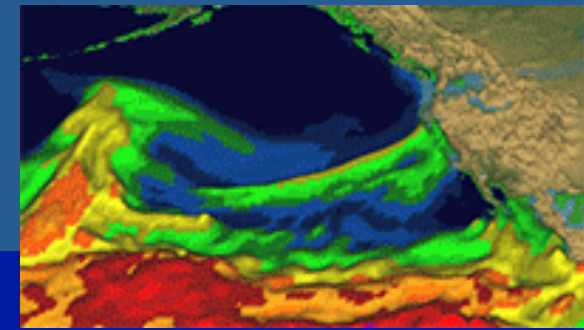
Severe
Drought
-3

Moderate
Drought
-2

Normal
Conditions
-1 to 1

Wet
Categories
> 1

Atmospheric Rivers

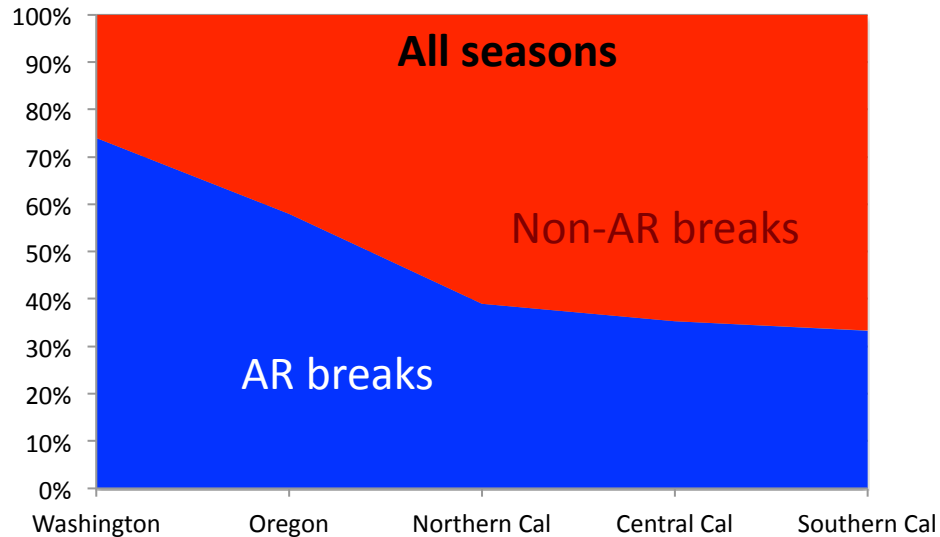


-Map-view structure (~400 km width & 2000 km long)--from satellite data

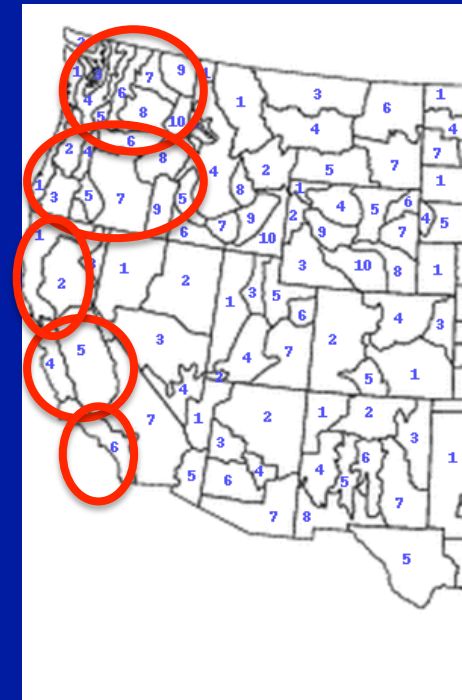
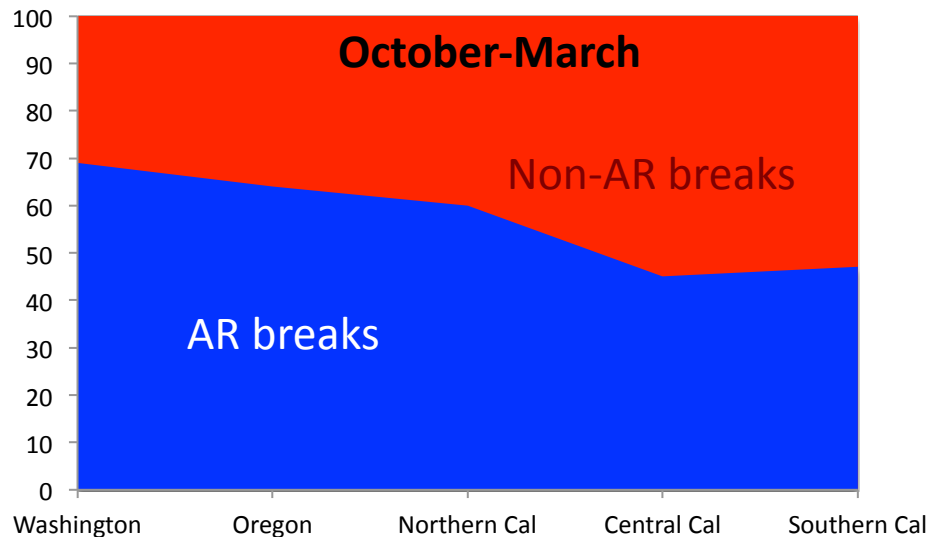
-Vertical structure (intense jet of vapor between 1 – 2 km above sea level; 10-20 Mississippi; easily uplifted)--from airplanes & AROs

ARs as West Coast drought busters

Percentage of
Persistent
Drought Breaks
Overall,
1950-2010

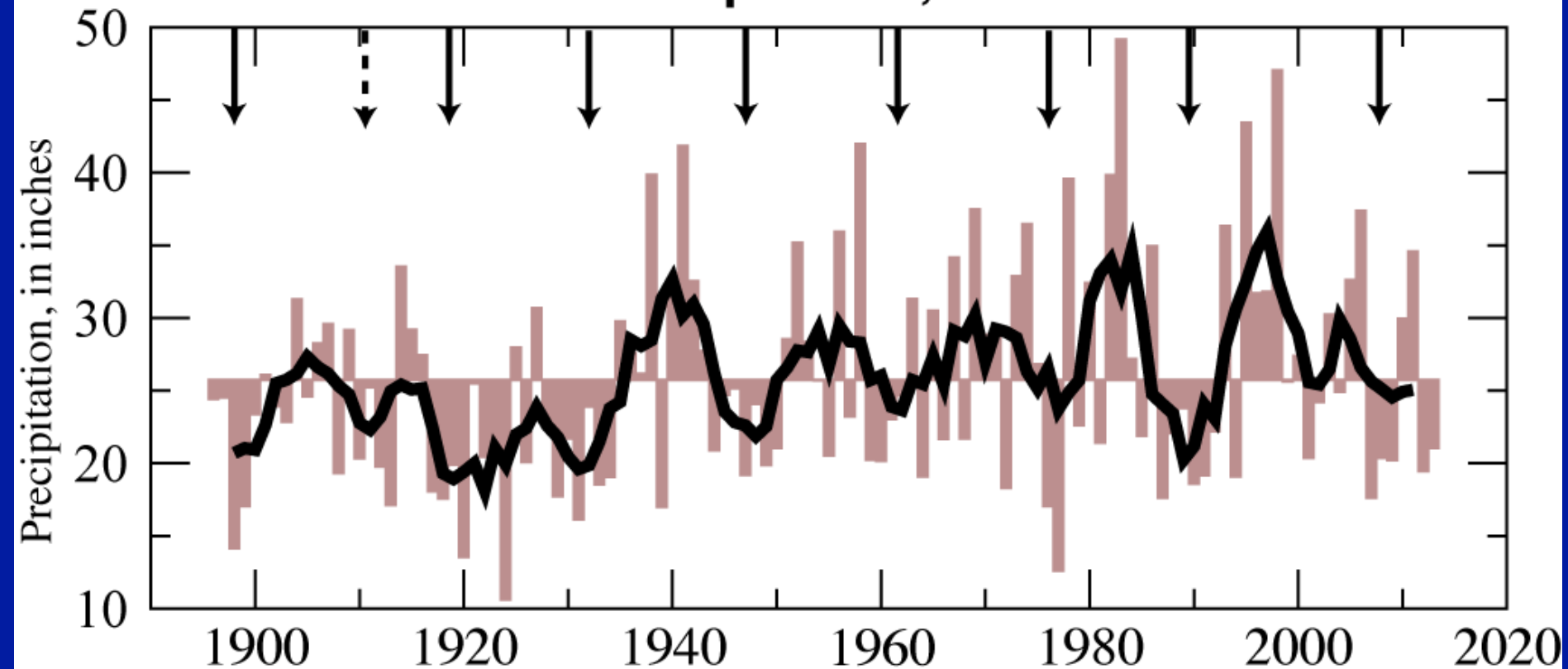


Percentage of
Persistent
Drought Breaks
in Wet (AR)
Seasons,
1950-2010

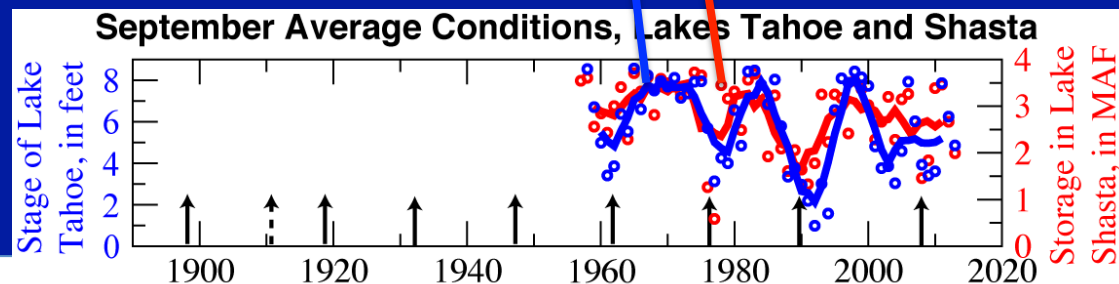
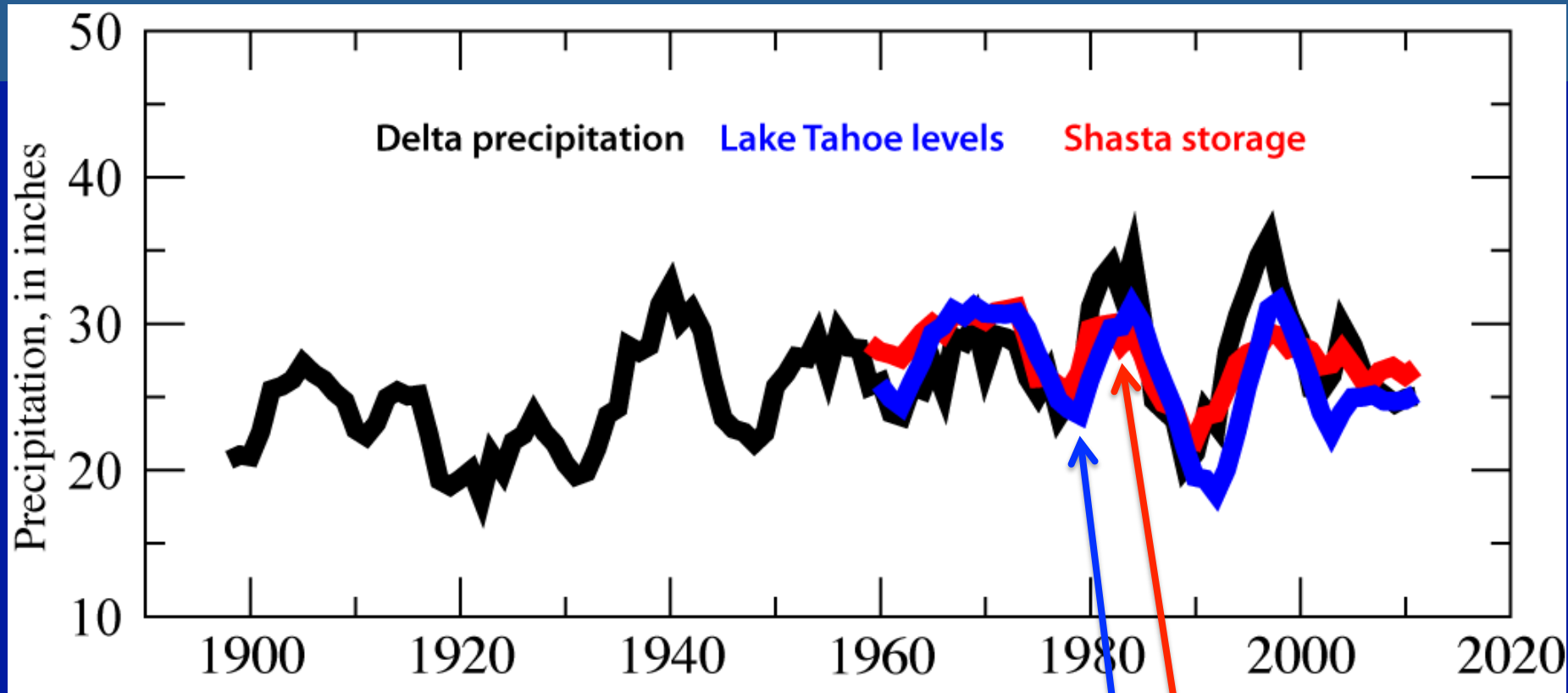


Drought and plenty in California...

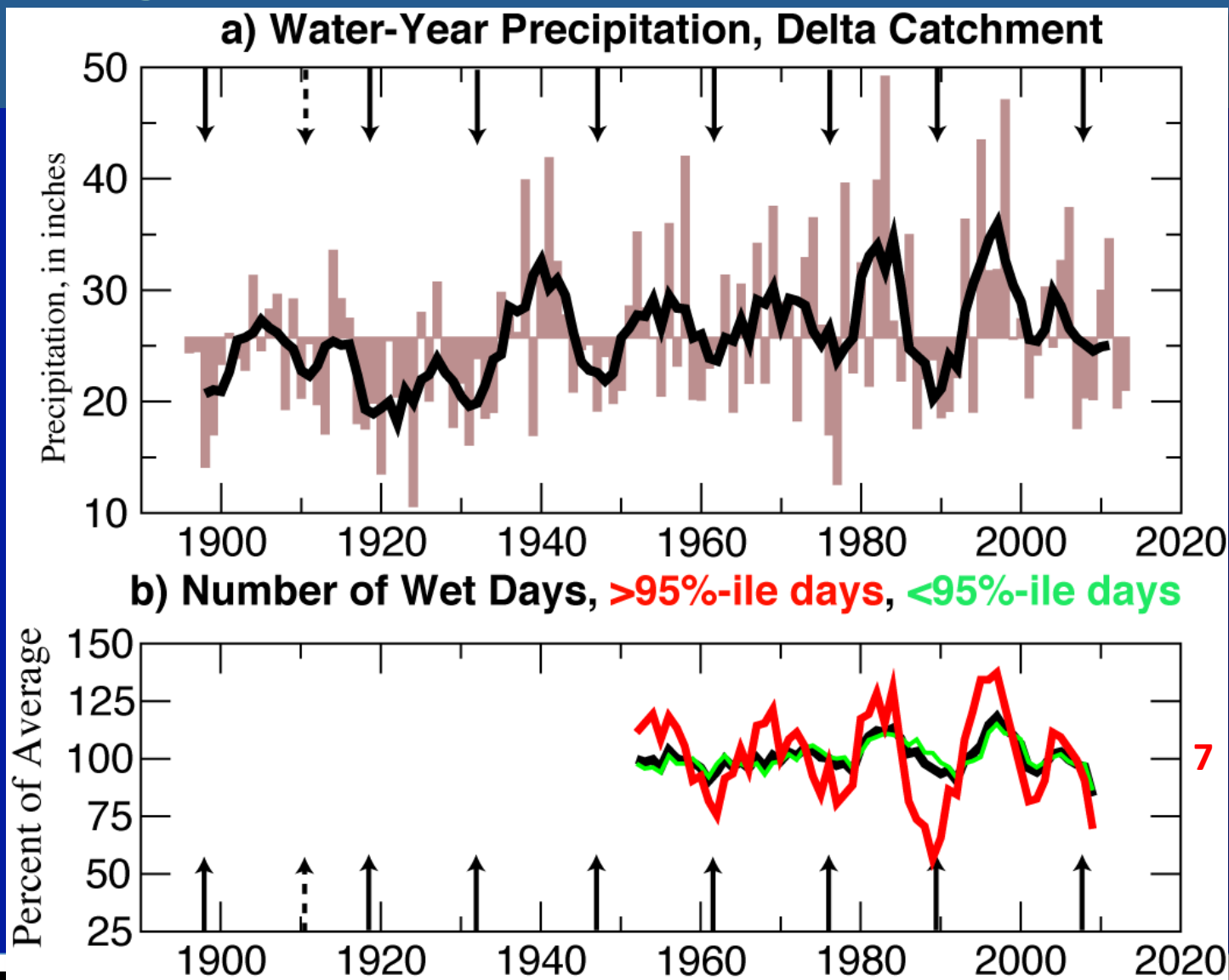
Water-Year Precipitation, Delta Catchment



Drought and plenty in California...



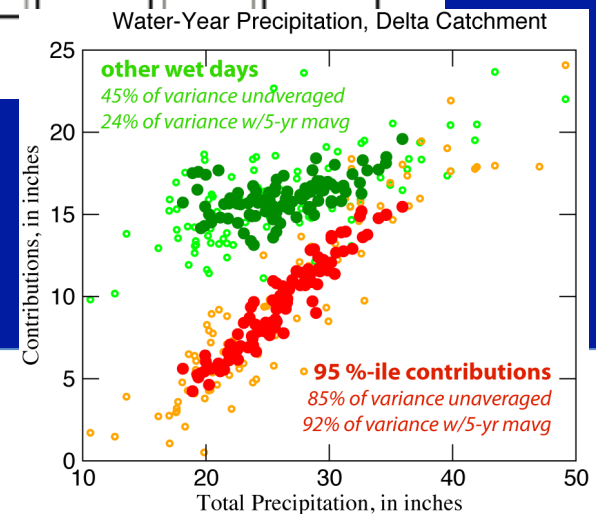
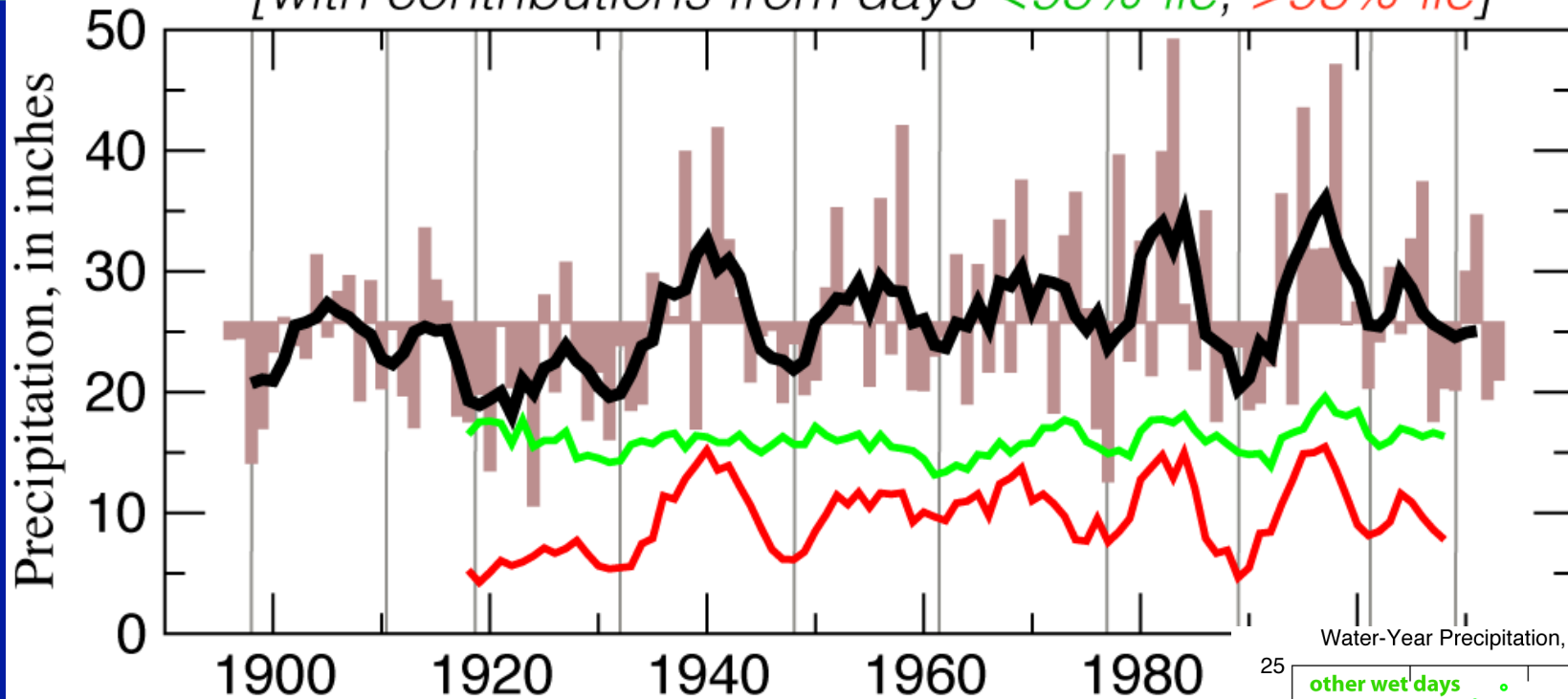
How are droughts made?



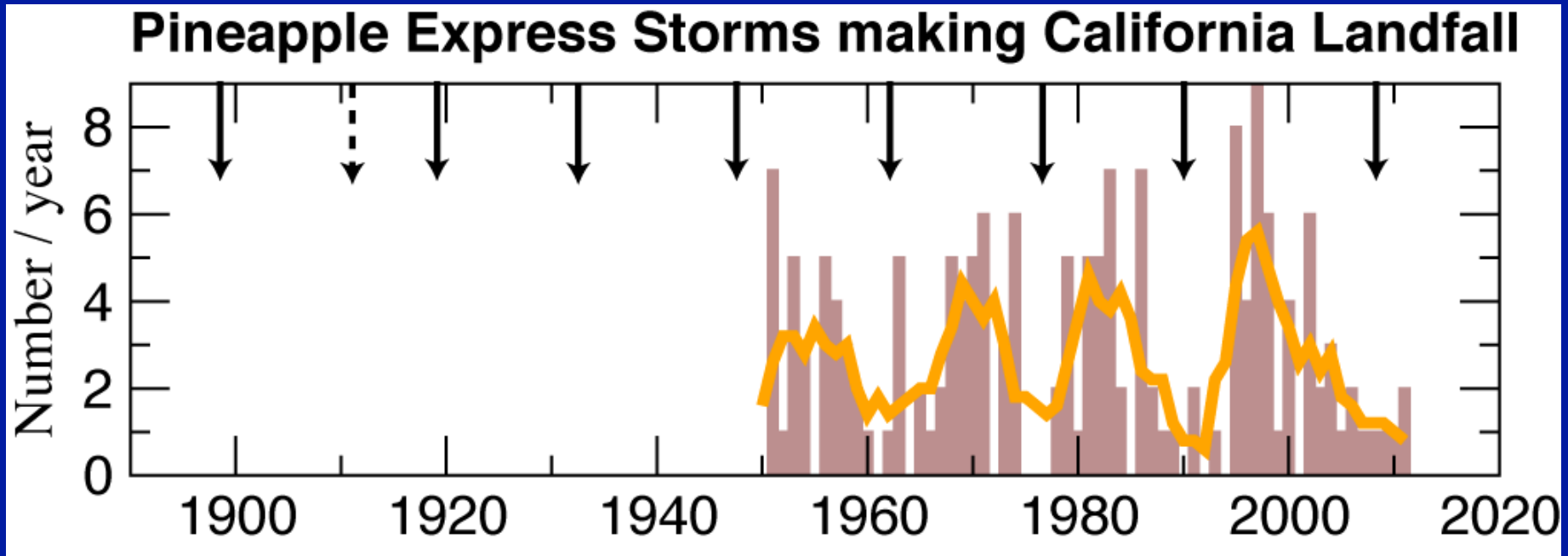
How are droughts made?

a) Water-Year Precipitation, Delta Catchment

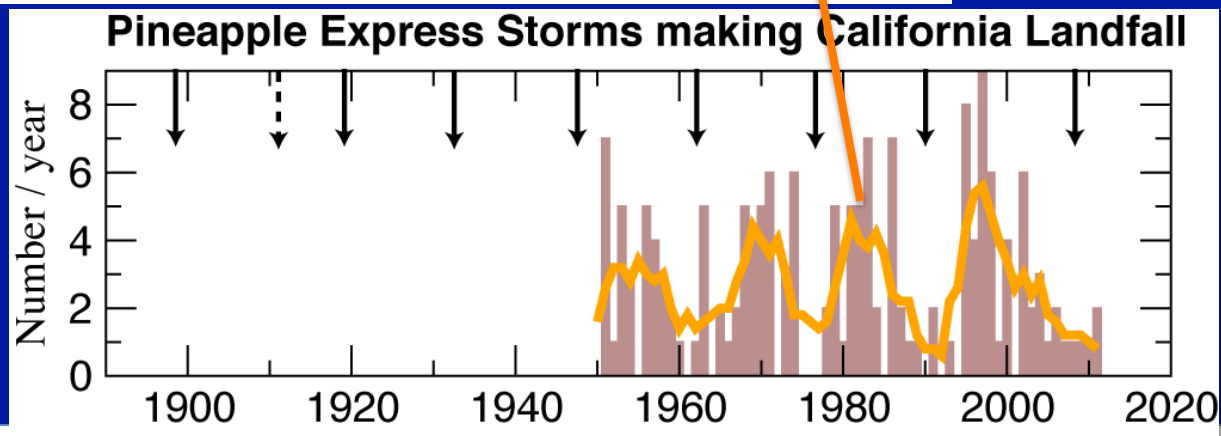
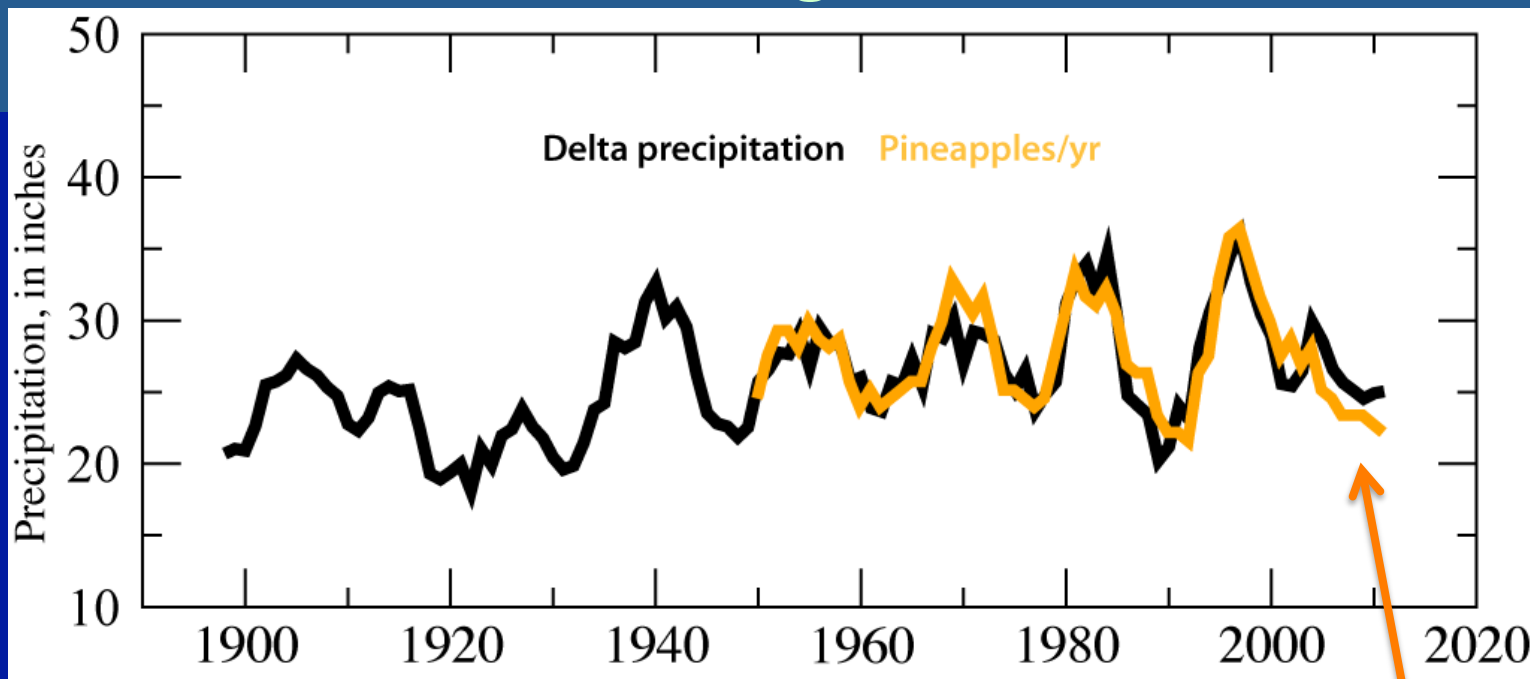
[with contributions from days <95%-ile, >95%-ile]



Are ARs part of all this?

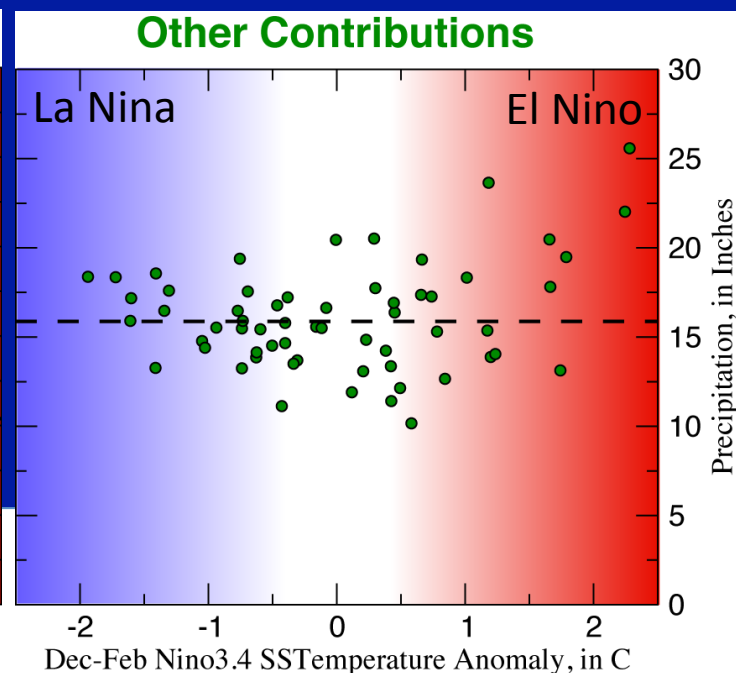
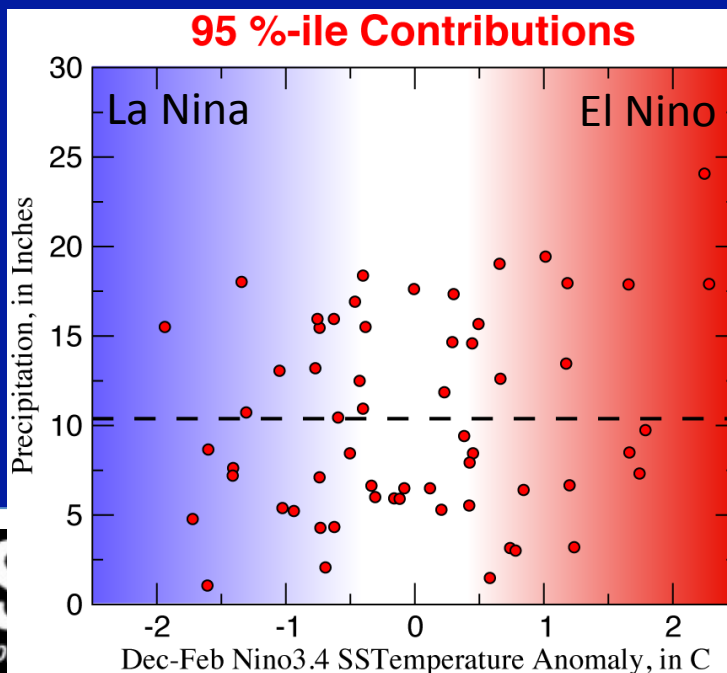
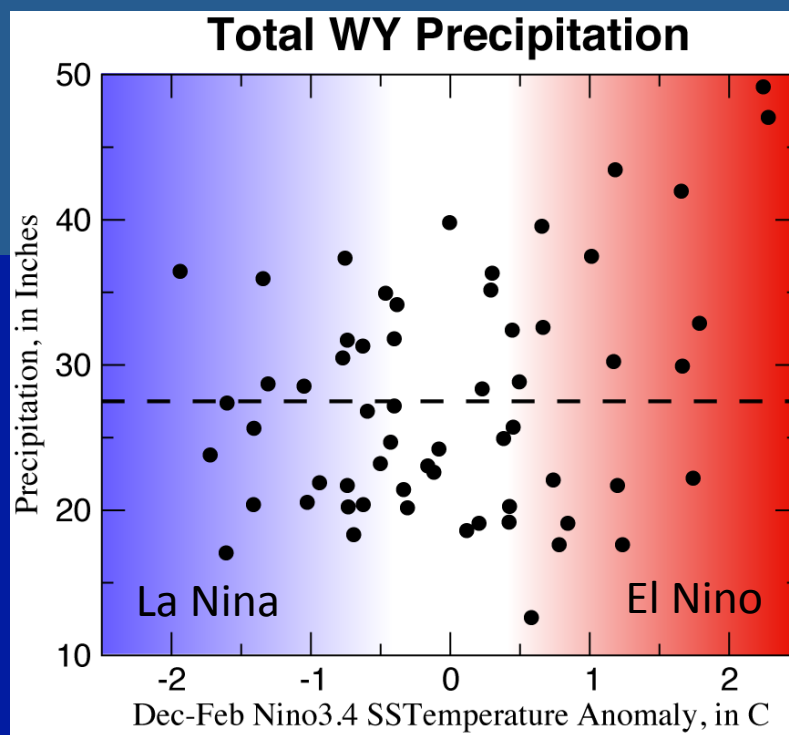


ARs as West Coast drought makers



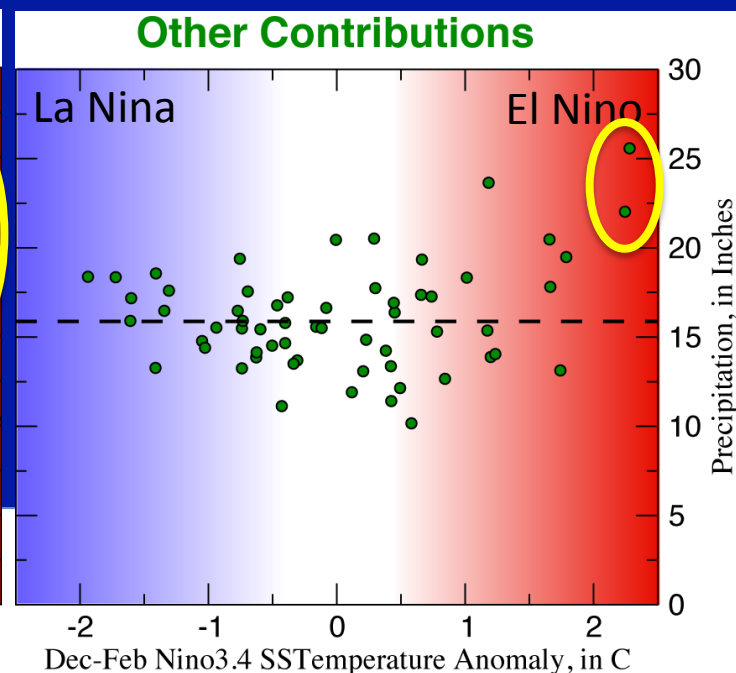
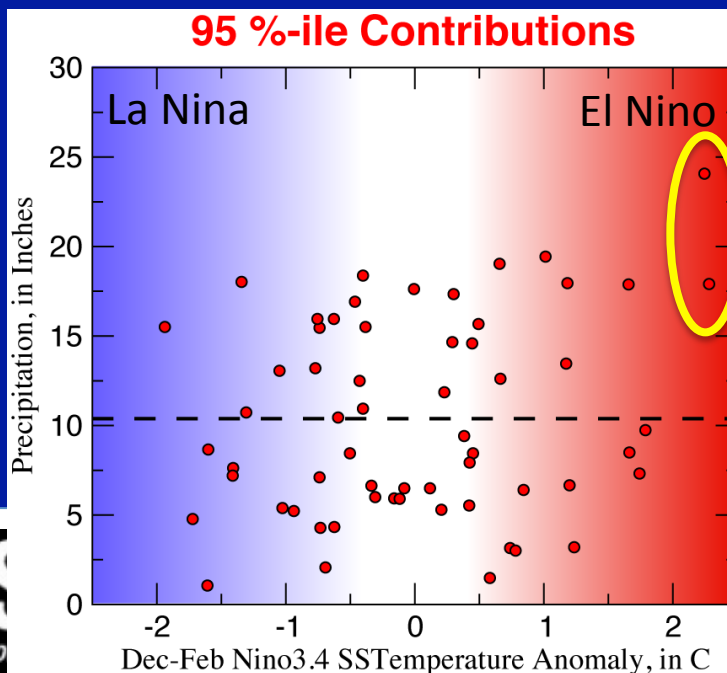
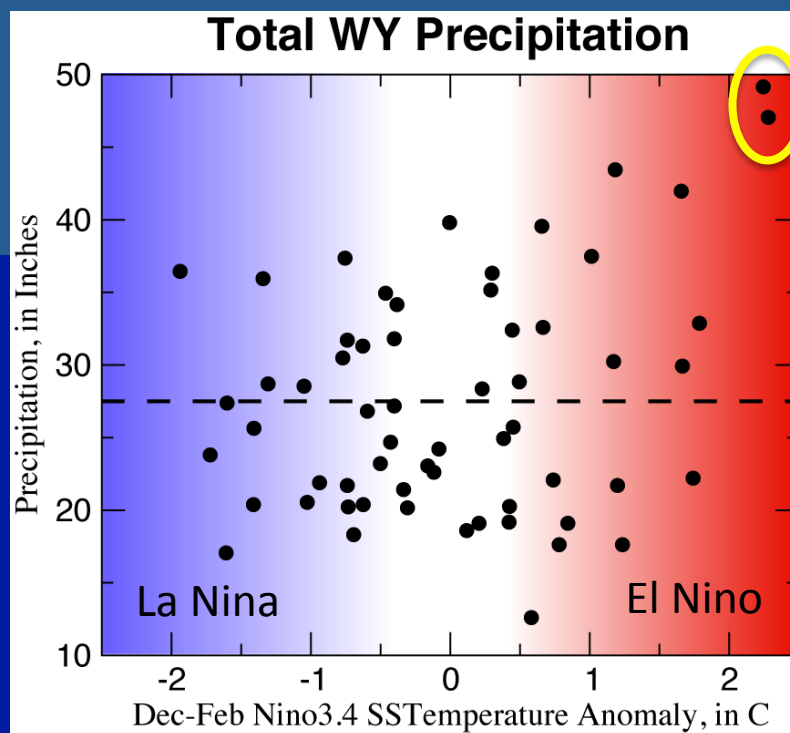
El Nino as savior?

Nothing is guaranteed...



El Nino as savior?

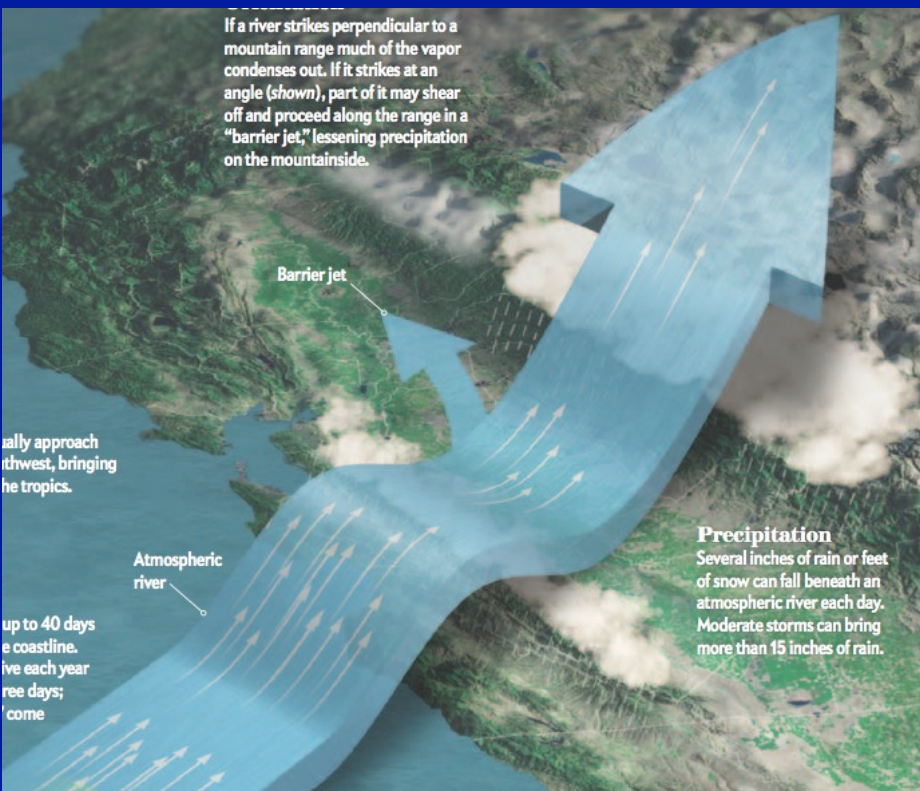
Nothing is guaranteed...
except maybe in a really
BIG El Nino



Conclusions

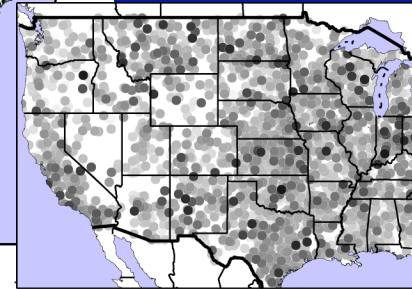
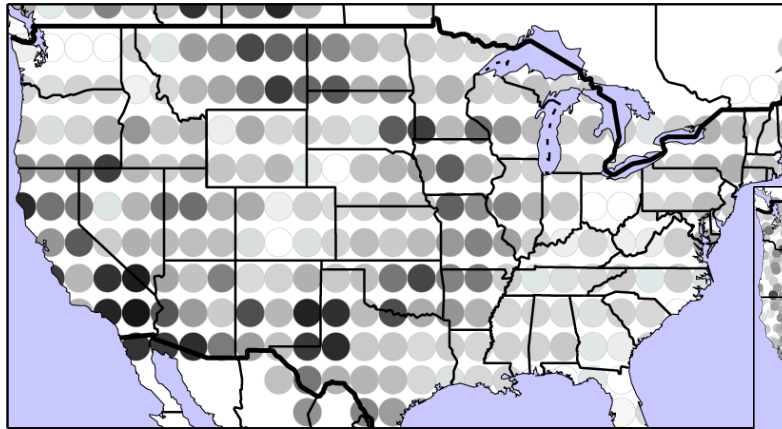
Nor/Cen California droughts:

- **End abruptly in big storms, *with ARs contributing disproportionately to drought busting***
- **Are mostly due to missing “big” storms (95 %-ile wet days), *with ARs contributing disproportionately to drought formation***
- **An El Nino does not guarantee a very wet year nor an end to drought, *except for unusually warm El Ninos?***

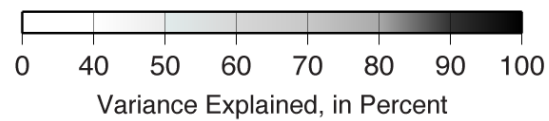
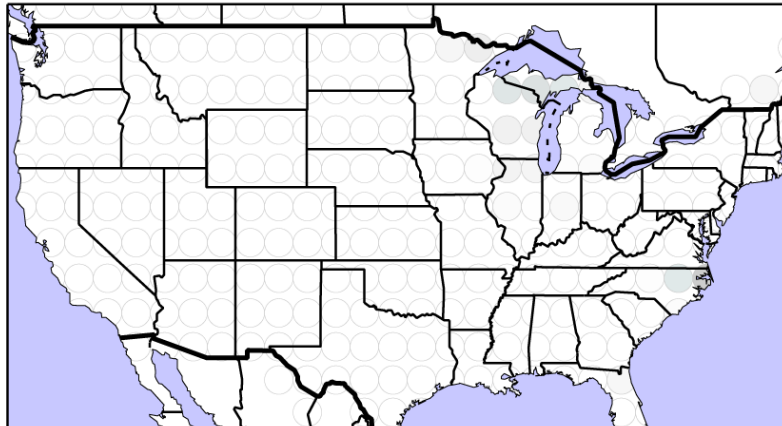


- Dettinger, M.D., Ralph, F.M., Das, T., Neiman, P.J., and Cayan, D., 2011, Atmospheric rivers, floods, and the water resources of California: *Water*, 3, 455-478.
- Dettinger, M.D., 2013, Atmospheric rivers as drought busters on the US west coast: *Journal of Hydrometeorology*, 14, 1721-1732, doi:10.1175/JHM-D-13-02.1.
- Dettinger, M., and Ingram, L., 2013, The coming megafloods: *Scientific American*, 308(1), 64-71.
- Dettinger, M.D., and Cayan, D.R., 2014, Drought and the Delta—A matter of extremes: *San Francisco Estuary and Watershed Science*, 7 p.

CONTRIBUTIONS OF 95th %-ILE DAYS TO 5yr avg TOTAL PRECIP, 1950-99



CONTRIBUTIONS OF REST OF DAYS TO 5yr avg TOTAL PRECIP, 1950-99



**PERCENTAGES OF WATER-YEAR TOTAL PRECIPITATION
VARIANCE EXPLAINED BY WET-DAYS WITH PRECIPITATION
LESS THAN VARIOUS PERCENTILES, WITH VARIOUS SMOOTHINGS**

