Anthropogenic Southwest Drying CMIP5 Style

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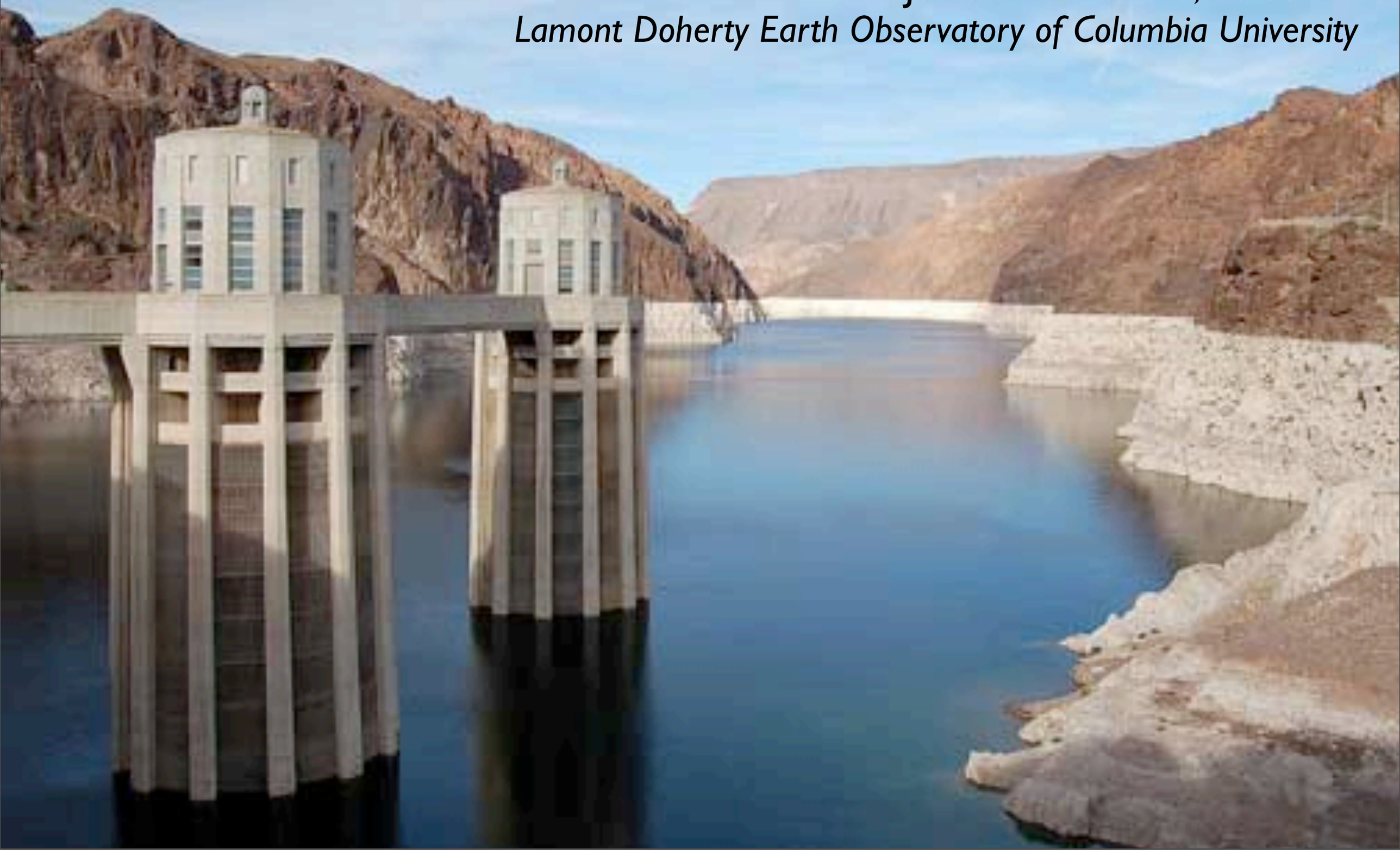
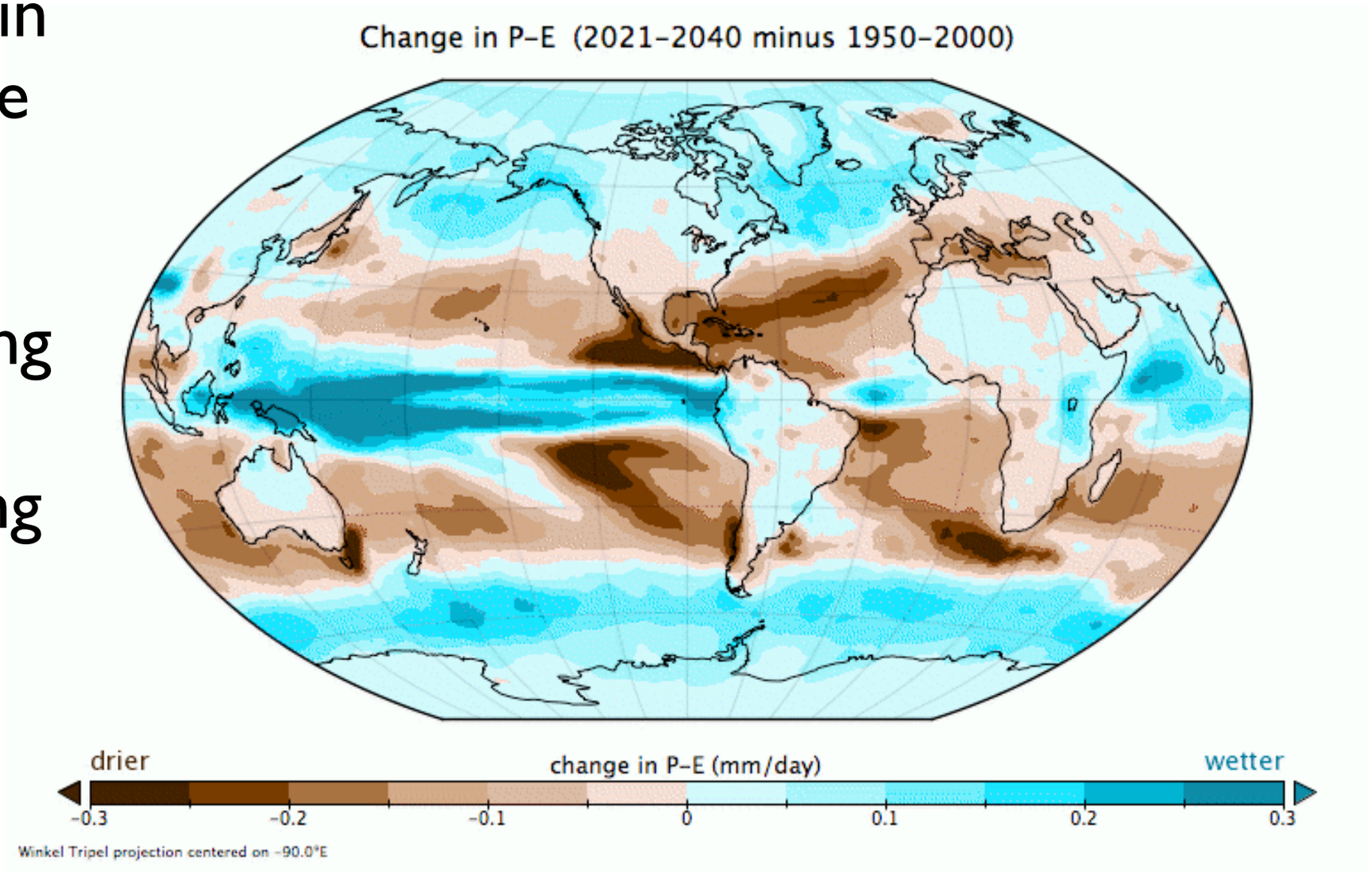


To recap ..... greenhouse warming will impact patterns of precipitation across the planet

Projected change in mean hydroclimate has

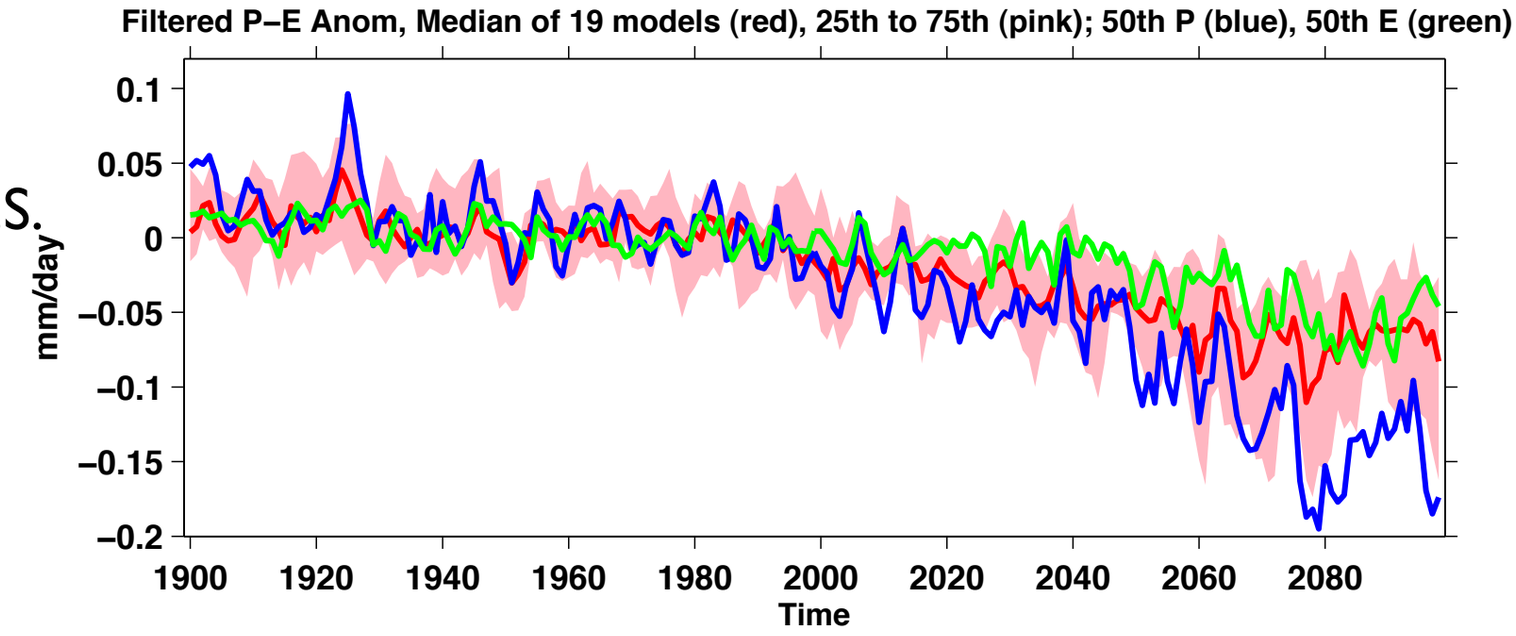
1) wet areas getting wetter
2) dry areas getting drier
3) subtropical dry zones expanding poleward



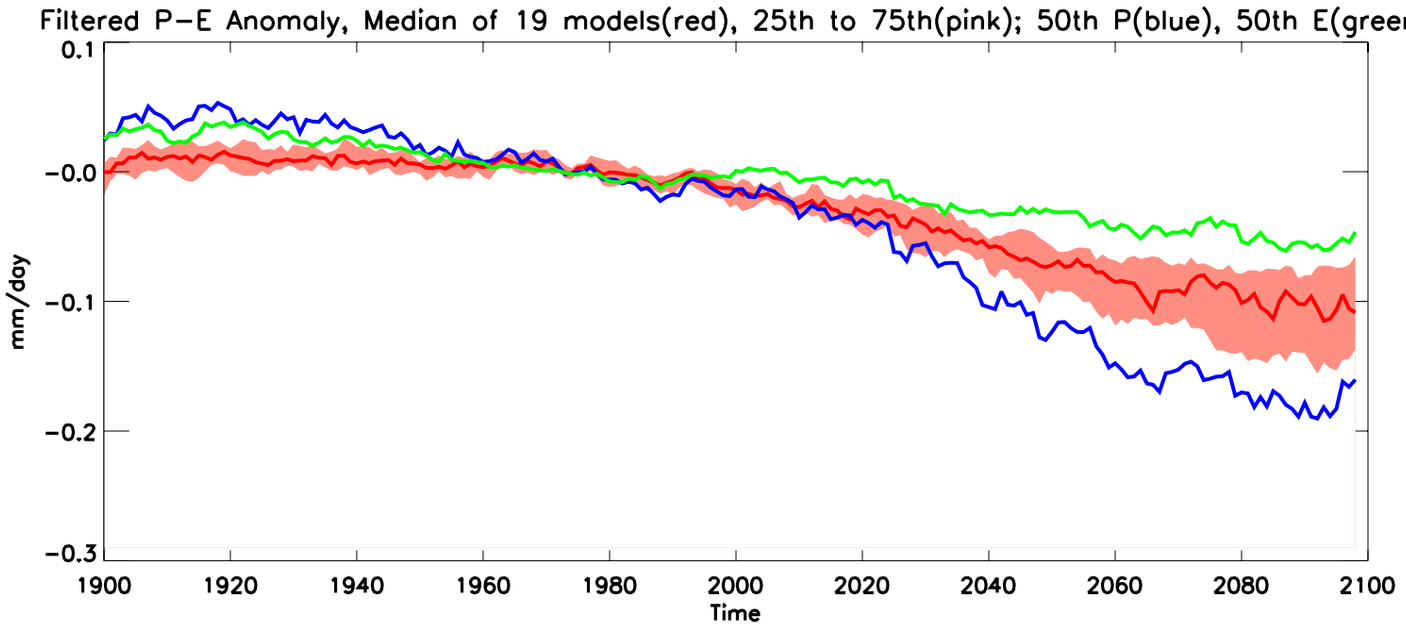
Held and Soden 2006, IPCC 2007,
Previdi and Liepert 2007, Seager et al. 2007, 2010

In semi-arid regions IPCC AR4 models predicted a robust, imminent, and serious drying, forced by rising GHGs

Southwest U.S. and Mexico



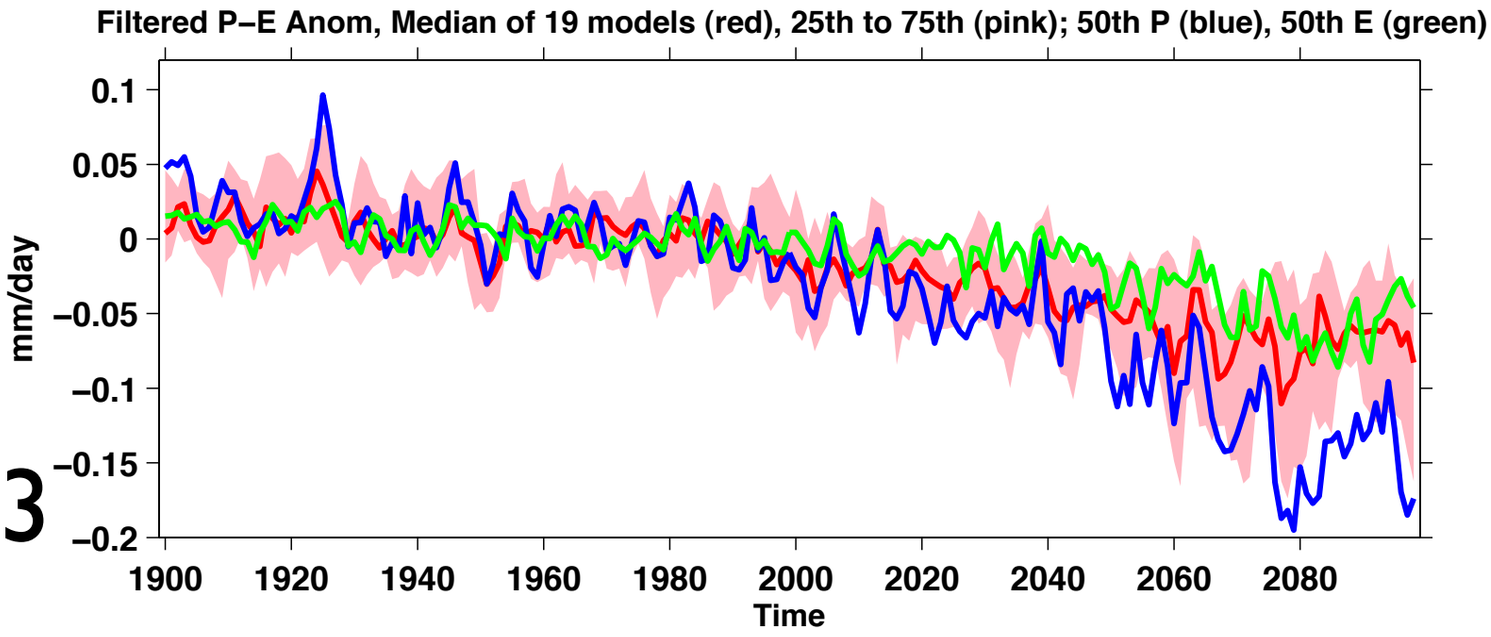
land areas around Mediterranean



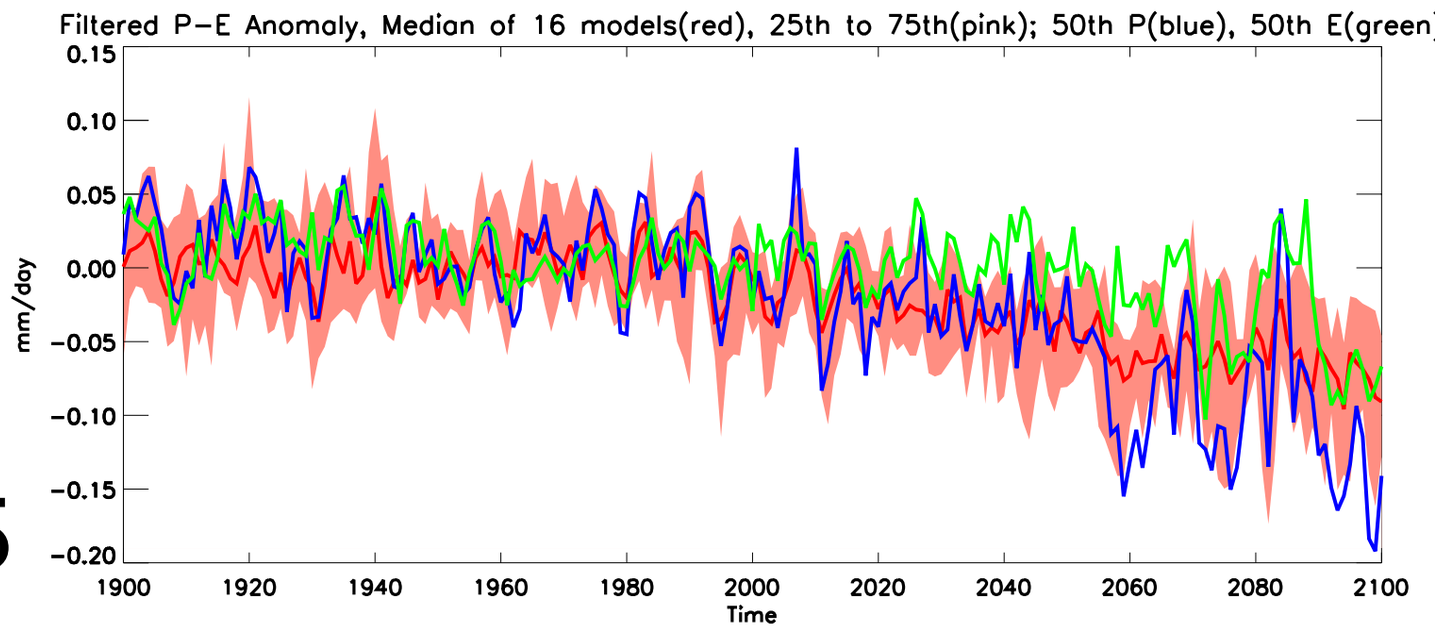
What about CMIP5?
Hydrological change by water resource region?
P, E, P-E, runoff, soil moisture?

P-E, *P* and *E* averaged over southwest N. America (25-40N, 125-95W)

CMIP3



CMIP5

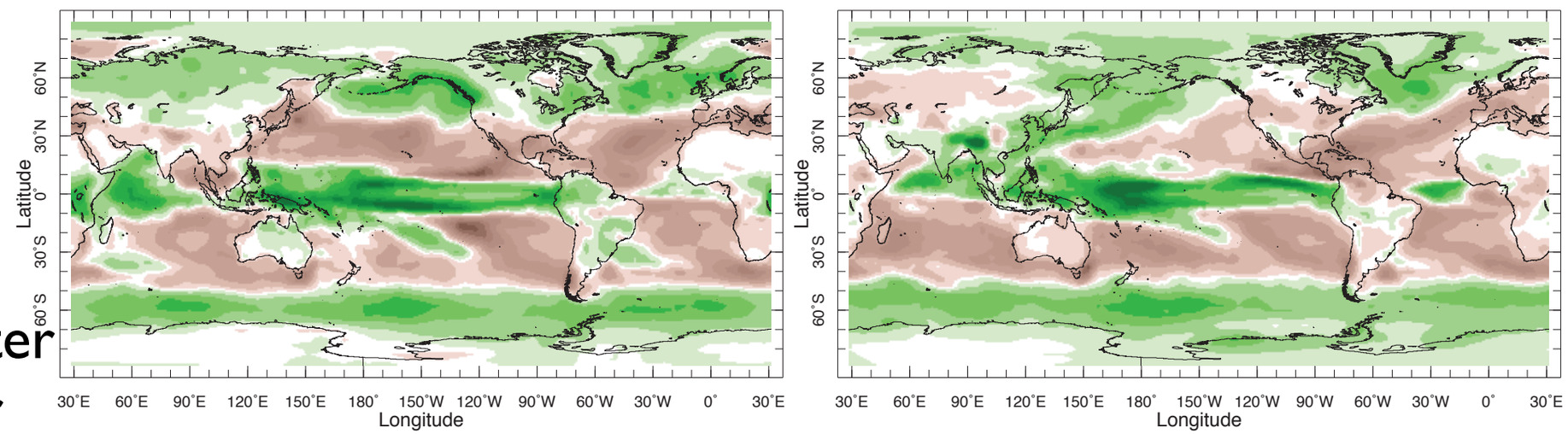


Large scale patterns of CMIP3 and CMIP5 are very similar (except Sahel)

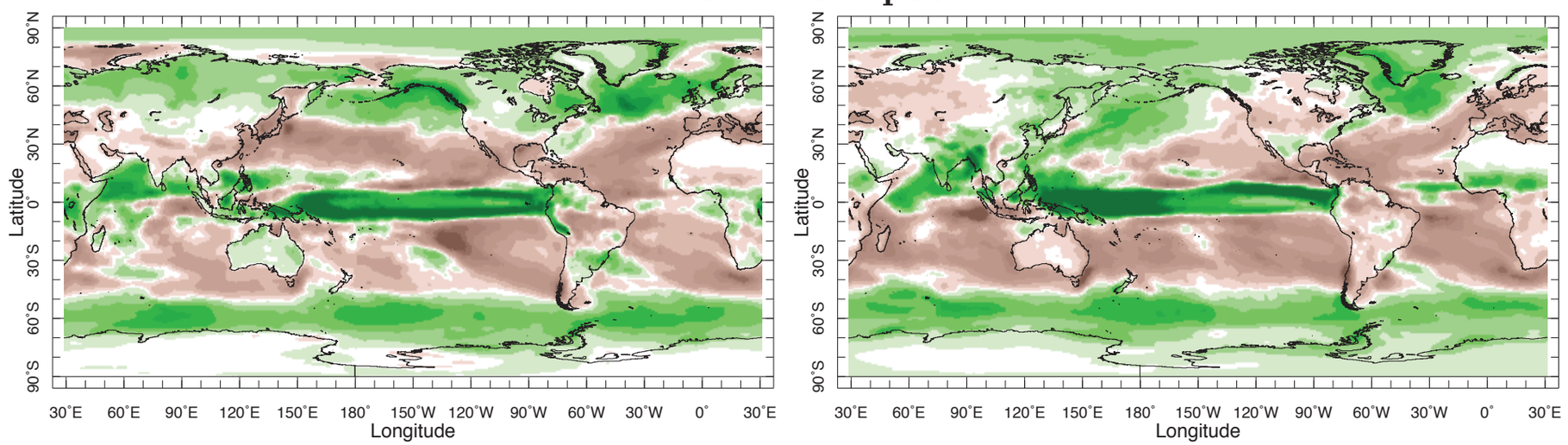
P-E (2021-2040) - (1951-1999)

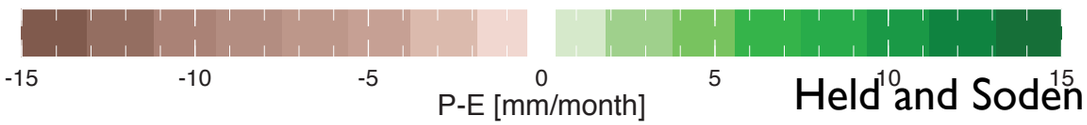
Oct-Mar **Apr-Sep**

CMIP3 sresa1b



CMIP5 rcp85



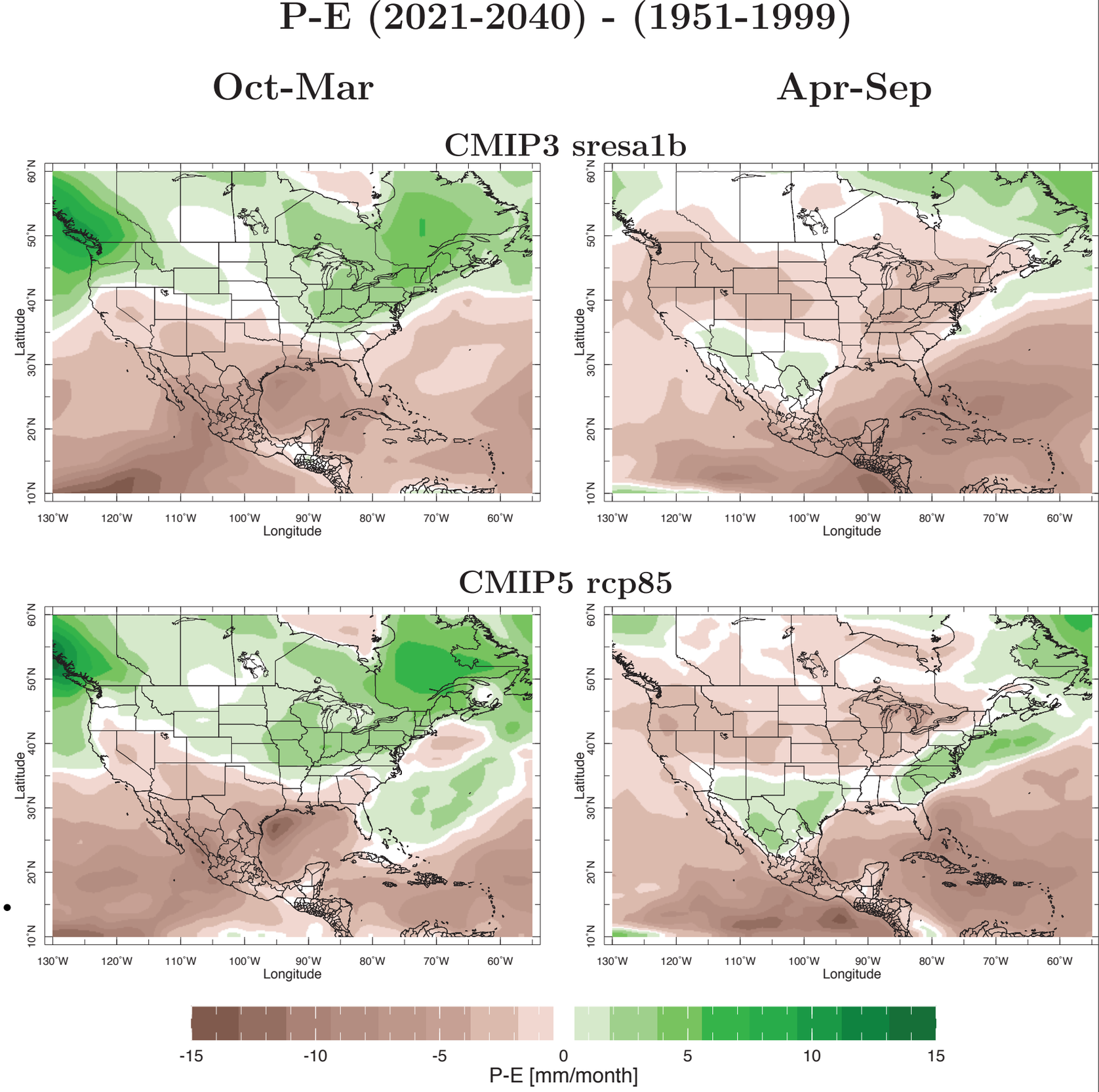


Still the case that:

1) wet areas get wetter
2) dry areas get drier
3) subtropical dry zones expand poleward

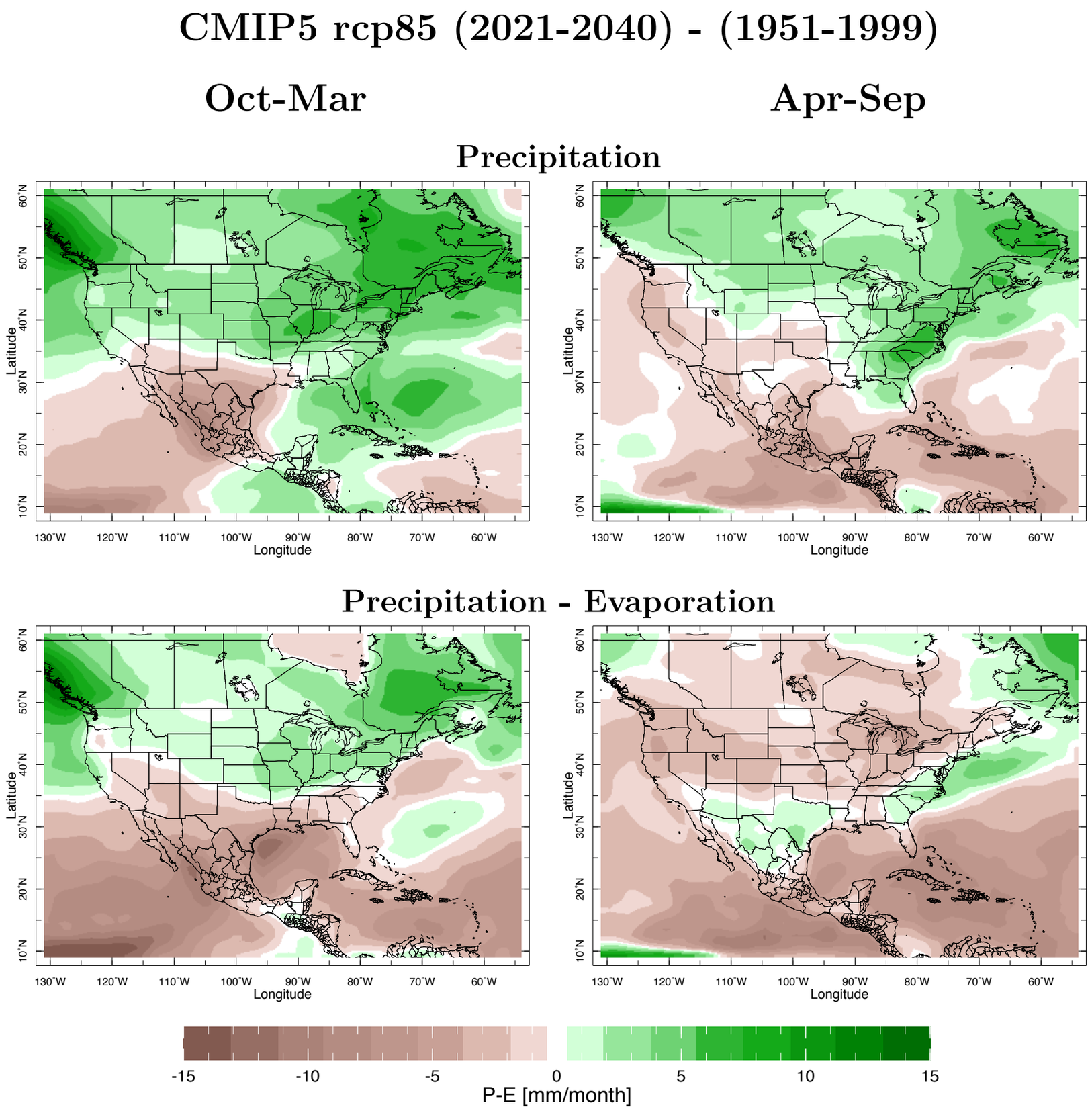
Held and Soden 2006, IPCC 2007, Previdi and Liepert 2007, Seager et al. 2007, 2010

CMIP3 and CMIP5 similarity holds up for Southwest N. America.
Dries in winter.
Northern monsoon region and TX have increased P-E in summer.
Impacts on agricultural production (irrigated, rain-fed), water resources, ecosystems ..



Evaporation increase - due to atmospheric warming - causes negative *P-E* region to extend poleward of negative *P* region

- most of CA, increased winter *P*, decreased *P-E*
- Texas and N. Mexico decreased summer *P*, increased *P-E*



California imports water to southern California from Colorado River and moves water from wet north to dry south

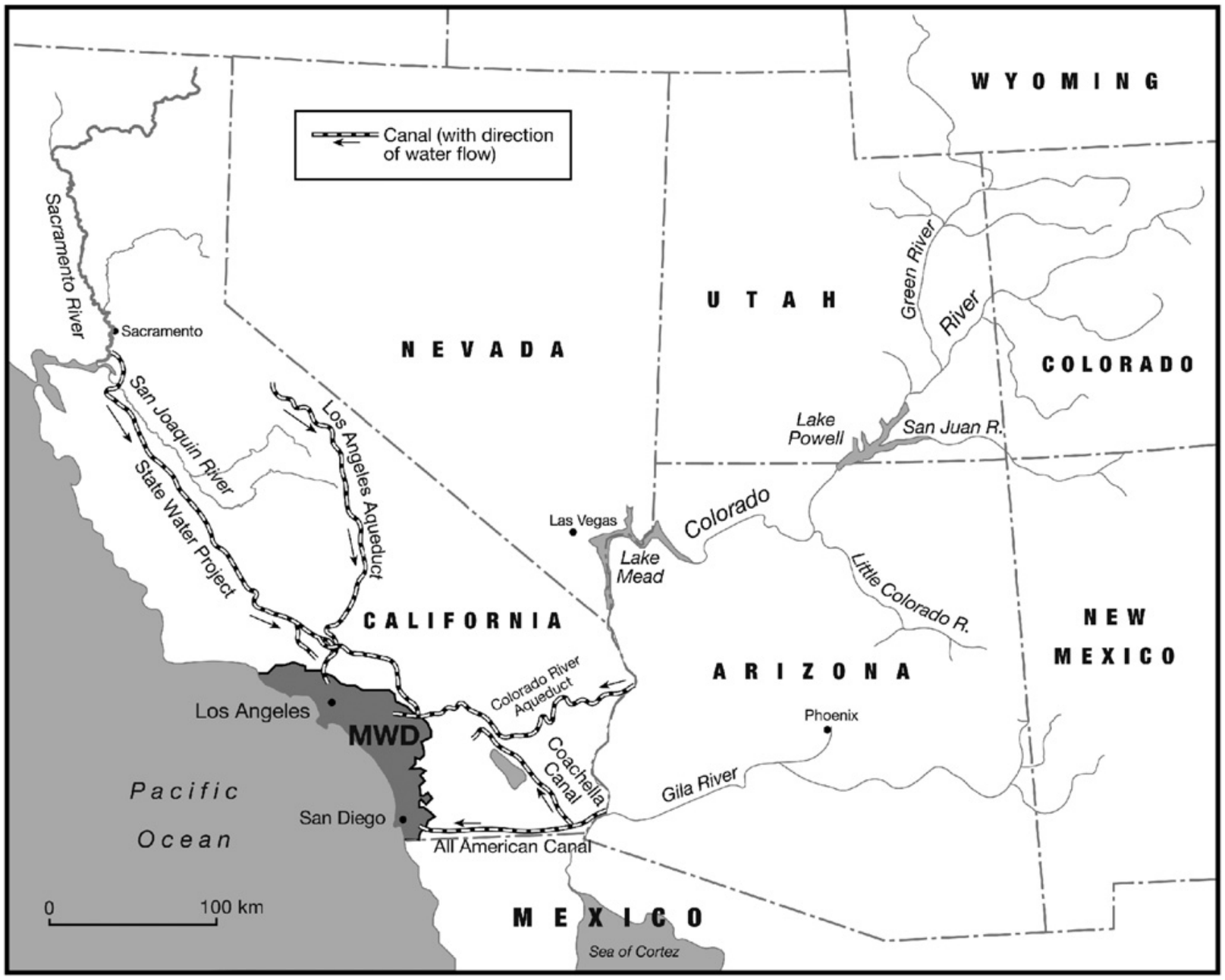
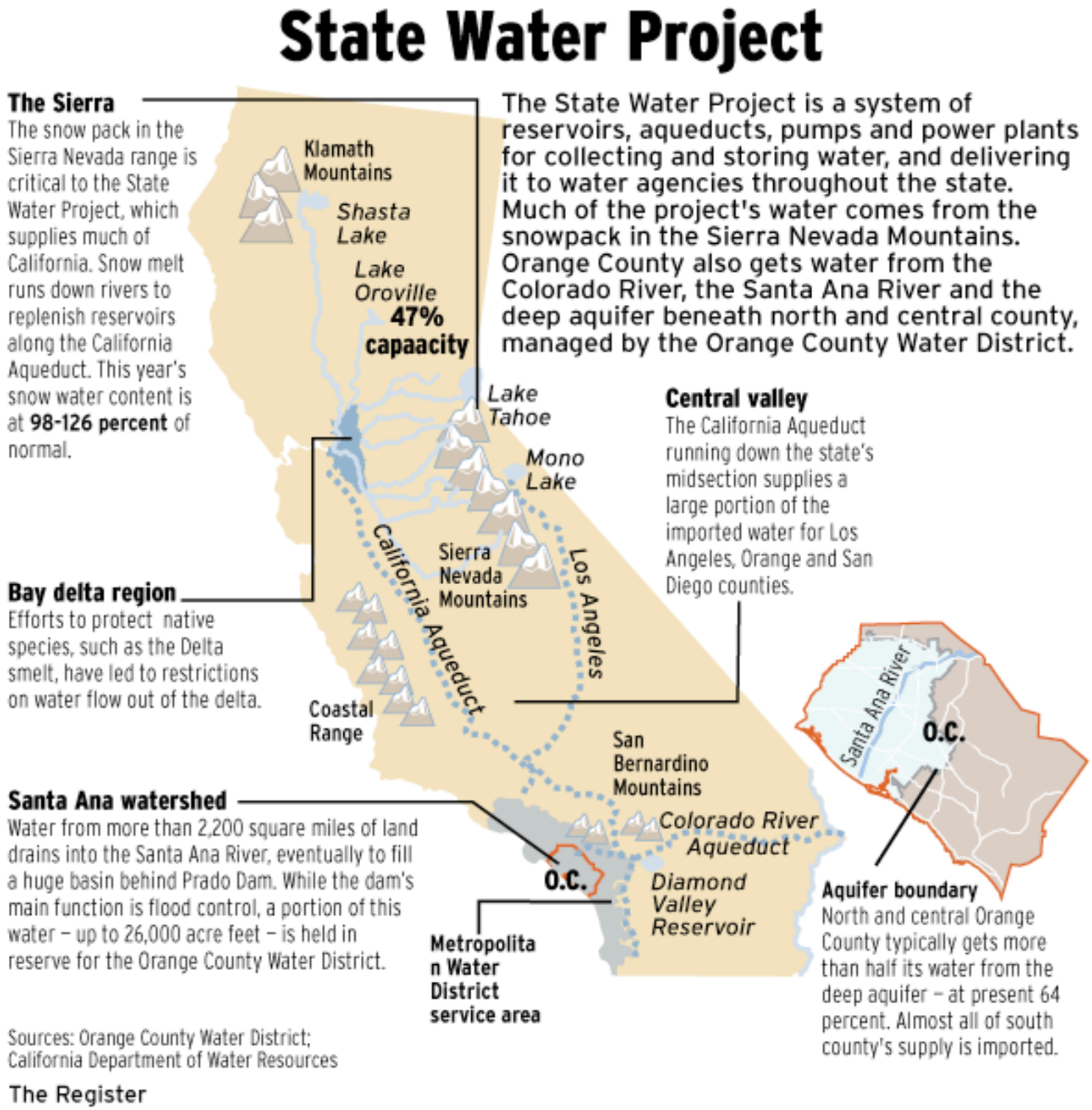


Fig. 1. Sacramento and Colorado river systems and major aqueducts supplying southern California and the Metropolitan Water District (MWD

Apparently in LA you can flush Mount Shasta water down your toilet. On its way it comes across the S.F. Bay delta - major ecological problems - and then up over the San Bernadino mountains.

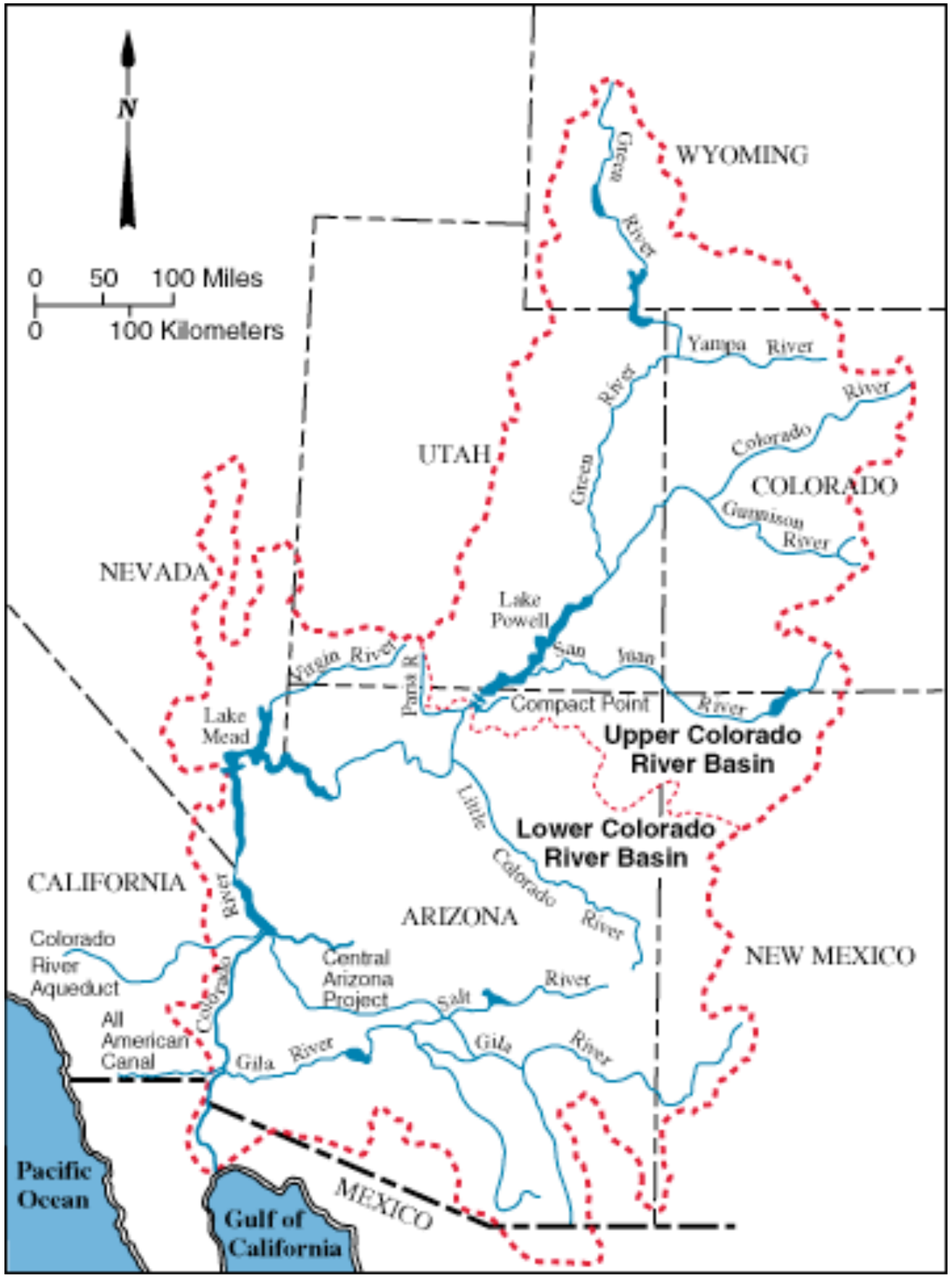


The Colorado River - mean annual flow about 15 maf - provides water to 7 states and Mexico (1.5 maf).

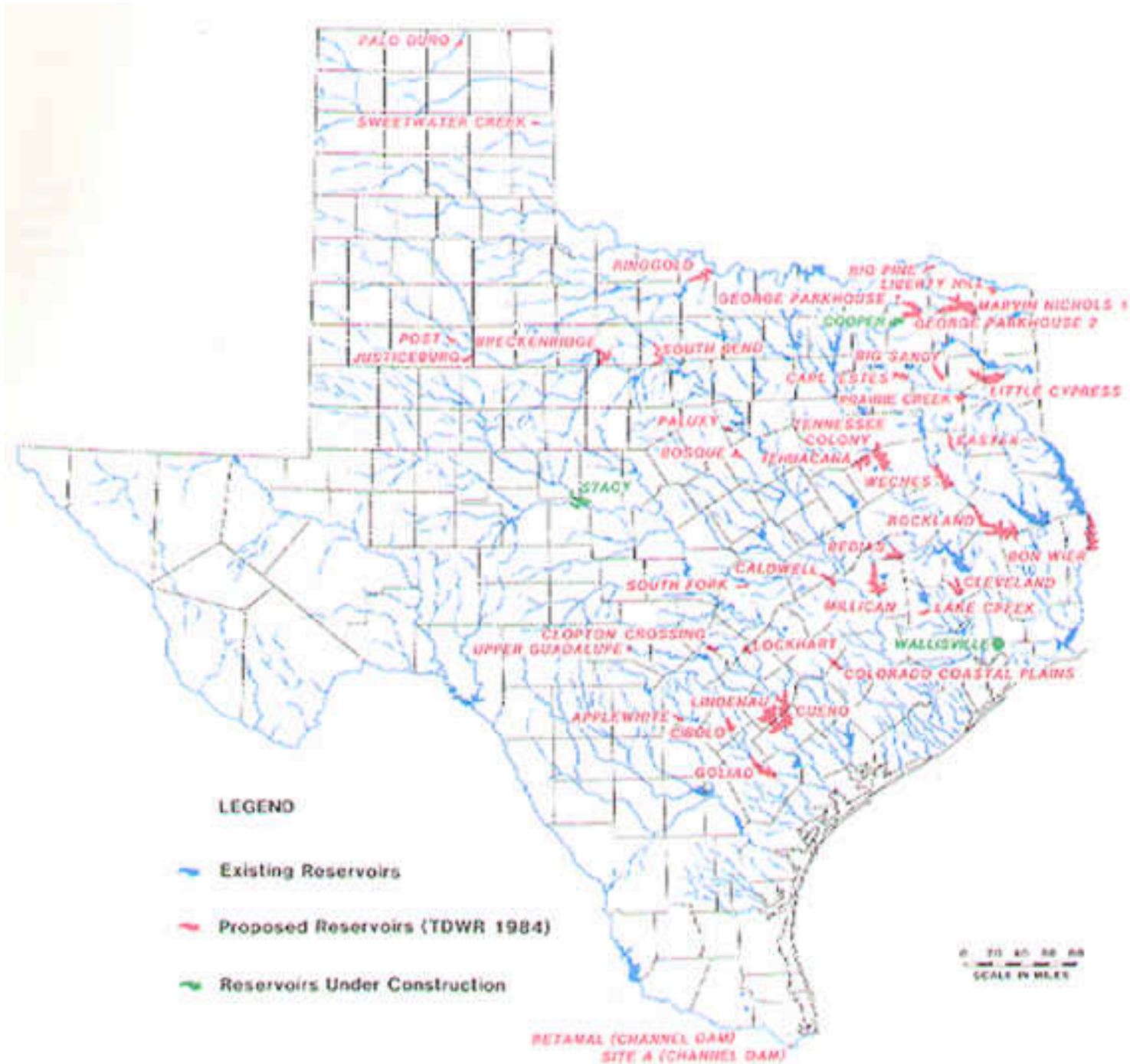
About 4.4 maf goes to CA via Colorado River aqueduct and the All American Canal.

Central Arizona Project diverts 1.5 maf to central and southern AZ (including Phoenix and Tucson).

85-90% of flow comes from snows in Colorado and Wyoming. Less than 15% of flow comes from Lower Basin tributaries but 60% of use is in the Lower Basin. Sort of like The Nile.



Texas relies for its water on a network of in-state reservoirs, a few on rivers flowing across borders, and extensive (unsustainable) groundwater extraction from aquifers

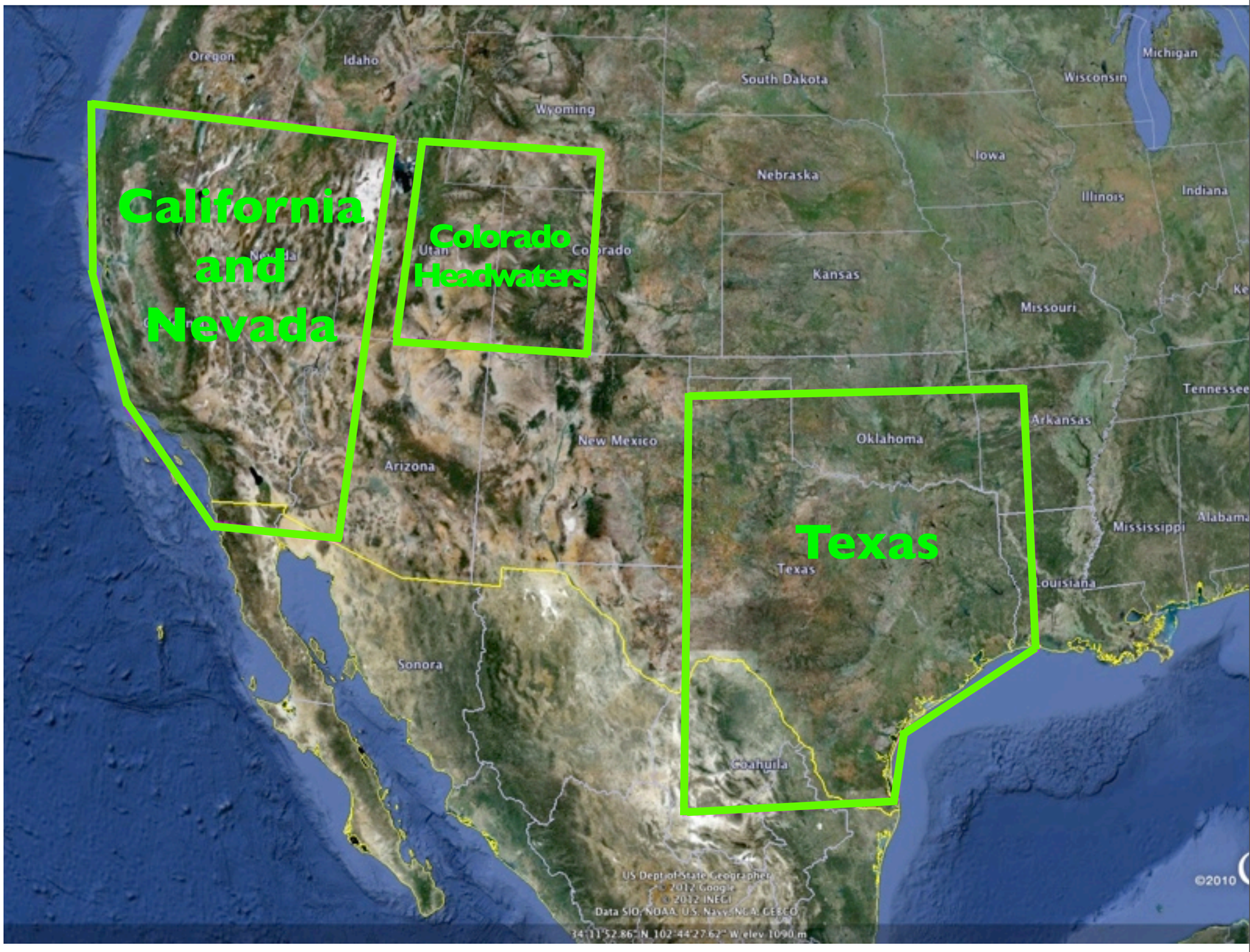


Focus on 3 regions

CA/NV
Winter *P*, dry summers

Colorado headwaters
Winter *P* but summer storms. CR provides water for 7 states plus Mexico

Texas
winter storms and summer 'monsoonal' *P*. Self sufficient in water.

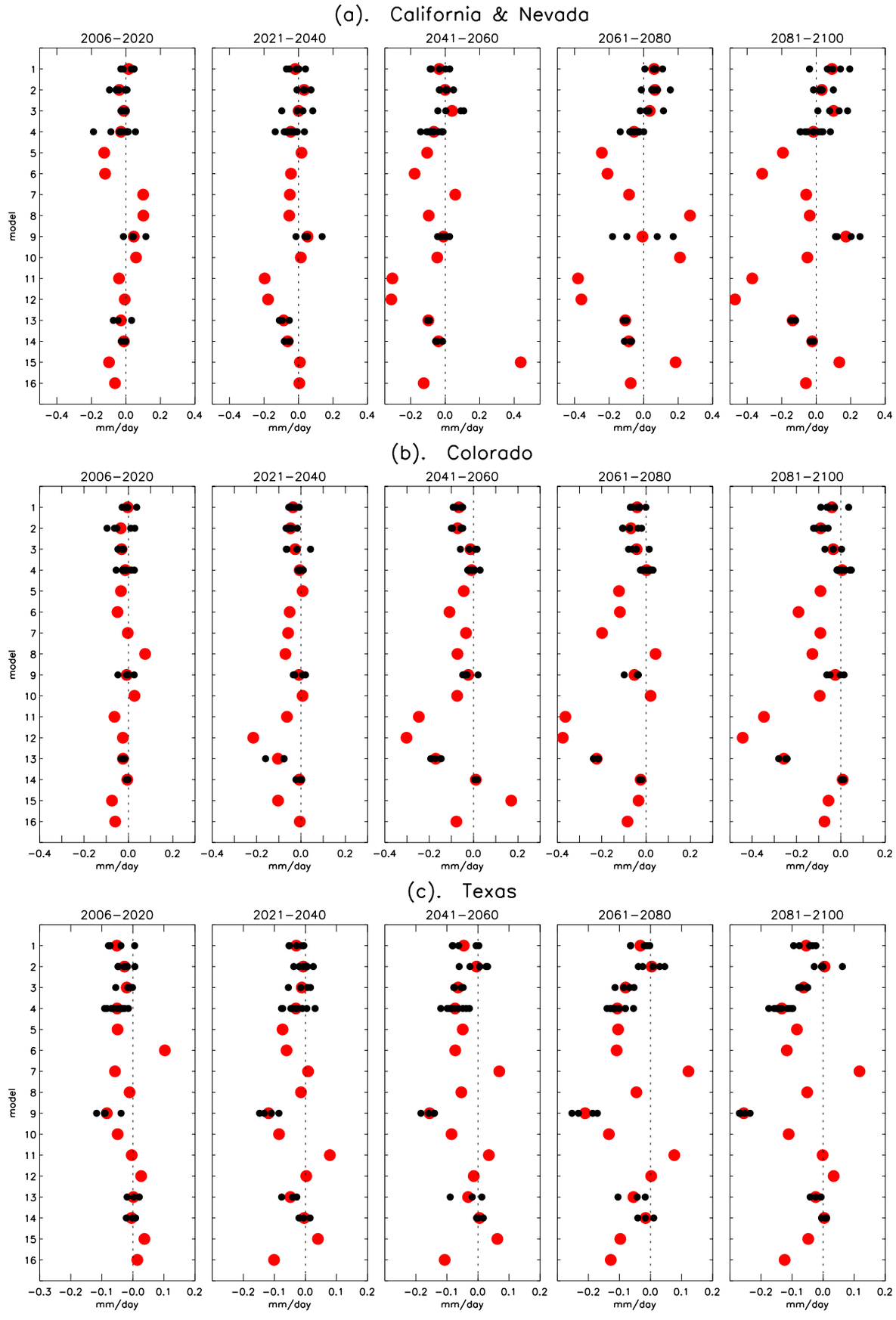


Change in *P-E* for all simulations of all models by two-decade 21st C periods

California + Nevada

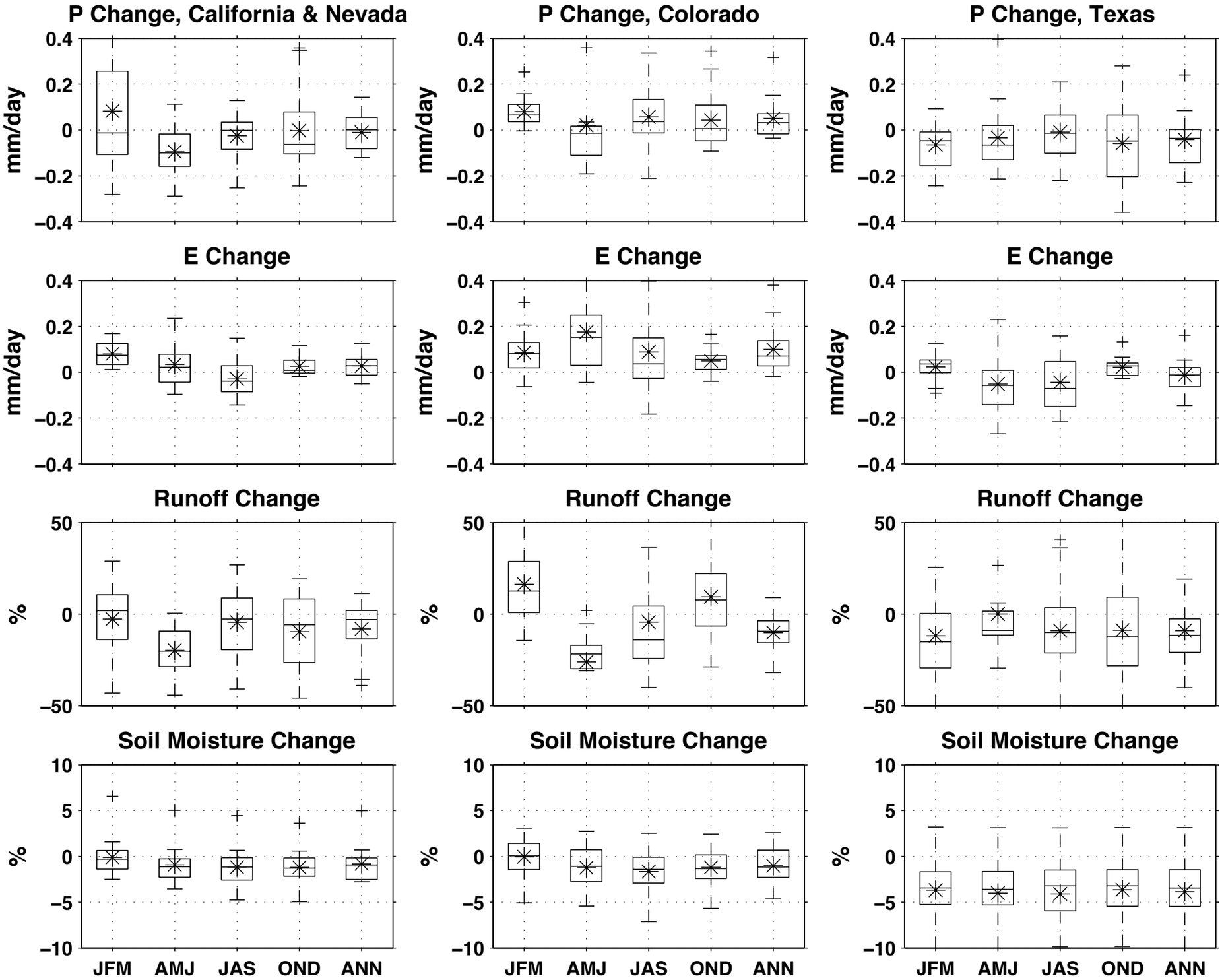
Colorado headwaters

Texas

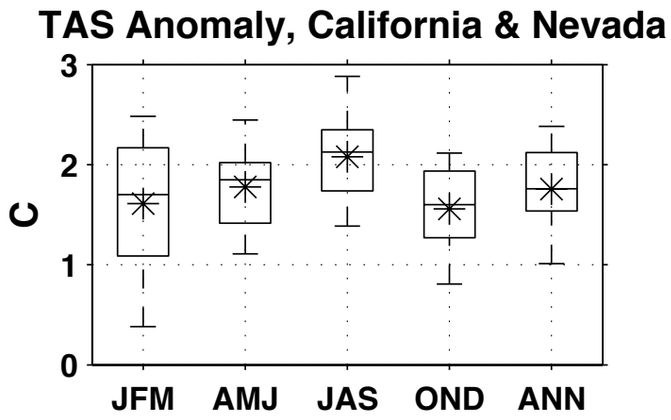


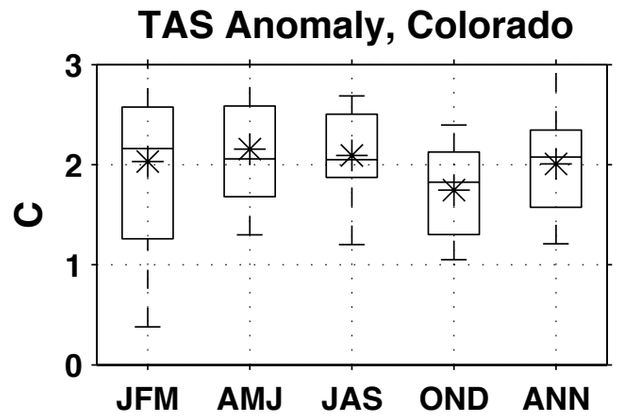
Seasonal changes for 2021-2040

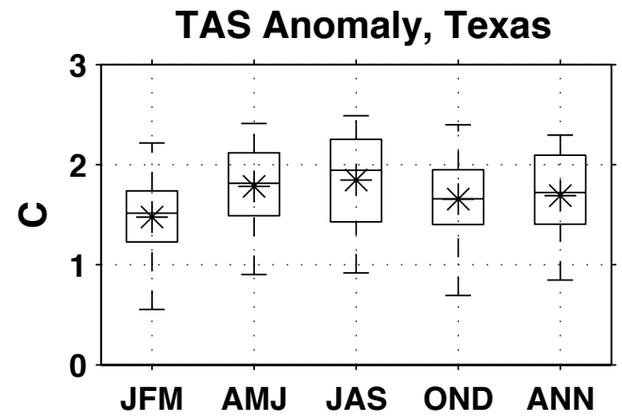
Drops in runoff throughout year in CA/NV and TX and in spring for CR. Modest drops in soil moisture for all regions.



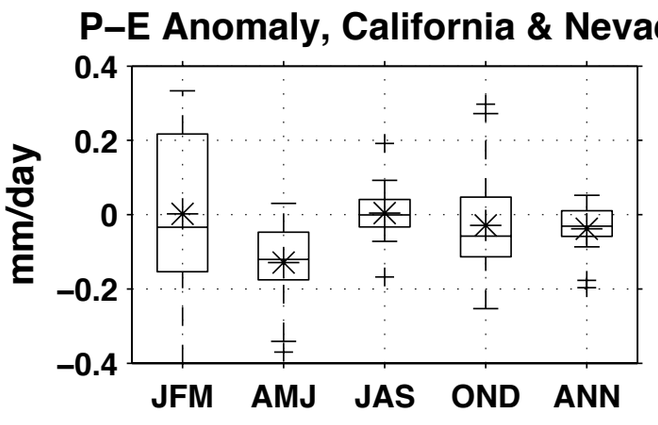
Every simulation warms in every season in every region, contributing to drop in *P-E*

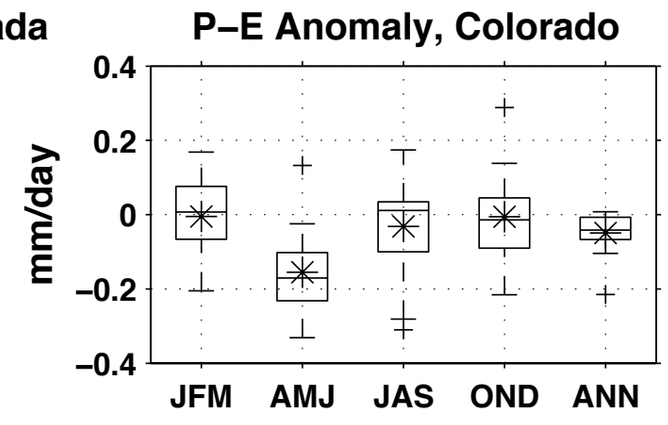


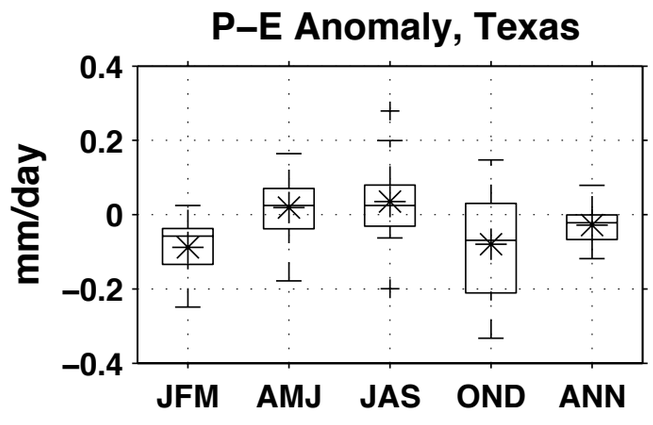




However TX has increased JAS *P-E* but reduced *P*

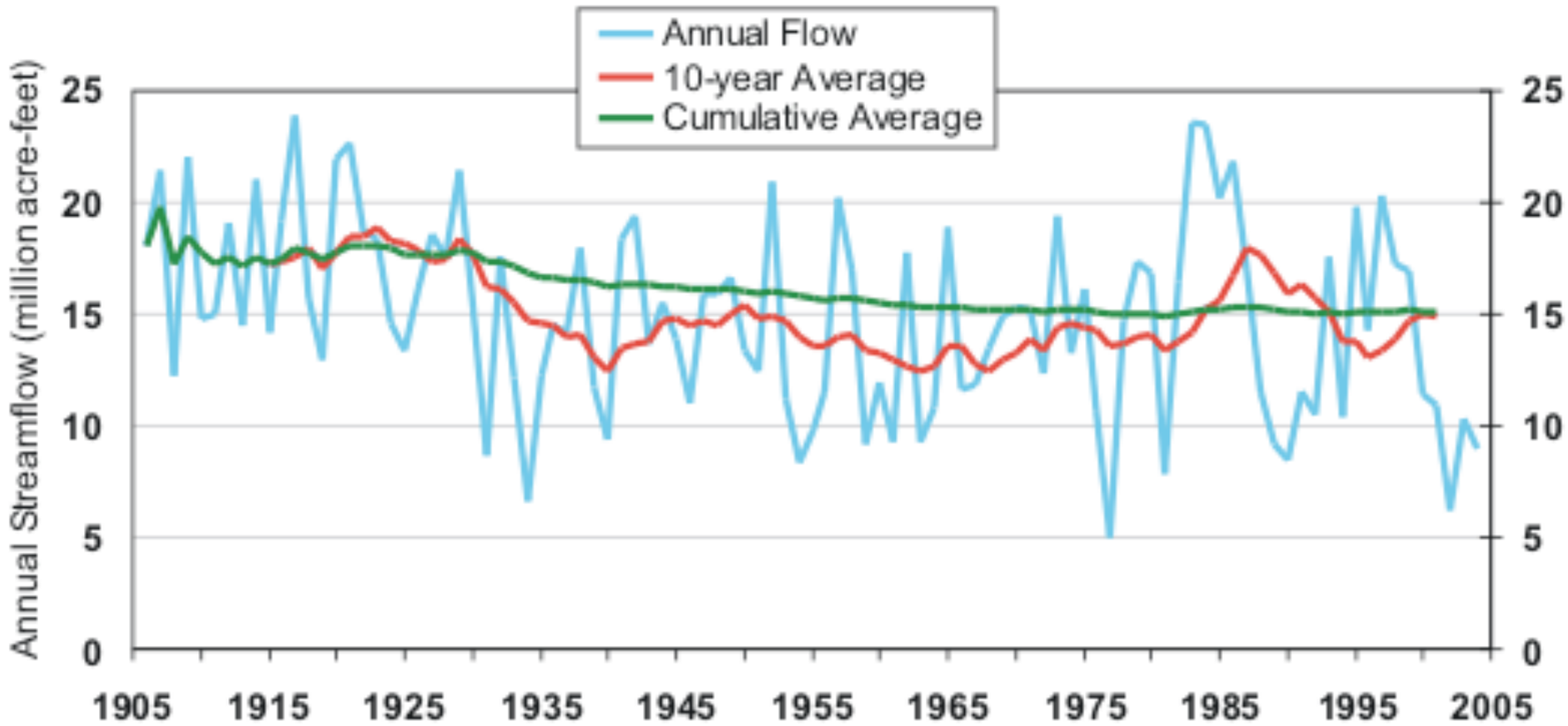






As point of comparison ...

Natural Colorado River Flow at Lee's Ferry



1906-2004 average = 15 maf

10 year average varies 12.4 to 18 maf (i.e. 17-20%)

Projected 2021-2040 annual mean decline about 10%

Conclusions

CMIP5 results confirm CMIP3 results of Southwest drying in coming decades - both pattern and amplitude

For CA/NV and CR winter increases in P cannot overwhelm increased E and spring and annual mean runoff declines

For TX P drops year-round and can cause E to drop such that P-E increases in summer but annual mean runoff declines

As multidecadal means, changes in runoff comparable in amplitude to past multidecadal variability