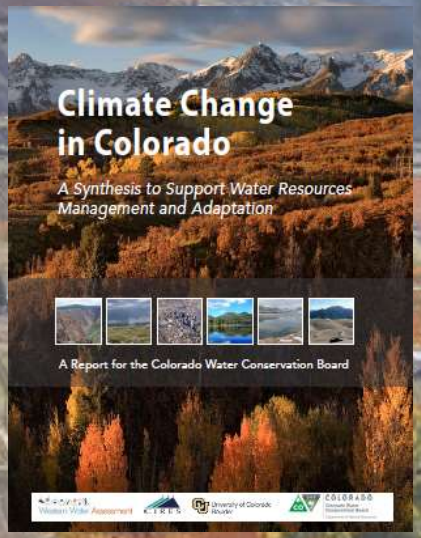
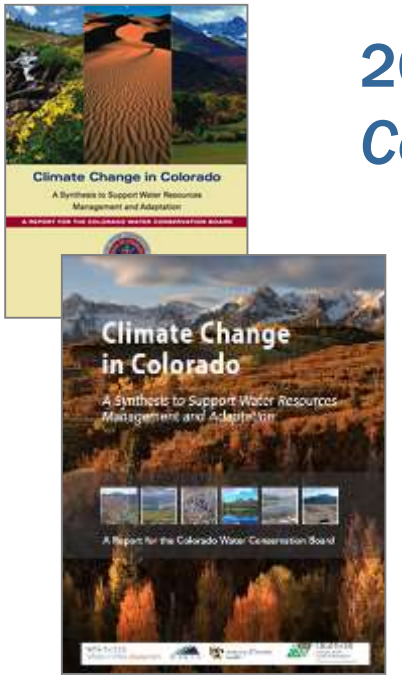
Future Climate Risk for the Colorado River Basin

Findings and insights from the 2014 *Climate Change in Colorado* report



Upper Colorado River Basin Water Forum
Grand Junction, CO – November 5, 2014
Jeff Lukas, CIRES Western Water Assessment
University of Colorado Boulder

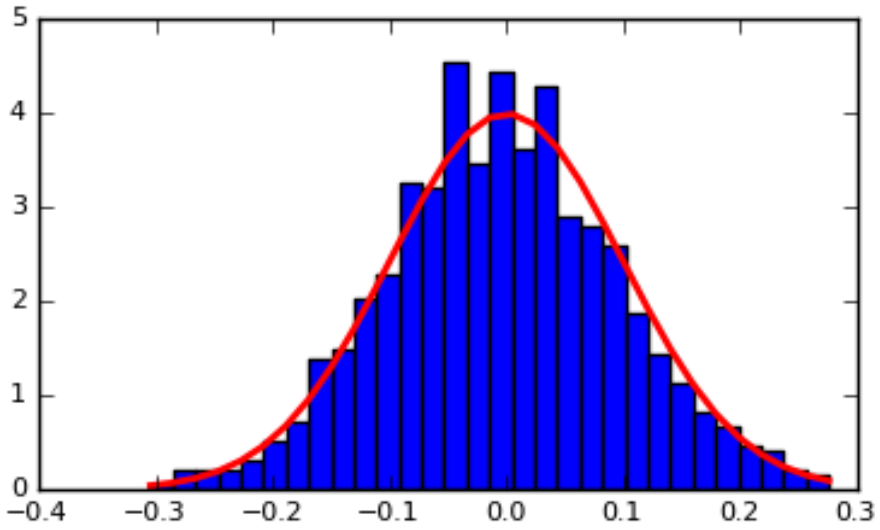


2014 revision of the 2008 *Climate Change in Colorado* (2008) report

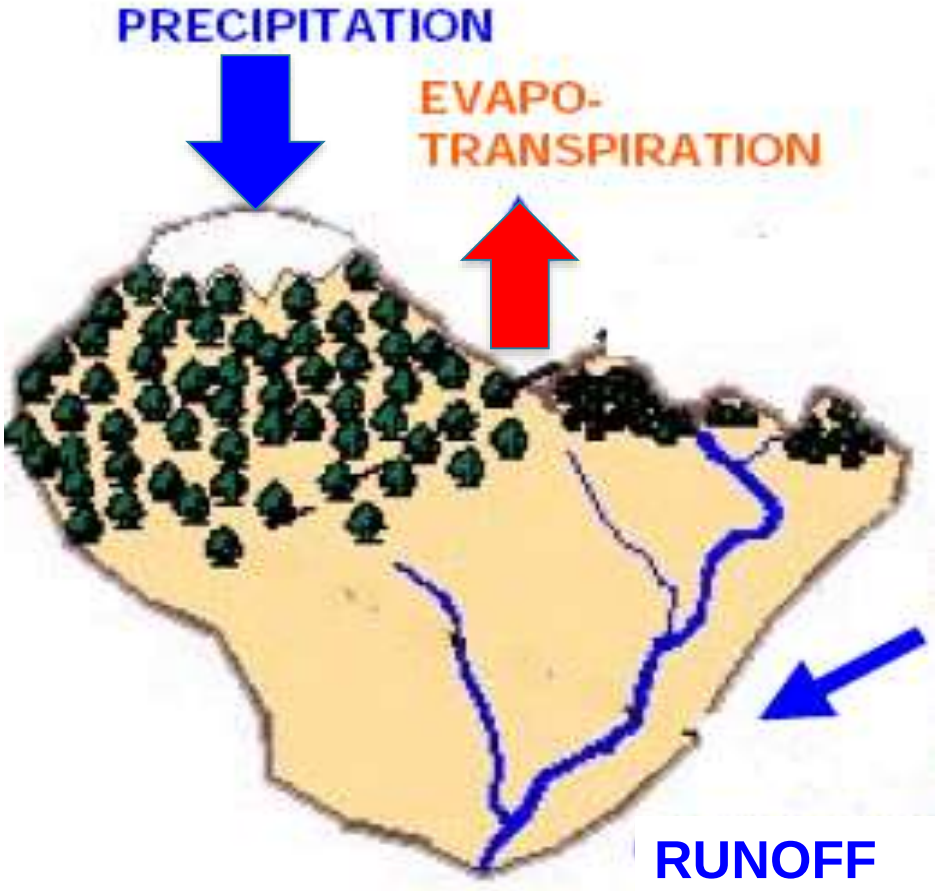
- The observed record of Colorado's climate
- A primer on climate models, emissions scenarios, and downscaling
- Linking Colorado's climate trends and events to global climate change
- Projections of Colorado's climate for the mid-21st century (~2050); implications for water resources
- Incorporating climate change information into assessment and planning
- PDF available via http://wwa.colorado.edu or http://cwcb.state.co.us/

Traditional risk assessment for water supply

- Estimate the probability of a particular outcome; i.e., 10% chance that runoff will be <50% average any given year
- Assumption of stationarity



Western Colorado's annual average water balance



Precip: 40 MAF

ET : -30 MAF

Runoff: 10 MAF

Image: D. Meko, U. of Arizona

Colorado has warmed significantly, 2° F over the past 30 years

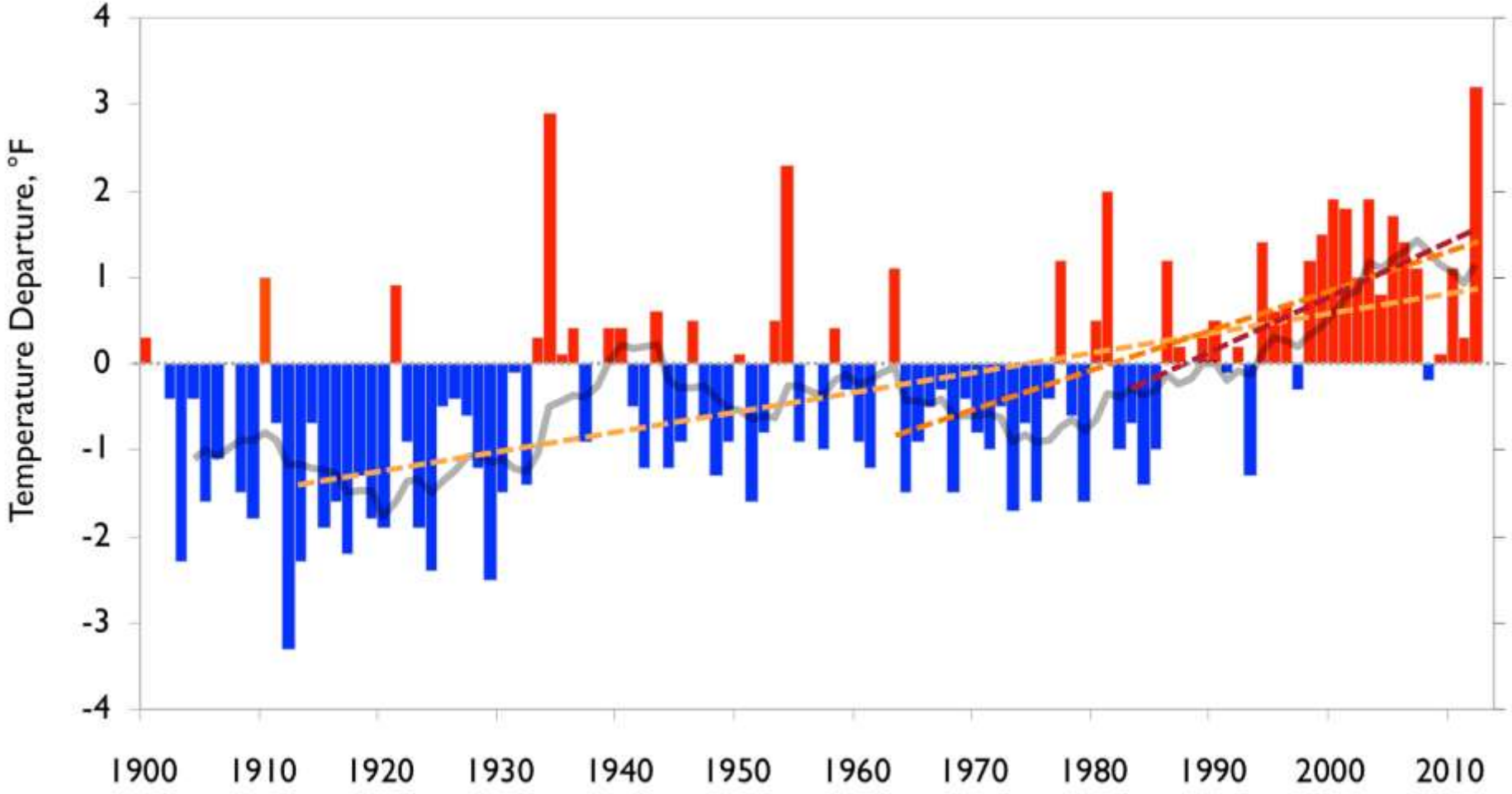
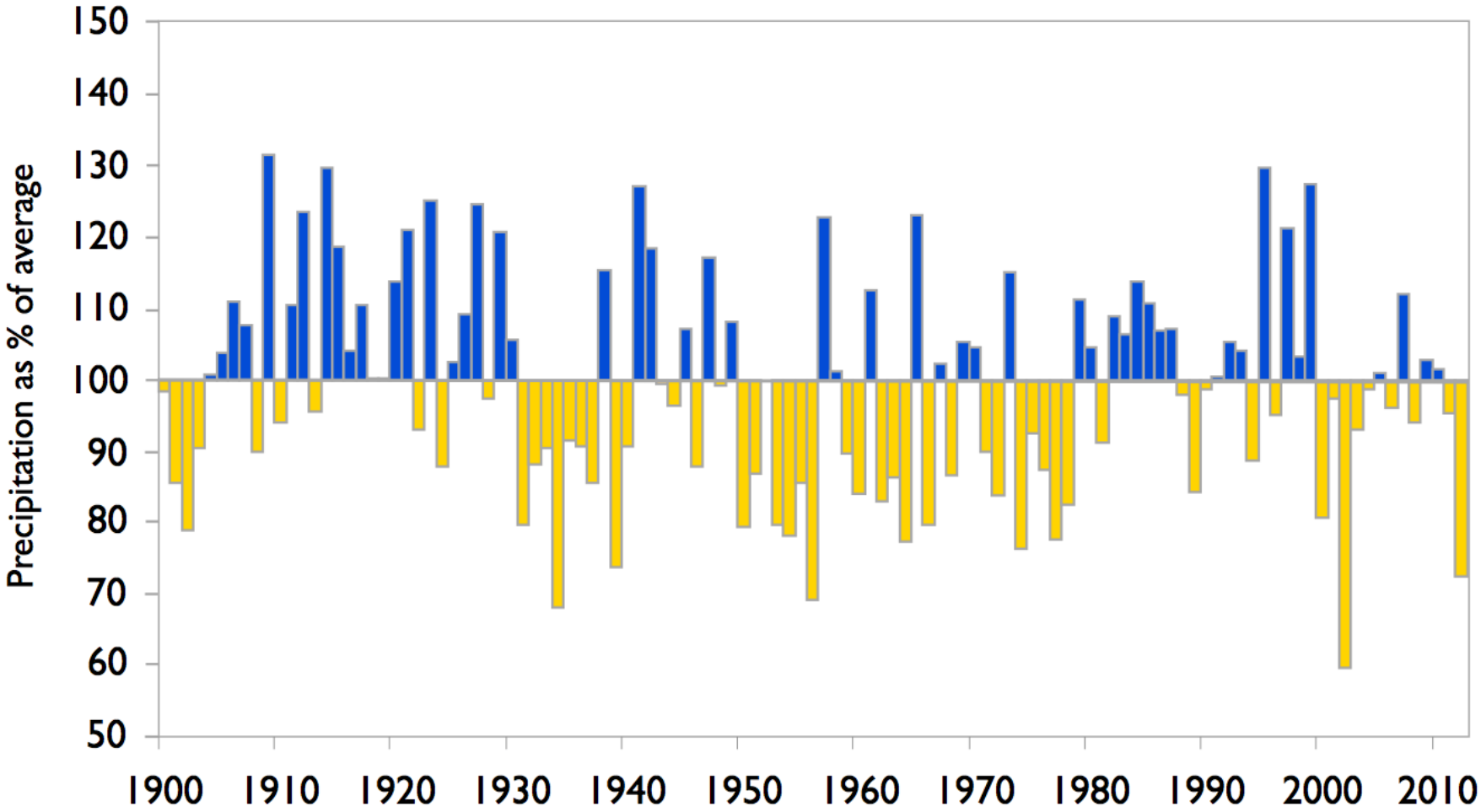


Figure ES-1 & 2-8

Observed

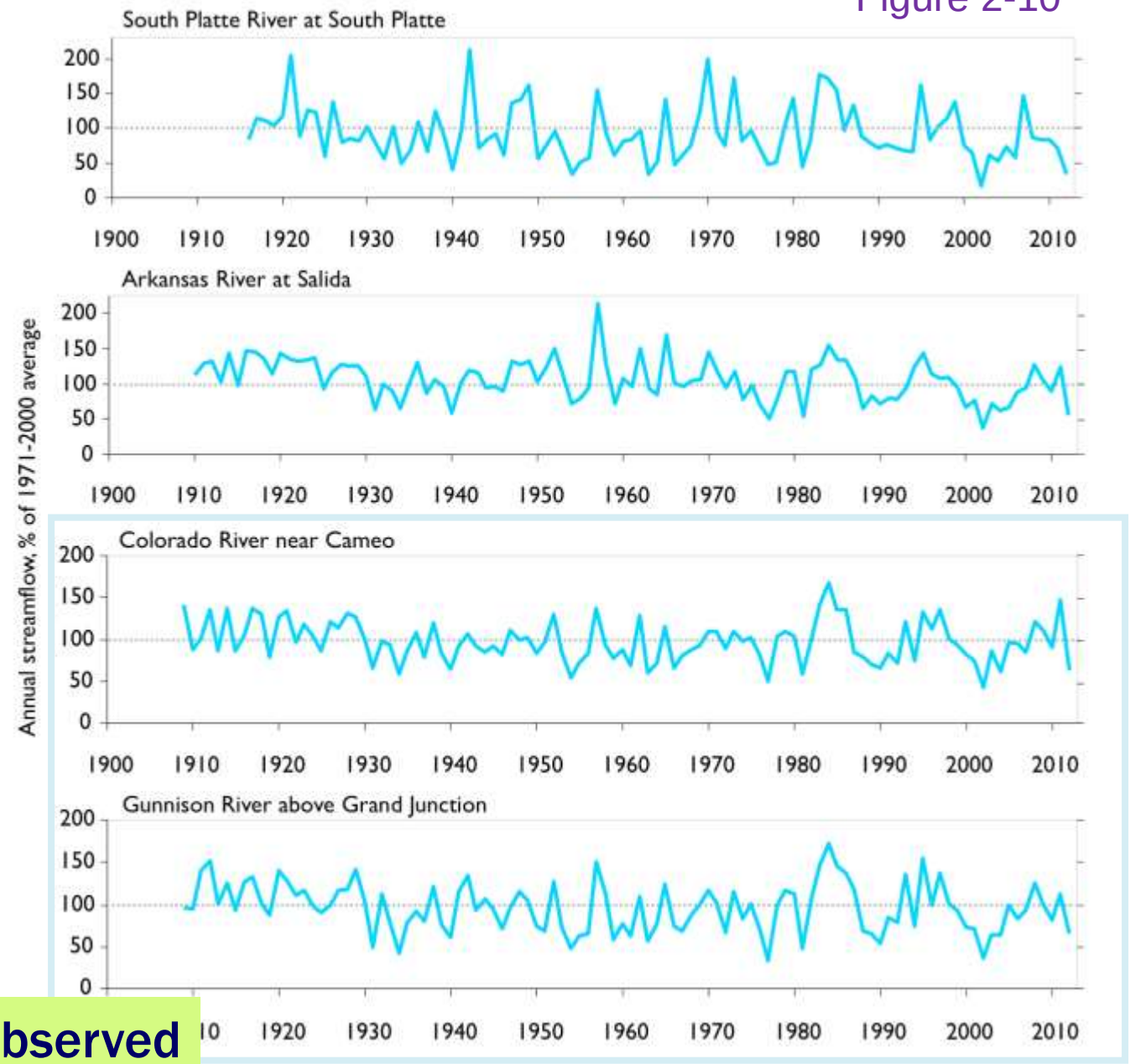
Annual precipitation, statewide: No significant long-term trends



Not in report; see Fig. 2-6

Observed

Figure 2-10



Observed

Annual streamflow in major river basins in CO: No significant trends

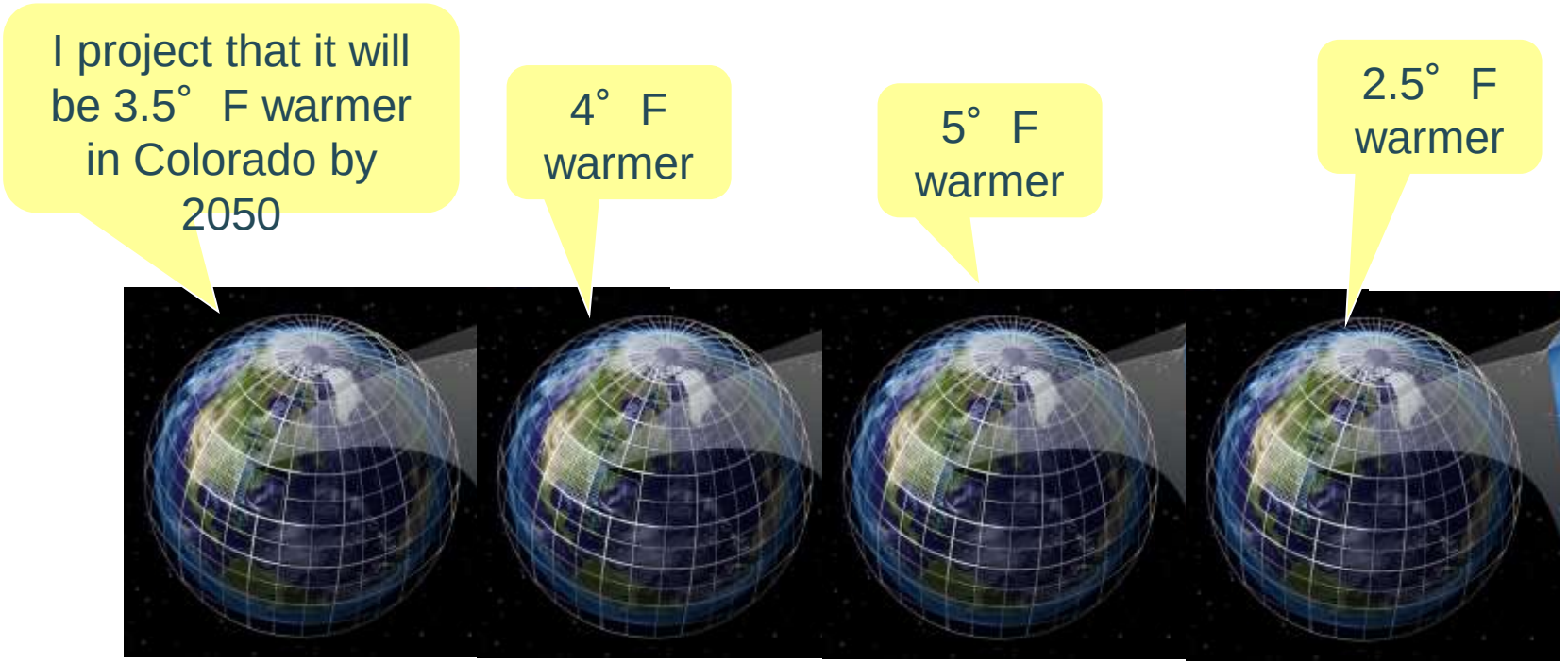
But runoff *timing* has shifted earlier by 1-4 weeks, due to warming, dust-on-snow, lower SWE since 2000

Long-term observed statewide climate trends

Annual temperature	warmer
Heat waves	more frequent
Cold waves	less frequent
Frost-free season	longer
Annual precipitation	no significant trends
April 1 SWE	no significant trends
Annual streamflow	no significant trends
Snowmelt	earlier
Peak runoff timing	earlier
Palmer Drought Index	more drought

Observed

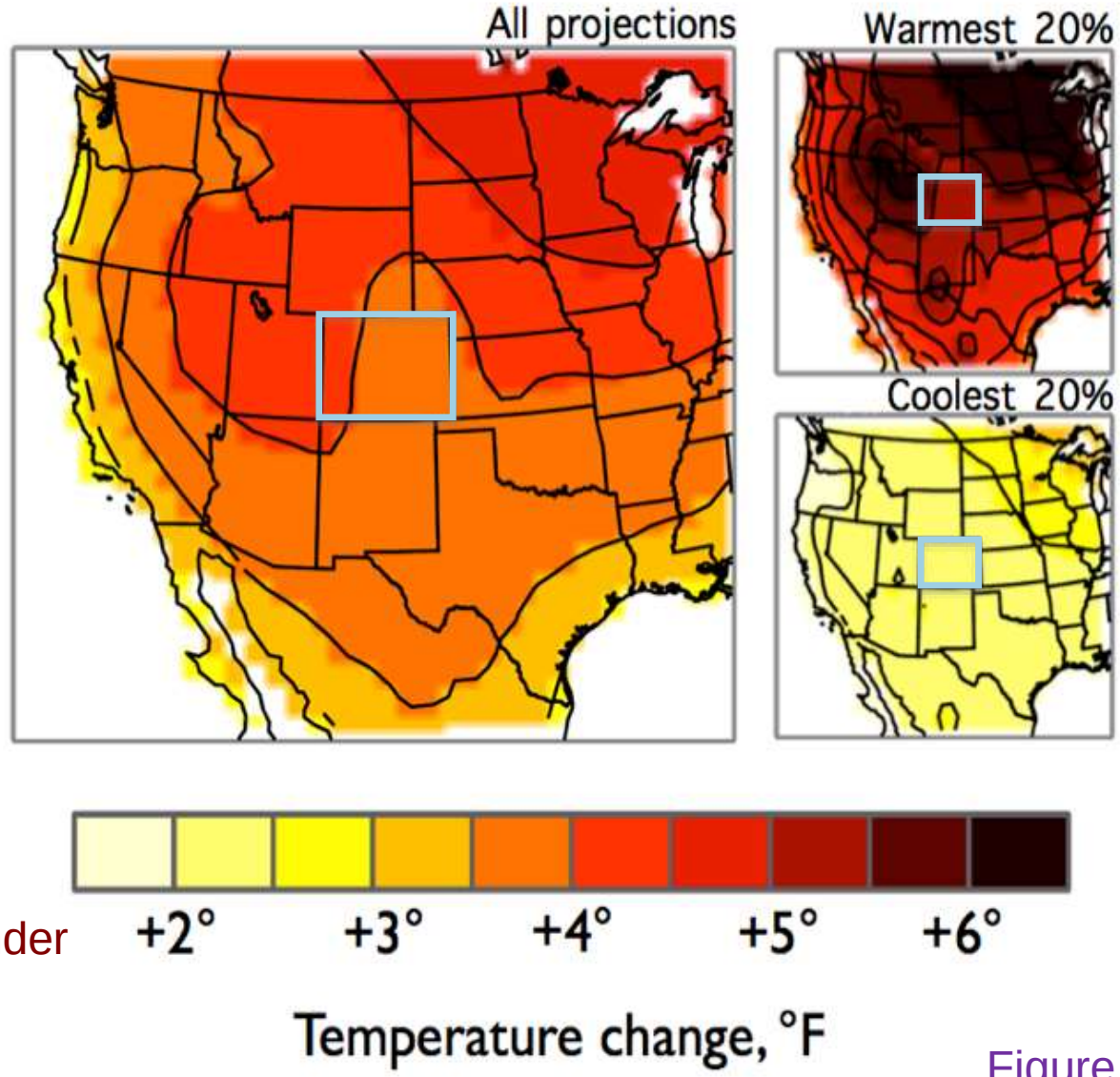
Global Climate Models = roomful of experts



- Different climate models will give you somewhat different answers about future climate
- New group of model projections (CMIP5) shown in this report; previous CMIP3 used in 2008 report, CRWAS, and Basin Study

Colorado continues to warm in all projections, by 2.5° F to 5° F by 205

CMIP5 shows similar warming for CO vs.CMIP3

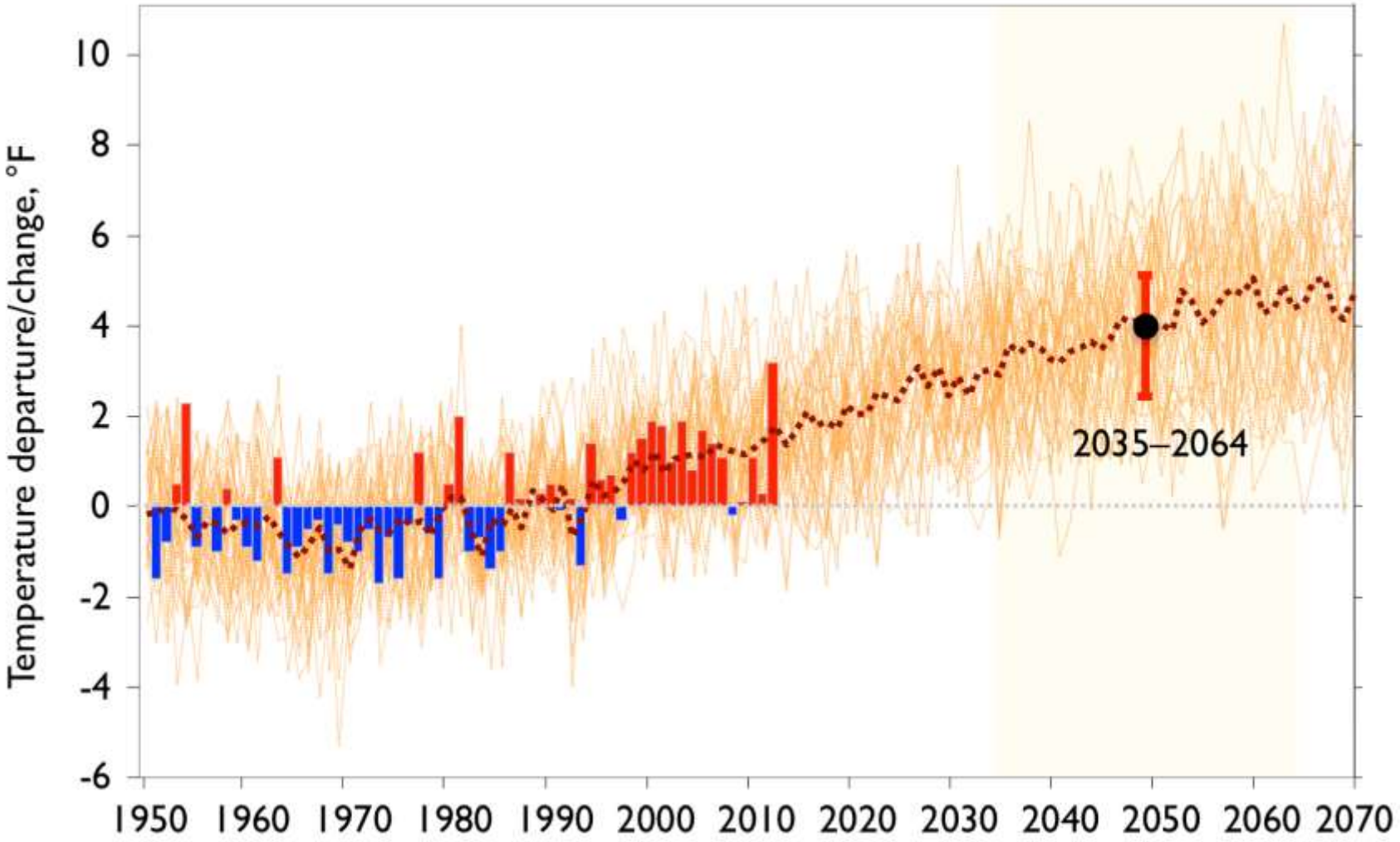


37 model projections under RCP 4.5

Projected

Figure ES-1; Figure 5-1

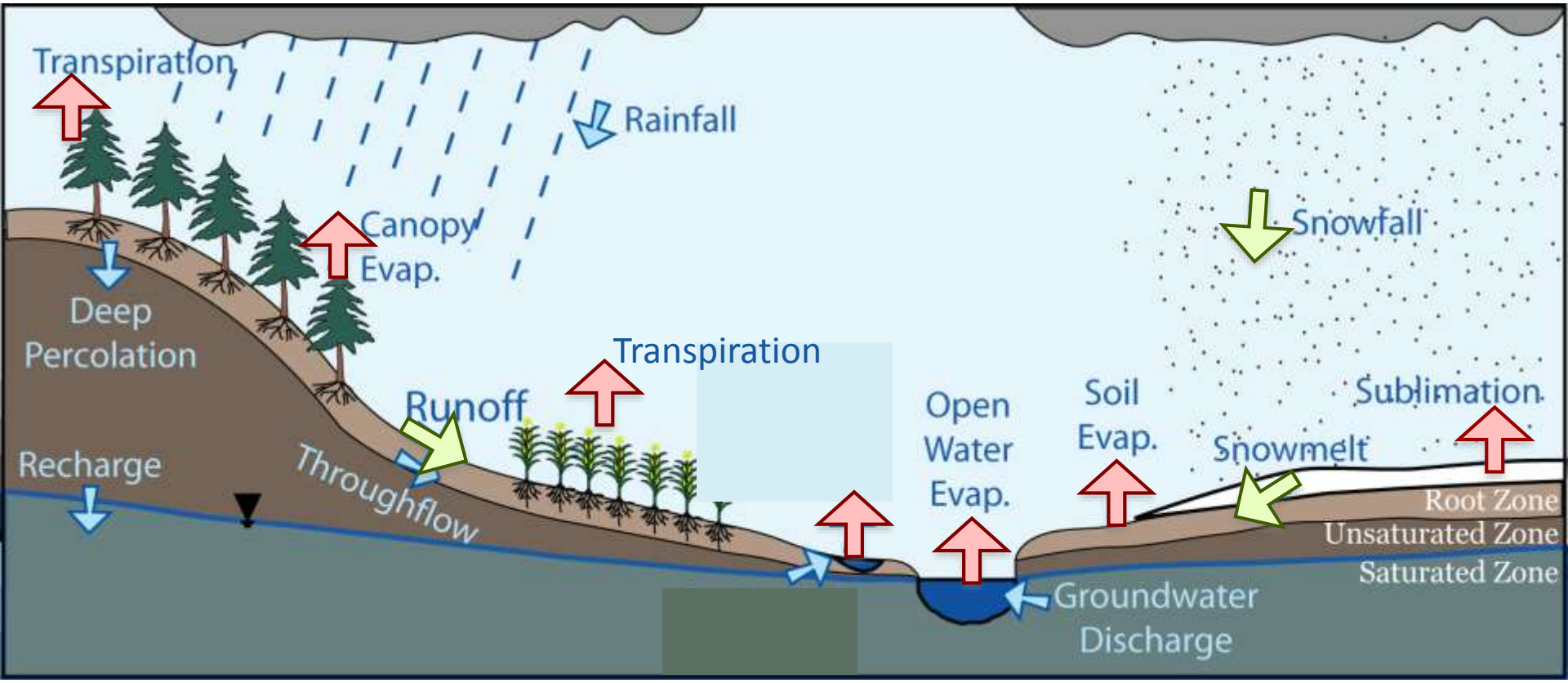
By 2050, typical year will be warmer than the warmest years of the past century



Projected

Figure 5-2

The projected warming alone will tend to have an overall *drying effect* on natural and managed landscapes

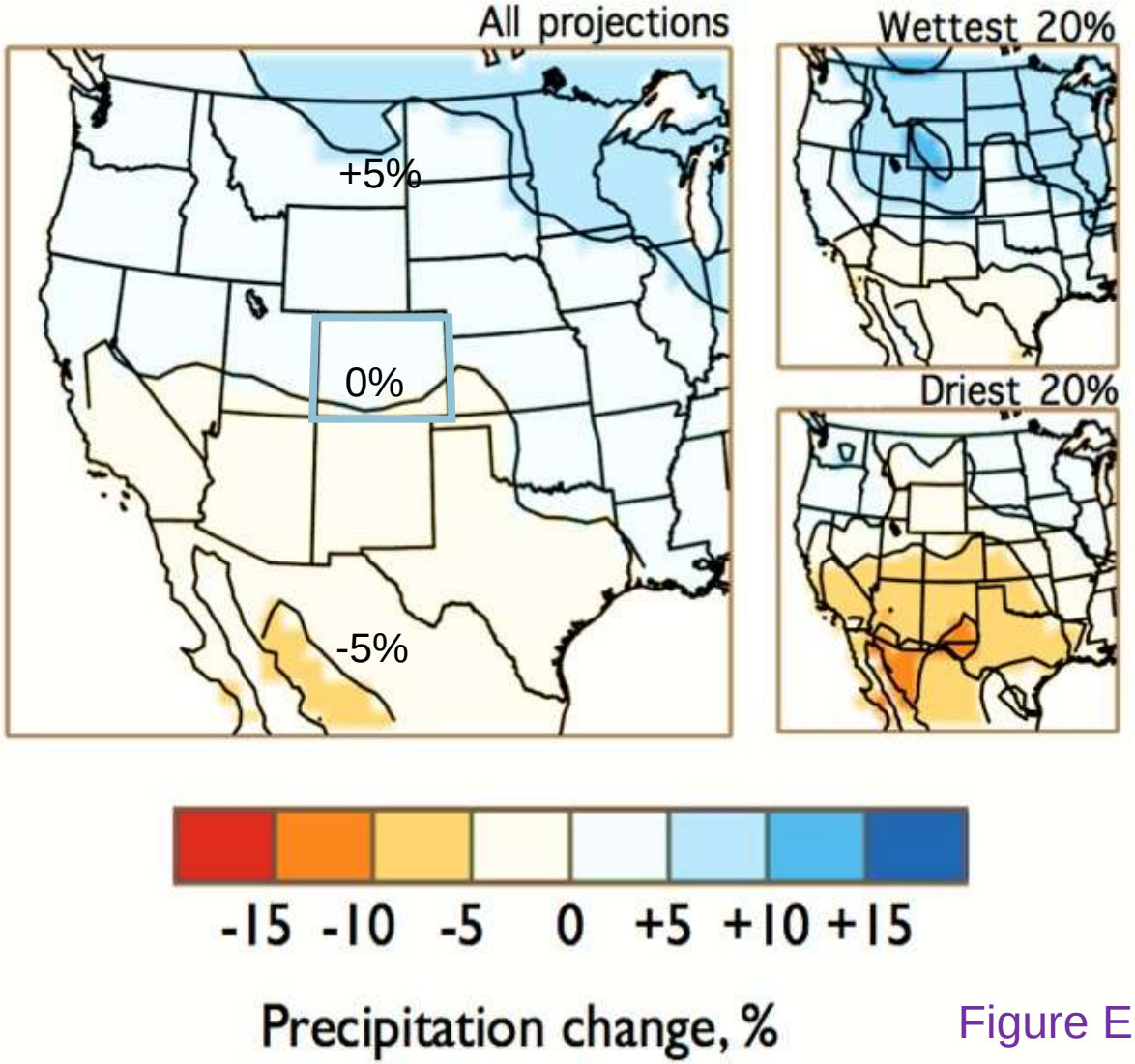


Moisture losses from plants, soils, water surface, and snowpack will tend to increase with warming

Tendency towards decreased snowfall, snowmelt, and runoff

Colorado statewide precipitation change by 2050 uncertain; we're between regions expected to get drier and wetter

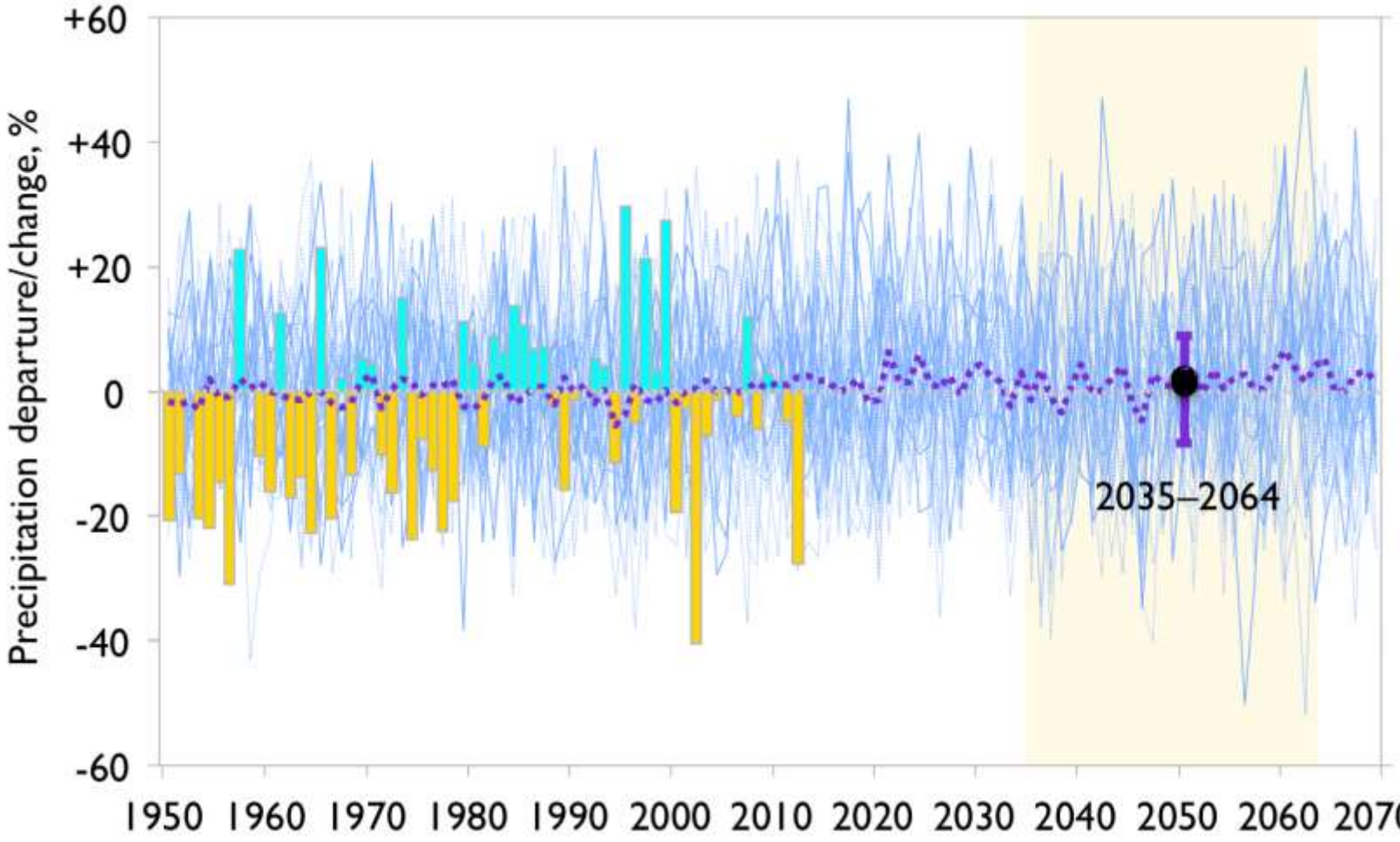
CO a little wetter in CMIP5 vs. CMIP3



Projected

Figure ES-1; Figure 5-1

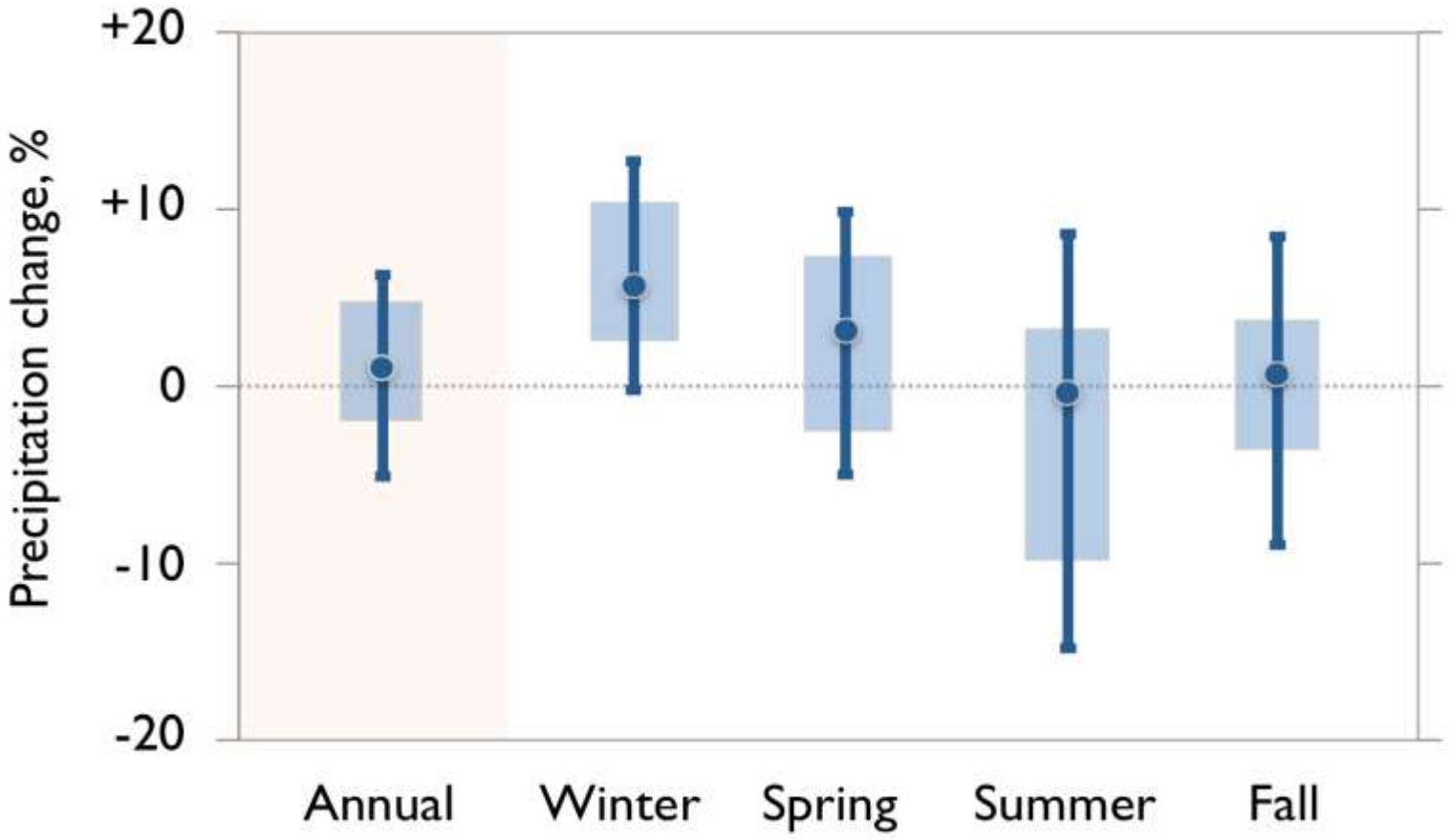
Any future change in annual precipitation will be difficult to detect as such against the high variability



Projected

Figure 5-4

Seasonal: overall, projections suggest more winter, but less summer precip

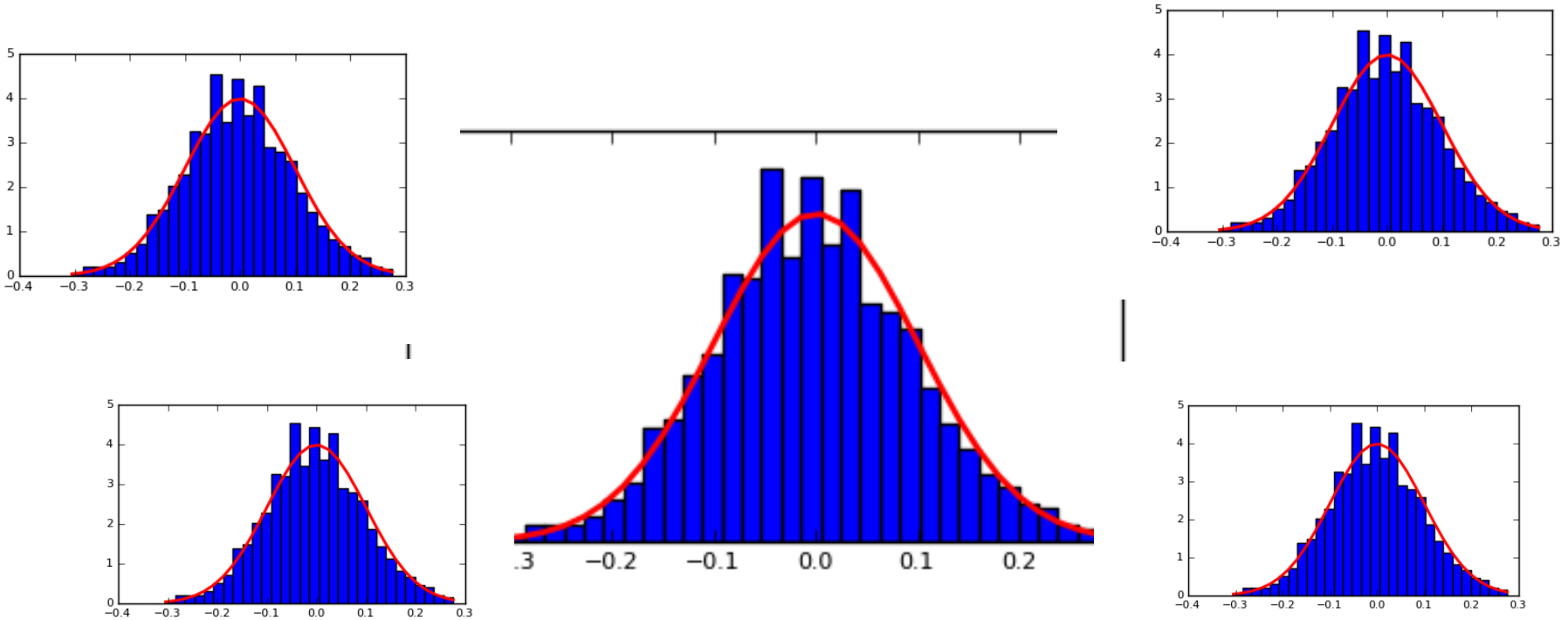


Projected

Figure 5-5

Can we quantify future climate risk?

- Can make a distribution of outcomes for *each* projection
- Merging the ensemble of projections into a single probability distribution is tempting but unwise



Big Risk #1 for the Colorado River basin

Annual streamflow – decreases in majority of projections

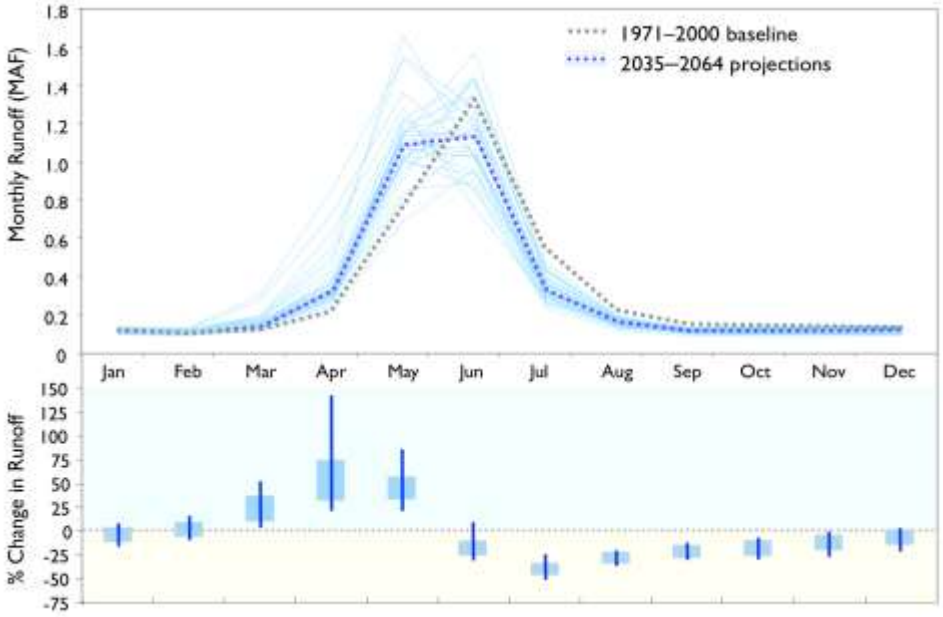
- Warming alone would reduce runoff, but uncertainty in precipitation means a wide range of projected outcomes, *tending towards decreases*
- More projections show decreases in San Juan and Rio Grande basins
- Nearly all projections show decreases in Lower Basin inflows to system

Projected

Big Risk #2 for the Colorado River basin

Peak runoff timing – shifts earlier

- April 1 SWE and runoff timing more sensitive to warming than annual streamflow is
- Peak runoff projected to shift another 1-3 weeks earlier (+ dust-on-snow impact), decrease in late summer flows



Projected

Big Risk #3 for the Colorado River basin

Ag/outdoor water demand – increases in nearly all projections

- Crop irrigation requirement and urban outdoor demand projected to increase ~5-30% by mid-century
- Combination of warming, and decrease in summer precipitation in most projections

Projected

Summary - Projected climate and hydrology changes

Annual streamflow	**decreases in majority of projections**
Peak runoff timing	**earlier in all projections**
Crop water use	**increases**
April 1 snowpack	decreases in most projections
Palmer Drought Index	more soil moisture drought
Heat waves	more frequent
Frost-free season	longer
Wildfires	more frequent
Heavy precipitation	more frequent

Projected

Planning for an uncertain climate future for the Colorado River

- Continued warming will tend to push both supply and demand in the wrong direction
- Increased average precipitation could (partly) compensate on the supply side
- But systems will tend to bend/break during drought, and future droughts will be more severe for a given precipitation deficit

- Given the uncertainty in future precipitation and streamflows, consider multiple scenarios that cover the range of projected outcomes

Comments? Questions? Please contact me at

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