Climate variability & change in the Santa Fe watershed

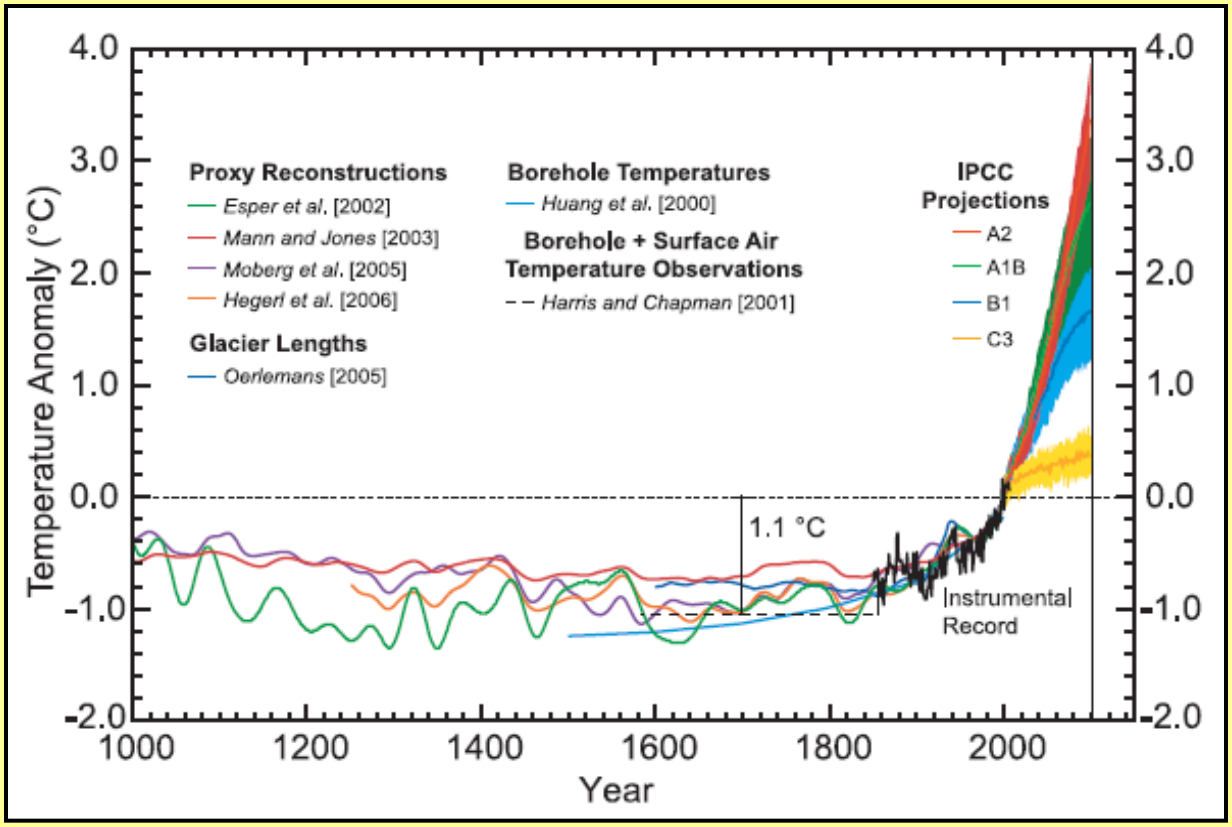
David S. Gutzler

University of New Mexico

Global mean temperature

Proxy data 1000-2000 AD
Instrumental data 1860-present
Model projections 21st Century

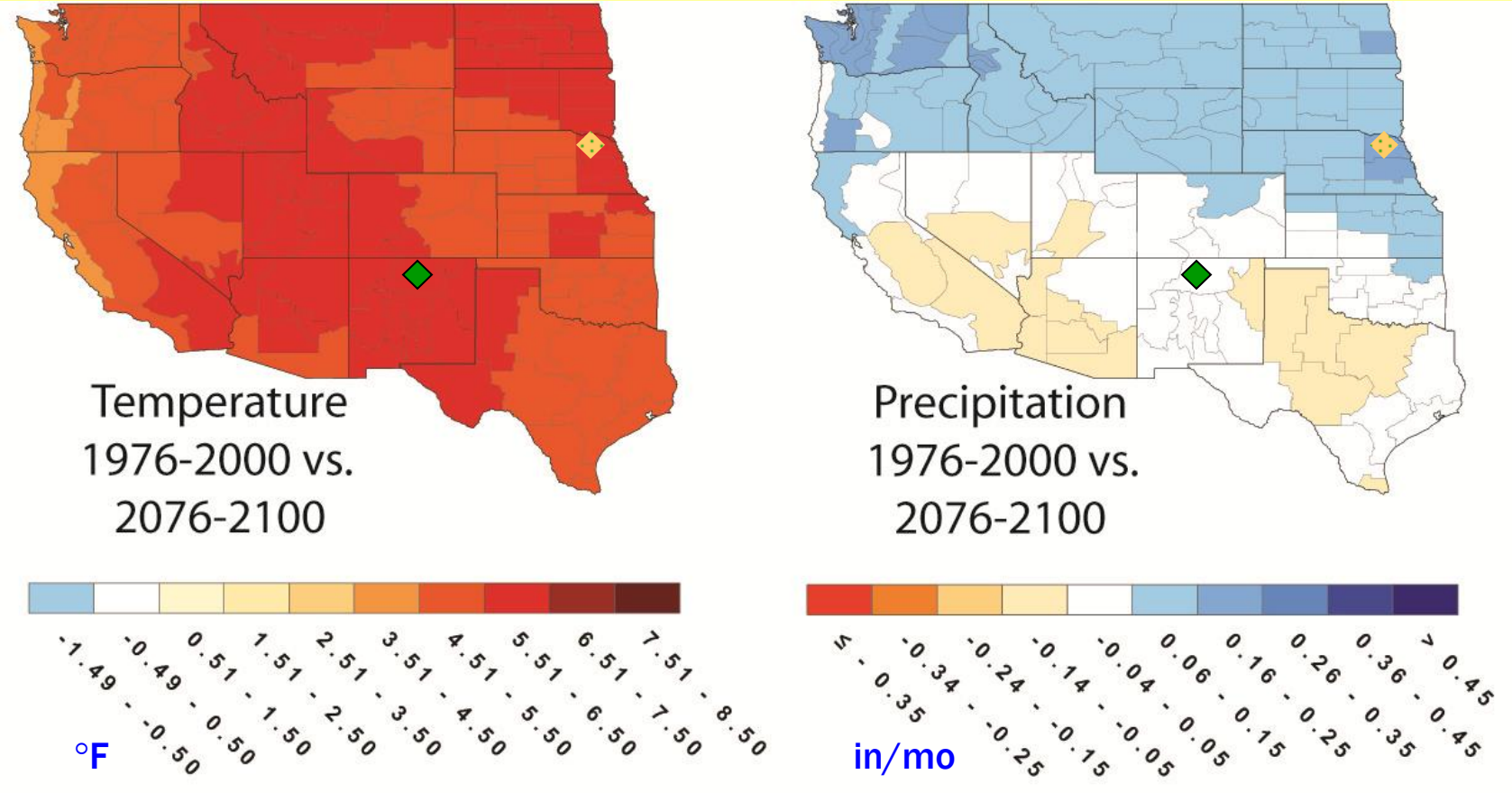
temp. relative to AD 2000



Chapman & Davis (2010)

Santa Fe Climate Workshop
March 6, 2012

Century-scale temperature and precipitation changes
A1B trend + historical interannual variability

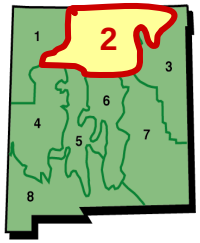


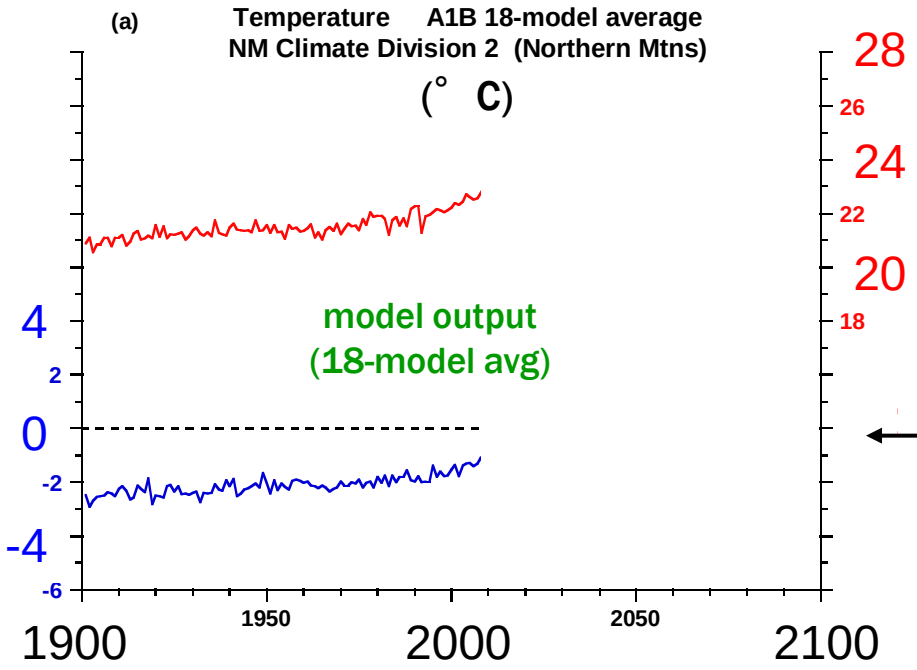
Gutzler & Robbins (2011)

Similar to USGCRP (2009) results

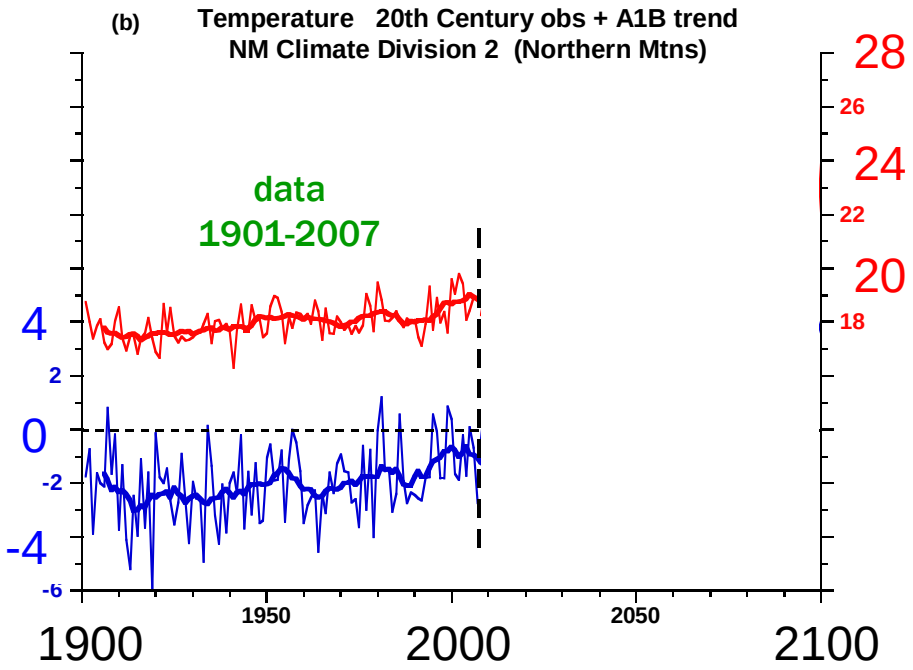
→ Implications of these changes for Palmer Drought Index values?

Projected Change
NM2 Temperature





← A1B-forced, 18-model average

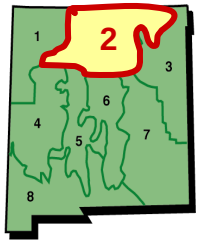


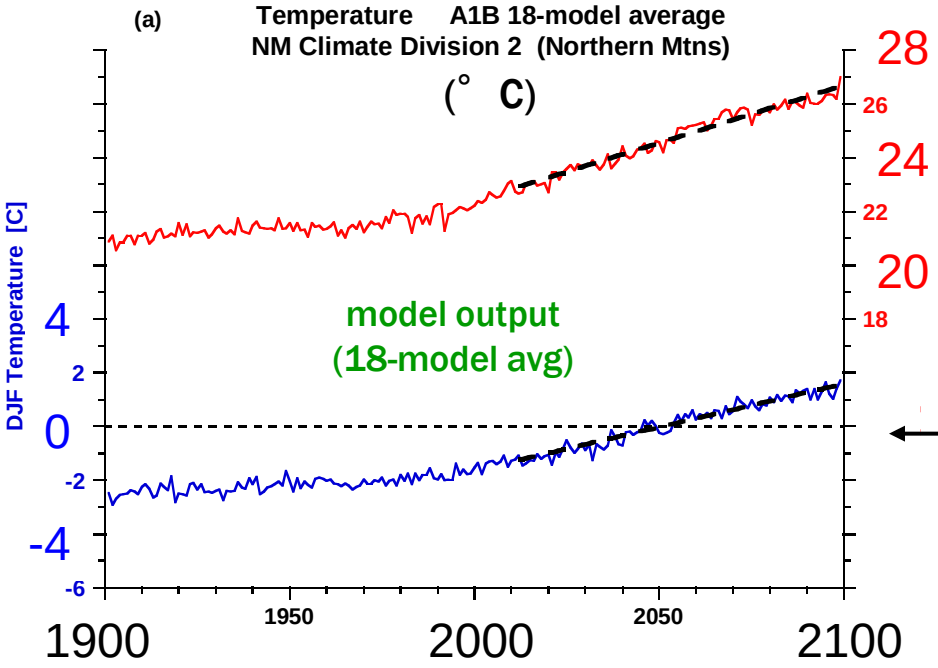
A data/model hybrid scenario:

a) 1901-2007: monthly data

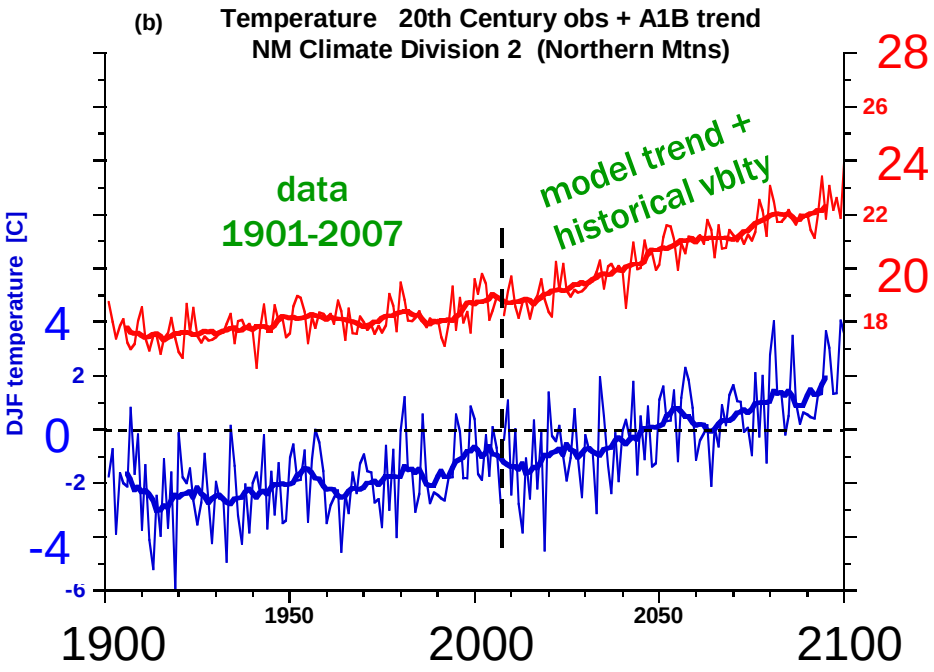
Gutzler & Robbins (2011)

Projected Change NM2 Temperature





← A1B-forced, 18-model average



A data/model hybrid scenario:

a) 1901-2007: monthly data

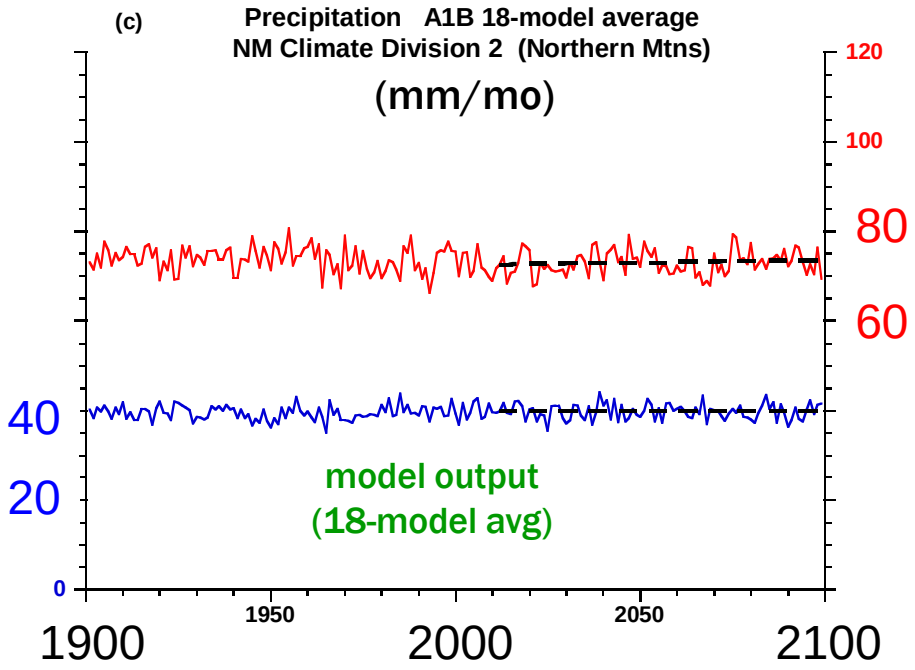
b) 2008-2100: sum of 3 terms:

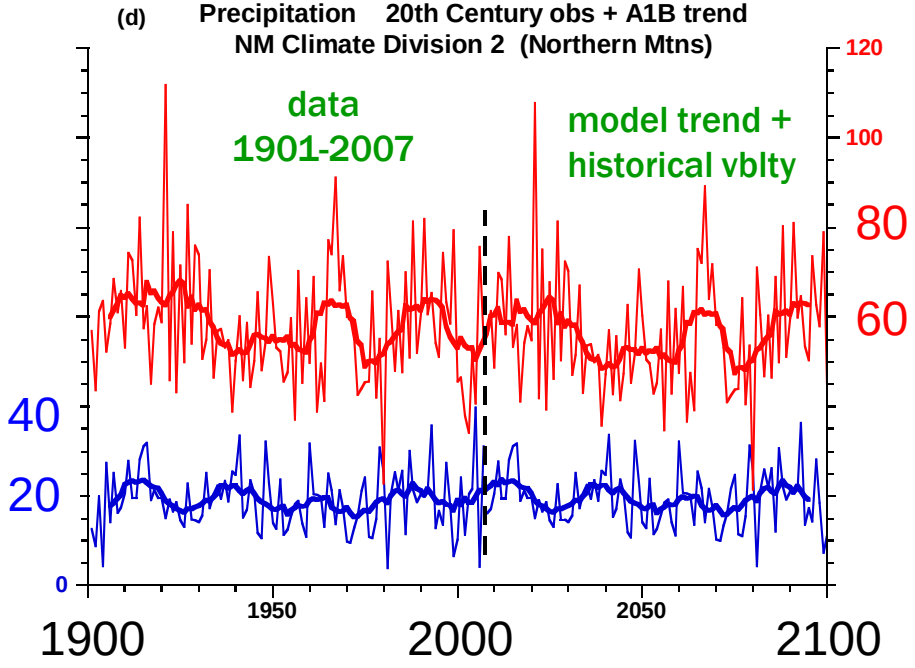
i) 1971-2007 climatology

ii) model-average linear trend

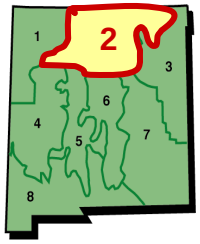
iii) interannual anomaly from data exactly 100 years earlier

Gutzler & Robbins (2011)





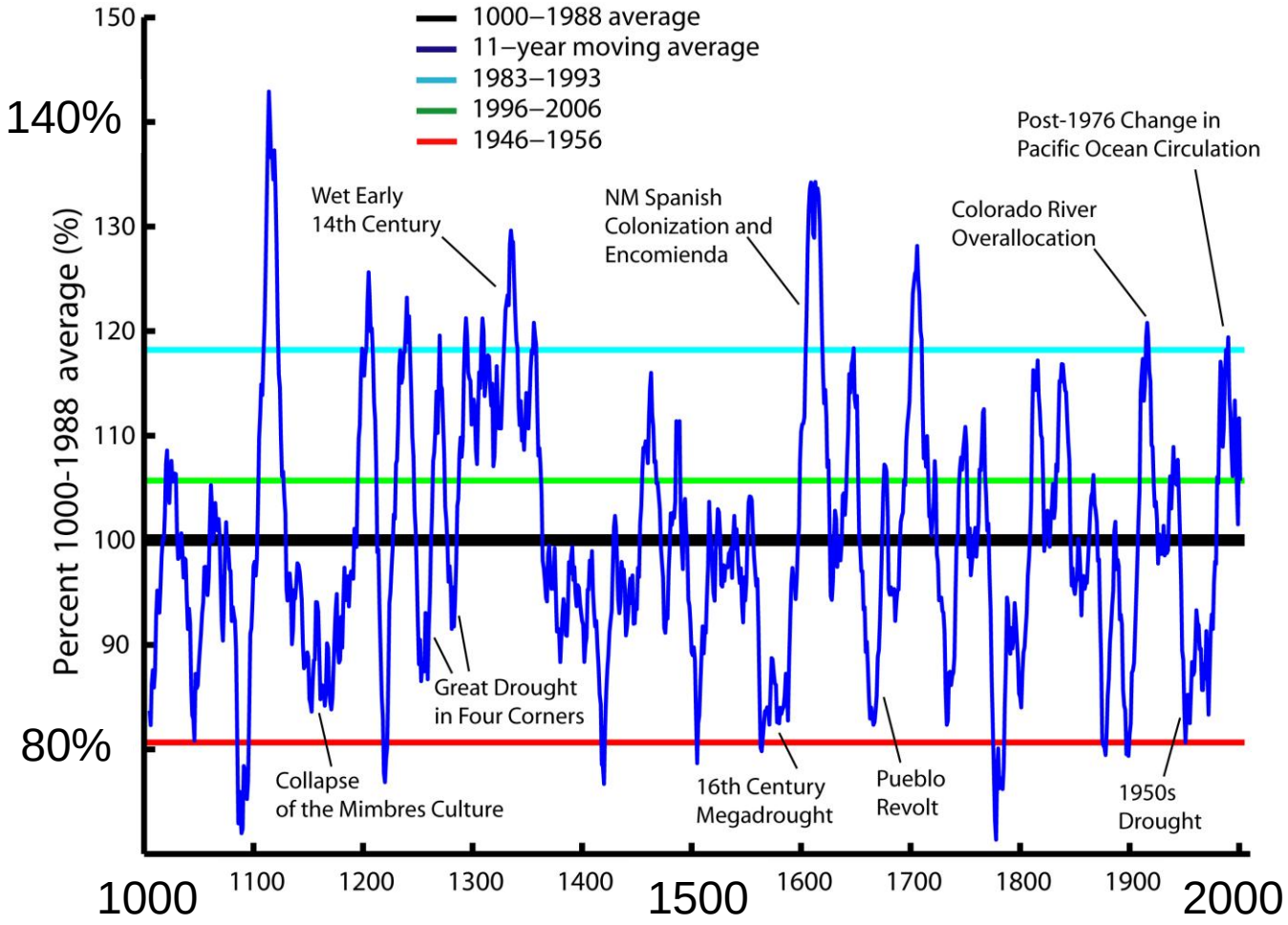
Projected Change NM2 Precipitation



Model-projected trends in precipitation are very small relative to observed interannual/decadal variability

Gutzler & Robbins (2011)

Proxy precipitation history of north-central New Mexico



based on tree ring data

NM Climate Division 2

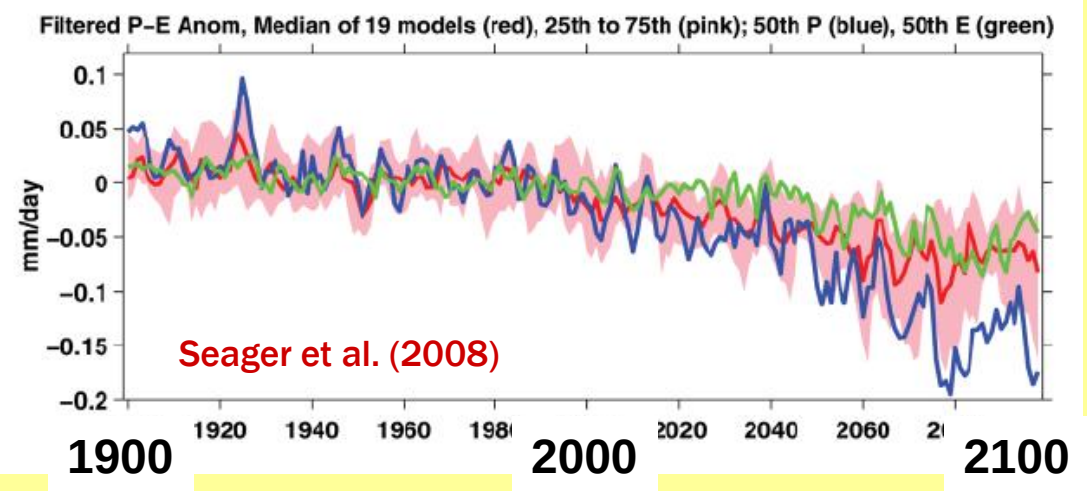
Taos Pueblo

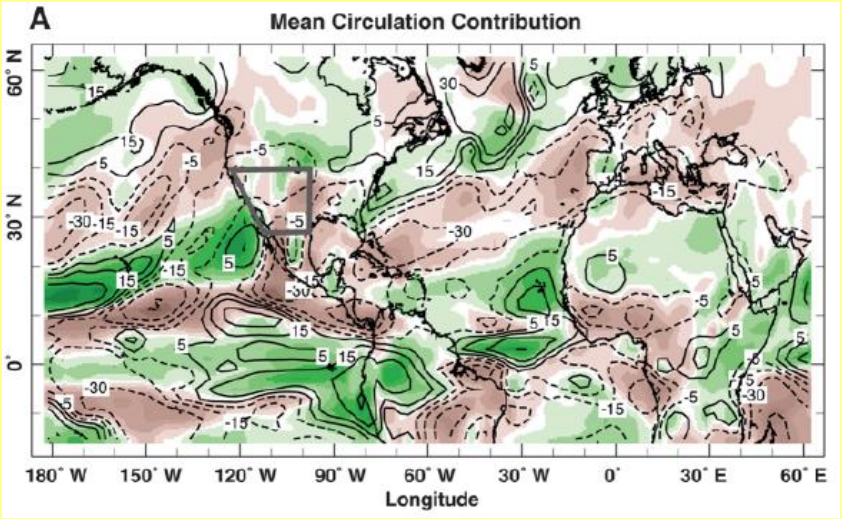
G. Garfin (U. Arizona)

The most prominent features in this data record are found in other SW climate records too

The projected "Drying of the Southwest"

Simulated P - E Anomaly



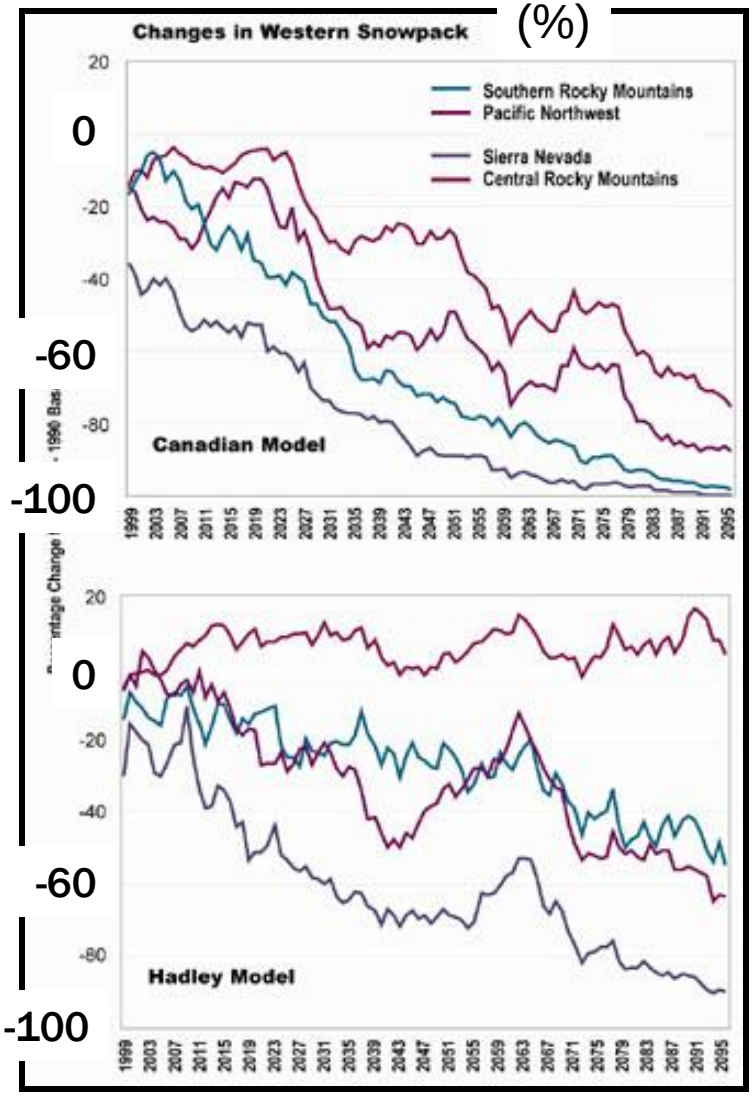


Global climate models predict a transition into a much more **arid** climate in the Southwest by the mid 21st Century

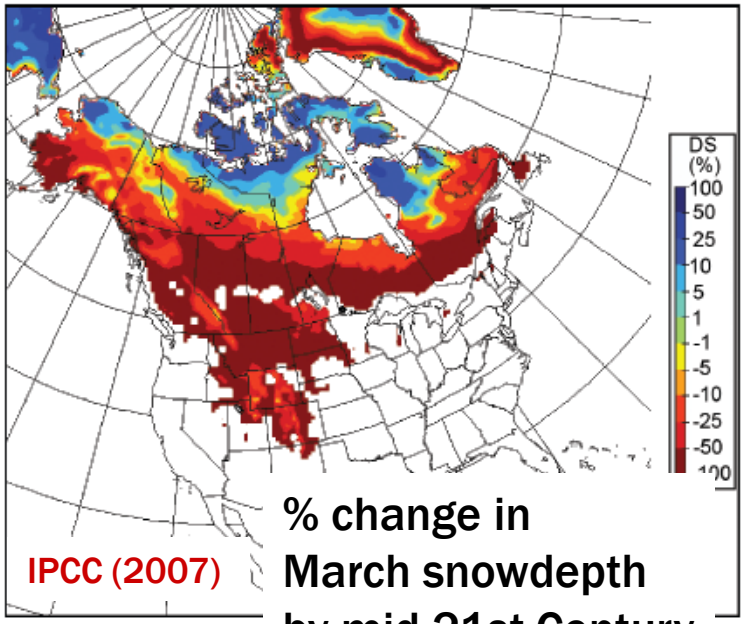
P – E becomes consistently negative (**drier surface**) by the latter half of this century in these simulations

E is a strong function of surface **temperature**

US GCRP (2000)



Projected change in western snowpack

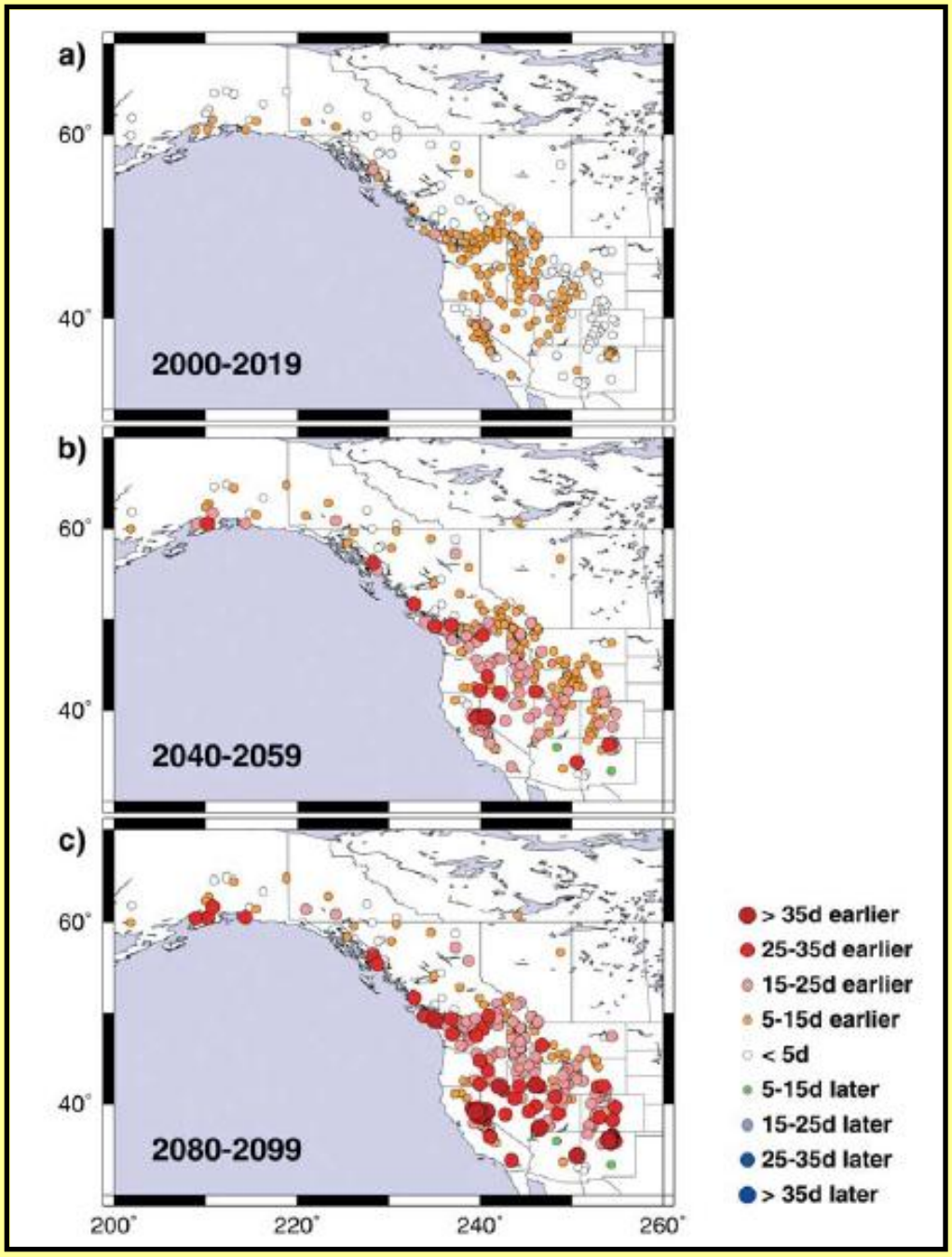


IPCC (2007)

% change in March snowdepth by mid-21st Century **A2** scenario

Decreases throughout western mountains are seen in climate model simulations

The decreases are due principally to temperature change (more rain, less snow)

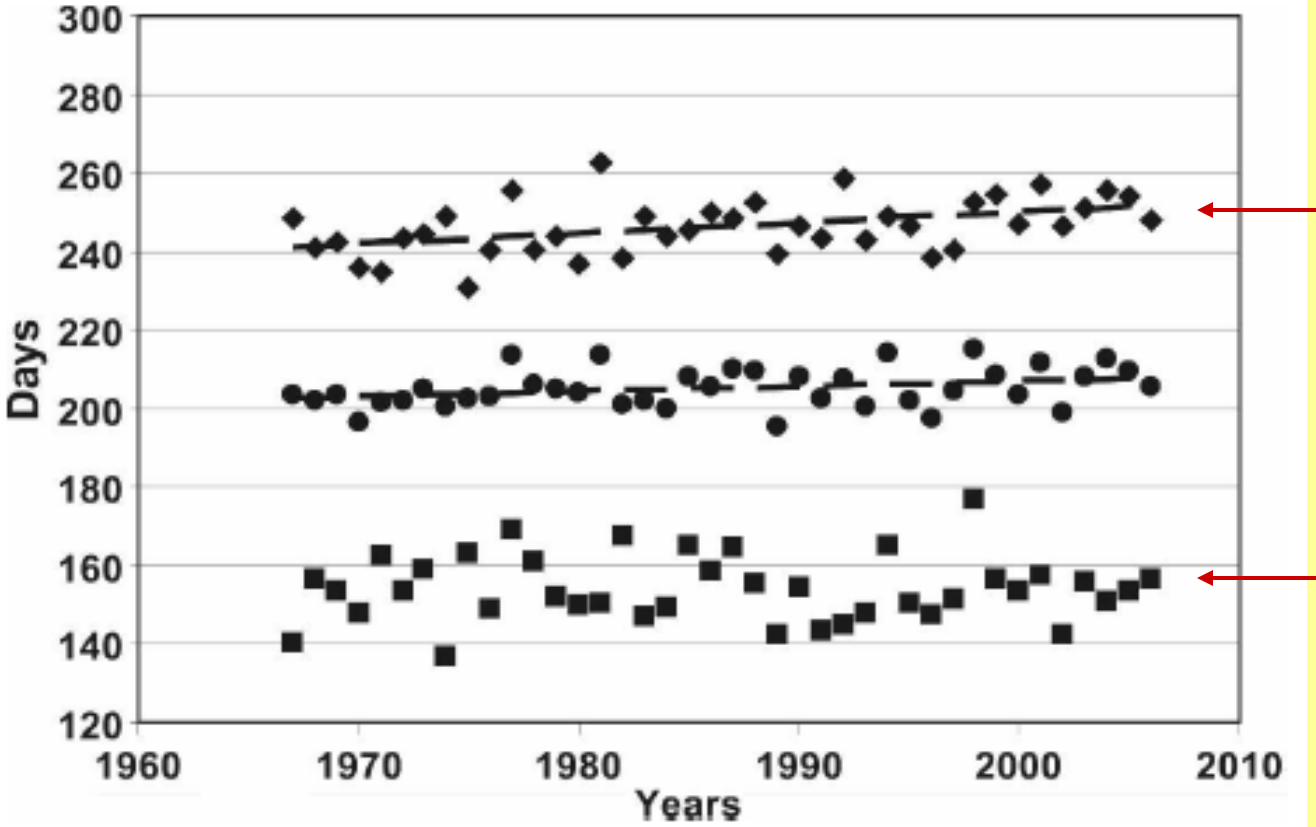


Projected change in snowmelt runoff timing

much earlier peak runoff date, driven by warmer temperature (less snow, warmer springtime temperatures)

Stewart et al. (2004)

Longer growing season (already observed here)



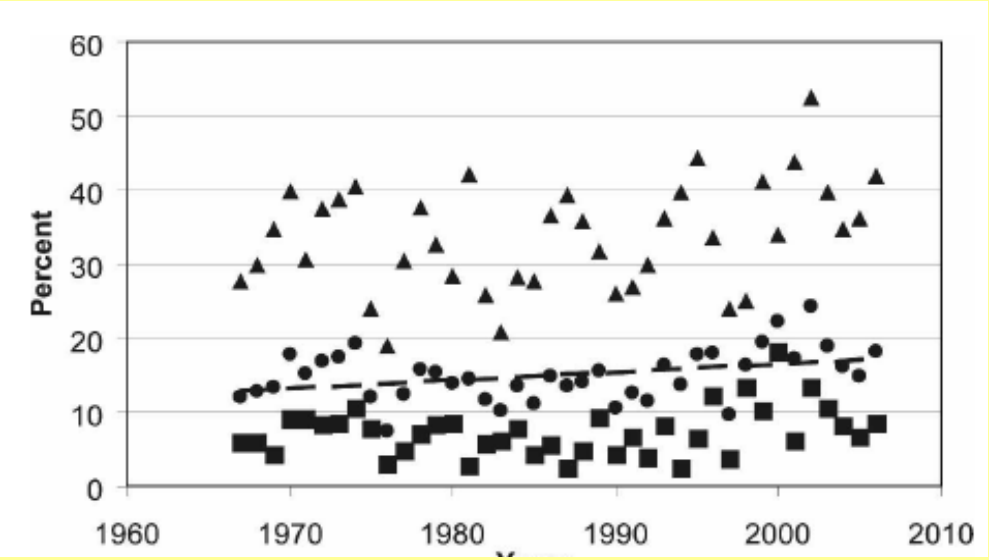
SW states

all 48 states

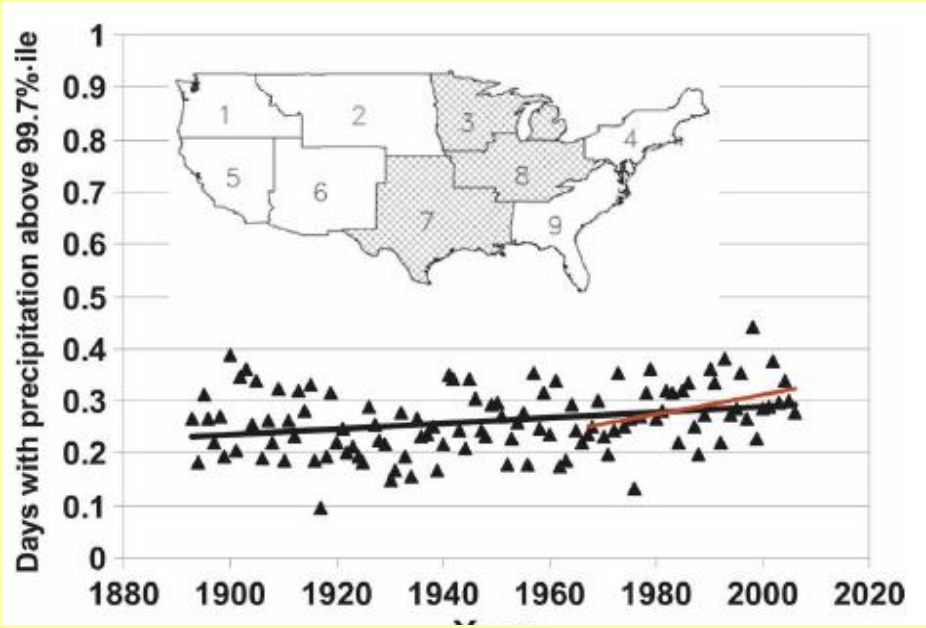
Groisman and Knight (2008)

Duration of the warm season
(avg daily T > 5° C)

Increasing *variability* of climate observations



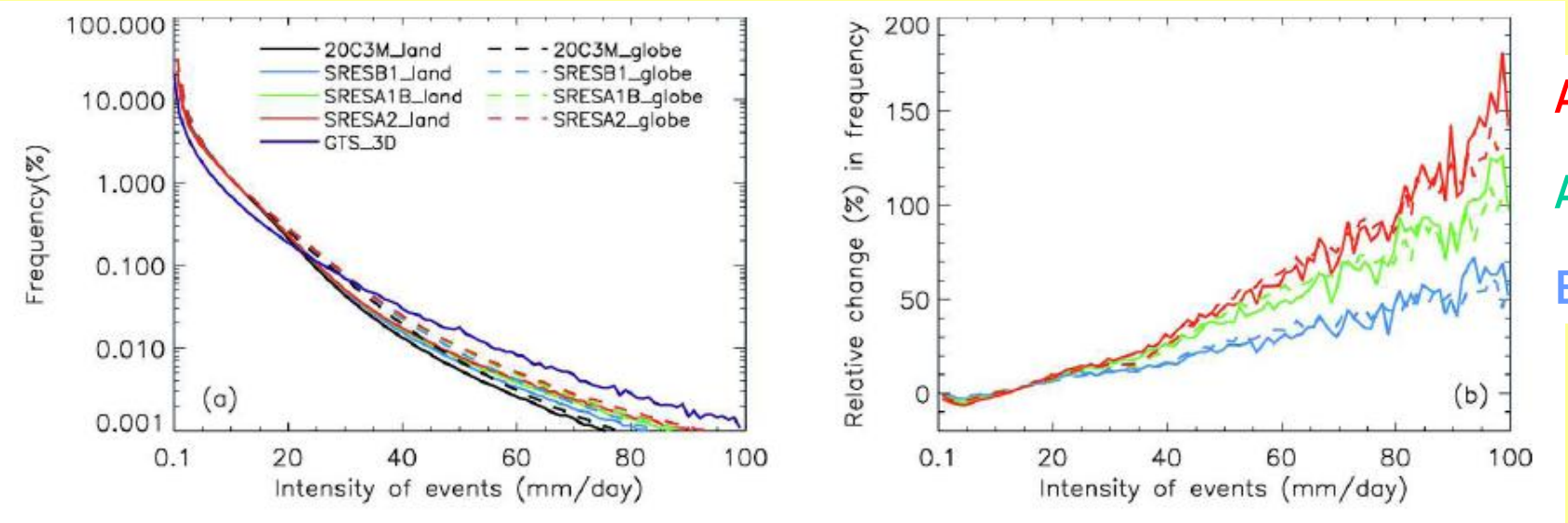
Probability of exceptionally long dry spells during the warm season (Southwest US)



Frequency of exceptionally heavy precipitation events (all 48 states)

Groisman and Knight (2008)

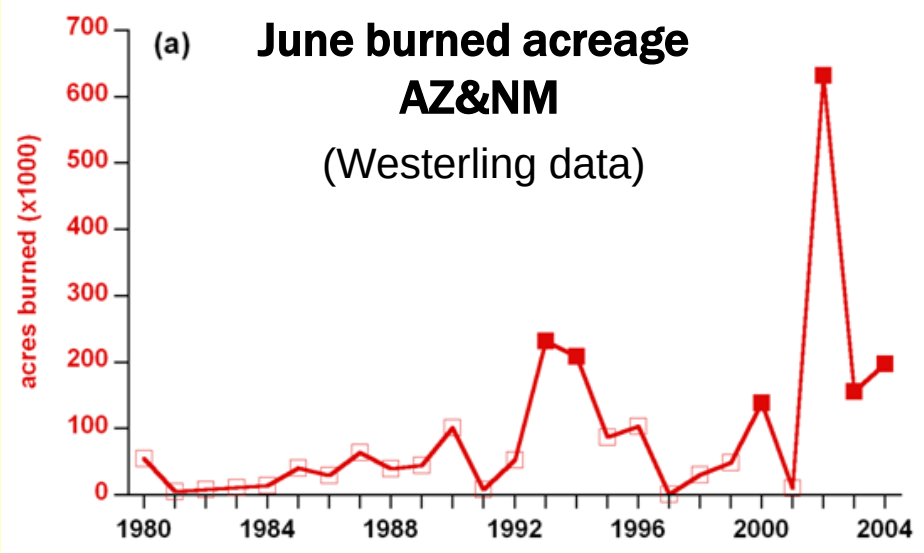
More intense precipitation in a warmer climate

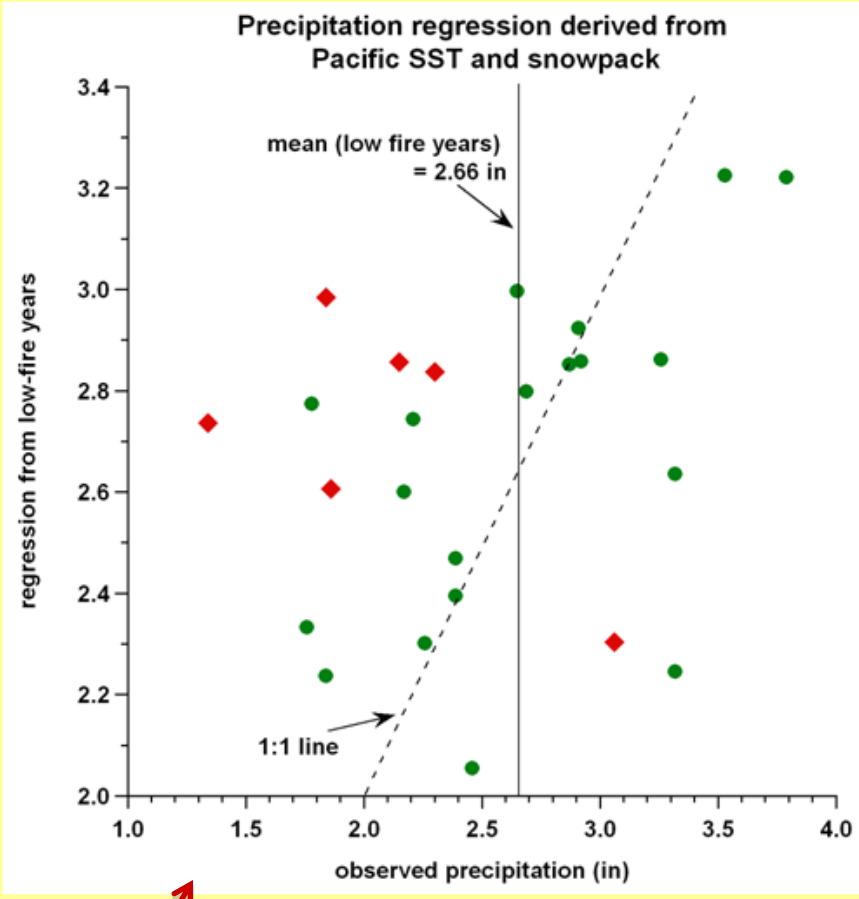


Sun et al. (2007)

Compared to simulations of current climate, global models generate fewer, but more intense, precipitation events as the climate warms up

Spring Wildfires and the Monsoon

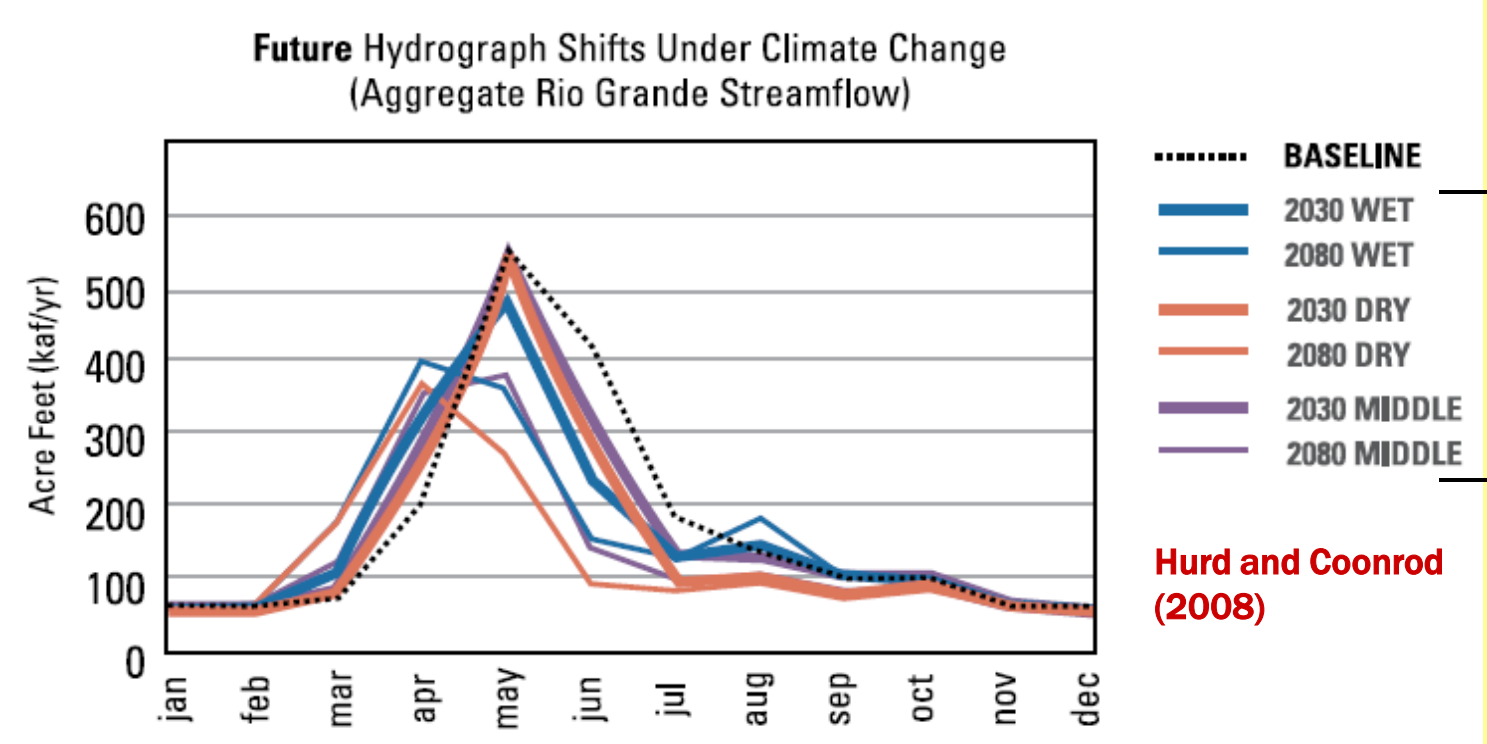




Gutzler & van Alst (2010)

* Many low-fire years, a few high-fire years
  (an upward trend?)
* Low-fire years don't affect the monsoon
  and snowpack/SST/monsoon relationship
  is significant
* High-fire years: monsoon is generally weaker

Present and Projected upper Rio Grande Streamflow



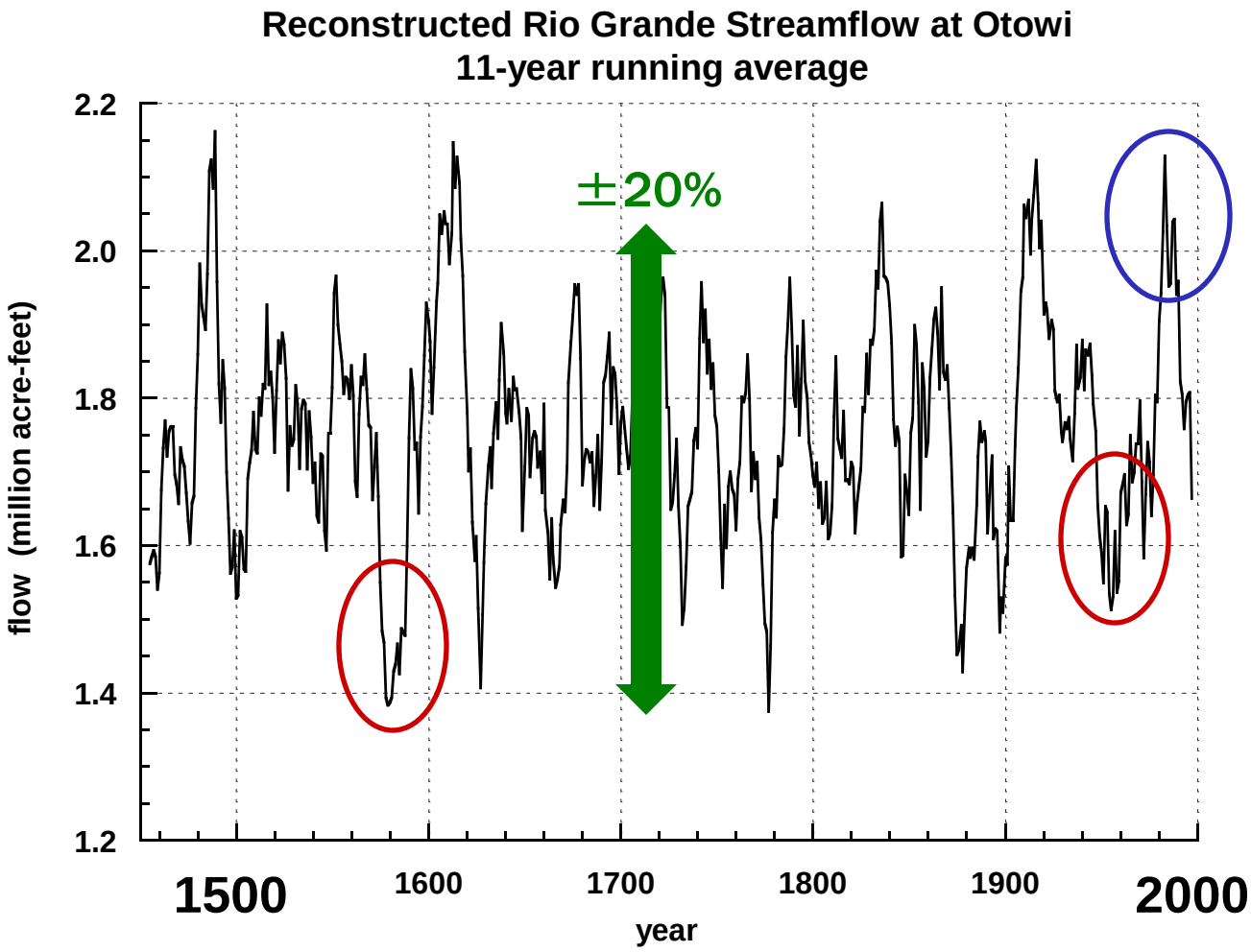
Snowpack currently feeds a late spring flood pulse on the upper Rio Grande and its tributaries
... providing base flow for the middle/lower river

In a warmer climate:

Earlier and smaller snow-fed flood pulse

Reduced total streamflow volume, especially in late spring/early summer
2030: 4 - 14% reduction
2080: 8 - 29% reduction

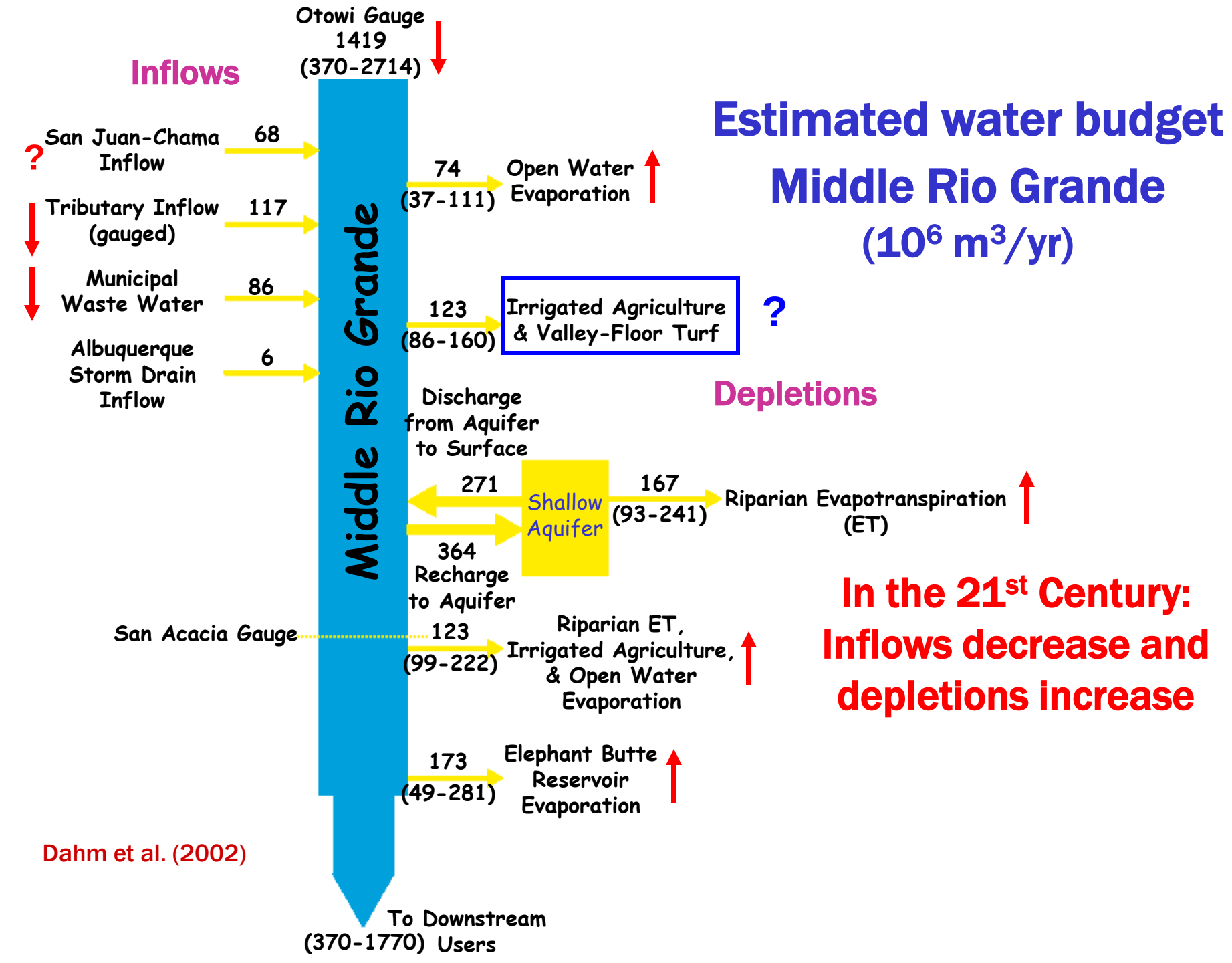
Proxy Rio Grande streamflow: Otowi gauge



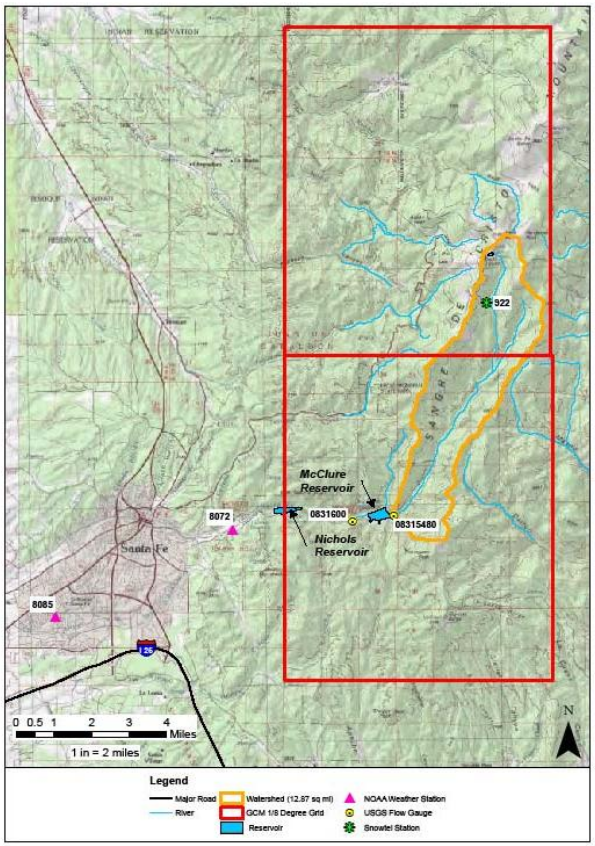
based on
tree ring data

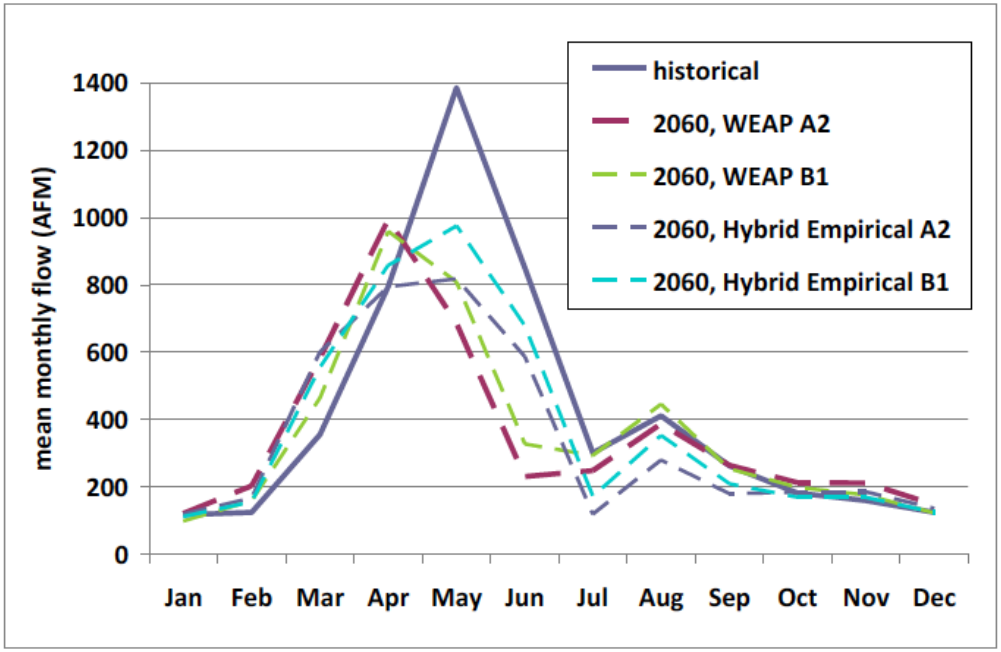
Otowi gauge

treeflow.org
Gutzler (2012)


Otowi Gauge
1419
(370-2714)
Inflows
San Juan-Chama Inflow
68
Tributary Inflow (gauged)
117
Municipal Waste Water
86
Albuquerque Storm Drain Inflow
6
Middle Rio Grande
74
(37-111)
Open Water Evaporation
123
(86-160)
Irrigated Agriculture & Valley-Floor Turf
?
Depletions
Discharge from Aquifer to Surface
271
Shallow Aquifer
167
(93-241)
Riparian Evapotranspiration (ET)
364
Recharge to Aquifer
San Acacia Gauge
123
(99-222)
Riparian ET, Irrigated Agriculture, & Open Water Evaporation
173
(49-281)
Elephant Butte Reservoir Evaporation
To Downstream Users
(370-1770)
Estimated water budget
Middle Rio Grande
(10^6 m^3/yr)
In the 21st Century:
Inflows decrease and
depletions increase
Dahm et al. (2002)

Santa Fe River streamflow projection





Cox et al. (2011)

Similar in many respects to the middle Rio Grande projection

Annual decrease in streamflow above McClure Res by 2060: **11-18%**

Discussion points

1) Earth is getting warmer – unequivocally
   New Mexico is getting warmer - significantly

   Precipitation trends are less clear, in data or projections
   Precip exhibits huge decadal fluctuations

2) Climate model projections of 21st Century climate show
   very large rates of warming
   …. with a lot of quantitative uncertainty
   Trend toward increased variability of weather & climate

3) Projected impacts: diminished snowpack
   (mostly temperature driven) lower streamflow
   much drier spring season, more wildfires
   more severe droughts

What Can You Do With This Information?

1) **Projections, not predictions**

   Count on warming (but how much and how variable?)

   … and direct consequences of warming (e.g. less snow)

   Precip-related projections are less certain

2) **Specific areas of high uncertainty**

   Summer precipitation trends

   Nonlinear thresholds (“tipping points”)

   Local expression of large-scale climate change