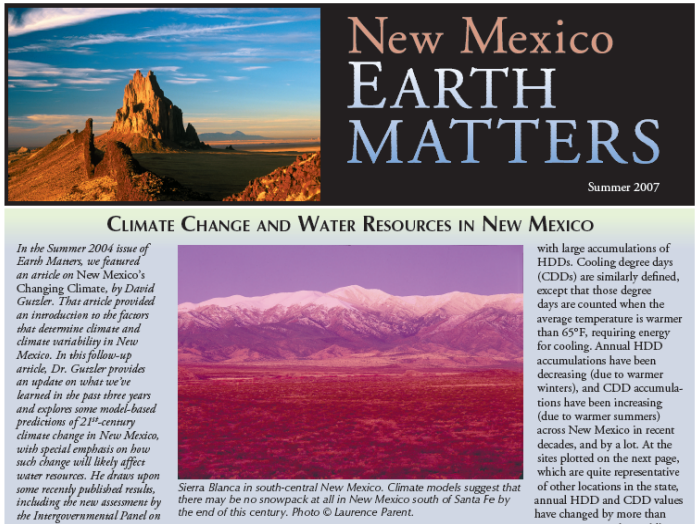


New Mexico EARTH MATTERS

Summer 2007

CLIMATE CHANGE AND WATER RESOURCES IN NEW MEXICO

In the Summer 2004 issue of Earth Matters, we featured an article on New Mexico's Changing Climate, *by David Gutzler. That article provided an introduction to the factors that determine climate and climate variability in New Mexico. In this follow-up article, Dr. Gutzler provides an update on what we've learned in the past three years and explores some model-based predictions of 21st-century climate change in New Mexico, with special emphasis on how such change will likely affect water resources. He draws upon some recently published results, including the new assessment by the Intergovernmental Panel on*

Sierra Blanca in south-central New Mexico. Climate models suggest that there may be no snowpack at all in New Mexico south of Santa Fe by the end of this century. Photo © Laurence Parent.

with large accumulations of HDDs. Cooling degree days (CDDs) are similarly defined, except that those degree days are counted when the average temperature is warmer than 65°F, requiring energy for cooling. Annual HDD accumulations have been decreasing (due to warmer winters), and CDD accumulations have been increasing (due to warmer summers) across New Mexico in recent decades, and by a lot. At the sites plotted on the next page, which are quite representative of other locations in the state, annual HDD and CDD values have changed by more than

Water and Drought in the 21st Century

Prof. David Gutzler

University of New Mexico

gutzler@unm.edu

POTENTIAL EFFECTS OF CLIMATE CHANGE ON NEW MEXICO

AGENCY TECHNICAL WORK GROUP
STATE OF NEW MEXICO
December 30, 2005

http://www.nmenv.state.nm.us/aqb/cc/Potential_Effects_Climate_Change_NM.pdf

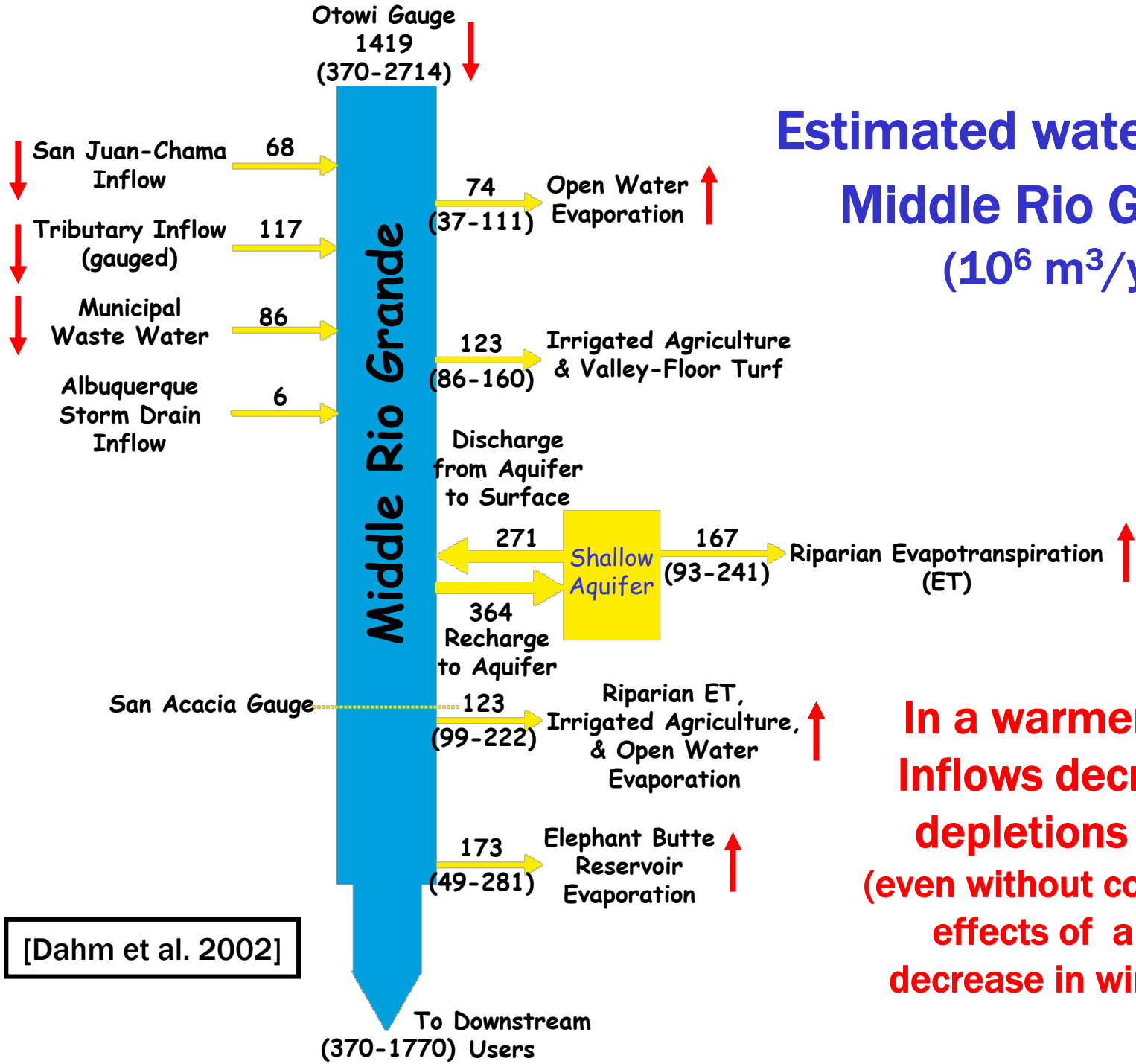
THE IMPACT OF CLIMATE CHANGE ON NEW MEXICO'S WATER SUPPLY AND ABILITY TO MANAGE WATER RESOURCES

New Mexico Office of the State Engineer/Interstate Stream Commission
John. R. D'Antonio, P.E., State Engineer

July 2006

http://www.nmdrought.state.nm.us/ClimateChangeImpact/completeREPORTfinal.pdf

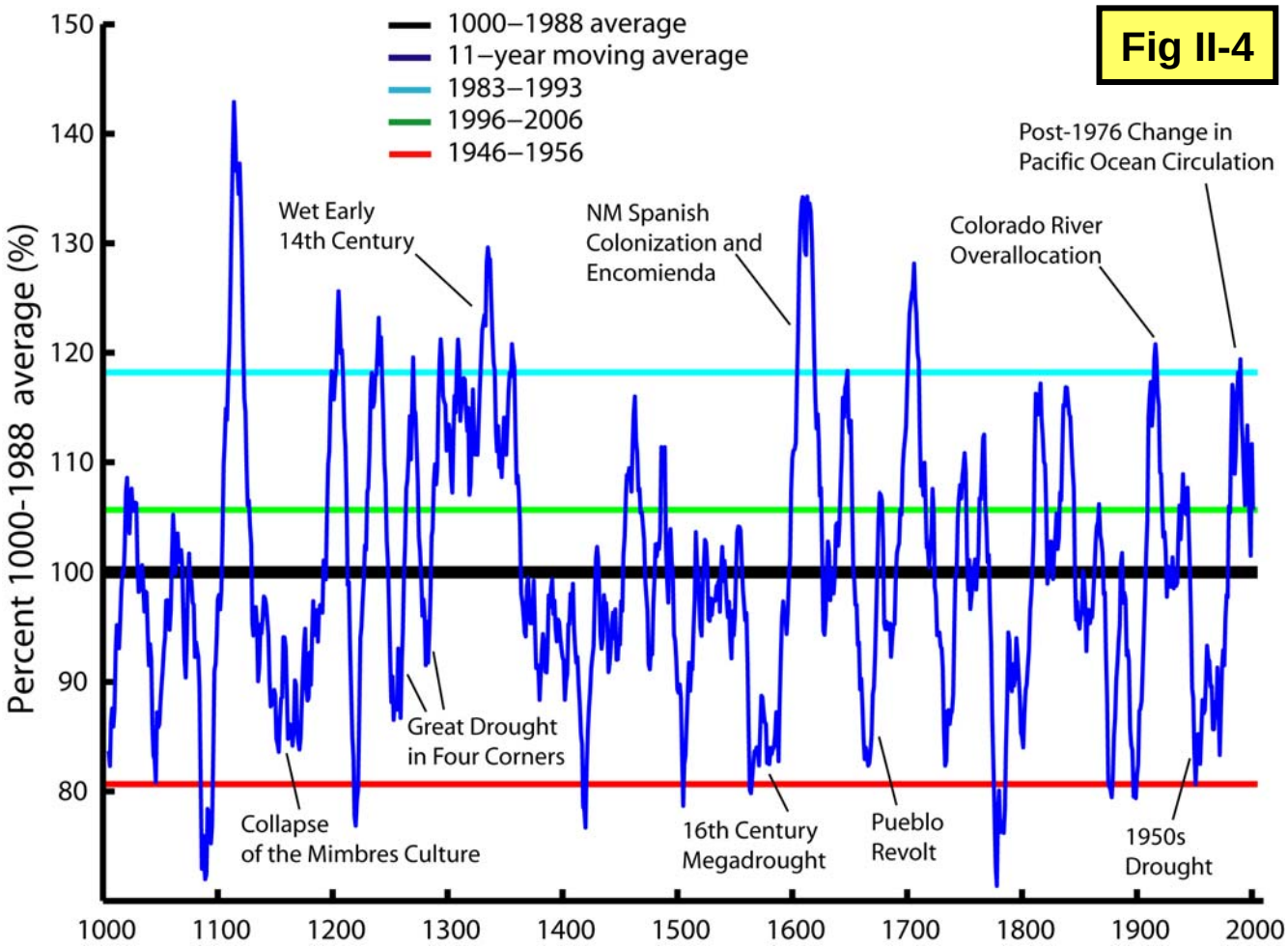
Estimated water budget Middle Rio Grande (10^6 m^3/yr)



[Dahm et al. 2002]

In a warmer climate: Inflows decrease and depletions increase (even without considering the effects of a potential decrease in winter precip!)

Proxy climate history of north-central New Mexico



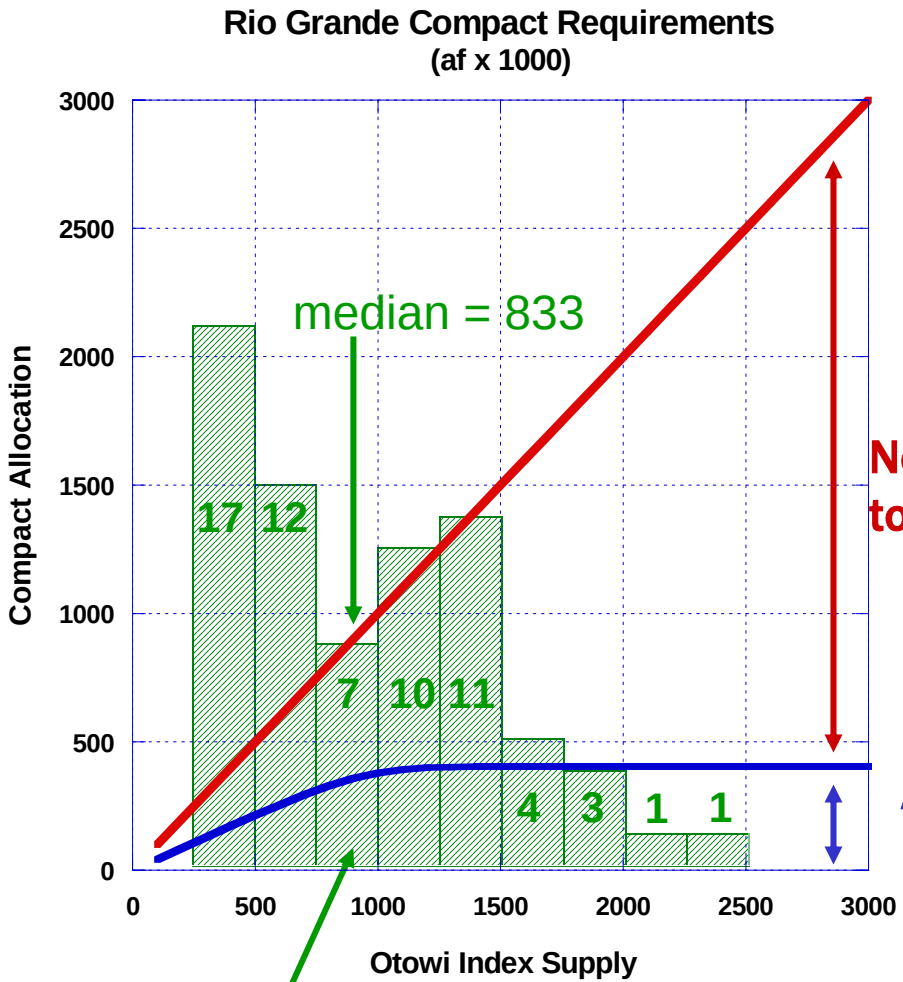
based on tree ring data

NM Division 2 (northern NM)

G. Garfin (U. Arizona)

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

Rio Grande Compact and Otowi Index Flow



Climate change is likely to shift the distribution of annual Otowi Index Flows toward lower values

New Mexico delivery obligation to Elephant Butte Reservoir

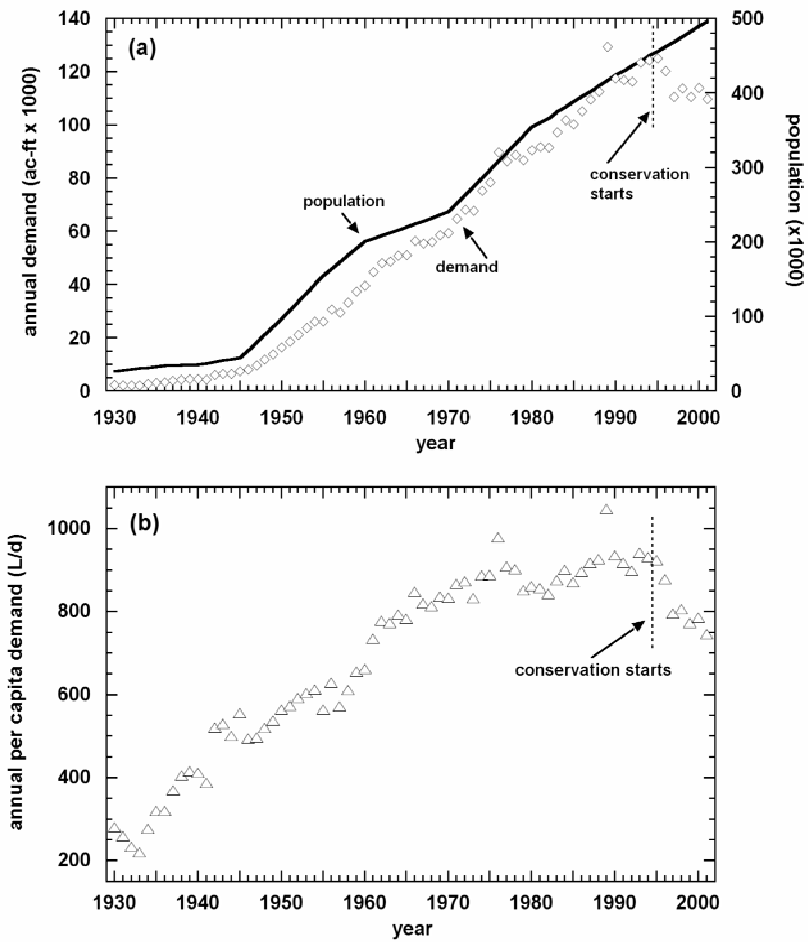
Available for depletion above Elephant Butte Dam

Hatching: Histogram of Observed Otowi Flows (1940-2005)

[data from NM OSE]

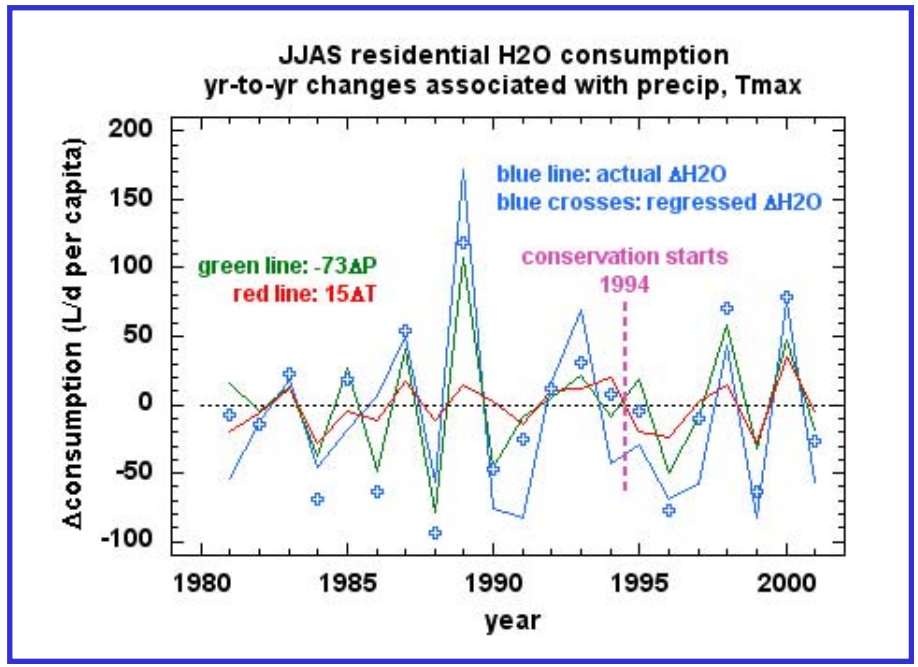
Water consumption in ABQ is sensitive to Temperature and Precipitation changes

Annual consumption since 1931



[Gutzler & Nims 2005]

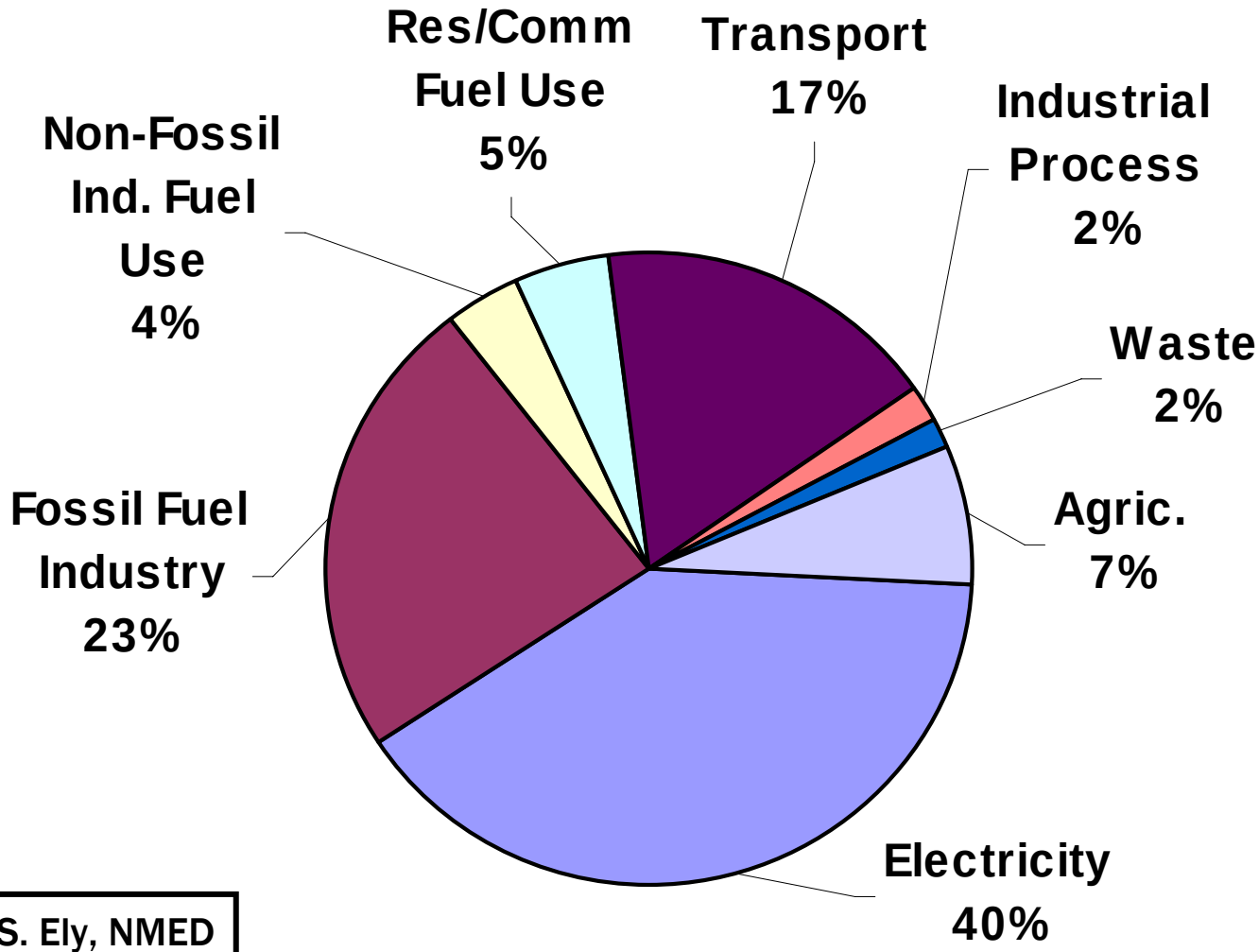
Summer residential consumption changes regressed onto T and P



1 mm/d precip change → 73 L/d change

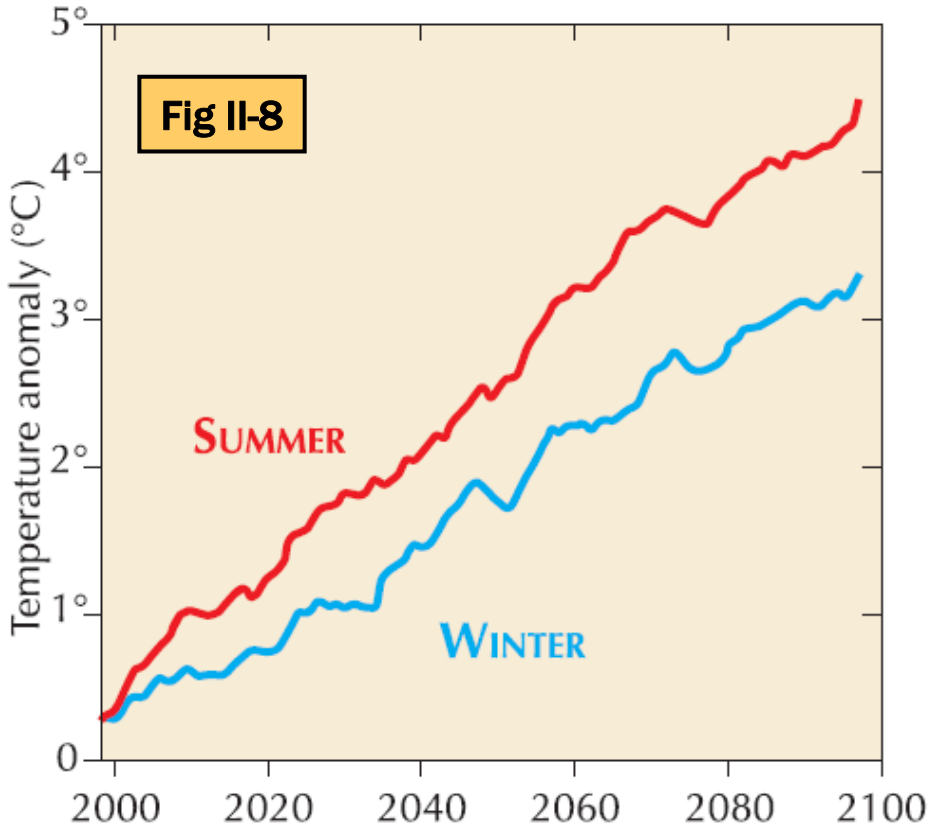
1°C T_{max} change → 15 L/d change

Greenhouse Gas Emissions by Sector (New Mexico)



S. Ely, NMED

Predicted 21st Century temperature
New Mexico statewide / mid-range emissions scenario



Simulated New Mexico temperature changes in the 21st Century, compared with model climatology (1971-2000)

The annual average 21st Century increase in these simulations is about 4°C, about four times the observed 20th Century temperature change

Temperatures are predicted to increase somewhat more rapidly in summer than in winter

Different rates of change are associated with other CO_2 scenarios, but the general warming trend is common to all predictions

Warmer temperatures would lead to less snowpack, drier soil and increased evaporation from reservoirs

Soil Moisture
March-April-May average

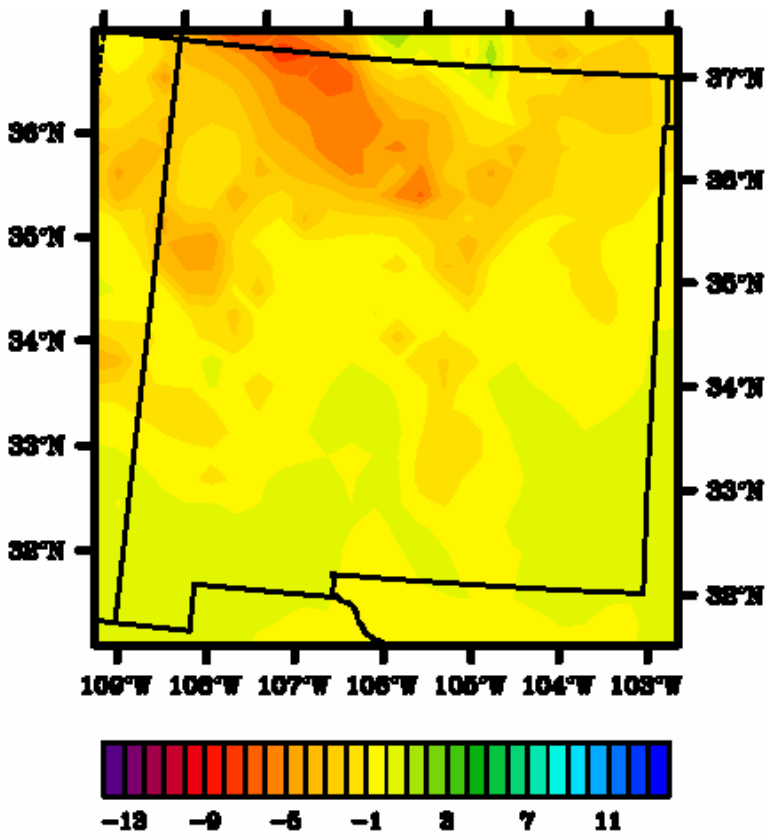


Fig II-14

Snowpack
March 1 average

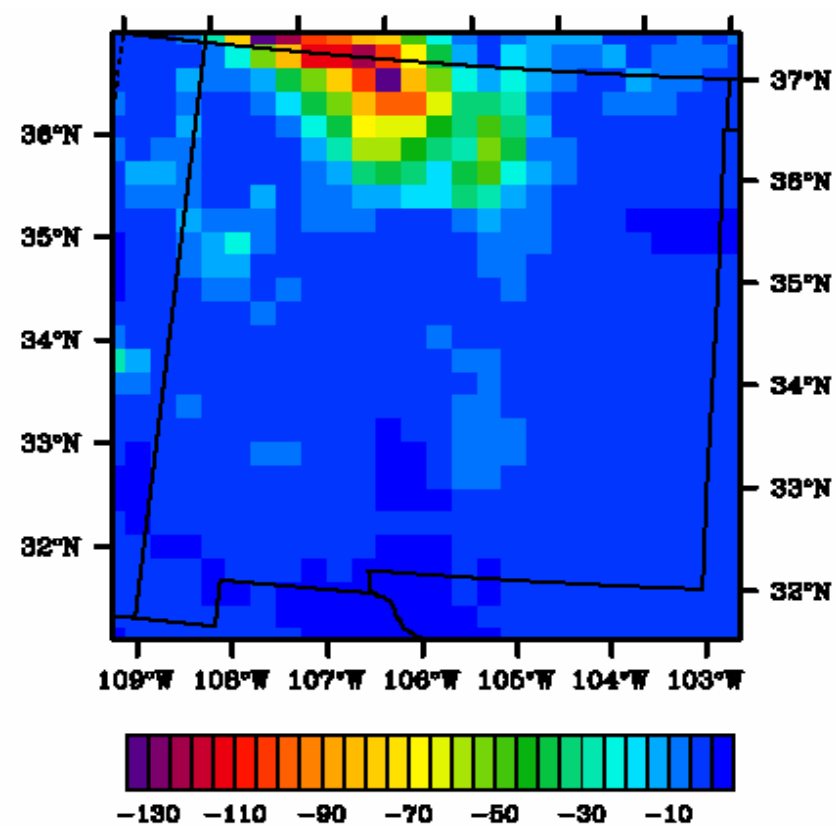


Fig II-13

Difference (2071-2095) - (1961-1985)

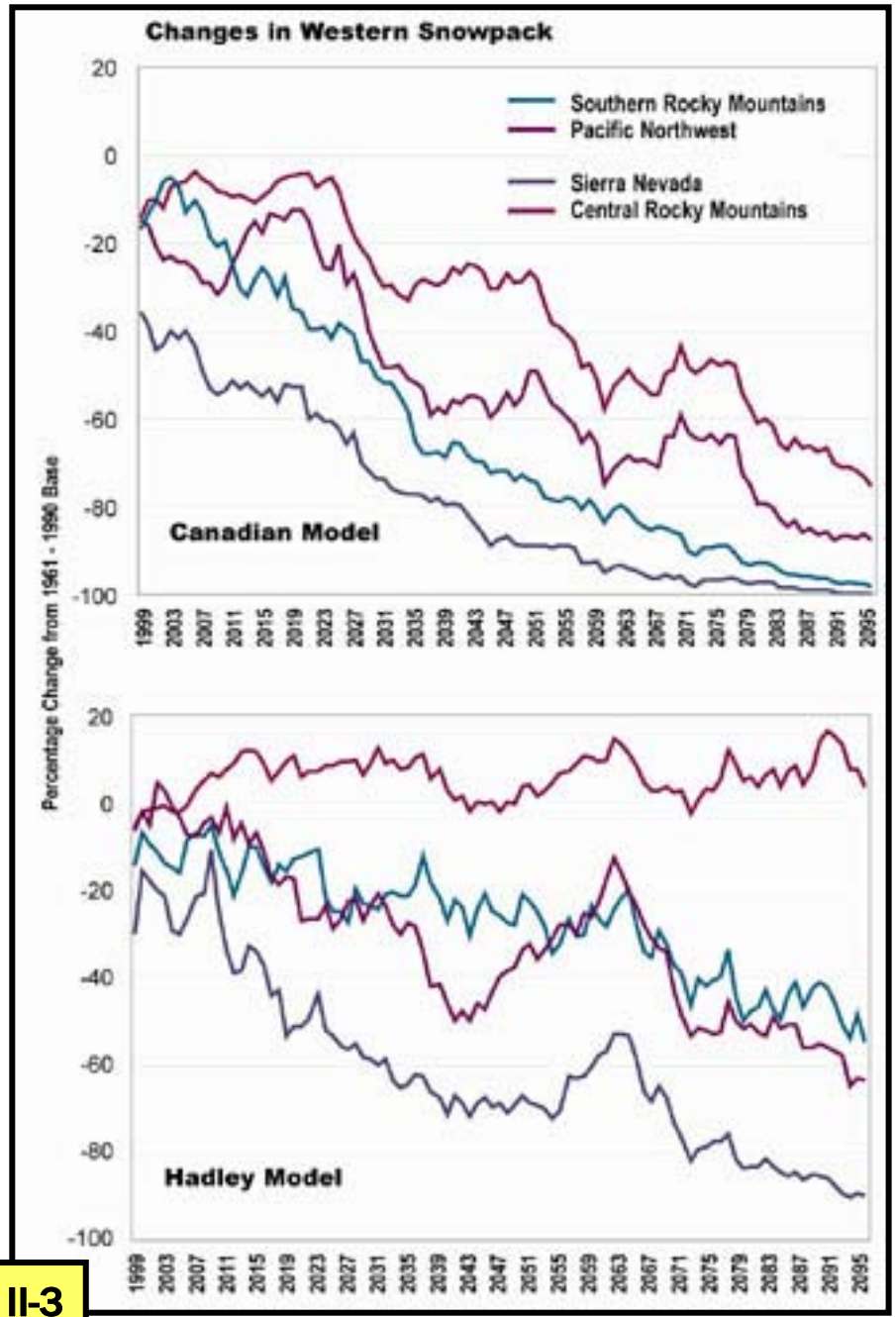


Fig II-3

Projected change in western snowpack

General decreases across the western mountains are seen in climate model simulations

The decrease is due principally to temperature change (more rain, less snow)

US GCRP (2000)

Projected change in snowmelt runoff timing

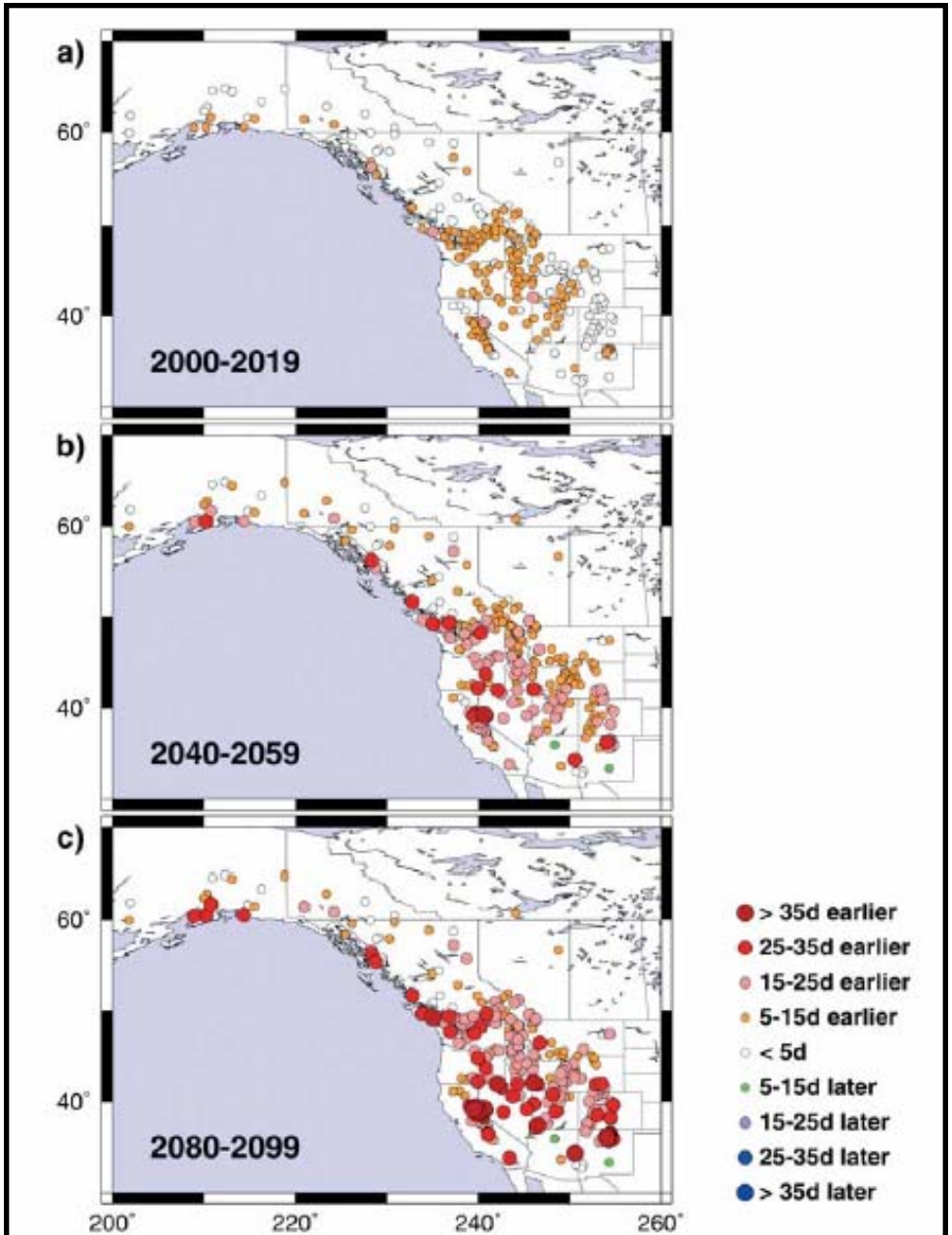
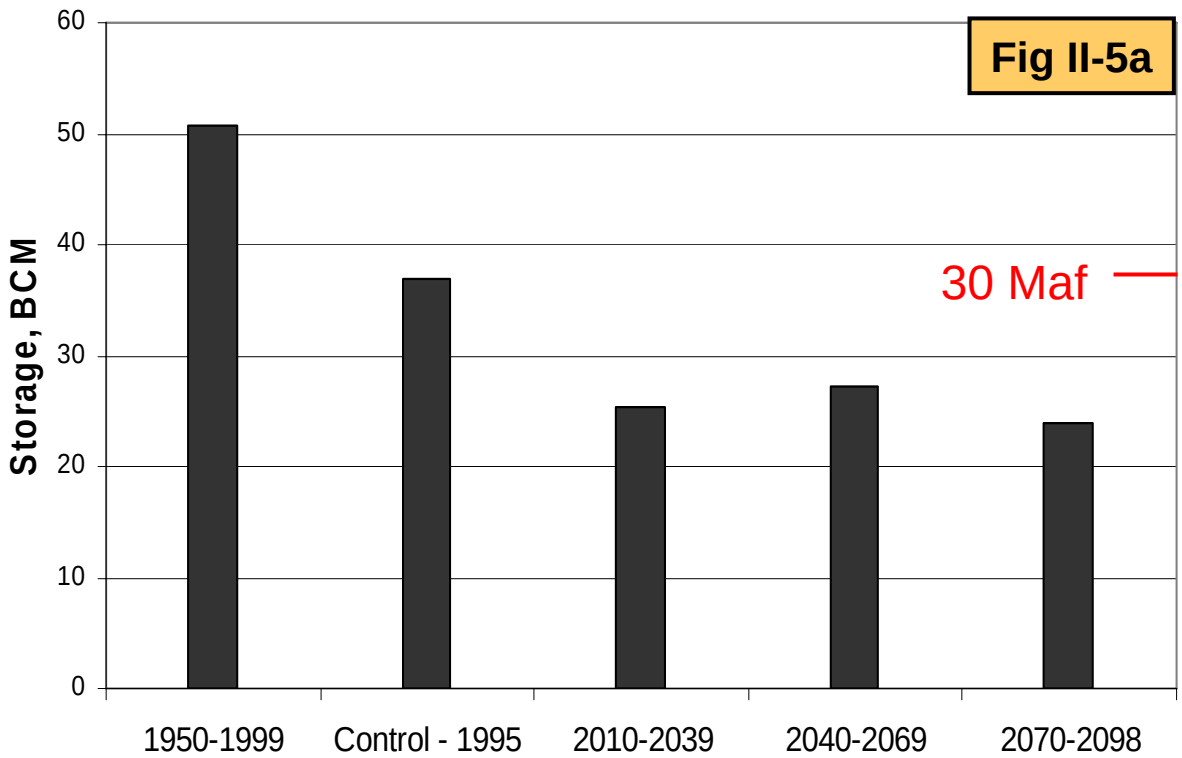


Figure 8. 20-year averages of projected changes in CT [days] as determined by regression with TI, and compared to the average CT using the 1951–1980 climatology. Projected CT is averaged over (a) 2000–2019, (b) 2040–2059, and (c) 2080–2099.

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

Stewart et al. (2004)

Predicted climate changes present a huge challenge for water management across the western U.S.



Projected changes in average total Colorado River Basin reservoir storage

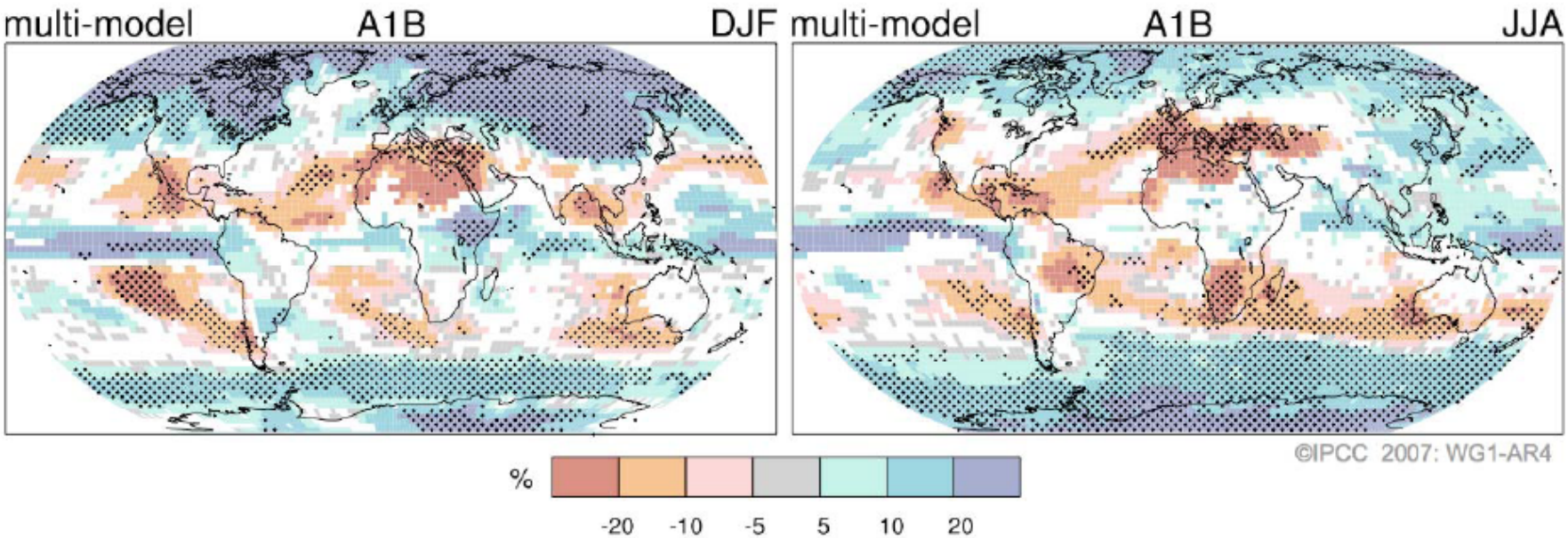
This model predicts less flow in the Colorado River, and a decrease of about 20% in reservoir storage.

No similar study has been carried out yet for the Rio Grande basin.

A statewide group of New Mexico scientists is proposing to examine this issue next year.

[Christensen et al. 2004]

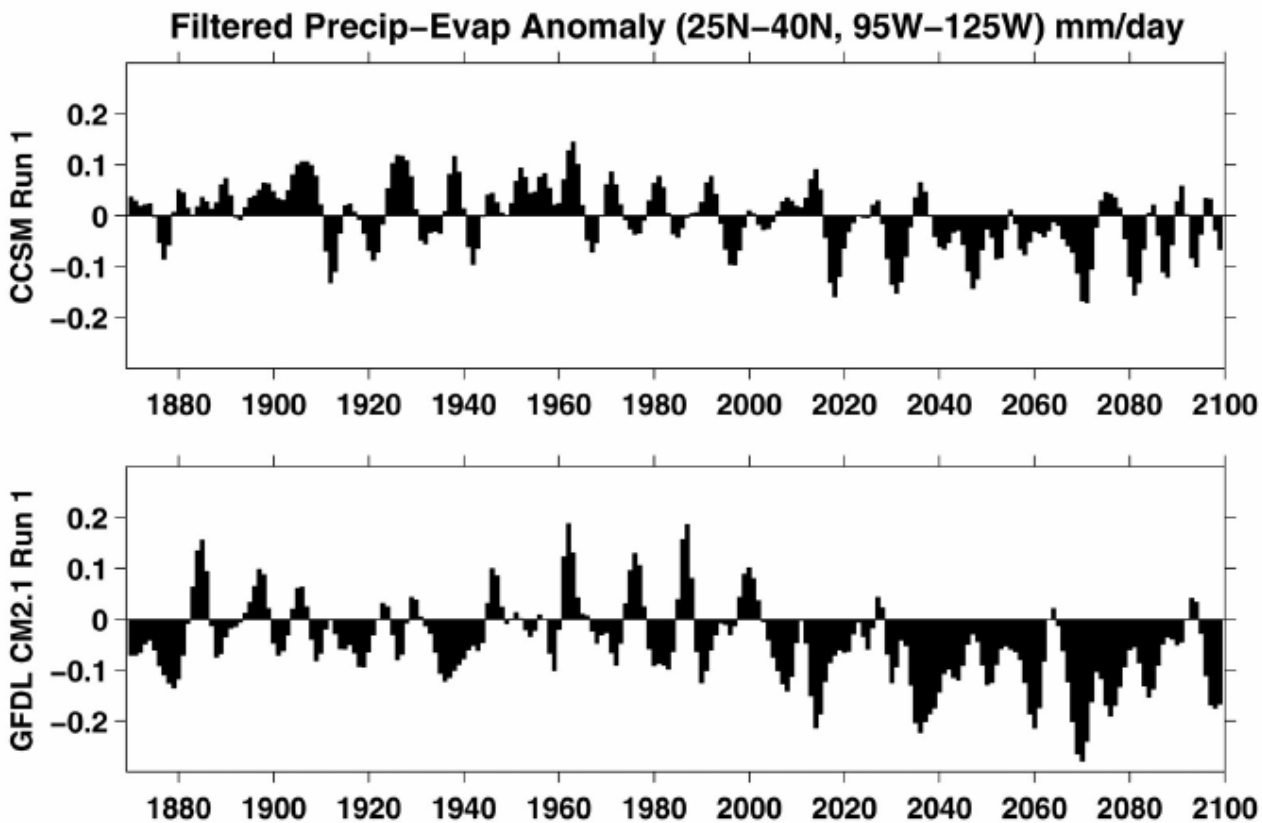
Predicted precipitation changes in late 21st Century



More precipitation near equator and in mid-latitude storm tracks
Less precipitation in subtropical latitudes
... Essentially an expansion of the Hadley Circulation

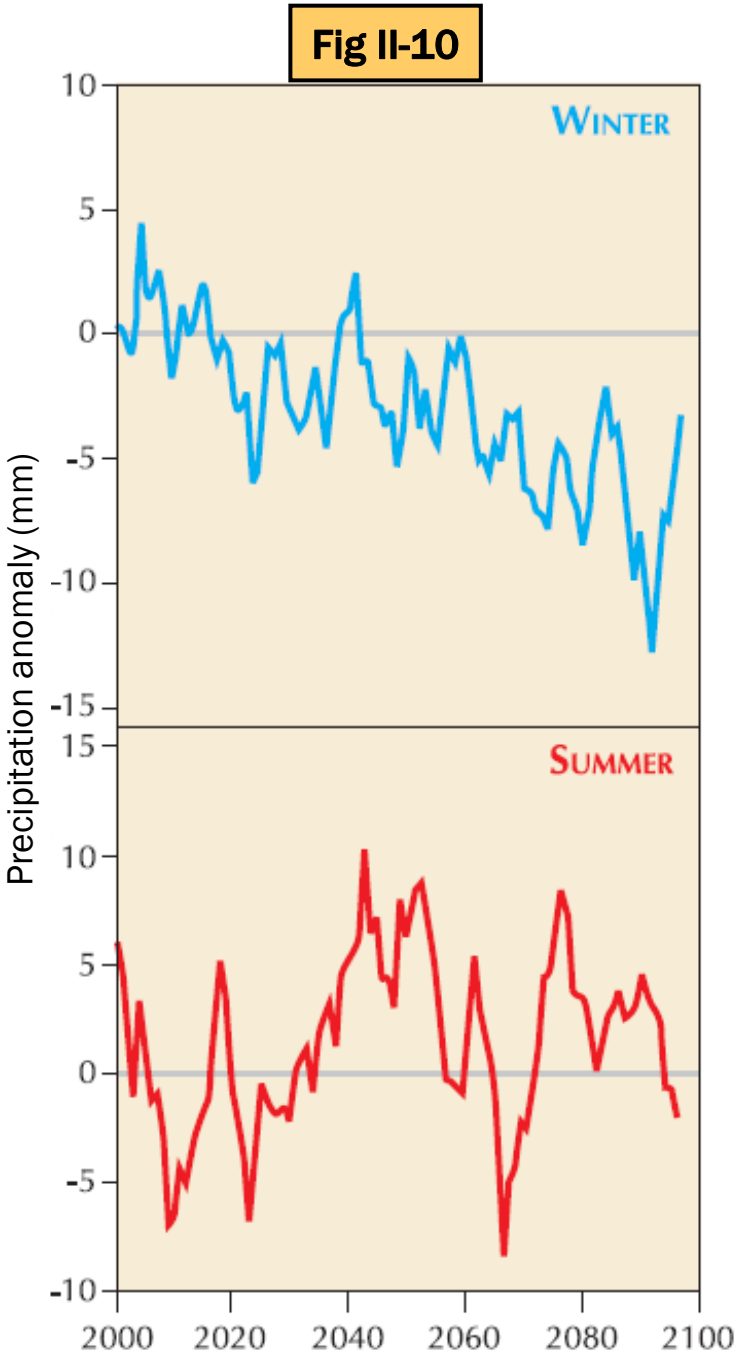
IPCC (2007)

Predicted precipitation changes in late 21st Century American Southwest



Climate change models predict a transition into nearly perpetual drought by the second half of the 21st Century

Seager et al. (2007)



Predicted 21st Century precipitation NM statewide

Interannual and decadal variability of precipitation is large relative to climate trends … but current models suggest a decrease in winter precipitation. If this downward trend in winter precipitation occurs as predicted, the Southwest would face a "permanent megadrought".

Regardless of trends, we must anticipate that intermittent drought episodes will continue to occur and prepare to cope with more severe drought in a warmer climate.

Simulated NM seasonal precipitation changes in the 21st Century, compared with model climatology (1971-2000)

Principal Conclusions:
Climate Change and New Mexico's Water Resources

- Significant warming trends are already clearly observed across the state. We can confidently predict that additional warming will continue, probably at an accelerated rate of change.
- Warmer temperatures will lead to higher rates of water consumption, reduced snowpack, less and earlier spring runoff, more evaporation from open water, and drier soil conditions. Each of these changes acts to diminish streamflow and exacerbate drought.
- Predictions of precipitation trends are less certain. However the most recent climate change simulations suggest that winter precipitation may decrease, perhaps substantially. Regardless of trends, we know that New Mexico precipitation is subject to large decadal drought and wet spells. These swings are likely to become more extreme in the 21st Century.
- Predicted climate changes would lessen the availability of surface water, but increase the demand for that water, during the next century.

Some questions for discussion

- How should we allocate surface water resources within the state, assuming a projected decline in snow-fed river flows and increased evaporation from reservoirs?
- How will New Mexico negotiate the projected overallocation of 21st Century river flows under existing interstate stream compacts?
- How should water availability factor into planning for new housing and economic development?
- How much value will we place on water for in-stream flows and agriculture?
- What is our plan for getting through severe droughts in the 21st Century?
- What is our plan for managing the depletion of groundwater resources?
- Are there sustainable new sources of fresh water that we could develop?
- What should New Mexico's energy policy be, considering the links between water, energy and national energy/water policies?
  - How can we ensure adequate energy for in-state use as the climate warms? (what sources, expanded supply vs aggressive conservation, …)
  - Should we support development of energy production for export?
  - What is the best role for NM to play in national energy/water policy development?