Upper Lake Mary: Lake Level Response to Climate Variability

Talia Anderson, Connie Woodhouse, Dan Ferguson

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THE UNIVERSITY OF ARIZONA
CLIMAS Climate Assessment for the Southwest
NOAA RISA Regional Integrated Sciences and Assessments

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5. What are the characteristics of ULM droughts?

Data used in analyses

Upper Lake Mary Lake Levels	Years	Units
ULM Inflow Report	1960 – 2018	Lake level maximums, minimums, and no production minimums
Precipitation		
PRISM gridded data for Rio de Flag and Walnut Creek Watersheds	1895 – 2017	Monthly sums
Temperature		
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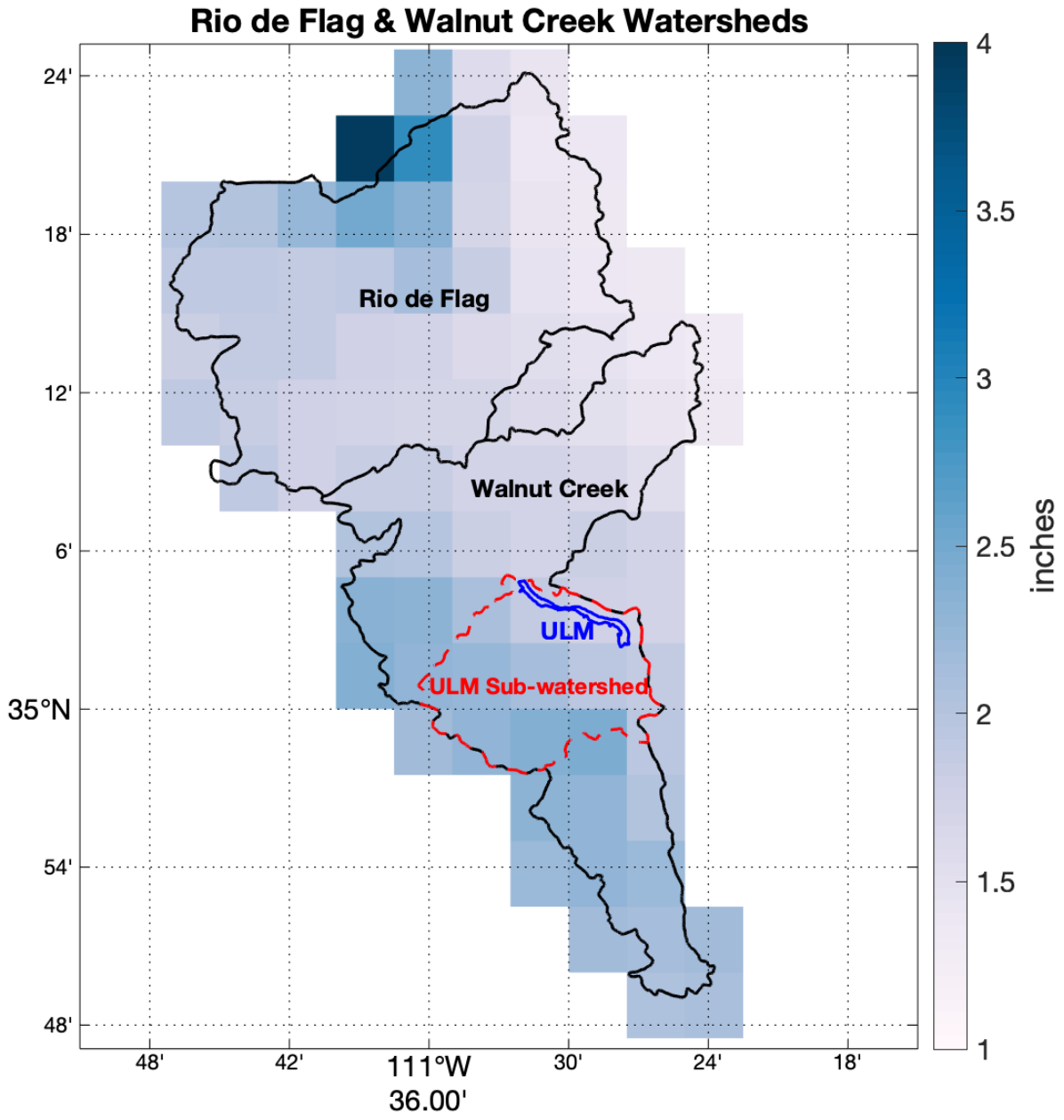
Snow Water Equivalent		
Fort Valley Snow Course (ID 11P02; HUC 150200150102)	1947 – 2018	March 1 SWE

Description of Study Area & Climate

Upper Lake Mary (ULM) Stats – 1960 to 2018	
Maximum Possible Volume	16,300 acre feet (100% full)
Maximum Lake Level Mean	10,459 acre feet (64% full)
Minimum Lake Level Mean (no production)	7,489 acre feet (46% full)
Absolute Minimum Lake Level (production included)	374 acre feet (2.3% full in 1978)
Absolute Minimum Lake Level (no production)	71,614 acre feet (9.9% full in 2003)
Years ULM has reached Max Possible Volume	15 years (100% full at highest spring levels)



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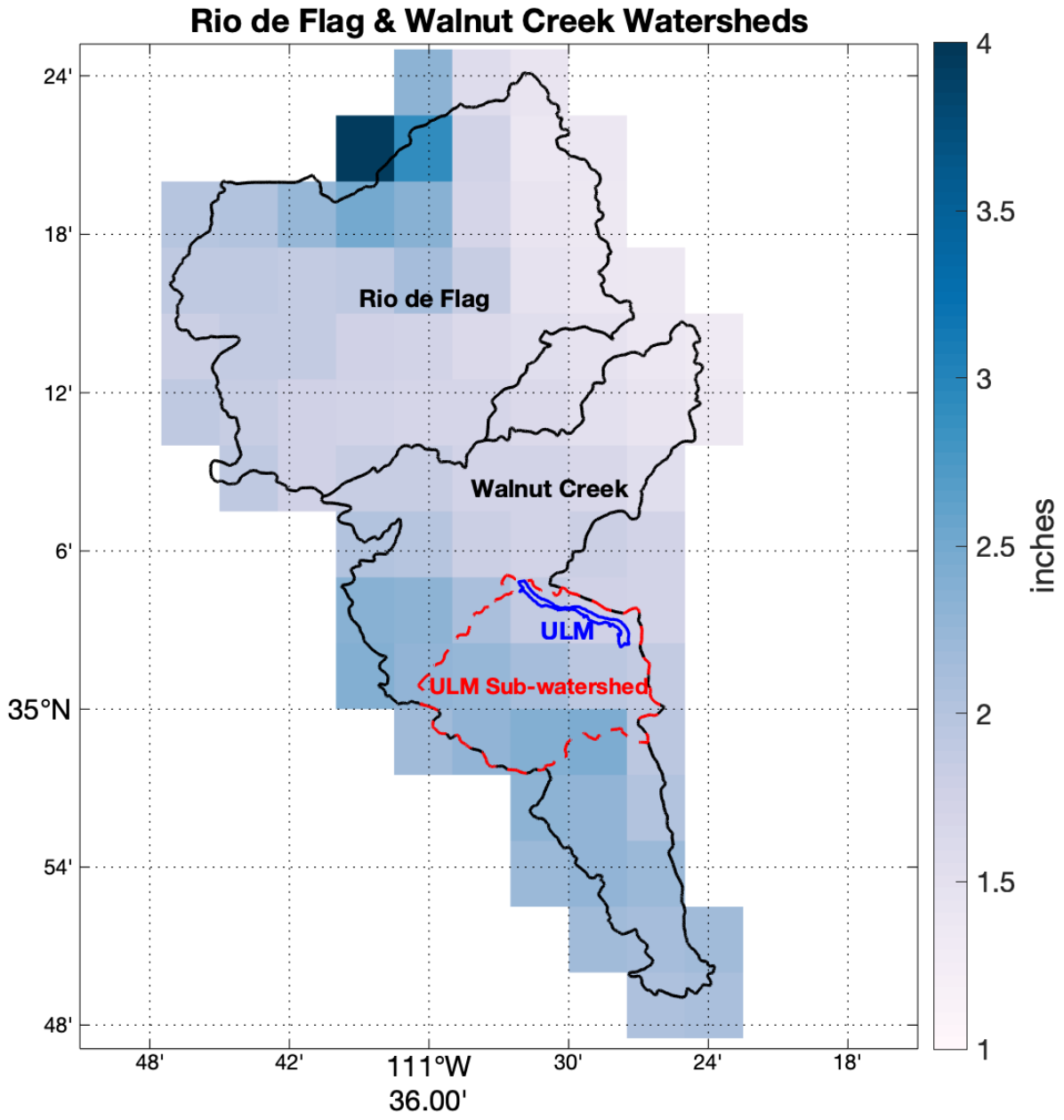

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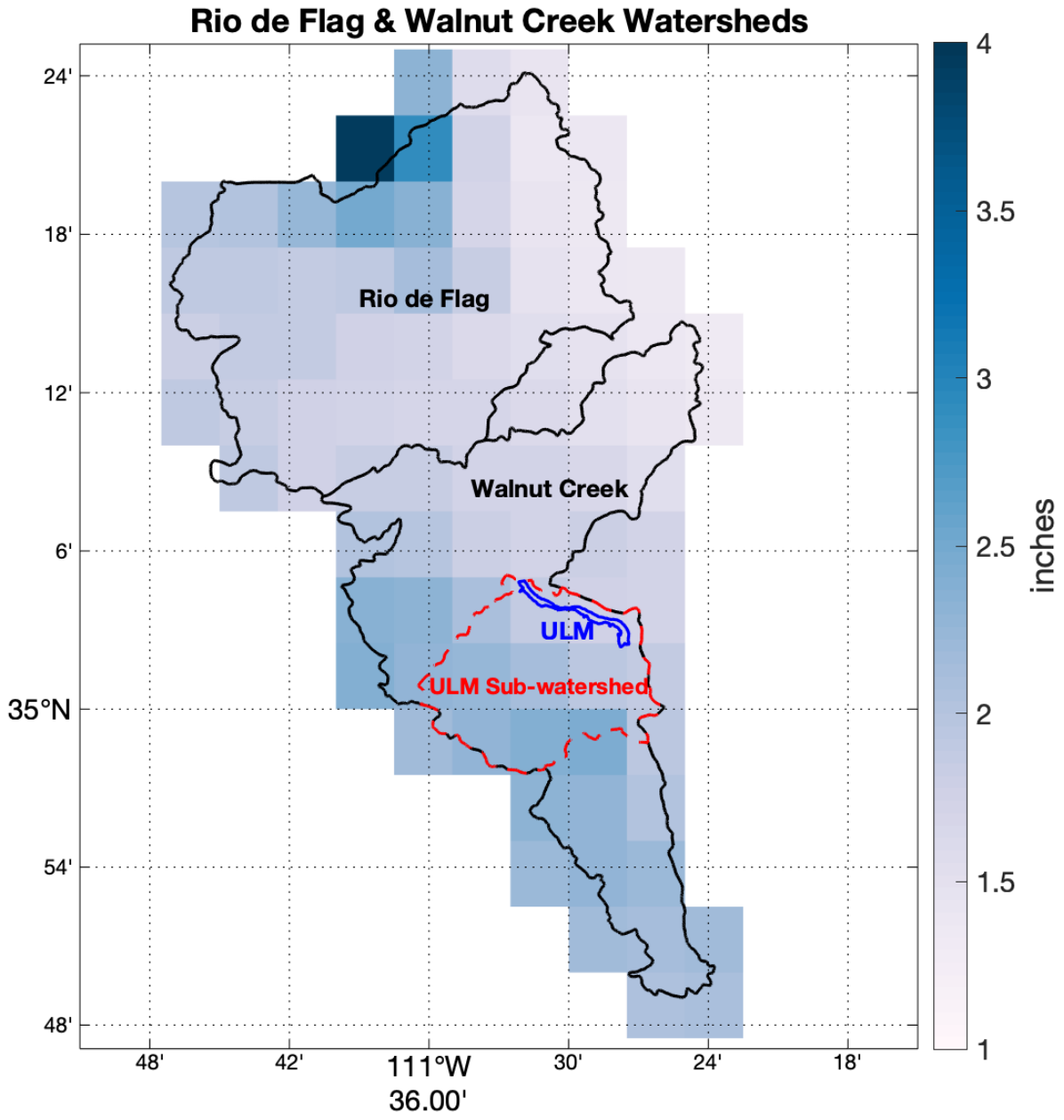


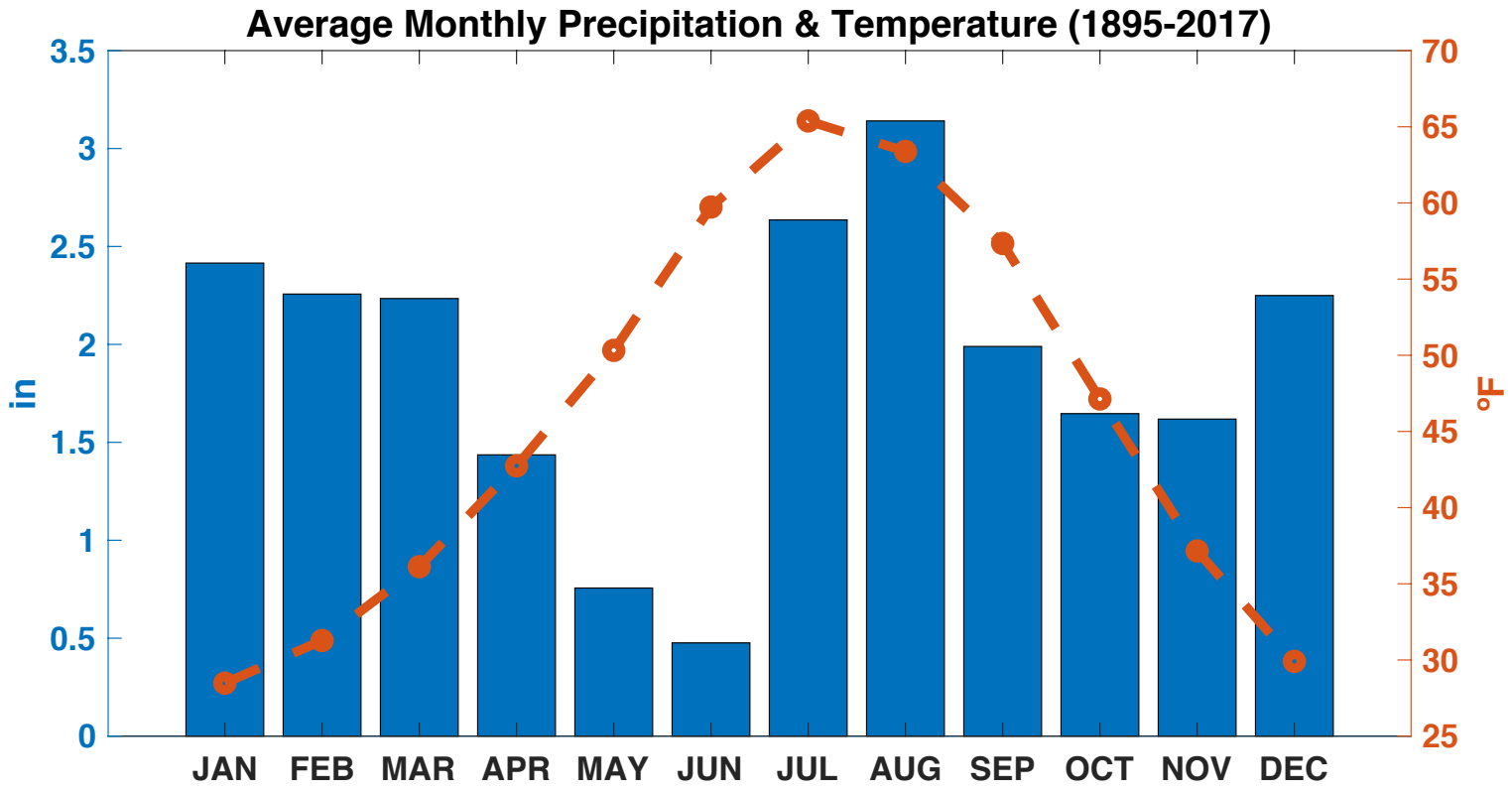
Description of Study Area & Climate

Two peaks in precipitation:

- January
- August

Average monthly temperature range:

- 28.5°F in January
- 65.4°F in July



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ULM Minimum Levels (no production)

ULM Maximum Levels

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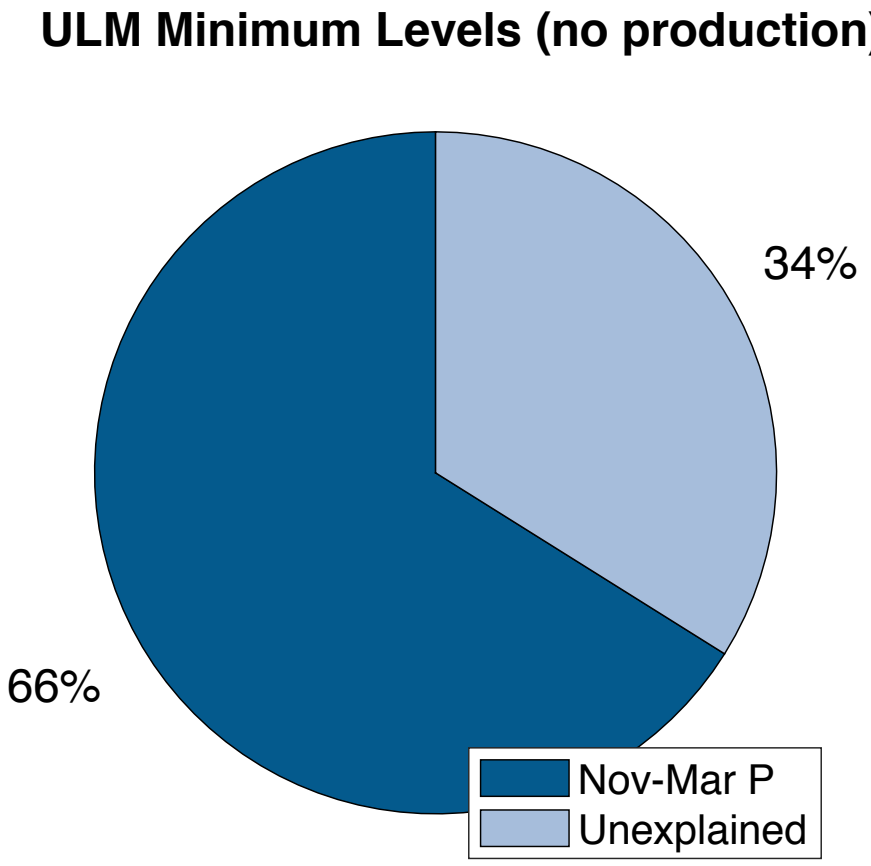

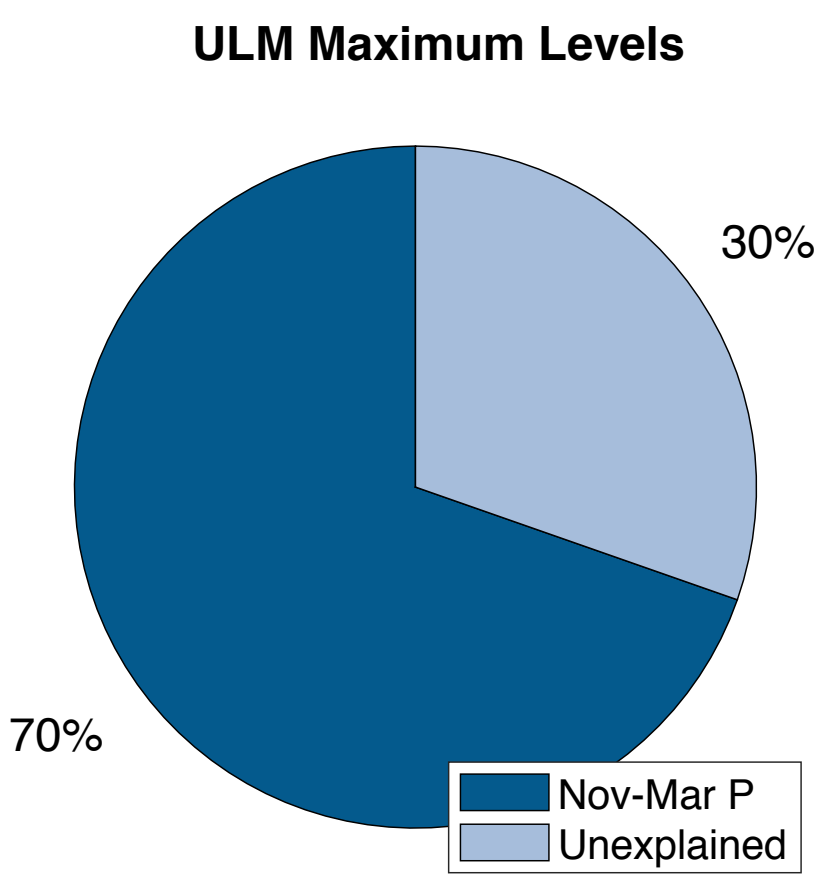

Nov-Mar precipitation most important for ULM lake levels.

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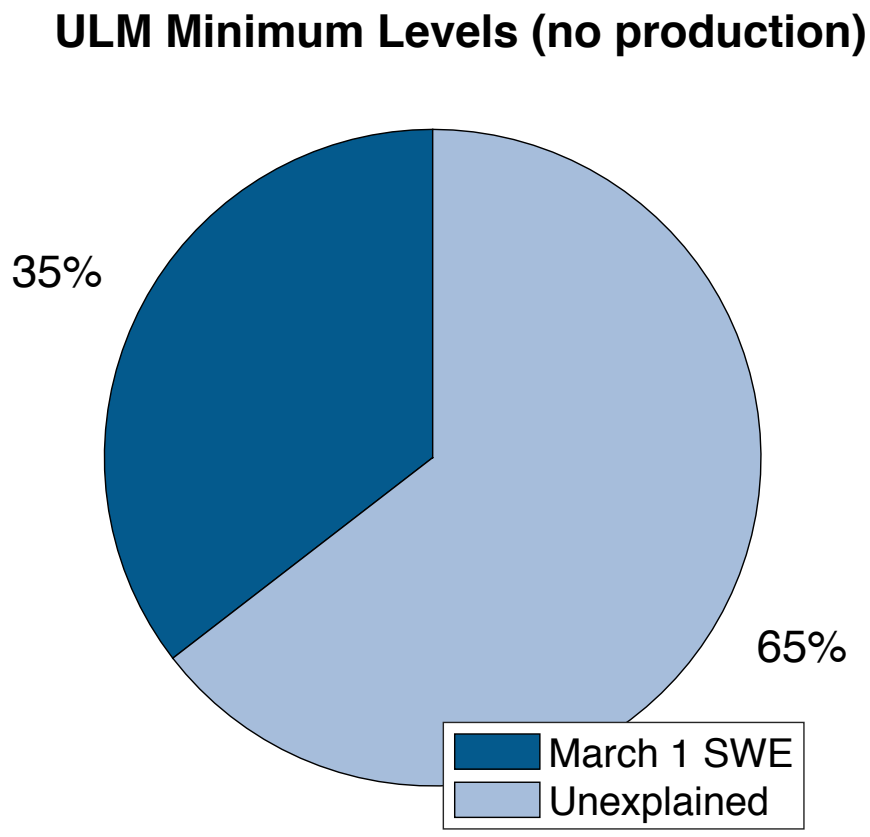

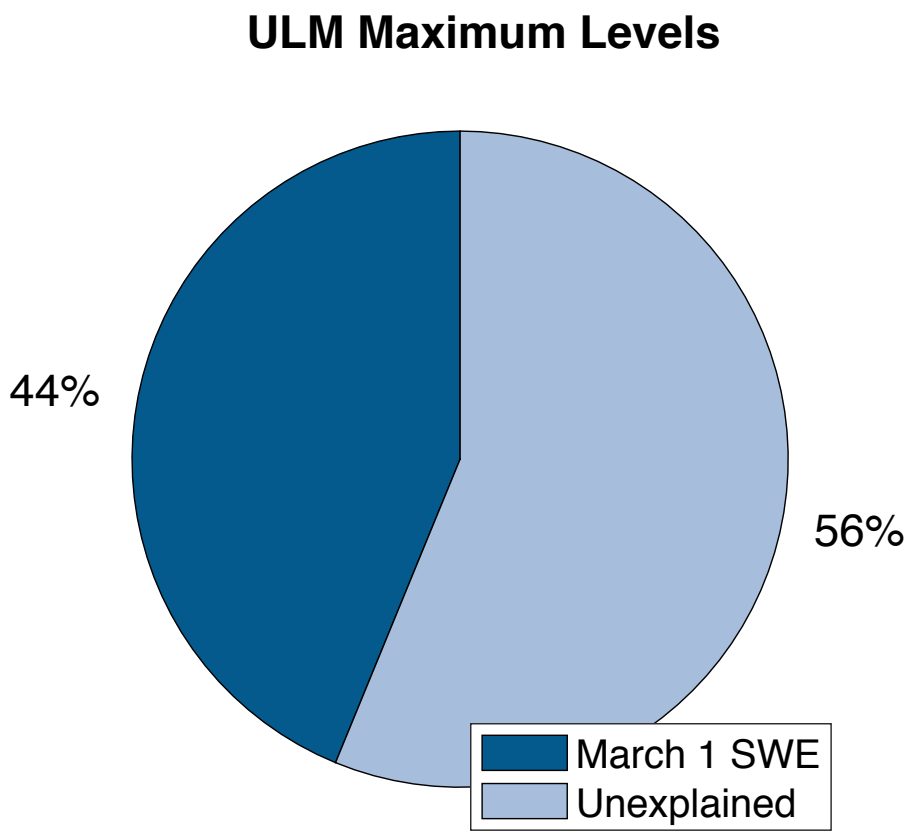

Snow is also an important predictor!

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ULM Minimum Levels (no production): 1960-1988

ULM Minimum Levels (no production): 1989-2017

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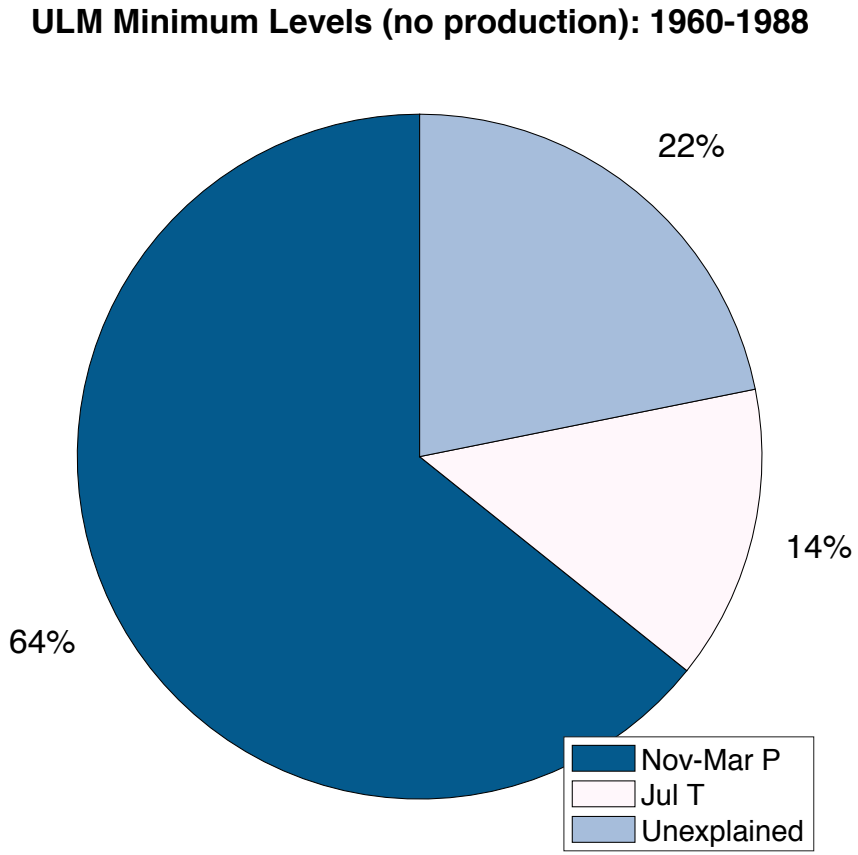

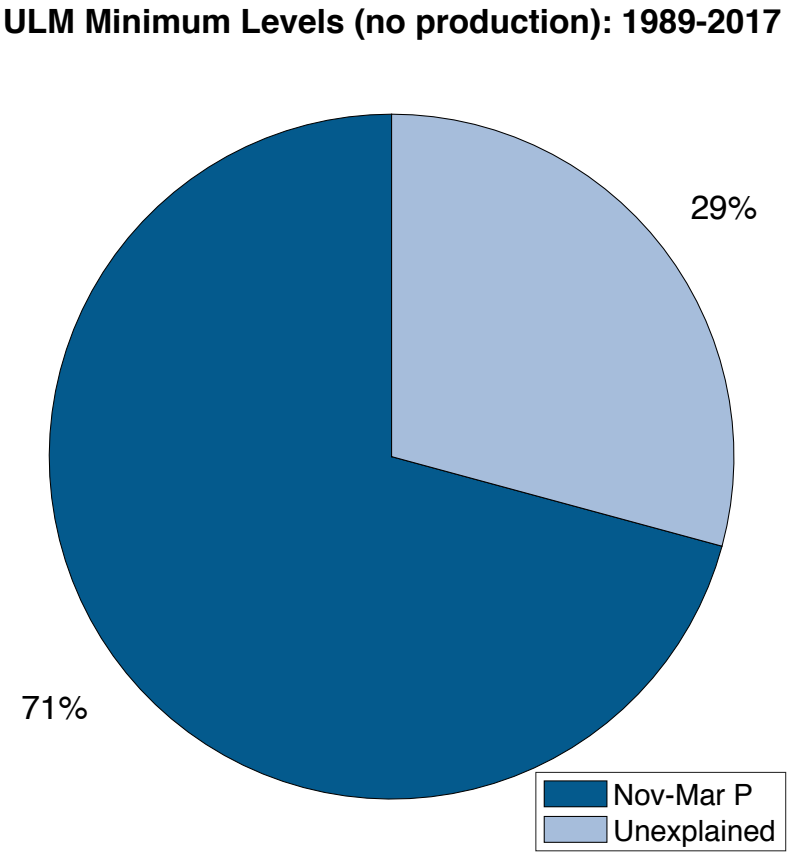

July temperatures are also a significant predictor of lake levels over the first time period (1960-1988).

1. What are the main climatic controls on ULM lake levels?

- **Primary control:** Nov-Mar precipitation
- **First time period (1960-1988):** July temps are a significant predictor
- **Second time period (1989-2017):** May-Jun temperatures appear to have a more important influence, but are not significant enough to make the model

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Questions?

2. Have there been trends in lake levels and/or in the climate variables that influence ULM?

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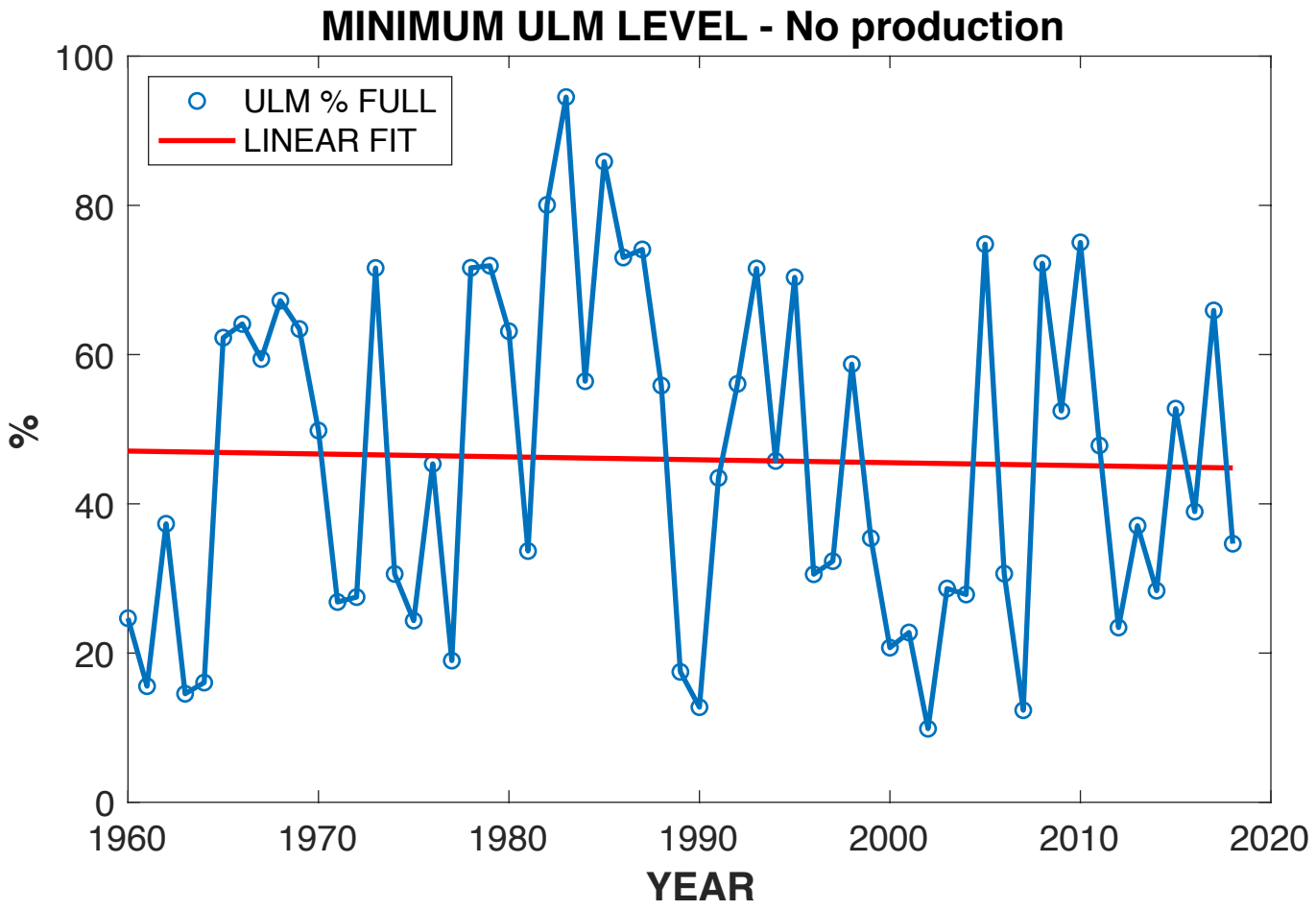
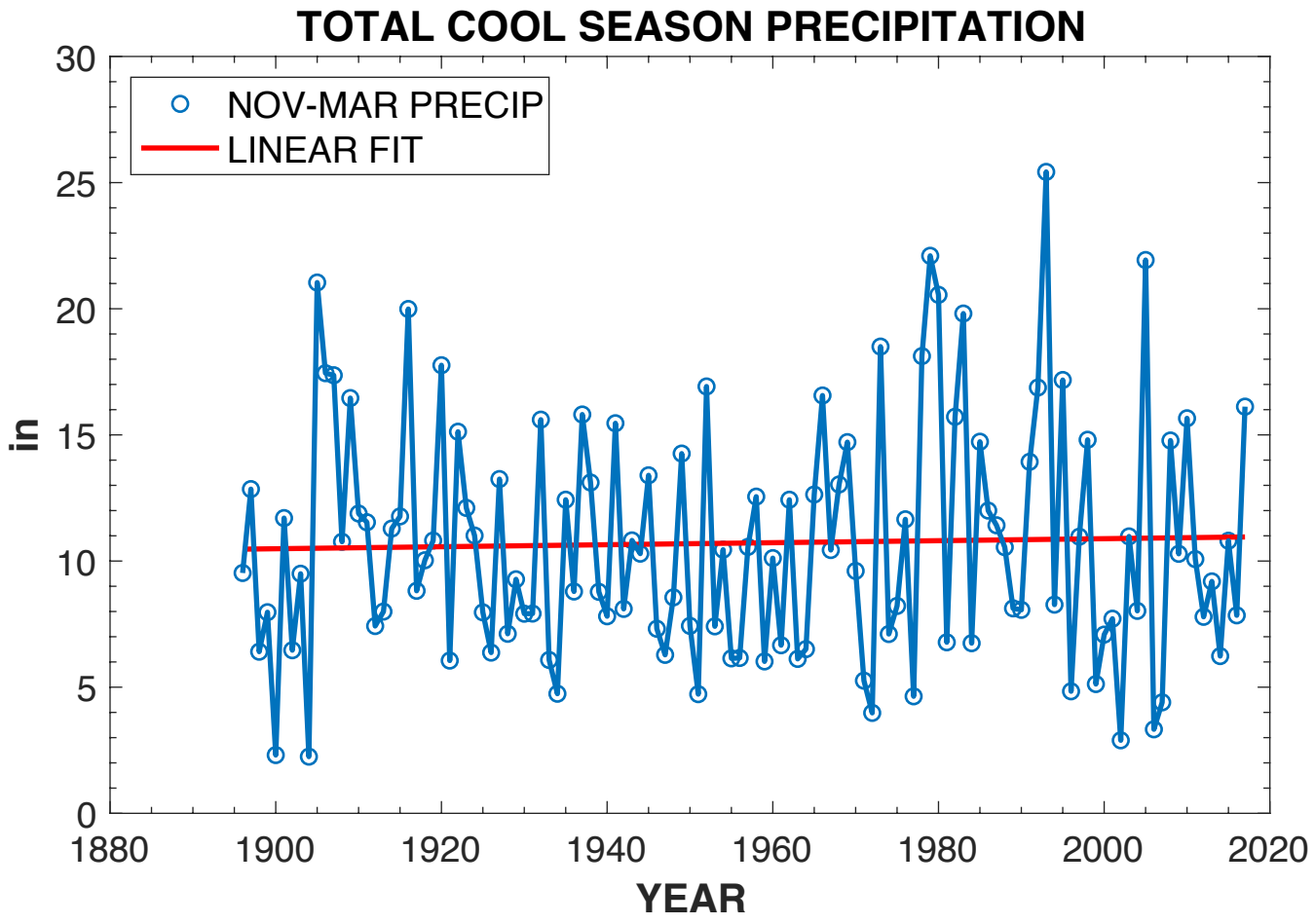


No production ULM lake level minimums:

No significant trend

2. Trends?



Nov-Mar precipitation:
No significant trend

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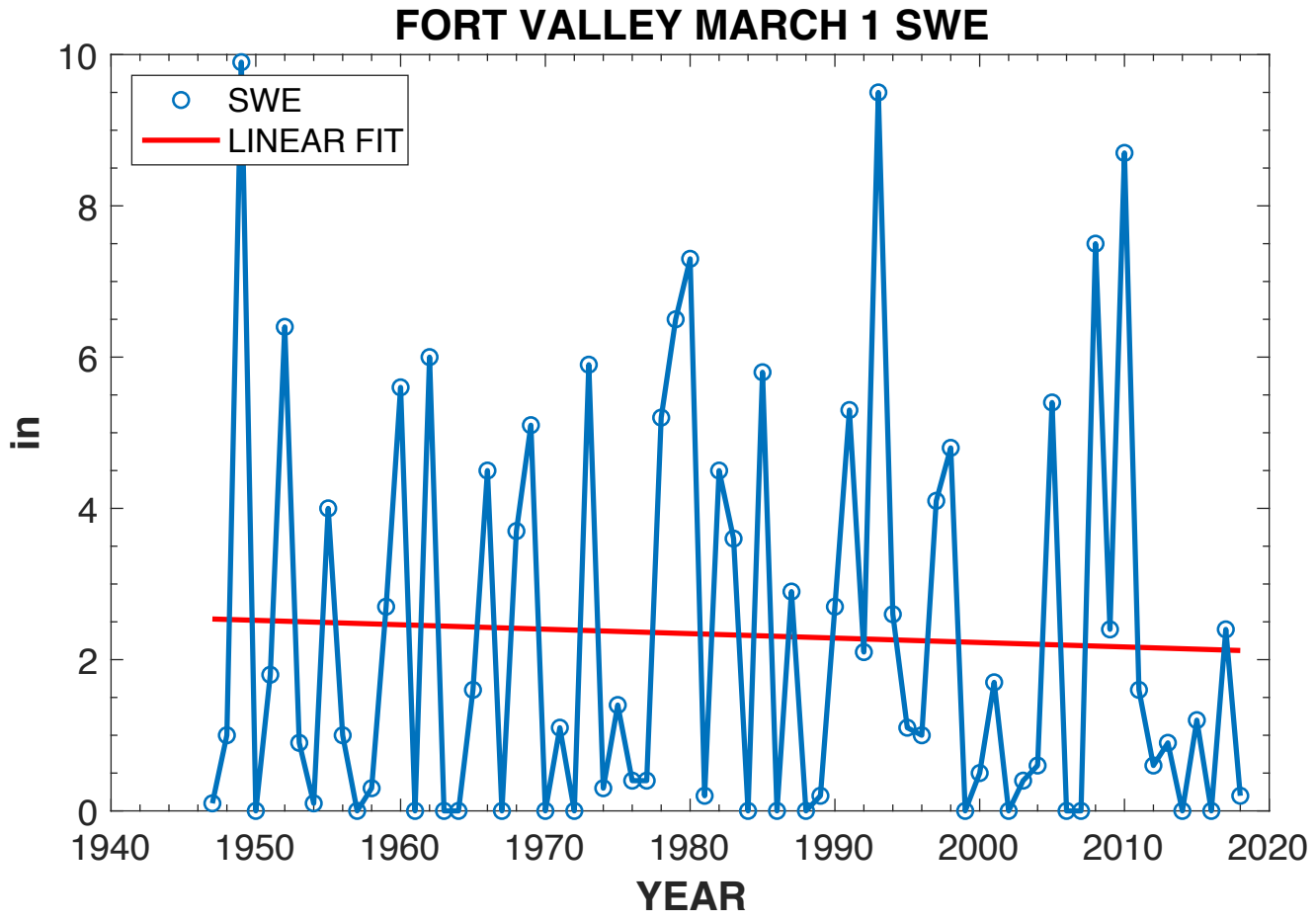

March 1 SWE:
No significant trend

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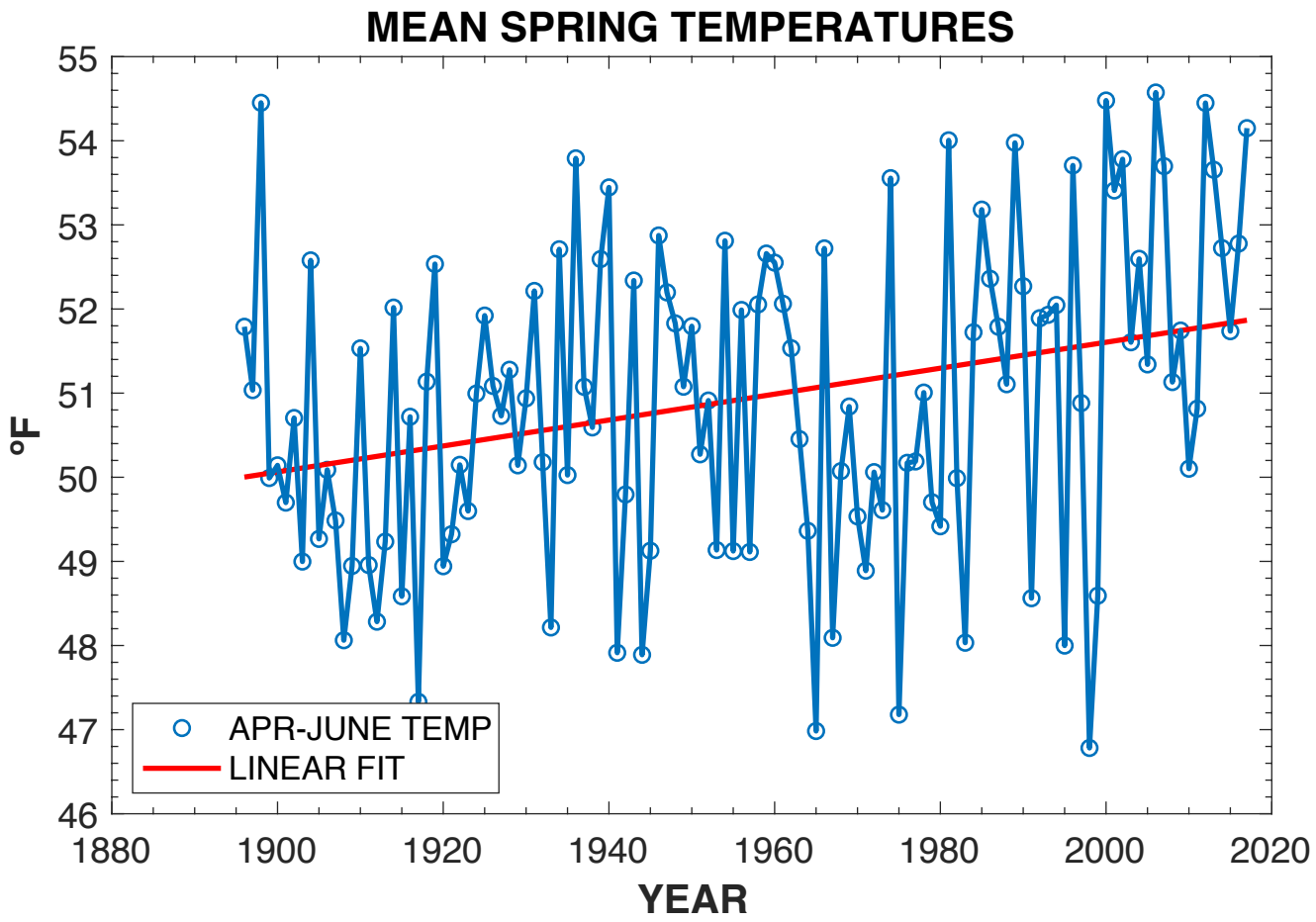

Apr-Jun Temps:
Significant trend for 0.02°F/year beginning in 1896

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Yes:

Apr-June temperatures, WY annual temperatures (increasing)

No:

Nov-Mar precipitation, WY annual precipitation

March 1 SWE

Minimum (no production) lake levels, maximum lake levels

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3. Unusual Years

Legend (percentiles)

Precip/lake levels	1-20	21-40	41-60	61-80	81-100
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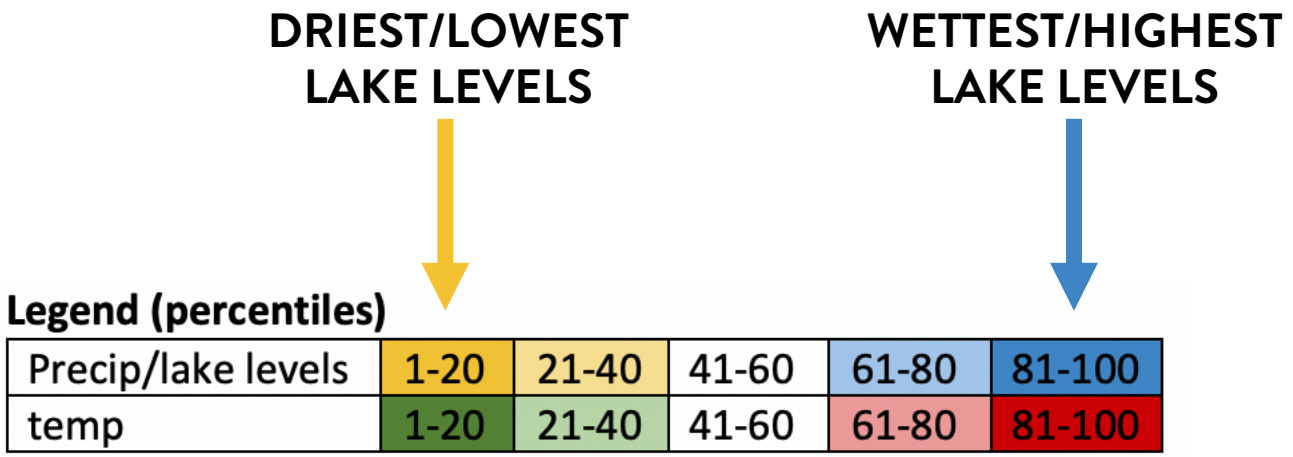
3. Unusual Years



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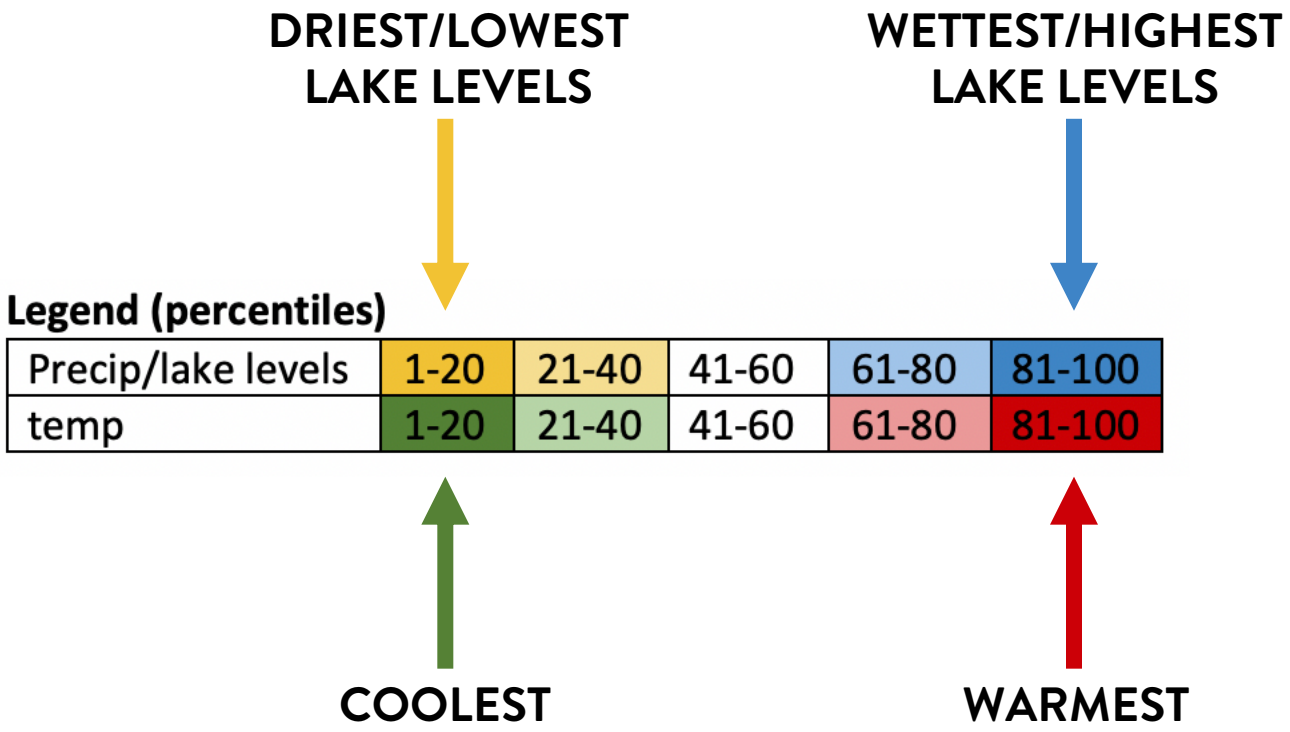

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5 driest years:

WY	Minimum lake level
2002	
2007	
1990	
1963	
1961	

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5 of the wettest monsoons with min lake levels > 60th percentile (and 1999):

WY	Minimum lake level
1967	
1983	
1984	
1986	
1999	

Jun-Sep Precip

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WY	Max Lake Level
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1969	
1973	
1978	
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1980	
1982	
1983	
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1995	
2005	
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2017	

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3. What climate factors may have additional importance in years that are somewhat “unusual”?

- **Cool season precipitation (Nov-Mar)** has the **largest influence** on ULM lake level variability

- That said…**temperatures** in different seasons do appear to **play a secondary role** in enhancing or counteracting the effects of cool season precipitation

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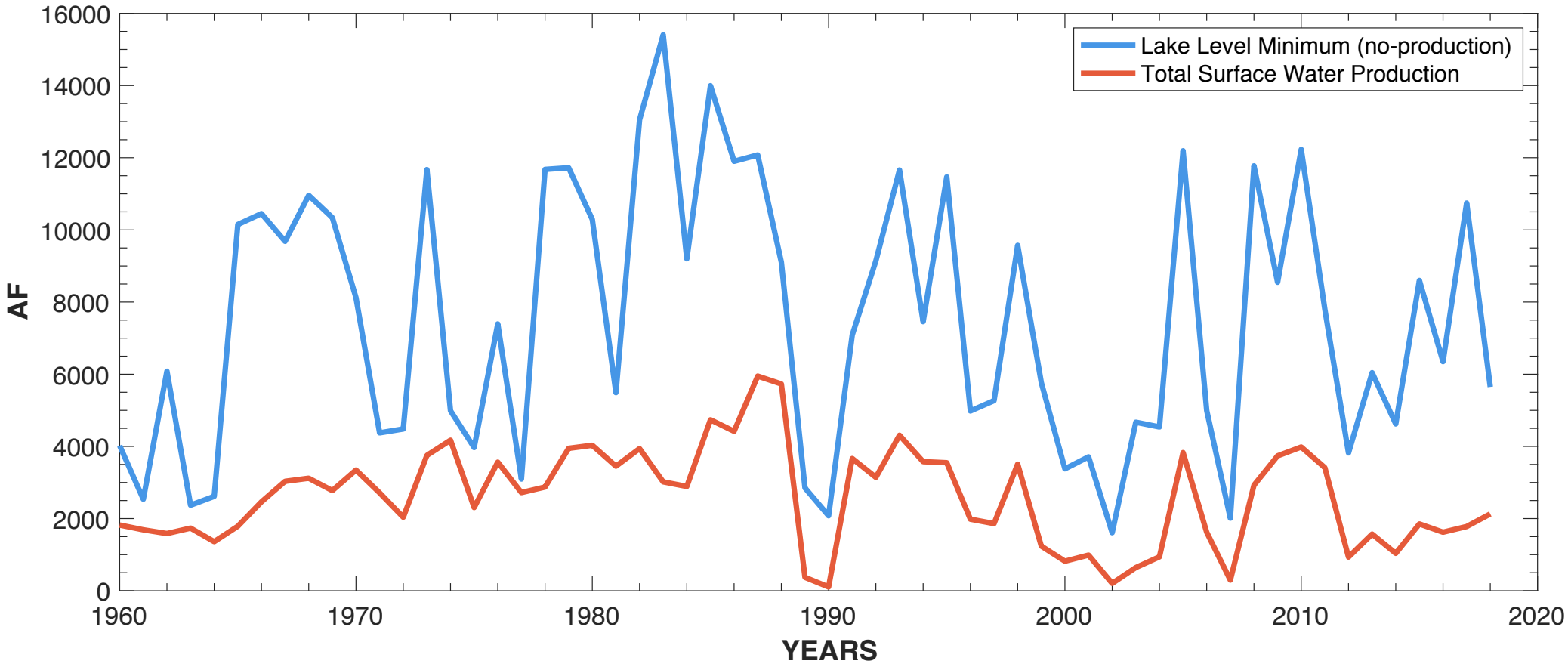

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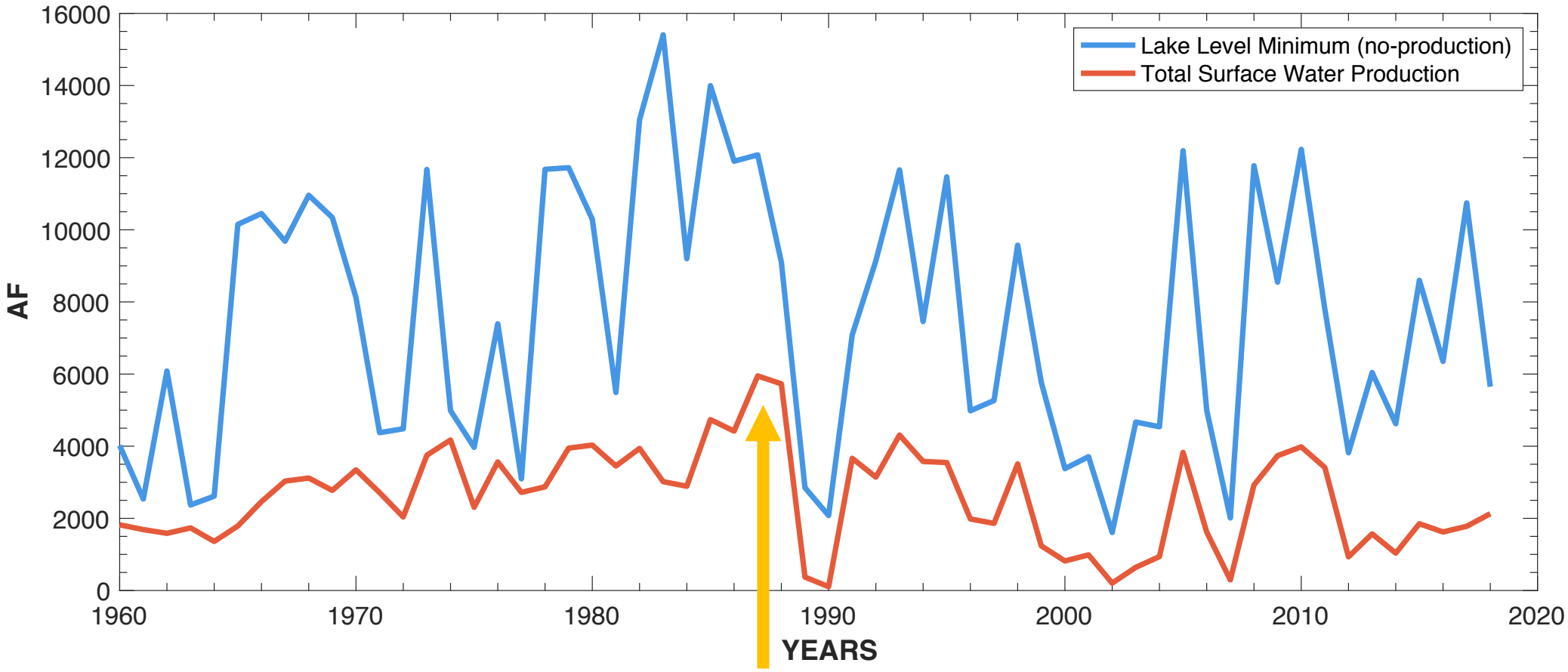

Questions?

4. Is temperature playing an increasingly important role in driving lake level variability?

4. Changing (?) role of temperature

All lowest lake level years:

WY	Min lake level
1961	
1963	
1964	
1975	
1977	
1989	
1990	
2000	
2001	
2002	
2007	
2012	

Legend (percentiles)

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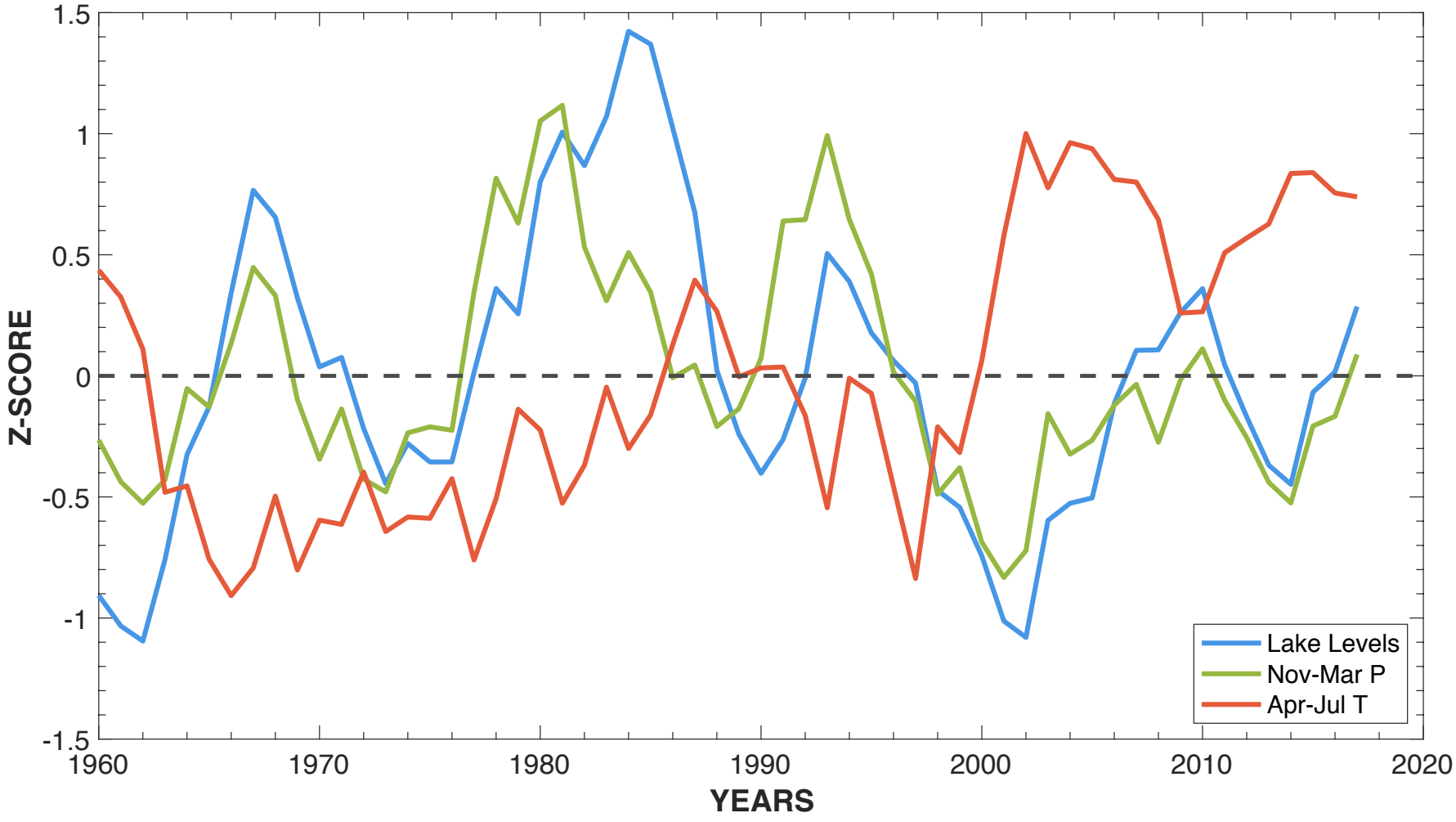

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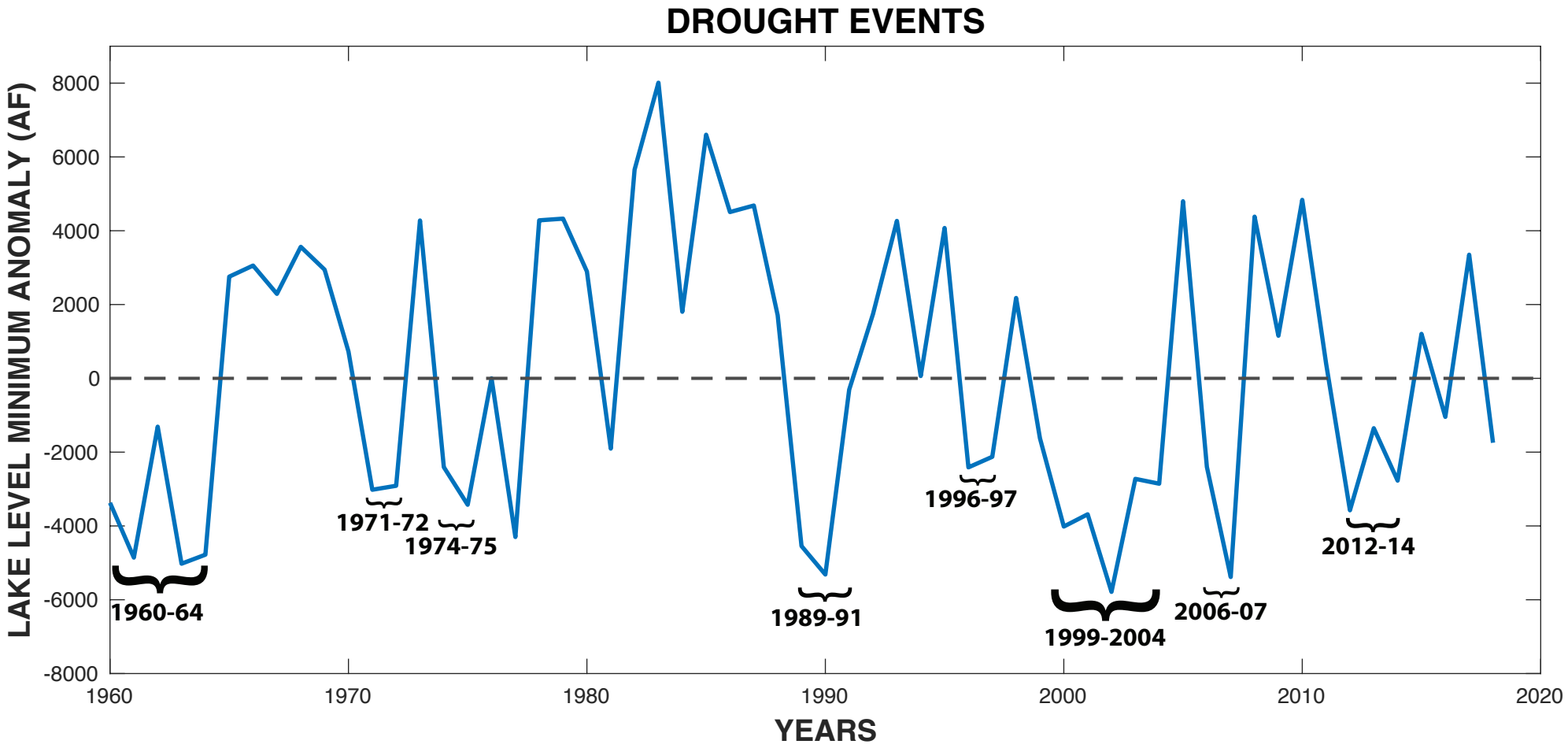

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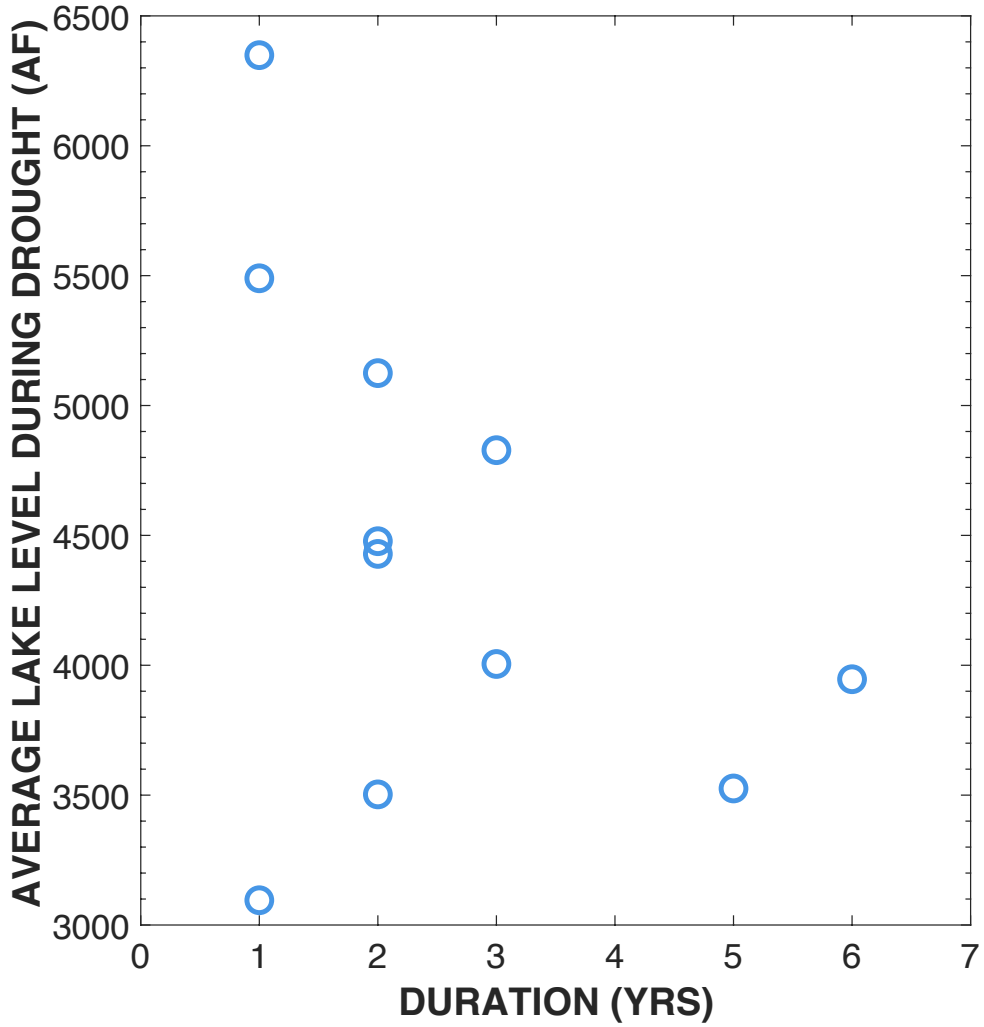

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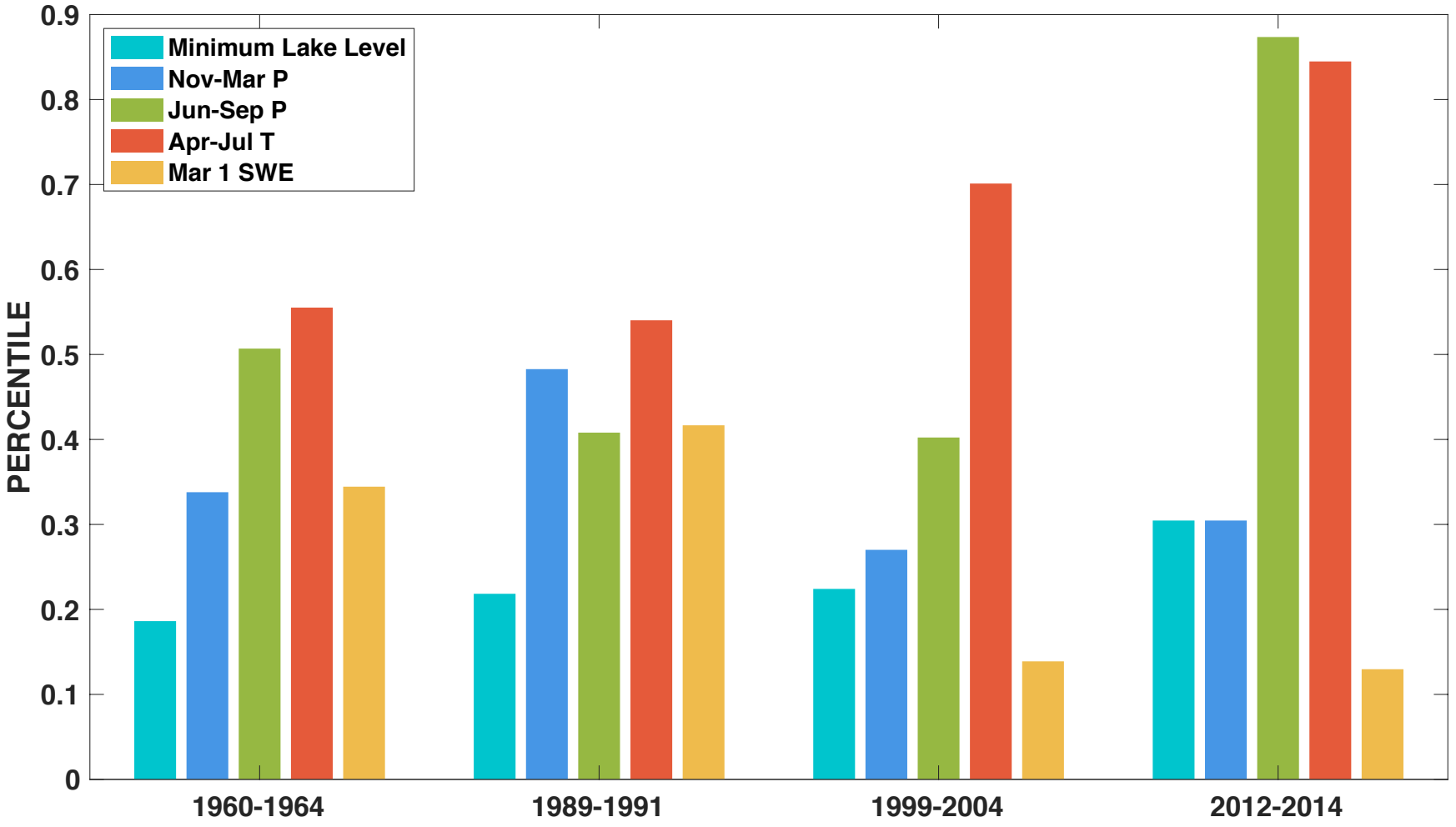

5. What are the characteristics of ULM droughts?

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- Most intense single year drought: 2002
- Extended drought events have below median Nov-Mar precip and March 1 SWE
- The two most recent extended droughts have temperatures above the 70th percentile

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Re-Cap of Main Findings:

- **Primary control on ULM lake levels:** cool season precipitation
- **Trends:** Only significant trends identified in temperature record (increasing)
- **Unusual years:** temperatures in different seasons do appear to play a secondary role in enhancing or counteracting the effects of cool season precipitation
- **Droughts:** 1-6 years, recent extended droughts have extremely warm spring/summer temps

Implications:

- Increasing role of temperature has been seen in recent droughts in California and in streamflow records from the upper Colorado River basin

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- While surface water production is relatively highly correlated with lake level minimums, understanding the characteristics of drought events could provide additional information for supply planning

Questions, comments, suggestions?

This project was funded by the NOAA RISA program, Climate Assessment for the Southwest (CLIMAS).

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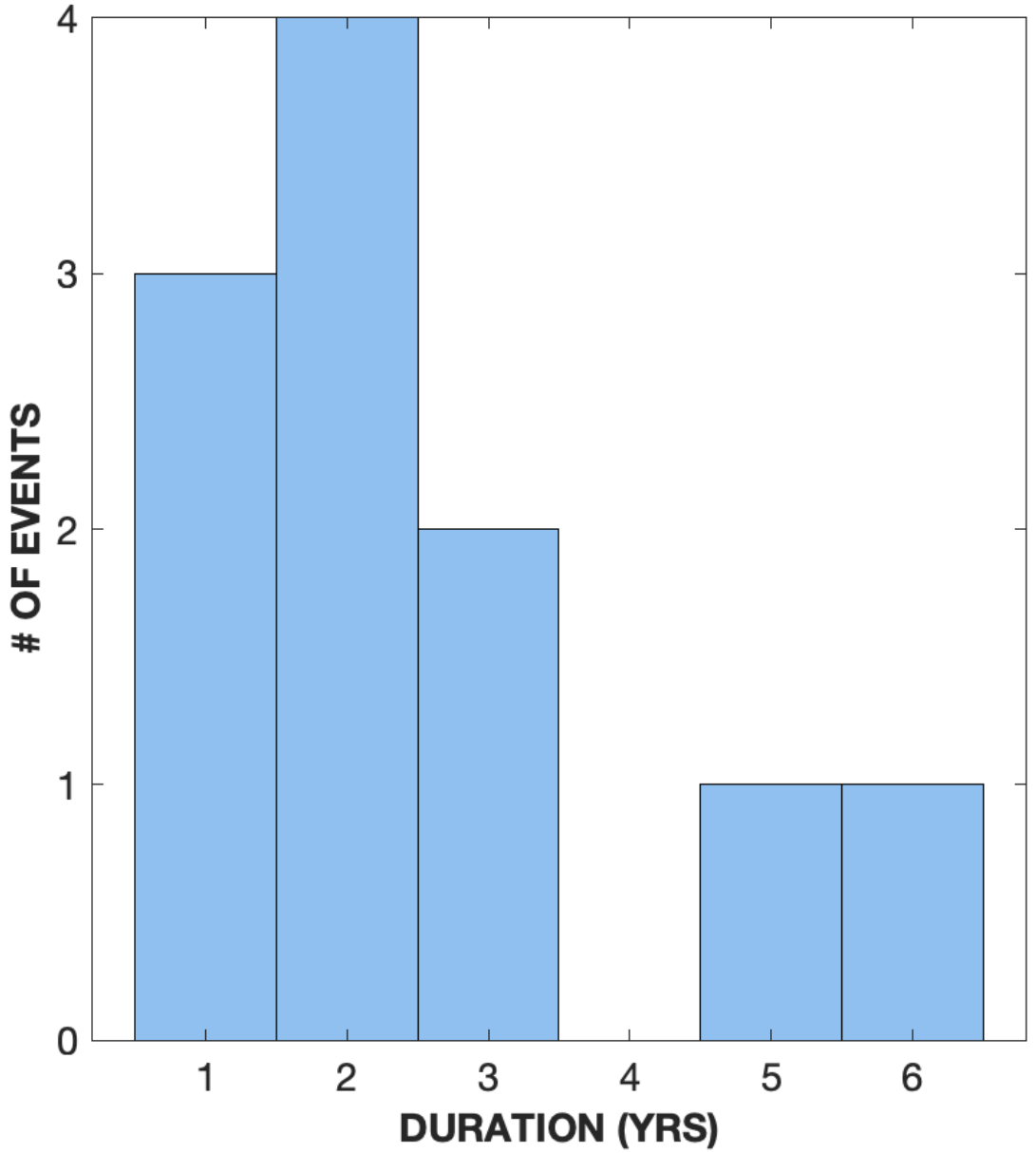
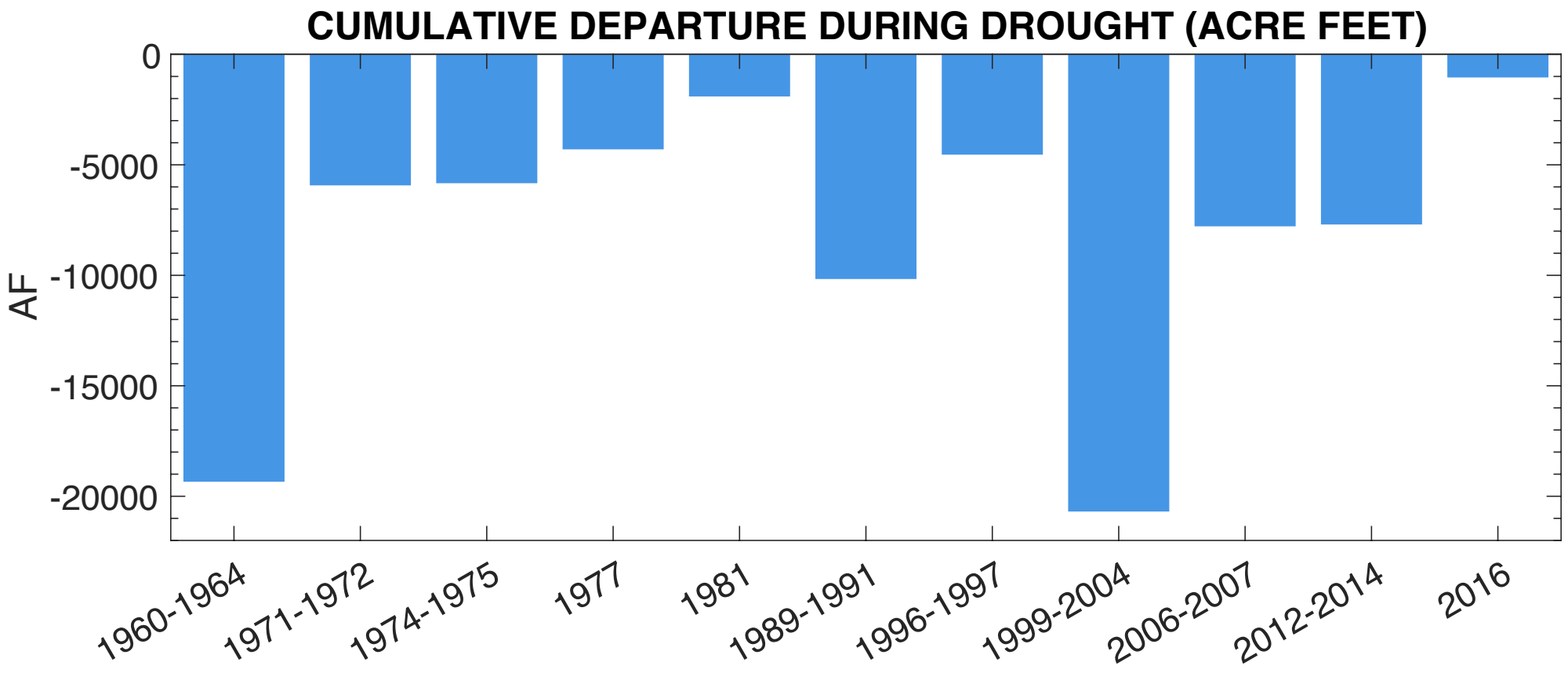
Drought Duration




CUMULATIVE DEPARTURE DURING DROUGHT (ACRE FEET)
AF
0
-5000
-10000
-15000
-20000
1960-1964
1971-1972
1974-1975
1977
1981
1989-1991
1996-1997
1999-2004
2006-2007
2012-2014
2016

Percentiles for Above & Below Median Years