CLIMAS
Climate Assessment for the Southwest

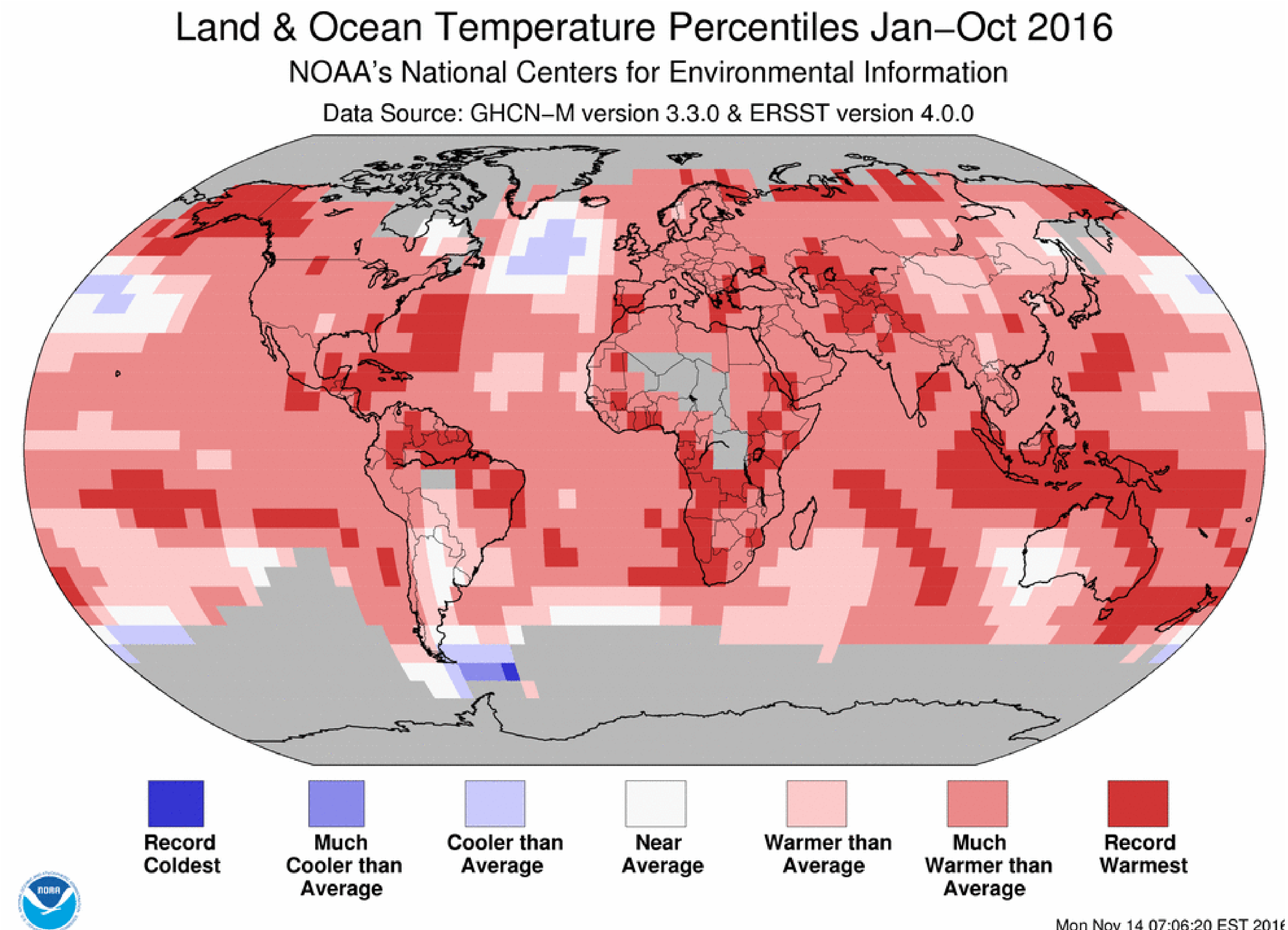
NM STATE UNIVERSITY

Our Changing Climate

Dave DuBois
State Climatologist

The NM Sustainable Agriculture Conference, November 30, 2016

Global Temperature in 2016



https://www.ncdc.noaa.gov/sotc/global/201610

Climate Change in the West

- Warmer – sure bet (happening)
- Hotter/longer heatwaves – sure bet (happening)
- Less snow – excellent odds (happening)
- Drier soils – excellent odds (happening)
- Less late winter snow/rain – good odds (happening)
- Less water in rivers – good odds (happening)
- More frequent/severe drought – good odds
- Hotter drought – excellent odds (happening)

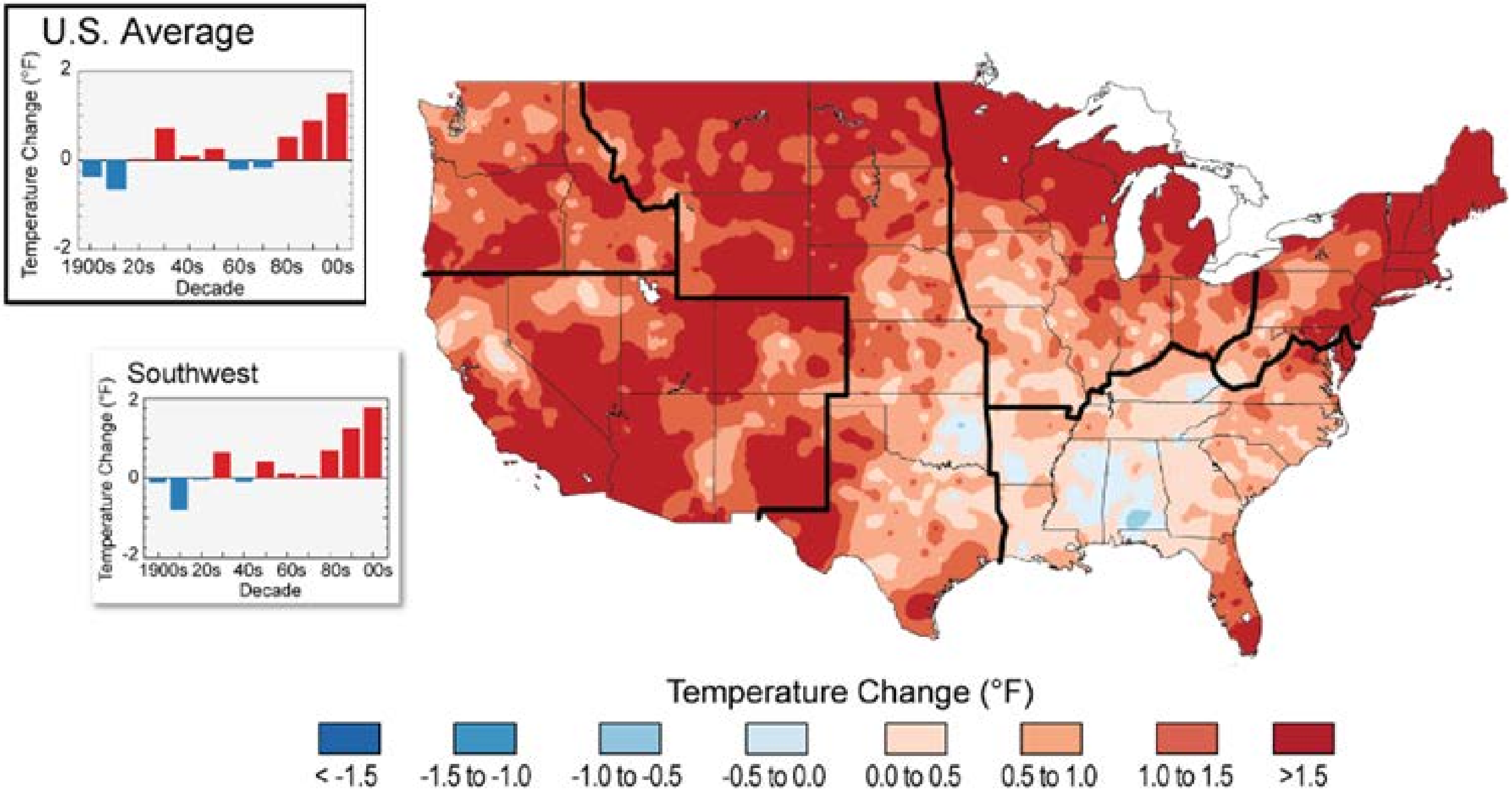
Source: CLIMAS, Jonathan Overpeck

Recent Observations of Change in NM

- State-wide temperatures of last decade were warmest of this century
- Morning lows getting warmer on top of urban heat island (not all locations however)
- Longer growing season
- Freezing level higher in elevation
- Dust storms not only affecting human health but slowly changing snowmelt timing

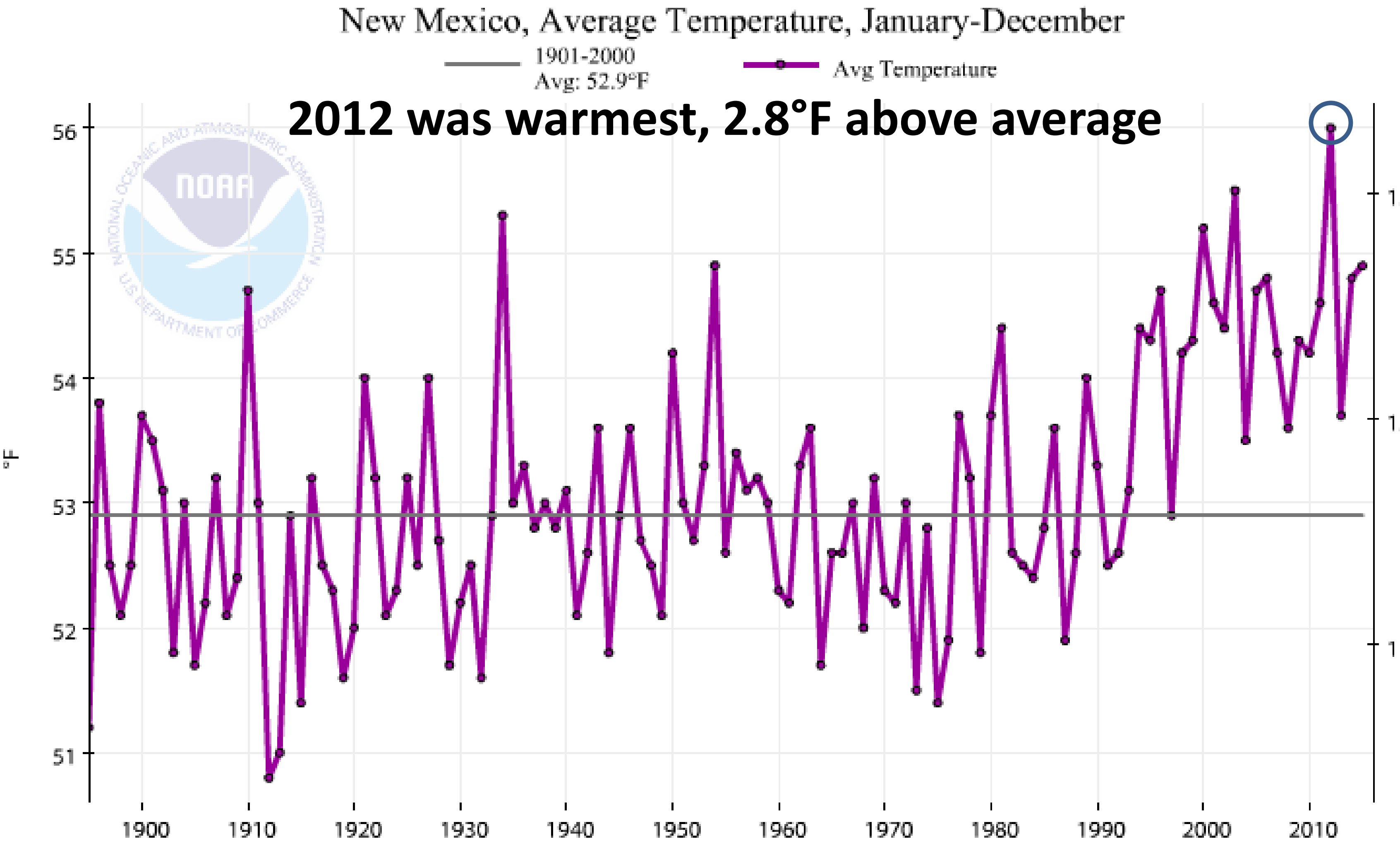
Changes in temperature from 1991 to 2012 (22 yrs) compared to the 1901-1960 average

(bars are changes by decade relative to 1901-1960 average)



Source: Modified from National Climate Assessment (2014)

NM Temperatures over past 121 yrs

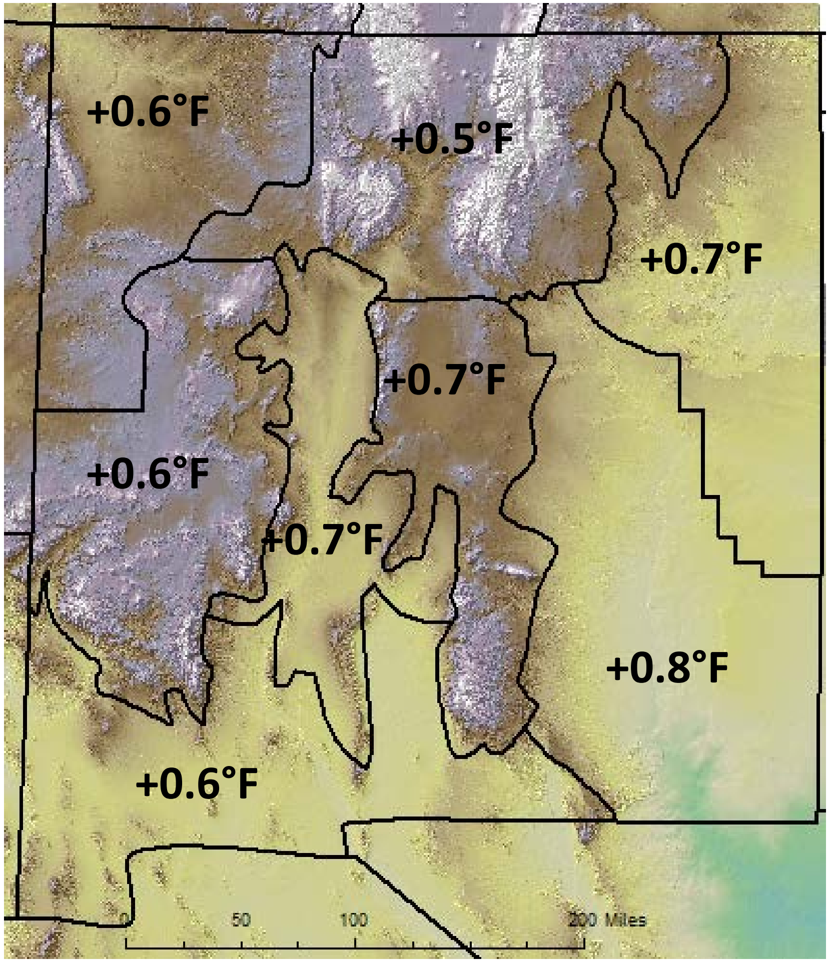


https://www.ncdc.noaa.gov/cag/

There's no doubt that we're warming

- Already in a warming trend & to continue into the future

Trend per decade in summer (JJA) temperatures since 1970 by climate division



Statewide +0.7°F per decade

Data source: https://www.ncdc.noaa.gov/cag/

Our high risk scenarios: Heat Waves

- Consecutive hot days
  - For example 5-day average of 111.4°F in 1994

Maximum 5-Day Mean Max Temperature for CARLSBAD, NM

Rank	Value	Ending Date	Missing Days
1	111.4	1994-06-29	0
2	109.4	1994-06-28	0
3	109.2	1994-06-30	0
4	108.6	1998-07-12	0
-	108.6	1994-07-01	0
-	108.6	1942-06-21	0
-	108.6	1902-06-28	0
-	108.6	1902-06-27	0
9	108.2	1998-07-13	0
10	108.0	2011-06-28	0
Last value also occurred in one or more previous years.			
Period of record: 1900-02-01 to 2016-04-18			

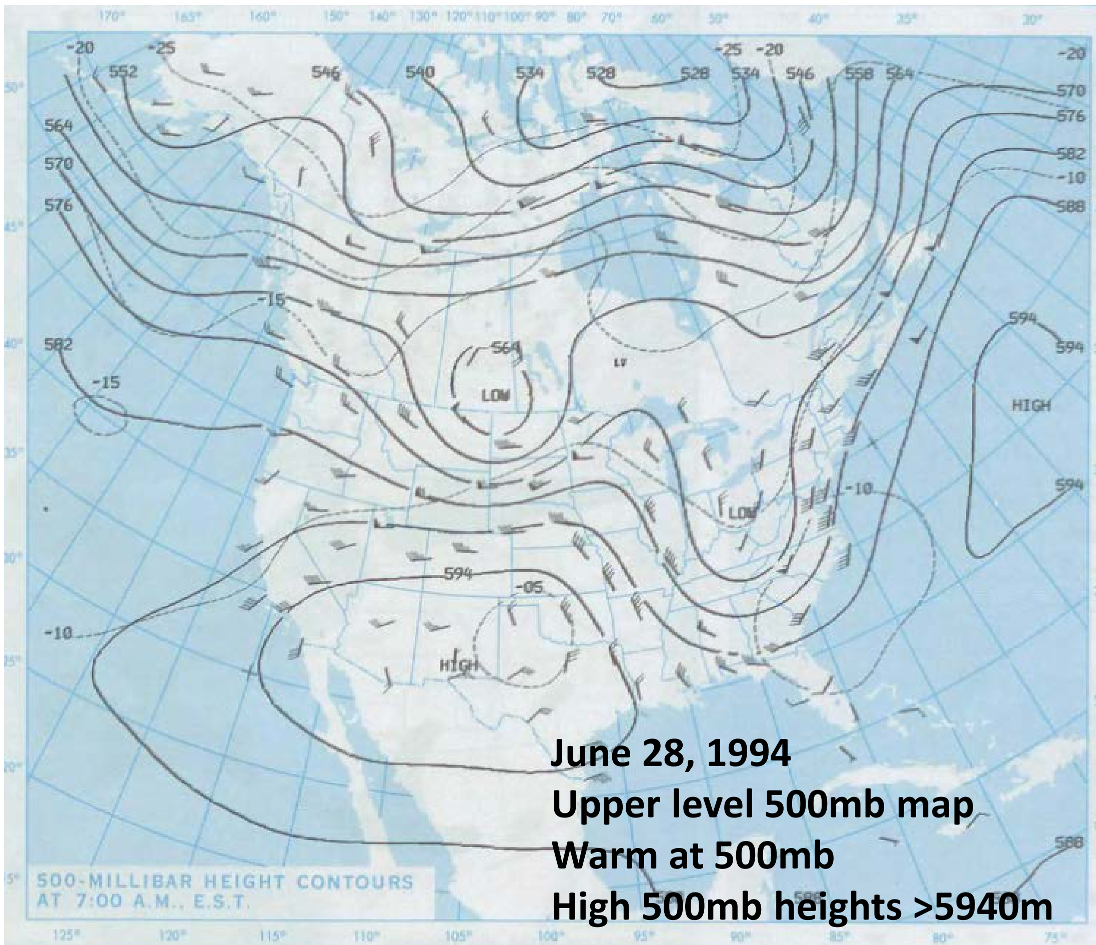
Top 10 hottest 5-day averages

Recall that all time high was 122°F at this location in 1994

Data source: http://scacis.rcc-acis.org/

June 1994 heat wave

- Very strong & persistent upper level ridge

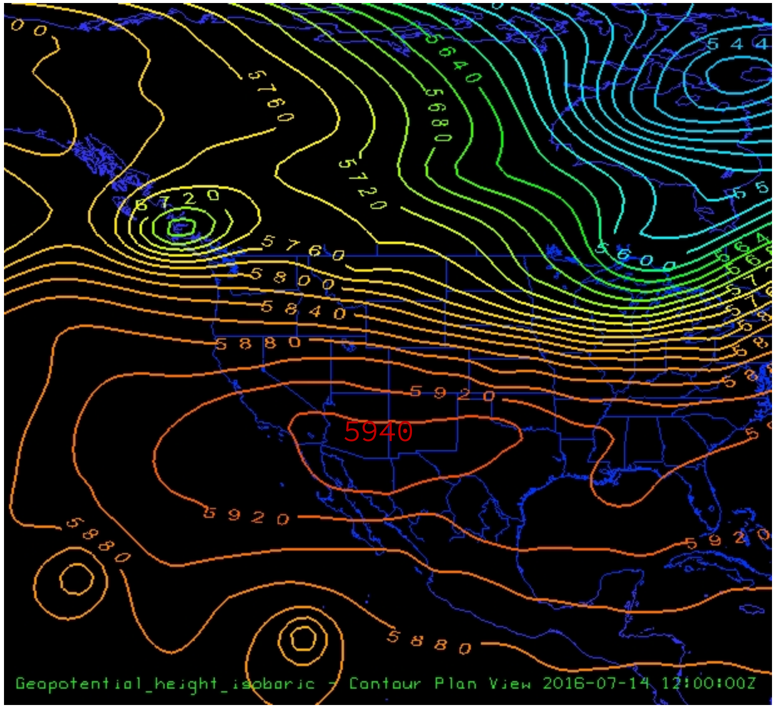


<u>High Obs. on 6/27</u>

Carlsbad 122°F
NMSU 109°
Cochiti Dam 106°
Shiprock 101°
Alcalde 100°
Jemez Springs 99°
Red River 87°

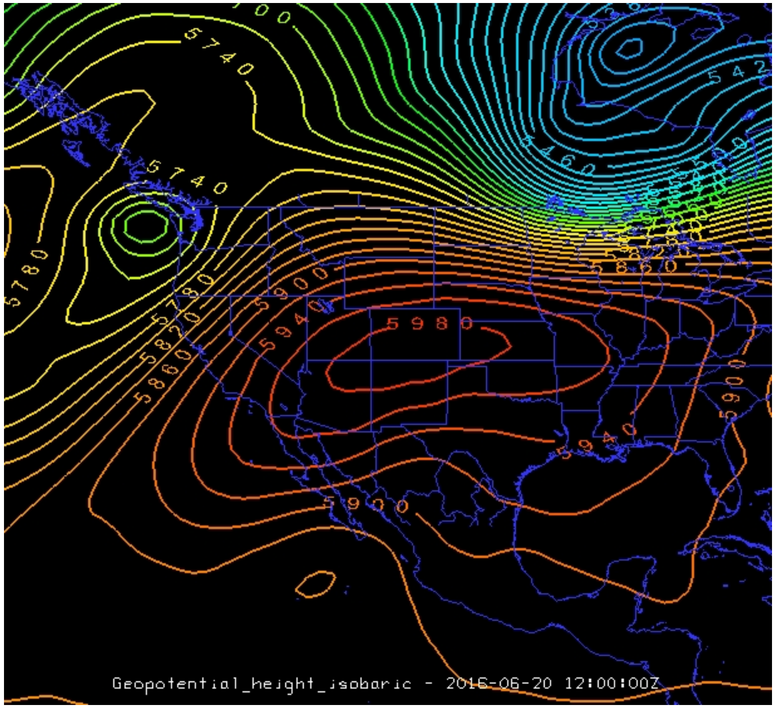
Heatwaves in 2016

- July 14 (southern NM)



Carlsbad 110°F
NMSU 106°
Cochiti Dam 102°
Jemez Dam 100°

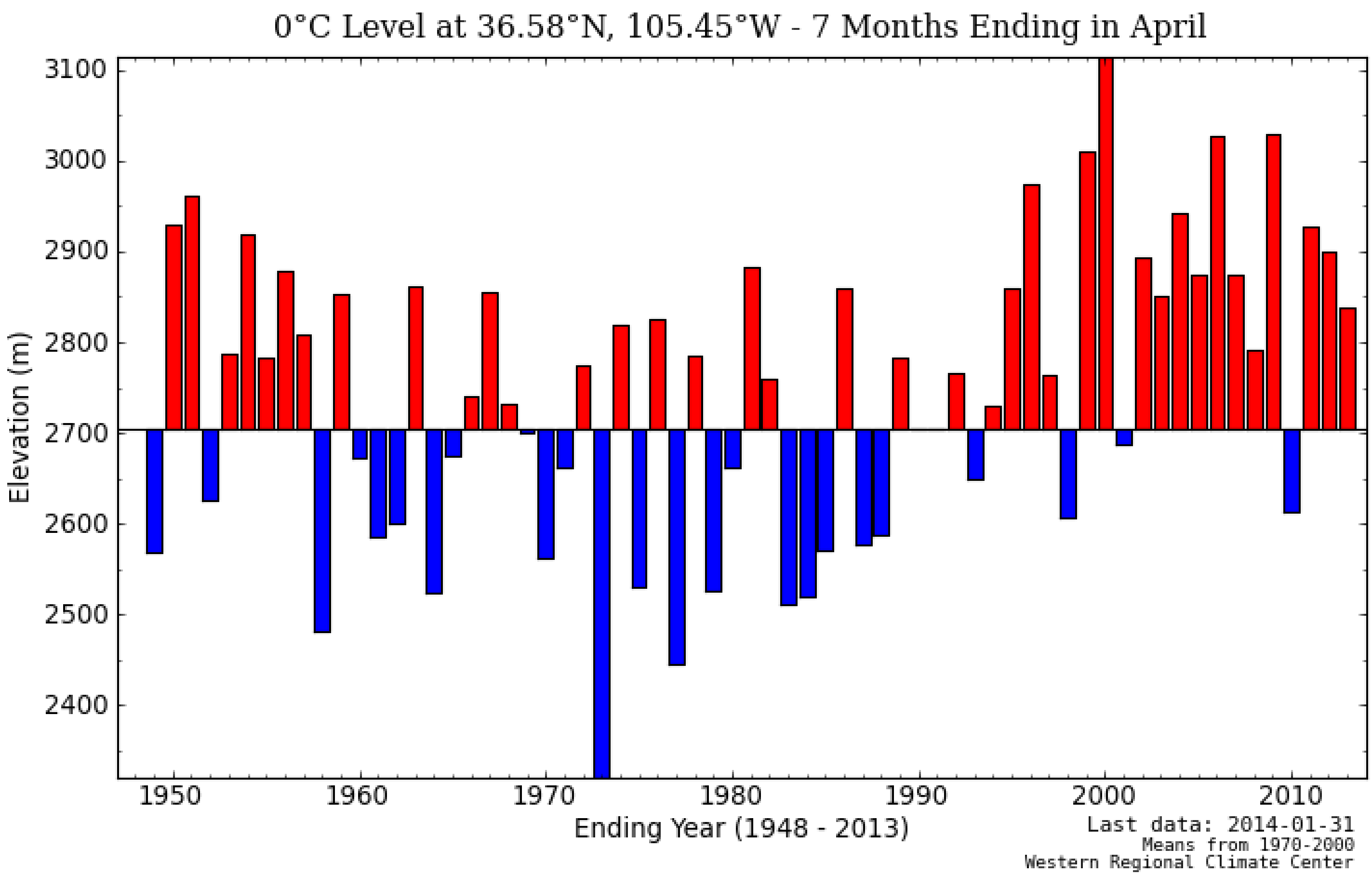
- June 20 (northern NM)



Rio Rancho 106°
Cochiti Dam 105°
Jemez Dam 103°
NMSU 101°

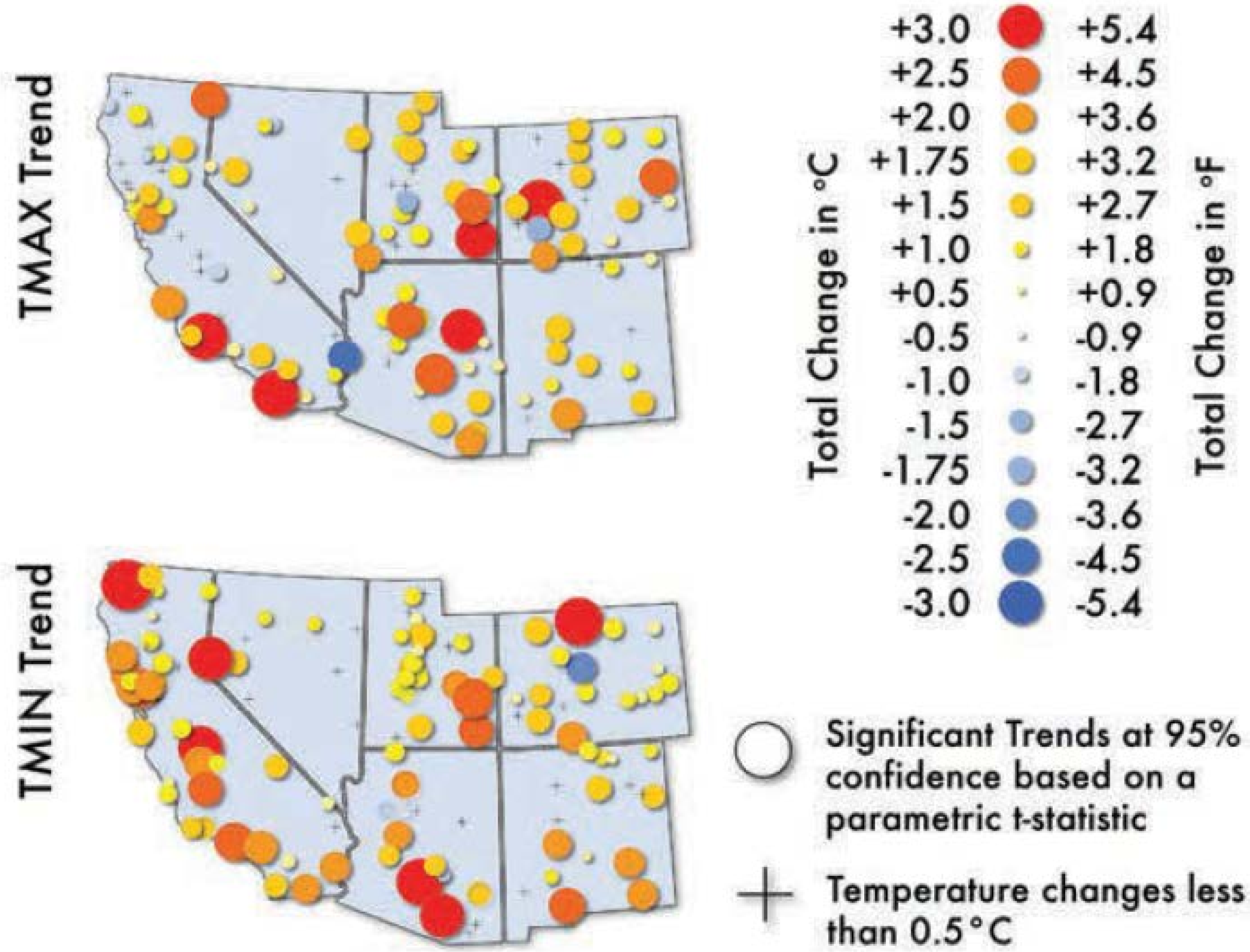
Freezing Level Higher now than 70s & 80s

Over Sangre de Cristo Mountains over most of water year
October to April



Source: Western Regional Climate Center

Temperature Changes over last century

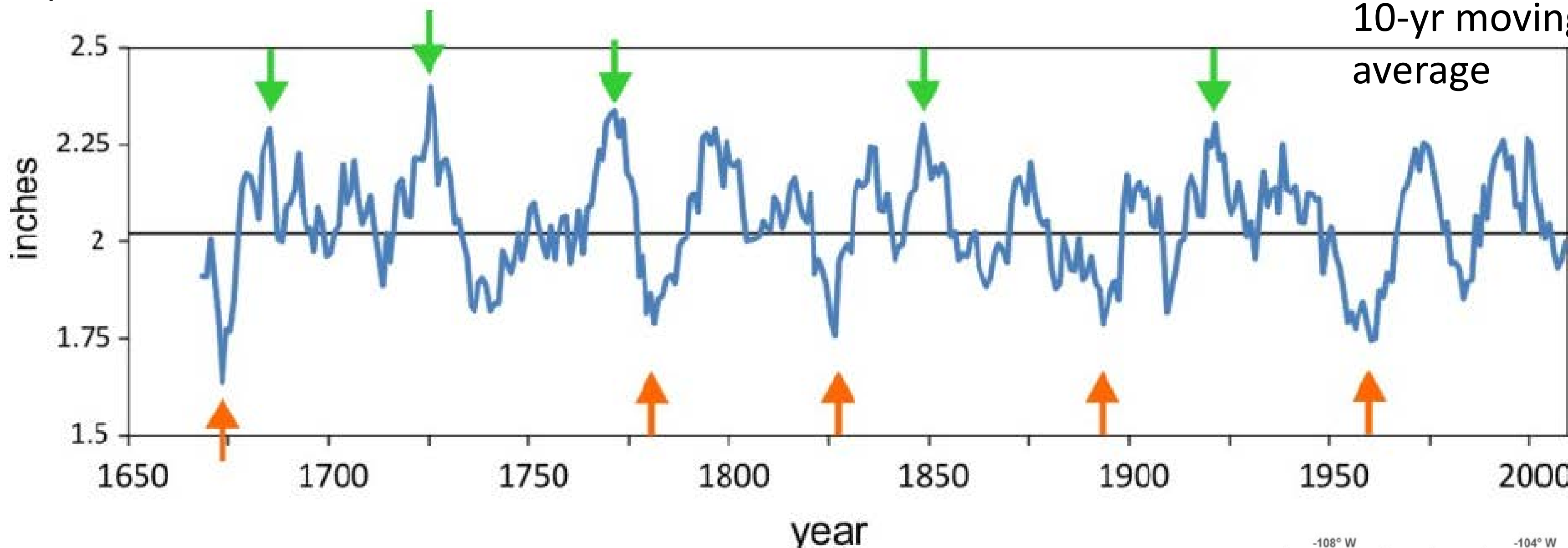


Southwest Climate Assessment (2013)

Lower Rio Grande June-July Precipitation Reconstruction

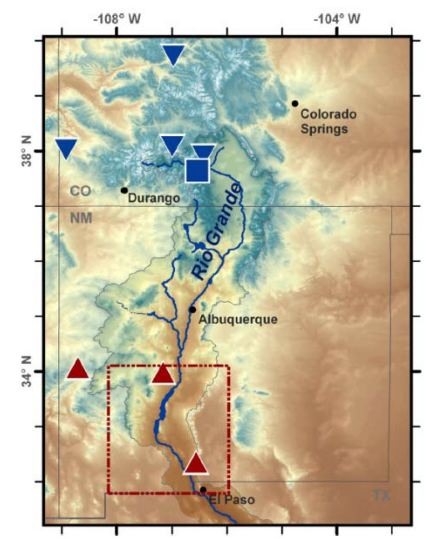
349 years of data

Blue line: 10-yr moving average



5 Driest Decades	5 Wettest Decades
1664-1673	1716-1725
1951-1960	1762-1771
1817-1826	1912-1921
1884-1893	1839-1848
1772-1781	1676-1685

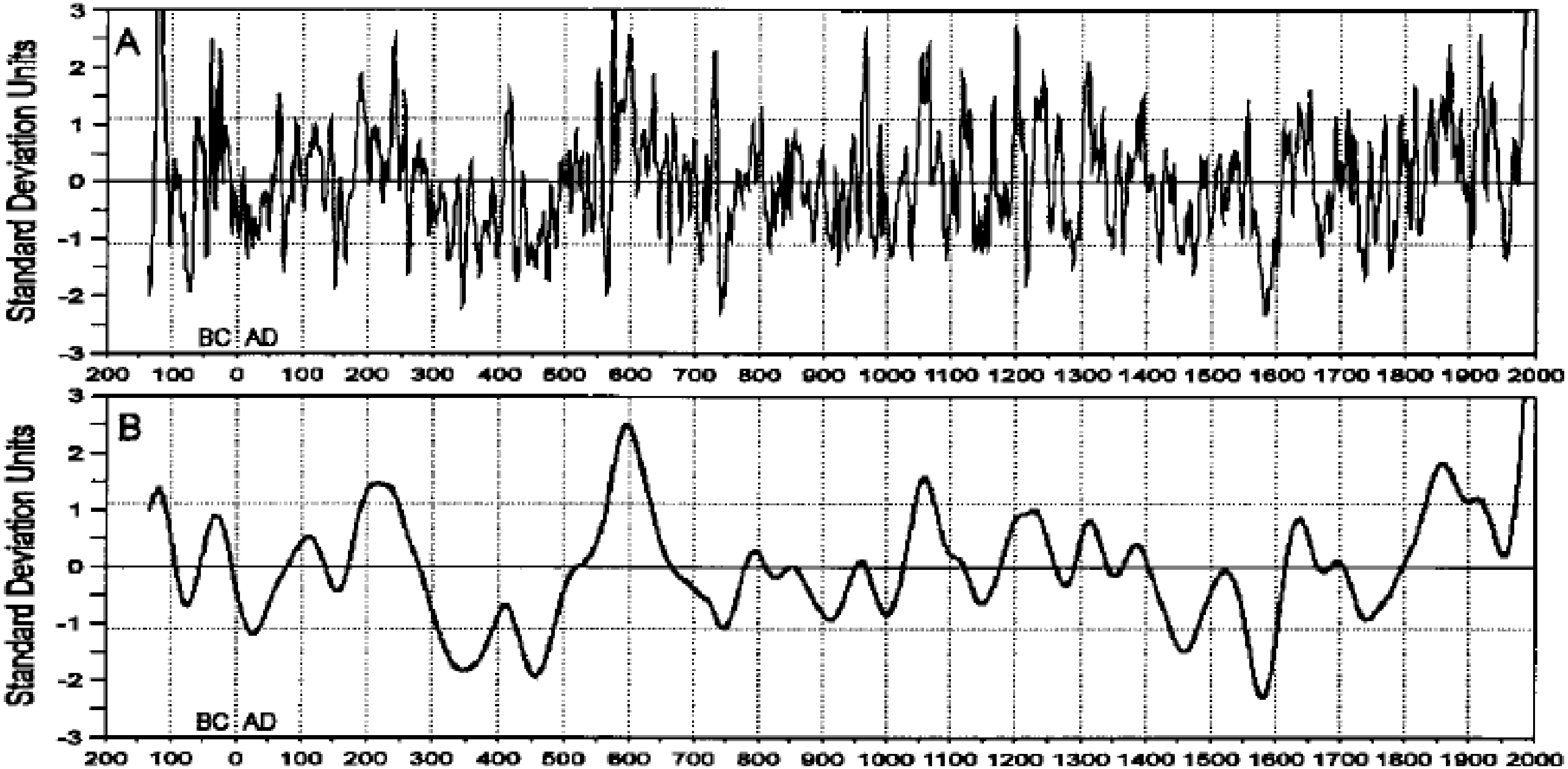
Recent droughts not as intense as those in the past



Woodhouse et al. (2013)

Precipitation over past 2000 Years in El Malpais

Note: units are in standard deviation



10-yr smoothed

100-yr smoothed

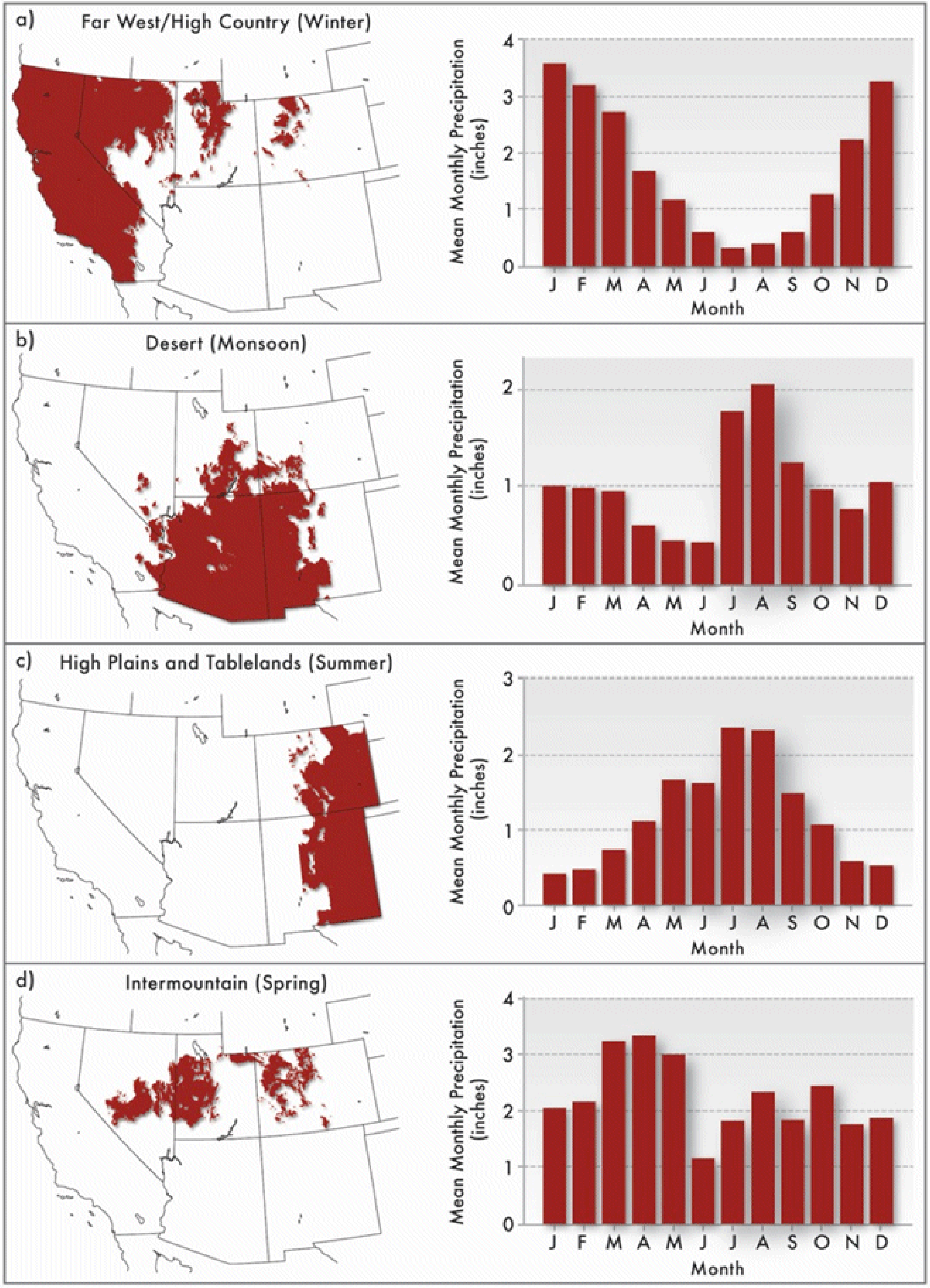
AD 0

AD 1000

AD 2000

Climate reconstruction from Ponderosa Pine and Douglas Fir tree ring data

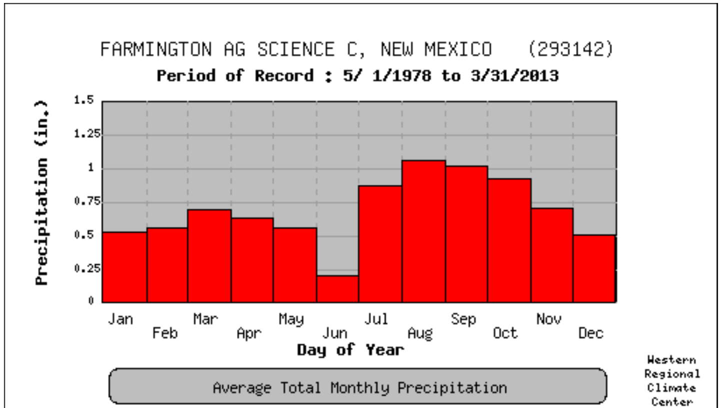
Grissino-Mayer (1996)

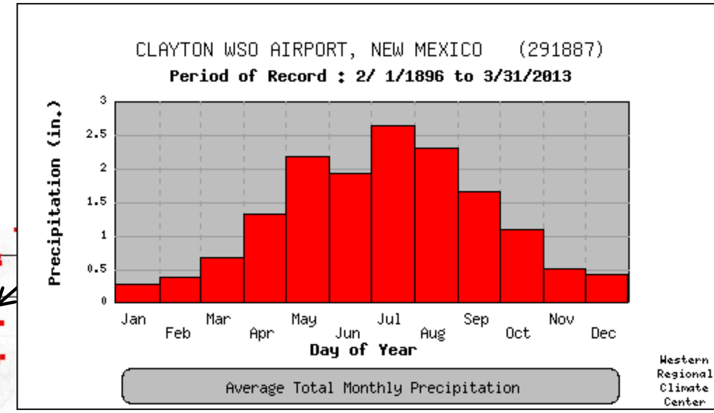


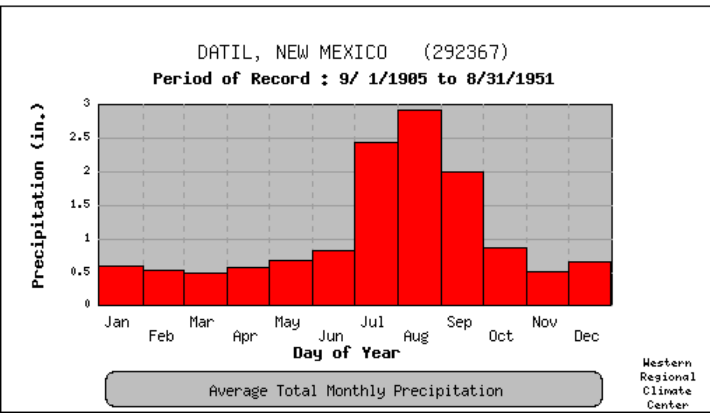
Precipitation Seasonality

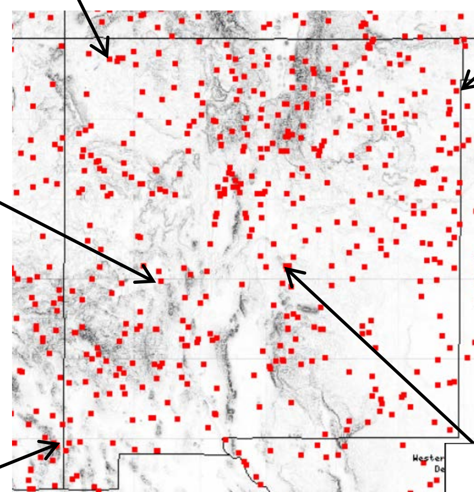
PRISM 1901-2010

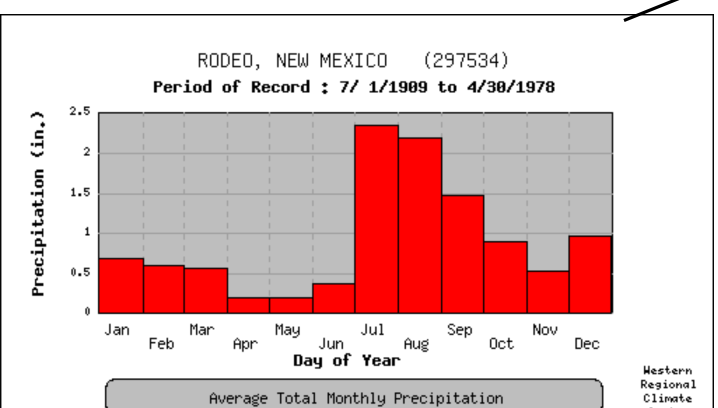
Seasonal patterns of precipitation in New Mexico

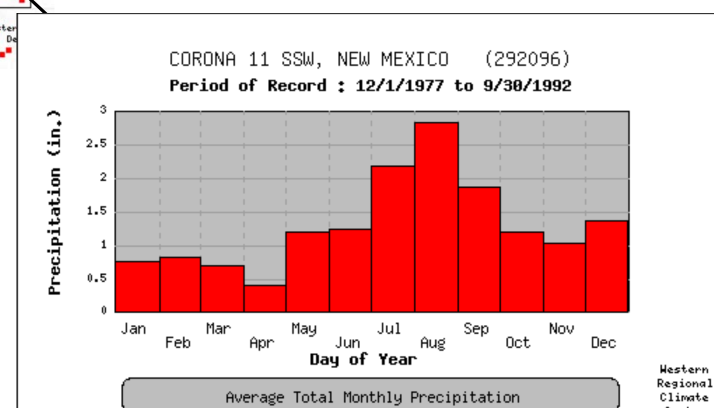






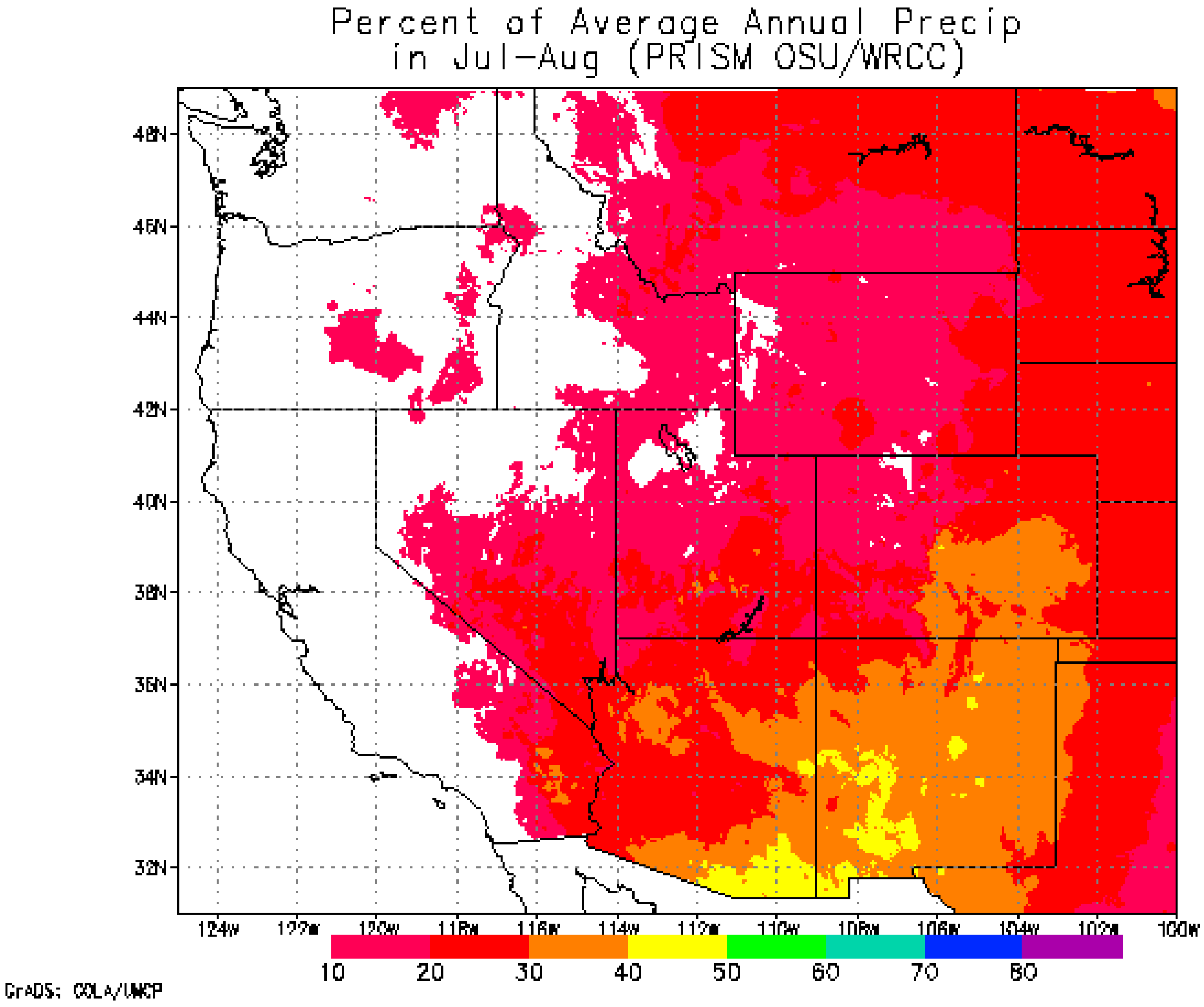






http://www.wrcc.dri.edu/summary/Climsmaz.html

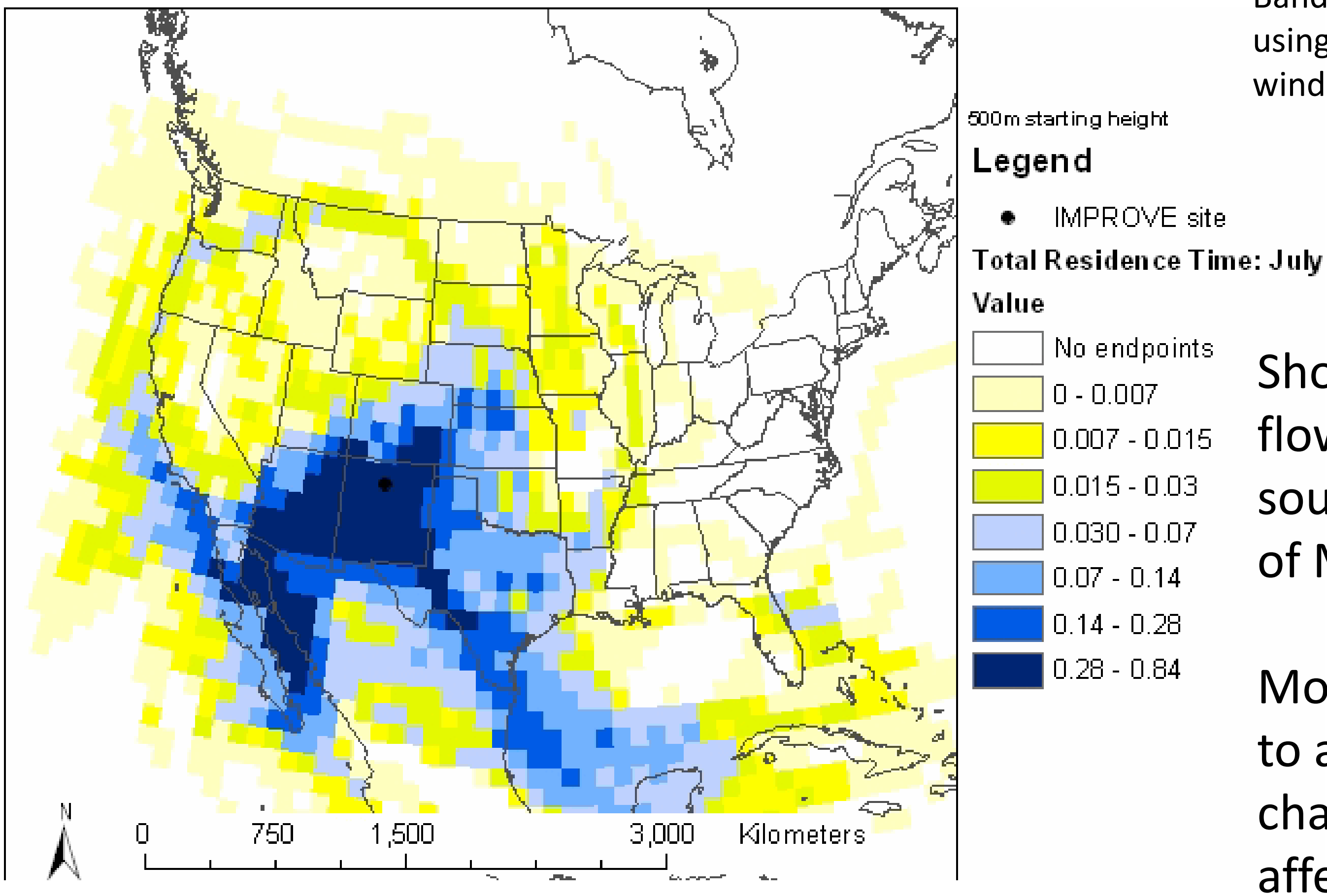
Importance of Monsoon Rain



Regions shaded in yellow are areas where 40 to 50% of the yearly rain falls during July and August

Our summer monsoon pattern

3-yr backtrajectories from Bandelier in July. Run every 3-hr using HYSPLIT at 500m with EDAS winds

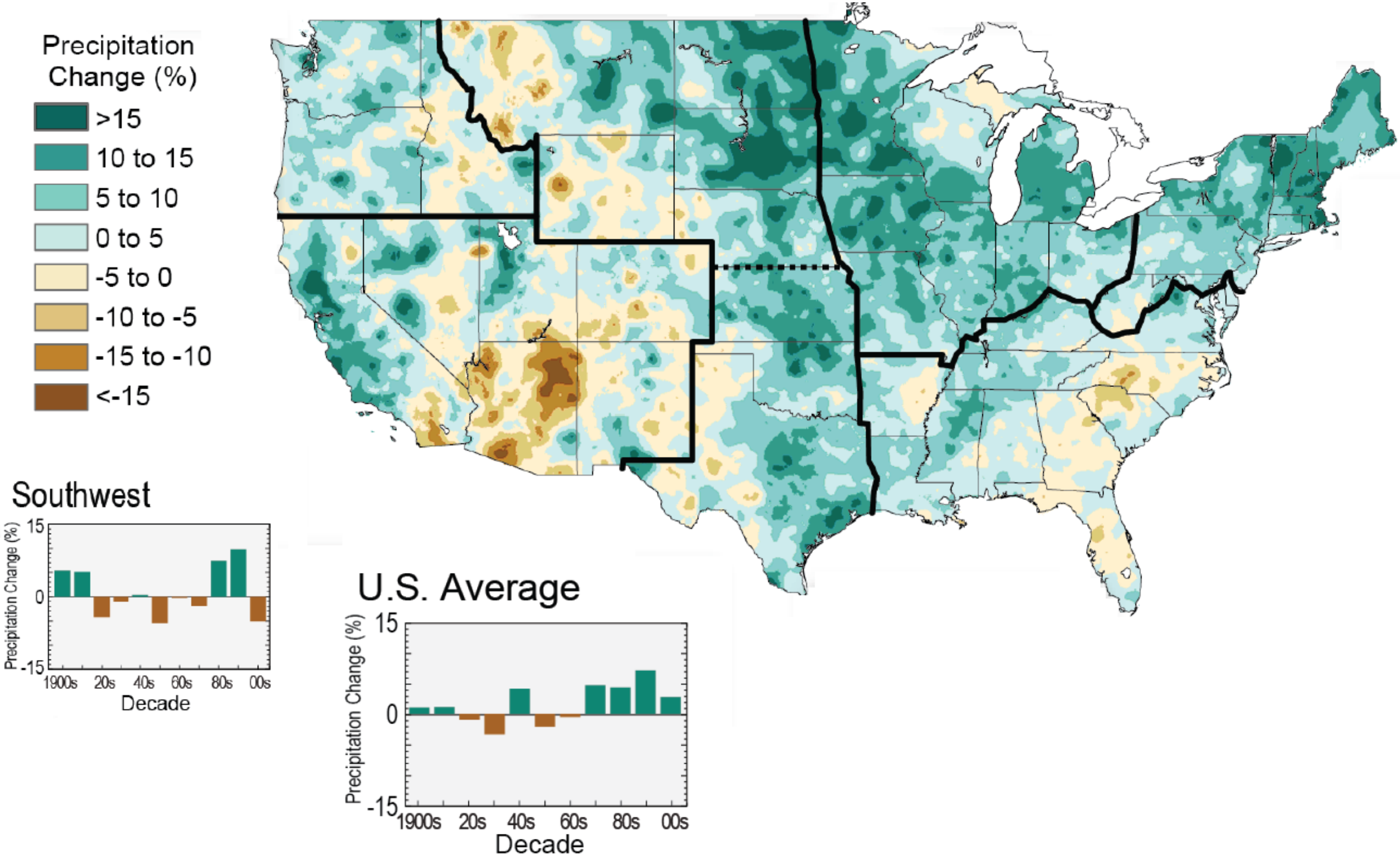


Shows southwesterly flow & a significant southeast flow from Gulf of Mexico

More research is needed to assess how climate change might be affecting our North American Monsoon

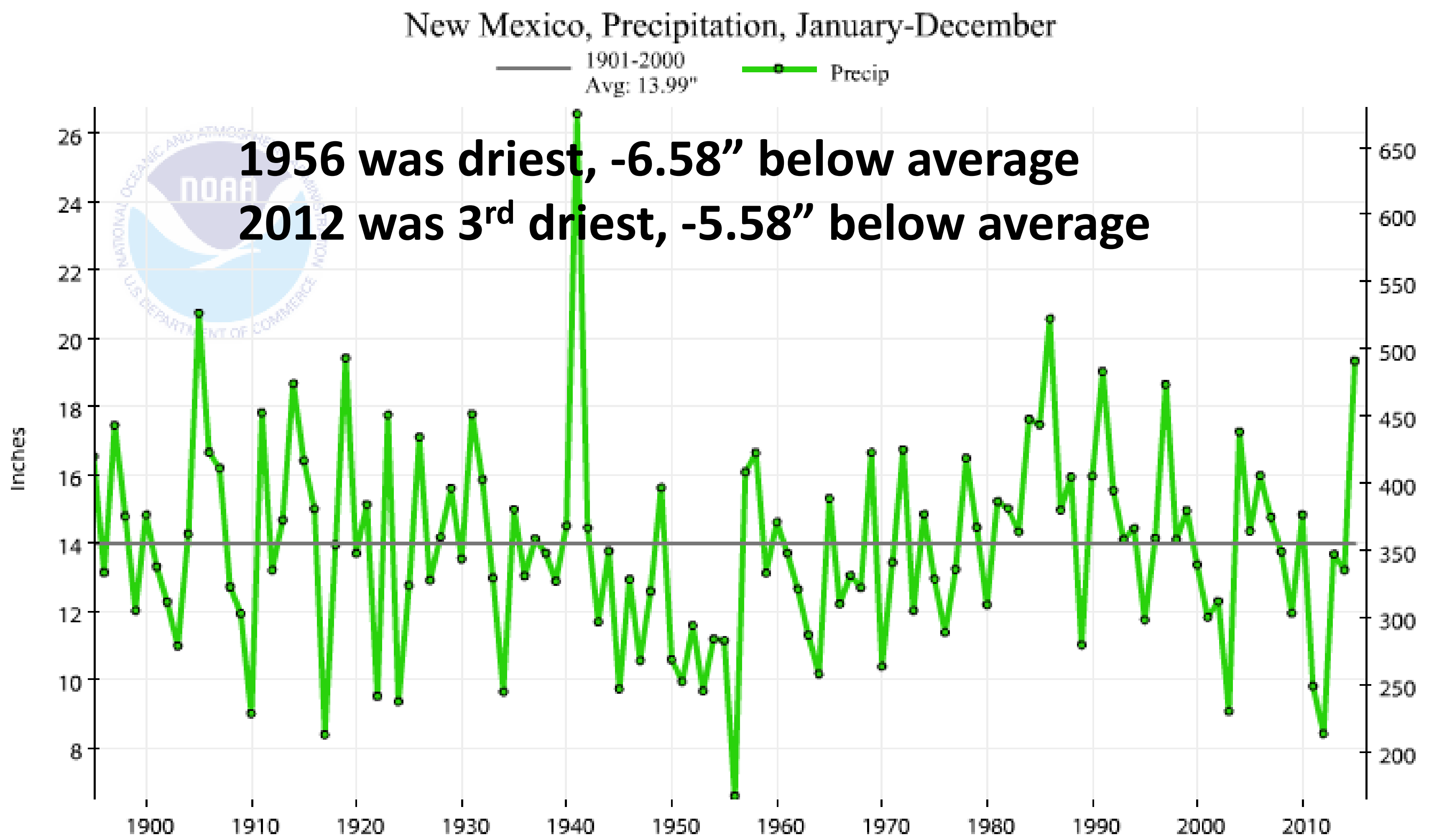
Changes in precipitation from 1991 to 2012 (22 yrs) compared to the 1901-1960 average

(bars are changes by decade relative to 1901-1960 average)



Source: Modified from National Climate Assessment (2014)

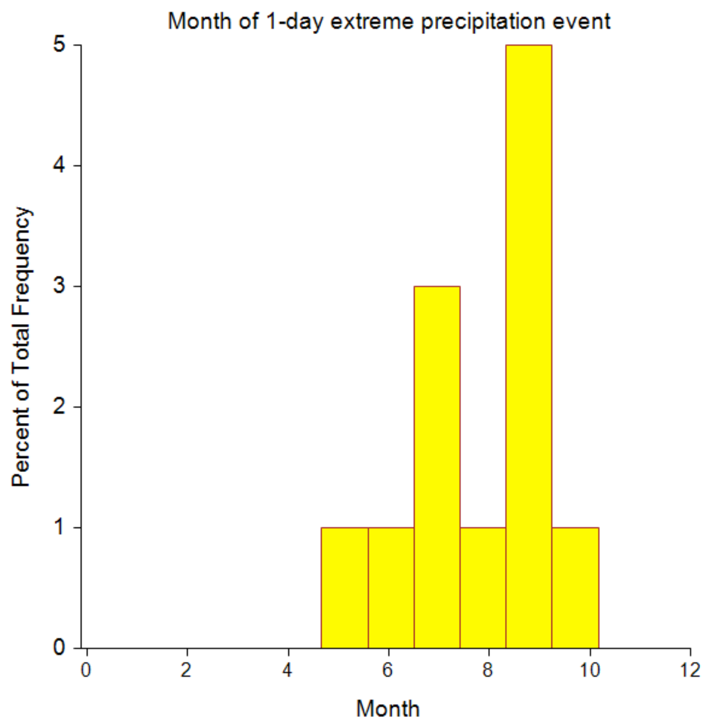
NM Precipitation over past 121 yrs

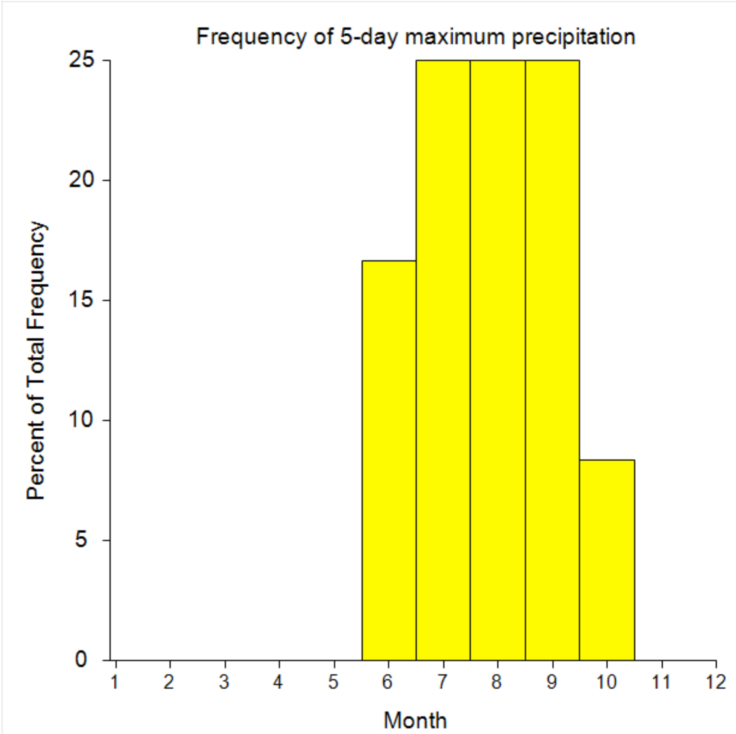


https://www.ncdc.noaa.gov/cag/

Seasonality of Precipitation Records

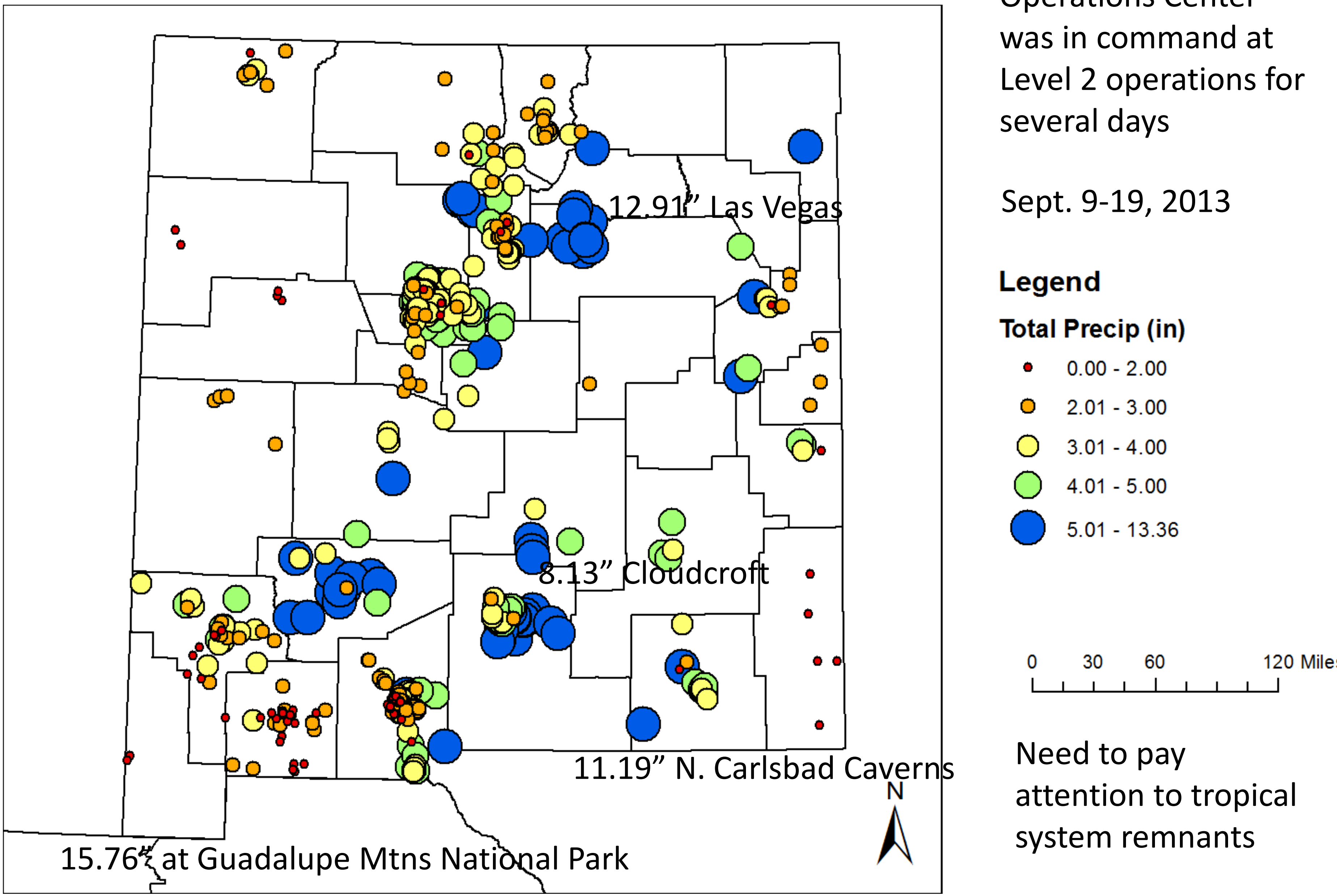
- <u>September</u> is most frequent month for 1-day record precipitation events across 120 NWS Cooperative stations
- 5-day record precipitation events equally spread over <u>July, August and September</u>





Data source: http://scacis.rcc-acis.org/

Sept. 2013 Rain Event



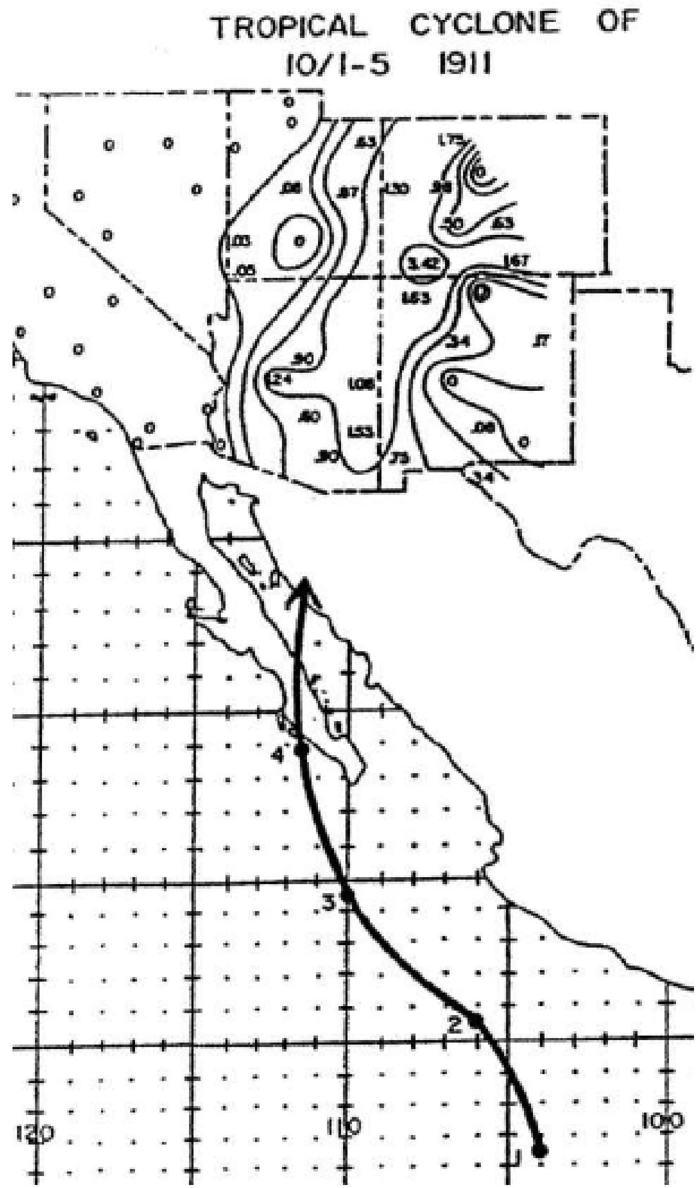
NM State Emergency Operations Center was in command at Level 2 operations for several days

Sept. 9-19, 2013

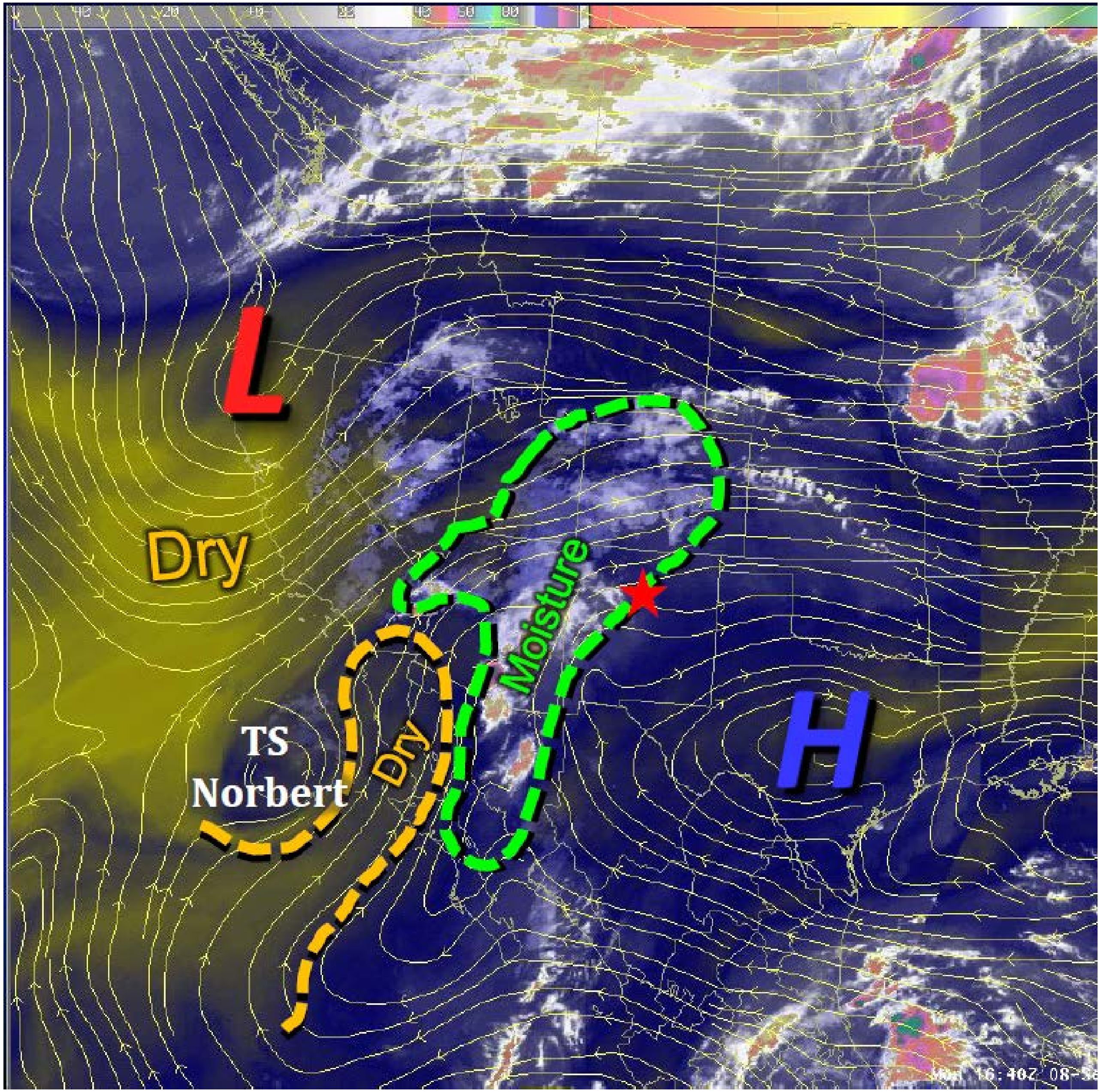
Need to pay attention to tropical system remnants

Extremes from tropical remnants

- September 1941
- September 1942
- October 1911
  - Flood of record for the Animas River at Farmington (estimated 30,000+ cfs)



Ed Polasko, ABQ NWS ret.



NWS ABQ briefing

Tropical Storm Norbert Sept. 8, 2014

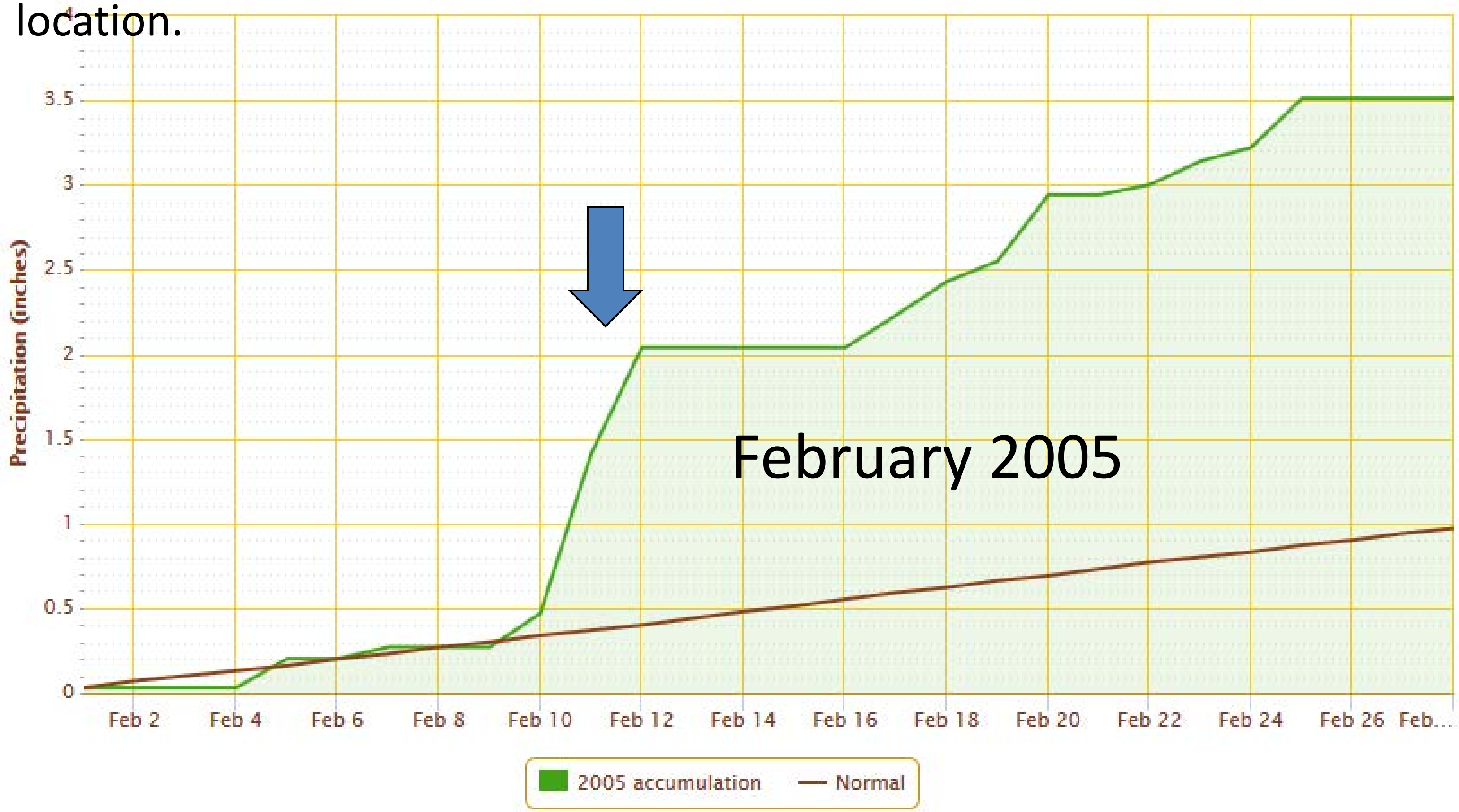
Dec. 1978 rain on snow event

- winter rain on mountain snow in southwest NM
- large scale orographic lift of moisture tropical airmass
- 72 hr rainfall ranged from 2 to 5"
- Record flood at Gila Hot Springs and Redrock (48,800 cfs)
- 19 homes/businesses at Reserve, NM damaged

Ed Polasko, ABQ NWS ret.

Recent rain on snow event

A large fetch of tropical moisture produced 1.5 to >3" of rain over the Gila. Much of the existing snowpack melted from the rain, which resulted in widespread flooding. The Gila River crested at 1 to 4 feet above flood stage, depending on the location.



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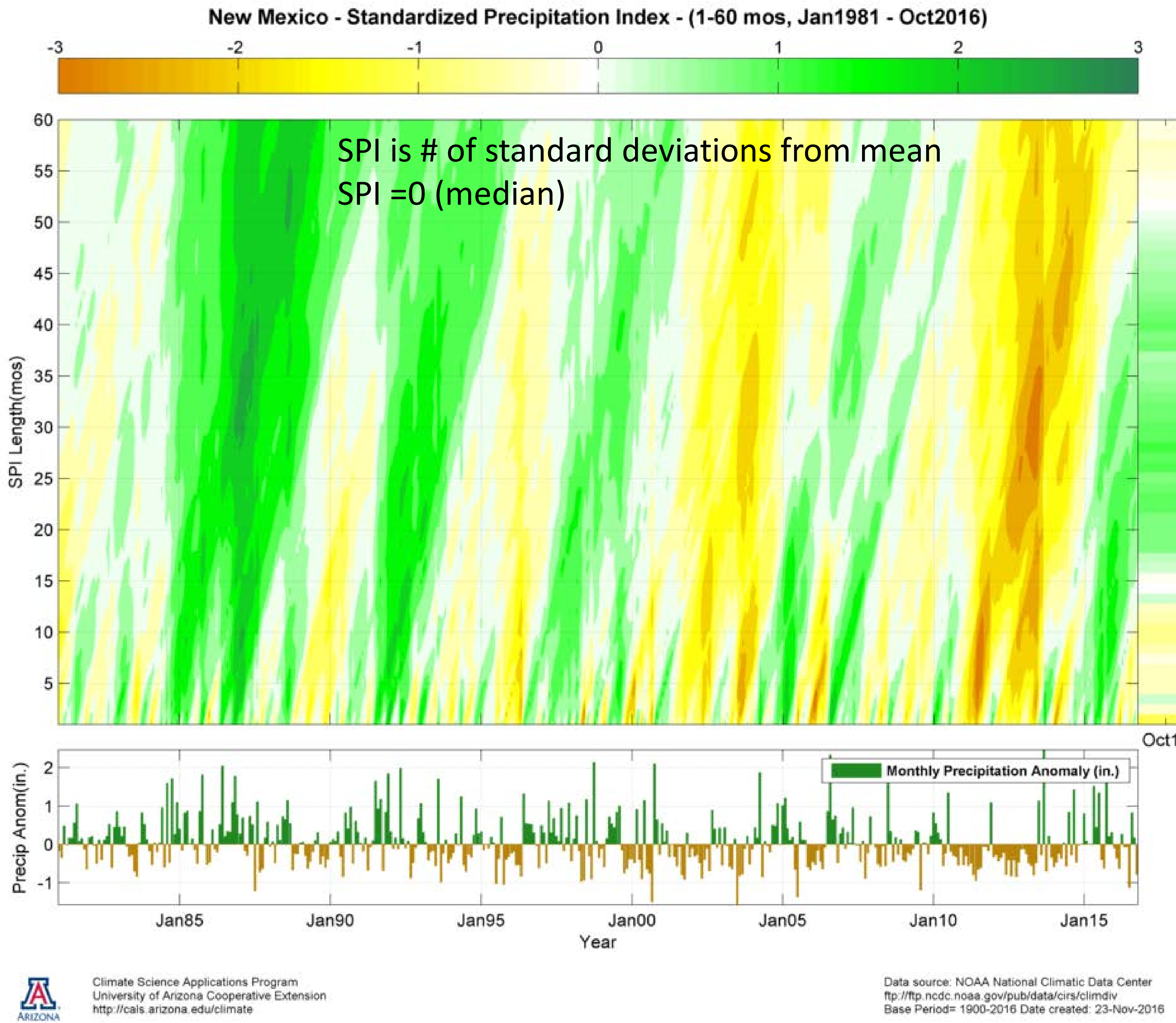
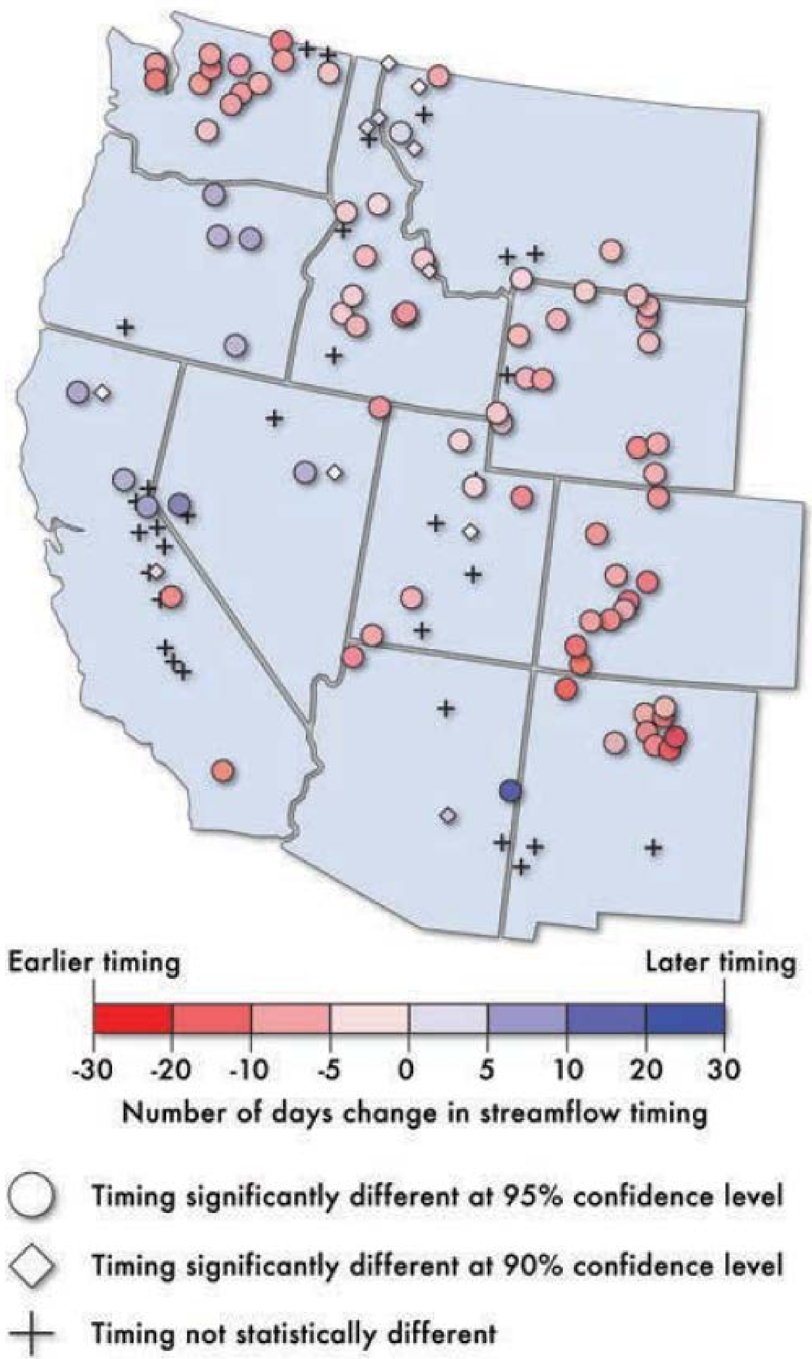

New Mexico - Standardized Precipitation Index - (1-60 mos, Jan1981 - Oct2016)
SPI is # of standard deviations from mean
SPI =0 (median)
SPI Length(mos)
Oct16
Precip Anom(in.)
Monthly Precipitation Anomaly (in.)
Jan85
Jan90
Jan95
Jan00
Jan05
Jan10
Jan15
Year
Climate Science Applications Program
University of Arizona Cooperative Extension
http://cals.arizona.edu/climate
Data source: NOAA National Climatic Data Center
ftp://ftp.ncdc.noaa.gov/pub/data/cirs/climdiv
Base Period= 1900-2016 Date created: 23-Nov-2016

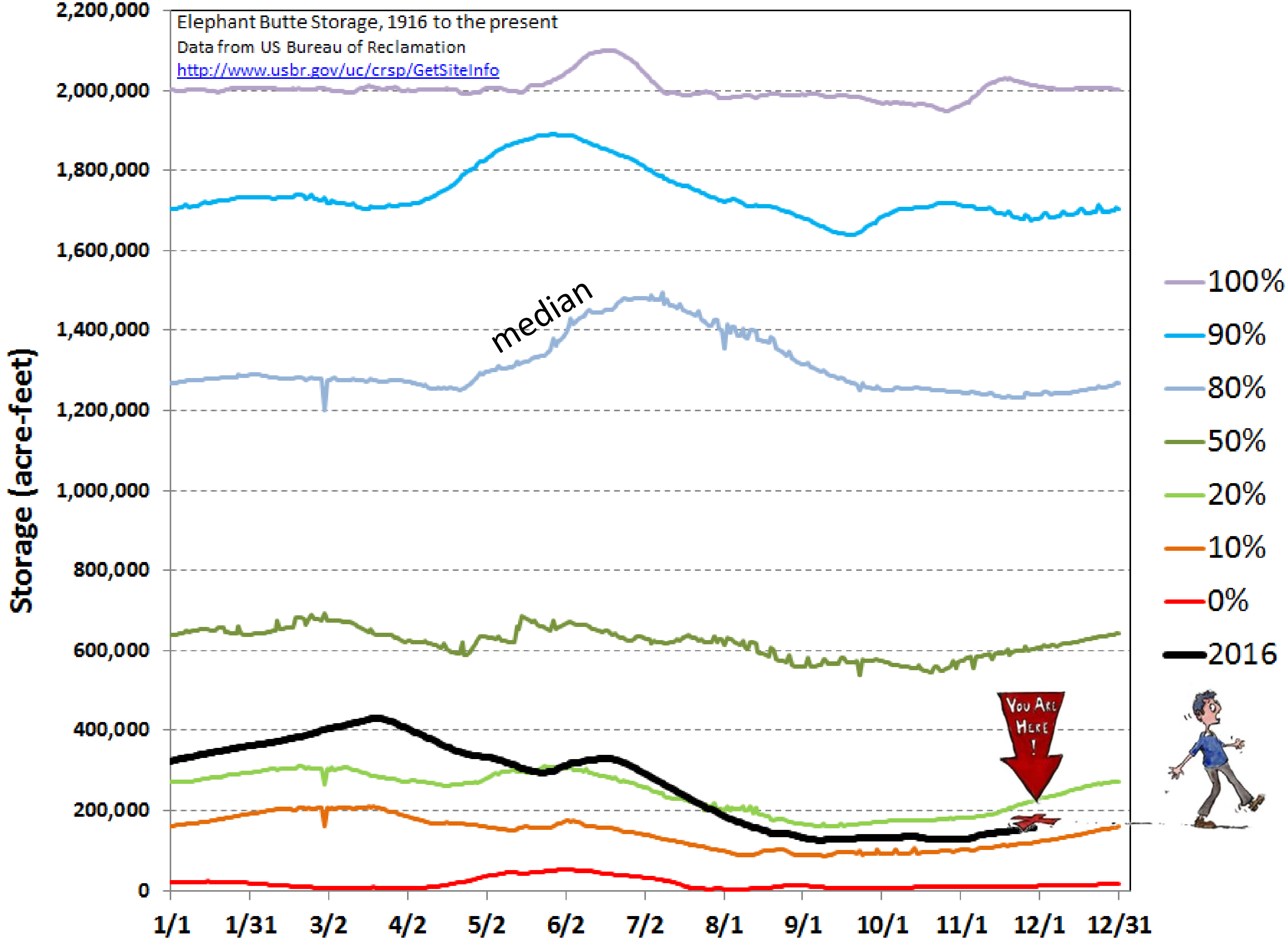


Changing streamflow timing 2001–2010 compared to 1950–2000

Differences between 2001–2010 and 1950–2000 average date when half of the annual streamflow has been discharged (center of mass) for snowmelt dominated streams (Stewart, Cayan and Dettinger 2005).

Southwest Climate Assessment (2013)

Elephant Butte storage percentiles



Drought Indicators

- Palmer Drought Index
- CPC Soil Moisture Model percentiles
- USGS Weekly Streamflow (Percentiles)
- Standardized Precipitation Index (SPI)
- Objective Short and Long-term Drought Indicator Blends (Percentiles)
- Numerous supplementary indicators and expert input

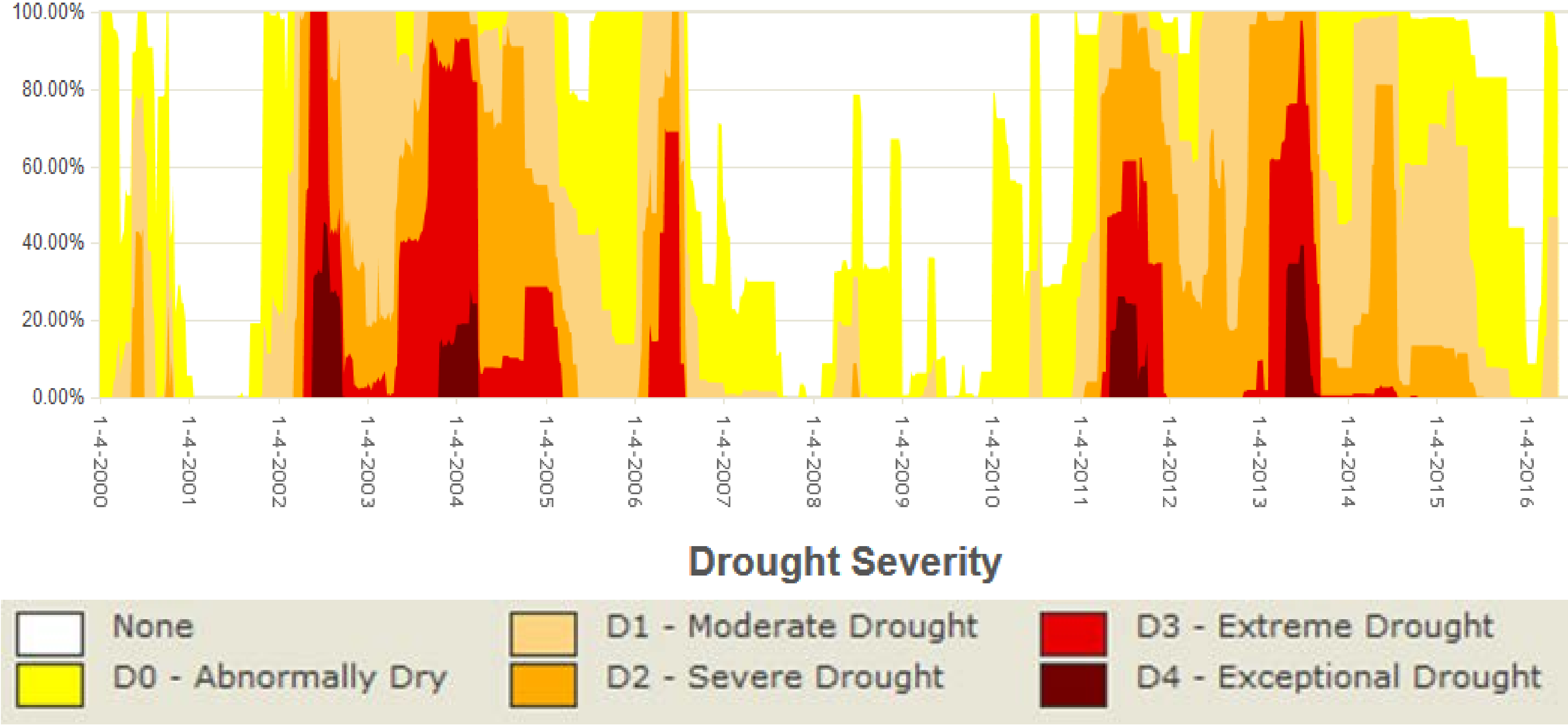
US Drought Monitor

Drought classification puts drought in historical perspective

DM Level	Name	Percentile
D0	Abnormally dry	21-30
D1	Moderate drought	11-20
D2	Severe drought	6-10
D3	Extreme drought	3-5
D4	Exceptional drought	0-2

US Drought Monitor: Rio Grande Basin

Percent area in each drought category (HUC 1302)

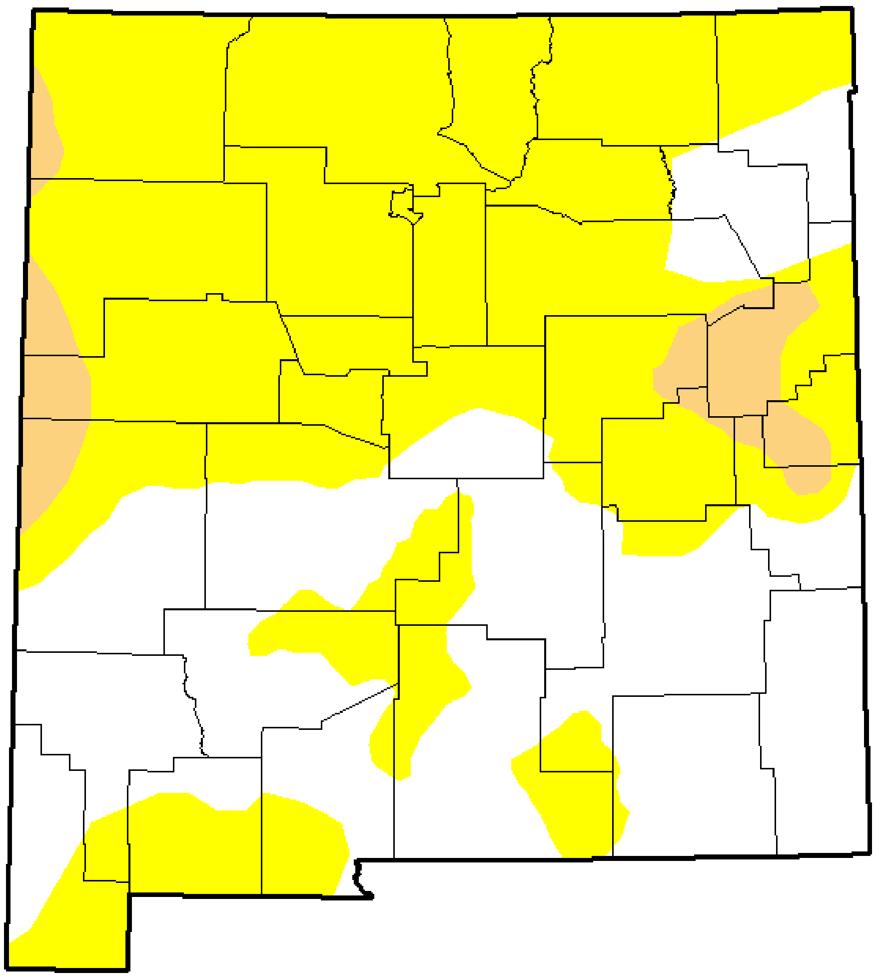


We've seen state-wide drought ebb and flow over the last 16 years

Current U.S. Drought Monitor

U.S. Drought Monitor

New Mexico



November 22, 2016

(Released Wednesday, Nov. 23, 2016)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	39.54	60.46	4.92	0.00	0.00	0.00
Last Week 11/15/2016	39.54	60.46	4.92	0.00	0.00	0.00
3 Months Ago 8/23/2016	12.91	87.09	26.61	1.14	0.00	0.00
Start of Calendar Year 12/29/2015	73.76	26.24	0.00	0.00	0.00	0.00
Start of Water Year 9/27/2016	53.33	46.67	3.85	0.00	0.00	0.00
One Year Ago 11/24/2015	73.76	26.24	3.20	0.00	0.00	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:

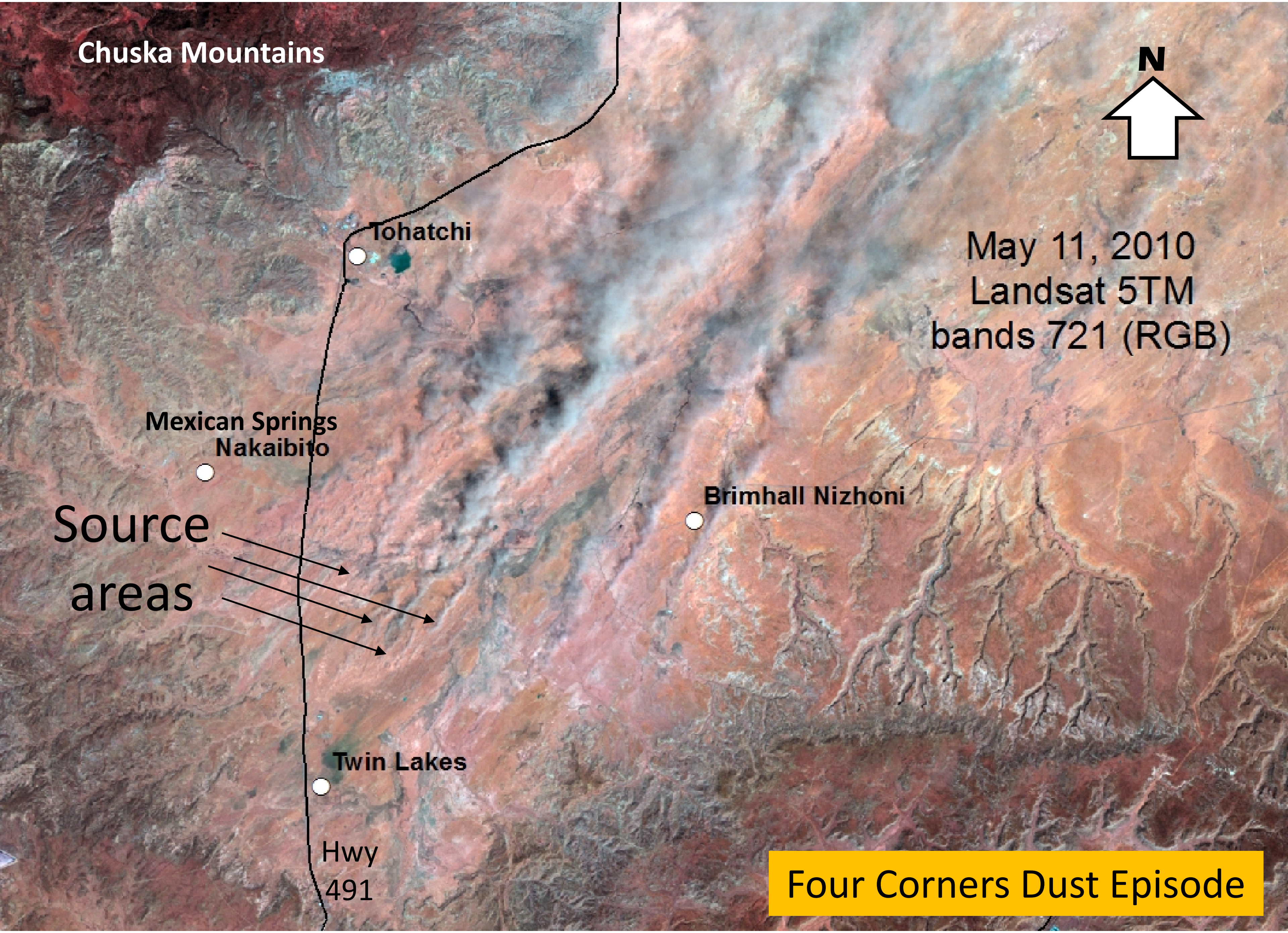
Richard Heim

NCEI/NOAA

http://droughtmonitor.unl.edu/

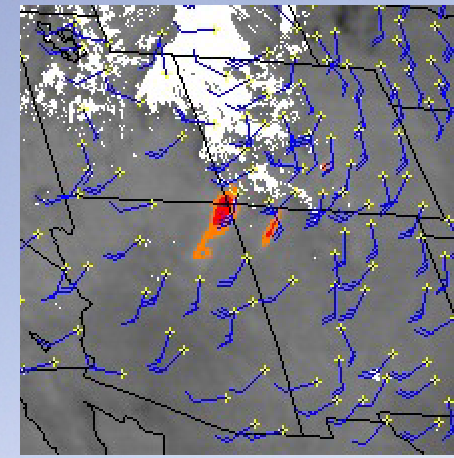
Concerns with Changing Climate

- **Dust storms** – increased aridity, intense spring storms; impacts transportation; snowmelt



Chuska Mountains
N
Tohatchi
May 11, 2010
Landsat 5TM
bands 721 (RGB)
Mexican Springs
Nakaibito
Brimhall Nizhoni
Source
areas
Twin Lakes
Hwy
491
Four Corners Dust Episode

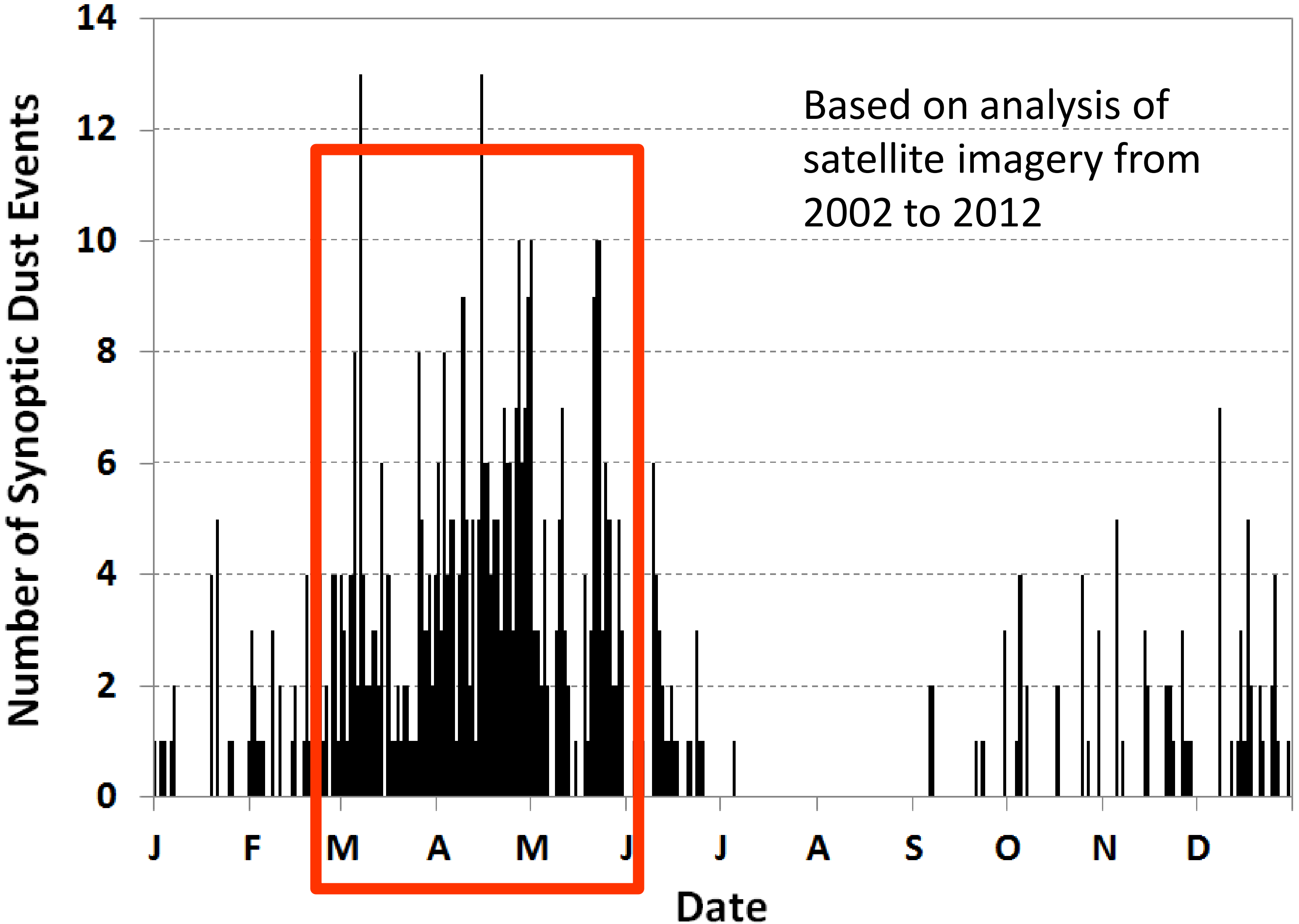
Dust storm lasted >6 hours and transported dust to San Juan Mountains in CO



Above: Longwave IR difference image shows dust plumes

erodible rangeland north of Gallup during the May 22, 2010 dust storm

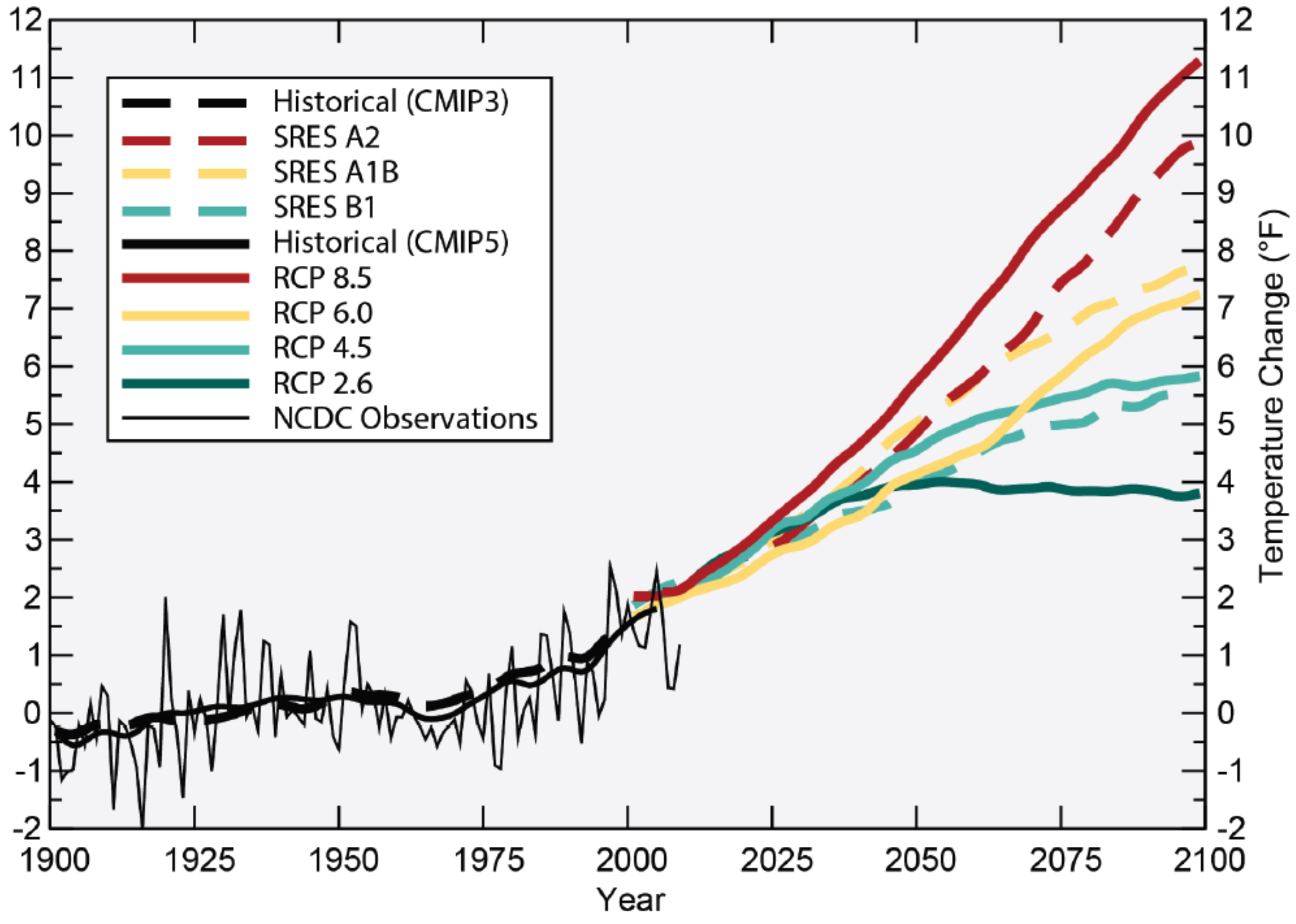
Spring dust events



Mainly in March, April and May

What do the models say about the future?

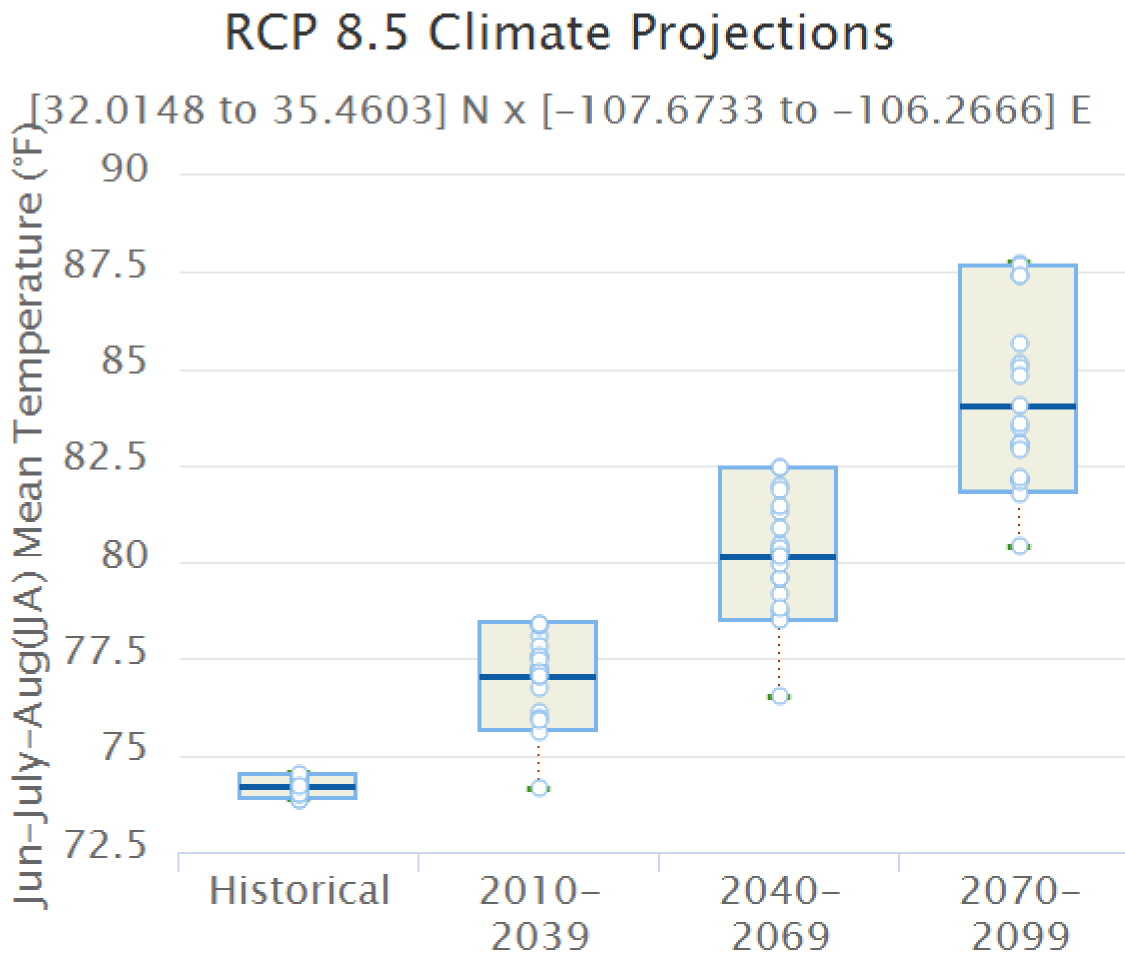
Projected annual averaged temperature changes relative to 1901-1960 average



Highlights of SW Climate Assessment

- Agricultural pests can persist year-around
- New pests and diseases may become established
- Optimal location for specific crops will change
- Need to consider adjustment costs such as capital investments, establishing new trees, etc.
- Shift the mix of crops grown
- Increase the use of water management info systems
- Increase use of decision making tools

Middle Rio Grande temperatures



Summer (JJA) mean temperatures

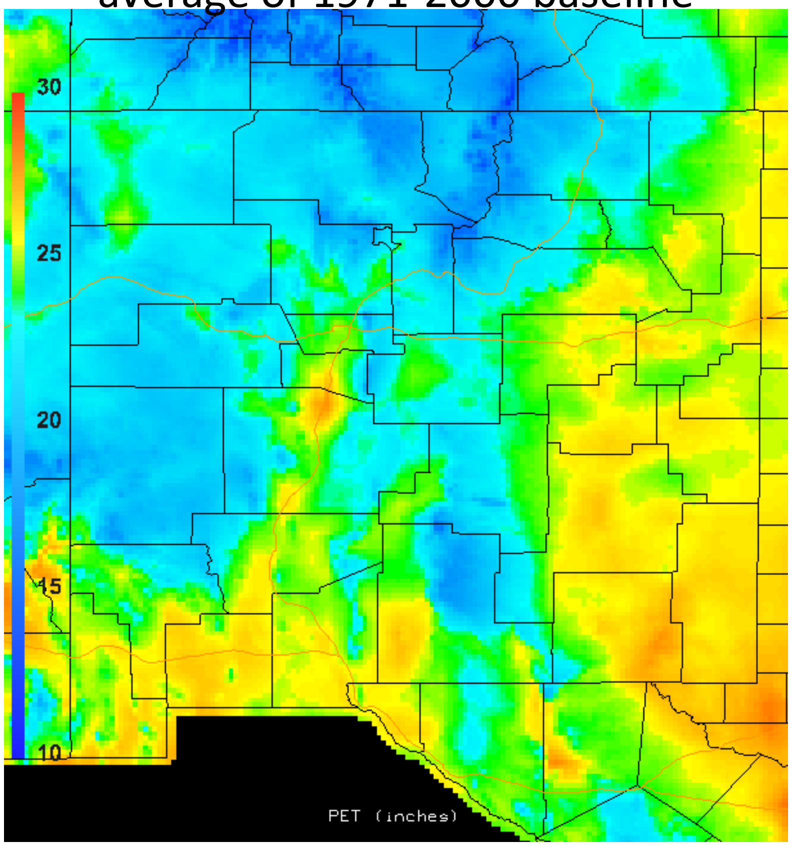
historical	74.2°
early century	77.1°
mid century	80.2°
end of century	84.0°

Multivariate Adaptive Constructed Analogs (Abatzoglou and Brown, 2012)

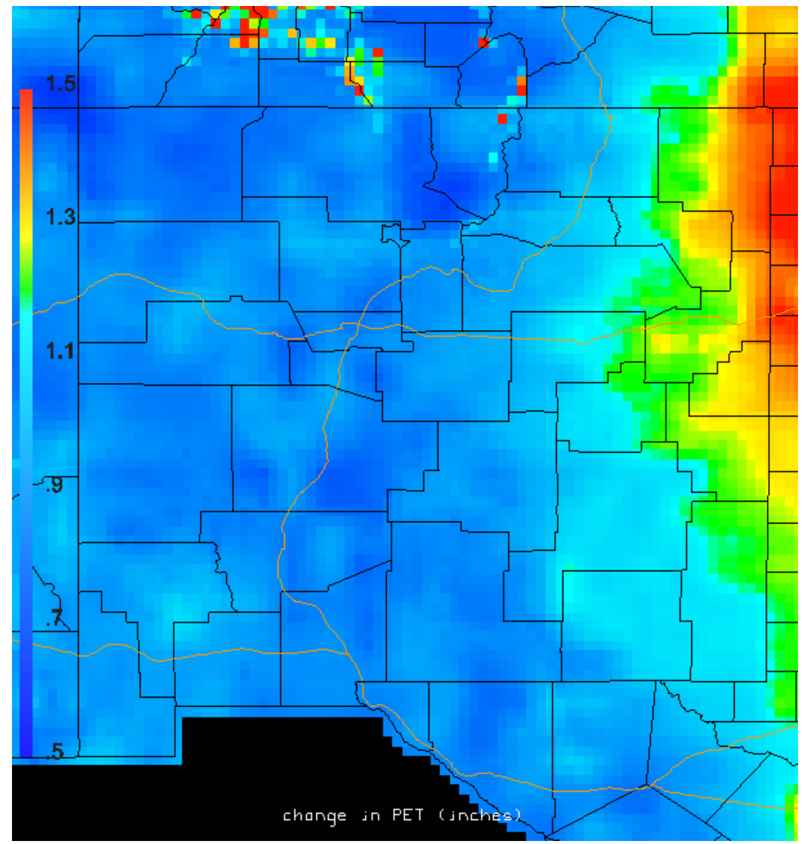
Data Source: MACAv2-METDATA, Multi-Model Mean

Changes in evapotranspiration

Reference June-Aug potential ET (inches)
average of 1971-2000 baseline



Early 21st century
June-Aug changes in potential ET (inches)
2010-2039 with RCP 8.5 scenario



Data Source: MACAv2-METDATA, Multi-Model Mean

Changes in evapotranspiration

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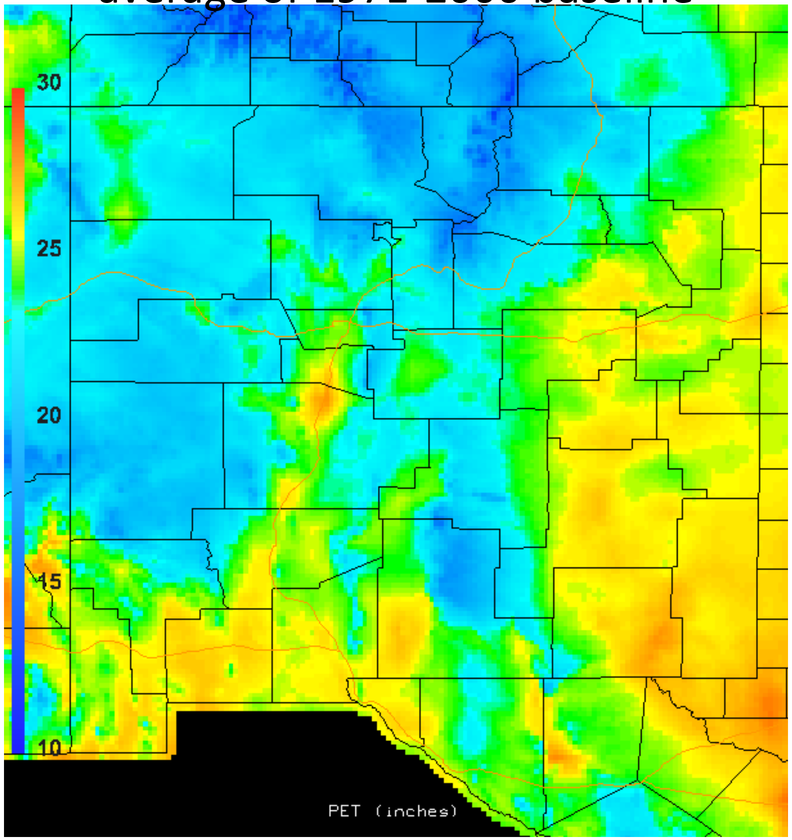
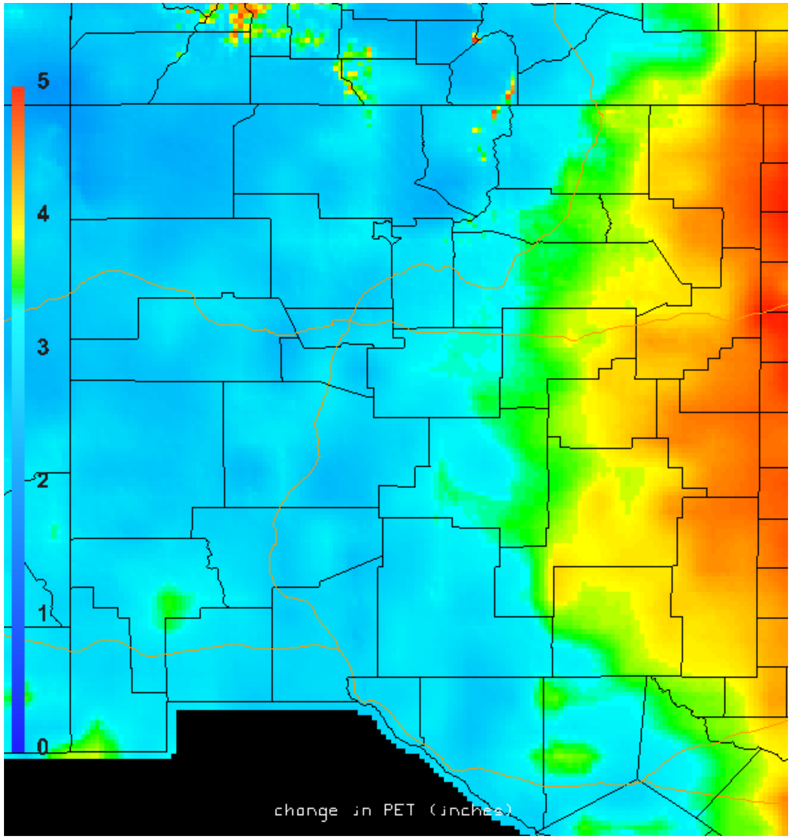


By end of century
June-Aug changes in potential ET (inches)
2070-2099 with RCP 8.5 scenario



Data Source: MACAv2-METDATA, Multi-Model Mean

Impacts of Extreme Weather

- Economic losses - agriculture
- Transportation shutdown - roads blocked, closed, cut-off (erosion/debris flows), airport delays
- Increase likelihood of traffic and accidents
- Loss of supply lines for food/medical assistance
- Loss of power and water
- Increase in vectors into our environment

Health Concerns with Changing Climate

- Heat waves – increased probabilities, higher overnight temperatures
- Allergens – earlier & longer frost-free season, longer allergy season
- Wildfires – frequency and size to increase; fine particulates or PM2.5 to increase, impacts large areas & can be transported long distances
- Drinking water – impacting surface water storage
- Ozone – depends on both emissions and weather patterns, federal standards lowering; concern from transport from outside of state

US Climate Reference Network USRCRN

USCRN Overview

The **U.S. Climate Reference Network (USCRN)** consists of 114 stations developed, deployed, managed, and maintained by the National Oceanic and Atmospheric Administration (NOAA) in the continental United States for the express purpose of detecting the national signal of climate change. The vision of the USCRN program is to maintain a sustainable high-quality climate observation network that 50 years from now can with the highest degree of confidence answer the question: How has the climate of the nation changed over the past 50 years? These stations were designed with climate science in mind.
Three independent measurements of temperature and precipitation are made at each station, insuring continuity of record and maintenance of well-calibrated and highly accurate observations. The stations are placed in pristine environments expected to be free of development for many decades. Stations are monitored and maintained to high standards, and are calibrated on an annual basis. In addition to temperature and precipitation, these stations also measure solar radiation, surface skin temperature, and surface winds, and are being expanded to include triplicate measurements of soil moisture and soil temperature at five depths, as well as atmospheric relative humidity. Experimental stations have been located in Alaska since 2002 and Hawaii since 2005, providing network experience in polar and tropical regions. Deployment of a complete 29 station USCRN network into Alaska began in 2009. This project is managed by NOAA's National Climatic Data Center and operated in partnership with NOAA's Atmospheric Turbulence and Diffusion Division.

USRCRN
United States REGIONAL Climate Reference Network
Click here for USRCRN

Highlight two sources of data that we need to pay attention

USRCRN

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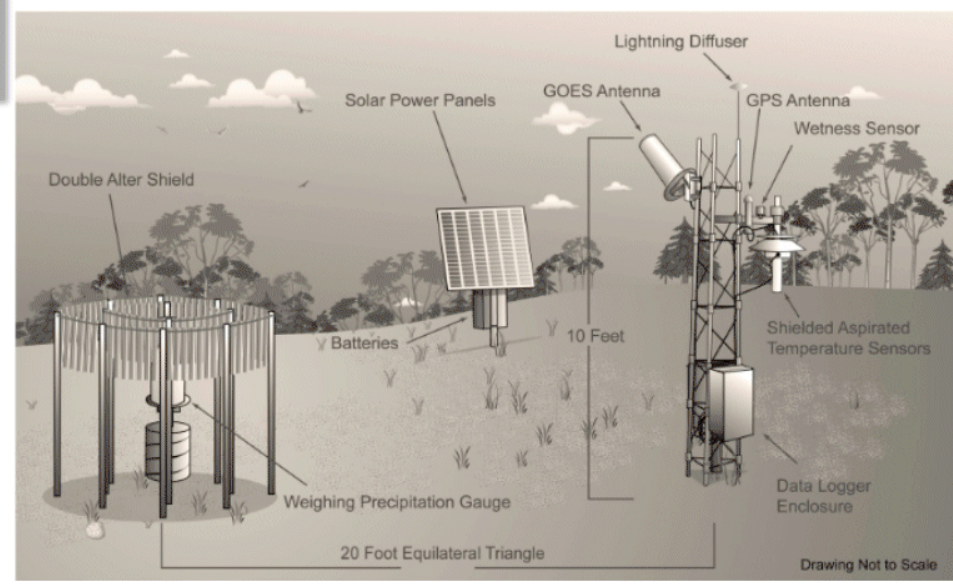
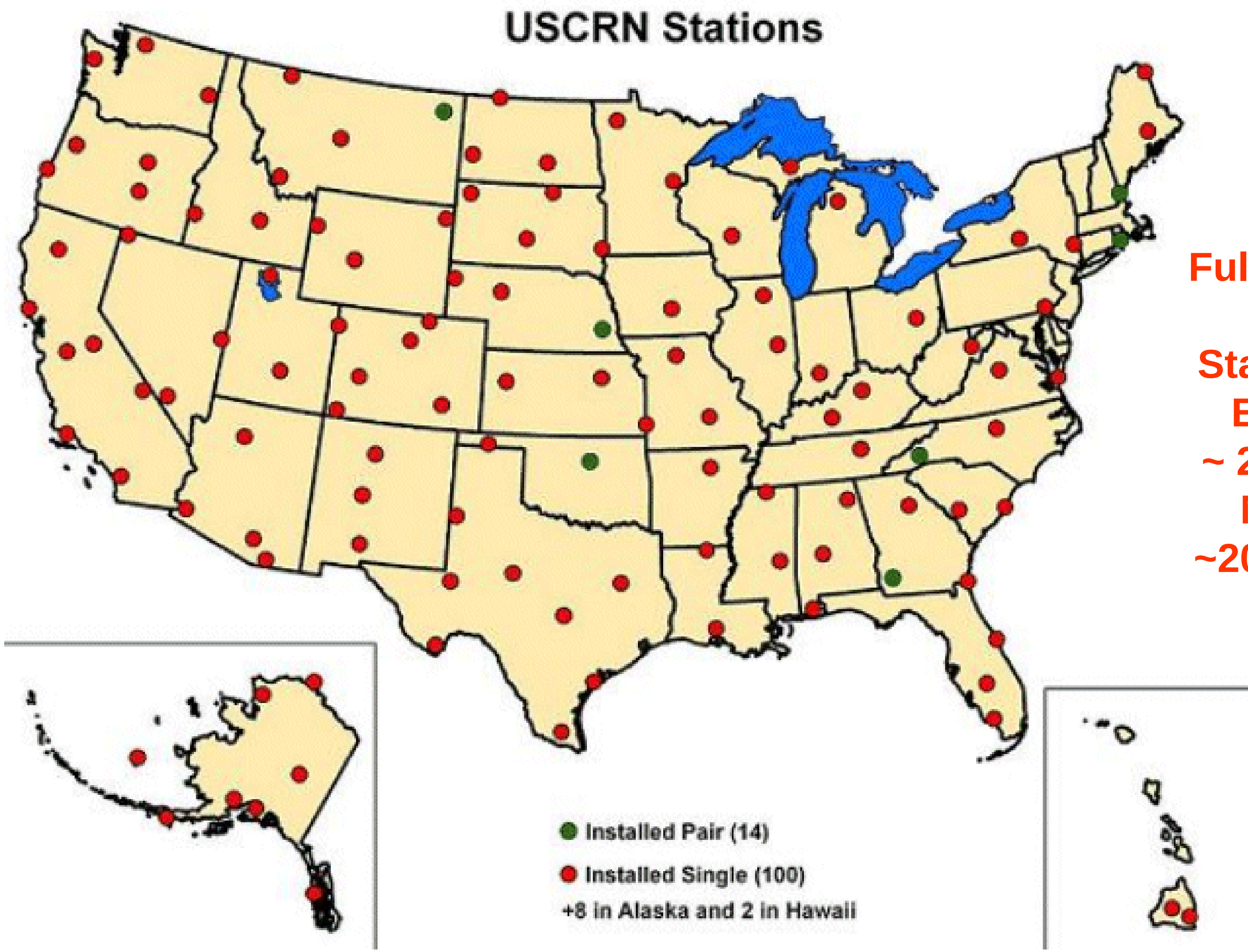
USRCRN Overview

A new network of stations called the **U.S. Regional Climate Reference Network (USRCRN)** is now being deployed by NOAA. These stations maintain the same level of climate science quality measurements as the national-scale U.S. Climate Reference Network (USCRN), but are spaced more closely, and focus solely on temperature and precipitation.
Beginning with a pilot project in the Southwest, USRCRN stations will be deployed at a 130 km spatial resolution to provide for the detection of regional climate change signals. Following completion of the pilot project, the long-term vision is deployment in each of the nine NOAA climate regions of the United States at a 130 km spatial resolution that will allow the detection of regional climate change signals. As with the USCRN, USRCRN stations have triple redundancy and are placed in pristine environments. About 538 locations in the United States will have either a USRCRN or USCRN station at the end of deployment for this project. This project is managed by NOAA???s National Climatic Data Center in partnership with the Office of Science and Technology in NOAA's National Weather Service and NOAA's Atmospheric Turbulence and Diffusion Division.



US Climate Reference Network USRCRN

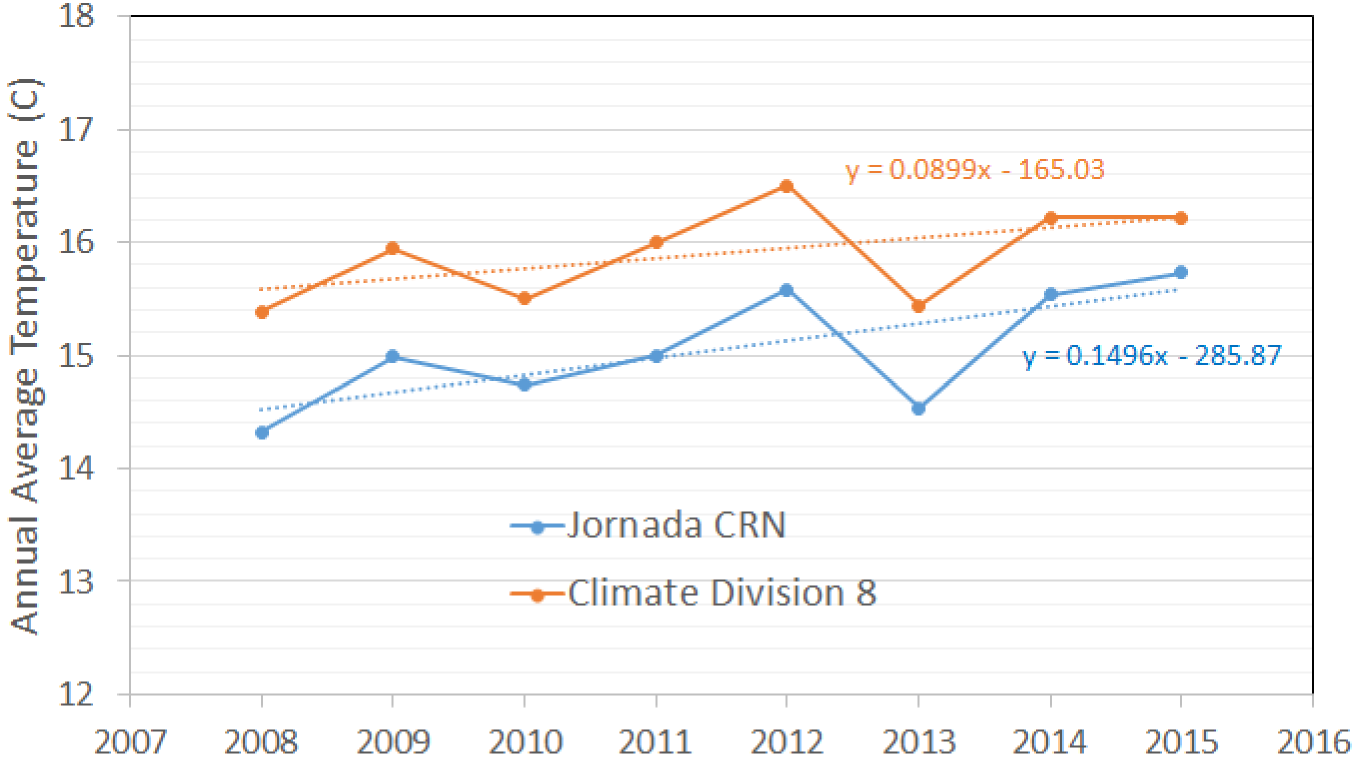
Map of USCRN Stations



Full US Map

Start Dates
Earliest
~ 2 in 2000
Mostly
~2003-4-5-6

Comparison between the Jornada Experimental Range station and that of the NOAA Climate Division 8 (southwestern deserts of NM) average
So far 8 continuous years of data



US CRN is specifically designed and deployed for quantifying climate change on a national scale
Located at plots in stable and open landscapes

Adapting to Climate Change

- Adopt a risk management approach to climate change
- We are vulnerable to drought – current drought is modest compared to past
- Improve infrastructure for drinking water
- Behavioral adaptation to heat waves and vector diseases
- Increase surveillance of disease & vectors
- Increase education

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Note: photo taken at close to lowest point of storage in recent years. Aug 29, 2013 90,634 acre-feet