

# **Kelly Redmond**

Regional Climatologist, Western  
Regional Climate Center Atmospheric Sciences Division

## **Climate and the Colorado and Columbia River Basins**



Presented at  
**The Aspen Global Change Institute**

June 5 - 10, 2003 Summer Science Session I

“Learning from Regions: A Comparative Appraisal of  
Climate, Water, and Human Interactions in the Colorado and  
Columbia River Systems”

# **Climate and the Colorado and Columbia River Basins**

**Kelly T. Redmond**

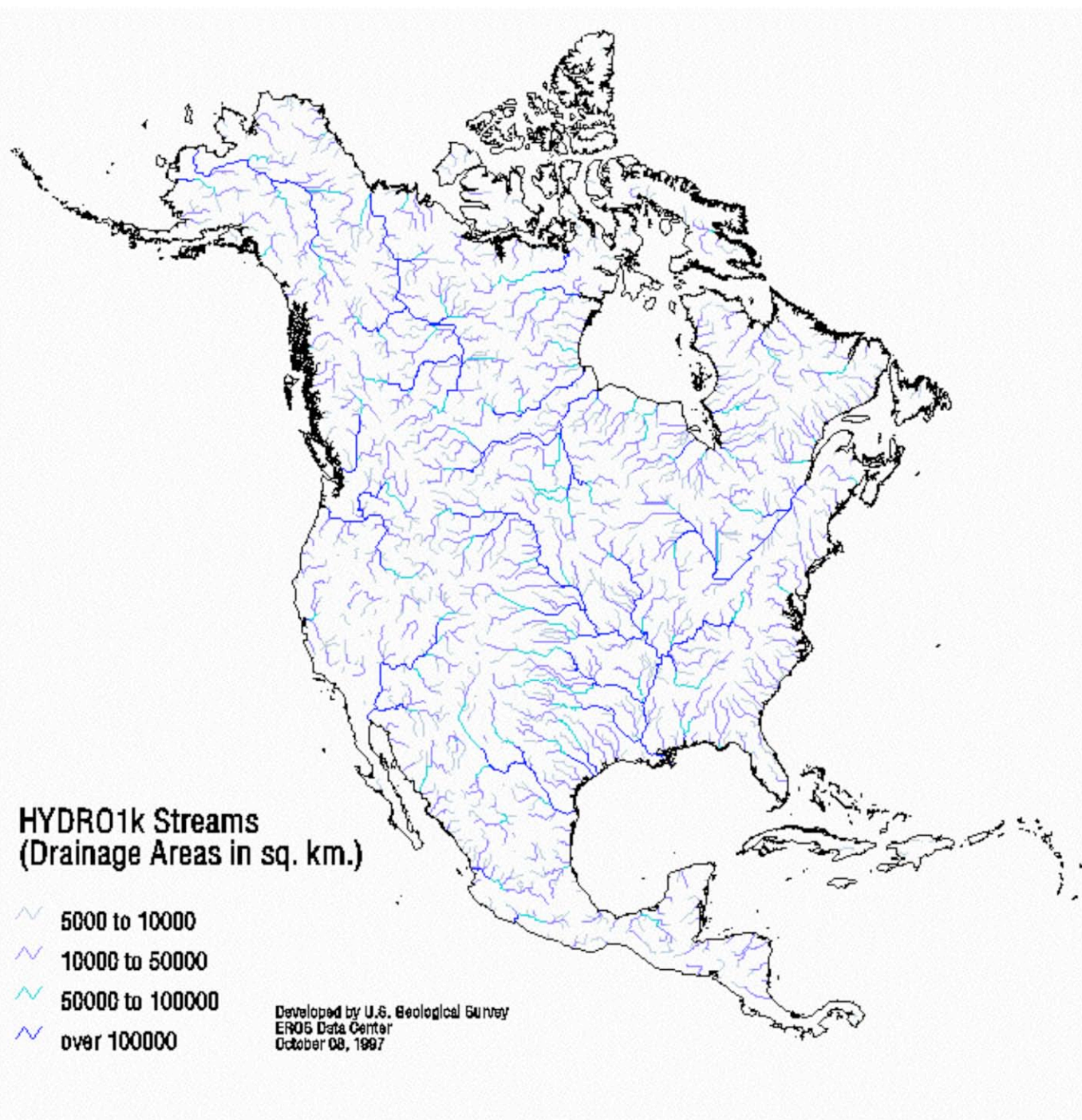
**Western Regional Climate Center**

**Desert Research Institute**

**Reno Nevada**



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## Water Resources Regions









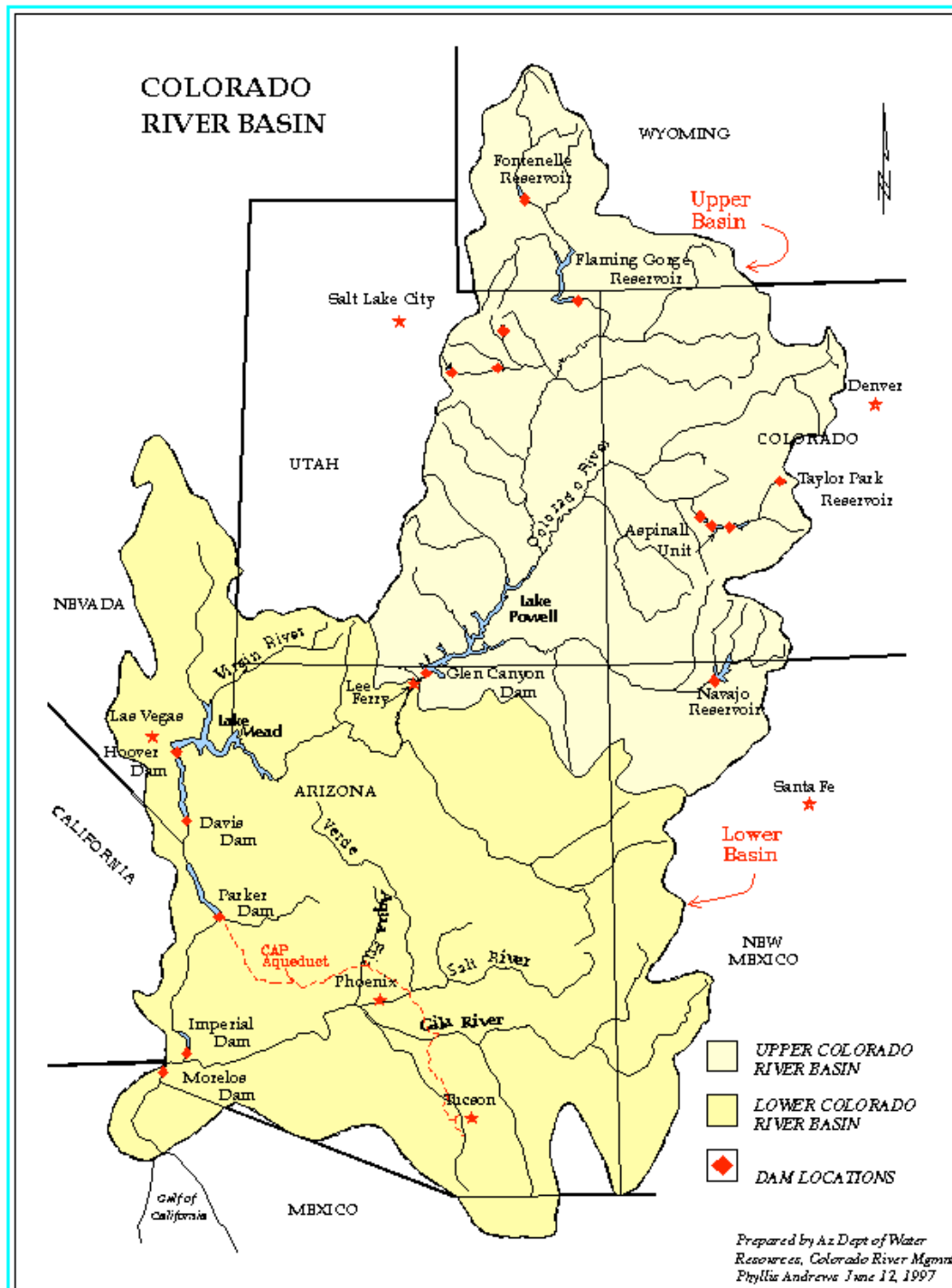


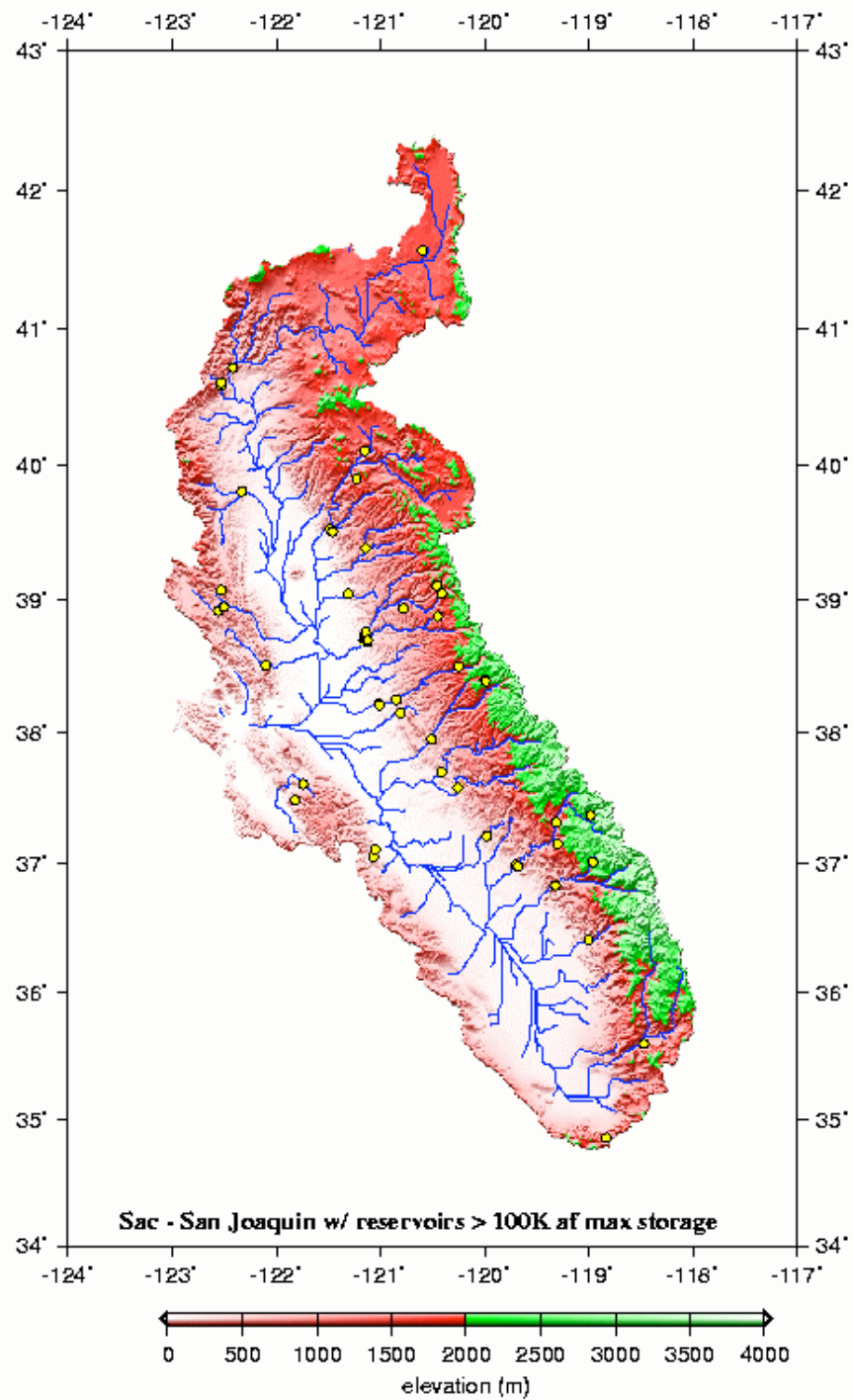
# Columbia River Basin



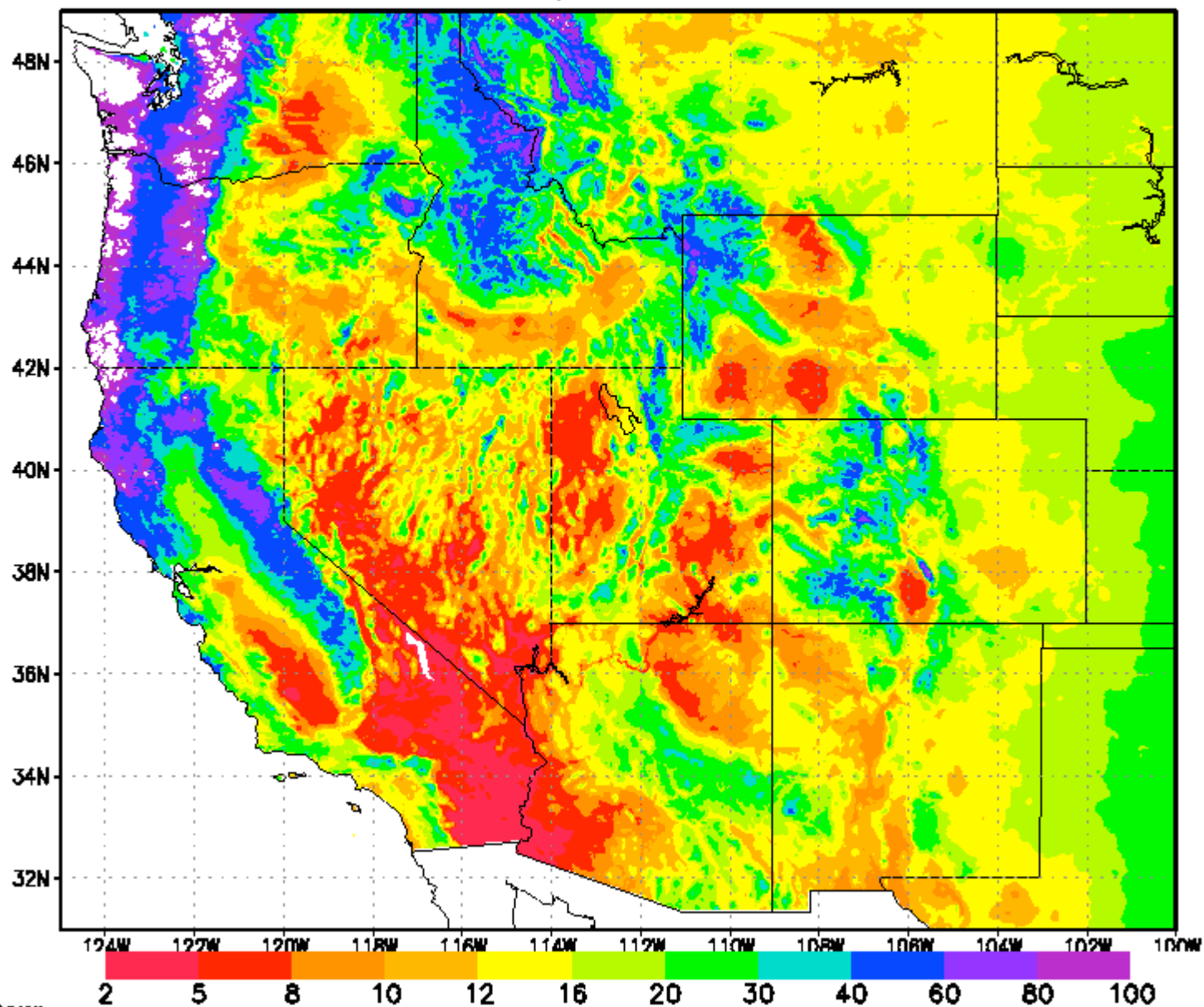


# COLORADO RIVER BASIN



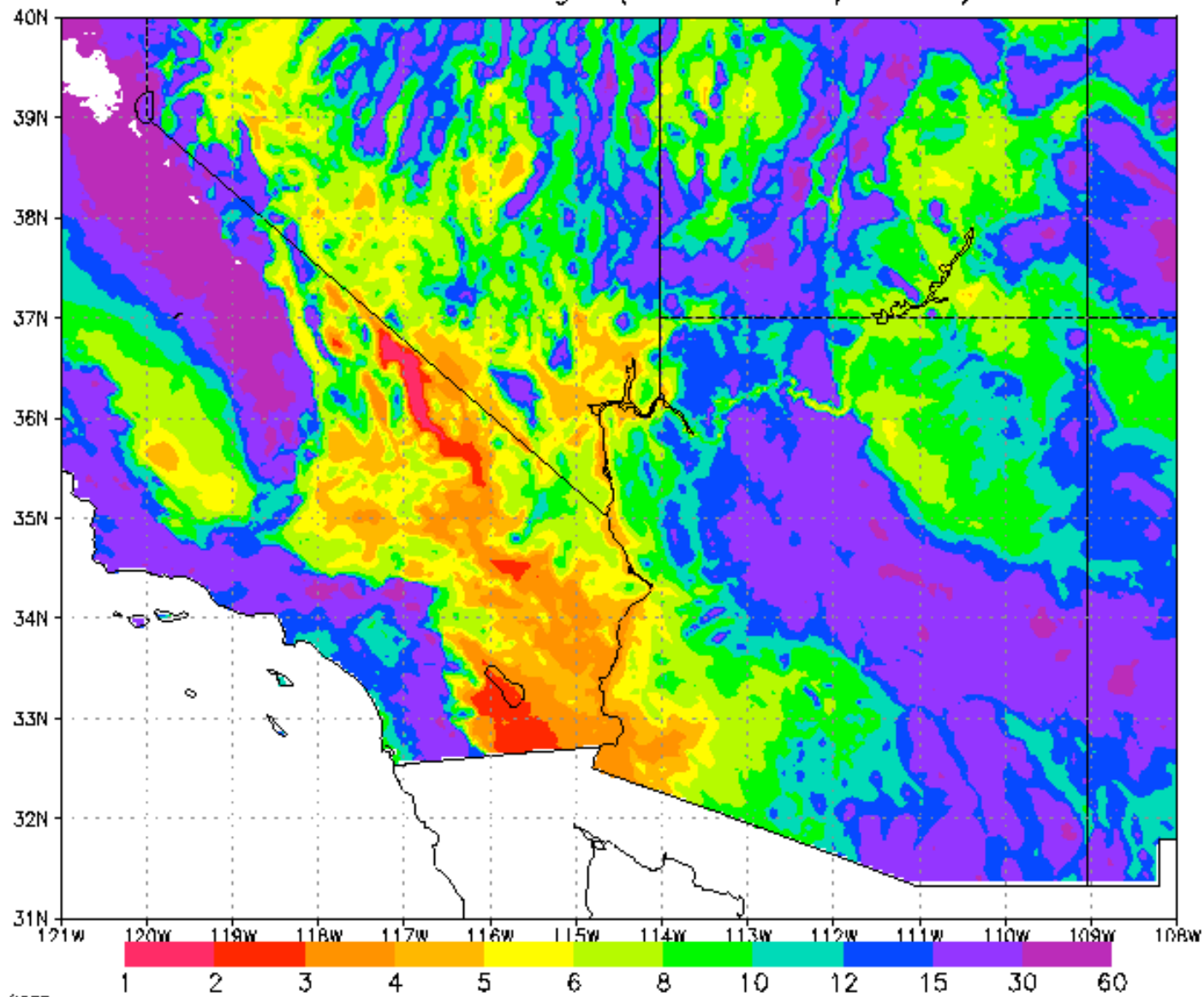


Annual Precipitation (inches)  
1961-90 Average (PRISM OSU/WRCC)



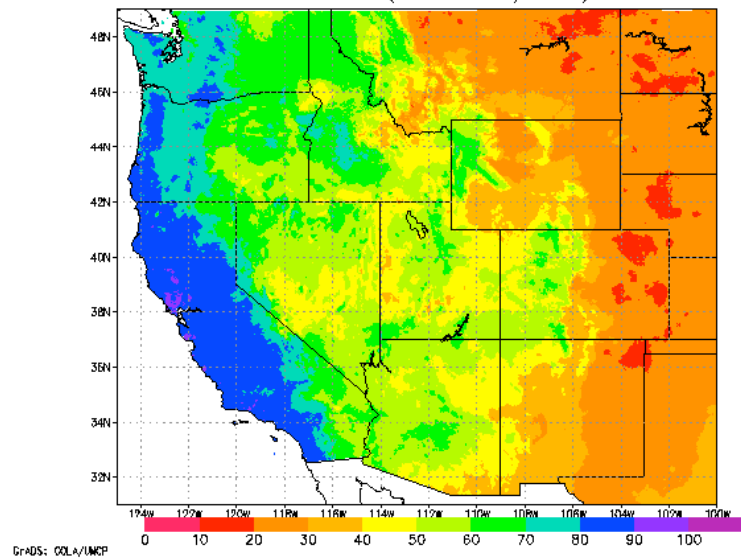


Annual Precipitation (inches)  
1961-90 Average (PRISM OSU/WRCC)

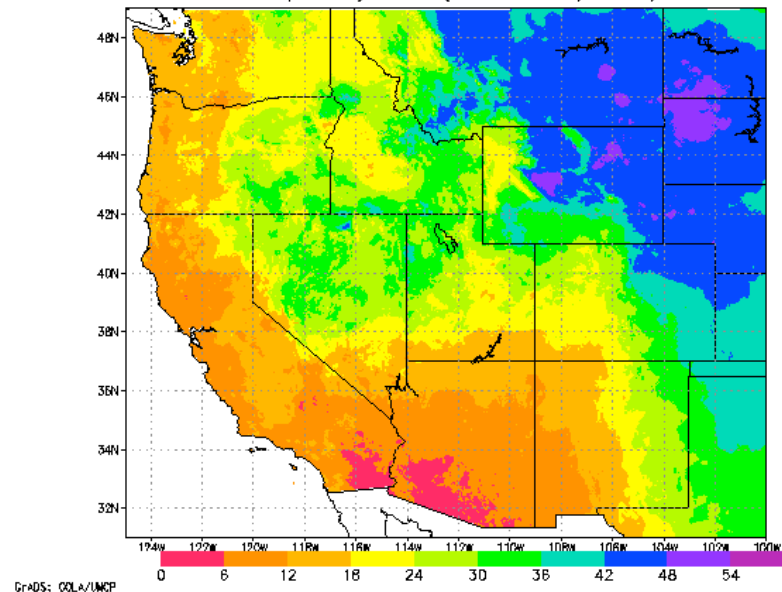


GrADS: COLA/IGES

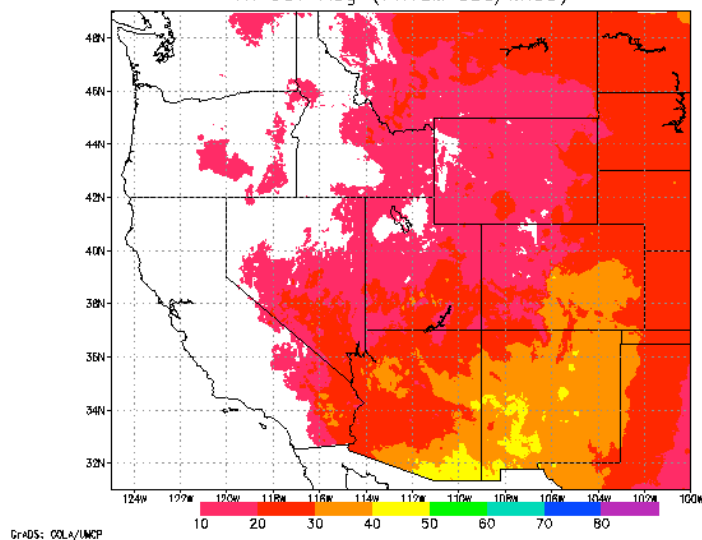
Percent of Average Annual Precip  
in Oct-Mar (PRISM OSU/WRCC)



Percent of Average Annual Precip  
in Apr-May-Jun (PRISM OSU/WRCC)



Percent of Average Annual Precip  
in Jul-Aug (PRISM OSU/WRCC)



Oct-Mar

Apr-May-June

Fraction of Annual Total  
Precipitation, by Season

July-Aug

## **Columbia River Basin**

**High symbolic significance in the West**

**Crosses an international boundary**

**Heavily regulated and dammed**

**Has endangered fish species**

**Substantial hydropower development**

**Strong predictive ENSO signal in winter within the basin**

**Significant tribal issues**

**Rapid population growth in basin**

**Enters the United States from a foreign country**

**Storage to flow ratio approximately 0.4**

**El Nino dry, La Nina wet**

**El Nino usually warm, La Nina usually cool**

**Largest flow volume is at mouth**

**“Water Services” needed from the river**

**Major transportation corridor**

**No out-of-basin water transfers**

**Relatively few protected corridors within basin**

**Anadromous fish populations**

**Few mainstem sediment and salinity problems**

**ESA fish is very well known, charismatic cultural icon**

**History of relative cooperation among managers**

**Water not divided by interstate compact**



## **Colorado River Basin**

**High symbolic significance in the West**

**Crosses an international boundary**

**Heavily regulated and dammed**

**Has endangered fish species**

**Substantial hydropower development**

**Strong predictive ENSO signal in winter within the basin**

**Significant tribal issues**

**Rapid population growth in basin**

**Leaves the United States to enter a foreign country**

**Storage to flow ratio approximately 4.0**

**El Nino wet, La Nina dry**

**El Nino usually cool, La Nina usually warm**

**No flow at its mouth**

**Water itself needed from the river**

**Essentially no commercial transportation**

**Significant out-of-basin water transfers**

**Extensive protected corridors within basin**

**No anadromous fish population**

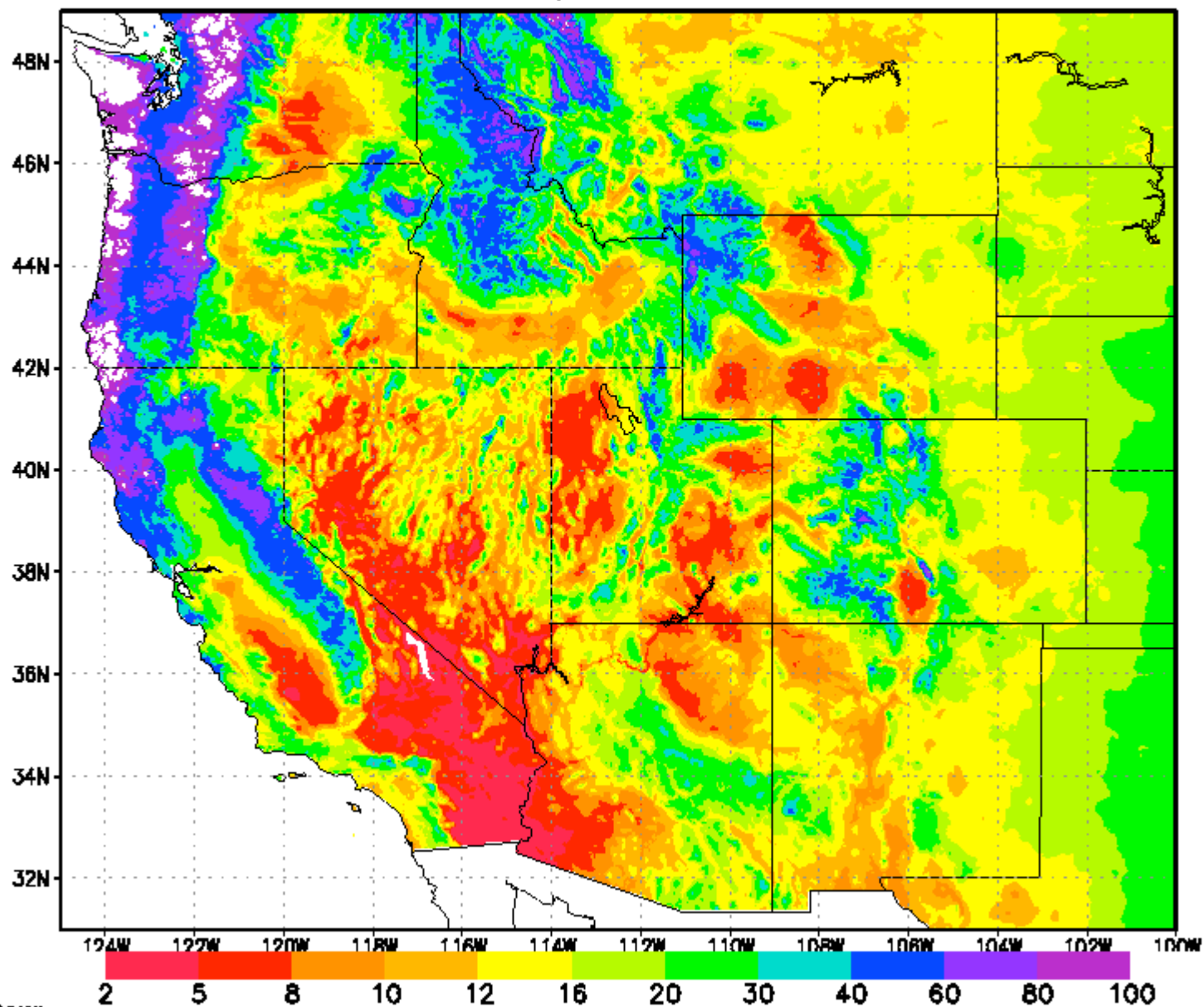
**Mainstem sediment and salinity problems**

**ESA fish is relatively unknown, not a big fan base**

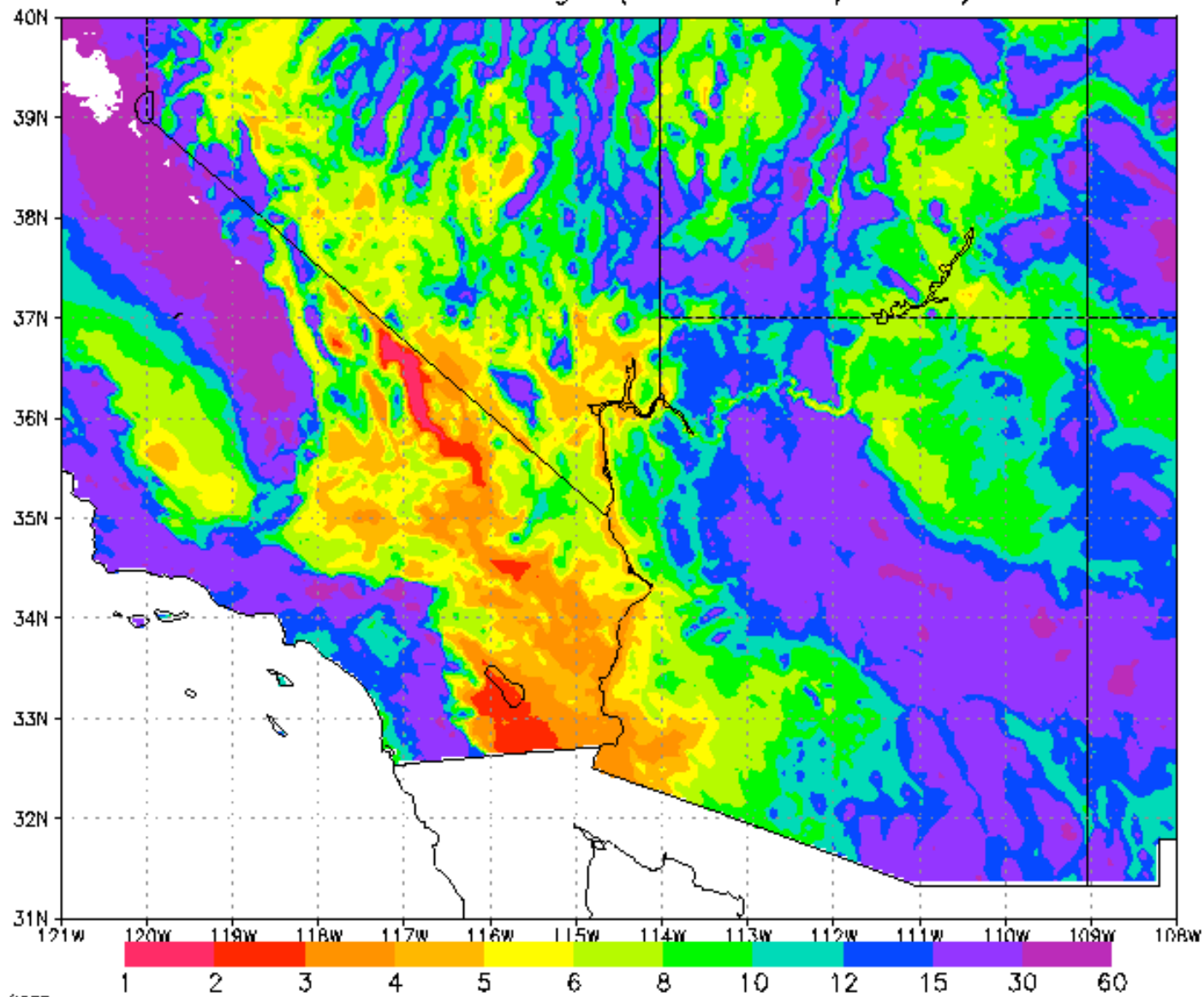
**History of relatively contentious water disputes**

**Water divided by interstate compact of 1922**

Annual Precipitation (inches)  
1961-90 Average (PRISM OSU/WRCC)

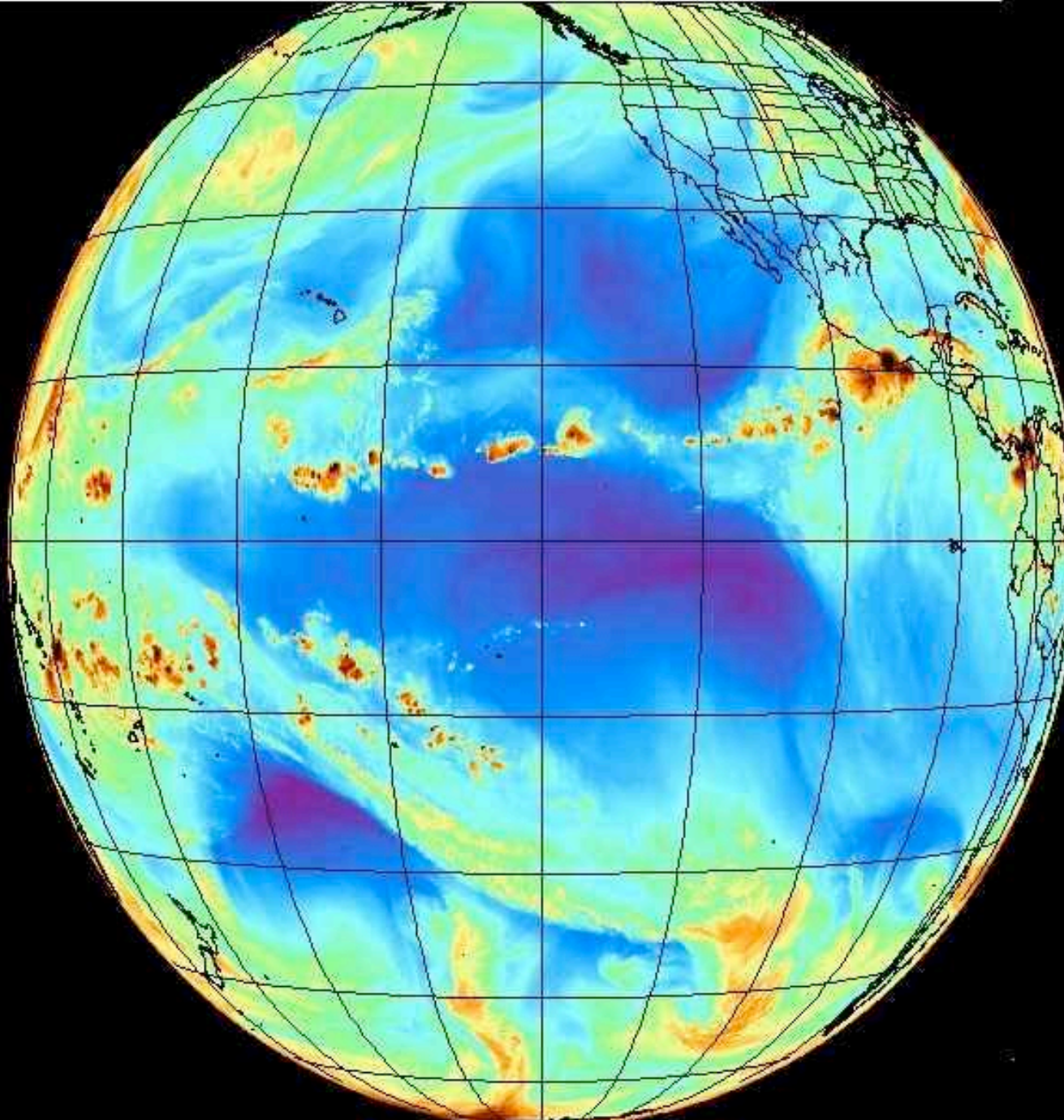


Annual Precipitation (inches)  
1961-90 Average (PRISM OSU/WRCC)





GOES10 VAPOR 06/01/2003 1800Z Naval Research Laboratory

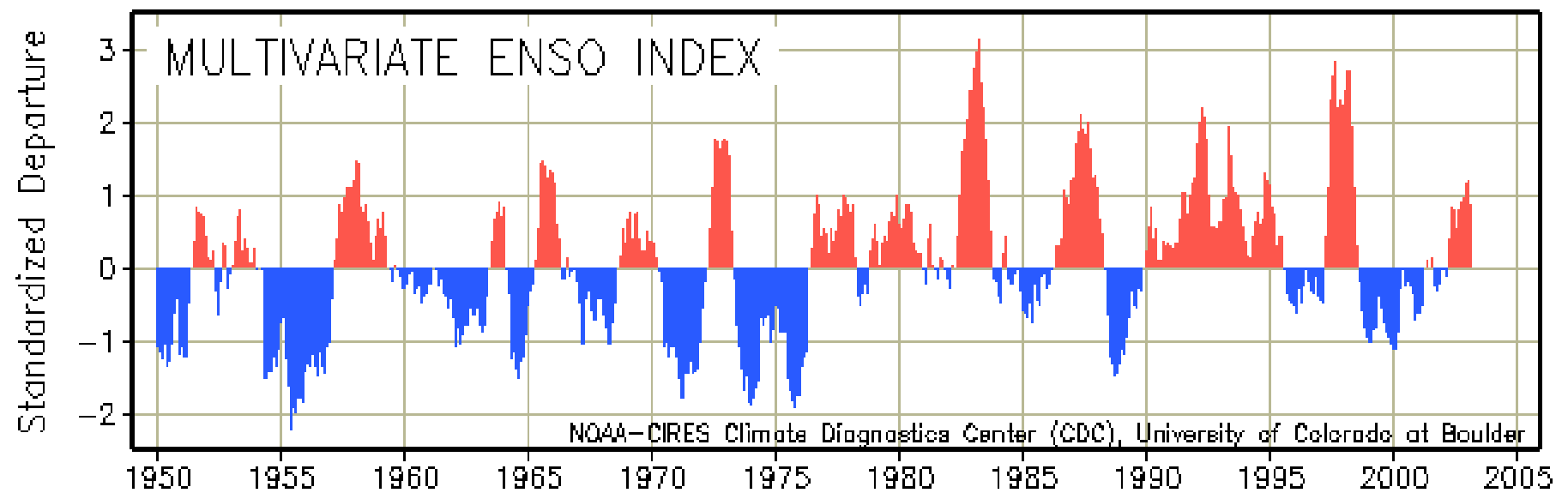


**Water  
Vapor**

**June 1**

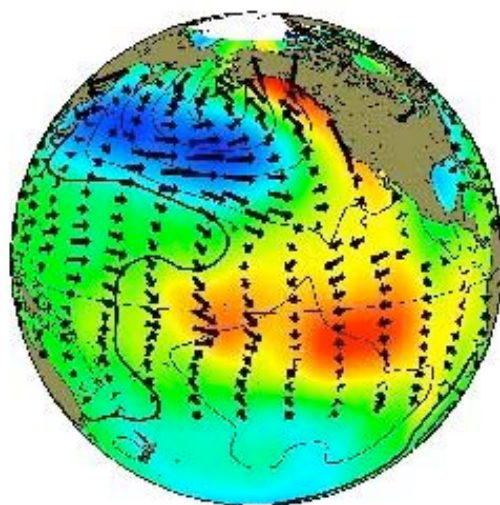
**2003**

**1800 GMT**

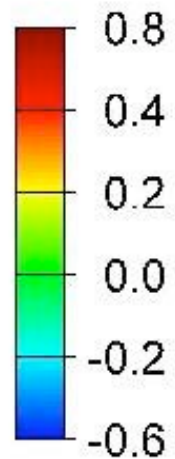
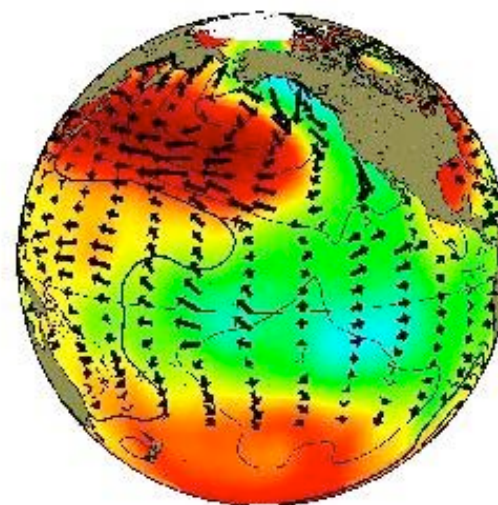


**Courtesy Klaus Wolter & Mike Timlin,  
Climate Diagnostics Center**

**Positive**

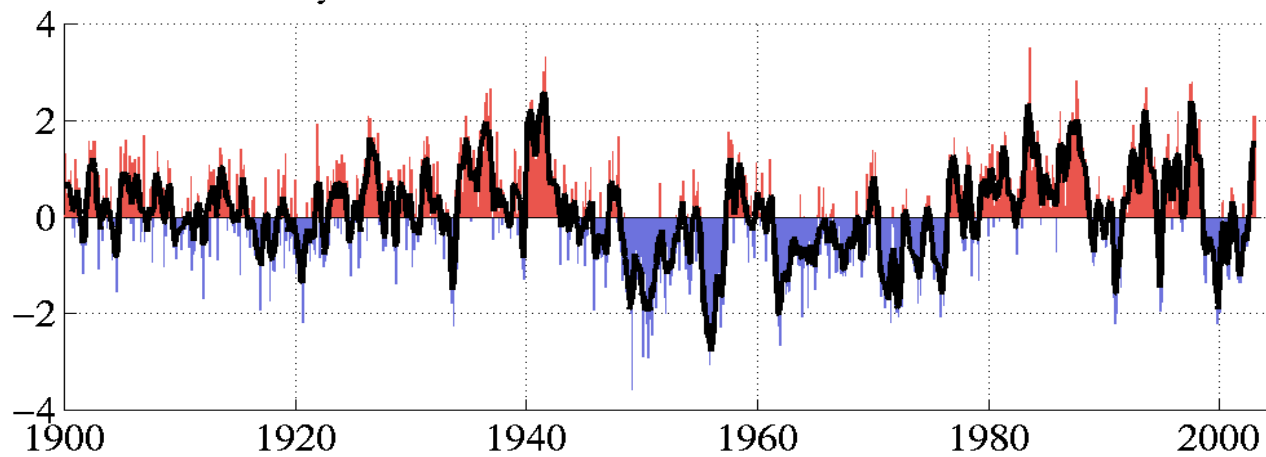


**Negative**

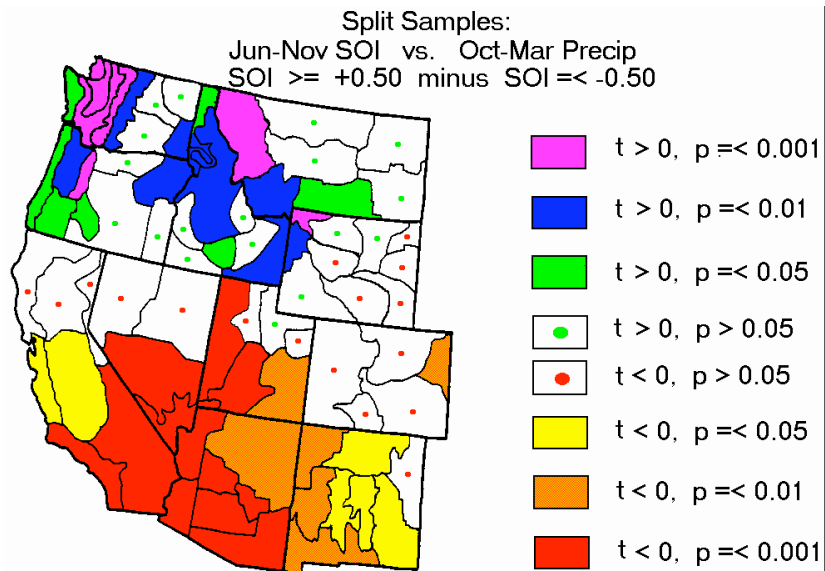


**Mantua  
et al.**

monthly values for the PDO index: Jan 1900–Feb 2003





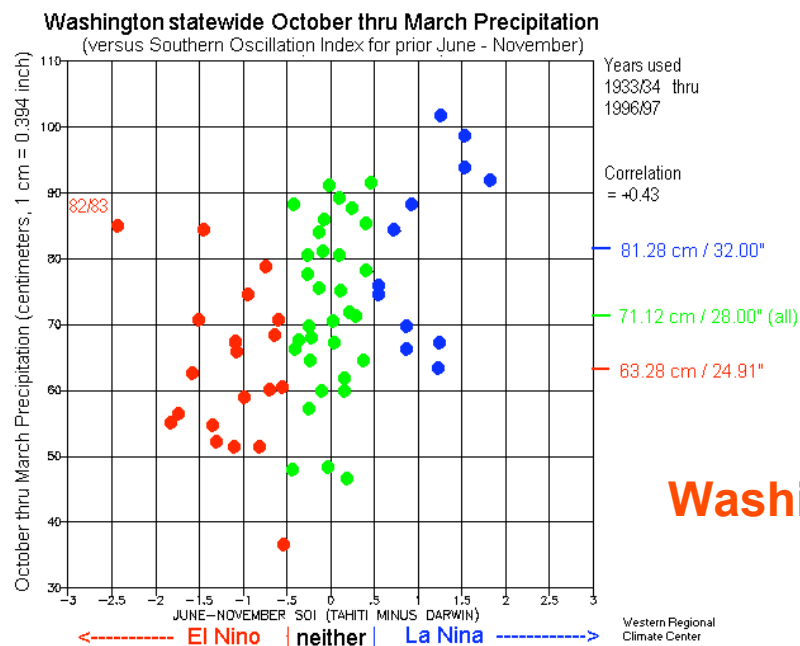


Updated from Redmond and Koch (1991). Winters of 1933/34 - 1994/95.  
Reddish: Composite El Nino winters are wet, La Nina winters are dry.  
Bluish/greenish: Composite El Nino winters are dry, La Nina winters are wet.

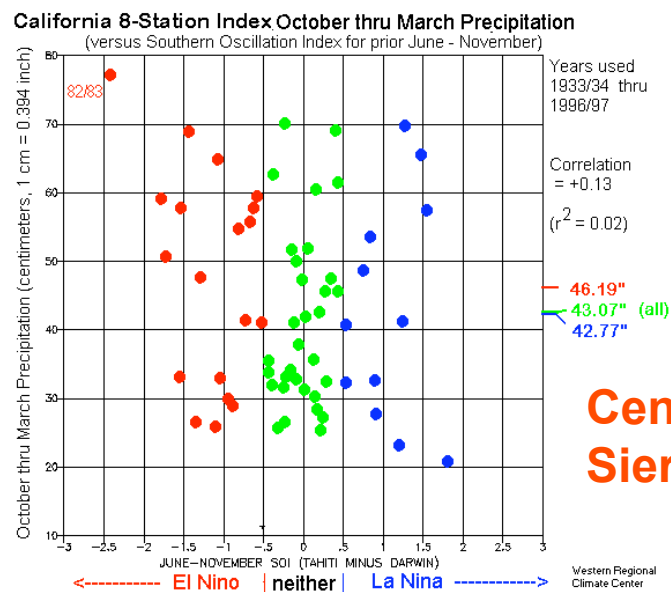
Redmond, K.T., and R.W. Koch, 1991. Surface climate and streamflow variability in the western United States and their relationship to large-scale circulation indices. Water Resources Research, 27(9), 2381-2399.

Redmond & Koch, 1991, updated.

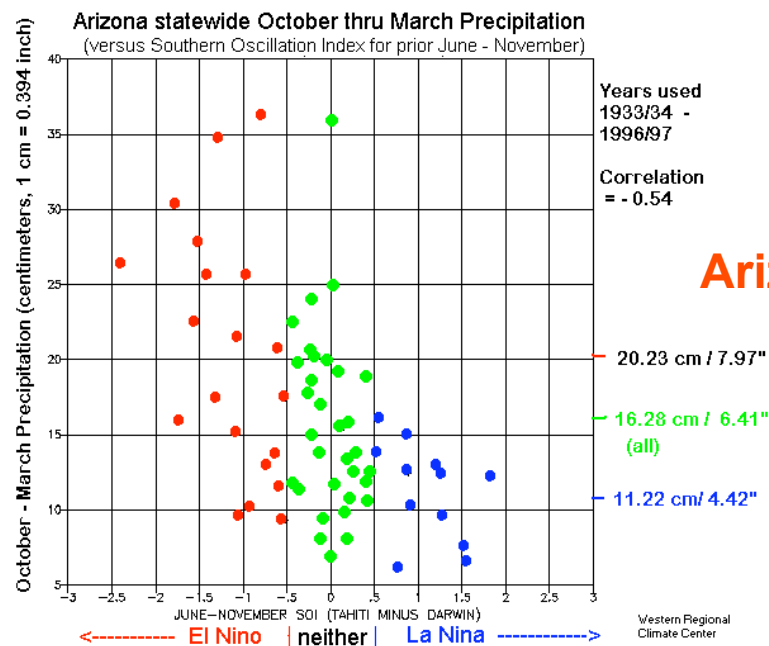
ENSO



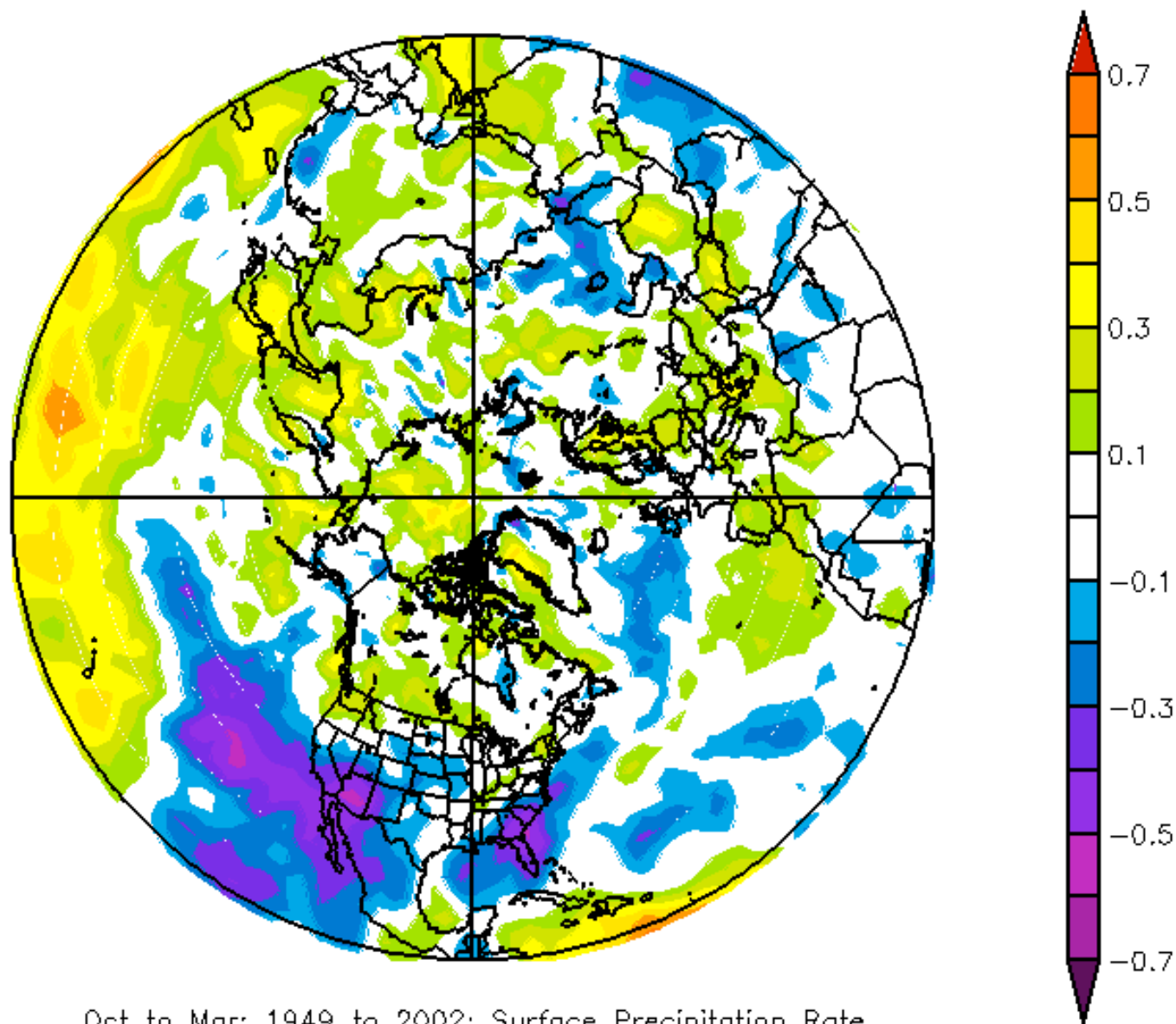
Washington



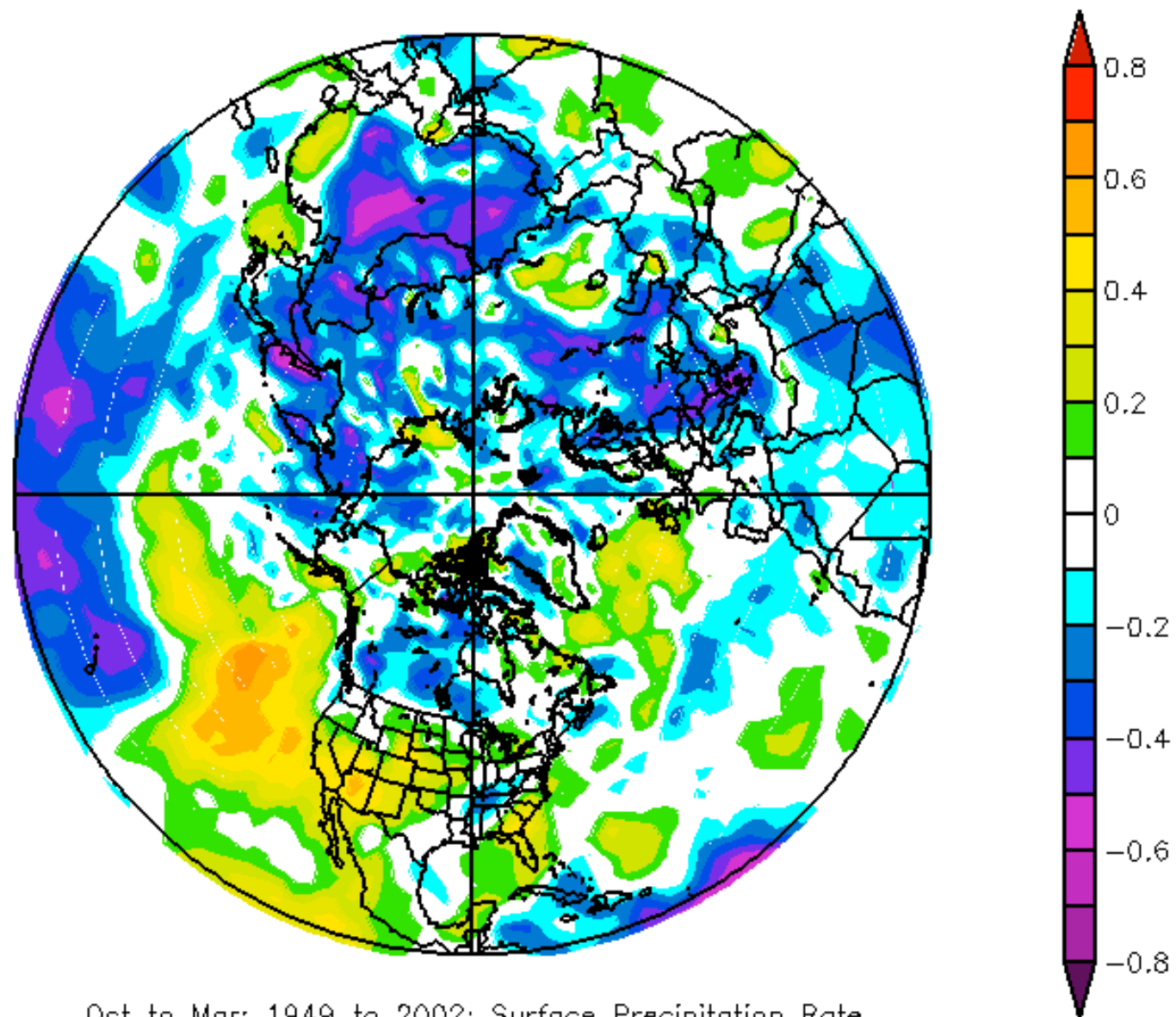
Central Sierra



Arizona



Oct to Mar: 1949 to 2002: Surface Precipitation Rate  
Seasonal Correlation w/ Jun to Nov SOI (index leads by 4 months)  
NCEP/NCAR Reanalysis

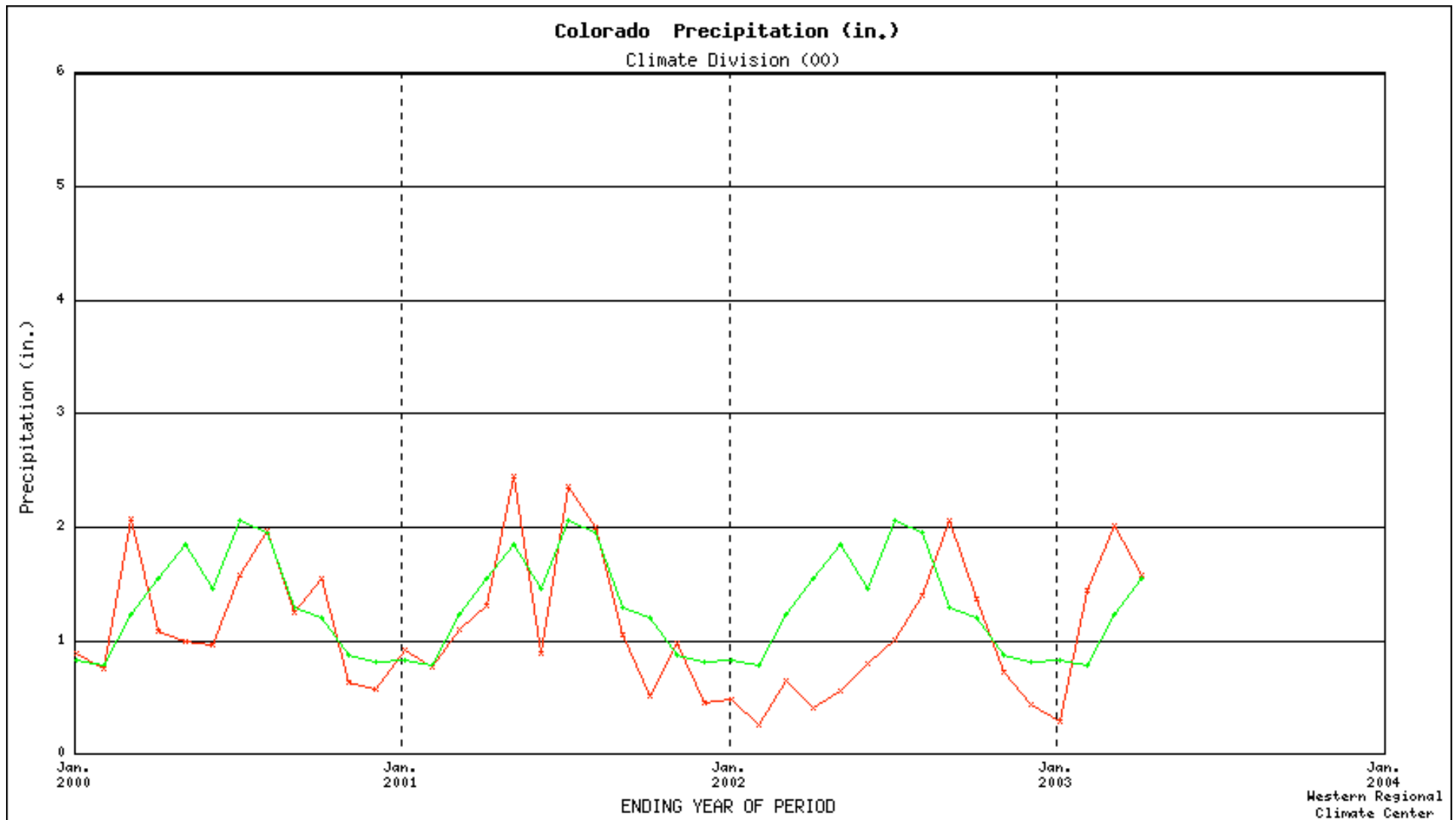


Oct to Mar: 1949 to 2002: Surface Precipitation Rate  
Seasonal Correlation w/ Oct to Mar PDO  
NCEP/NCAR Reanalysis



## Colorado Statewide Average Precipitation, by Month. Jan 2000 – Apr 2003.

Long term Average (1895-2003)



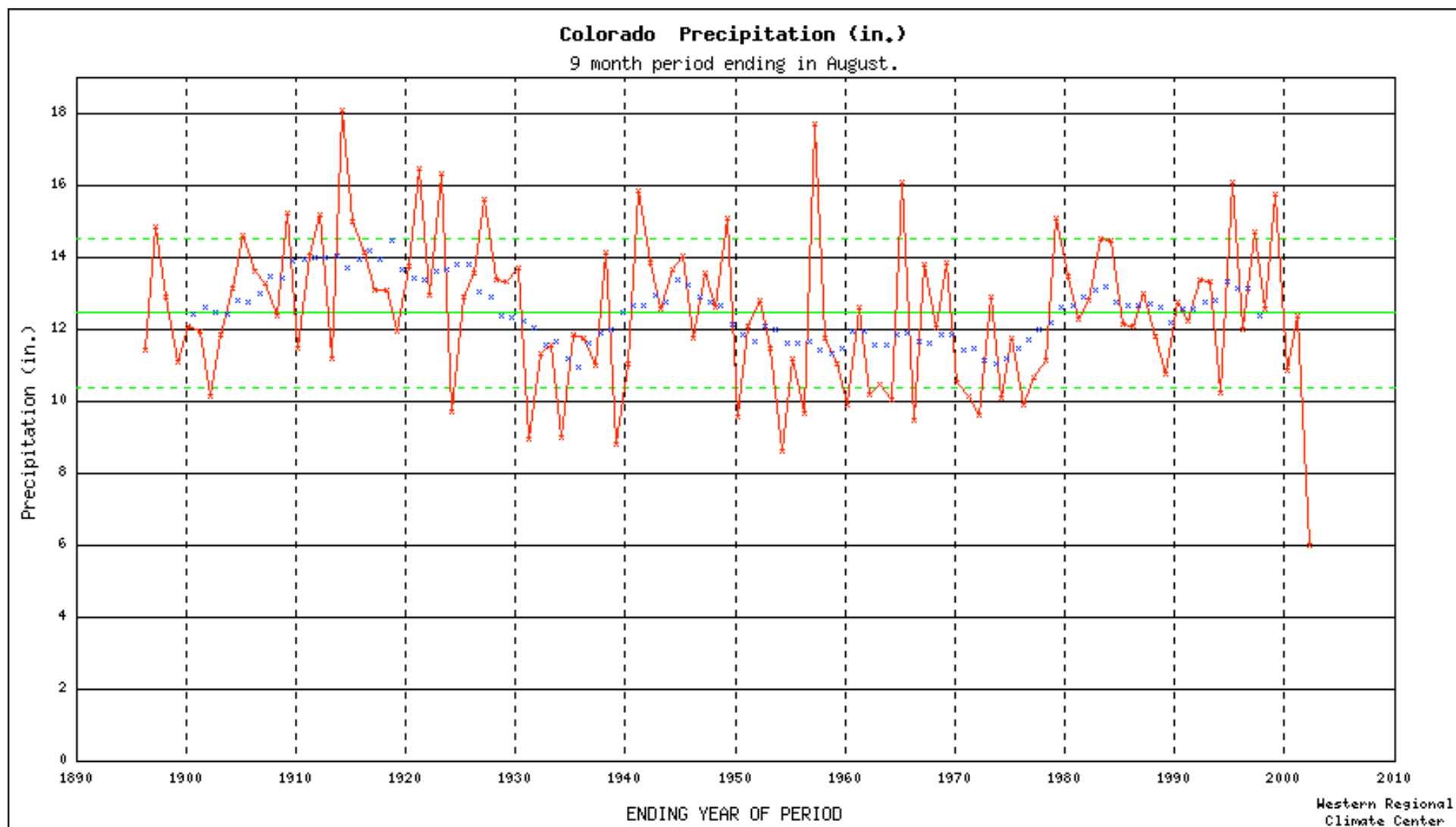
Jan 2000

Jan 2001

Jan 2001

Jan 2003

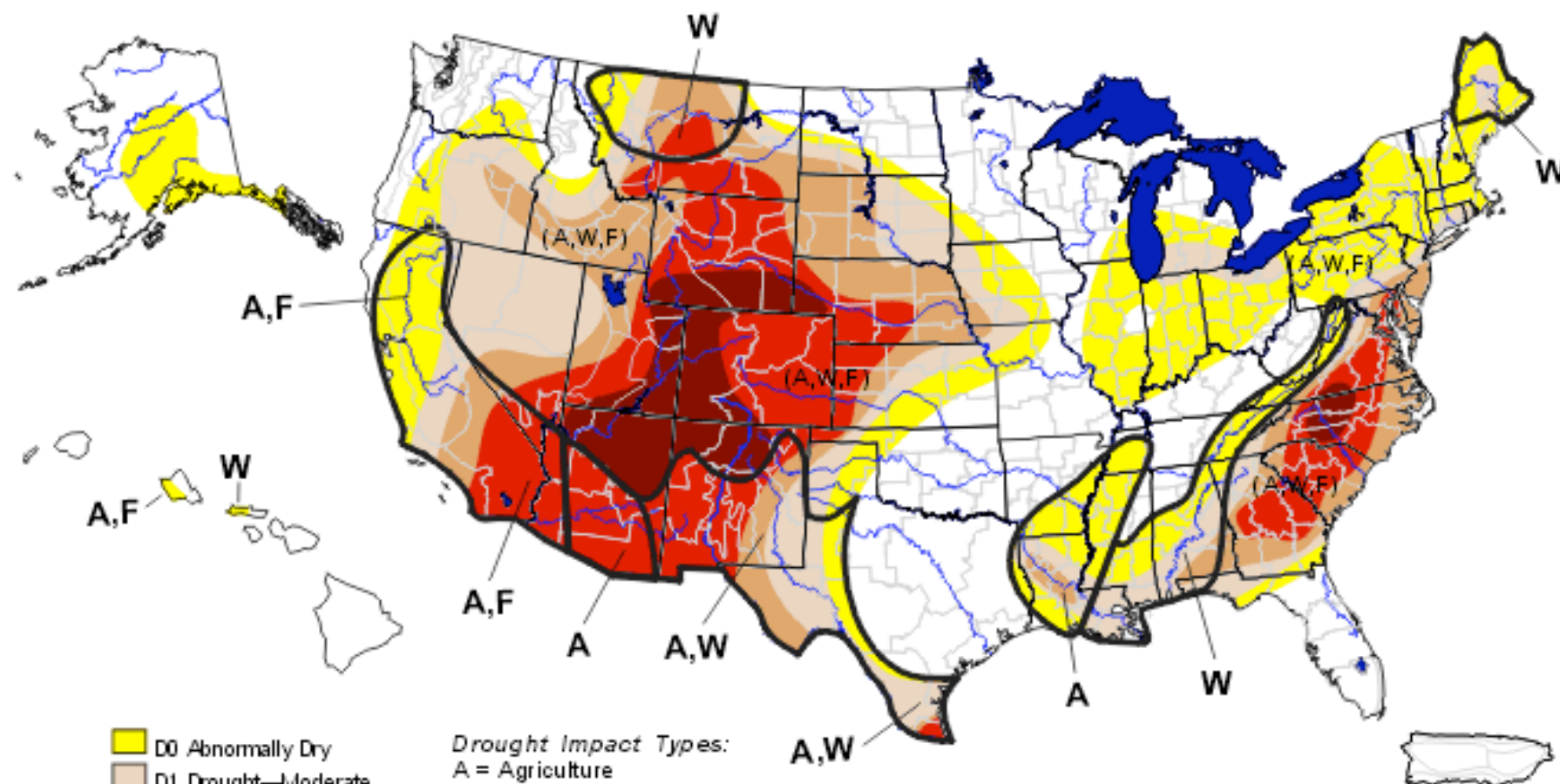
**Colorado Statewide Average Precipitation Dec – Aug      & 10-Year Running Mean**  
**1895 – 2003. (9-month period)**



# U.S. Drought Monitor

July 23, 2002

Valid 8 a.m. EDT



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

## Drought Impact Types:

A = Agriculture

W = Water (Hydrological)

F = Fire danger (Wildfires)

Delineates dominant impacts

(No type = All 3 impacts)

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

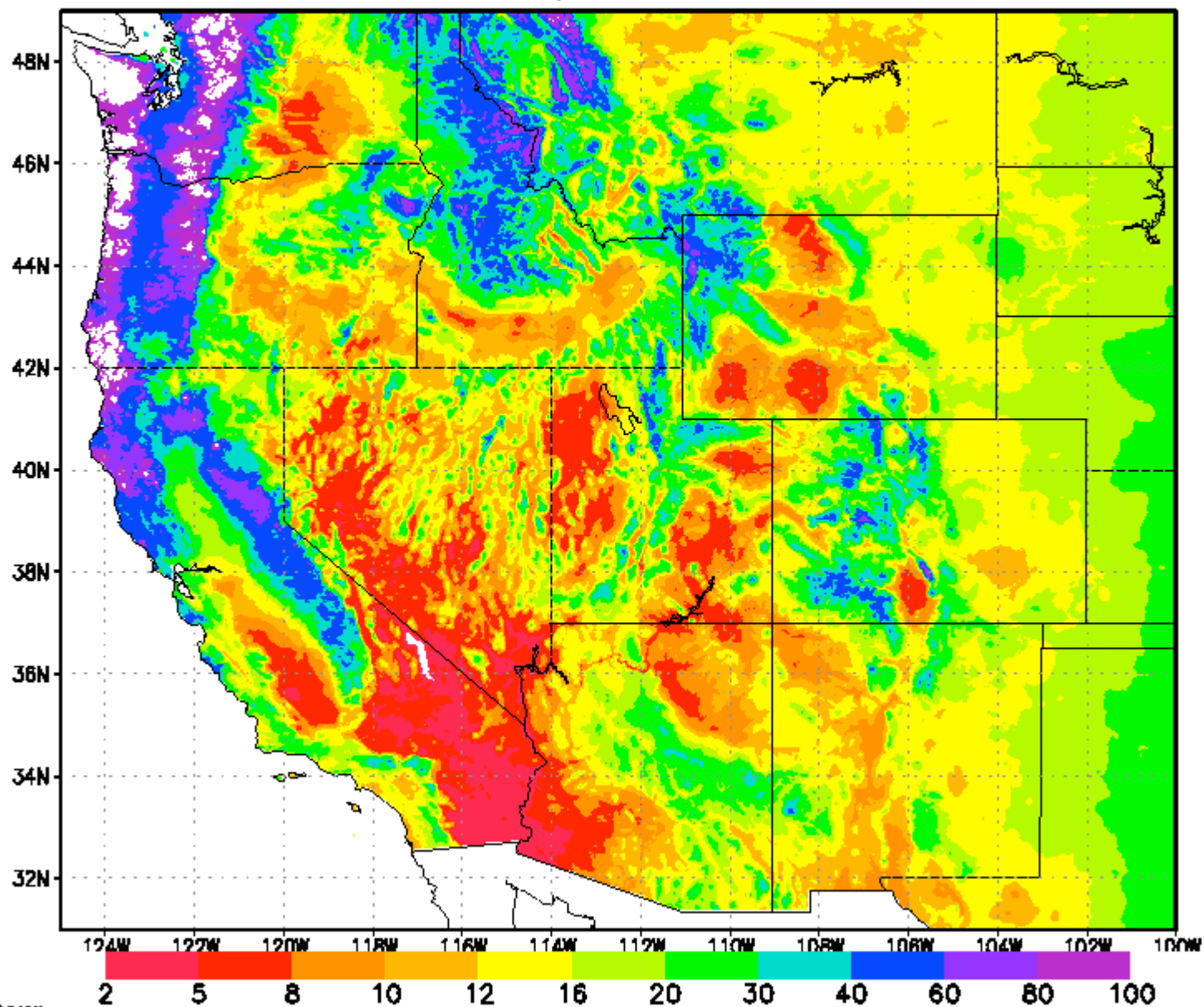
<http://drought.unl.edu/dm>



**Released Thursday, July 25, 2002**

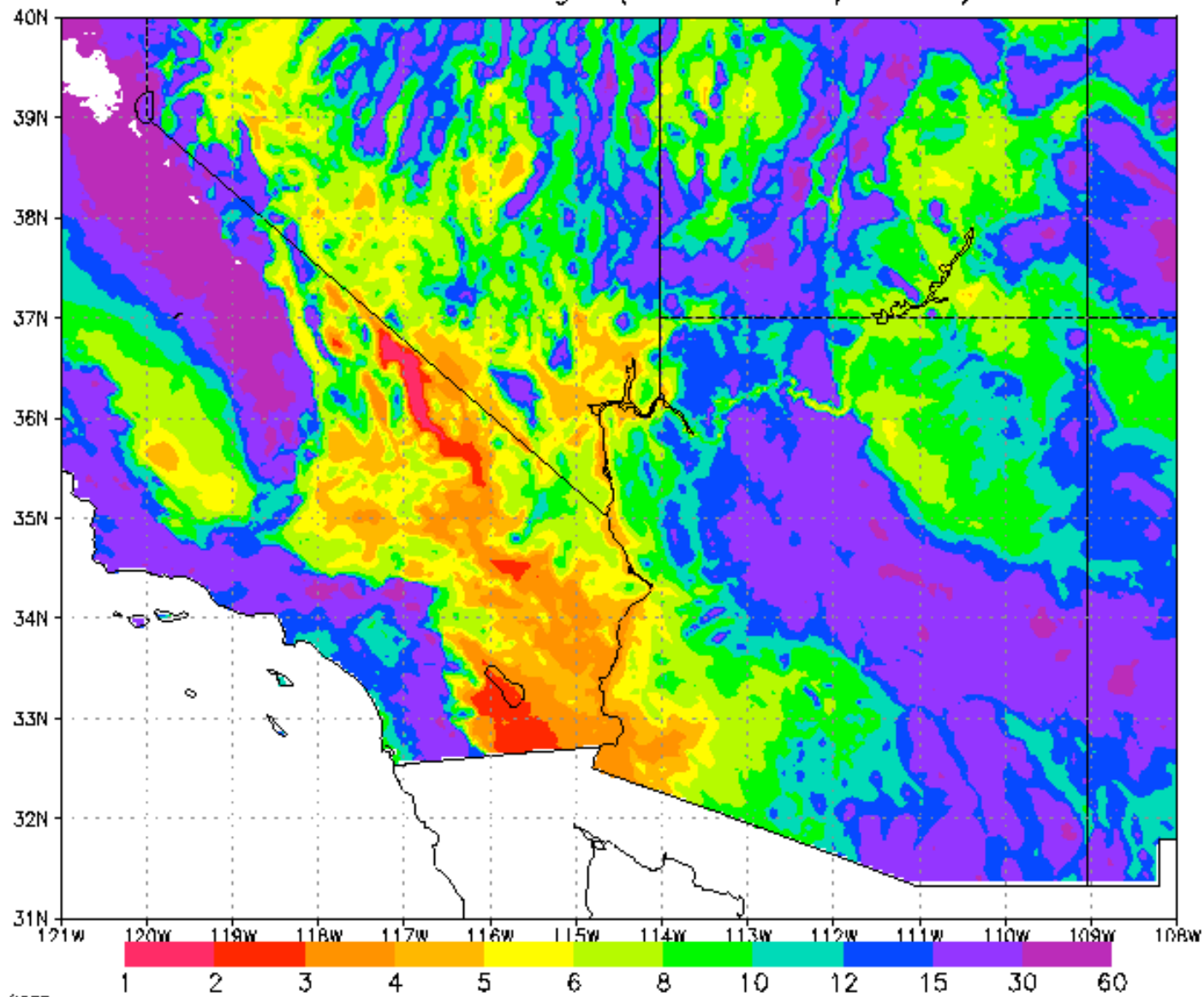
**Author: Brad Rippey, USDA**

Annual Precipitation (inches)  
1961-90 Average (PRISM OSU/WRCC)



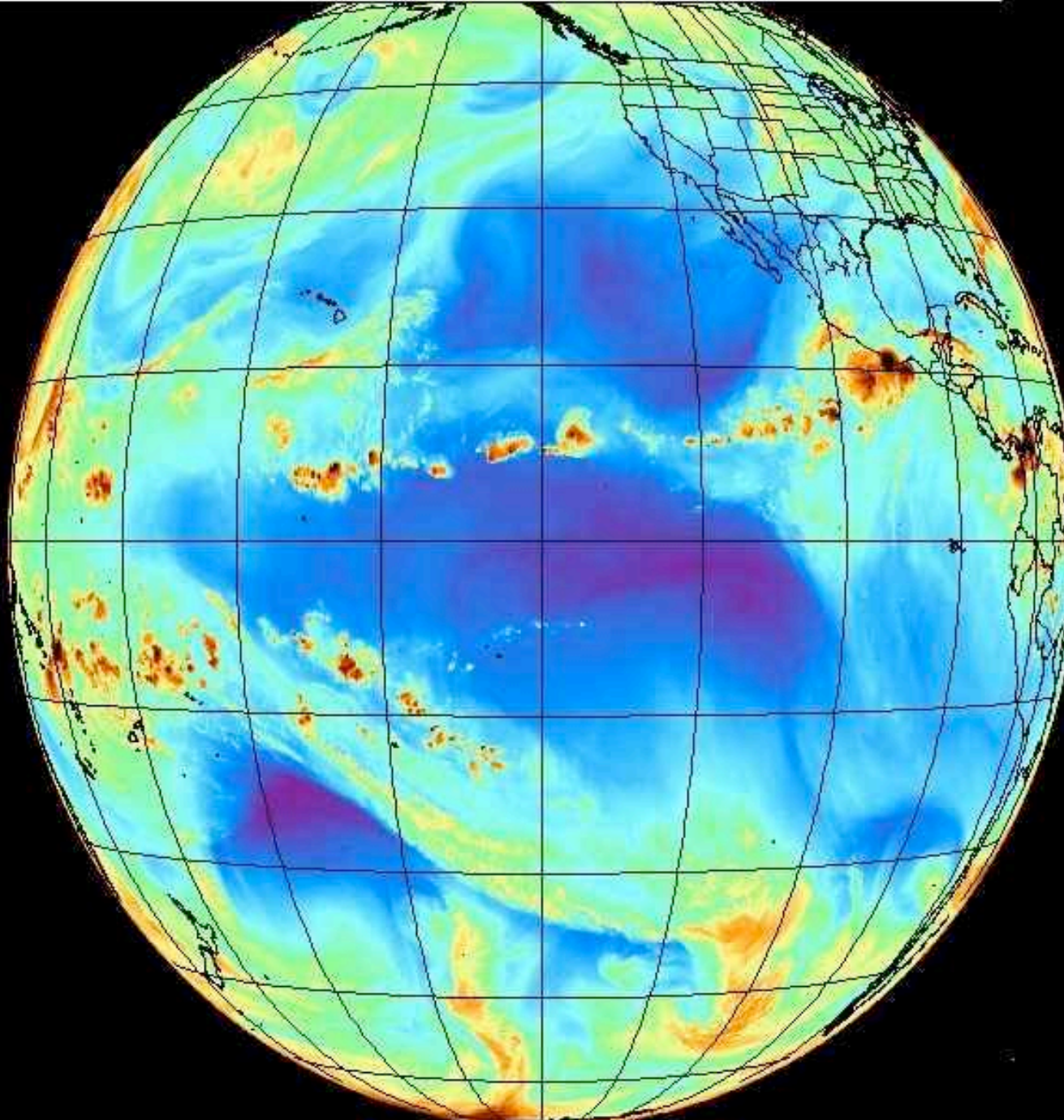


Annual Precipitation (inches)  
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GrADS: COLA/IGES

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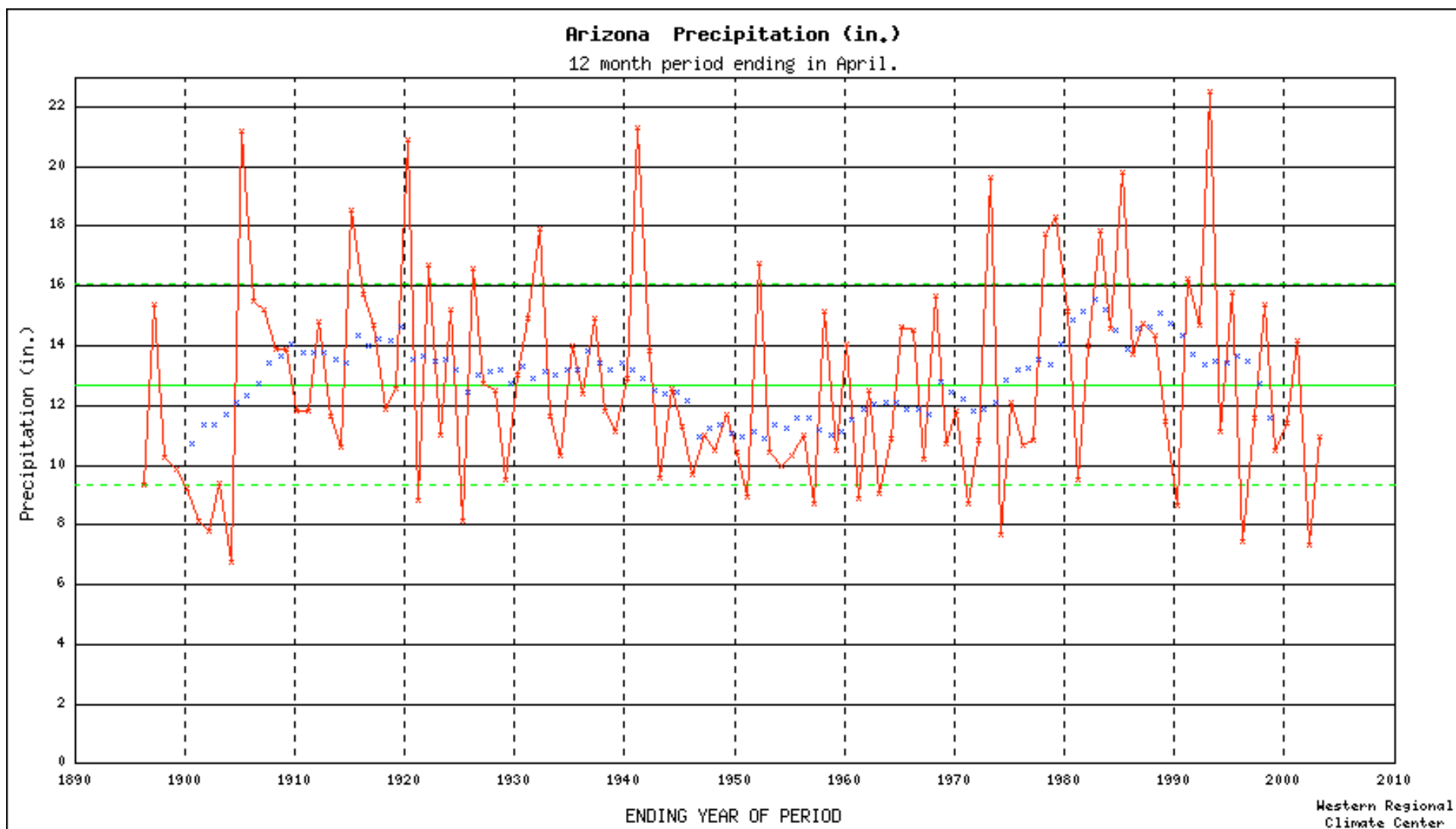
**Water  
Vapor**

**June 1**

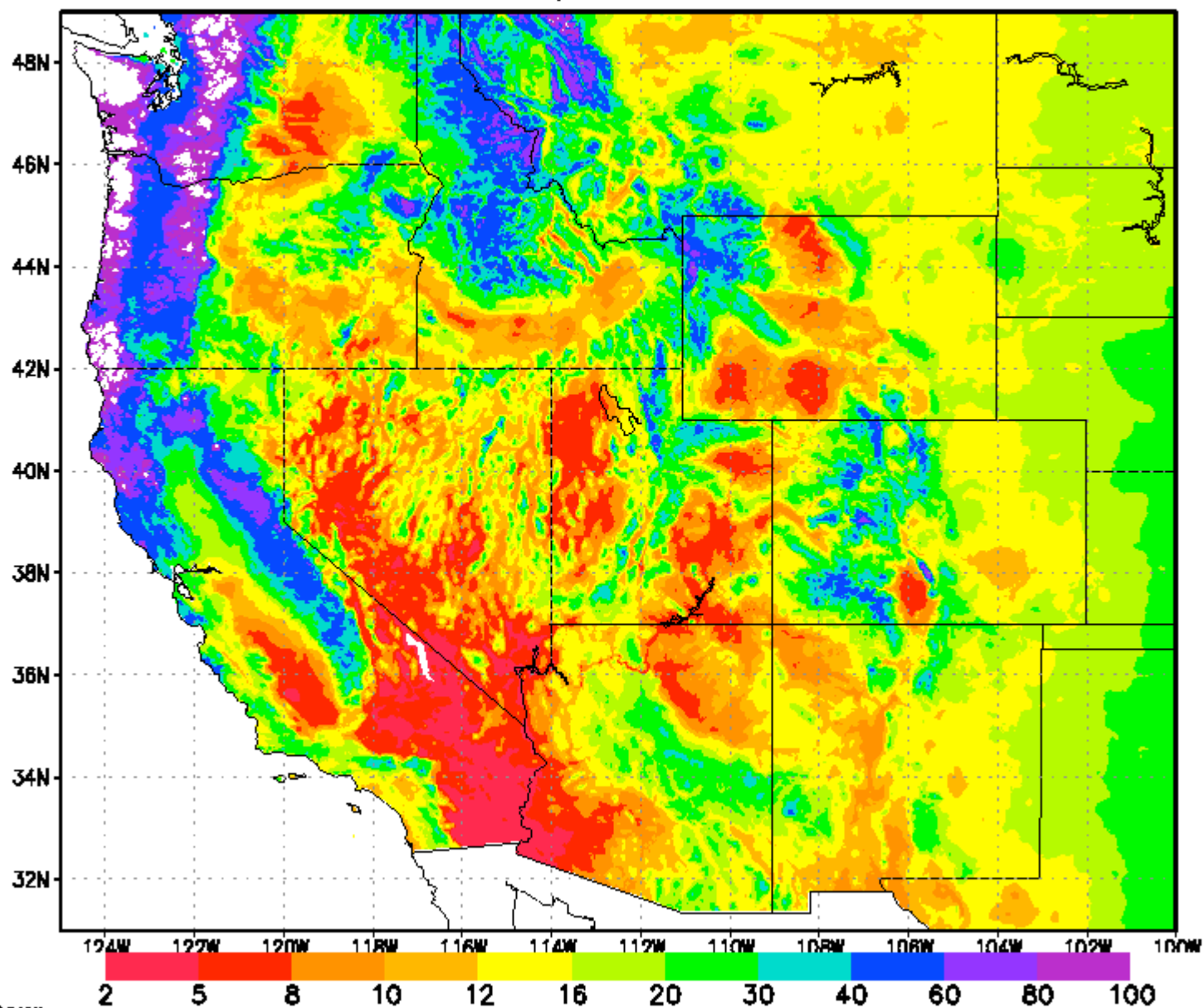
**2003**

**1800 GMT**

## Arizona Statewide Precipitation (12-Months: May – April) & 10-Yr Running Mean 1895 - 2003

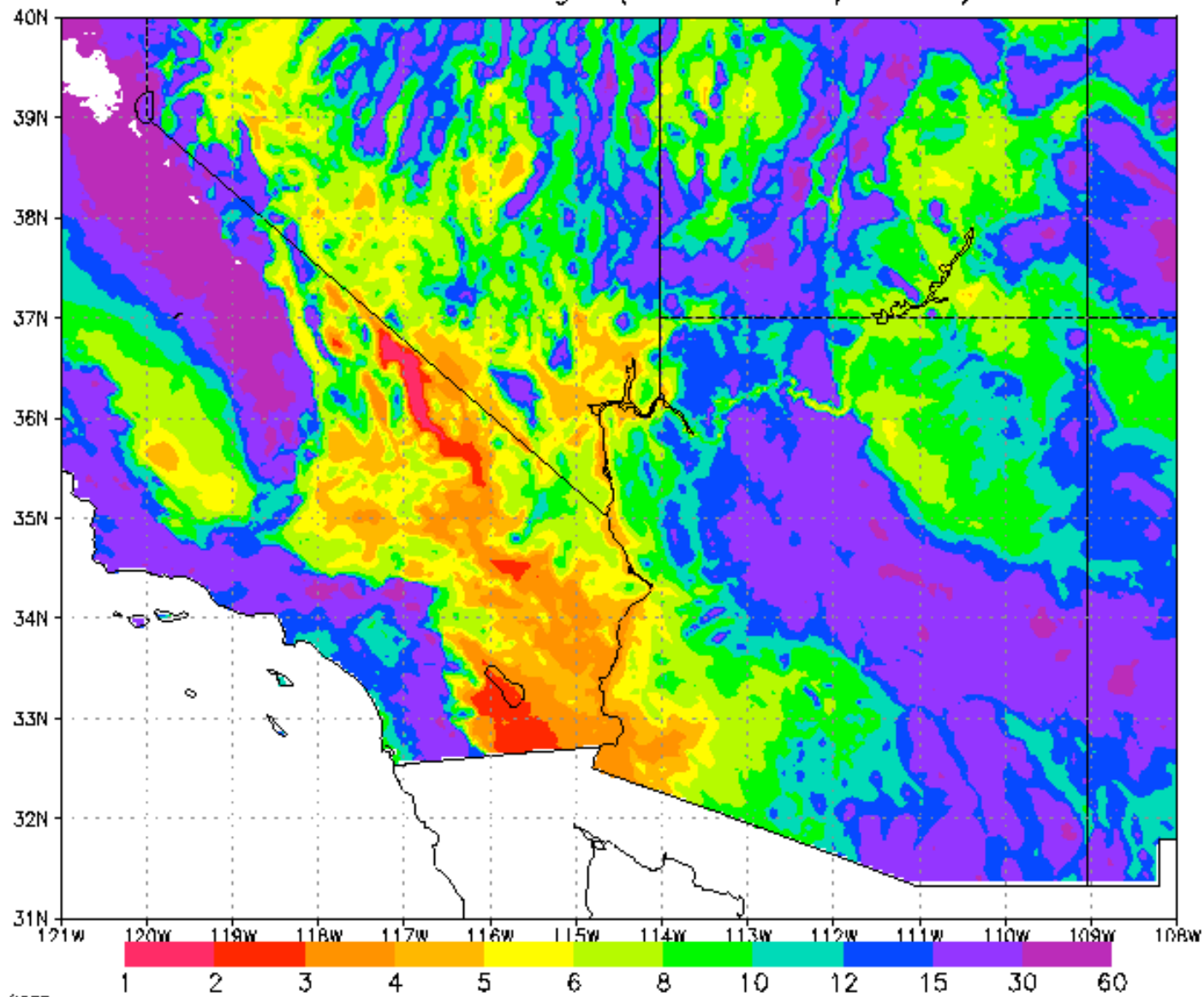


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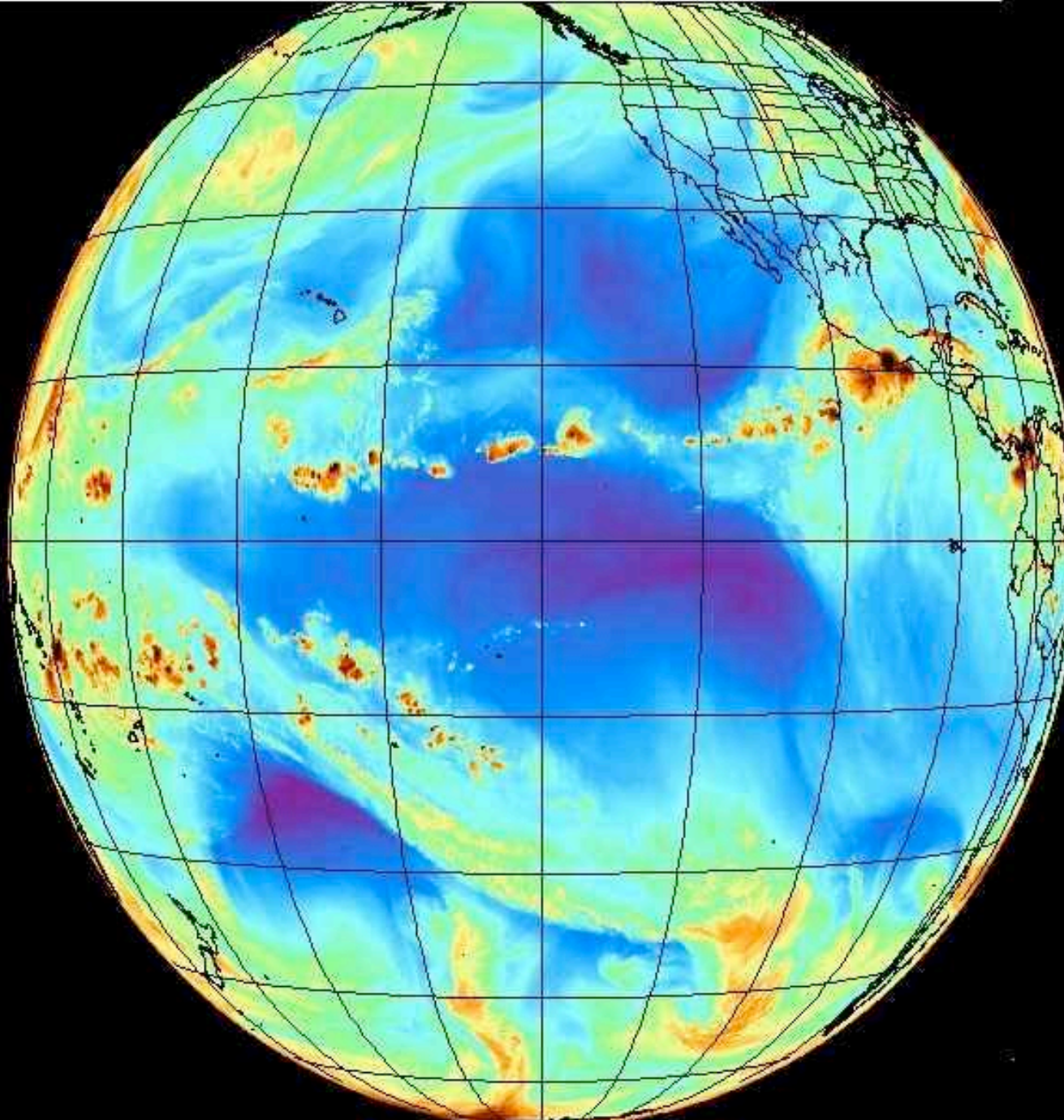


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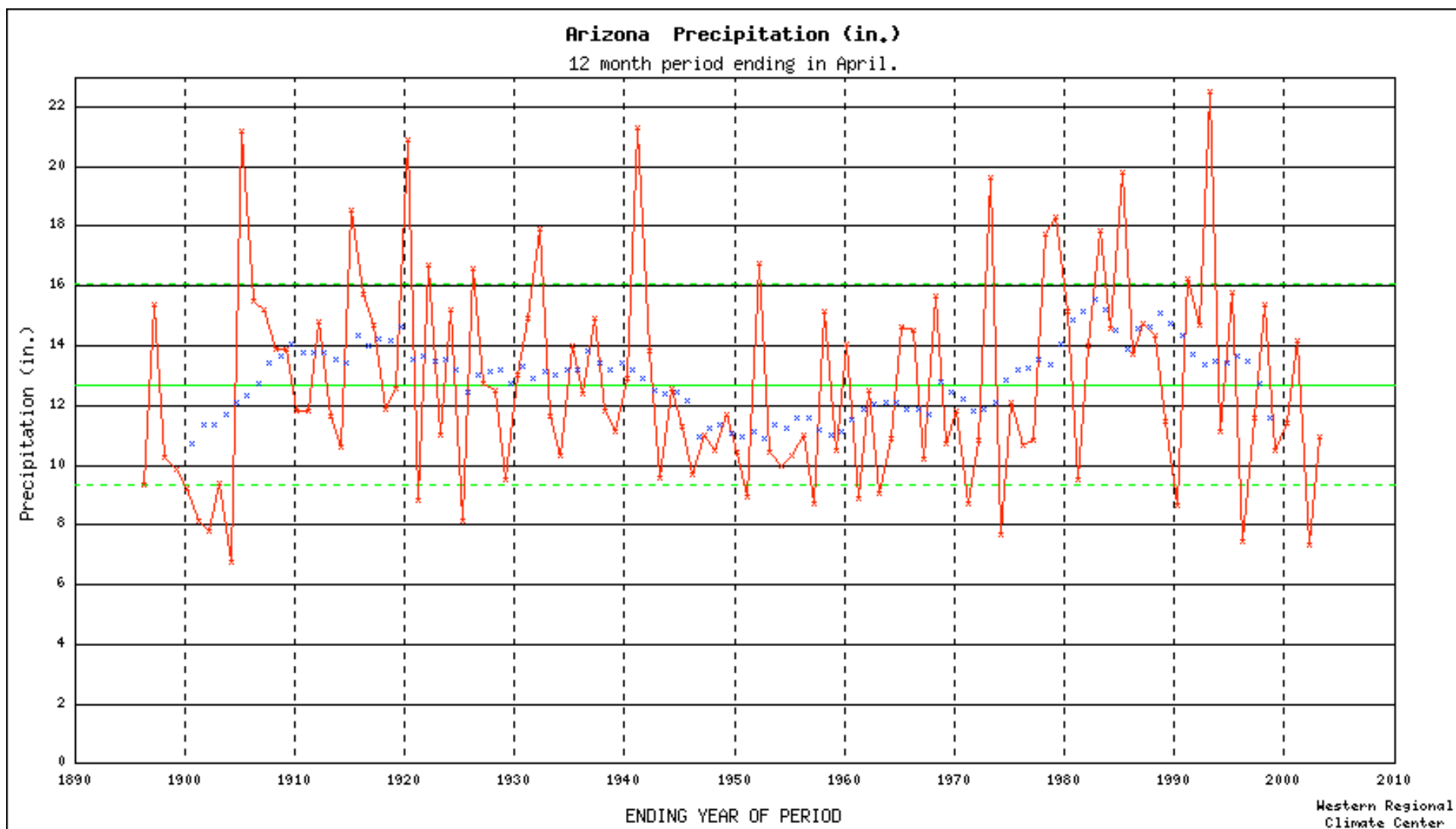
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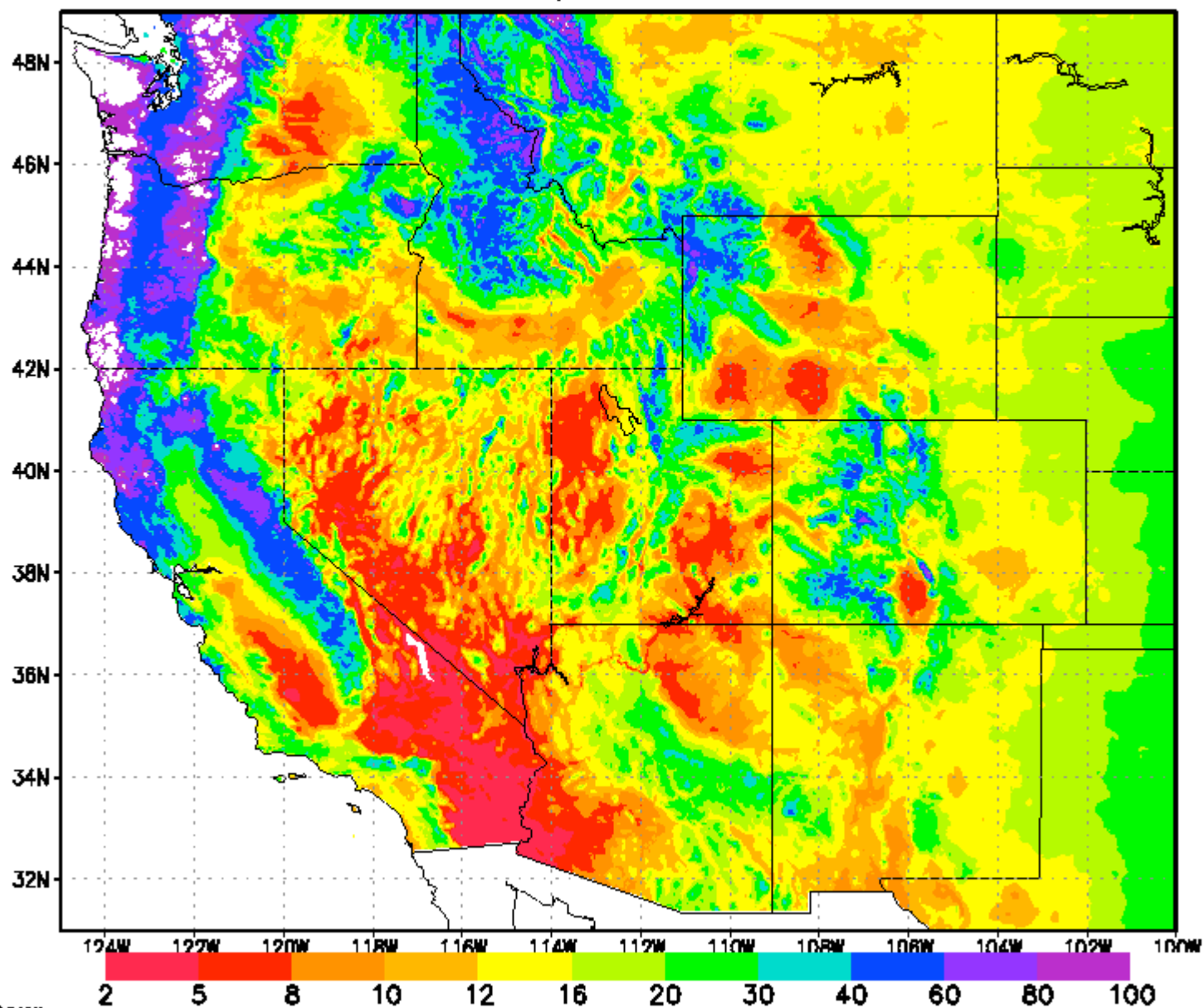
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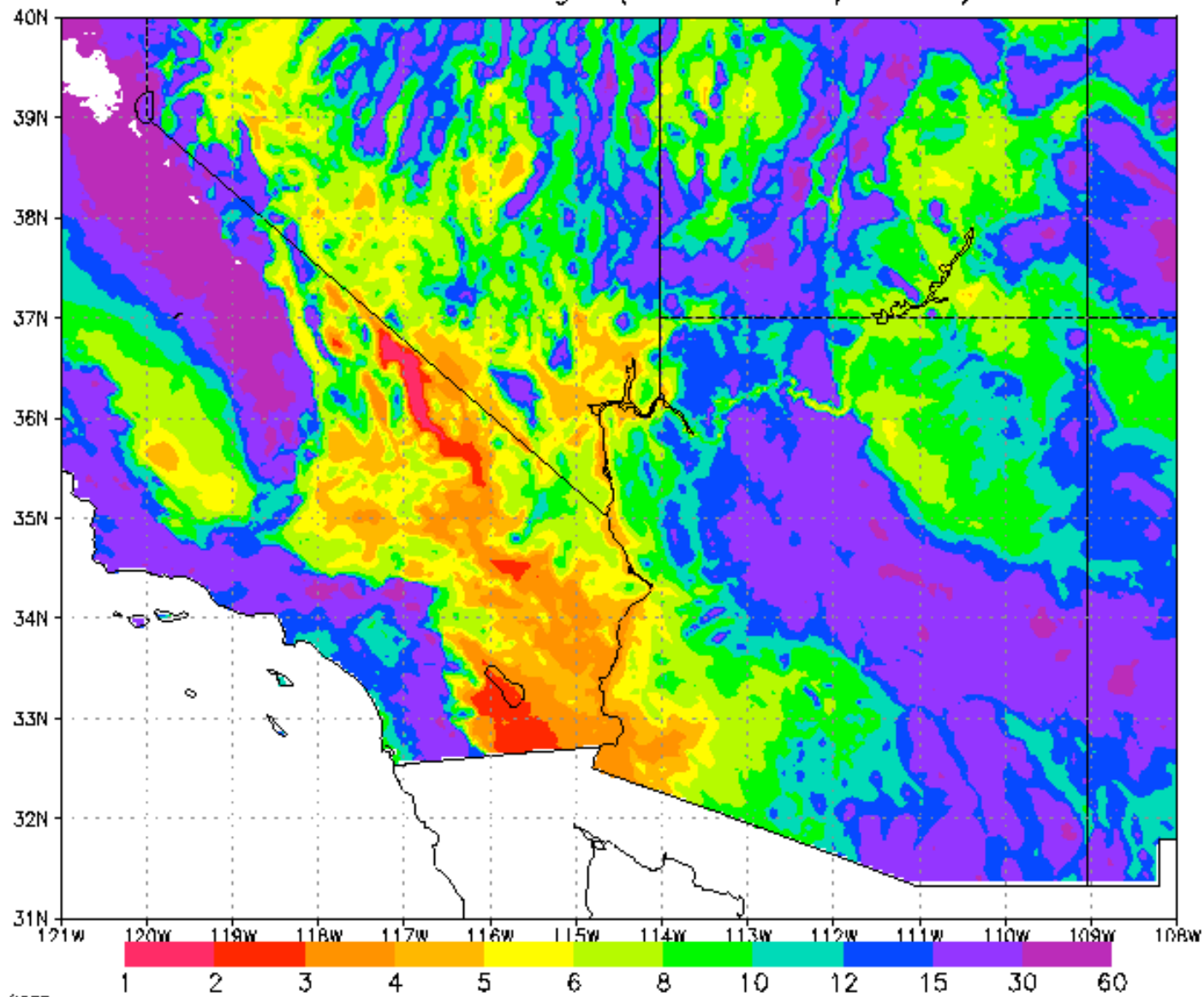


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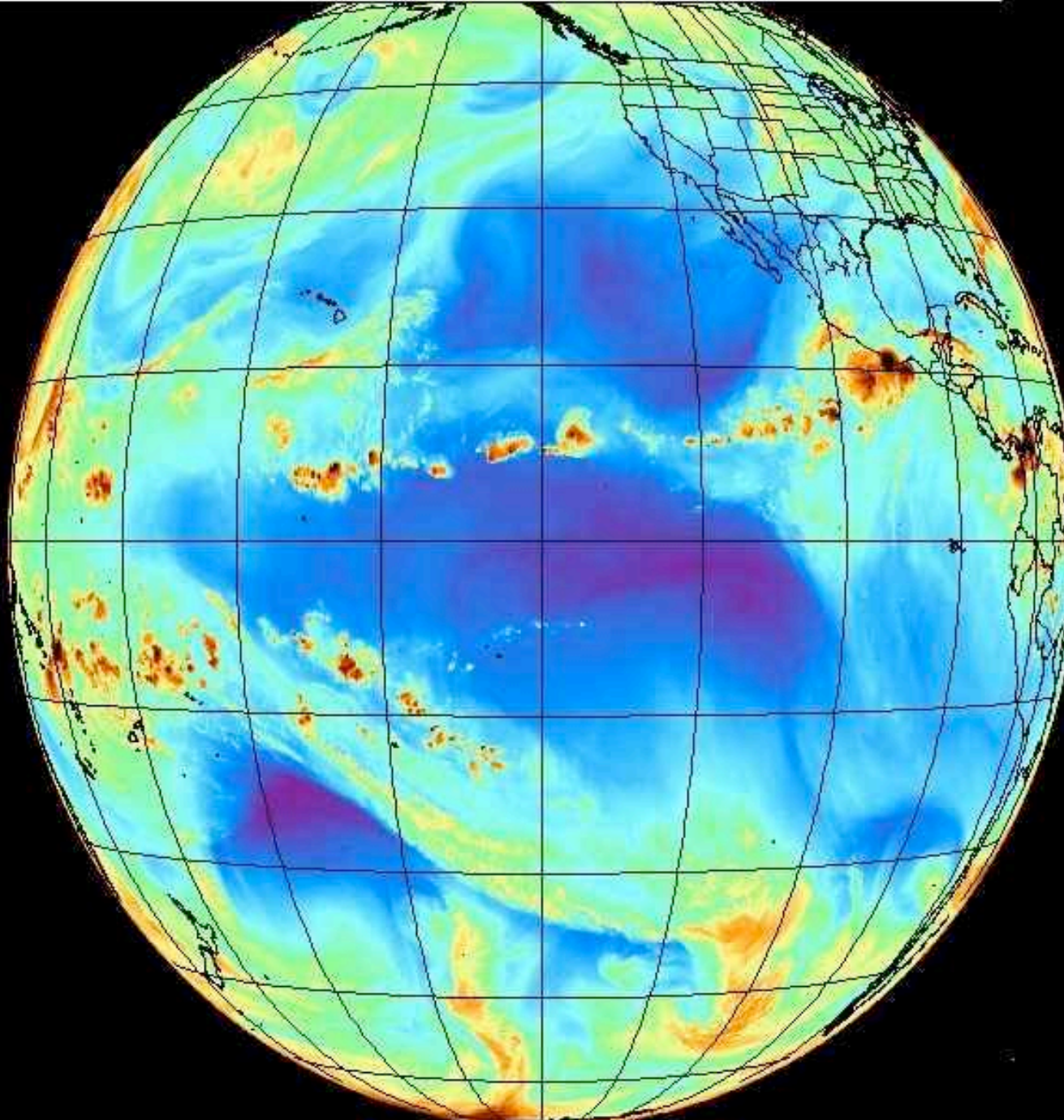


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GOES10 VAPOR 06/01/2003 1800Z Naval Research Laboratory



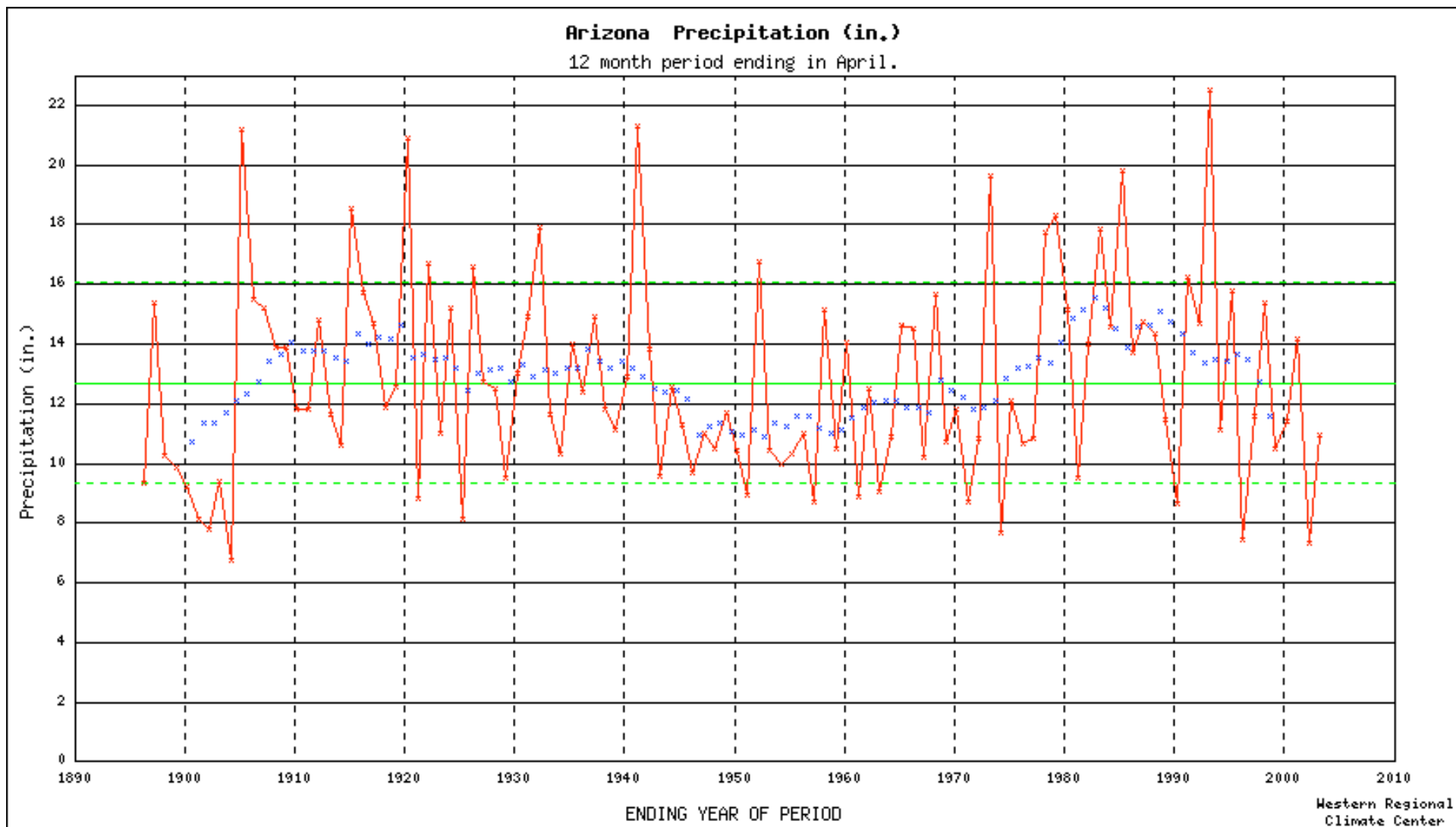
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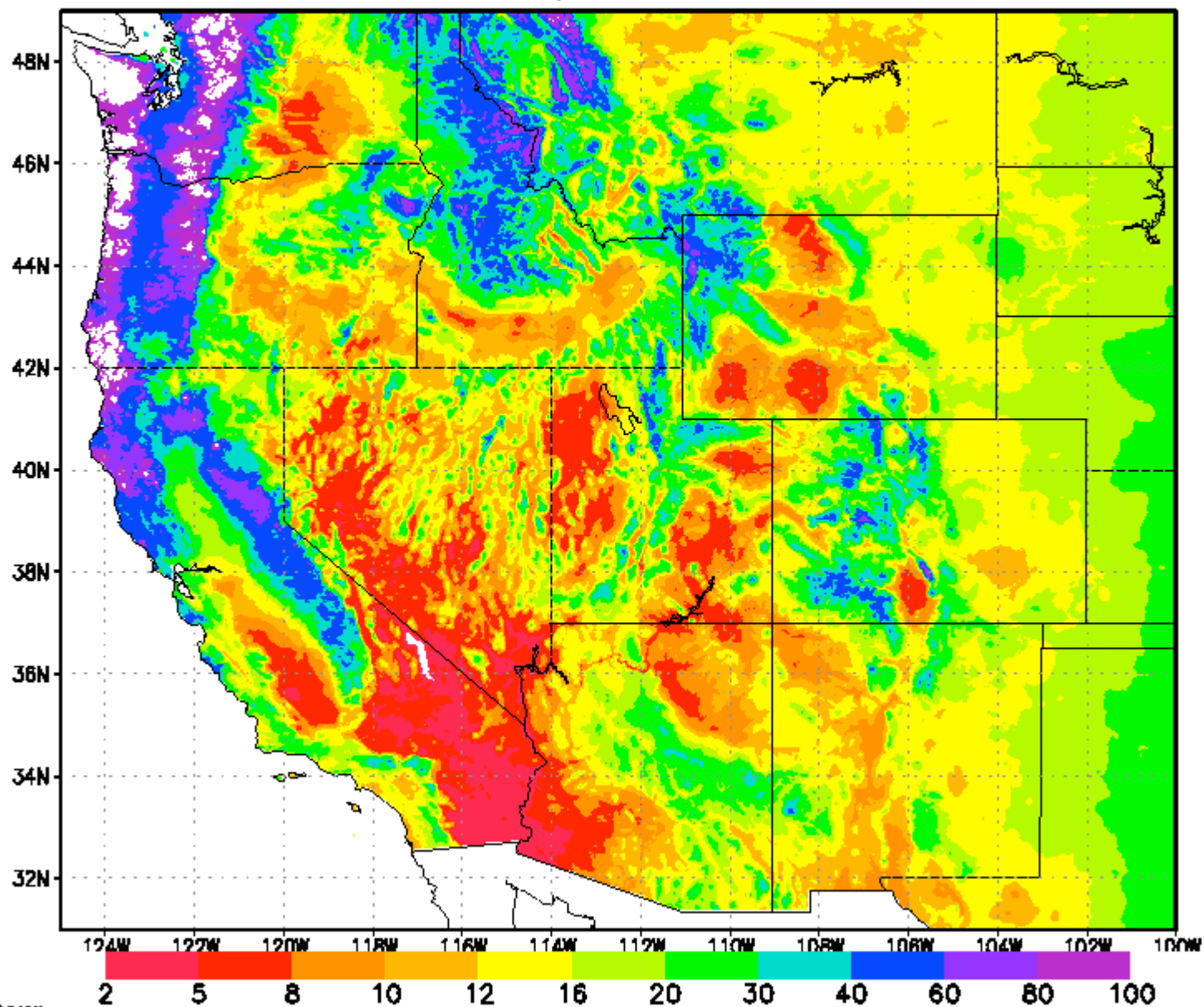
**2003**

**1800 GMT**

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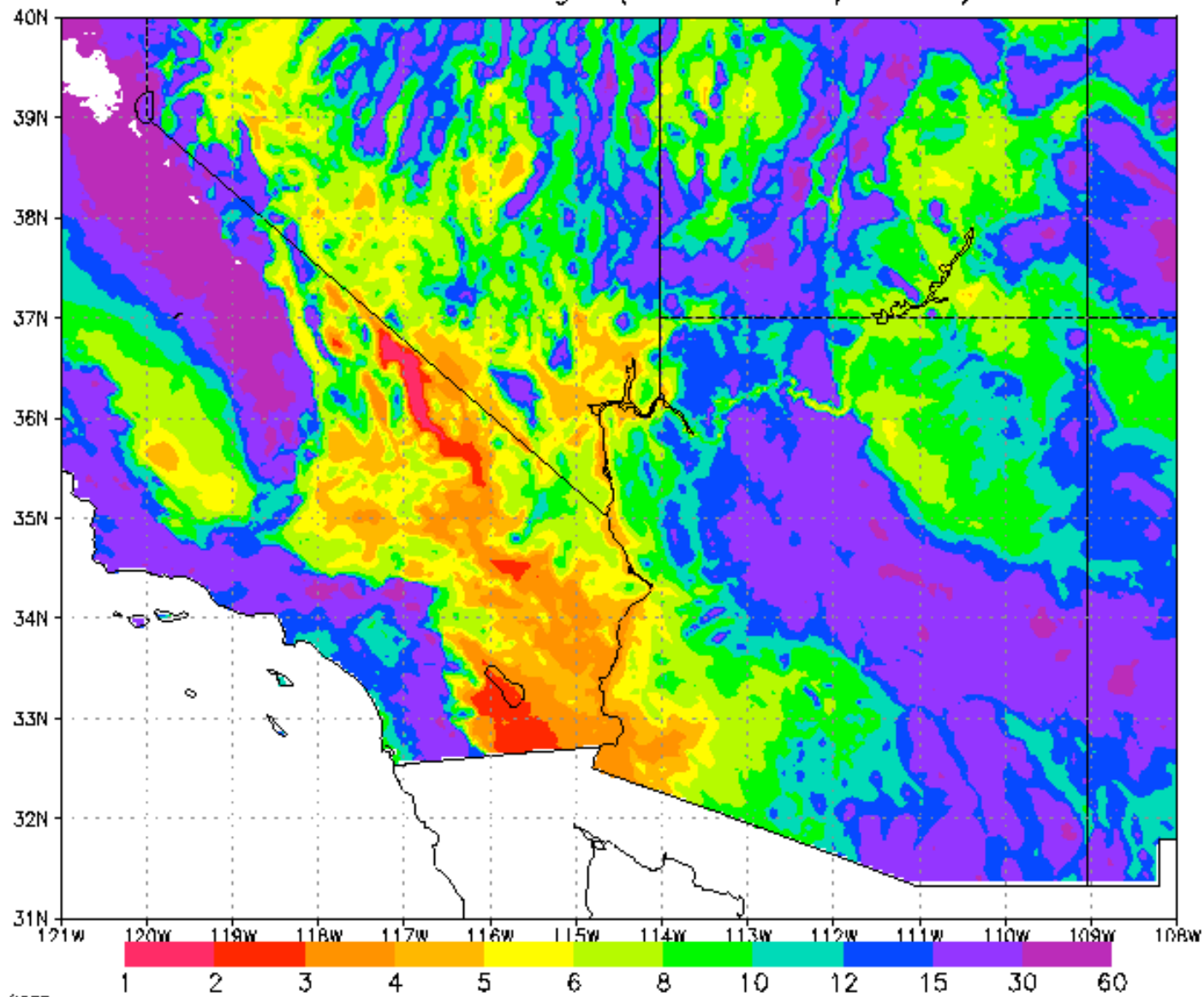


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1961-90 Average (PRISM OSU/WRCC)



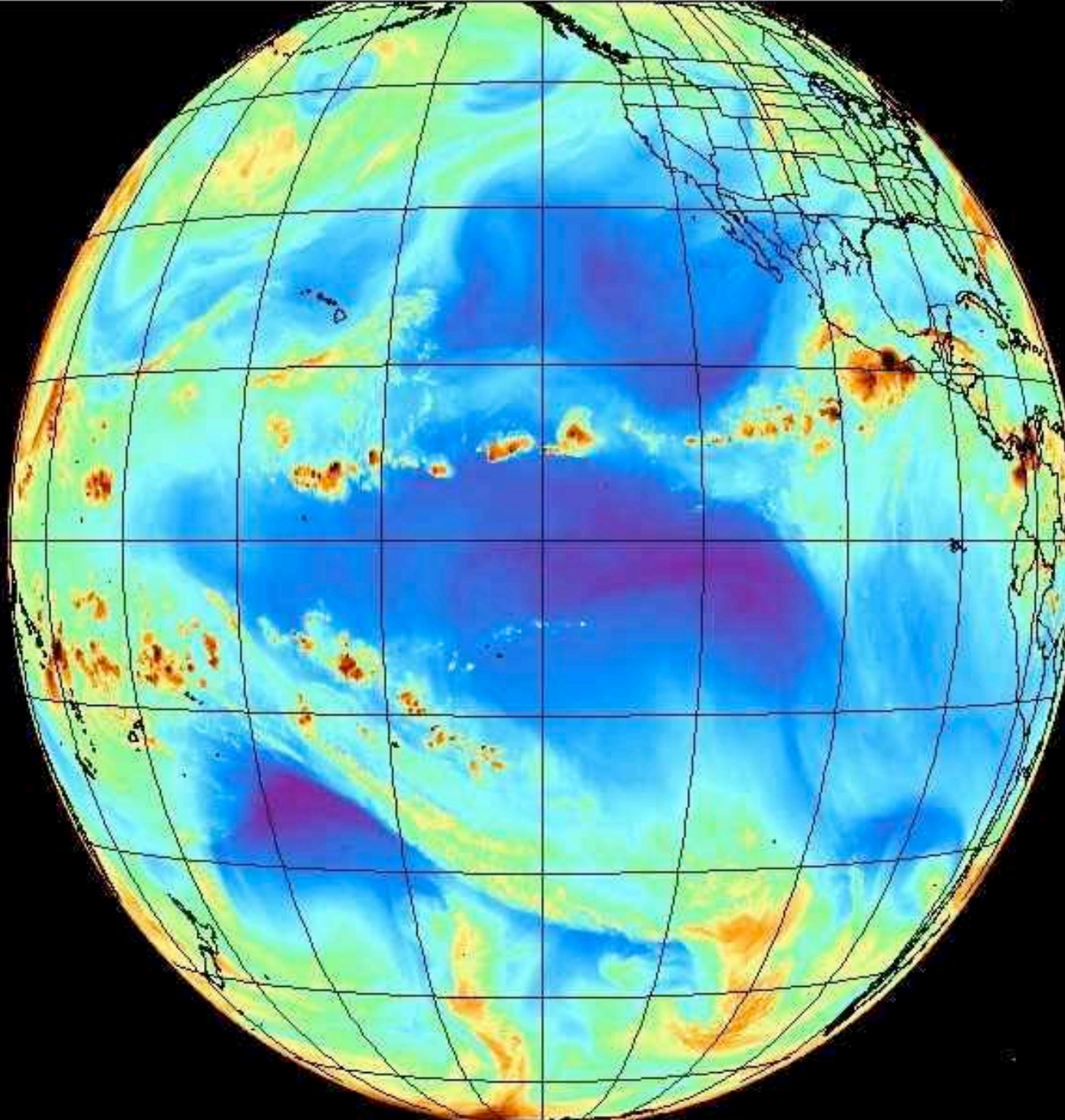


Annual Precipitation (inches)  
1961-90 Average (PRISM OSU/WRCC)



GrADS: COLA/IGES

GOES10 VAPOR 06/01/2003 1800Z Naval Research Laboratory



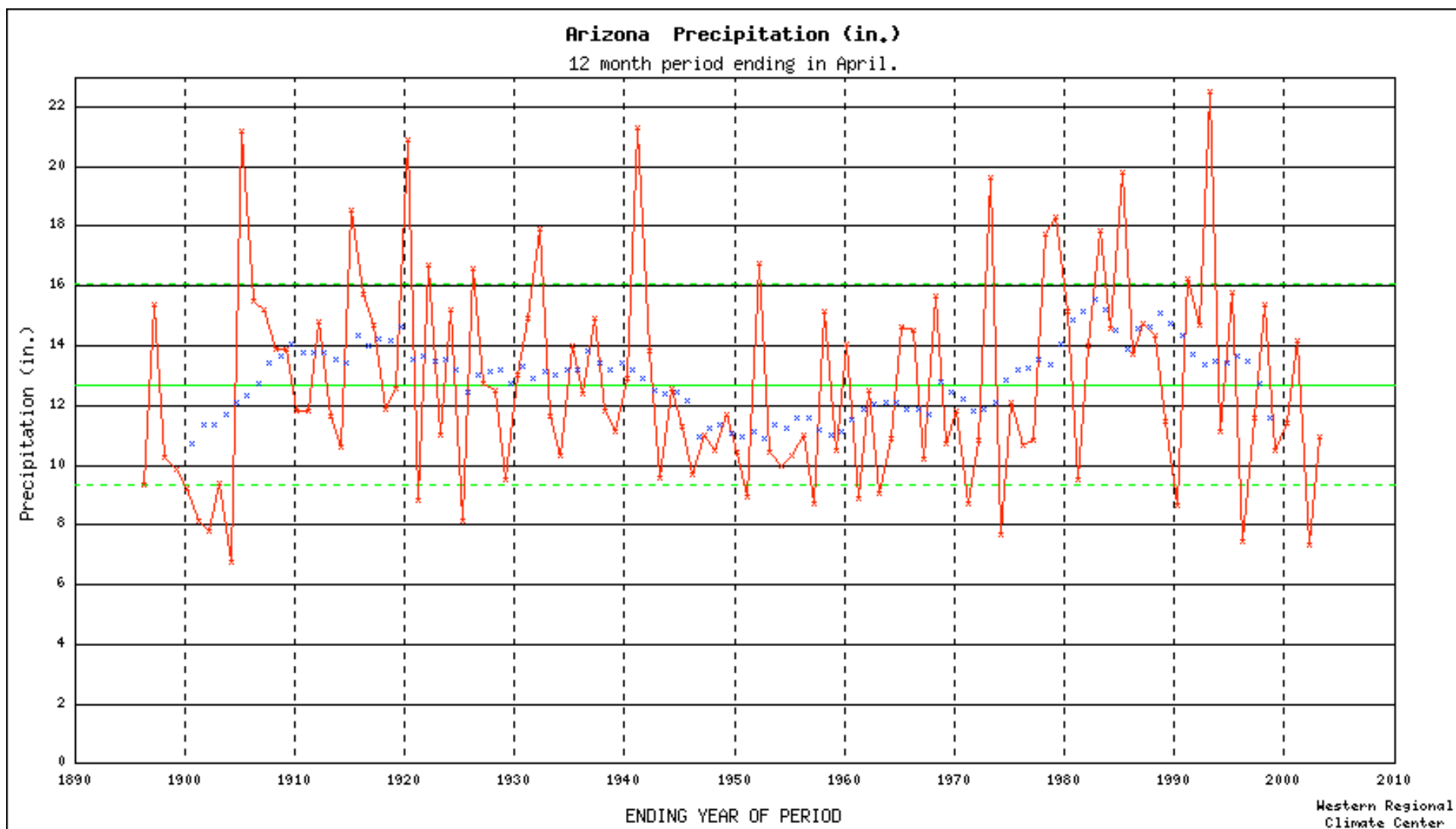
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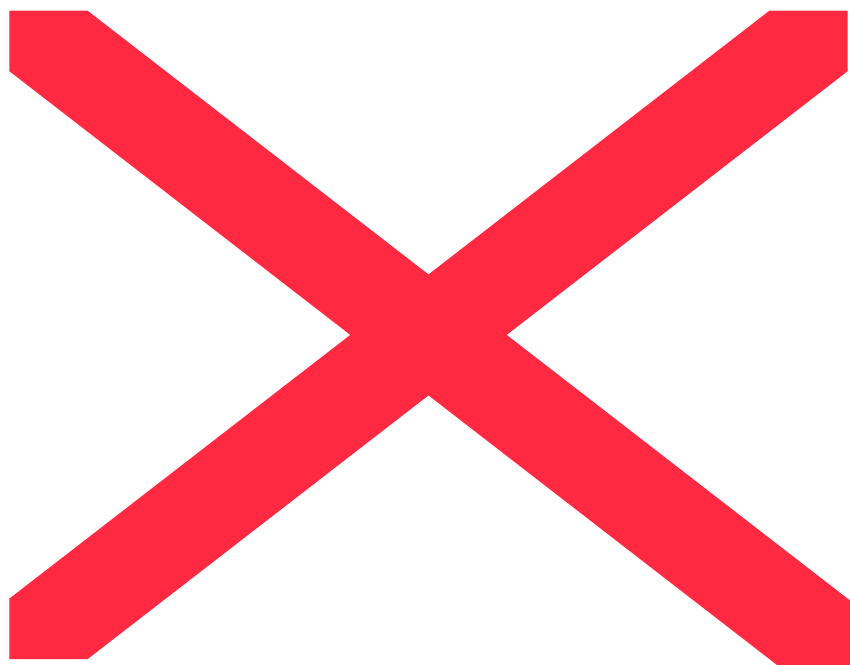
**June 1**

**2003**

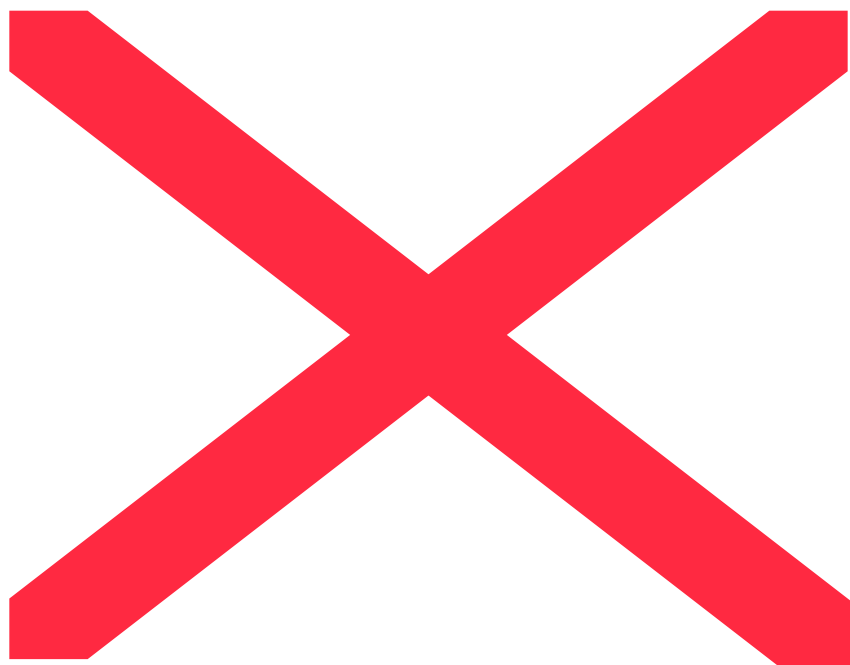
**1800 GMT**

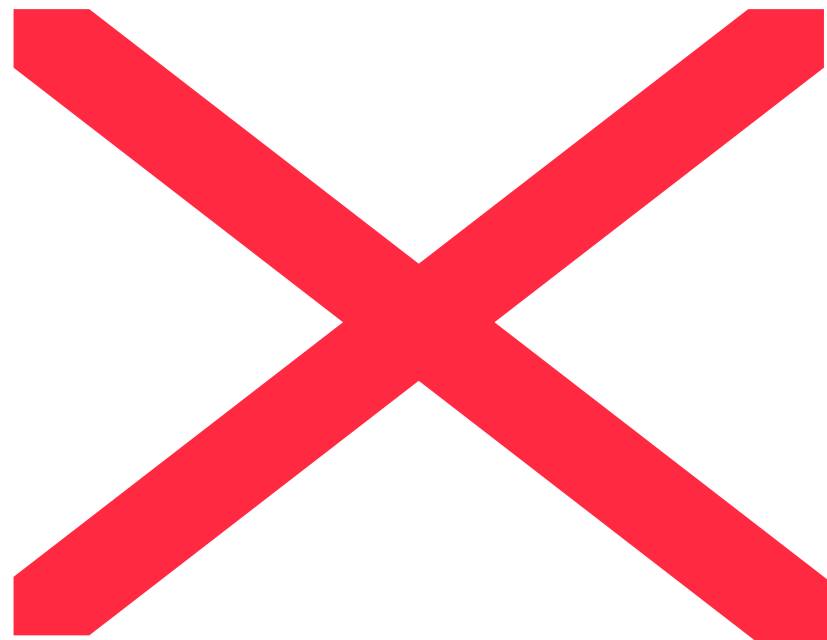
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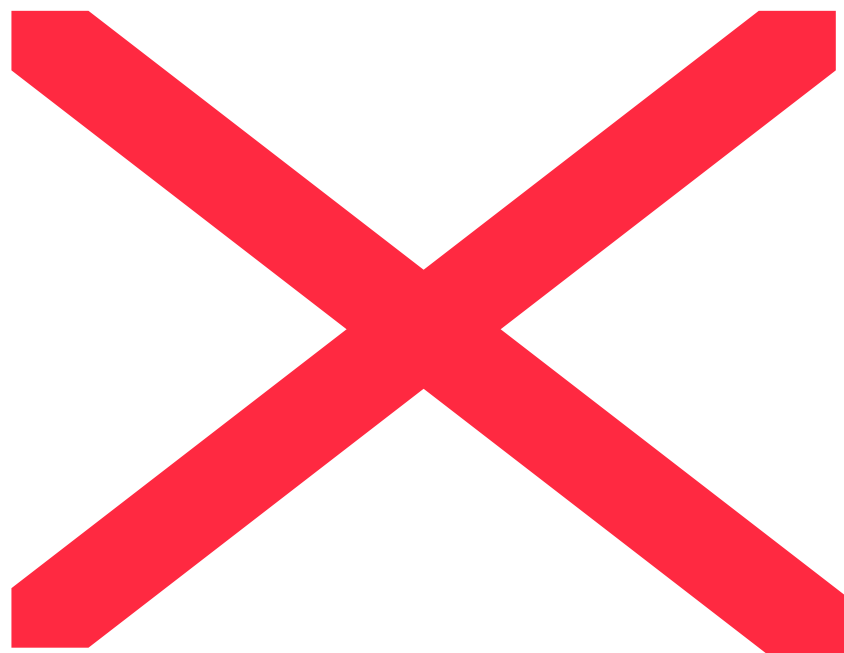








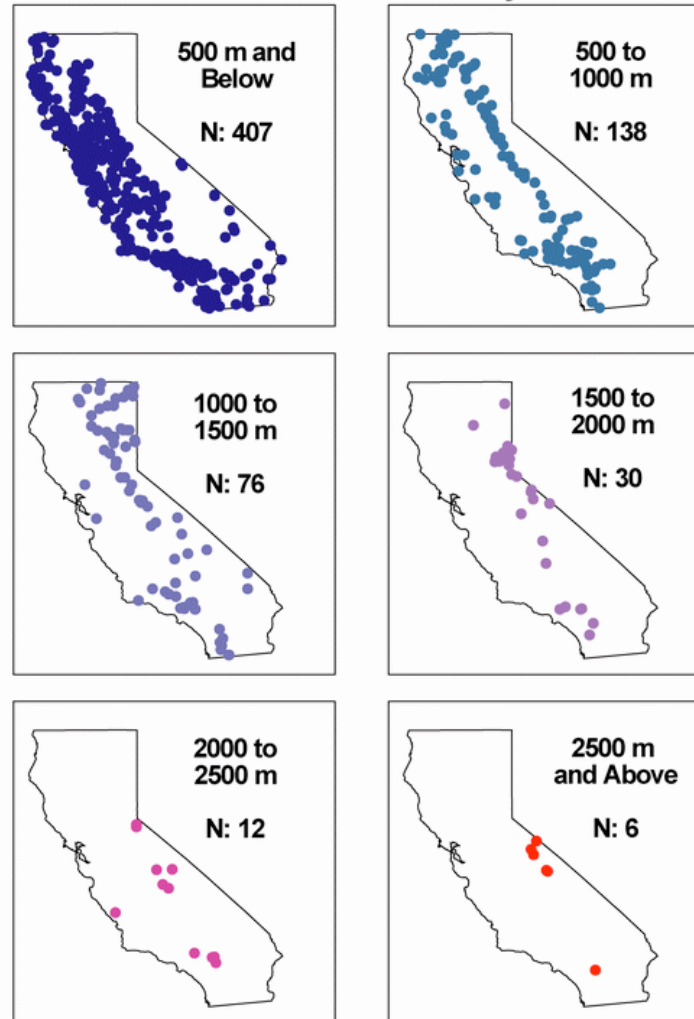




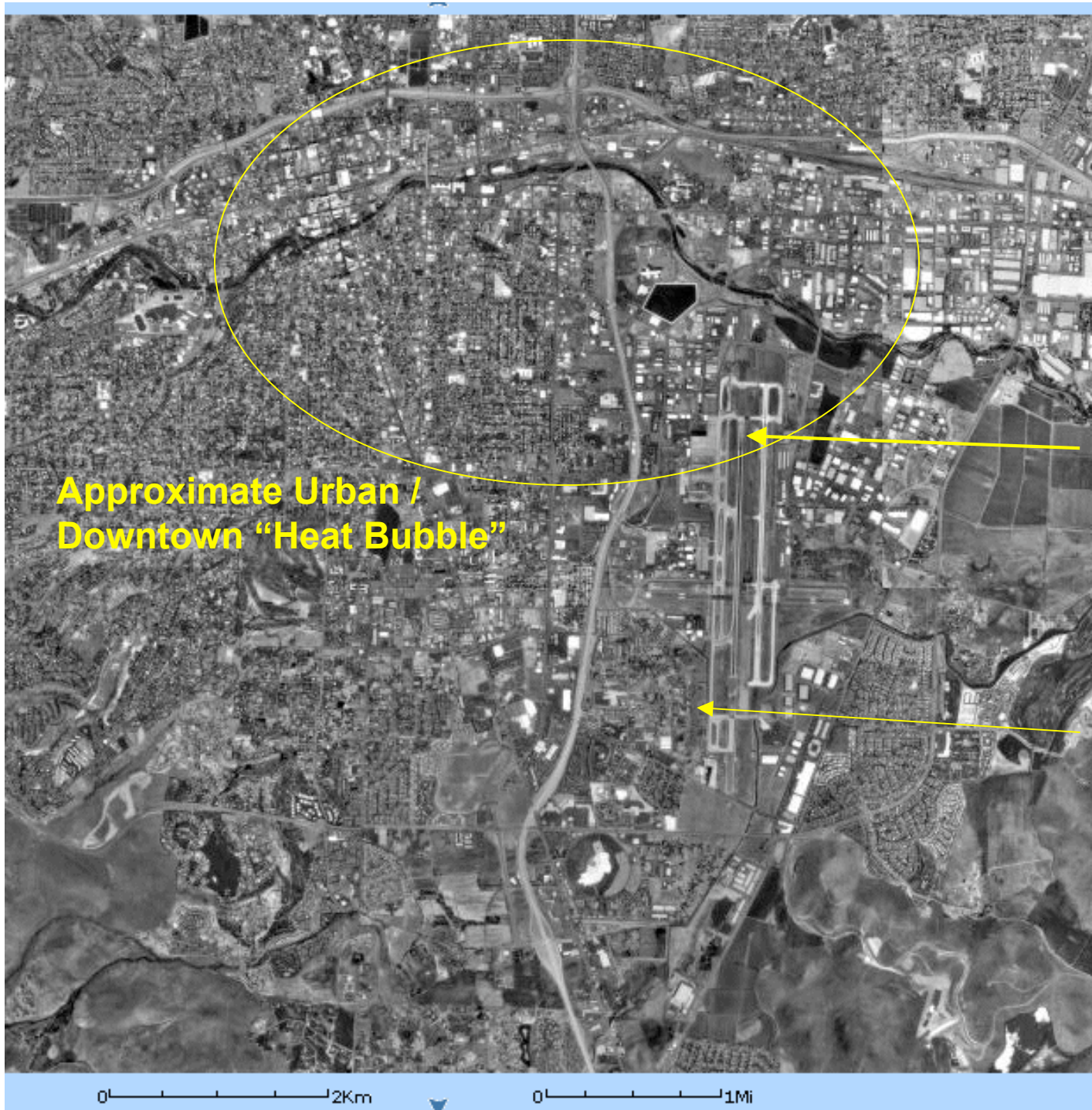
**We need more  
high elevation climate  
stations!**

**Most of California's  
Precip gauges are  
sited in low  
elevation population  
centers. Yet,  
a lot of our concern  
is for climate  
changes in mid-high  
elevations.**

**California Precip Stations with  
at Least 10 Years of Record by Elevation**







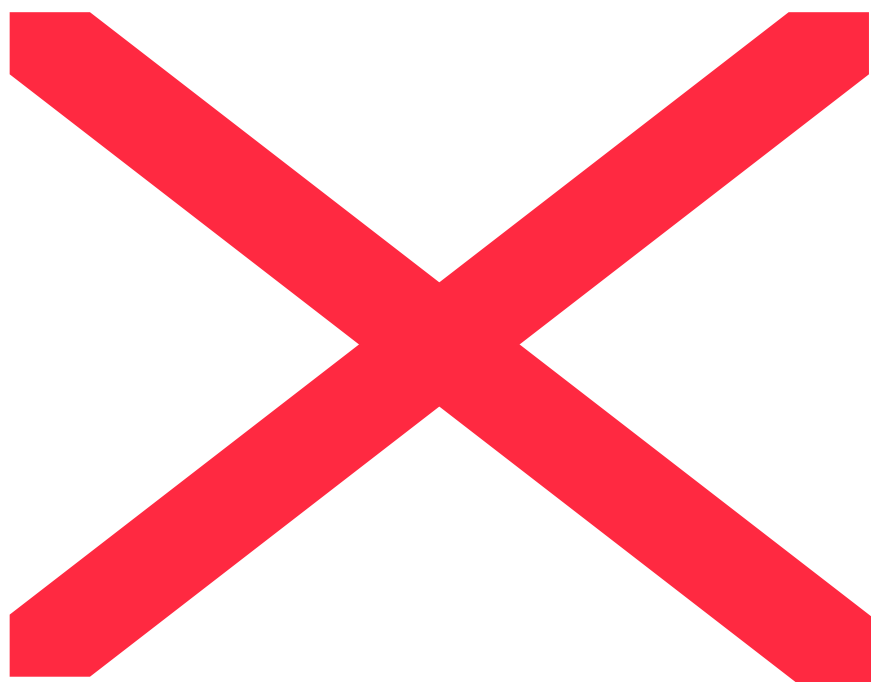
## **Reno Airport (KRNO)**

**KRNO ASOS  
(between runways)**

**Temporary ASOS  
("not windy enough")**

\*\*\*\*\*

**Temperature  
differences can be 6-8  
degrees F from one  
end of runway to the  
other, at night.**



































STATION NUMBER 422173

ELEMENT : DAILY MAX TEMPERATURE                      QUANTITY :                      MONTHLY MAXIMUM

STATION : DINOSAUR NM QUARRY AREA

FROM DATA WITH UNITS: DEGREES F

\*\*\* Note \*\*\* Provisional Data \*\*\* After Year/Month 200301

a = 1 day missing, b = 2 days missing, c = 3 days, ..etc.,

z = 26 or more days missing, A = Accumulations present

Long-term means based on columns; thus, the monthly row may not

sum (or average) to the long-term annual value.

MAXIMUM ALLOWABLE NUMBER OF MISSING DAYS : 9

For 80-column screen, values more than four digits produce 4 asterisks (\*\*\*\*).

For 80-column screen, values have been multiplied by 1, skewness by 10

YEAR(S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1958	9999z	9999z	9999z	77b	94a	99	102a	103	95d	82d	70a	59h	103
1959	54b	52	64d	83a	90a	102a	102a	100	95	78b	65b	50b	102
1960	40	45a	71	82e	90a	98	105b	102b	94b	83d	67h	46d	105
1961	49a	57d	70	78d	87b	105e	100i	97e	811	9999z	57a	43	105
1962	51	51	66	83a	86	98	99	101	93	82f	69	54	101
1963	48	59	71	77	88	97	100	100	91	84	62	44	100
1964	47	54	69	78	91a	98	104	102	93	83	65	42	104
1965	50	42	68	81	86	92	96	98	86	80	65	48	98
1966	42	45	75	80	90	97	102	100	91	75	62	46	102
1967	40	44	69	75	93	95	100	98	103	83	66	38	103
1968	41	52	73	76	90	101	100	93	91	76	58	44	101
1969	46	47	67	83	94	96	100	102	93	76b	61a	54	102
1970	45	58	61f	74a	91a	100	100	100	92	83c	62	52	100
1971	60a	59b	77a	78b	87	102	105	101	9999z	80d	48a	45a	105
1972	56c	65	75	77b	90e	94b	105	102a	80z	9999z	9999z	9999z	105
1973	41	43	56	71	89	98	103a	100	90	87	63	43	103
1974	32	38	71	80	91	102	101	98	97	84	66	44	102
1975	56	54	66	73	88	98	100	101	95	85	64	42	101
1976	49	59	66	77	89	101	106	99	97	82	68	50	106
1977	49	64	69	85	90	102	102	98	98	82	68	60	102
1978	41	46	74	74	87	96	106	100	99	86	74	35j	106
1979	36	42	59	78	88	102c	103	105	96	86	55	49	105
1980	42	54	60	82	85	98	101	100	93	85	70	55	101
1981	52	64	67	85	87	104	102	99	92	77	62	52	104
1982	45	57	63	74	88	99	103	100	93	70	56	42	103
1983	40	51	66	73	90	95	99	101	94	77	68	34	101
1984	24	39	56	79	93	99	100	97	92	74	9999z	39	100
1985	35	42	68	82	85	99	102	97	94	77	64	39	102
1986	41	66	77	79	89	100	99	101	89	73	65	49	101
1987	52	55	64	85	88	97	101	99	94	84	66	51	101

1988	33	50	72	82	91	105	103	100	97	83	68	49	105
1989	33	49	70	88	93	101	107	98	94	86	68	51	107
1990	50	52	71	84	91	104	104	102	99	84	71	47	104
1991	32	57	65	82	86	95	103	97	95	84	64	47	103
1992	34	60	68	89	91	98	97	100	90	88	56	45	100
1993	41	42	72	79	90	98	98	100	94	87	59	50	100
1994	55	60	76	86	94	105	103	104	94	73	60	48	105
1995	49	63	70	76	82	96	105	101	99	82	66	61	105
1996	53	58	72	84	92	96	102	100	96	93	61	49	102
1997	51	45	72	76	90	96	102	98	90	83	63	43	102
1998	50	53	75	80j	87	96	106	99	99	82	59	57	106
1999	47	60	72	81	88	97	101	97	87	84	65s	42z	101
2000	48	52	65	80	9999z	96	98	100	93	84	56o	54	100
2001	48	58	71	84	92	105	110	102	100	87	70m	42p	110
2002	341	541	72k	82	103	105k	110	105	97	75m	58m	40n	110

Dinosaur Nat Mon,  
Utah Quarry Site

MEAN	45	53	69	80	90	99	102	100	94	82	64	48	102
S.D.	8	8	5	4	3	3	3	2	4	5	5	6	2
SKW10	-5	-2	-6	0	12	3	5	-2	1	-5	-7	1	3
MAX	60	66	77	89	103	105	110	105	103	93	74	61	107
MIN	24	38	56	71	82	92	96	93	86	70	48	34	98
YRS	43	43	44	45	44	44	45	45	42	42	39	40	31

STATION NUMBER 052286

ELEMENT : DAILY MAX TEMPERATURE      QUANTITY :      MONTHLY MAXIMUM

STATION : DINOSAUR NATL MONUMENT

FROM DATA WITH UNITS: DEGREES F

\*\*\* Note \*\*\* Provisional Data \*\*\* After Year/Month 200301

YEAR(S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1965	9999z	9999z	9999z	9999z	9999z	59	74b	71	30	55	35	15	15
2000	53	53	65	80	92	94	99	99	91	79a	48	47	99
2001	47	49	65	78	85	97	100	94	91	82	66	45	100
2002	42	53	66	74	96	98	104	96	91	70	55	46	104

MEAN	46	52	65	76	85	94	98	96	89	78	60	48	99
S.D.	6	6	5	5	4	4	3	3	4	4	6	5	2
SKW10	-3	1	-7	4	7	-3	-4	-4	-6	-7	-6	1	2
MAX	57	64	73	87	96	100	104	102	96	84	69	58	104
MIN	32	40	53	68	78	86	90	88	79	69	46	37	94
YRS	37	38	38	38	37	38	37	38	38	38	37	38	34

Dinosaur Nat Mon,  
Colorado HQ.



April 1  
Mountain  
Snowpack

Pct of  
average

1980

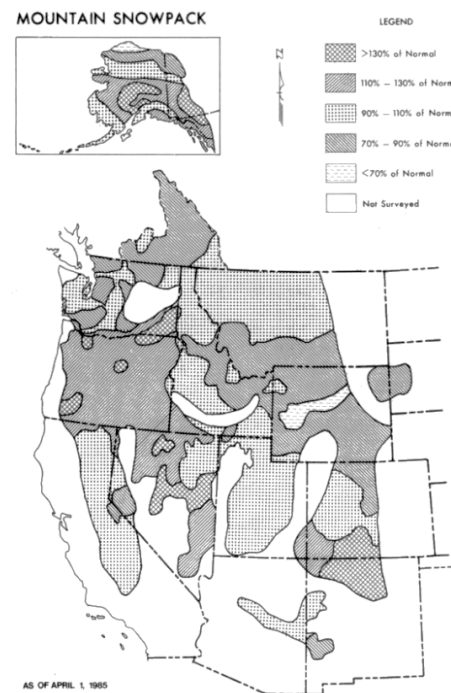
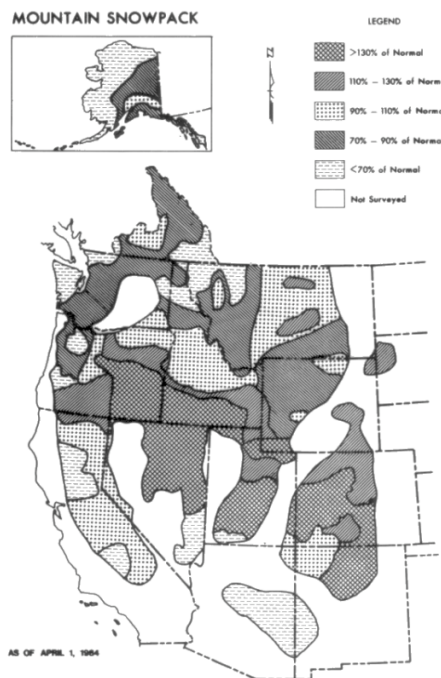
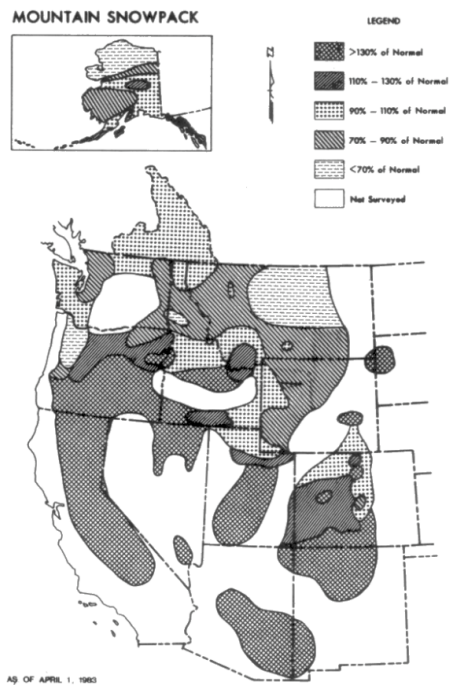
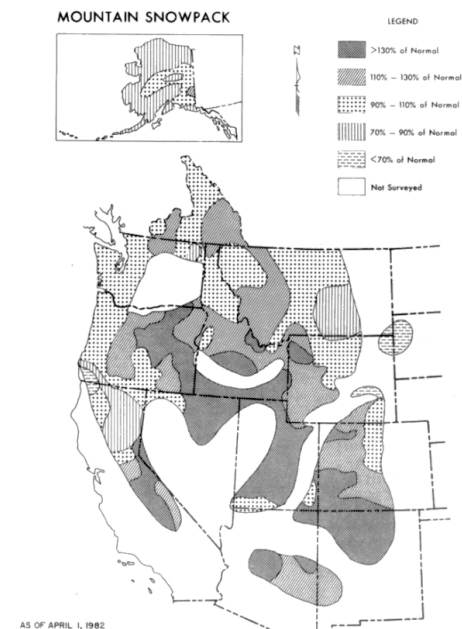
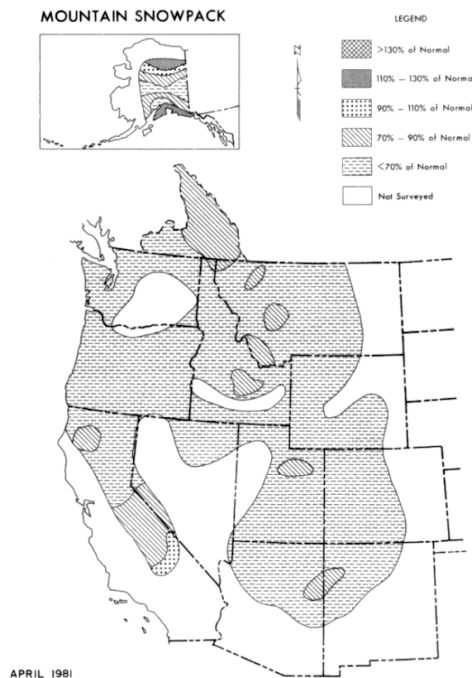
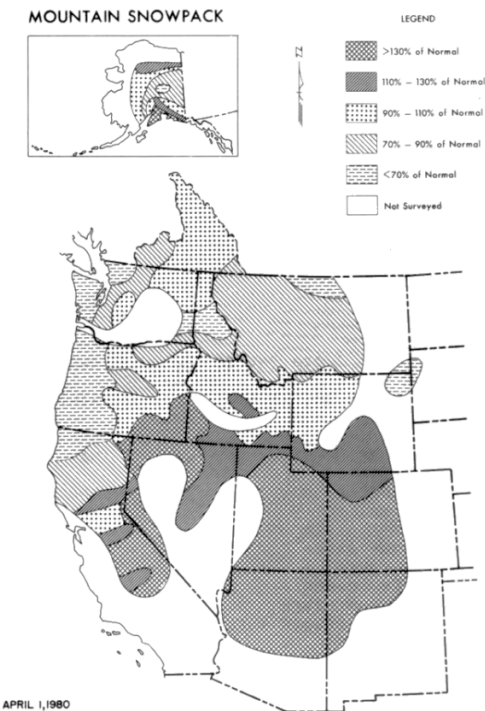
1981

1982

1983

1984

1985



April 1  
Mountain  
Snowpack  
Pct of average

1986

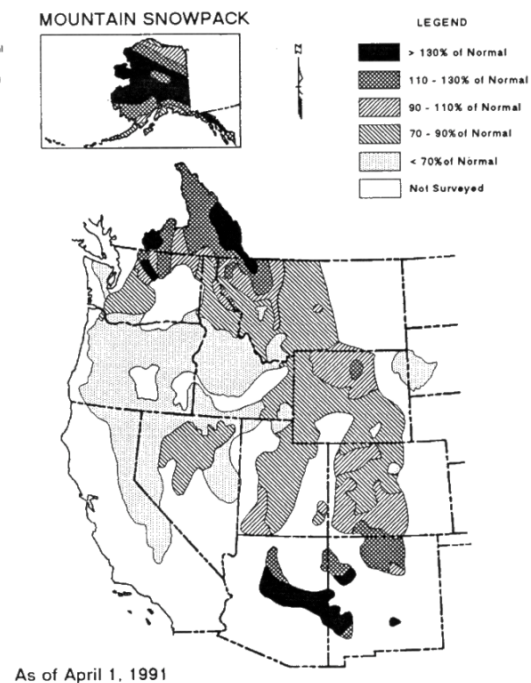
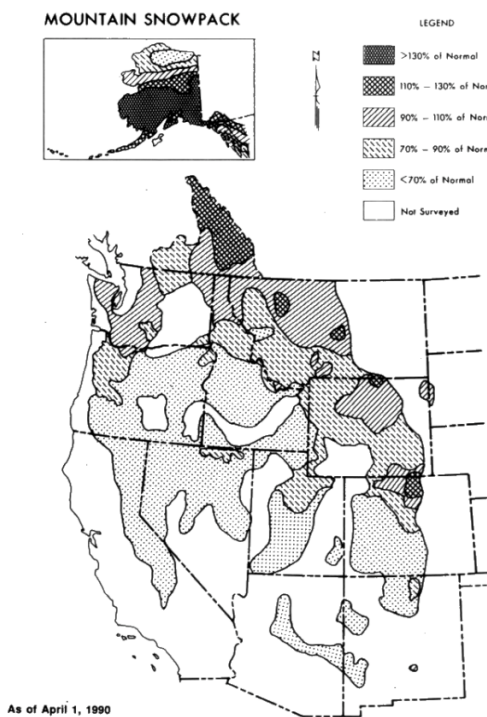
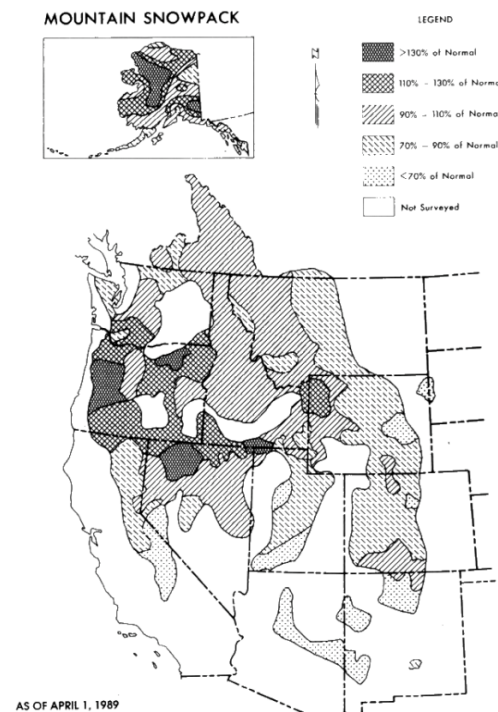
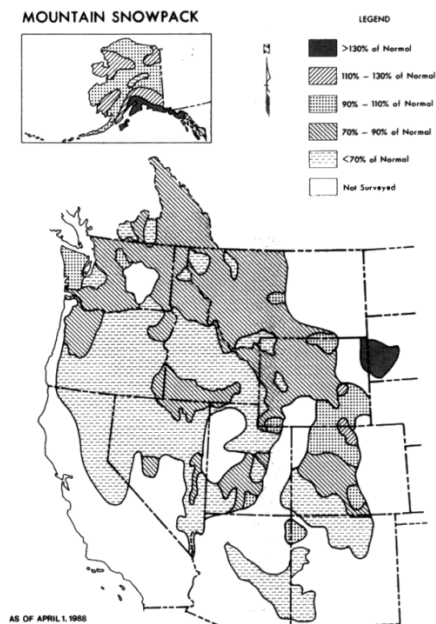
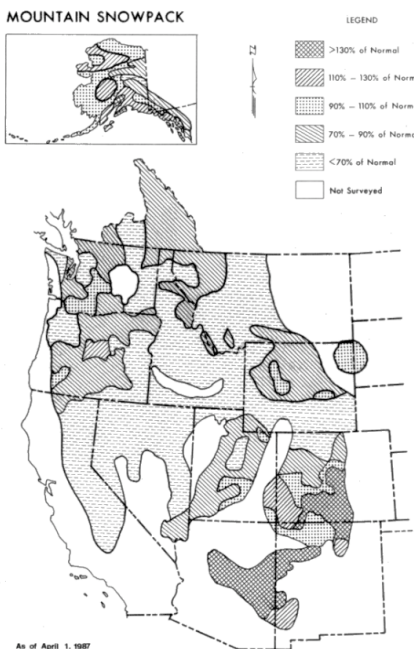
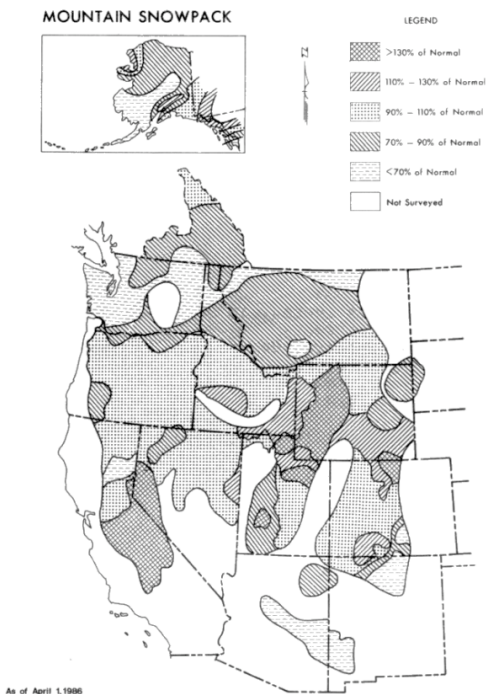
1987

1988

1989

1990

1991





April 1  
Mountain  
Snowpack  
Pct of average

1986

1987

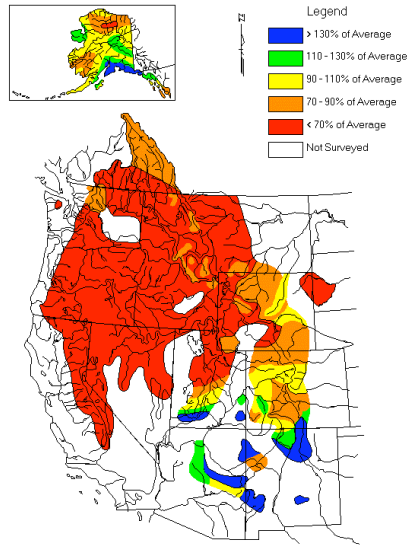
1988

1989

1990

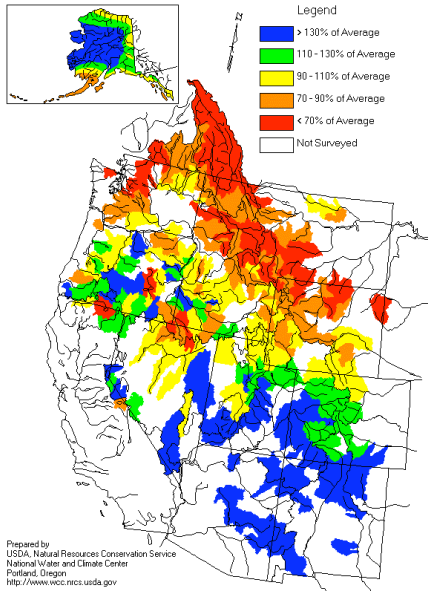
1991

Mountain Snowpack as of April 1, 1992



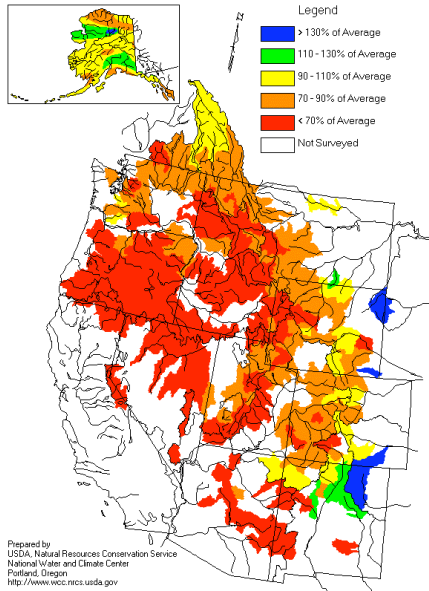
Prepared by  
USDA, Natural Resources Conservation Service  
National Water and Climate Center  
Portland, Oregon  
<http://www.wcc.nrcs.usda.gov>

Mountain Snowpack as of April 1, 1993



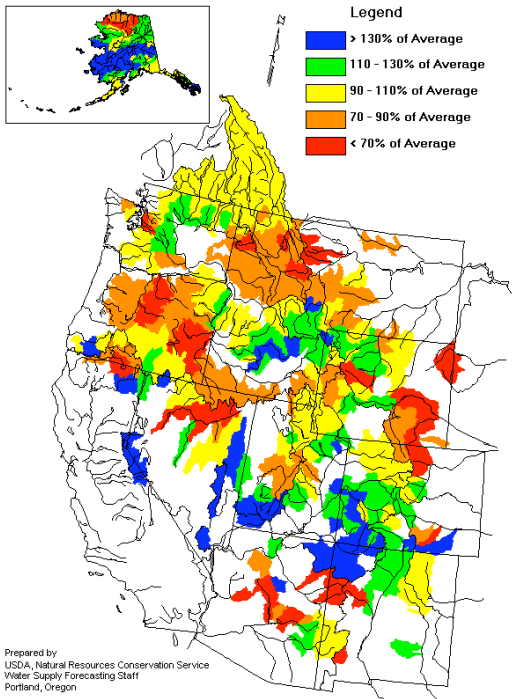
Prepared by  
USDA, Natural Resources Conservation Service  
National Water and Climate Center  
Portland, Oregon  
<http://www.wcc.nrcs.usda.gov>

Mountain Snowpack as of April 1, 1994



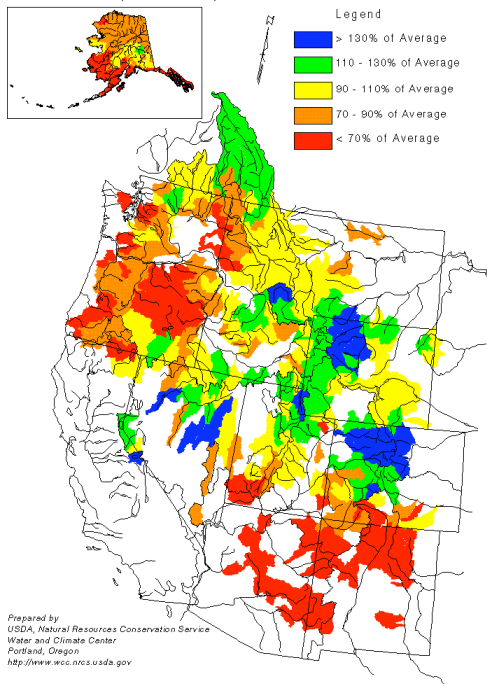
Prepared by  
USDA, Natural Resources Conservation Service  
National Water and Climate Center  
Portland, Oregon  
<http://www.wcc.nrcs.usda.gov>

Mountain Snowpack as of April 1, 1995



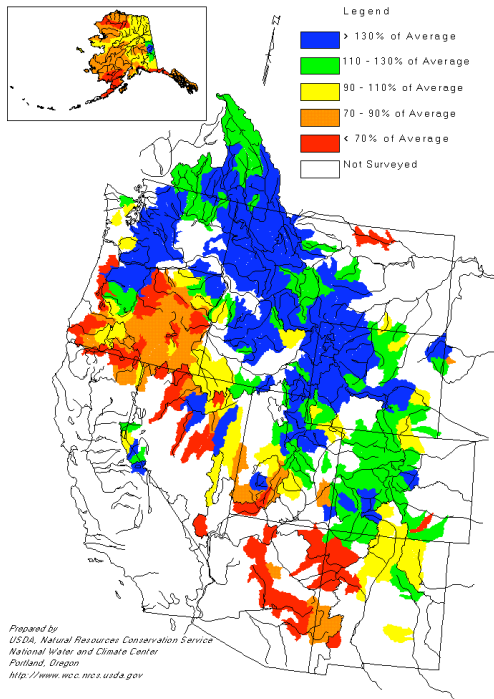
Prepared by  
USDA, Natural Resources Conservation Service  
Water Supply Forecasting Staff  
Portland, Oregon

Mountain Snowpack as of April 1, 1996



Prepared by  
USDA, Natural Resources Conservation Service  
Water and Climate Center  
Portland, Oregon  
<http://www.wcc.nrcs.usda.gov>

Mountain Snowpack as of April 1, 1997



Prepared by  
USDA, Natural Resources Conservation Service  
National Water and Climate Center  
Portland, Oregon  
<http://www.wcc.nrcs.usda.gov>

**April 1**  
**Mountain**  
**Snowpack**  
**Pct of**  
**average**

**1998**

**1999**

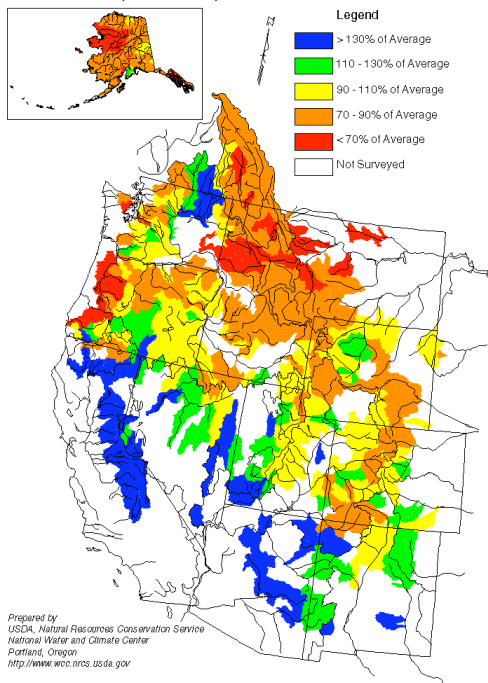
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**2001**

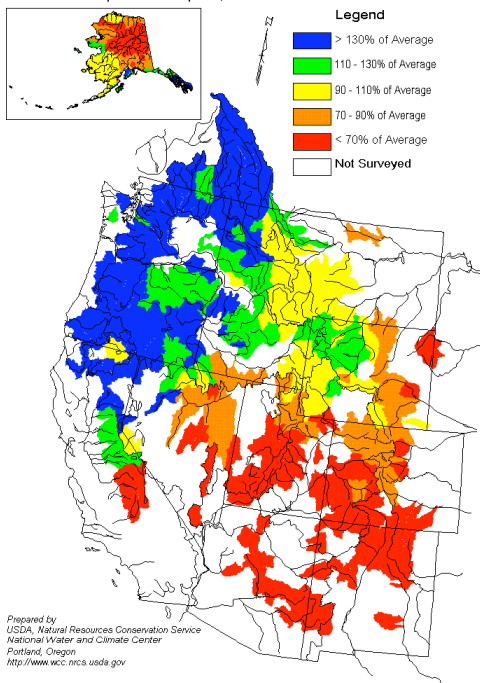
**2002**

**2003**

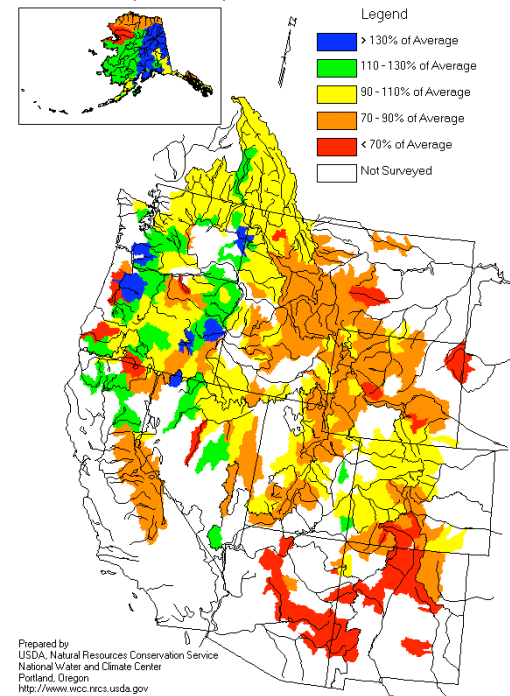
Mountain Snowpack as of April 1, 1998



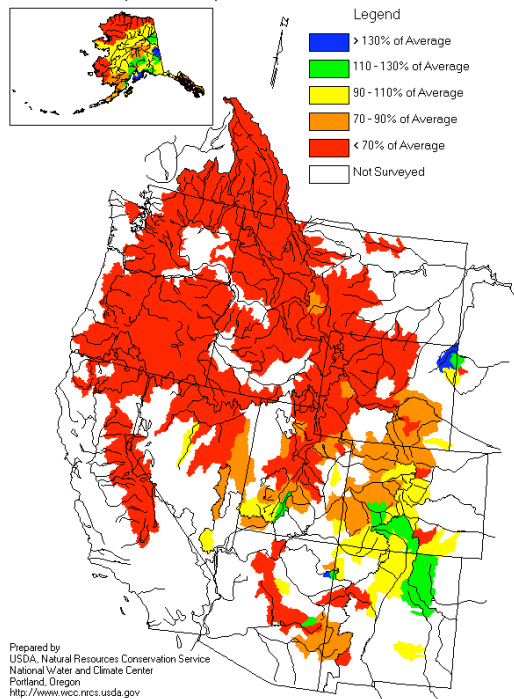
Mountain Snowpack as of April 1, 1999



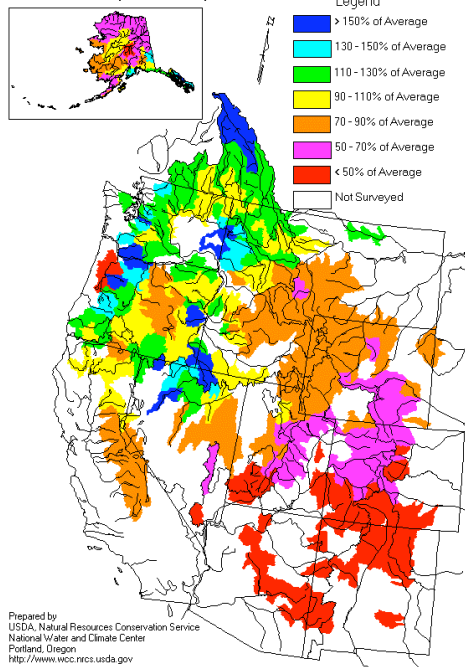
Mountain Snowpack as of April 1, 2000



Mountain Snowpack as of April 1, 2001



Mountain Snowpack as of April 1, 2002



Mountain Snowpack  
 as of April 1, 2003

