Colorado Basin River Forecast Center

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National Weather Service

NOAA

DOC

David Brandon
Hydrologist in Charge

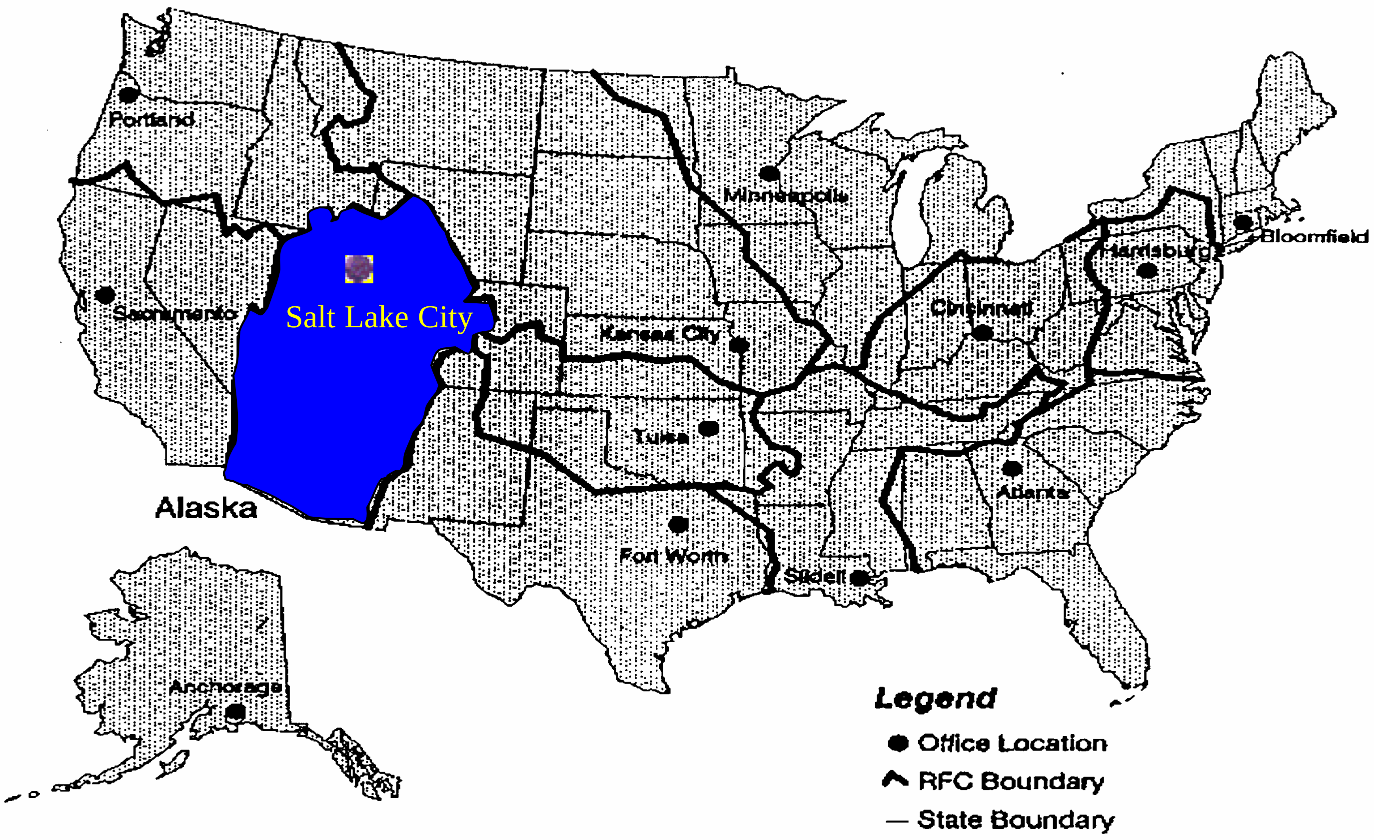
OUR MISSION …

Flash Flood Forecasts/Warnings

River Forecasts/Warnings

Recreational Forecasts

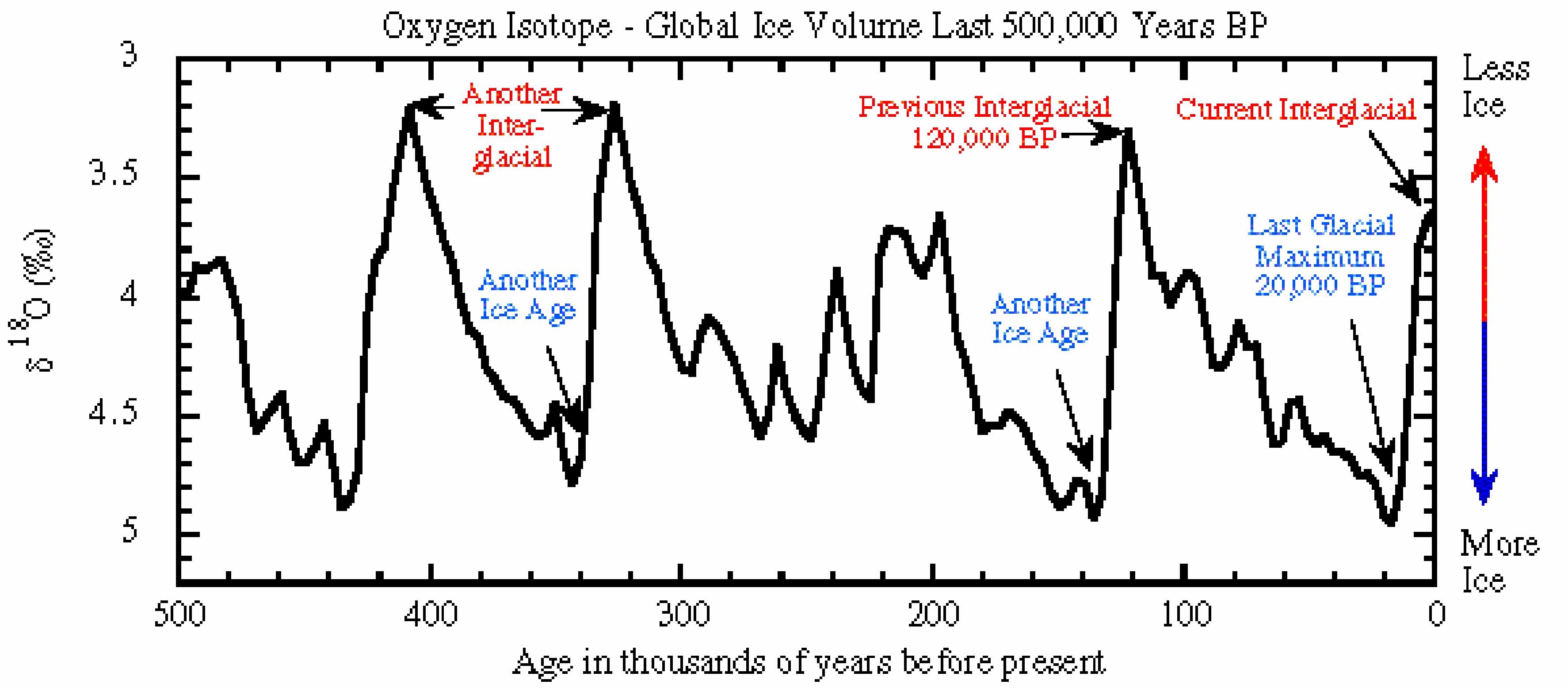
Water Supply/Management



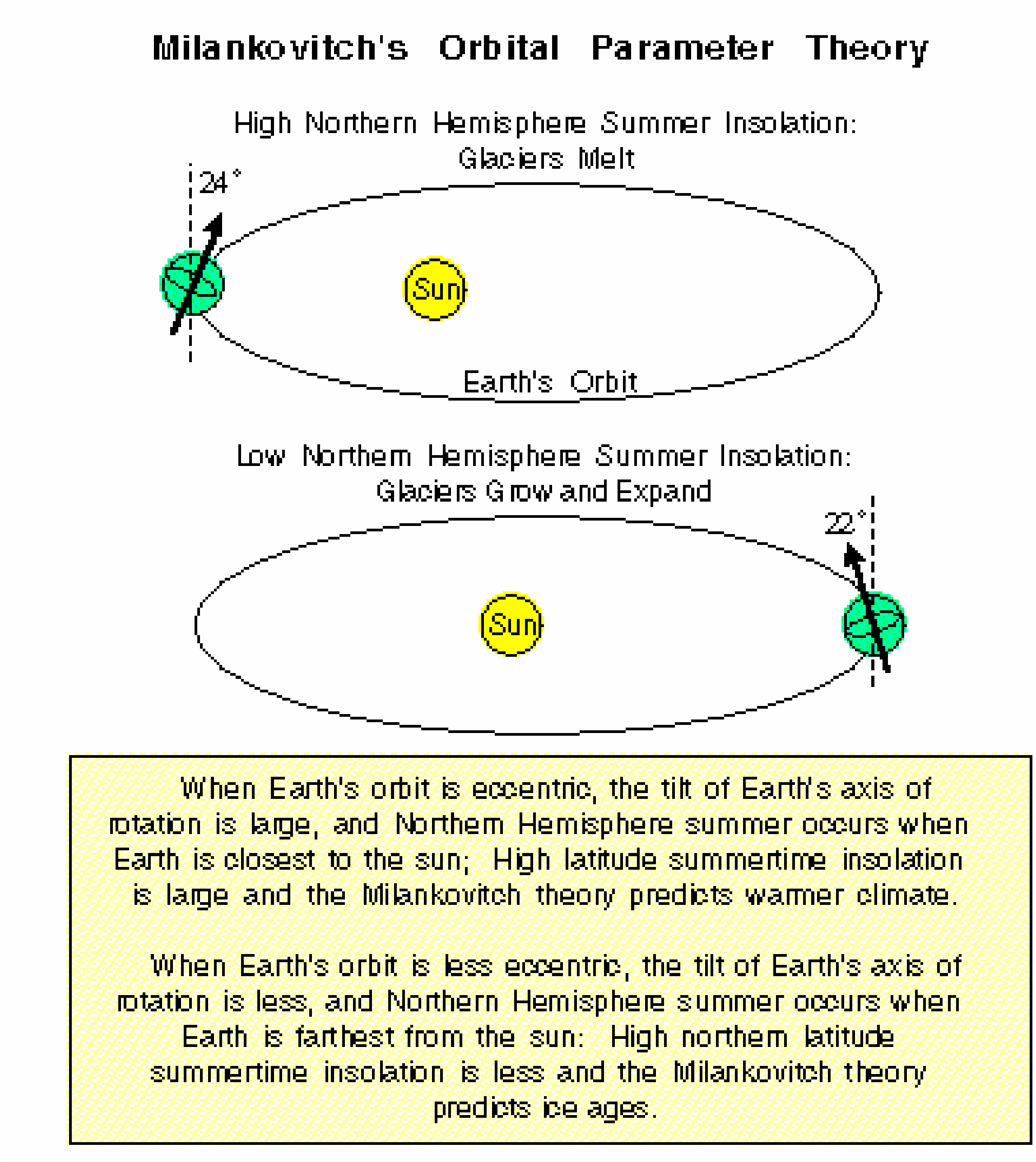
NWS RIVER FORECAST CENTERS

Brief Examination of Climate Change

Oxygen Isotopes and Ice Sheets
Milankovitch Theory
Tree Ring Reconstruction
CO_2 Emissions



Oxygen isotope record in ocean sediments can be used to estimate the mass of water contained in the ice sheets in the past.

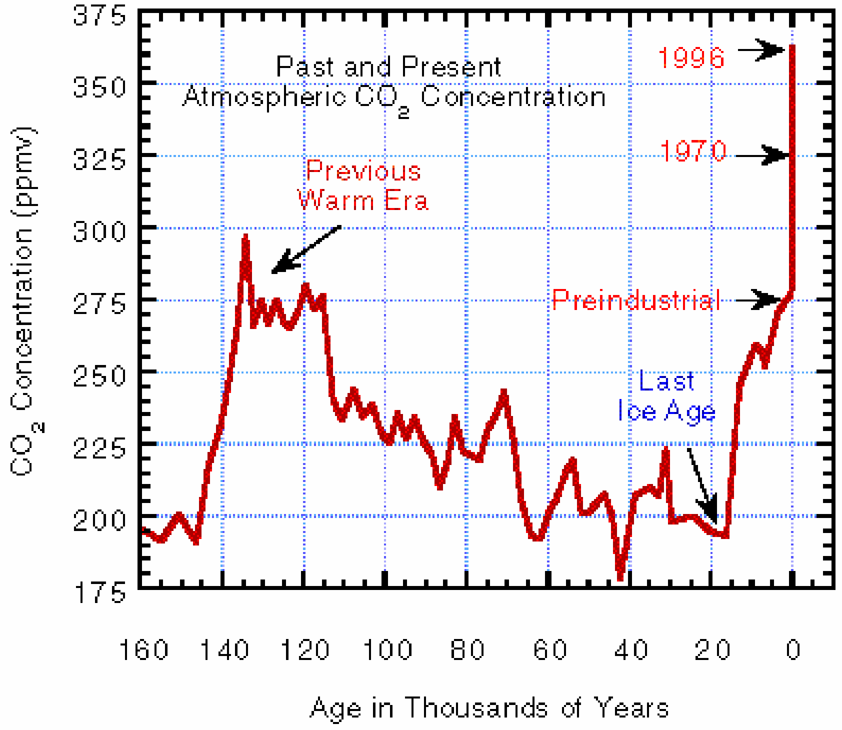


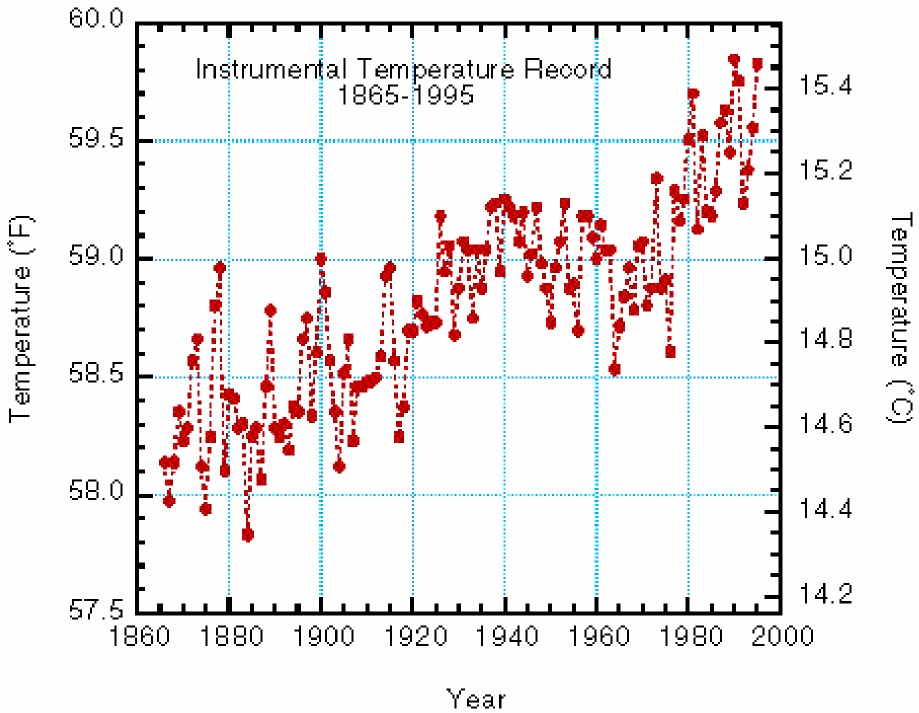
Axis tilt varies
22 – 24.5 with a
period of 41,000 years

Orbit deviates from
perfect circle with
periods of 100,000
& 400,000 Years

Day of Year when earth
is closest to the sun
varies on 23,000 year
cycle

Milutin Milankovitch
Serbian Mathematician
1924

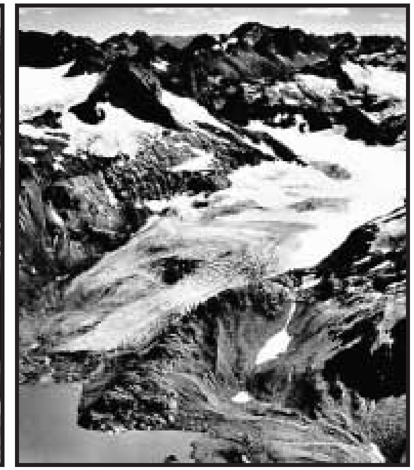

Past and Present
Atmospheric CO_2 Concentration
1996
1970
Previous
Warm Era
Preindustrial
Last
Ice Age
CO_2 Concentration (ppmv)
Age in Thousands of Years
375
350
325
300
275
250
225
200
175
160
140
120
100
80
60
40
20
0


Instrumental Temperature Record
1865-1995
Temperature (˚F)
Temperature (˚C)
Year
60.0
59.5
59.0
58.5
58.0
57.5
15.4
15.2
15.0
14.8
14.6
14.4
14.2
1860
1880
1900
1920
1940
1960
1980
2000

1928

1960

1986

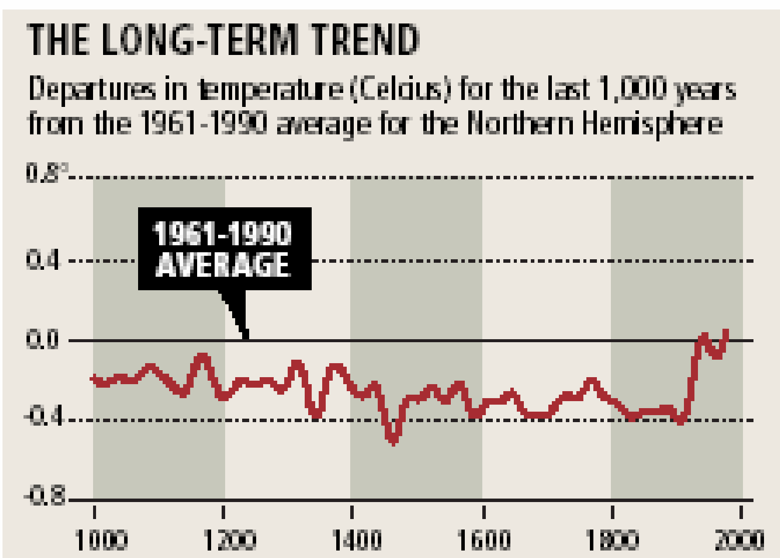


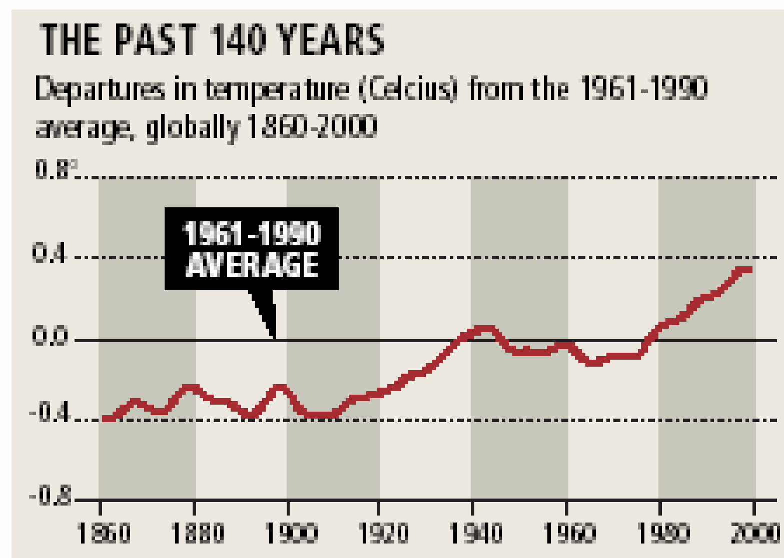
2000

The toe of the glacier, frozen solid in 1928, has melted into a lake.

MELTING GLACIERS

The continent's best-studied example of glacial wasting over the last half-century has been the South Cascade Glacier, about 25 miles northeast of Darrington, outside North Cascades National Park.





Source: "Our Warming World", Lisa Stiffler & Robert McClure

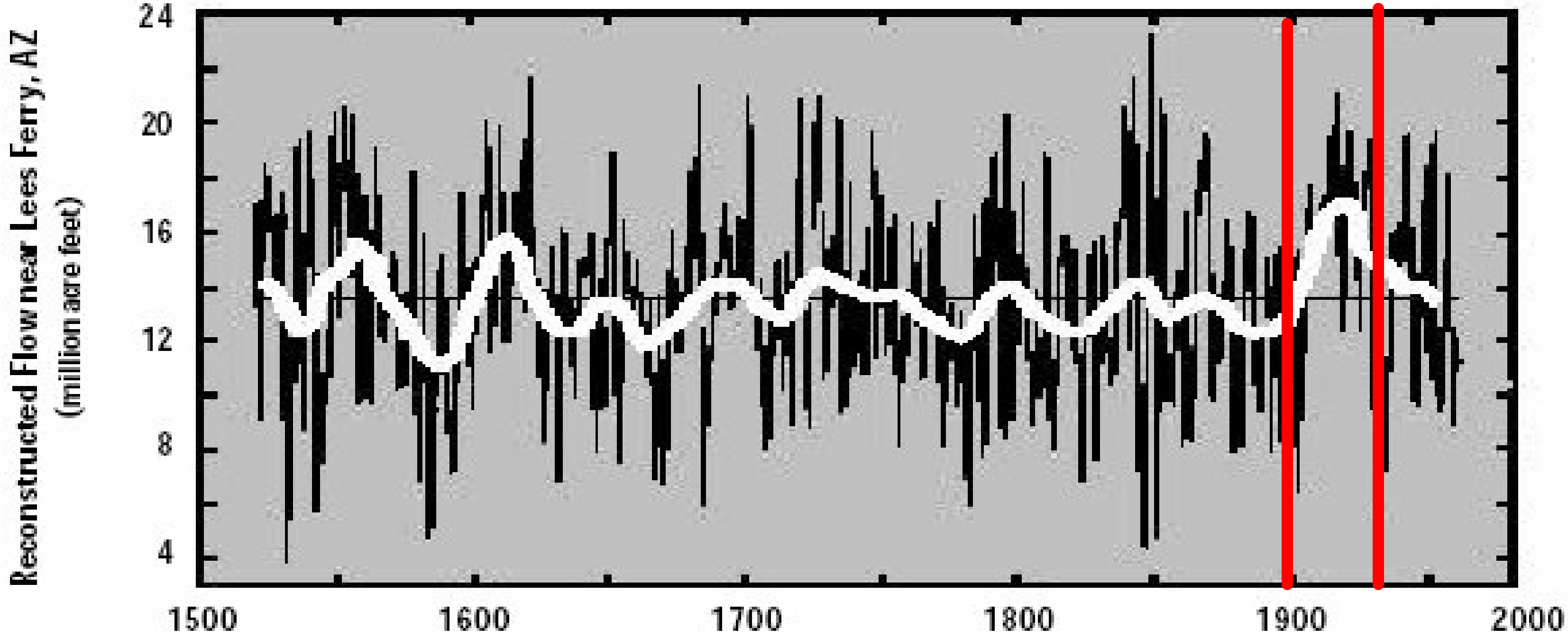
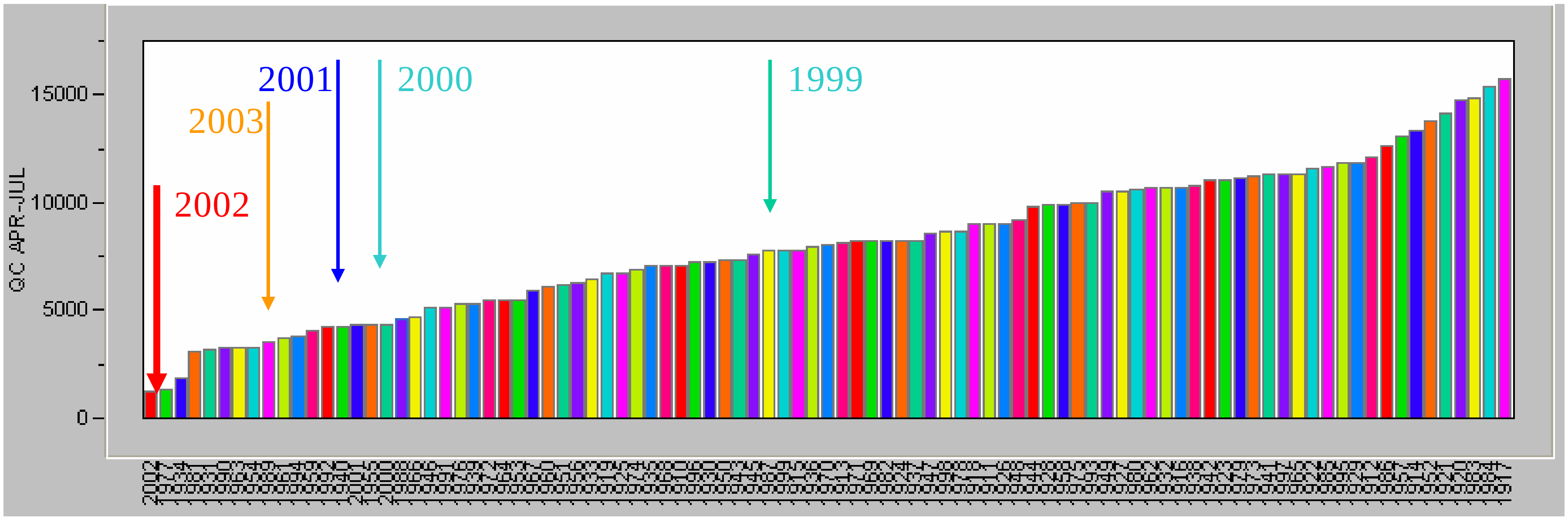


Figure 2. Historic Colorado River Streamflow Based on Tree-Ring Records

Average or mean (white line) and variation (black lines)

Source: Meko, *et al.*, 1995.

APRIL-JULY Runoff Above Lake Powell/Lees Ferry
2002 Was the Lowest for 93 Years of Record &
Five Consecutive Dry Years of Runoff



1981

1990

1984

The Last Year We Had Above Average Flow

Since Then:
Five Consecutive Dry Years

1998	8.6 (maf)
1999	7.8
2000	4.4
2001	4.3
2002	1.2
2003	3.9

FORECASTING WATER SUPPLY IN THE UPPER COLORADO BASIN

APRIL THROUGH JULY VOLUME OF WATER

EARLY SEASONAL OUTLOOKS:
BEGIN IN THE PRECEEDING FALL

PROBABILISTIC FORECASTS:
BEGIN IN JANUARY

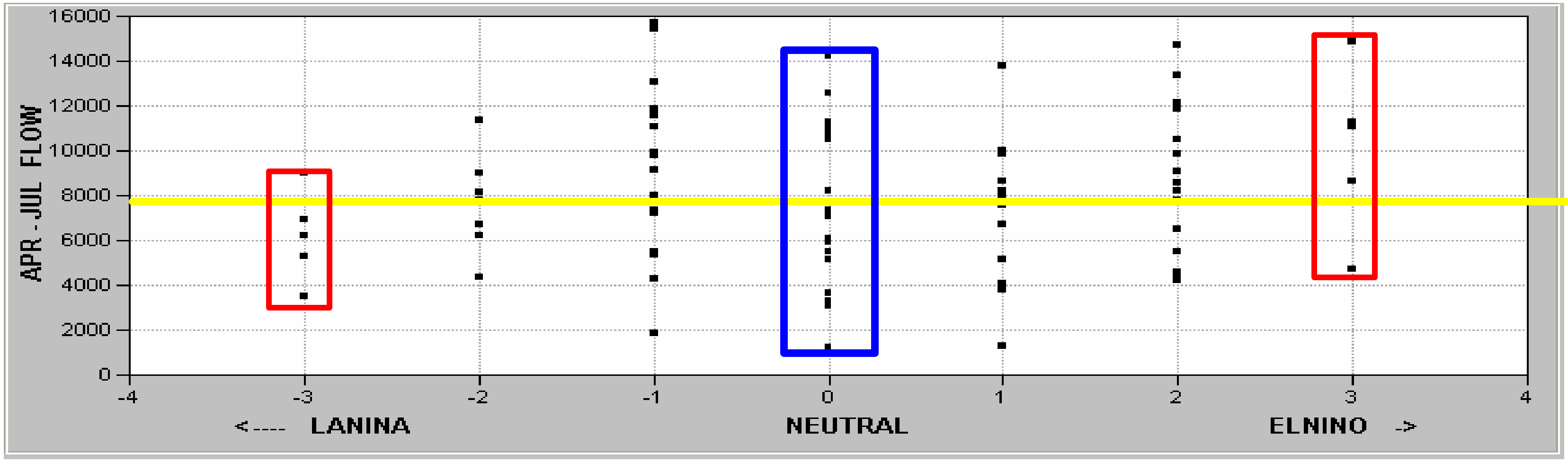
EARLY SEASONAL OUTLOOKS

We Use Several Methods

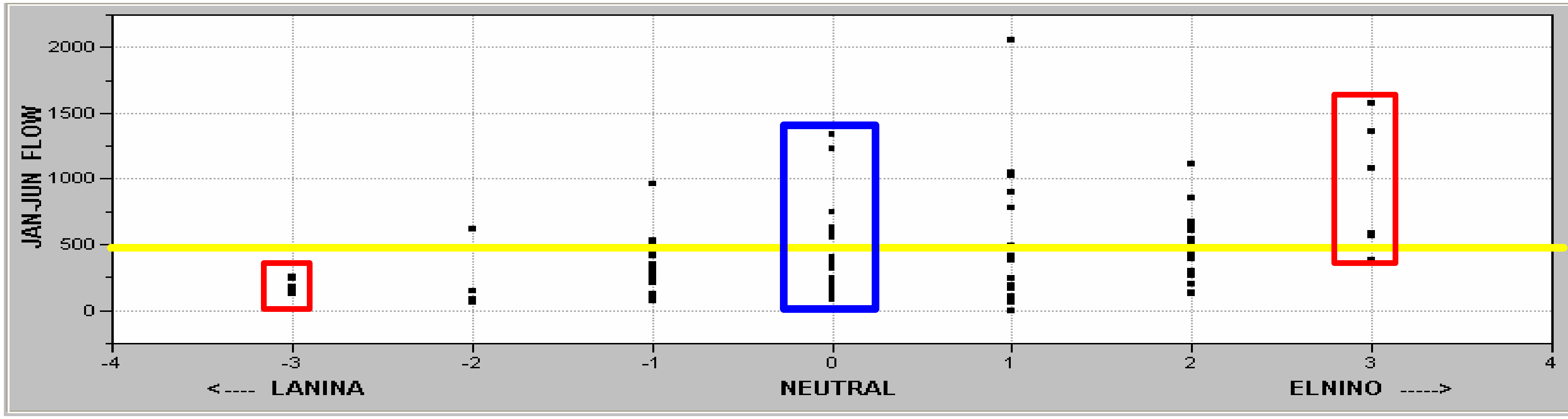
Teleconnection-Longer Frequency Patterns
Time Series Analysis
Ensemble Streamflow Prediction
Statistical Relationships
Climate Prediction Center Seasonal Forecasts

TELECONNECTION/INDICES	IDENTIFIER
North Atlantic Oscillation	(NAO)
East Atlantic Pattern	(EA)
East Atlantic Jet	(EA-JET)
East Atlantic/Western Russia Pattern	(EA/WR)
Scandinavia Pattern	(SCA)
Polar/Eurasia Pattern	(POL)
Asian Summer Pattern	(ASU)
West Pacific Pattern	(WP)
East Pacific Pattern	(EP)
North Pacific Pattern	(NP)
Pacific/North American Pattern	(PNA)
Tropical/Northern Hemisphere Pattern	(TNH)
Pacific Transition Pattern	(PT)
Pacific Decadal Oscillation	(PDO)
Southern Oscillation Index	(SOI)
Multivariate Elnino Index	(MEI)
Atlantic Multidecadal Oscillation	(AMO)

Upper Colorado – Lake Powell Inflow



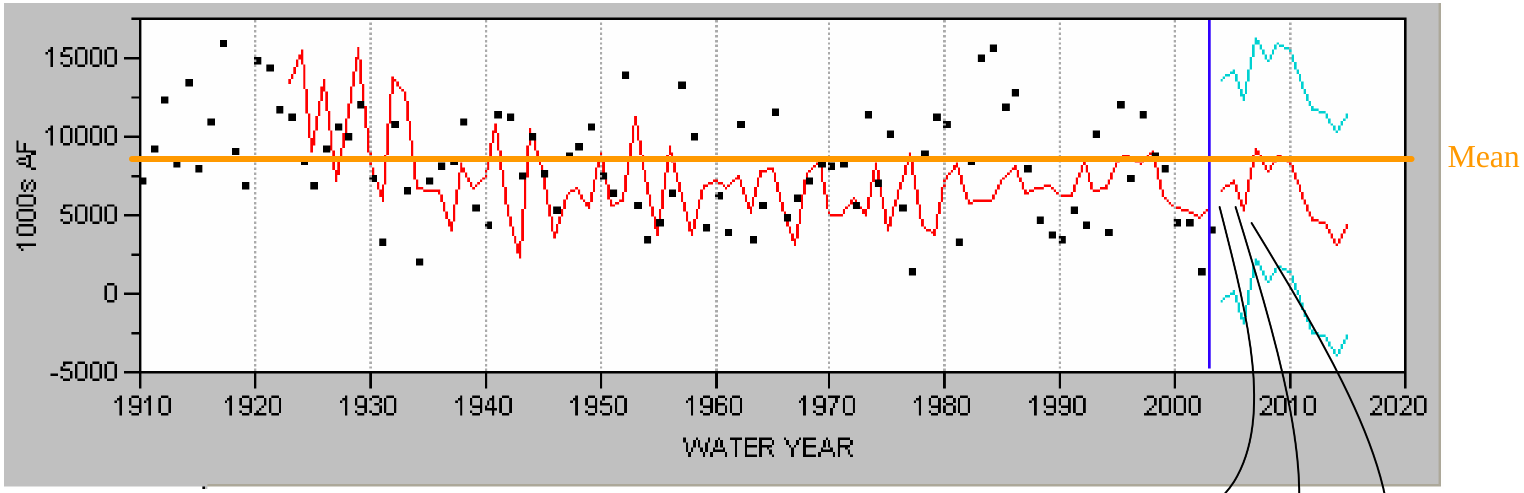
Weaker **Lower Colorado – Salt River Inflow** Stronger



Oct/Nov/Dec Sea Surface Temperature Analysis 150 West to Date Line

Strong Warm(+3) /Cool Periods (-3)
Moderate Warm(+2)/Cool Periods (-2)
Weak Warm(+1)/Cool Periods (-1)
Neutral (0)

Forecast For APR-JUL Streamflow for Lake Powell
Winter's Method Time Series Analysis of Past Flows
Ran: November 2003



2004 6.6 (maf)
2005 7.2 (maf)
2006 5.2 (maf)

OUTLOOK-SPRING RUNOFF INTO POWELL 2004

	Year	
Procedure	2003	2004
Time Series Analysis	5.900	6.6 (maf)
Ensemble Streamflow Prediction	6.400	5.3
Statistical Relationships	4.100	6.9
Observed	3.900	????
Average	7.930	

Two Basic Models Are Used to Forecast Streamflow

(1) Statistical Regression Models

Relates input variables such as snowpack, precipitation, climate indices to an output variable, volumetric streamflow

(2) Ensemble Streamflow Prediction

Uses historical traces of precipitation and temperature and conditions these based on current soil moisture conditions…traces can be weighted

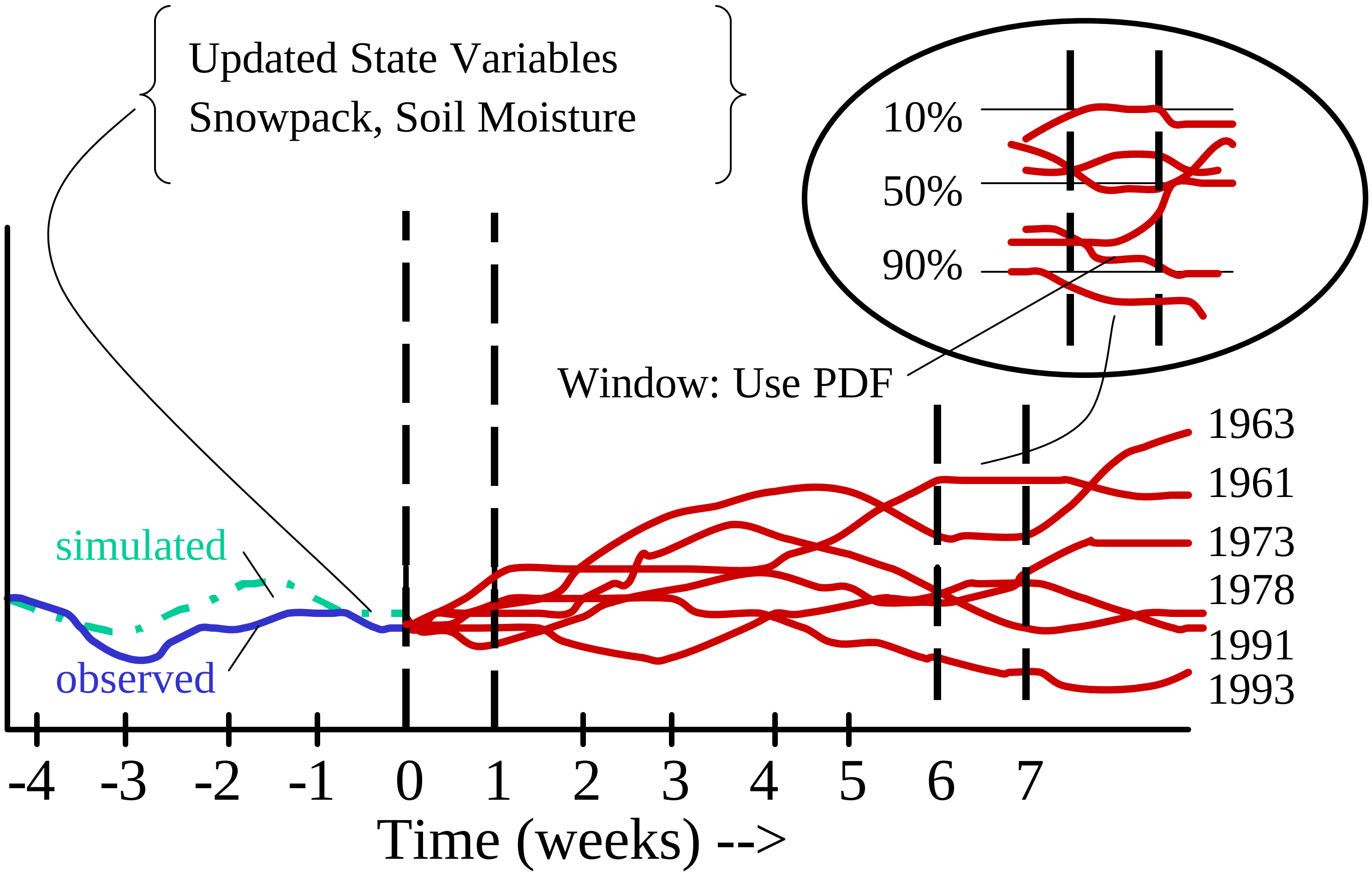
Statistical Regression

Used since late 40's
Simple Model-Easy to Implement
Good at predicting a single variable
Breaks down in extreme years
Non-Linear capabilities
- Neural Networks
- Power Functions
- Nearest Neighbor Analogs

ESP: A conditional forecast simulation based on:

1. Current watershed conditions and model states, snow, soil moisture, flow

2. Known historical precipitation, Temperature and streamflow (can be weighted)



Model Input

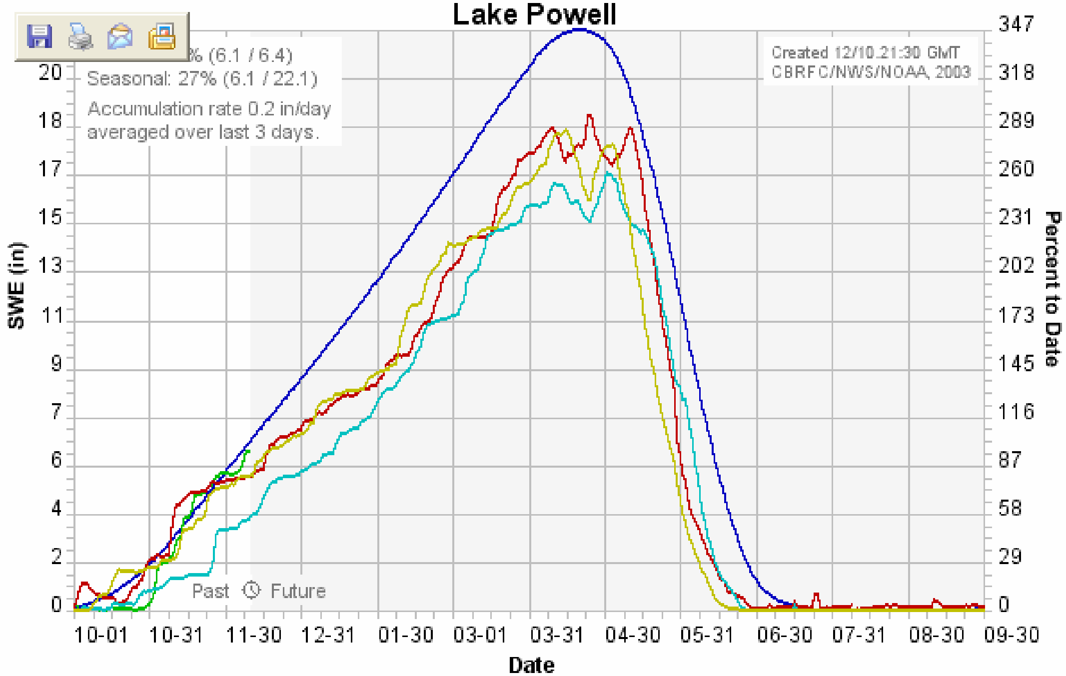
Observations
TA, PP, QC

QPF
QTF

Yearly Historical Time Series PP & TA
based on Weighting Schemes

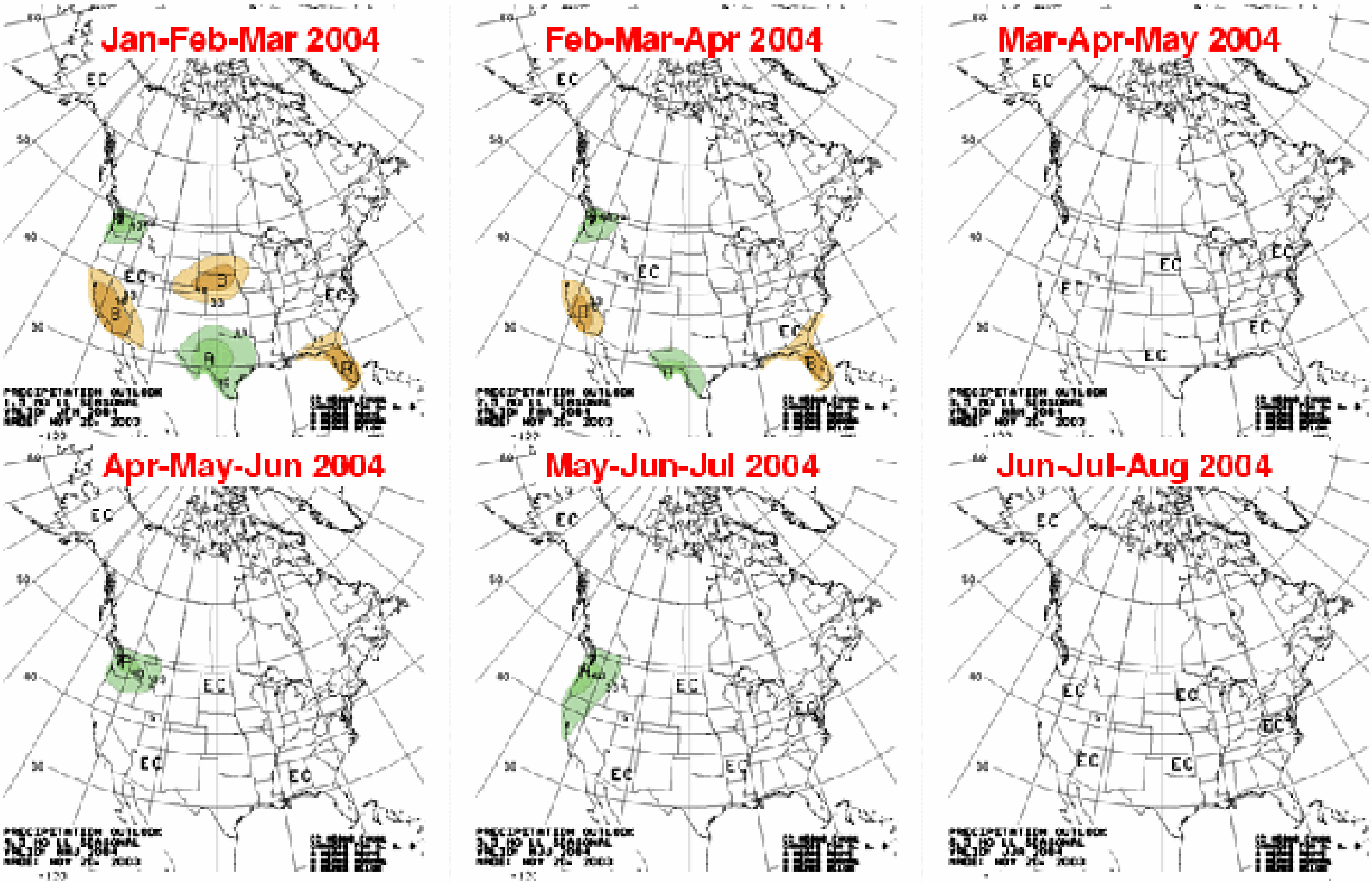
Lake Powell Multiple Station Snotel Plot

The current time is: 12/10.21:27 GMT.

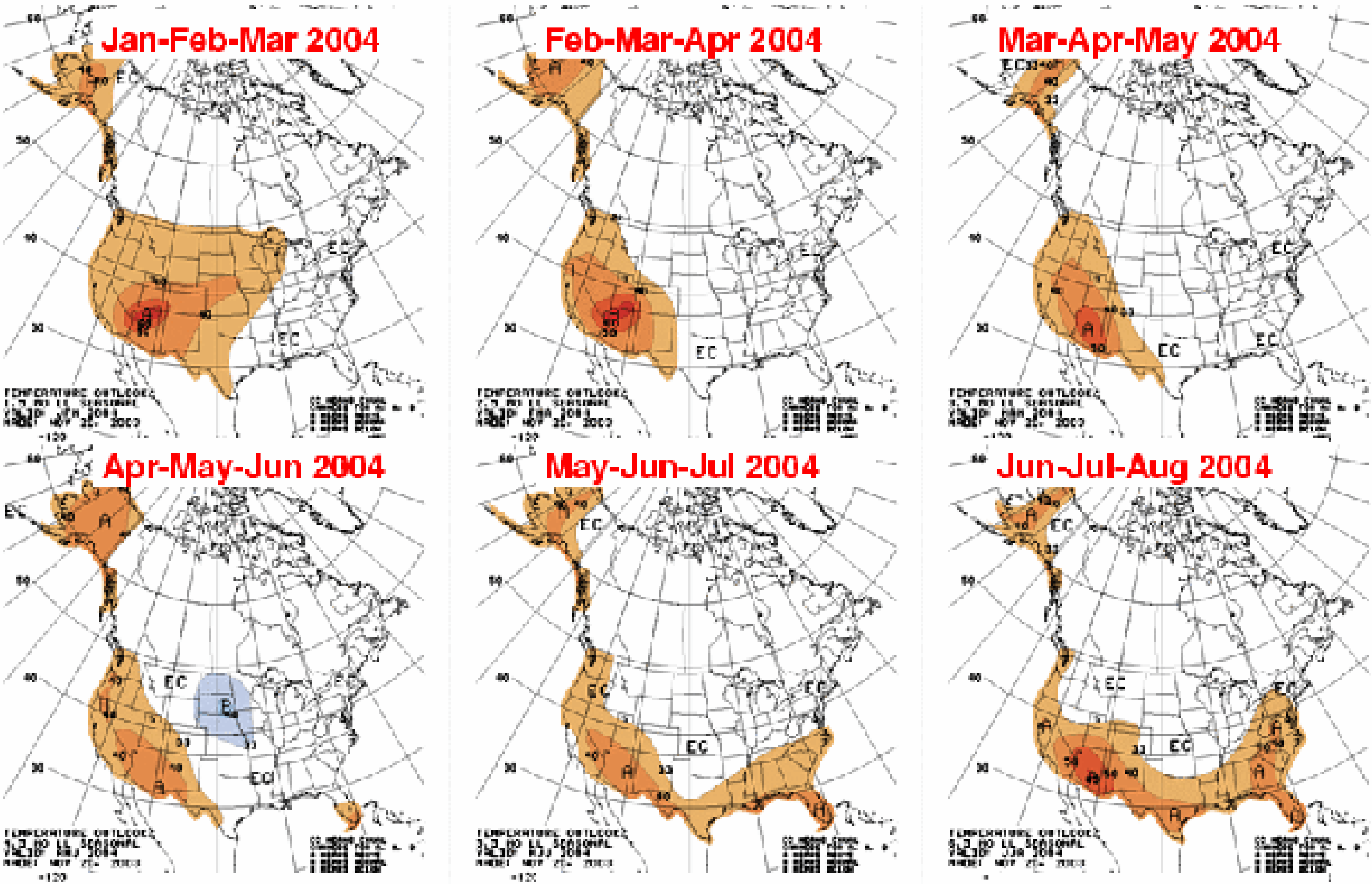


BGSW4 BIG SANDY OPENING
TOWC2 TOWER
EKPW4 ELKHART PARK G.S.
SCKU1 STEEL CREEK PARK
BNDU1 BROWN DUCK
MMTU1 MOSBY MTN.
STDU1 STRAWBERRY DIVIDE
OLDW4 OLD BATTLE
SEEU1 SEELEY CREEK
FMTC2 FREMONT PASS
BTSC2 BERTHOUD SUMMIT
VLMC2 VAIL MOUNTAIN
IDPC2 INDEPENDENCE PASS
SUMC2 SUMMIT RANCH
RMPC2 RED MOUNTAIN PASS
MCPC2 MCCLURE PASS
WCSC2 WOLF CREEK SUMMIT
BRTC2 BEARTOWN

Precipitation Outlooks for 2004



Temperature Outlooks for 2004



NATIONAL WEATHER SERVICE

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www.cbrfc.noaa.gov

National Weather Service

Climate Prediction Center

www.cpc.ncep.noaa.gov

NOAA-CIRES

Climate Diagnostics Center

www.cdc.noaa.gov